

2nd IAG Yangtze Fluvial Conference

EMECS/NIES Session

River Basin to Estuary: Processes and Management

Shanghai June 27 2004

Conference Report



International EMECS Center



EMECS/NIES Session

2nd IAG Yangtze Fluvial Conference



Dr. Nobuo Kumamoto



Dr. Masataka Watanabe



Dr. Kinga Krauze



Dr. Joseph Hun-wei Lee



Dr. Hi-Il Yi



Dr. Ying Wu

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2nd IAG Yangtze Fluvial Conference



Dr. Kaiqin Xu



Dr. Zhu Jianrong



Dr. Tran Duc Thanh



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1 Overview

1.1 Objectives

The Second Yangtze Fluvial Conference, a conference on the Changjiang (Yangtze) River, the geomorphology of its river basin and environment, organized by the International Association of Geomorphologists (IAG), was held at East China Normal University in Shanghai, China. The First Yangtze Fluvial Conference was held in 1999, and this second conference was planned by the Large River Working Group of the IAG in order to follow up on subsequent developments in research since the first conference.

River and river basin environments have a profound effect on estuaries and other coastal zone environments through the transport of water, sediments, nutrients and so on. For this reason, when discussing the environmental impact of geomorphological changes in river basins, rainfall, the use of water and land and various other natural phenomena and human activities, it is necessary to think of river and ocean environments as an integrated whole. In the case of huge rivers such as the Yangtze in particular, the impact on coastal zones is enormous and extends over a wide area.

For this reason, on the final day of the Second Yangtze Fluvial Conference, the International EMECS Center and Japan's National Institute for Environmental Studies (NIES) co-organized a session on the impact of river basins on coastal zone environments.

1.2 General Outline

1.2.1 Session title

EMECS/NIES Session – River Basin to Estuary: Processes and Management

1.2.2 Organizers

- International EMECS Center
- National Institute for Environmental Studies, Japan
- State Key Laboratory of Estuarine and Coastal Research, East China Normal University
- International Association of Geomorphologists Working Group on Large Rivers

1.2.3 Date

Sunday, June 27, 2004 8:30 a. m. - 2:50 p. m.

(The 2nd IAG Yangtze Fluvial Conference was held Thursday, June 24 - Sunday, June 27)

1.2.4 Venue

Huashen Academic Exchange Center, East China Normal University,
Shanghai, People's Republic of China

1.2.5 Schedule

The conference was organized into three sessions, each held on a different day:

June 25	Fluvial Session and Poster Session
June 26	Fluvial to Estuarine Session and Poster Session
June 27	EMECS/NIES Session and Open Discussion
June 28 (departure June 27) - July 1	Field trip

Approximately 30 of the participants went on a field trip to view the river basin topography and environment of the tributaries in the upper reaches of the Yangtze (primarily Min Jiang) at the eastern edge of the Tibetan Plateau.

1.2.6 Participants

A total of 100 persons attended the conference.
There were 67 registered participants from 16 countries.

1.2.7 Publication

Post conference publication of the papers presented at the Yangtze Fluvial Conference including EMECS/NIES Session is planned in the following two academic journals at a later date.

- Presentations relating to rivers will be published in *Geomorphology*
Information on *Geomorphology*:
http://www.elsevier.com/wps/find/journaldescription.cws_home/503334/description#description
- Presentations relating to coastal zones will be published in *Estuarine, Coastal and Shelf Science*
Information on *Estuarine, Coastal and Shelf Science*:
http://www.elsevier.com/wps/find/journaldescription.cws_home/622823/description

1.3 Session Summary

1.3.1 Keynote Lectures

The first half (morning session) of the June 27 session featured six keynote lectures.

Dr. Yoshiki Saito of Japan's National Institute of Advanced Industrial Science and Technology (AIST) served as chair for the morning session. At the beginning of the session, Dr. Saito said that, compared to the sessions on the previous days, this session would focus more on the topic of scientific research aimed at achieving sustainable coastal zone environments.

The first keynote lecture was presented by Dr. Nobuo Kumamoto of Hokkaigakuen University, Japan (who also serves as chair of the Scientific and Policy Committee, International EMECS Center). In his presentation, Dr. Kumamoto described how the EMECS Conferences came to be held, and he gave an overview of the achievements and significance of past EMECS Conferences and the major issues discussed at the conferences. Dr. Kumamoto also mentioned that the next EMECS Conference would be held in Caen, France in 2006, and he noted the theme of the conference and other particulars.

The second keynote lecture was given by Dr. Masataka Watanabe of the National Institute for Environmental Studies (NIES), Japan. Dr. Watanabe spoke on the environment in the region of the East China Sea, which is based on the balance of water masses such as the river water from the Yangtze River, the Kuroshio Current, the water in the Yellow Sea and so on. Dr. Watanabe used the results of plankton and other tests and surveys to show the impact of these water masses on the coastal ecosystems in this ocean region. Numerical simulations of the outflow from the Yangtze River into the East China Sea revealed that, during the large-scale flooding that occurred in the river basin in 1998, the suspended solids from the Yangtze River crossed the East China Sea in a short period of time and reached locations near the coast of Japan. Along with indicating the extent of the impact on the coastal zones of the Yangtze River, Dr. Watanabe also talked about the predicted impact of future anticipated environmental changes in the Yangtze River basin on coastal zone environments.

The third keynote lecture was given by Dr. Kinga Krauze, International Center for Ecology, Polish Academy of Sciences, Poland. Dr. Krauze spoke about a UNESCO program devoted to research into sustainable use of water resources and management of river basins. Dr. Krauze pointed out that sustainability meant that it was impossible to separate the ecosystem from hydrology. She also pointed out the need to consider land-based development, societal concerns, environmental restoration and so on in an all-inclusive manner, and she gave examples of the restoration of the ecosystem through hydrological control and so on in Poland.

The fourth keynote lecture was given by Dr. Joseph Hun-wei Lee of the University of Hong Kong in China. Dr. Lee spoke about red tides in Hong Kong, located near the mouth of the Pearl River, and his presentation involved both continuous water quality measurements and other site surveys as well as simulations using numerical models. Dr. Lee discussed such issues as inflow loads from land, trends in the occurrence of red tides, the status and mechanism of the spread of red tides from one sea area to another, and the relationship between the occurrence of red tides and dissolved oxygen and other water quality indicators, and he introduced a method for predicting the occurrence of red tides using numerical simulations and data-driven modeling.

Following a short intermission, Dr. Joseph Hun-wei Lee (University of Hong Kong) served as chair for the remainder of the keynote lecture portion of the session.

The fifth keynote lecture was given by Dr. Hi-Il Yi of the Korea Ocean Research & Development Institute. Dr. Yi presented an overview of policies aimed at integrated coastal zone management in Korea. She focused in particular on the creation of a Coastal Management Information System that uses satellite imageries and geographic information systems (GIS) to integrate various types of information on ocean and coastal land regions such as water quality, topography, fishing operations and the use of coastal zones. Dr. Yi also discussed methods for evaluating the vulnerability of coastal zones to disasters.

The final keynote lecture was given by Dr. Yin Wu, State Key Laboratory of Estuarine and Coastal Research, East China Normal University, China. Dr. Wu gave a

presentation on the results of an analysis of the carbon flux from the Yangtze River to ocean regions. She presented broad-based data on transport quantities in various forms (inorganic or organic and dissolved or suspended) for both main river and tributaries, from the upper reaches of the Yangtze River to the estuary, as well as the results of an analysis of the influence of the environmental changes in the river basin on the carbon flux and the extent of its impact on changes in coastal zone environments. Dr. Wu also pointed out that, in addition to the normal monitoring in the Yangtze River, greater attention must be paid to the impact of flooding.

1.3.2 General presentations

In the afternoon, there were three general presentations. Dr. Hi-Il Yi (Korea Ocean Research & Development Institute) served as chair.

First, Dr. Kaiqin Xu of the National Institute for Environmental Studies (NIES), Japan gave a presentation on research into methods for predicting inflow quantities of nutrients from the Yangtze River basin into the East China Sea. Dr. Xu noted the scarcity of data compared to the size and complexity of the Yangtze River system and said that the inflow load is not yet clearly understood. Accordingly, he introduced a method to estimate the inflow load from limited measurement data obtained by a joint Japanese - Chinese research project conducted to gather existing data as well as the implementation of site surveys. Dr. Xu also discussed a study involving the use of a mesocosm to study the impact on the Yangtze coastal ecosystem.

The second general presentation was given by Dr. Jianrong Zhu of State Key Laboratory of Estuarine and Coastal Research, East China Normal University, China. Dr. Zhu reported on research conducted by means of three-dimensional numerical simulations of the flow in the Yangtze River estuary, showing predicted changes in the salt water intrusion from the estuary accompanying the changes in river flow and other effects on the estuary caused by the construction of the Three Gorges Dam and the project to pump water from the Yangtze River to North China.

The final general presentation was given by Dr. Tran Duc Thanh of the Haiphong Institute of Oceanology in Vietnam. Dr. Thanh reported on the impact of sediment transport in Vietnam's Red River on the formation of the delta, coastal erosion and so on. He also touched on the impact on coastal tourism and coral reefs, and on problems in the management of river basin environments resulting from anticipated future increases in water use in the river basin.

1.3.3 Conclusion

Throughout the session, the Yangtze River basin and the coastal zone environment were considered as an integrated whole, and the impact on the area from river to ocean and the problems of environmental management were discussed from multiple perspectives. The holding of this session in particular at the Yangtze Fluvial Conference, which focuses on research and discussion of river geomorphology and environments, added a clear perspective of the effect of environmental problems in river basins on ocean environments. Issues relating to an extremely broad area, from the upper reaches of the Yangtze River to the East China Sea, were discussed from an interdisciplinary and comprehensive perspective by researchers from different specialist fields who had come not only from China but from many other regions as

well.

It is hoped that this discussion will contribute to the development of comprehensive environmental management for the Yangtze River basin and coastal zones in the future.

2. Program

EMECS/NIES Session

River Basin to Estuary: Processes and Management

June 27 2004

Keynote Lectures

Chair: Dr. Yoshiki Saito

Institute of Geology and Geoinformation/Geological Survey of Japan,
National Institute of Advanced Industrial Science and Technology

- | | |
|-------------|---|
| 8:30-9:00 | EMECS Activities and Its Future Role for Sea Water Protection
Dr. Nobuo Kumamoto, Hokkaigakuen University, Japan / Chair,
Scientific and Policy Committee, International EMECS Center |
| 9:00-9:30 | Impact of Large Variations in the Changjiang River Flux on
Environmental Properties in the Estuary and the East China Sea
Dr. Masataka Watanabe, National Institute for Environmental
Studies, Japan |
| 9:30-10:00 | Ecohydrology - An Interdisciplinary Tool for Sustainable
Management of Fluvial Systems - UNESCO Program
Dr. Kinga Krauze, International Center for Ecology, Polish Academy
of Sciences, Poland |
| 10:00-10:30 | Eutrophication, Algal Blooms and Red Tides in Hong Kong -
Observations, Modeling and Prediction
Dr. Joseph Hun-wei Lee, The University of Hong Kong, China |
| 10:30-10:50 | Tea / coffee break |

Chair: Dr. Joseph Hun-wei Lee, The University of Hong Kong

- | | |
|-------------|--|
| 10:50-11:20 | Coastal Management Database and Satellite Imagery for ICM
(Integrated Coastal Management) in Korea
Dr. Hi-Il Yi, Korea Ocean Research & Development Institute, Korea |
| 11:20-11:50 | Biogeochemistry Characteristics of Dissolved and Particulate
Carbon in the Changjiang System
Dr. Ying Wu, State Key Laboratory of Estuarine and Coastal
Research, East China Normal University, China |
| 11:50-13:50 | Lunch, Poster Unloading, Check out for Field Trip |

General Presentations

Chair: Dr. Hi-Il Yi, Korea Ocean Research & Development Institute

- 13:50-14:10 Estimation of Sediment and Nutrient Fluxes from the Changjiang River into the East China Sea
Dr. Kaiqin Xu, National Institute for Environmental Studies, Japan
- 14:10-14:30 Impact of the Three Gorges Dam and Project Pumping Water from the Changjiang River to North China on the Saltwater Intrusion in the Changjiang Estuary
Dr. Jianrong Zhu, State Key Laboratory of Estuarine and Coastal Research, East China Normal University, China
- 14:30-14:50 Changes in the Discharge and Distribution of Water and Sediments from the Red River and their Effect on the Coastal Zone
Dr. Tran Duc Thanh, Haiphong Institute of Oceanology, Vietnam

3. Keynote Lectures

3.1 Keynote Lecture 1

EMECS ACTIVITIES AND ITS FUTURE ROLE FOR SEA WATER PROTECTION

Dr. Nobuo Kumamoto

President, Hokkaigakuen University

Chair, Scientific and Policy Committee, International
EMECS Center



Distinguished guests, participants, my colleagues, friends, ladies and gentlemen. It is my special honor and pleasure, as a chairperson of Scientific and Policy Committee, International EMECS Center, to make this presentation of its activities and role for present and future generation in this Second Yangtze Conference.

Let me begin my presentation with an explanation of the name EMECS first. EMECS is an abbreviation of Environmental Management of Enclosed Coastal Sea, which aims to promote domestic and international activities for protecting enclosed coastal sea and its surroundings. We use a word: International EMECS Center or Kokusai Emekkusu Sentar in Japanese when we talk of its activities.



Main office of International EMECS Center is located in Kobe, Hyogo Prefecture, in Japan since 1987, when it was organized and started its activities in international level.

Let me shortly trace to its original activities which started in the United States. Dr. Ian Morris of the University of Maryland Center for Environmental and Estuarine Studies invited international experts of sea water protection in early 1980s from several countries including Sweden, England, Japan and some others to the University of Maryland Center in Cambridge, Maryland, in order to organize a joint international comparative study group for the enclosed coastal sea water, which was supported by the State of Maryland and concerned companies and citizens as well.

The motivation of this study stemmed from substantial water pollution observed in the Chesapeake Bay, which is surrounded by Washington DC, the state of Pennsylvania, state of Maryland, Virginia, Delaware and West Virginia. The quality of water of the Bay is much influenced by polluted water discharged from these concerned states and towns in the Chesapeake Bay area. Such physical surroundings caused easily degradation of sea water by discharged polluted water from farms, factories, pastures, cattle farms, domestic used water. The polluted sea water had strong influences to the marine products such as fish, shellfish or crabs in the Bay region, which has been well known as one of the famous fishery products of the United States of America.

The original study experience guided by Dr. Morris could easily combine with future international activities for protecting sea water in the world.

As you may see, the water pollution process of the enclosed coastal sea is caused by inflow of various elements of contamination into the sea. Thus it is quite easy to see that land generated materials of contamination flow into the enclosed sea through various measures such as rivers, underground water or some other ways.

It is important to know that the enclosed coastal sea has basic characters such as:

First, the water within the enclosed sea does not easily change its qualities, because of its physical situations surrounded by land and some other objects such as islands. This means that poor exchange of water in it with the open sea causes serious accumulation of contaminated materials.

Second, because of such physical conditions, the enclosed sea water easily polluted by river water which brings polluted materials from land based facilities into the sea.

Third, the enclosed coastal sea water plays an important role for fostering baby fish, shellfish and other small animals and small unit of plants as well which fit for their growing. As the results of it, contamination of the sea water causes serious damages of its production.

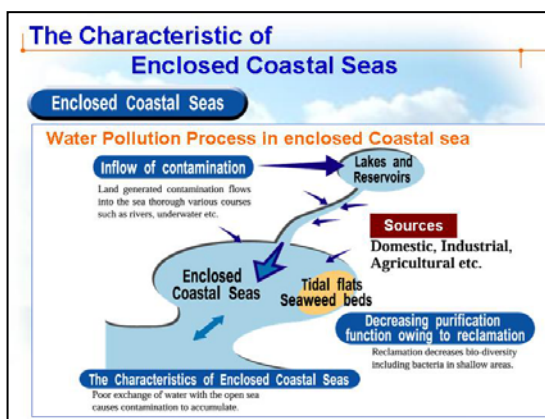
Fourth, the enclosed coastal sea water is, needless to say, easily influenced by red tides, which spoils cultured fish and shellfish and other marine products.

Fifth, owing to reclamation in large scale, purification function of natural sea water decreases its normal function and bio-diversity in shallow water areas.

Sixth, in addition, in many cases scenic beauty and historical monuments abound in and around enclosed coastal sea area. Seto Inland Sea of Japan is a good example of this scenic beauty.

Now the enclosed coastal sea, however, has been broadly given damages by human activities for production and usage, such as various constructions for harbors, bridges, recreational facilities, highways, warehouses, factories, shopping centers, housings and others. Among these human activities, reclamation is the worst reason of decreasing wetlands everywhere in the world.

In addition to such human activities, the enclosed coastal sea has been polluted by agricultural activities, daily farm functions as well. Another type of destruction is caused by human productive activities mainly for cultured fish and shellfish. It is quite important to know, however, that the sea water pollution has been as well caused by eutrophication of water in which cultural



fish and shellfish are fostered. Domestic used detergent discharged into river also may cause serious eutrophication in the enclosed sea. As to the chemical and scientific causation link between red tides and materials has not yet been established by scientists concerned. It is still left in our hands to solve it.

I would like to draw your attention to serious oil spills or discharge oil problems from oil cargos or wrecked ships in the enclosed seas. It causes serious disasters in and around the beaches concerns as you know.

Let me introduce examples of enclosed coastal seas in the world. Here we may cite such major enclosed coastal seas in the world as follows: Chesapeake Bay, in the United States, which I had mentioned before, San Francisco Bay and Puget Sound in the United States as well, Gulf of Mexico, Bo Hai, in China, Mediterranean Sea, in Mediterranean Sea area, North Sea, between England and Europe, Black Sea, surrounded by several countries such as Turkey, Georgia, Ukraine, Russia and some other countries, Persian Gulf and Arabian Sea, Gulf of Thailand, Seto Inland Sea, in Japan, as I mentioned, Caspian Sea, and other numerous places in the world.



We, members of the International EMECS center, have made our efforts to organize several international conferences in these areas for almost last fifteen years. As a result, it is important to know that the comparative study of the enclosed coastal seas may make it possible for us to learn broad knowledge of physical conditions of various areas and to find common problems and countermeasure policies for enclosed coastal sea areas. We may say that, natural phenomena in Chesapeake Bay are similarly observed in Seto Inland Sea. We may take effective measures against them.

From this reason, the freedom of information policy should commonly be adopted, and thus the exchange of information concerning enclosed sea area can be effectively promoted among concerned countries.

I just skip the background knowledge of the relation between the international activities of EMECS and the activities started by Dr. Ian Morris. I'd like to later explain it. Just one point, Dr. Ian Morris came to Japan as a mission to investigate the studies in Seto Inland Sea, Japan. We had a chance to see Governor Kaihara of Hyogo prefecture. We talked about future planning for the project in environment of the sea. And then, Governor Kaihara got an idea, then, it took three years to organize a conference in Kobe. It was in 1990. It's considered as the first EMECS Conference. I can say such a relationship between United States and Japan is considered quite important, which plays an important role in addressing the environmental problems.

Now I would like to explain the activities of EMECS Center. As activities of the EMECS Center, we have promoted various projects as follows until today:

Several projects to promote the prevention of enclosed coastal sea pollution such as international symposiums and conferences which we organized in previous years.

The second activity is collection, circulation and utilization of information

such as issues of newsletter, CD-ROMs, internet systems and some other devices.

The third activity is conducting education and training activities to foster experts such as the previous training courses, short term schoolings and seminars.

As one of the major activities, as I mentioned, the international conferences that I can explain something here, we organized six international EMECS Conferences until today:

The first one is Kobe conference in 1990. The second one is EMECS Conference 1993 in Baltimore, Maryland. The third one was in Stockholm, Sweden, which was jointly organized with 7th Water Symposium. The fourth one was in 1999, Antalya, on Mediterranean, located in southern part of Turkey. It is a famous place for resort area. It was held in 1999 and this one was combined with the activities of Medcoast meeting. Medcoast is mainly intended to organize an international scientific group providing education on environmental management to people around eastern part of Mediterranean area. Fifth EMECS Conference of 2001, we invited the conference to Kobe again. That was organized in 2001. Then, the most recent one is the sixth conference in Bangkok, Thailand, 2003.

Now I would like to summarize the previous EMECS Conferences. Through these experiences, we may tentatively conclude previous conferences as follows:

The 1990 Kobe Conference reported a disaster caused by red tides in Seto Inland Sea of Japan, due to the interaction of biological and chemical materials, in addition to other topics such as governance of land and sea, environmental education, value of cultural heritage of coastal sea, and exchange of information to citizens, economists, fishery unions, lawmakers and administrators. Thus, the Kobe Conference had opened the most important gate to comparative studies of coastal water and oriented directions afterward of discussions in domestic and international meetings.

The second one, the 1993 Baltimore Conference selected six issues such as the role of philosophy in environmental protection as well as the roles of citizens, the role of science and technology, and environmental education among citizens, and the concepts of governance and integrated management. This concept is considered quite

EMECS Center's Activities

- (1) Projects to Promote the Preservation of Enclosed Coastal Sea Environments
- (2) Collection, Organization and Utilization of Information
- (3) Conducting education and training activities

1st EMECS Conference (EMECS90)

- Aug.3~6,1990
- Kobe ,Japan
- Theme
"Environmental Management and Appropriate Use of Enclosed Coastal Seas"
- Participants
42 countries, 1,200 people



2nd EMECS Conference (EMECS93)

- Nov.10~13,1993
- Baltimore,U.S
- Theme
"Toward Effective Governance of the World's Enclosed Coastal Seas"
- Participants
46 countries, 2,300 people



important, trying to consider various elements as a whole.

After the Baltimore Conference, we resumed the tasks imposed by previous Conferences to the third EMECS Conference in Sweden in 1997, which was jointly organized in cooperation with the 7th Stockholm Water Symposium. The Water Symposium in Stockholm, I suppose some of you know about quite well, is considered about not only sea water but land water as well. In this Conference, the "Interaction of Land Activities, Fresh Water and Enclosed Sea" was adopted as the main theme, to introduce various aspects of the relations of land and sea water. That beautiful sea port city of Sweden gave us an opportunity to make a review on the role of citizens again, the meaning of exchange information, and the evaluation of policies overcoming barriers in governance. The barriers are very basic key elements in sustaining and creating good environment. Five case studies on the Baltic Sea, the Black Sea, the Seto Inland Sea, Chesapeake Bay and Gulf of Thailand, which were introduced by experts, provided particularly important information of comparative studies. We could see a similar situation which happened in various areas in the world. We may take some good examples and we may learn some experiences from these case studies.

In the 4th EMECS Conference in Antalya, Turkey in 1999, we focused on several topics such as land-sea interaction again, coastal management, coastal engineering as a whole, the reaction of coastal and marine biology, the importance of managing coastal ecosystems. This joint conference with MEDCOAST Conference adopted some other additional topics such as promoting training and education, because MEDCOAST is very famous, as I shortly mentioned, for the important role they played in fostering young generation, they have tried to provide a good example of information to concerned experts in that area. In this Conference, a Declaration of Coastal Seas was adopted, in which we emphasized new information technology which plays quite an important role for conveying the results of our research and experience to younger generations. That is quite important.

We invited the fifth EMECS Conference to Kobe again in 2001. In that Conference, much attention was paid to Asian sea water problems, in addition to NGO activities, which were newly invited to our concrete activities. Needless to say, the relation with NGO's

**3rd EMECS Conference
(EMECS97)**
joint with 7th Stockholm Water Symposium

- **Stockholm, Sweden**
- **Aug. 11~14, 1997**
- **Theme**
"With Rivers to the Sea:
Interaction of Land Activities,
Fresh Water and
Enclosed Coastal Seas "
- **Participants**
80 countries, 1,000 people



**4th EMECS Conference
(EMECS99)**
joint with 4th MEDCOAST

- **Nov. 9~12, 1999**
- **Antalya, Turkey**
- **Theme**
"Land-ocean Interactions:
Managing Coastal
Ecosystems"
- **Participants**
50 countries, 500 people



**5th EMECS Conference
(EMECS2001)**

- **Nov. 19~22, 2001**
- **Kobe / Awaji, Japan**
- **Theme**
"Toward Coastal Zone Management
that Ensures Coexistence between
People and Nature
in the 21st Century"
- **Participants**
41 countries, 1,100 people



activities is important to continue in future as well, and that is why we invited the experts of NGOs to our Kobe Conference.

The sixth Conference in Bangkok in 2003 suggested to us various attractive activities including participation of young students, which will take full responsibilities in our future. The idea should be sustained in future as well and opportunities for young generations should be provided. We should listen to their voice.

Now at the end of this summary of previous EMECS Conferences, I am quite happy to announce you that the seventh EMECS Conference in 2006 will be held in Caen, C-A-E-N, in Normandy area in France, to which all of you in addition to many colleagues in Europe are cordially invited as participants. The first announcement will be issued in October, or September, I hope. The main theme is “Enclosed Coastal Seas: Our joint Responsibilities”

**6th EMECS Conference
(EMECS2003)**

- Nov.18 - 21,2003
- Bangkok, Thailand
Montien Riverside Hotel
- Theme
“Comprehensive and Responsible Coastal Zone Management for Sustainable and Friendly Coexistence between Nature and People”
- Participants
23 countries, 600 people



**EMECS2003 Special Session:
EMECS Schools and Students Partnership 3**



Now, the conclusions. Considering these results of the past EMECS Conferences, it is time to review the results of previous activities from the beginning until today and to step forward to which we should proceed and what we should do for our future in preserving and creating better environment of coastal water and its surroundings. Out of many valuable presentations and suggestions in these previous EMECS Conferences, we may find several important and urgent policies for the next steps forward.

In addition to chemical or scientific measures for protection of our environment, promotion of comparative studies and so forth, it is important to adopt effective legal measures to land based sources of water pollution to the enclosed coastal sea. Another urgent point is to find effective measures for recovery and creation of coastal water. We need to consider various related elements concerning the protection of sea water. Moreover, in order to sustain at least present condition of sea and land water, a zero emission policy should be broadly adopted by legal and incentive measures. Freedom of information is another element for being adopted and sustained among concerned countries and areas as well.

As a conclusion, I would like to cite a phrase: “from environmental preservation to creation for better environment” which was stated in a keynote speech by the ex-governor Kaihara at one of the previous Conferences. This phrase, which closely connected with knowledge, technique and information, shall be a key concept for the future coastal sea protection movement.

I would like to conclude my short presentation of EMECS activities in Japan with my appreciation to Organizing Committee of this conference.

Thank you very much for your attention.

3.2 Keynote Lecture 2

IMPACT OF LARGE VARIATIONS IN THE CHANGJIANG RIVER FLUX ON ENVIRONMENTAL PROPERTIES IN THE ESTUARY AND THE EAST CHINA SEA

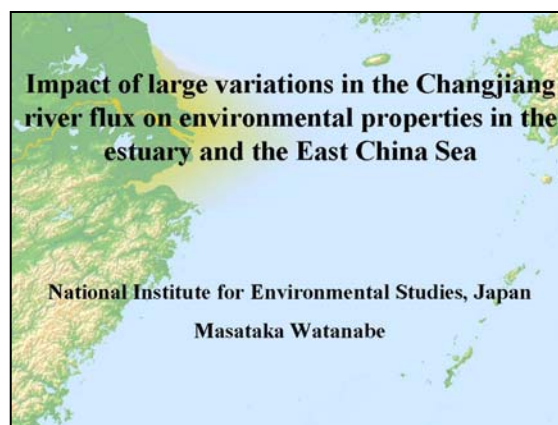
Dr. Masataka Watanabe

National Institute for Environmental Studies, Japan



Thank you very much. We're delighted to open this special session, since NIES has been working very closely with our Chinese colleagues and various agents. Professor Chen is one of the key collaborators with us, but I also have many friends in China, including State Oceanic Administration (SOA) and the Ministry of Water Resources and the Chinese Academy of Sciences. Today, I would like to introduce some of the work, which I've been doing in the past ten years.

First of all, maybe I'll try to answer Professor Chen's question of how the catchment affects the estuary. This is one of the scenarios that we are considering in the Changjiang catchment and Changjiang estuary. The scenario is that we have the present condition, which is that the ocean typically receives phosphate/nitrogen and silicate from land. The ocean ecosystem is pretty much determined by the ratio of nitrogen/phosphate and the silica ratio. However, the Changjiang is a very special river that has lots of sediment. Therefore, most of the phosphates are absorbed on the surface of particles. Therefore, when it comes to the estuary, most of the phosphate is lost by the sedimentation of the particles. Therefore, after 100 km off the Shanghai area, the total amount of phosphate is pretty low compared with nitrogen. Therefore, the nitrogen, phosphate and silicate ratio is very high, particularly the nitrogen-phosphate ratio, in this estuary.



Right now we are considering the two big effects on the catchment. One is the construction of dams, and the other is the policy of transporting water from south to north. By introducing these two engineering exercises, we anticipated some kind of change in biogeochemical cycles.

One is that the eutrophication in the dams will probably be accelerated and more suspended solids will be trapped in the dam. As a result, phosphate will also be trapped and probably silicate will be trapped too. We also have to anticipate the rapid economic growth in urban areas and industrial areas, which will lead to an increase in nitrogen and phosphate load.

Another important factor is that demand for fresh water is increasing tremendously right now. Most of the data are based on the lowest measuring point datum, but the datum is still quite remote from the estuary area and Nanjing and other

big cities are located downstream from the datum. The freshwater usage will be very high in that area because of the rapid industrialization.

Therefore, our scenario is the following. By increasing the nitrogen and phosphate load, and decreasing silicate, should we expect the dinoflagellate red-tide bloom to increase in the estuary? As a result of the succession in the phytoplankton community, should we expect some kind of fish-catch decrease in the estuary? Thirdly, by increasing fresh water demand, should we expect some kind of salinity intrusion into the estuary?

First, I would like to introduce the various schematic views of the complexity of the estuary. This was probably already discussed yesterday and two days ago, in the opening session. In the estuary, from the temperature and salinity and density diagrams, we can characterize the different types of water combination in the estuary area. One is the Changjiang diluted water, here, and Yellow Sea water is coming in here and the Kuroshio current comes in here and also the Taiwan warm current is coming in here on the surface.

In the bottom layer, again the Yellow Sea cold water is connected in here, the Taiwan warm water deep current is coming in here and Kuroshio deep water is coming in here. Those water masses do not mix well, rather they co-exist. Depending on the oceanographic and meteorological conditions they move around, but basically these four water masses co-exist in the estuary.

This is again the schematic view of the flow distribution in the estuary in the East China Sea, as well as the Yellow Sea area. As a result, those water masses determine the ecosystem characteristics as well as distribution. For example, these are the results of one of our past surveys. These red areas are pretty much dominated by Changjiang diluted water. Therefore, the phytoplankton community is dominated by coastal diatom and some of the dinoflagellates. On the other hand, these blue lines are dominated by more oceanic phytoplankton carried by the Kuroshio Current. Therefore the community is entirely different and the diversity is also different. These areas are a mixture of coastal and oceanic plankton communities.

According to the change in location, from coastal areas to offshore, the vertical distribution of the phytoplankton community, as well as other environmental factors, is also significantly dominated by those water masses. For example, Station 9 is strongly influenced by Changjiang diluted water, and therefore most of the nutrients are very high in the surface but very low in the bottom area and as a result the phytoplankton community is abundant in the surface area but there is not much in the bottom layer. On the other hand, Station 20 is the area where the Kuroshio Current penetrates deeper areas, therefore high levels of nutrients exist in the bottom layer but there are quite low concentrations in the surface area. In other words, most of the nutrients are utilized on the surface. Therefore the phytoplankton communities are abundant in the middle layer, somewhere around 30m in depth. Therefore, these phytoplanktons are located where there is a balance between the light penetration from the surface and nutrient availability from the bottom. As a result, the maximum layer exists at 30m in depth. Station 18 is a kind of mixture between coastal and oceanic communities. Not much biological activity exists.

We also made observations at Station 6, which is at the end of the Changjiang dilution water. This is pretty much at the end of the dilution spreading. Most of the nutrients have been utilized. We can still see the maximum biological activity, dominated in particular by dinoflagellates. In this case, the *Prorocentrum dentatum* of red tides has been observed. By continuous measurement at the fixed stations, we can

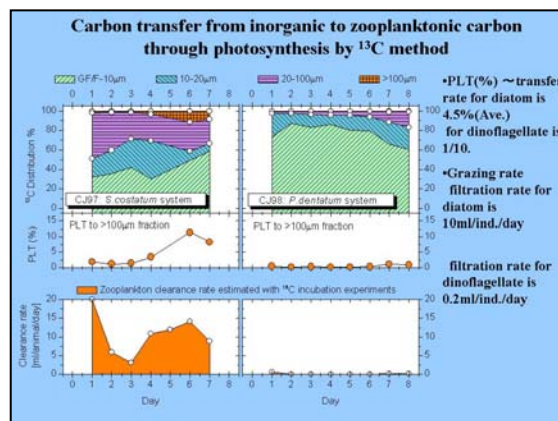
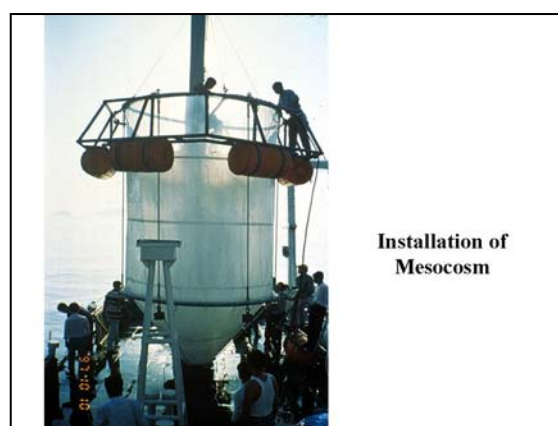
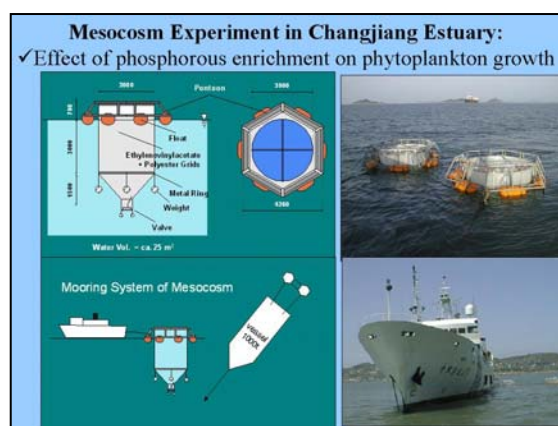
see a very beautiful diagonal or vertical migration of the *Prorocentrum dentatum* going through the salinity stratification. In other words, going through the nutrient and salinity stratification, the *dentatum* is moving up and down to migrate vertically and diagonally and obviously uptakes the nutrients in the bottom. This slide is other, similar data.

Therefore, I can say that the ecosystem, particularly the phytoplankton level, has been completely dominated by the nutrient supply as well as the complex water mass movement in the estuary area.

We also conducted the so-called mesocosm experiment in the estuary. This experiment was designed to see the effect of nutrient perturbation in the ecosystem. In this case, phosphate is a limiting factor in this estuary, and therefore we perturbed the system by adding phosphate to it. We installed a floating mesocosm we call it, enclosure of the ecosystem, with a diameter of 4m and a height of 5m. We put the two floating systems in the estuary, one of which was control and the other perturbed. This is the method that we used in the Changjiang. This is the installation of the mesocosm which was done in collaboration with State Oceanic Administration (SOA).

We conducted two consecutive years. One year was dominated by diatom and one year dominated by dinoflagellates. In essence, I can say that from different phytoplankton communities in the first primary production, the second primary production of the zooplankton level has an entirely different community. The diatom has an abundance of zooplankton, while on the contrary the dinoflagellate community has a very small zooplankton community. As a result, the silicate pattern is also entirely different. Diatom requires silicate as a nutrient, therefore the silicate decreases rapidly. The others had the same nutrient pattern observed.

Strikingly, by using a radioactive carbon tracer, we incubated the system with organic and inorganic carbon sources, and traced how much of the tracer of carbon was transferred from inorganic levels, as well as organic levels, to a different condition, from phytoplankton or bacteria, up to the zooplankton level. In other words, how much of the carbon is transferred to the zooplankton level. This is one measure



of analyzing the ecosystem of the biogeochemical cycle. Astonishingly, we found that in the case of diatom, in this case *Skeletonema costatum* system, there was very strong carbon transfer up to zooplankton level. In other words, the zooplankton community eats a lot of the diatoms as a nutrient, and therefore the zooplankton community is really abundant. On the other hand in the *Prorocentrum dentatum* system, which is a case of dinoflagellate, the zooplankton did not graze on much of the dinoflagellate. In other words, the carbon flows are not active from the inorganic level up to the zooplankton level.

This is a very crucial finding, that zooplankton could be one of the foods for higher trophic levels. Therefore, depending on the phytoplankton communities, the higher level carbon flux is entirely different, and in the diatom case, we can probably expect a huge zooplankton community. Therefore, fish production will be abundant. In contrast, in the dinoflagellate case, carbon does not go up to zooplankton level and so fish production may not be as high as the diatom case. Of course, in the case of fish, we have to introduce many other factors; we understand that. Still, based on our limited experiment, as in this scenario, we can postulate that depending on the red tide condition or healthy diatom blooms, higher trophic levels will be significantly controlled.

Other activities we carried out, we also develop the so-called ‘simulation model’ to understand the whole system. This is the bottom topography for the area. We divided it into two areas for various reasons. This is the ‘near’ field, and this is the ‘far’ field. First we tried to solve the entire far field, including the near field too, keeping those values as a boundary and solve the inside. We used the model developed by the Chesapeake Bay Project, which partially utilized the Princeton Ocean Circulation Model.

We also included the river. The river flow on a daily basis is known only in the case of Changjiang. Only the monthly average value is available in the case of other rivers. Also, we have the continuous validation site here as an ocean buoy. Those values have been utilized as an validation. When we apply the existing model to this size of simulation, we have to include the more important factors, the cycle of rivers and the tidal excitations as a boundary.

Another important factor is wind stress on the surface. The East China and Yellow Sea Basin is strongly influenced by seasonal variation in the wind, particularly typhoons and winter winds. Therefore, we incorporated the ECMWF General Circulation Model results as an input to the surface information. Those data are taken every ten minutes, and are incorporated as a surface boundary condition.

This is the Asian monsoon area. You also have to include the rainfall from the surface to the sea. This is a very significant amount. If we see the freshwater supply only from the rivers, that salinity budget does not match. Much more fresh water is supplied by the atmosphere. This is the important information, deducting from the top, I have to read that, the distribution of precipitation by the TRMM satellite. In other words, the TRMM satellite is a tropical satellite. Twice a day, we can observe the precipitation in the tropical zone. Luckily, the Bohai Sea is also included as part of the tropical zone. These data has again been assimilated on a daily basis. Every day those data are assimilated into the model input, as with the fresh water supply.

Also, we input the fresh water in two ways. One is the measured value, but we also developed the so-called ‘whole-catchment’ simulation model. The whole Changjiang catchment was modeled by the so-called ‘water cycle’ model. This is the validation, the comparison of simulated value with the measured flow rate at the

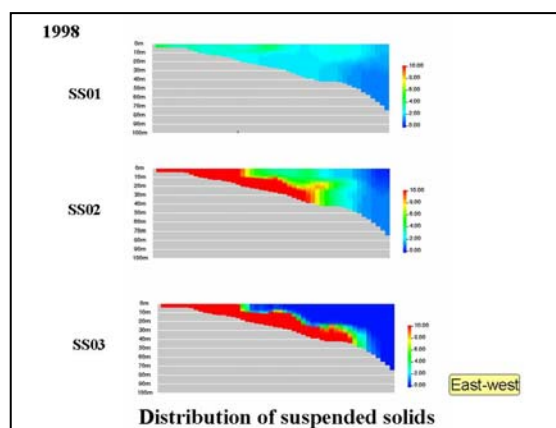
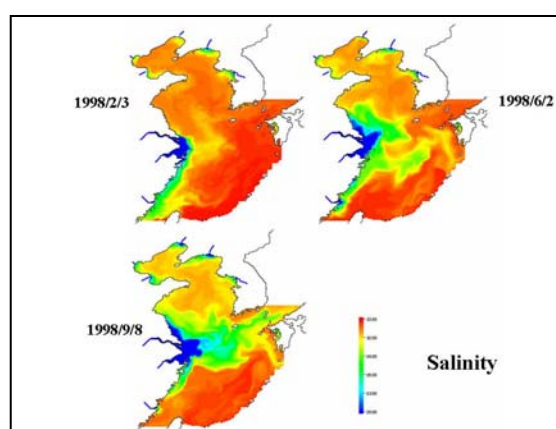
datum station. It shows very good agreement with the datum data. We input this data as the river flow for the Changjiang and this is the comparison of the observed measure at the buoy, and calculated temperature on the surface, at 50m and at 100m. Basically, we believe that these comparisons show very good agreement. Also, this slide shows the simulation result of salinity distribution on September 8th, 1998. This is when the biggest flood occurred in the Changjiang river catchment, and we compared the simulation result with the measured values at Tsushima Straits. This is the calculation and this is Tsushima, this is the Korean side and this is the Japanese side. It shows very good agreement in terms of the salinity distribution.

We also conducted a near-field observation of temperature and salinity and other flow- through and nutrients. Those are also utilized as a validation.

We also applied a simple suspension distribution model, for different sizes. This is smaller than four microns, and this is four microns to twenty, and larger than twenty microns. This model also included simple mixing not only by tidal but also by surface waves.

This is the distribution of salinity for 1998, with seasonal change. I have no way to validate the horizontal scale. We've been trying to use satellite data to calculate horizontal temperature.

Also, as shown by Professor Chen in yesterday's presentation; these particles are smaller than four microns. This is the four-micron to twenty-micron particles. We simply applied the Stokes sedimentation velocity. We can see that during the flood period of August-September 1998, those small particles are spreading on the surface of the East China Sea, crossing the East China Sea and approaching the Sea of Japan and coastal areas of Japan. On the other hand, the larger sized particles are spreading in the near-field, but then flowing at the same density. In other words, at the intermediate depths of 20m to 30m; it's penetrating to the central part of the East China Sea. So, depending on the size of the particles there is a different distribution and behavior.



We also conducted a long-term simulation of the system, starting from 1997 and continuing for three years. The first year data was deleted simply because we reached a certain kind of steady state. Then, we ran the model for two years, and put in a tracer from each river; how each river flow behaved in the East China Sea. This is July 10th, 1998. This is probably the beginning of the flood in the Changjiang, and those particles are crisscrossing the East China Sea and flowing into the Sea of Japan.

But also we can see that other rivers, such as the Han River, are also contributing to part of the Yellow Sea cold water. It's only the case of the Changjiang for a two-year simulation, starting in January, 1998. For most of the winter, the Changjiang waters are spreading along the coast of the south of China. In this case,

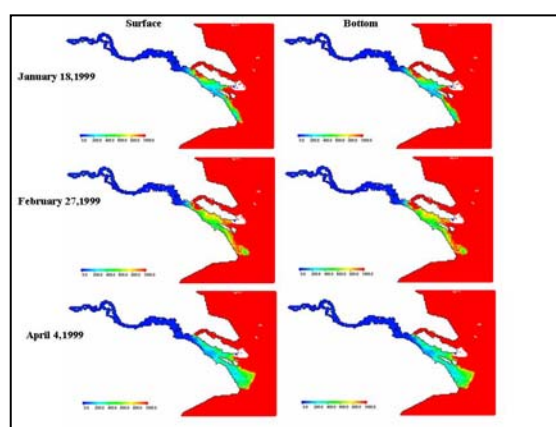
this symbol shows the depth of the fresh water coming from the Changjiang, first spreading on the surface, but through this circulation it sometimes goes to the deeper areas, such as depths of 20m. The color of particles is changed. Therefore, the deep water first goes to the coast of Korea and mixes with the Han River and of course water coming from the Bohai Sea. Those are mixed together here to form the deep cold water of the Yellow Sea, approaching the bottom area of the Changjiang estuary. Therefore, this simulation indicated that the water is always circulating within the system, and it's not a single source, but it's always re-circulating – round and round and round. Those data indicated that in order to achieve a better understanding of the ecosystem in the East China Sea and the Yellow Sea, we need a solid database, not only from the Changjiang River but also from the Korean side as well as the other big rivers, like the Yellow River and others.

The second application of this model is that those boundary data from the large-area simulation are used as input to the near-field computation. This is the estuary of the Changjiang, including the rivers, and we set several validation sites for the measurement of salinity. We produced this scenario. The datum station is around here up to Nanjing. From Nanjing to Shanghai we estimated how much of the water would be utilized in the future, including the south-to-north water transport. Approximately 3,000 m³/s will be utilized. The maximum flow in the Changjiang River is 80,000 – 90,000 m³/s, as yesterday's presentation indicated. But, during the wintertime, it's less than 10,000 m³/s, sometimes it's 7,000 m³/s. In this case, 3,000 m³/s of water usage is a significant influence on decreasing the flow rate of the Changjiang in the dry season.

This is the simulation result for the whole year of 1998 to May 1st, 1999. Station 10 is outside the estuary, and we can see that during the dry season of January, February, March and April the salinity is gradually increasing at certain points inside the river. This is the surface and this is the bottom. Comparing the surface and the bottom, obviously the bottom includes more salinity than with the surface. This is the normal condition in the present Changjiang system. By introducing the scenario of 3,000 m³/s in water usage, we estimated these figures. In other words, significant salinity will be included inside the Changjiang River.

This is the present system of the Changjiang salinity distribution, January 1999 – again the salinity is higher here. In other words, the north mouth had higher salinity coming in and a major flow comes through this direction and helps mixture. Now, on February 27th, 1999, more salinity is coming in here, and in April goes back again. In other words, an increase in fresh water pushed back the salinity front.

If we introduce the 3,000 m³/s water usage scenario, then the horizontal salinity distribution will be changed significantly and more saline water will come from the north and will go partially up the mainstream of the Changjiang. Those areas will be entirely saline water. The reason why we conducted the simulation, in this case the scale is ppm - parts per million of salinity, is that highly industrial modern factories have been introduced in the Shanghai area, and those factories have very

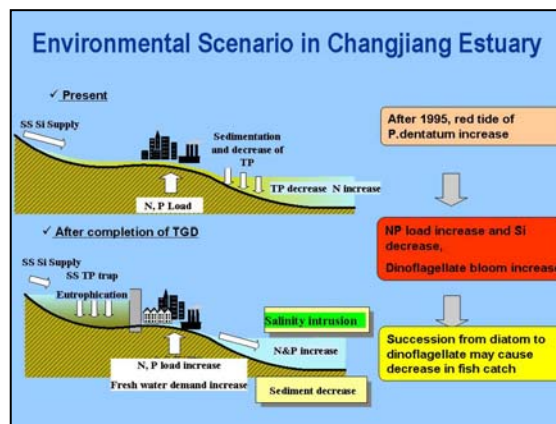


severe salinity requirements or standards for the boiler water. So, they require a maximum of 50ppm of salinity as a standard. If we exceed that, then they stop the intake of the water. So, it has a significant effect on the environment, and also on economic activities in the engaged area.

As a conclusion, according to my interpretation, to those scenarios, unfortunately, I have to say, yes. Salinity intrusion: Yes. Dinoflagellate bloom increase: Yes. Decrease in fish catch: Probably yes. I'm not sure in that our experiment was only at the zooplankton level and we didn't do any investigation of upper-trophic levels, but probably: Yes.

This is the end of our presentation. Again, in order to understand the estuary, we have to understand the catchment as a whole, and we have to pick up the basic elements. In our case the biogeochemical process has been simulated as a whole.

Thank you very much.



3.3 Keynote Lecture 3

ECOHYDROLOGY – AN INTERDISCIPLINARY TOOL FOR SUSTAINABLE MANAGEMENT OF FLUVIAL SYSTEMS – UNESCO PROGRAM

Dr. Kinga Krauze

International Center for Ecology, Polish Academy of Sciences, Poland

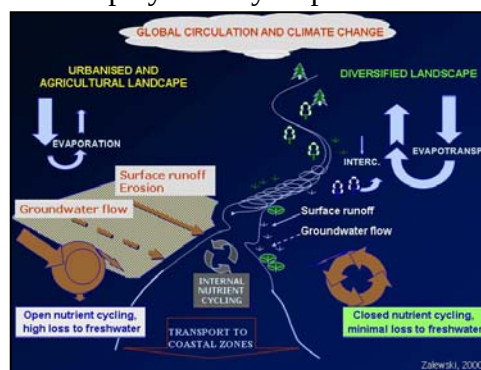


Thank you. I'm very sorry for the problems with the computer. I would like to thank the organizers for inviting me, and I would like to present today some aspects of the ecohydrology approach developed under UNESCO IHP V and VI Ecohydrology Programme. At this time ecohydrology is an interdisciplinary tool for sustainable management of fluvial systems. This is a joint paper of Professor Zalewski and myself, and data which are presented are result of ten-year work of the teams of the International Center for Ecology, Polish Academy of Sciences and the Department of Applied Ecology, University of Lodz.

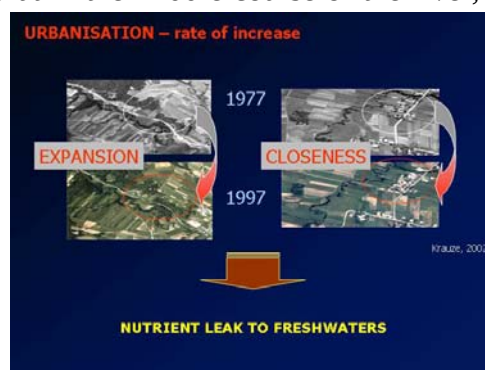
We know that the activity of man in a river catchment is always affecting the biogeochemical cycles. Therefore I would like to start with some very brief and big facts about our role in shaping a dynamics of river catchment ecosystems, and then show you a few examples from Poland.

Analyzing the processes at landscape scale we see that man activity within river catchment leads in general to decrease of its diversity. We transform a natural diversified landscape to unified one, what is not of no significance for biogeochemical processes. In diversified catchment natural plant-cover plays a very important role in pumping water, which circulation occurs through evapo-transpiration and interception. The role of natural vegetation is also to stop surface runoff and act as a filter for groundwater so it possess the ability to keep nutrient cycles enclosed and to minimize loss of chemical compounds to rivers. Rivers, lakes and reservoirs – freshwater systems – as situated in landscape depressions – are sensitive indicators of landscape changes. Any change of land use has it cause-effect in the quality of fresh water systems, and in consequence in coastal zones. Landscape transformations resulting from human activity are mostly related to removal of natural vegetation. This is a trigger for problems with hydrological balance and the hydrological regime of the area, surface runoff, erosion, and pollutants leaking from groundwater to freshwater systems. Hence in urbanized and agricultural landscapes we are dealing with open nutrient cycling and loss of nutrients and other chemicals to freshwaters and coastal zones. In case of reservoirs and ponds we also have to deal with an exaggeration of internal nutrient load.

Here are a few examples of man role as a driver of landscape and freshwater processes. This is an example from the Central Poland, where we analyzed 30-year



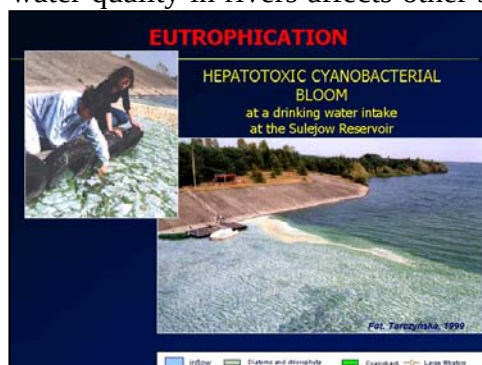
changes in landscape structure. What we have found was, a significant increase in the rate of urbanization. The problem is that urbanization appears the most intensively in the middle sections of rivers. So, you can see that in the middle course of the river, I mean the third up to the fifth or sixth order streams, the rate of urbanization is really high. There are two processes responsible – an expansion of new urban areas and an increase in building-closeness. It means that we create more and more impermeable surfaces and pollutant sources in areas which are crucial, according to our research, for fish spawning and as refuges for fish-larvae and even older fish.



What we also observed, was that this urbanization appeared in two ways. One is linear development of urban areas – along transportation pathways, which is typical in development of villages or towns. Another one is dispersal expansion of urban areas, which is related to recreation. Of course this is a sign of human well-being, but still, this kind of expansion usually occurs in areas, which are really crucial to biodiversity preservation.

These are the results of mentioned changes at the landscape level. One is nutrient leak to surface water. We observed especially an increase in concentrations of total nitrogen and other nitrogen compounds in water, but also an increase in concentrations of phosphorus and other ions, what may indicate an increase of erosion rate.

This is another example from Central Poland showing how decreasing of water quality in rivers affects other systems. This is the Sulejowski Reservoir, one of the main reservoirs which we are working on. This is a supply of drinking water for several cities, among them the city of Lodz, with a population of above 1 million. The picture shows toxic algal blooms occurring in July. They appear to be very serious problem because we discovered that their toxins influence human health in many ways, e.g. they increase risk of cancer. That is a consequence of chromosomal aberrations in human genes caused by cyanobacterial toxins.

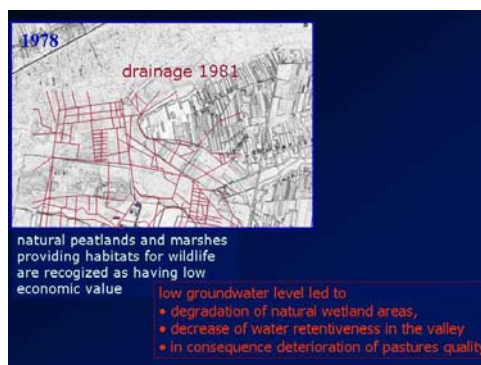


Water quality is one of problems we deal with, another one – equally important – is water availability. We have observed in our country, that during last thirty years the average temperature has increased by about 1 degree centigrade, and winter temperatures have increased about 3 degrees centigrade. These changes caused lack or timing variation in appearance of typical hydrological events like for example snow melting in the spring, which provides water for our rivers. Together with temperature rising – the decrease in precipitation, of about 150mm was observed for the last thirty years (average for Poland is about 600mm). That resulted in decrease of river discharges, which indirectly influences also water quality.

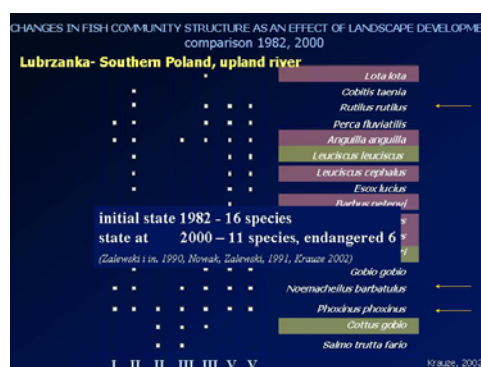
Decrease in discharges influence ecosystem functions in many rivers, but in the case of lowland rivers the situation is not so critical as in the case of upland and mountain ones. The reason is different characteristics of catchment and river valley

structure, which is not conducive to stabilization of hydrological dynamics, and accumulation of nutrients (especially under increasing anthropogenic stress).

Another example are peat bogs, being one of the protected areas designated under Nature 2000 network. Need for encourage of agricultural production, resulted in building of a drainage system in 1981. What happened was a complete change in land and marsh structure. Here is the marshland; here are meadows and crop fields developed in place of natural vegetation. The final effect of precipitation decline and conducted drainage was lowering of groundwater level. This led to degradation of natural wetland areas, decrease in water retentiveness in the whole river valley, and in consequence also deterioration of pasture quality – so the goal was not achieved.

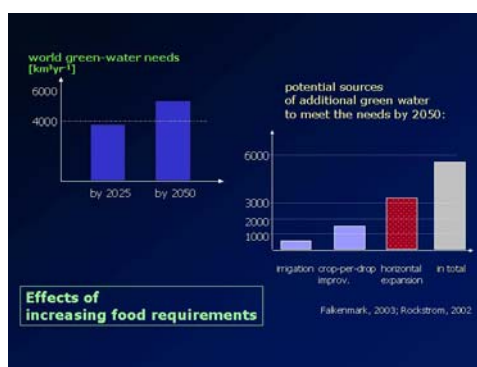


What happened in the river? I don't know if it's very visible (in this slide), but this is a list of fish species for one of the river presented earlier. At the beginning of the 80s we observed 16 species. Now 6 of them are no longer present. Two more are seriously endangered- what means that they disappeared completely at some studied sites, and three others are getting rare in at least some river sections. That's the response of fish communities and rivers to changes in landscape use.



We are wondering if and how we are able to improve the situation, considering that man faces increasing water requirements. In the case of some developed countries or some countries in Central and Eastern Europe, we will probably need to increase our food production. Here is an example from two countries of the former Soviet Union. We can increase our production by using more pesticides, or by using fertilizers. So, in the future we will probably cope with even more serious problems with water quality. Simultaneously according to brief estimations, by 2050 our green-water needs, water for agriculture and food production, will probably reach 6,000 km³ per year for Asia region only.

How can we increase our production in terms of providing water? We can irrigate new areas, we can improve crop-per-drop efficiency. Another solution is horizontal expansion of agricultural areas. But this will not change the fact that by 2050 many countries, basically in Africa but also in Asia and Europe, will face the problem of water scarcity. Poland is included here, so that is why we are so worried about the situation.



Another thing is that, now we know that it is water and availability of nutrients that decides in which place on this graph our system will be situated. So, if we change water balance, if we change nutrient availability, and if climatic changes result in

temperature variation, our ecosystems will probably move along certain axes on the graph, what means change in biodiversity. It is important to predict, what the change will be, how it influences ecosystem functions and services and how we can adjust our management strategies to a new situation.

Some solutions are proposed within the Ecohydrology approach. We have to realize that traditional methods of ecosystem management and protection are not sufficient. They require application of expensive technical solutions, exclusion of big areas from human use (unrealistic in many countries), and finally they enable only limited regulation of catastrophic events like droughts and floods.

Ecohydrology proposes integration of different disciplines into one approach. That is what we are trying to do now. We are trying to put together knowledge related to physical factors- geology, geomorphology, and especially hydrology, as a driving force responsible for the structure of ecosystems and our knowledge of biota – biology, genetics, biochemistry, ecology and other disciplines.

The concept of Ecohydrology is based on two hypotheses. The first suggests that hydrology can be used as a tool to control dynamics of biota. The second proposes biota (biological component of ecosystem) as a tool for regulation of hydrological processes.

Therefore we have to order and applied our knowledge about these two entities at different levels – from molecular to catchment scale.

Proposed ecohydrological solutions are based on these three points (shown on the slide). The framework for all activities is provided by hydrological knowledge, the target of action is the ecology of the system, and possible methods are eco-technological ones.

Going into details. According to the concept of ecohydrology, the minimal scale at which we should integrate our knowledge on hydrological and biological processes is the catchment scale. This is because it allows us properly understand the whole range of biogeochemical processes and analyze the complete water cycle.

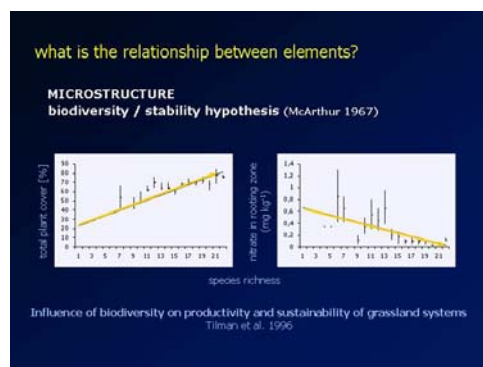
Then, we have to understand and keep in mind, what the driving forces are. So, what is the role of water and temperature? Water and temperature are responsible for the rate of primary and secondary production in land and water systems. Here you can see relationship between rate of primary production, radiation and evapotranspiration.

Then, there is a hierarchy of factors. We have to be conscious of the fact that the primary factors are biotic ones, and only when they are stable and predictable, the biotic interactions become more and more important in the regulation of biochemical processes.

What is our target? The target is understanding of mechanisms which determine the resistance and resilience of ecosystems to stress, because we would like to enhance the capacity of ecosystems to absorb human impact.



Actually, we have quite a good basis for this understanding. We know, briefly, what is the relationship between different elements in ecosystems. We know that the microstructure of ecosystems is very important and that there is a link between biodiversity and the stability of processes. At least there are some examples which show, that when we've got systems rich in species, like here, we've got quite a persistent structure of ecosystem. This is illustrated by changes of total plant cover, which occur to be smaller when the community is very diverse. We also know that in diverse communities, nutrient uptake is much more efficient, what at landscape scale means diminishing of nutrient leak into freshwaters.



We can apply this knowledge. We can improve vegetation in buffering zones along the river courses. This is an example of one of our projects. We are trying to find species, which will be the most efficient in nutrient uptake. What is important it is not only how much they accumulate, but also how the process proceed during the season and which part of plant plays the crucial role: leaf, stem or root. It is important because cutting and removing plants at the end of the season, we can remove also nutrients, and 1kg of phosphorus reaching the reservoir system, is responsible for production of several tons of wet biomass of phytoplankton.

We know also, looking at macrostructure, that it is diversity of landscape which guarantees stability of biogeochemical processes. Another example from our research. This table shows the comparison of nutrient transport to ground water and water out flow from the uniform and mosaic landscapes. You can see that in watersheds, where fields are separated by woodlands and wood strips, a rate of nutrient removal is higher and also water out flow from the catchment is much lower, especially in the summer months.

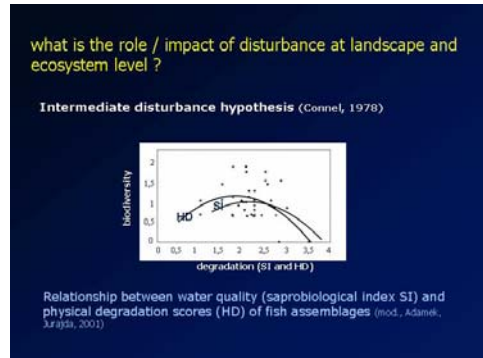
what is the relationship between elements?

MACROSTRUCTURE
stability of landscape processes is related to land patchiness
(Naiman et al. 1989, Ryszkowski, Bartoszewicz 1989)

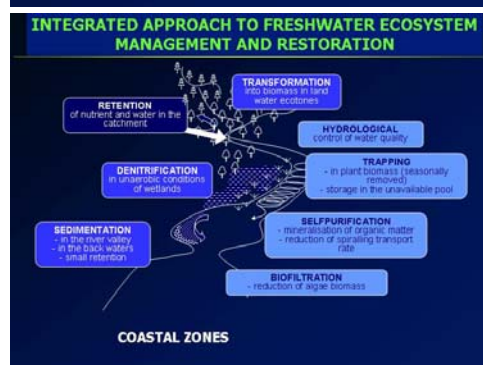
Season	Precipitation (mm)	Uniform watershed			Mosaic watershed		
		Water output	N-NO ₃	N-NH ₄ ⁺	Water output	N-NO ₃	N-NH ₄ ⁺
Winter season (Nov.-April)	220.7	60.8	12.3	3.0	56.8	0.90	0.95
Summer season (May-Oct.)	292.9	41.2	4.0	1.1	13.4	0.05	0.23
Whole year	513.6	102.0	16.3	4.1	70.2	0.95	1.20

Annual mean water output and nutrient loss from two small watersheds
(Bartoszewicz, 1984)

Therefore this type of agricultural landscape demonstrates also that, in concordance with intermediate disturbance hypothesis, intermediate disturbance, is a factor which not only impacts biodiversity, but is also a factor useful in its shaping.



Looking at our target processes-ecological processes. There are some of them that we are especially interested in under the concept of ecohydrology. One is the transformation of nutrients and other compounds into biomass and soil components. The others are: self purification processes, nutrient trapping by catchment vegetation,



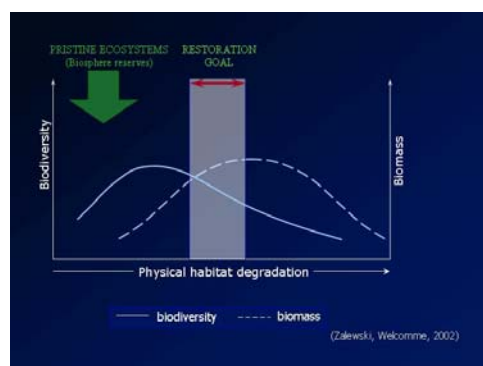
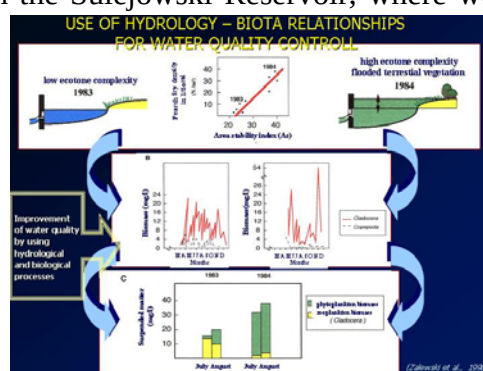
denitrification and sedimentation. All of them may become incorporated into effective, and low-cost eco-technological solutions hence we consider use of ecosystem properties as most efficient management tool.

Here are two examples. One is from a terrestrial ecosystem. This is the floodplain of the Pilica River, which supplies with water the Sulejowski Reservoir. We constructed a hydraulic model of the flood plain in order to know the pattern of water flow, especially during peak flows, areas where intense sedimentation occurs and what is relationship between current velocity, sedimentation rate and vegetation cover. The aim is such an improvement of the structure of wetland area, which allows us to lower sediment and nutrient load into reservoir. To achieve that goal we also prepared a map of vegetation, and then we estimated the potential of this vegetation to remove sediment and nutrients depending on hydroperiod. Then, we developed a plan of its restructuring, toward enhancement of its capacity to accumulate nutrients. For example, we would like to enhance the development of some species, which are already present on the floodplain, but are not very abundant and introduce patches of autochthonic willow species.

This is another example, this time from the Sulejowski Reservoir, where we want to use hydrology to regulate biotic structure of invertebrate and fish communities for improving water quality. We found that when the water level in the reservoir is low during the spring months, fish reproductive success is low due to unavailability of spawning areas. When the juvenile-fish are not abundant, biomass of plankton is balanced throughout the year. This results from limited pressure of fish juveniles on zooplankton (filtrators), which is able to control dynamics of alga and cyanobacteria. When there is no such regulation of water level and all spawning habitats are available for fish, you obtain very high reproductive success at the beginning. Too numerous fish larvae and juveniles cause depletion of zooplankton. Then, many juvenile fish die out because of a lack of food and space, but filtrators are too scarce to control phytoplankton. Here you see - low zooplankton biomass, and toxic algal blooms as a result. That is one of the methods we are applying now at the Sulejowski Reservoir to regulate the density and abundance of fish and, as a consequence, of zooplankton and algae.

In many cases it's impossible or very difficult to restore ecosystems to pristine conditions. It would be too money and time consuming and often human population needs make such a target unrealistic. What is the realistic target? Coming back to the intermediate disturbance hypothesis, we see that the highest biodiversity and highest biomass are obtained at the intermediate disturbance level. Hence the goal of our activities should probably be placed somewhere here to optimize both biodiversity and biomass. This example shows riverine systems but it is also true for terrestrial ones.

However, it is of course impossible to obtain sustainable management in a catchment without considering also socio-economic aspects. We are also trying to



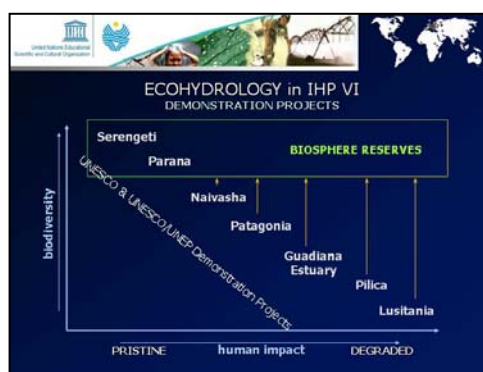
apply ecohydrology as a tool for solving such problems. Ecosystems undergoing anthropopressure, which symptoms are: water pollution, degradation of agricultural land and erosion, are not providing services to people. The secondary effects are loss of landscape and biological diversity and decrease of the income for people. What we want to do, and what we are doing in the case of the Pilica River catchment and the Sulejowski Reservoir



catchment, is trying to improve buffering functions of wetland areas by carefully planned introduction of energetic willow species. Then, we make it possible for people to obtain biomass for bioenergy. It also helps to reduce of other fuel use, and therefore helps to reduce air pollution. Finally it enables effective protection of land and water- because wetlands are very efficient as biofilters and it increases landscape (patchiness) and habitat diversity. These lead to improvement of water quality and to biological diversity enhancement. So, that creates an additional or alternative source of income for people based on tourism development, bioenergy production and helps to reconcile local population needs with nature protection. That's why we observed that in many regions of Poland, and also in other countries all over the world, this concept is receiving increasing interest. The attempts to implement the ecohydrological approach is quite advanced.

Now we are developing the UNESCO/UNEP demonstration project in the Pilica River catchment, which incorporates all mention above components. So, we are working on hydrology and possibilities for using it to control the biological structure of the catchment and to use, as I showed you, vegetation for the control of hydrology. We are also trying to involve people, local governments and to create some alternatives for economic development of the region.

This kind of demonstration project is also going to be developed in other countries. The basic knowledge is that obtained during studies of biosphere reserves – model ecosystems illustrating original patterns of natural processes. Then there is series of proposed demonstration projects in other parts of the world, to look at ecosystem functions along the continuum from pristine up to very degraded systems. The aim is to understand how the systems work and how efficient ecohydrology methods will be there.



If anyone is interested in the concept, several articles have been published. One is in *Ecological Engineering* from 2000. Another is in *Hydrological Science Journal*. We have also our own journal, *The Journal of Ecohydrology and Hydrobiology*. It is edited by the *International Center for Ecology*, but under the auspices of UNESCO. There are two other recent publications: *Guideline for Integrated Management of Watershed*, and *Manual* – both available at the UNEP website. I brought them with me, so if anyone is interested in seeing them it is possible.

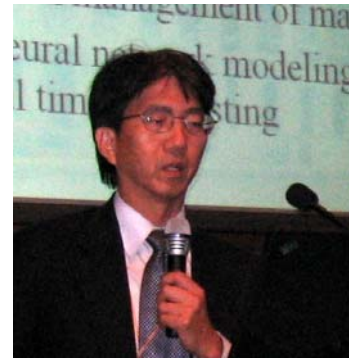
Thank you.

3.4 Keynote Lecture 4

EUTROPHICATION, ALGAL BLOOMS AND RED TIDES IN HONG KONG – OBSERVATIONS, MODELLING AND PREDICTION

Dr. Joseph Hun-wei Lee

Professor, Redmond Chair of Civil Engineering
Department of Civil Engineering, The University of Hong Kong



Thank you very much. Thanks to the EMECS organizing committee. It's a privilege to be here today to share with you some of our work in connection with algal blooms and red tides in the past fifteen years or so.

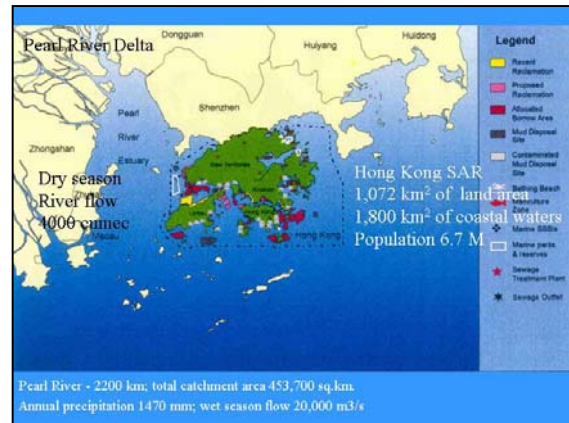
I myself am a hydraulic engineer by training, and we work a lot with, for example, outfall design and turbulent jets, actually. But as one of our main interests, we were drawn into this topic of algal blooms and red tides pretty much by necessity, by the necessity to cope with fisheries management in Hong Kong, and also by the need to actually understand many of the observations we make.

I'd like to talk about several things today revolving around, if you like, fisheries management and some of the recent research we have done. I'd like to talk about some real time field observations of dissolved oxygen and algal-dynamics. We were drawn to look into these topics mainly because of a need to understand dissolved oxygen variations in our coastal seas. Many of our coastal seas, as you will see, are enclosed or semi-enclosed. I'd like to talk about something which came up recently, the hydrodynamic tracking of the massive spring, 1998 algal red tide. Something about management, because we develop models pretty much for management purposes besides trying to interpret the often complex observations. I'd also like to talk about real time forecasting. As today I only have half an hour, I'd like to talk about the various kinds of approach, maybe slightly engineering oriented, and I'd like to start up a dialogue with many of the oceanographers here.

I'd like to talk about some of the approaches we've used to tackle these problems. Sometimes just plain hydrodynamic tracking explains a lot of things. Sometimes you need to couple ecological concepts with physical concepts. If there is anything that comes out of this talk, I'd like to stress that through our experience we've found that the integration of physical processes and ecological processes is a must in tackling some of these fisheries problems.

Many of you probably have been to Hong Kong, but just to give you some background data; it is, I suppose, a pretty small place, a thousand square kilometers of land. It is also a very intensively used space. In that little space are 800 square kilometers of coastal waters with a population of 6.7 million. There are a lot of activities going on. This water is used for a lot of things: navigation, reclamation, beaches, scientific use,

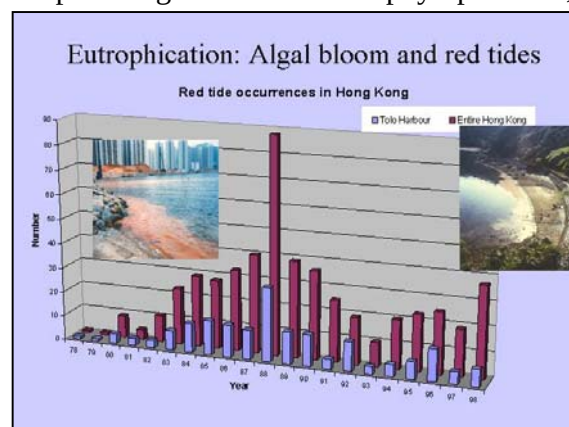
marine borrow areas, and so on. One characteristic of course is that we are situated right at the mouth of the Pearl River estuary. We are also influenced by the huge nutrient loads coming down the Pearl River estuary. Hong Kong is located right next to the Shenzhen Special Economic Zone in South China, the largest industrial base in the world. Picture this freshwater flow coming down, a wet season flow of about 20,000 cumec, and a dry season flow of about 4,000 cumec. All the human activity that has developed in the last two decades in the Pearl River estuary plus the developments in Hong Kong; all the domestic and industrial wastewater would end up in this estuarine region. This pollution problem is what we have to grapple with.



Just to give you an idea of the developments, ever since mainland China opened up in the late 1970s, the population has grown, at least officially, to over 30 million in this Pearl River delta region. The unofficial figure may be more. Just Shenzhen alone grew from a town of 300,000 to tremendous population of 3 million over a span of two decades. It's almost unimaginable. You can see with this increase in human population and industrial activities, that we are getting a lot of domestic wastewater discharges, which are treated to a lesser degree than industrial discharges. You can see we have been getting something like 2,000,000,000 tons of wastewater per year, in the Pearl River estuary. This of course is entirely related to economic development and anthropogenic activities.

Just to give you an idea, the nutrient load in Hong Kong's waters is about 8,000 tons of total nitrogen per year. This is derived from many sources, from human activities, from livestock waste, from non-point source pollution, from a variety of sources. This is just the Hong Kong load – about 8,000 tons per year, and 1,500 tons of phosphorus. On top of that, based on the population ratios, you can probably find at least six-times that amount coming down the Pearl River estuary. All that (these nutrients), have to be assimilated somehow in the Pearl River estuary. Partly because of this process of nutrient enrichment, Hong Kong historically has witnessed many red tides and algal blooms. As you know 'algal blooms' really refers to the explosive growth of marine phytoplankton, and for certain types of species, like dinoflagellates, the water will be discolored. It will grow to very high concentrations, sometimes of the order of half a million cells per milliliters.

I'll just show you the number of occurrences of red tide observed in the past twenty years or so; we had a maximum rate of occurrence in the late eighties of up to eighty red tides per year, and then it subsided a bit after the introduction of pollution control, but in



recent years it has picked up again. In 1998, in particular, an El Nino year, again we observed a lot of red tides.

The point about red tides is, I think, nobody as yet can predict red tides and nobody as yet can say there is a very definitive cause and effect relationship between some of the perceived human activities and the occurrence of red tide. The point is that red tides can occur in very clean waters. For example, this is Kat O, which you will see a bit of later. It has very pristine waters. This is a red tide observed in Kat O, in our eastern waters. In fact, it's strange that every year in Hong Kong we observe red tides first in this very clean water. This was observed very close to one of our new towns, Shatin, in Tolo Harbour, one of our very weakly-flushed semi-enclosed seas. Most of these coastal (urban infrastructure) developments occur in semi-enclosed seas or next to semi-enclosed seas. The point I introduced earlier is that there are very limited tidal exchanges, exchange of "clean ocean water" between these semi-enclosed seas and the open ocean.

So, we observe a lot of red tides, and often when red tides and algal blooms occur it can lead to severe dissolved oxygen depletion and sometimes fish-kills. The point is, let's say you have a diatom bloom, then you can have a lot of algal biomass, and under certain combinations of hydro-meteorological conditions, very, very low DO can result, less than 1 milligram per liter. All the fish in a fish-farm can be killed, and we have about 26 of these gazetted fish culture zones in Hong Kong. You can get massive fish-kills that have not only economic but also very important social implications. Sometimes it's like this, it can be just related to decay of algal biomass. You can see there's a need for management, there's a need to understand why and under what conditions red tides occur. Unless you do that you cannot really talk about control.

Sometimes it can occur due to very strange reasons, like this example from 1998. In March – April, spring 1998, Hong Kong was invaded by a massive red tide, it was an El Nino year, and it spread all over Hong Kong like an infectious disease. It seems to have occurred in some of our eastern waters, and then drifted, it seems, to the southern waters, and 80% of our fisheries were wiped out; and our beautiful beaches in the southern waters of Hong Kong were closed and so on. It's not so much the economic loss; it had a very significant social impact.

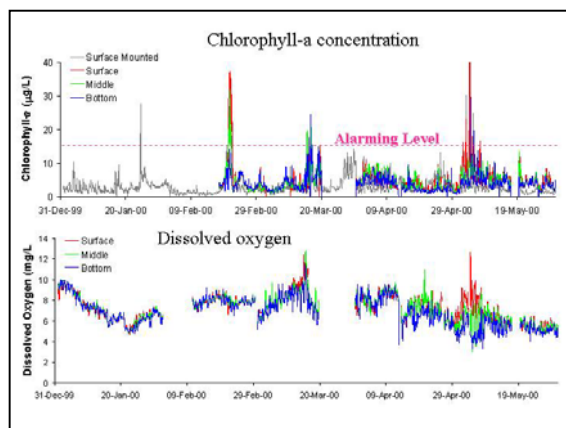
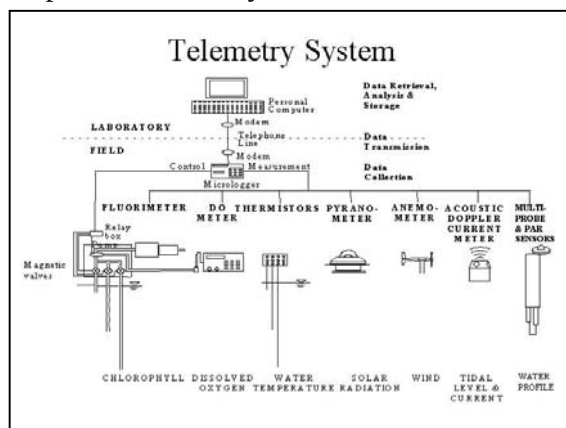
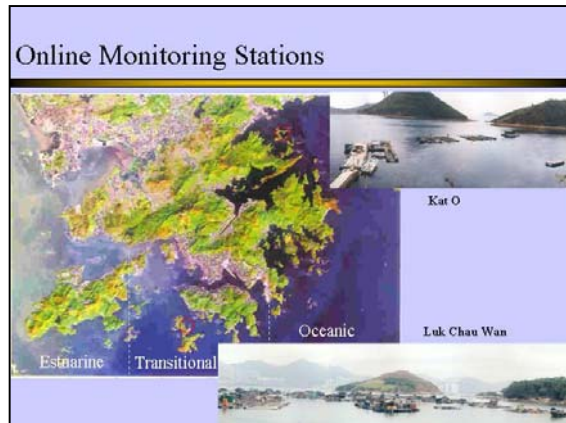
We've been grappling with these problems for a while, but especially after 1998, we started a group research project, sponsored by the *Hong Kong Research Grants Council*. Many engineers, mathematicians and biologists got together and started this group project. Three years later we have nearly finished the project. Basically we asked several questions.

- What were the main causes of the massive red tide fish kills in March/April 1998?
- Why do red tides occur more frequently in some of our waters, especially the eastern waters? Often they apparently originate in a certain bay.
- What is the relationship between dissolved oxygen and algal dynamics and can we predict algal blooms?
- How do we determine the carrying capacity of fish-farms for sustainable fisheries management?

These are the sort of questions that interest us. As you can see this actually points to many interesting, I would like to say, theoretical questions that are worthy of research. So, what we did was to set up real-time monitoring stations in two places in Hong Kong. One is at this place called Kat O, which has very pristine waters. I don't think you would mind swimming there. This is pretty much oceanic, more ocean like, in our Eastern waters. The other station is on Lamma Island, where the fish kill occurred. It's more estuarine and more influenced by the Pearl River estuary. So, we set up two, if you like, 'real-time coastal observing systems'.

We did something very simple. We just bought a used old fish raft and we loaded a lot of instruments on it. We designed our own system. We withdrew water from three depths. We measured chlorophyll fluorescence. We measured dissolved oxygen at three depths to very good accuracy, to 0.1 milligram per liter accuracy. We did a lot to achieve the accuracy required of research quality data. Of course we measured temperature, salinity and the like. Then we measured solar radiation, wind, we had an ADCP and pyranometer to monitor tidal currents and light intensity. This system evolved and was refined over time, and we believe it is a cost-effective system. Basically, we were monitoring chlorophyll fluorescence continuously, at two-hourly intervals. This was supplemented by weekly nutrient measurements, because those were much more costly measurements of nitrogen, phosphorus and so on.

You can see from this example that it is a very dynamic system. In fact, it's an early detection system so whenever there is an algal bloom, an alarm in our laboratory will ring. This is the observed chlorophyll at three depths, middle, surface and bottom. We have an extra surface-mounted fluorimeter. Whenever it goes above this level it is a bloom. You see here, it's very fast changing. Along with these phytoplankton dynamics, if you like, you have a very distinct dissolved oxygen dynamics. You can see that the surface and bottom dissolved oxygen levels differ greatly during an algal bloom. In fact, our aim is eventually to be able to predict algal

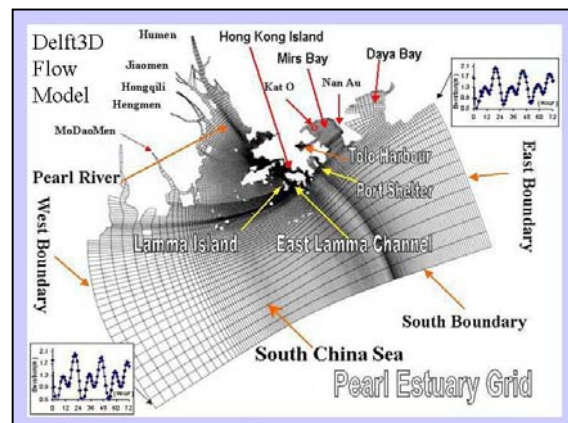
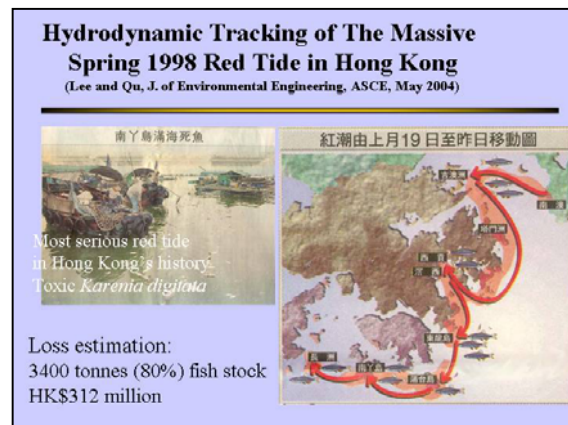


blooms just by looking at the DO signature, because DO is so much more robust, so much more accurate, to measure than chlorophyll biomass.

In addition we have other measurements, but this is just to show you that usually it's a very dynamic system and, especially in our subtropical coastal waters, the time scale is usually of the order of 7-10 days. So, it won't be covered by any routine, biweekly water quality monitoring carried out by our environmental protection agency at all.

Not only that. These algae are sometimes diatoms. Usually with diatoms you have a higher dissolved oxygen level at the surface and lower at the bottom, it behaves like a regular pattern. But sometimes, a lot of the harmful algal blooms are actually due to dinoflagellates, these algae species which can move up and down the water column. What this means is that during the daytime these algae will go up to get solar energy, and during the night they will swim down to get nutrients. As a result you get this vertical migration, which Dr Watanabe showed a little bit. This plots the measurements of chlorophyll levels – you can see that during the daytime it comes to the top and at night it moves to the bottom. It moves up and down, and as a result you see this vertical profile of algae, if you like, with time. The point is that this is a very complex phenomenon. You try to model it; you try to predict it; to get some understanding. That's why you need different approaches, and that's what I'm going to talk about today. In fact, I'm going to talk about three approaches. We've tried many more than that, but I'll just talk about three approaches today.

The first approach I would suggest: sometimes, as our Korean colleagues often say, red tides are entirely due to physical factors, hydrodynamics, and nothing to do with nutrients. We think this is what happened in spring 1998. In spring 1998, as I mentioned, there was a massive red tide which seems to have drifted from the eastern coast to the southern coast, where there are a lot of pretty beaches, Repulse Bay etc. and fisheries; The massive red tide caused this massive fish-kill at Lamma Island. It was a toxic species *Karinia Digitatum*. It suffocates the fish gills by secreting mucus. At first, it wasn't clear why the red tide had occurred – it could have been due to the change of weather, and so on. We used a model to describe this. We've been using this Delft3D model in collaboration with the Hong Kong government and Delft Hydraulics. It's a model which simulates three dimensional water flows. So, you force the flow - it's nowhere near

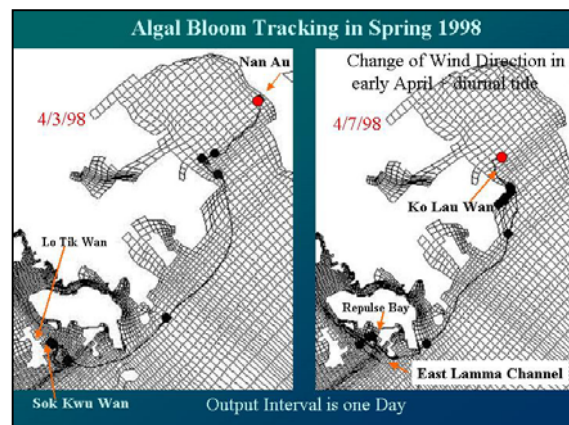


the same scale as the East China Sea, but it's still about 200 km across. You impose the tidal forcing here; we having very complex tides in Hong Kong. Spring tidal range is about 2m range, neap tides around 1m. Let's say you impose 9 tidal constituents (M2, S2, O1, K1 and so on) along with the oceanographic current forcing the Kuroshio Current. Then you have boundary conditions, then you have your forcing here, you have your fresh-water flow coming down the Pearl River estuary, and then off you go (with the hydrodynamic model simulation)!

So what you see is a tidal wave moving up the estuary, and, if you like, a long wave, generally moving up the estuary like this and moving down like this - this is during the dry season, around March - going up like this and coming down and out like this. If you picture this, it is the propagation of a tidal wave, which creates the currents, which generates the flushing - you see, ultimately you have to link up to ecology - which generates the flushing of these tidal inlets. This is what we must be after if we are going to describe the process. In other words, this model gives you the tidal current, the tidal level and the salinity at every point in the estuary.

This shows in general the salinity variation. This is the dry-season. This is the bottom salinity and this is the surface salinity. There's not much difference in the dry season, as you would expect. It changes from about 34 parts per thousand to about 10 parts per thousand in the mouth (of the river). This is around the border between the mainland and the Hong Kong Special Administrative Region. Even in the dry season there is a longitudinal salinity gradient.

I don't want to go into details, but what we found is that it seems what happened in 1998 was entirely due to the wind. It was a very strong, windy March that year and somehow the wind, and changes in wind direction, changed the circulation patterns in this bay. If you get a red tide that's, for example, brought into the bay by a ship, then it can have the chance, which it usually doesn't have, to be transferred very quickly into southeastern waters, and cause the massive fish-kill which occurred at Lamma Island.



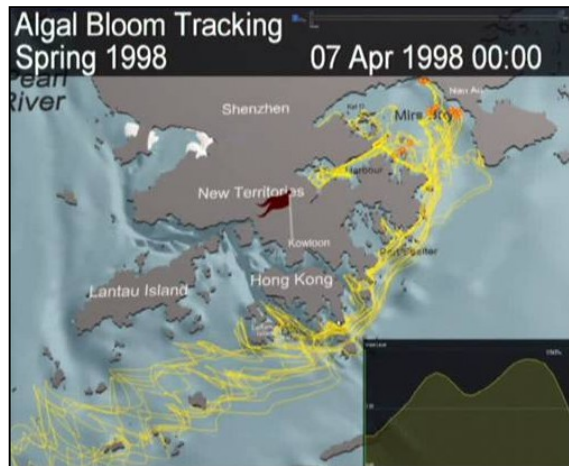
After conducting many studies we came to this conclusion. In other words, it wasn't due to the weather. Weather probably had a part to play but it was mainly due to the hydrodynamics. This is the wind speed in March and April 1998. There were very strong winds in March, which created the chance for whatever algal blooms present in these eastern waters to be transferred out of Mirs Bay. Also, there's a significant change in direction to this southeasterly wind at the beginning of April. This is the wind direction. These are the tide levels. You can see we have complicated mixed tides.

Mainly because of this change in wind direction, we've proven this through extensive drogue tracking calculations, there was a change in the fundamental flow direction. There was a change from a counter-clockwise, to clockwise gyre, which transported things out of the bay. Now, you see this located here. Normally, not in 1998,

if you get a red tide here, transferred by ship, it usually goes to Kat O, goes to Tolo Harbor. Usually, it will make its way towards the South China Sea, without going into Repulse Bay, and the southern waters. This is a real-time calculation. Normally, that's what will happen, and that's why we usually observe a red tide; our hypothesis is that it has probably come into Hong Kong on a ship, there's a container terminal here in northern Mils Bay. It's transported to Kat O then some may go into these landlocked harbors, Tolo Harbor – you saw a red tide there already, and then it will go along this path.

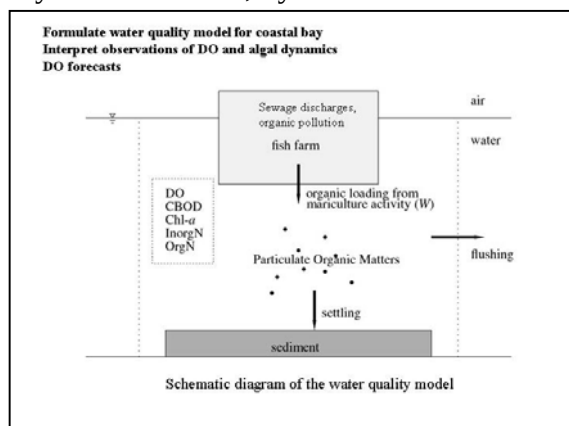
However, in 1998, you see, this is the same time scale, it came out of the bay very rapidly because of the wind and the drogue tracks rushed pretty much to the southern waters because of a change in wind direction to southeasterly winds. This caused the fish-kill. This also coincided with the recorded sequence of events of observed algal concentrations at different beaches and so on.

So, my first point is sometimes red tides occur for innocent reasons. They may have nothing to do with pollution. This is my first point. The massive red tide which occurred in southern waters originated from this. We believe it was the change in wind direction and the diurnal tide conditions which gave rise to this consistent clockwise gyre, which greatly enhanced the transfer of blooms into the region. This work was recently published in *the ASCE Journal of Environmental Engineering* – last month.



However, you still need to somehow link red tides to ecology, because we believe they are in some way related to pollution. I'd like to suggest something like this. Suppose you have a polluted coastal bay - it can be a fish farm; it can be a kind of inlet. Nowadays, with supercomputers you can compute forever if you like. You can compute the 3D flow for a long period. But we suggest this is probably not a good way. What we suggest is that what determines whether there is an algal bloom in a bay is mainly affected by the organic loading, and by the flushing rate. Do you see that tidal wave coming up? That exchange process is driven by that tidal wave, by the baroclinic as well as barotropic forcing. Actually, in many subtropical coastal waters it turns out that it is heavily driven by hydro-meteorological conditions.

So, let's say we have a very simple picture. You have a tidal inlet. You have pollution, either from a fish farm or from human activities, and you have organic pollutant regenerated from the sediment ... Let's say we focus on the important water quality parameters: dissolved

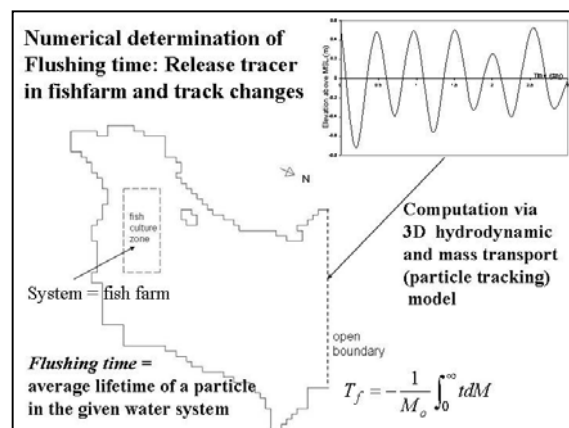
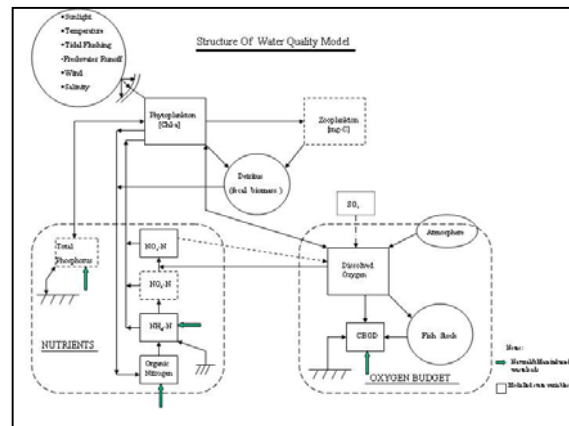


oxygen, organic waste, something we call BOD, which may not be familiar to all of you, but chlorophyll is a measure of algae biomass, nutrients, here. Then this system flushes, it's exchanged, it's renewed at a certain rate by clean ocean water, so to speak.

Let's say we conceptualize everything just to let you have some kind of model, a standard water quality model of some kind, which essentially models the growth of algae as a function of tidal flushing, wind, salinity, and sunlight. The growth of algae depends on nutrients, it uptakes nutrients, and when it dies it generates nutrients. It also takes up oxygen and it gives off oxygen through photosynthesis. Basically, you close the material cycles of carbon nutrients, phosphorus and so on, but what we suggest is that what determines it physically is mainly the flushing rate. So how do you determine the flushing rate?

It turns out it's not as trivial as we first thought. We have come up with a method that's very simple. Let's say, I want to determine the flushing rate of a tidal bay. So you say, this is the ocean, so in your system it can be the mouth of the Yangtze; this is just one of the bays. You have a system and you define flushing time as the average lifetime of a particle in a given system. You give it a tidal forcing, you compute the 3D hydrodynamics, the currents and so on. Let's say, we do a tracer experiment to determine the flushing time. In other words, let's say, initially, I paint this with color and I see how the color changes in the bay. This is the Lagrangian particle tracking which minimizes problems with numerical diffusion. This is real-time 3D. By tracking the particles you come up with a single number that characterizes pretty much the physical exchanges with the open sea.

What we found surprising is...for example, you try to change the change in mass in this system, this is a 3D calculation. But what you will find is you can describe the tracer mass change in the bay very simply with a double exponential curve. You do it for the dry season and you do it for the wet season when there is a lot of river flow. You can fit it to a double exponential, from the best fit curve you can determine these parameters K1, K2 and gamma, just to describe that curve



3D models and laboratory experiments show that the tracer mass removal process due to tidal flushing can be approximated by a double-exponential decay curve that is described by 3 flushing parameters only, from which the flushing time (or flushing rate) can be uniquely determined.

$$\text{Tracer mass} \quad \frac{M}{M_0} = \gamma e^{-k_1 t} + (1-\gamma) e^{-k_2 t}$$

$$\text{Flushing time} \quad T_f = \frac{\gamma}{k_1} + \frac{1-\gamma}{k_2}$$

The three flushing parameters α , k_1 and k_2 can be interpreted in terms of the size of the fish farm, the exchange flows between the fish farm and its surrounding and that between the water system and the external "clean ocean" using a two-segment model

you saw. From that you can determine the flushing time in a very concise way. For example, you color the whole bay because you want to track the change of mass in this system. In the dry season the flushing rate is lower, in the wet season the mass changes very quickly. The whole point is that this change of mass is driven by these baroclinic as well as barotropic processes. You see, the clean ocean water comes in, it renews the water, and it flushes it out. That's the basic idea.

One point we found is that the flushing time, in this system for example, can be very different in the dry and wet seasons. Sometimes it's just a factor of two difference in this bay. So in the wet season it stays in the system for a much shorter time, it renews itself much faster. But sometimes, it can be one order of magnitude faster when you have stratification. In other words, the rain and the effect of stratification, can make a significant difference to these exchanges. We have established a systematic way to

quantify this. So, very schematically the flushing time is, if you like, the time it takes a bottle to be transferred from the inner sea to the outer sea. Even in a small place, that can take about a month or two, forty days. Recall we have all these fish-farms inside these coastal seas; in fact, this situation has parallels all over South East China.

Basically we have quantified the first part, the flushing time. Now on top of that, suppose I tell you that these algae grow in a certain way, which can be quantified. They grow in response to sunlight, so this is the growth of algae. They grow in response to nutrients. They grow in response to temperature. Suppose I tell you that we can model this, and in biological oceanography this is commonly accepted – there are some difficulties. There is a 'light extinction' of algae as you go beneath the surface, due to the algae itself, and there's a nonlinear feedback. There are very highly nonlinear dynamics, and you see this is a function of the extinction coefficient, this is an exponential curve, as a function of the algae itself. I don't want to go into a lot of details. Then the algae like to take up ammonia nitrogen more than nitrite or nitrate nitrogen. There are a lot of these biological processes that need to be modeled.

Supposing you can model this, then let's say you can come up with these predictions; for example, you can predict the dissolved oxygen changes. At nighttime, it will drop because of the consumption processes, and in the daytime it will rise because of the production due to the hydro-meteorological conditions. Then, let's say you can model this to give forecasts of dissolved oxygen. For example, this is the actual fish-kill, which occurred in 1987, a massive one which we predicted some years ago. Very often you can see there is a certain trend to the dissolved oxygen, due to the hydro-meteorological conditions, high water temperature, prolonged sunny clear skies followed by overcast skies and neap tide. Dissolved oxygen dropped to below one milligram per liter when all the fishes in that fish-farm were killed. So, suppose you can do this. You can do a reasonable job of DO forecasts, and you can also predict long term trends.... Anyway,

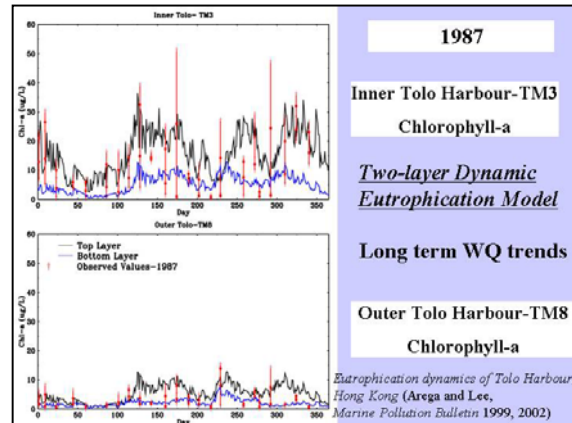
"System-wide" Flushing Times Computed by 3D Model

Global flushing time (day)	Wet	Dry
Yung Shue Au	14.2	23.6
Yim Tin Tsai East	14.8	27.2
Yim Tin Tsai	14.4	38.0
Lo Fu Wat	7.1	15.8
Sok Kwu Wan	3.5	25.8
Ma Wan	1.54	3.08

Greatly increased flushing rate in wet season, even with mild density stratification

the point is, you can predict long term water quality trends, as well, for management purposes.

I want to drive home the point that the water quality is very often very dependent on hydro-meteorological conditions. For example, in 1987, this is the predicted total output for one of our cases. This is the predicted chlorophyll on the surface and at the bottom at one of our inner stations, and this is the range of measurements. These are the inner stations and these are the outer stations. Outer stations have a lot less algal biomass, chlorophyll, because the area is better flushed. You see in 1987, the monthly average water temperature was something like this. Now, in 1992 we had a very cold year, at the beginning. Because it was a very cold year, then the algal dynamics did not have a chance to take off for the greater part of the year. In fact, it didn't take off until very late in the year. This is actually mimicked by the model.



The point is, with water quality you can have this sort of models to predict long term trends and make short term forecasts of DO. Then, you can couple these to come up with a model for determining the carrying capacity. In other words, in the tidal inlet, what is the carrying capacity? What is the pollution loading capacity?

This is what we've been doing in the last two or three years or so. Really, the most challenging thing about it is: Can you do real time forecasting? Over the past four years we've accumulated about three years of continuous data. We've observed something like fifteen blooms, diatom blooms and dinoflagellate blooms. You see, with all these water quality models you need to calibrate and so on, so they're not very robust for real-time forecasts and if you use the models for real-time forecasts, you're bound to be disappointed. In recent years the idea has been: Let's switch away from the knowledge based models; let's go to data-driven models, or maybe data assimilation. I just want very briefly to mention our experience of applying these data-driven methods, in particular neural networks.

Data-driven modelling of algal blooms

Objective: To develop *real time forecasting model* of algal bloom dynamics

- Deterministic multi-parameter water quality models capture the essence of the response of the receiving water to organic loading.
- Properly calibrated models can be very useful in water quality management, in data interpretation/planning of field monitoring
- **The lack of sufficient data and uncertainty of rate coefficients in the highly simplified model limit accurate or robust real time forecasts**



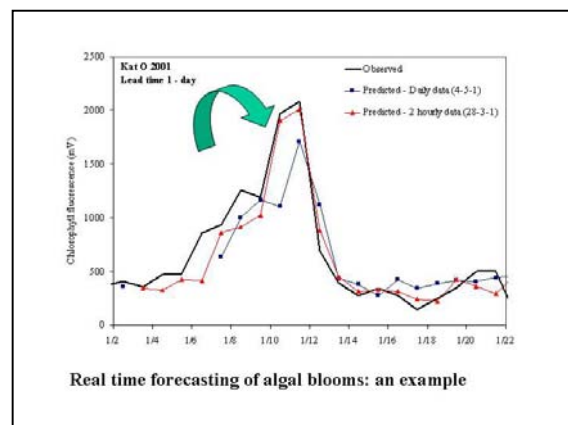
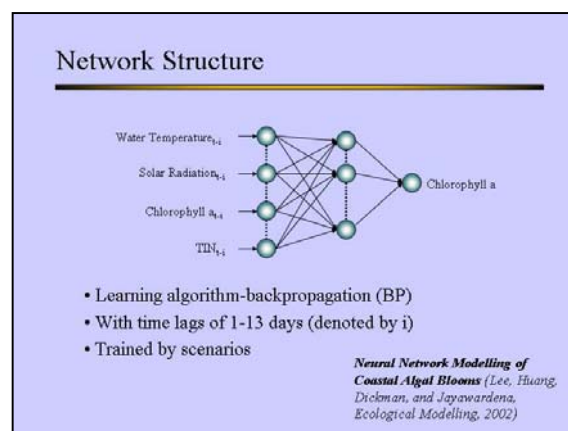
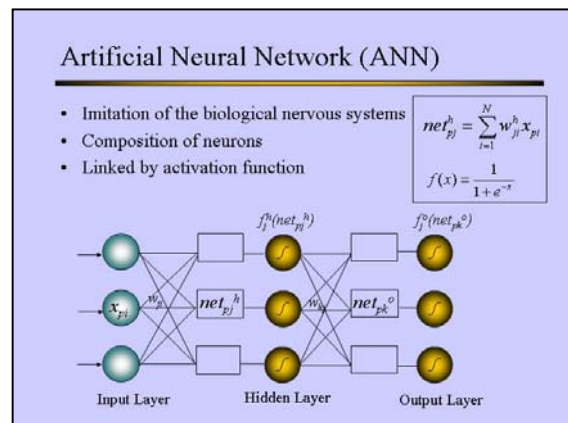
Only recently has water quality data been of sufficiently high frequency to make real-time forecasts. I don't want to go into the theory of neural networks, but let me just go into one point. The idea is: Let's say, I treat this very complicated marine ecological system. It's so complicated I don't have the process knowledge and don't have the money to buy a model to understand it. So, I treat it as a black box but I have some idea of what the input nodes, what the input variables are. Very simply speaking, it's something like

this. Suppose I have a bunch of input nodes, and I have a bunch of outputs - in my case there is only one output node - and they are linked by a “hidden layer”, if you like, linear combinations and nonlinear activation functions. Basically we treat it as a black box - that’s the idea - and you can model highly nonlinear events.

Let me just say a word about what the key variables are. We think these are the key variables. In fact, you can obtain from the water quality models what the key variables are. For example, phytoplankton, water temperature, solar radiation, etc. In other words, you can learn from the study itself what the key variables themselves are. This was recently published in *Ecological Modeling* – What we found is that what matters is the chlorophyll itself, plus solar radiation, water temperature and so on. The idea is: Can we have a real-time system whereby, based on the observations of the past, I can make some forecasts for the future? Just like a weather forecast, it need not be absolutely correct, but it would be nice if we could do this type of rough forecast.

I’ll just show one example. I’m skipping things, but I’ll show you the latest example. This is our latest data; we have three years of data. It’s not the whole lot, but it’s almost continuous data. You just need one value per day to see whether there’s an algal bloom or not....This is an example of a real-time forecasting of algal bloom. If we make use of the data of the previous four days, then for diatom blooms at least the prediction seems very promising. For dinoflagellate blooms we haven’t been very successful as yet.

That brings us to the end. I’m sorry, I wanted to just give an idea of what is available. Basically, we are working on data assimilation techniques for these real-time forecasts. I hope you at least got a taste of some of our work. Thanks. (applause)



3.5 Keynote Lecture 5

COASTAL MANAGEMENT DATABASE AND SATELLITE IMAGERY FOR ICM (INTEGRATED COASTAL MANAGEMENT) IN KOREA

Dr. Hi-Il Yi

Korea Ocean Research & Development Institute, Korea



Thank you. Now we move to another side of the coastal zone in Korea. Today, actually, I'm happy to talk about general management and not in detail about science. I'm so glad it's related to fluvial systems; however I did not bring the data or information at all. It's a real pity, but next time, when we have another chance I want to integrate them and show you again, if I have a chance.

First, I have to thank you for organizing this conference and also international EMECS for inviting me here to share this work together. I really appreciate it. Also, thanks to Dr Watanabe for actually initiating the invitation for me, thanks.

First, let me introduce the history and development of ICM in Korea, and then how we established the information system for coastal management, and thirdly the high-resolution satellite imagery application for coastal zone management and how to provide a data service for it. Then, we've still got other problems to solve about this ICM, and finally a conclusion and suggestions.

First, the history and development of ICM in Korea. At the beginning of 1996 the idea was formulated and the people got together. I was involved then, too, and we got the social scientists to look at how to prepare for coastal zone management at the CCMA. It was passed 1998, in congress. However, because we had an IMF crisis in 1998; a lot of our economy collapsed at that time. People suggested the idea of so-called 'IT New Deal projects' for all kinds of areas, which was initiated by the Ministry of Information and Communication. This was purely for the purpose of offering for people. The idea was for people to input previous coastal information data, which would be nice. This was started in 1998.

Meanwhile, people started talking about the need for a real coastal management project. Eventually MOMAF, Ministry of Maritime and Fisheries, appealed to get a fund from the upper Ministry of Policies and Plans. Now the policy system is different because they got funding from the Ministry of Policies and Plans. They got money and they started the project of coastal management, the information database.

The progress is that they annually put the coastal data by combining measurements and nautical charts data, and also putting the basic coastal database. Also, we studied data for a web service which is provided for end users. To do this, web service technology had to be developed. Also, it is operated and conducted for business people with some support from MOMAF. At the end of 2001, the Coastal Management homepage was primitively completed so that information has been provided to national and local government and agencies, regional districts and

recently institutes like KORDI and academia. Now annual projects have been continued with more extension and upgraded information of ICM since 2000.



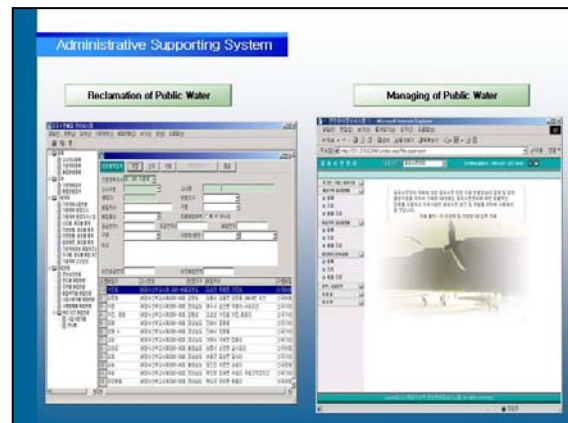
bottom sediment and water depth etc... including tidal flats and harbor limits, too. So coastal information is now digitized and provided on the internet and CD. As such, the viewing software was developed for the users to use them easily.

That's the thematic information of the coastal map showing public water reclamation etc... here. When we go to the sea around southern Korea we can have all

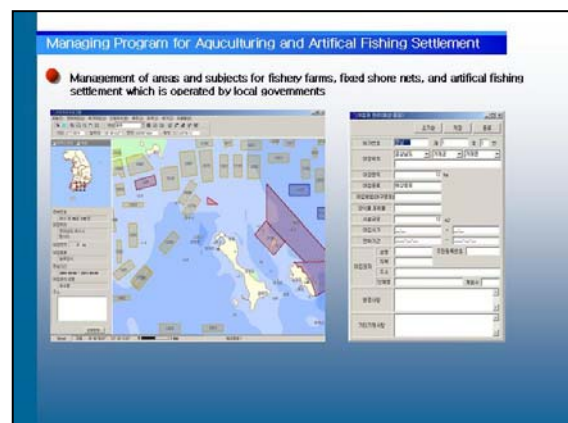
the information about harbors, culturing farms and industrial complexes and public water reclamation and so on. We also collected statistical data from coastal areas and wrote annual reports for 78 cities and more than one hundred streets, also including human and inhuman islands, here. You'll see here annual report for coastal cities and island statistics. If you want to, you can find all kinds of information about islands, including legends or local history. We also have fisheries statistics; how much and what kinds of fish is being caught, total production, licenses people have, etc. There is also information about the kinds of coastal industrial complexes, which is related to both the economy and pollution. It's very important to control pollution. Fishing villages are important. They are the end-users, who really need it for their own livelihoods, for their own work etc.. So, it's very important to have this information.



There is also the administrative supporting system. I have already mentioned reclamation of public water, including basic licenses, who can apply for them and for what purpose. Public water does not belong to private enterprise. They need to ask for permission from the government, but to be honest the underlying philosophy is that they are not allowed to have reclamation of public water. But there are implications. We have boundaries between public and private measurements which are still unclear, so people claim private estate in public waters. This is still going on a study for a more detailed survey there. There is also management and maintenance of public water. Sometimes seawalls or roads are destroyed by squalls etc...



There is also management of culturing farms. In Korea I would say the entire coastal zone is covered with culturing farms. Wherever you go, it's very difficult to avoid culturing farms. However, there is no specific incorporated leader or network for government. They established a lot of projects which were done segmentally or separately. Now they don't know where they put artificial reefs. It's not clear. Now, people are starting to solve this again, finding out where are the fixed nets or the culturing farms or reefs. Sometimes they use ships, etc... They really need to find out what the seafloor bottom situation is.



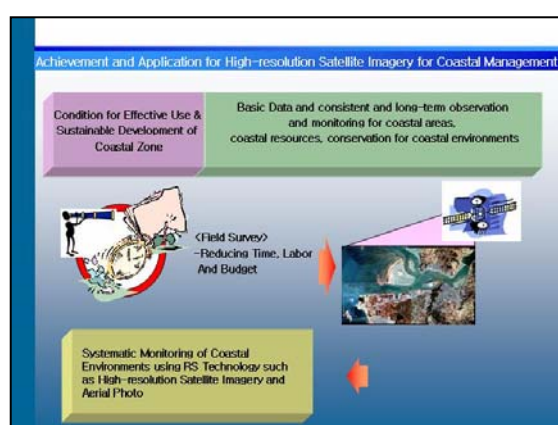
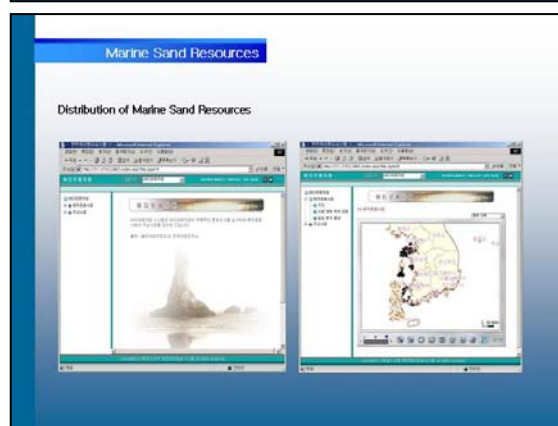
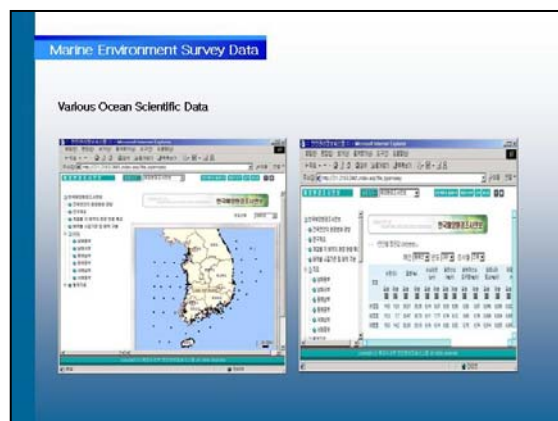
Next is the coastal satellite image map. It is a 6m-level color satellite image, which is a combination of the IRS-1C and Landsat images. We cover the entire coastal zone.

Next is marine environment survey data. It is related to scientific ocean data, so it's from academia, research centers and national research groups. They monitor and collect data concerning water quality and parts that are polluted, physical data, chemical data and geological data.

The next point is marine sand resources. Another issue in Korea is the rapid land-based rate of construction, due to the demand for apartments and so on. At present we have a real problem with marine sand mining. River sand mining is completely prohibited. I am on the national committee which is advising where marine sand mining can take place, and we have a real problem balancing the development of marine sand mining and the conservation of the marine environment. Many people argue that marine sand mining will cause coastal erosion and reduction of fish stocks and will affect ecology and water quality. We started a specific 10-year project this year concerning marine sand mining problems. The information database should be included in the ICM in Korea.

Also, the soil surface map along the coastal zone, very in detail, and the basic coastal map with satellite image data. We have included seafloor morphology, sub-bottom geology and other data.

Next, is how we were able to achieve and how we can apply high-resolution satellite imagery for coastal management. One thing is that we need to use it effectively. As we know, if we are limited to fieldwork it can take a lot of time, money and manpower – satellite images are helpful for reducing this kind of investment. To use satellite imagery effectively for the sustainable development of coastal zones we need to collect basic data through consistent and long-term observation and monitoring of coastal areas, resources and conservation of the coastal environment is also an issue. After we have done this we can have systematic monitoring of the coastal environment using remote sensing technology, such as high-resolution satellite images and aerial photos



Planning for the high-resolution satellite imagery data service was as follows. In 2000, 1m-level IKONOS satellite imagery was introduced for the systematic monitoring and also more scientific study of coastal environments. Since January 2003 higher resolution satellite images of the entire coastal area of Korea have been in use through internet with the national and local governments. It's not accessible for academia or private use yet. Academics and private citizens need to get permission from the government to use it. This year 1m-level satellite will actually be used by the Arirang 2 satellite, which is an entirely Korean-developed project. I don't know if they might test or not, but it looks like they will have cheaper use of satellite imagery.

Now to problems to be solved in the future. The software is still very primitively developed. I don't think it's compatible with ArcGIS or ArcView and the like. How can we combine our software with existing software? I'll mention it later, but MOMAF and NOAA have a treaty for developing this kind of thing. Making them compatible is still a problem; how we can do it will be resolved in the future.

Also we always have the problem that we have a lot of kinds of research data along the coastal zone. We still need to have accurate data for this kind of ICM because we have a lot of research to do.

There is also an urgent need for management on fishery resources and coastal disasters. We always lose people when we have storms and typhoons and we repeatedly have floods, every year. We argue that this is not well done due to very inconsistent monitoring and predictions from the government. So basically, for this reason we need to have this kind of integrated coastal management for fighting coastal disasters.

Also, we need more professionals and more consistent organizations for coastal information. In Korea this means officials change on average about once a year. Then once they start looking for this kind of system and they got transferred to other departments. It's difficult to follow consistently, that's one problem. We find it hard to do this kind of maintenance of coastal information.

We also have to try to train local government officials and also encourage researches in coastal management.

Conclusions and suggestions. First, we need to have consistent investment and support. As long as we continue to have coastal management operated by the Korean government, the changes of new information about coastal management should be upgraded continuously. Therefore, the development and input of new technology related to coastal management is necessary.

Second, I've already mentioned systematic surveys planned for scientific data collection and for problems to be solved. Because the basic coastal data are not sufficiently accumulated along the coastal zone of Korea, it is very difficult to perceive and predict environmental changes. And hence, it is very basic and urgent to conduct field surveys in the coastal zone of Korea.

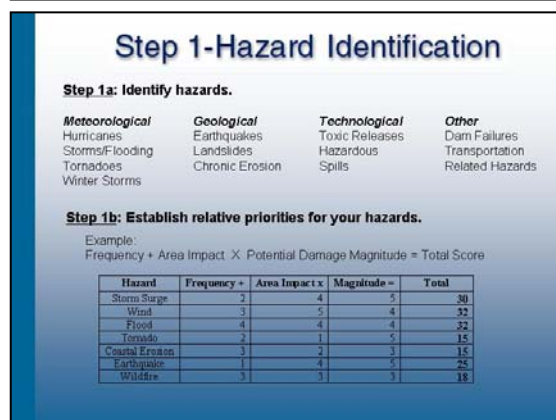
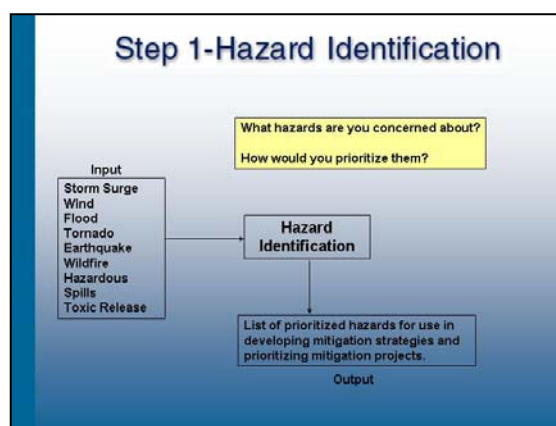
Finally, recognition and advertising are important for coastal information. I have to say advertising is very important to try to really persuade people. We're using tax-money so we need to convince people of why this is important and why it is beneficial to them. Even though it is easy to say that scientific statistical data is important for policy-making decisions, actual support in the budgets and manpower is not well established yet, even at the national government level. It is our duty as scientists to really persuade national government officials of how it is important. As we know, the development of a coastal information system can only be successful as a

result of investment from national and local governments, the private sector and other agencies, including research institutes and academia. This attitude and willingness will play a key role in the successful establishment of integrated coastal management in Korea.

Let me just briefly show you one example. We will start this project from this year – coastal hazards.

This information actually came from NOAA. How can we apply GIS to this coastal hazard? This simple idea is pretty much related to the other one, too, so let me just show it to you briefly. I will not read all of the parts about risk and probability and what their definitions are etc... but here the most important thing is people's property and resources located in risk area are considered to be at risk from hazards and may or may not be vulnerable to hazard impact. So, the vulnerability of people's property and resources is a function of their individual susceptibility to hazard impact. We have to know how to apply all this, and then what we can do about hazard mitigation, how we can prevent, or at least mitigate hazards. There are several systems – there is the CVA (Community Vulnerability Assessment) tool, which was developed by NOAA. We are using this kind of tool. Of course, we don't use completely the same approach – we will modify it, but we will follow several steps.

Hazard identification is very important from scientific data too - critical hazard analysis, societal analysis, economic analysis, environmental analysis and finally mitigation opportunities analysis. The first step in hazard identification is to input the data here, for scientific data, and identify them and prioritize the hazard for use for developing mitigation strategies and help about projects. Each step has meteorological, geological, technological and other data including human resources. Then we use this as a score to determine what the most important things are. We have a total score. Then we have a second step, which is put here, and then eventually we get where the risk is most important, if you need the wind, we use models, soil erosion rates and hazardous waste etc...The third step is critical facilities, which more related to human beings, right? Here are the details. The fourth stage is societal analysis. People who are poorer have very poor housing system and receive greater impact. The higher the population, the higher the risk.



3.6 Keynote Lecture 6

BIOGEOCHEMISTRY CHARACTERISTICS OF DISSOLVED AND PARTICULATE CARBON IN THE CHANGJIANG SYSTEM

Dr. Ying Wu

Associate Professor

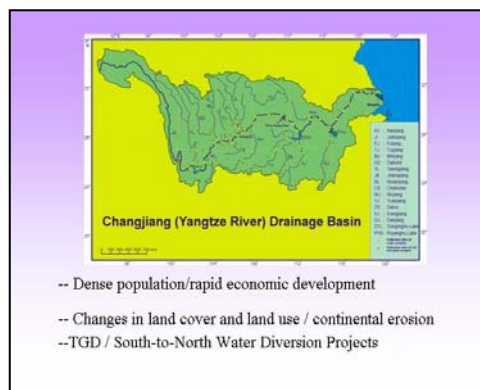
State Key Laboratory of Estuarine and Coastal Research,
East China Normal University



Thank you. My topic is the biogeochemistry of inorganic and organic carbon in the Changjiang. The recent results of the field observations carried out in 1997 and 2003 were finished by the Marine Biogeochemistry Group directed by Professor Jing Zhang.

The quantity of carbon transferred to the ocean by rivers is an important and well documented component of the global carbon flux. Among the 0.9 gigatons carried by the world's rivers to the oceans every year, about 40% is organic carbon and 60% is in the inorganic phase. Though the percentage of the carbon to the oceans is smaller on the global carbon scale, it is important for coastal regions because it provides a considerable food source to coastal ecosystems. Also, the terrestrial organic matter barrier in coastal areas of the ocean is the most important mechanism for its preservation. River carbon flux provides essential information on the rate of the continental yield and also the contribution of terrestrial organic matter to the oceans. For some areas the fluvial matter could be most important in such coastal regions. This figure shows the discharge data for the world's largest rivers. It was completed in 2004. We find that the Yangtze River plays a significant role in the global carbon budget. The data seems to be a little bit old. I wish it were later.

More concerns are focused on the larger Changjiang Basin because of its economic significance and the changes in the land cover and land use and also continuous building of big projects such as the TGD(Three Gorges Dam) and the South to Northwest Water Diversion Project. As we know the total population living in the watersheds is about one-third of the national population. The rice harvest of the watersheds comprises 70 – 75% of the national harvest.



Also, the economic benefits of the whole Changjiang Basin amounted to almost half of the GNP in China in the 1990s. Such a dense population and rapid economic development brought about great changes in land cover and land use. Soil erosion in particular has increased dramatically, especially in the upper reaches, which was mentioned in the last presentation.

The big projects such as the TGD and the South to North Water Diversion Project have caused big changes in the hydrodynamic, sediment discharge, carbon flux and nutrient flux. Such changes will bring about significant changes in the coastal

ecosystem and even their community structure, as Dr Watanabe mentioned this morning. However, recently, most work has focused on the estuary and coastal areas. Limited work is available in the literature about the whole Changjiang Basin. What we will show in the presentation is the background of the carbon biogeochemistry in the Changjiang, especially regarding the Three Gorges Dam project. The ultimate aim of our research is to answer the question of how changes in land use and human activity affect the carbon biogeochemistry of the Changjiang, including the sustainability of development in the region and the influence of the Changjiang on the global climate. However, what we have done is just the first step in answering the question.

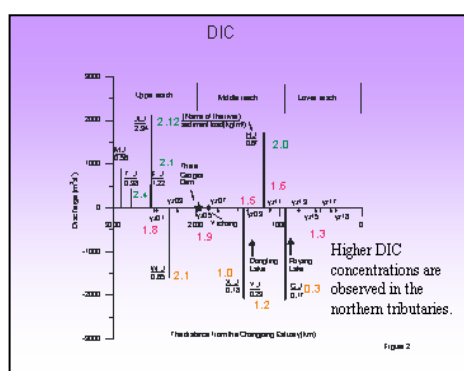
Question

*How is the "background" for carbon biogeochemistry in the Changjiang?

*How will changes in land use and human activities affect the carbon biogeochemistry of Changjiang, including the sustainability of development in the region and the influence of Changjiang on Global climate?

The field observation of the Changjiang was carried out from April to May in 1997 and 2003. Samples included dissolved and particulate matters and even plants and soil collected from the mainstream and the 15 major tributaries. This has been simplified to indicate the sampling sites of the field observation, and also include the main tributaries from the northern and southern parts. As we show, the discharge and the sediment load are also included in these figures. The y axis stands for the discharge, and the numbers below the names of the tributaries stand for the sediment loads. This shows the parameters determined in this study, and their quality control. I think that maybe the last review for the three gorges; this picture was taken just before the closure of the Three Gorges Dam last May. The picture shows where we collected the samples on the upper-reaches of Jinshajiang.

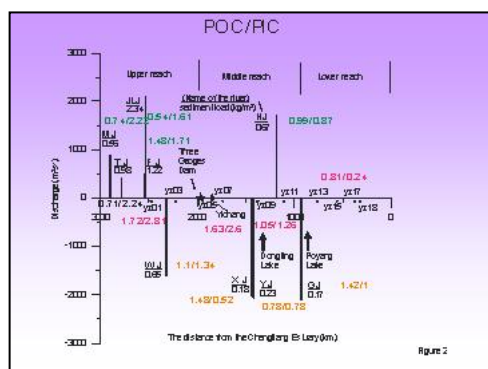
Very briefly, I will show some results of our field observations. We can find DOC distribution along the mainstream, from the upper-reaches to downstream. The lowest concentration we found was in upper pristine areas. Where the river runs into Sicuan province, the DOC concentration increased dramatically. In the middle and lower reaches the concentration keeps constant. The average DOC concentration in the mainstream is around the 105 μ mol. The DIC concentration decreased from the upper reaches to the lower. It seems that in the middle and lower- reaches the DIC concentration could have been diluted by the Great Lake system. Higher POC was observed in the Sicuan Province and the tendency of the POC distribution is similar to the DOC. The PIC concentration also decreased from the upper-reaches to the lower reaches, but the decrease was much sharper than the DIC.



Particulate samples were also collected from the mainstream and the southern and northern tributaries for the study of carbon isotope and nitrogen isotope ratios. It seems that the carbon isotopes have a very narrow range, from just -27 to -24, which indicates the dominance of C3 vegetation in the Basin. However, nitrogen isotopes were involved in a larger variation, from 8 to 2. In a comparison between the southern and northern tributaries, carbon isotopes and nitrogen isotopes showed similar ranges but the variation is much larger in the southern than the northern tributaries.

Here we would like to compare the DOC concentrations from the different tributaries. The numbers in green indicate the northern parts, orange the southern parts and red for the mainstream, just for comparison. It confirms that the higher DOC concentrations are found in the upper-reaches, especially in the northern tributaries.

The POC was similar. The highest concentration was located in the northern tributaries. Anyway, the upper-reaches of the southern tributary also have quite a high concentration. When the samples come from northern tributaries the DIC concentration seems much lower than those taken from the northern parts.



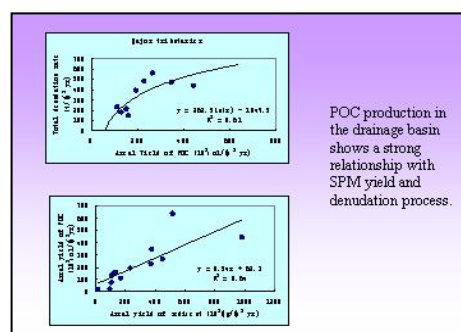
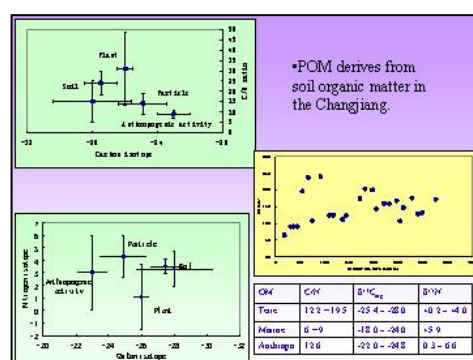
These figures show the POC and the PIC in combination, so the left-hand number shows the POC and the right the PIC. The variation in the POC is not easy to conclude from such a contribution, but the PIC percentage is much higher in the northern parts than the southern parts.

We compared the observations from the two years, one 1997 and the other 2003. For the most part they are comparable. The DOC shows a slight increase, especially in the middle and lower reaches. Similar findings were made in the tributaries' contributions. Except for a few stations, most contributions were comparable in the two years.

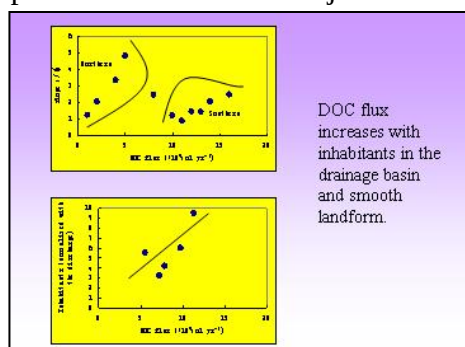
We want to consider combining multiple approaches to determine the source of particulate organic matter in particular, in the Changjiang. Here is the general information. Normally, terrestrial inputs could indicate a higher C/N ratio, and carbon and nitrogen isotopes will be attributed to this range.

According to such distributions as could be found, for most of the particulates collected in the mainstream, the C/N ratio will be much higher than ten, even as much as 24. For the carbon isotope distribution and the nitrogen isotope distribution, the terrestrial contribution is dominant for the particulate organic matter in this large system. Normally phytoplankton contribution in such larger systems could be relative of higher suspended particles and light limits. Anyway, anthropogenic activity could also have some affect on the carbon isotope distribution.

We would like to look over what the control process is for the POC and DOC production in such large Changjiang Basin. We used the POC and DOC ratios to guess what happens in such watersheds. For most samples collected from the upper reaches the erosion process is dominant, and also it was possible they could have higher POC and DOC ratios. For example, the plants collected from the middle and the lower reaches, which is where the leaching can be controlled, the POC and DOC are much lower. Similar finds were made in the tributaries. For the tributaries located upstream, such as Jialing, Chu-xue and

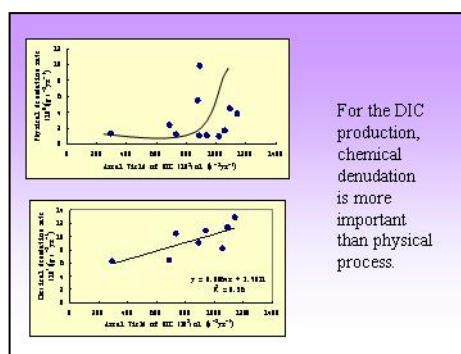


Niulang, the erosion process is dominant and there are higher POC and DOC ratios. For the middle and lower reaches, such as Yuangjiang and Hangjian, the POC to DOC ratio is much lower, where sedimentation is dominant. So POC production in the basin shows a strong relationship with the suspended particle yield and the denudation process. We used the major tributaries of the Changjiang Basin to combine all the data together. The DOC flux in the Changjiang Basin increases with the number of inhabitants. It's easy to integrate this because when inhabitant numbers increase in the watersheds, the points of non-point pollution will increase too, the DOC flux will increase. We also found that topography could affect the DOC flux. Water normally overruns smooth landforms, such as those in the southern tributaries, and so DOC can easily leech from the soil and plant detritus



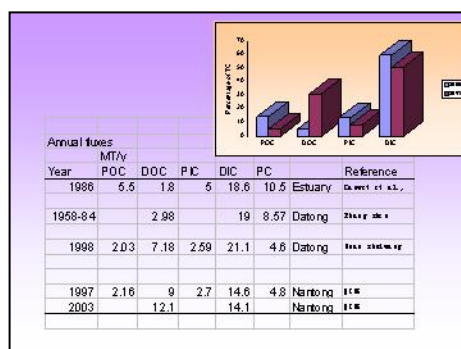
and increase DOC flux. For sharp topography, such as the tributaries around the plateau areas, the DOC is not easily contained and so the DOC flux decreases.

The relationship between the DIC production and chemical weathering is random in the Changjiang, contrary to our expectations. For DIC production, chemical denudation is more important than the physical process. This brings our eyes back from 2004 to 256 BC the Qin dynasty, when the famous Dujiangyan project had just been built. At that time, the Changjiang Basin had good forest conservation. Forest covered around 60 to 70% of the Basin. As time passed, the number of inhabitants increased, in 86 AD, the number of inhabitants per square kilometer was just around three persons, then in the Qing Dynasty a tenfold increase, around 40 inhabitants per square kilometer. In modern society, the number increased to almost 700 (people). Also, the soil erosion is more serious and the forest covering area has decreased to almost 12%.



This just gives us some brief impression of the soil erosion in Jiangxi province, which is located in the lower-reaches of the Changjiang. From the 1950s, the soil erosion rate was around 5%, but by the 1990s the percentage increased almost four fold, to 20%. Anyway, soil erosion does not always mean a higher sediment yield in the river, as we have learned from the last few presentations. Long-range records for the river indicate that the water discharge keeps constant, but the sediment load decreased dramatically. This is for the water discharge, and this is for the sediment load. You can see that in 2004, it's much lower than the average for the long-range records. Such a decrease is not only indicated in the mainstream, but also in some major tributaries, such as the Han River, the major tributary for the northern part in the middle reaches. In the 1950s the number reached around 1.5; in the 1980s to 2000 the number decreased by one to 0.5.

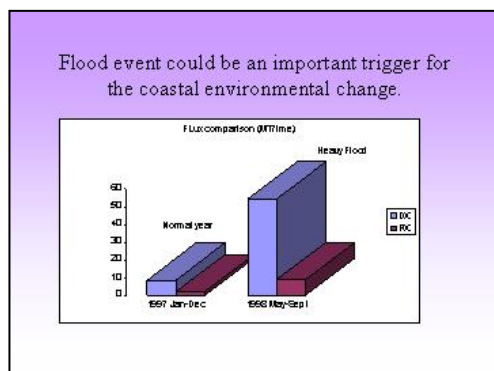
We combined the all the water discharge and the sediment load to calculate the carbon



flux. That's what we want to do with this study. The annual flux varied from 1986 to 1997. If we refer to figure two, we can find that the POC and PIC flux decreased. However the DOC flux has increased in recent years.

We will give a very short brief view of the effects of the flood of 1998. We compared the concentrations. This is for a normal year – we got the data in 2003 in Xu liujing and this is for the heavy flood season. We got the data from the Datong stations. We found that, with the exception of DIC, which remained normal, concentrations of the likes of DOC and POC were much higher than in normal years. The DOC concentration was almost five fold higher. Just look at the flux. In the flood

season the sediment load also increased dramatically, which is the reason why the DOC production was much higher than in normal years. In just one period, 1998, the number is much larger than in normal years – the whole year's flux. We couldn't have imagined such a large DOC and POC flux in such a short period. It could be an important trigger for coastal environmental changes.



Just some closing remarks- I would like to confirm this again: besides the annual monitoring of the Changjiang, more emphasis should be given to unexpected floods, such as those of 1998.

Thank you for your attention.

Some remarks

- Soil organic matter is the main contribution to particulate organic carbon of Changjiang.
- Carbon flux seems more relevant to soil erosion process.
- Particulate carbon flux decreases in recent year while DOC flux increases.
- Suggestion: besides annual monitoring of Changjiang, more emphasis should be paid on the unexpected floods.

4. Abstracts

ESTIMATION OF SEDIMENT AND NUTRIENT FLUXES FROM THE CHANGJIANG RIVER INTO THE EAST CHINA SEA

Kaiqin Xu*, Jiqun Zhang, Masataka Watanabe* and Zhongyuan Chen*****

*Watershed Management Research Team, National Institute for Environment Studies,
Tsukuba 305-8506, Japan

** Water Resources Management Center,
Ministry of Water Resources, Beijing 100053, China

*** Department of Geography, East China Normal University,
Shanghai 200062, China

The Changjiang(Yangtze) River is the third longest river in the world. The watershed of the Changjiang River covers twenty percent of China's land area, and about four hundred million people live in this watershed. This area produces about forty percent of agriculture and industrial products in China. To support this dynamical human activity, land uses are being changed dramatically in the watershed. For example, agricultural land is being converted to use for human settlements and industry, and forests are being cut and converted to agricultural land. These changes result in more pollutant loads from factories and towns flowing into the Changjiang River, as well as greater amounts of soil, fertilizer and agricultural chemicals from farms. The combined effects of these factors are creating enormous problems. One serious impact is the rich marine ecological system of the East China Sea, Caused by increased amounts of soil, fertilizer (nitrogen, phosphorus) and hazardous chemicals from the watershed flowing into the river.

A lot of chemical fertilizer was washed away from the soil into the runoff and the sea. The concentrations of N and P have obviously increased in the Changjiang runoff during the last thirty years and nutrition's level was unceasing raised in the Changjiang estuary and its adjacent water areas as well. In recently years, the red tide occurred frequently that the eutrophication problem seems to be an important issue in this area. It is essential to estimate the pollutant loads flowing into the East China Sea by a simple, effective equation. However, there are few researches on the prediction of the material fluxes from the Changjiang River flowing into the East China Sea. The reason why may be the complicated system of the huge catchment of the Changjiang River, limit knowledge of the prediction methods, lack of necessary data source of the River. The objective of this study is to estimate the sediment and nutrient fluxes from the Changjiang River flowing into the East China Sea. Especially, the relationships of SS, COD, TN, TP and discharge data were discussed.

In order to have a better understanding of the biogeochemical cycles of the Changjiang River Basin and to provide protection of ecological environment and water resources with scientific basis, the work on this field was carried out in the Japan-China joint study, during 1998-1999. Through the collection of the best available past water quality and daily discharge data in year 1987 and 1988 and the field surveys along the Changjiang River in 1998 and 1999, relationship of the sediment and nutrient loads with the discharge has been established.

The result obtained showed that the relationship of SS, COD, and DIN loads with the discharge had good correlation from the 1987 and 1988 data. On the other

hand the relationship of SS and TP, TN and DIN were found from the data sources of the field survey in 1998 and 1999. Thus mainly pollutant load of SS, COD, TN, TP with discharge were achieved through the analysis of these data. The sediment and nutrient fluxes from the Changjiang River can be easily estimated if the discharge at the Datong station which is the last hydrological station in the River was available. It suggested that the long-term pollutant loads of SS, COD, TN, DIN and TP flowing into the East China Sea can be preliminary estimated from the discharge data at the Datong station and the pollutant load discharged from the Shanghai city.

IMPACT OF THE THREE GORGES DAM AND PROJECT PUMPING WATER FROM THE CHANGJIANG RIVER INTO NORTH CHINA ON THE SALTWATER INTRUSION IN THE CHANGJIANG ESTUARY

Zhu Jianrong, Wu Hui, Shen Huantitng

State Key Laboratory of Estuarine and Coastal Research, East China Normal University, Shanghai 200062

The Changjiang estuary has three-order bifurcations and four outlets into the sea, and saltwater intrusion in each outlet is different. The saltwater intrusion in wintertime in the North Branch is very serious due to its funnel shape and small discharge, and its saltwater can flow into the South Branch. So, the saltwater intrusion in the South Branch is influenced by the high saline water from downstream and upstream. Observation data and numerical simulation show that the saltwater intrusion in the whole Changjiang estuary is determined mainly by the Changjiang discharge and tide range. Other dynamic factors influencing the saltwater intrusion are the wind stress, continental shelf current and mixing. The improved three dimension ECOM model was used to analyze the impacts of the Three Gorges Dam and project pumping water from the Changjiang River into North China on the saltwater intrusion in the Changjiang estuary in this paper. The calculated domain includes the whole Changjiang estuary, northern Hangzhou Bay and western inner shelf of the East China Sea. The non-orthogonal curvilinear grid was adapted to fit the coastline and improve the local resolution. The highest horizontal resolution in the upper North Branch near the bifurcation and in the deep waterway is 50m, and vertical grid was divided 5 layers. The dry-wet judge method was added into the model to reproduce the moving boundary in the tidal flats. The 2.5 order turbulence close sub-model was used to calculate the temporal and spatial variation of vertical turbulence mixing induced by tidal current at bottom and wind stress at surface. The open boundary at upstream was specified by the monthly mean Changjiang discharge in Jan. observed at Datong station. The main 8 tidal constituents M2, S2, K1, O1, N2, K2, P1, Q1 were considered to reproduce spring and neap tide, and residual water level is added to reproduce the continental currents at the open boundaries off the Changjiang mouth. The continental shelf currents off the Changjiang mouth are mainly the Taiwan Warm Current and Subei Coast Current which can bring salt seawater just into the area off the Changjiang mouth, and become the source of the high saltwater that can intrude into the Changjiang estuary by the flood tide current and density-driven current. It prevails monsoon in Eastern Asia, the strong northerly wind in wintertime induce the landward Ekman transport that is favorable to the saltwater intrusion. The model calculated results are fairly consistent with observed data in Jan. of 2004. The Three Gorges Dam increase the Changjiang discharge about 1500 m³/s in Jan. and Feb. in dry year, and the project pumping water from the Changjiang River into North China reduce about 800 m³/s at the eastern line at first phase. Compared with the results before the projects, the calculated results show that the Three Gorges Dam reduce the saltwater intrusion and the project pumping water from the Changjiang River into North China enhance it due to the change of the Changjiang discharge.

CHANGES IN THE DISCHARGE AND DISTRIBUTION OF WATER AND SEDIMENTS FROM THE RED RIVER AND THEIR EFFECT ON THE COASTAL ZONE

Tran Duc THANH^a, Yoshiki SAITO^b, Dinh Van HUY^a

^a Haiphong Institute of Oceanology, 246 Danang Street, Haiphong City, Vietnam.

Fax: 84-31-761521, E-mail: tdthanh@hio.ac.vn

^b MRE, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba 305-8567, Japan.

The Red River (Song Hong) has a length of 1126 km, of which 556 km is in Vietnam, and a gradient of 2.3 m/km. The mean basin elevation is 1090 m, and its maximum is about 3000 m. The river catchment includes parts of China and Vietnam and has an area of 169 000 km², 51% of which is in Vietnam (including 14 000 km² in the catchment area of the Thai Binh River, which is entirely in Vietnam). Mean rainfall is 1500 mm/yr over the whole catchment, 1200 mm/yr in Chinese territory and 1600 - 2000 mm/yr in the coastal zone. The wet season is from May to October, and precipitation during that season accounts for 85%-90% of the yearly rainfall.

The Red River is formed by the confluence of the Da, Thao and Lo Rivers at Viet Tri, which is located at the apex of the Red River delta. In the delta, the Red River divides into many distributaries, of which the Duong River (upstream) and Luoc River (downstream) link the Red River to the Thai Binh River. Water and sediments from the Red River system are discharged into the sea through three river mouths to the north of Do Son Cape and nine river mouths to the south of the cape.

The annual water discharge of the Red River is 137 billion m³, including 9 billion m³ from the Thai Binh River. The discharge in the flood season (June to October) accounts for about 75% of the annual discharge, and that in the dry season (November to May) accounts for only 25%. From the water discharge of the Red River system, a volume of 40% is supplied from Chinese territory.

The sediment concentration in the river is very high, with an annual mean value of 1000 g/m³ at Son Tay, near Hanoi. The annual sediment discharge of the Red River System is 116 million t: 114 million t from the Red River, measured at Son Tay Station, and 2 million t from the Thai Binh River. The sediment discharge in flood season accounts for 91.6% of the annual discharge and that in dry season accounts for only 8.4%. Monthly, the sediment discharge is highest in June and August, and lowest in February and March.

The sediments supplied from the Red River system have built a delta with an area of 17 000 km². The total Cenozoic sediment thickness is up to 5000 m, including a Quaternary thickness of 250 m and a Holocene thickness of 30 – 60 m. The delta front extends to a water depth of 20 m, and the prodelta to 30 m. At present, the delta is prograding rapidly seaward, especially to the southwest, at a mean rate of 25-30 m/yr and a maximum rate of 120 m/yr.

Recently, the discharge and distribution of water and sediments from the Red River have undergone obvious changes caused by climate change and human activities.

Water and sediment discharge vary significantly with climate; for example, during the wet climatic regime from 1932–1951, water and sediment discharge were high, but during the dry climatic regime from 1952–1967, they were low. Moreover,

they also fluctuate between extreme climatic years. For example, the discharges of water and suspended sediments in 1963, a dry year, were 93.1 billion m³ and 52.6 million t, respectively, and those in 1971, a wet year, were 159 billion m³ and 202 million t, respectively.

Human activities in the Red River catchment, such as deforestation, water use for irrigation and dam construction, greatly affect the water and sediment discharge and distribution from the Red River. Between 1943 and 1991, the forest cover in the upper Red River catchment within Vietnam decreased from 95% to 17% in the mountains and from 55% to 29% in the midlands. The volume of river water used for irrigation has increased as well, from 6.6 billion m³ in 1985 to 7.4 billion m³ in 1990 and 8.9 billion m³ in 2000. Among the many dams on the Red River System, the largest, the Hoa Binh Dam, which was completed in 1989 for electric power generation, has a reservoir area of 208 km² and a volume of 9450 million m³.

Human activity in the coastal zone has a very important effect on the distribution of water and sediment in the river mouth areas and coastal zone. In the entire Red River Delta, there are 3000 km of river dikes and 1500 km of sea dikes, all of which were built during the last thousand years to protect the plain and its inhabitants from river and sea floods. A total of 24 000 ha of the tidal flood plain in the RRD were reclaimed during 1958-1995.

The annual water discharge of Red River fluctuated in the large range, maximum 159 billion m³ in 1971 and minimum 68 billion m³ in 1906. Generally, there have been the small water discharge periods of about 10 - 15 years and the big water discharge periods of about 15 - 20 years alternately. It is noticed the small water discharge periods from 1952 - 1967 and 1989 - 1998, and the big water discharge periods from 1932 - 1951 and 1968 - 1988. Operation of the Hoa Binh Dam decreases the water discharge in the flood season by 6.6% and increases it in the dry season by 18.8%. Comparing the two periods, 1976-1985 and 1986-1995, the water discharge supplied from the Red River to the Thai Binh River by crossing the Luoc River increased from 24% to 27% of the total annual discharge of the Red River.

The sediment discharge from the Red River fluctuated in the large range, maximum 202 million t in 1971 and minimum 56 million t in 1963, and has decreased during recent decades. Since the completion of the Hoa Binh Dam in 1989, 48 million t of sediments - equal to 83% of the suspended sediment load - have been transported into the reservoir and deposited annually; and the annual suspended sediment discharge of the Red River at Son Tay Station near Hanoi has decreased from 114 million t to 79.4 million t. The distribution of the sediments discharged to the different coastal areas has also changed. Before the completion of the Hoa Binh dam, 113 million t/yr of suspended sediments from the Red River were discharged into the coastal area north of Do Son Cape, and 3 million t/yr were discharged south of the cape. Since the completion of the dam, 65 million t/yr have been discharged to the north of the cape, and 5 million t/yr have been discharged to the south.

These changes in discharge and distribution of water and sediments from the Red River system have caused some coastal hazards.

The loss of the great volume of river sediment discharge has changed the accretion rate in some coastal parts of the delta. At Ba Lat, where the biggest tributary of the Red River has its mouth, the accretion rate, which was 62.8m/yr during 1930-1965, increased to 88.8m/year during 1965-1990, and then decreased to 58.7m/yr during 1990-1998.

The decrease in the current velocity at the river mouths has contributed to their becoming obstructed by sedimentation because of the altered coastal sea dynamics (as

in the case of Ninh Co River mouth), and to increased coastal flooding during heavy rains (as in the case of Day River mouth). Moreover, the increase in sediment discharge from the Cam River, a tributary of the Thai Binh River, north of Do Son Cape is one cause of the obstruction of Haiphong Port by heavy sedimentation.

The violent acceleration of coastal erosion caused by the loss of massive sediment volume has been recognized along the Van Ly coast. This 20-km stretch of coast has been eroding for the last half-century. The mean rate of coastal erosion along this coast increased from 8.6 m/yr during 1965 - 1990 to 14.5 m/yr during 1991 - 2000, after completion of the large Hoa Binh Dam.

The increase in the volume of river-generated water with high turbidity and low salinity in the coastal area north of Do Son has negatively affected tourist activities at Do Son Beach and on the coral reefs off nearby Cat Ba Island.

In the near future, when the demand for water for hydroelectric power and irrigation will be even higher, further changes in the discharge and distribution of water and sediments from the river will create critical problems for the management of the Red River basin.

5. References

5.1 Yangtze Fluvial Conference Schedule

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	Morning				Afternoon				Evening
Thurs. June 24					Registration 15:00-19:00				
Fri. June 25	Opening Ceremony 8:30-9:00	Fluvial Session Keynote Lectures 9:05-12:25			Lunch Poster Sesseion 12:25-14:20	Fluvial Session 14:20-17:40		Welcome Party 17:50-	
Sat. June 26	Fluvial to Estuarine Session Keynote Lectures 8:20-10:20	Tea/ coffee break Poster Session 10:20-10:40	Fluvial to Estuarine Session 10:40-12:00	Lunch Poster Session 12:00-14:00	Fluvial to Estuarine Session 14:00-15:20	Poster Introduction 15:40-17:15		Buffet 18:30-	
Sun. June 27	EMECS/NIES Session Keynote Lectures 8:30-11:50			Lunch Poster unloading Check out for Field Trip 11:50-13:50	EMECS/ NIES Session 13:50-14:50	Open Discussion 15:10-16:10	Closing Ceremony 16:20-16:30	Departure for Field Trip 17:30 to Airport	

5.2 List of Participants

Name	email	address
Adrian M Harvey	karina@lambrenos.freemove.co.uk	Dept of Geography, University of Liverpool, UK
Bai mingzhou	mzhbai@sina.com	School of Civil Engineering and Architecture Northern Jiaotong University, Beijing, 100044
Chen Guojin	cpqn110@sina.com	Hydrogeological Team, Hubei Bureau of Geology and Mineral Resources, Jinzhou Hubei, China
Chen Xiqing	13611642410@vip.163.com	State Key Laboratory of Estuarine and Coastal Research, East China Normal University, Shanghai, China, 200062
Cheng Heqin	hqch@sklec.ecnu.edu.cn	State Key Laboratory of Estuarine and Coastal Research East China Normal University, Shanghai, China, 200062
Dénes Lóczy	loczyd@ttk.pte.hu	Department of Physical Geography, Institute of Geography, University of Pécs, Pécs, Ifjúság útja 6. Hungary H-7624
Dingpingxing	dingpingxing@hotmail.com	State Key Laboratory of Estuarine and Coastal Research, East China Normal University, Shanghai, China, 200062
DuYun	duyun@asch.whigg.ac.cn	Institute of Geodesy and Geophysics, Chinese Academy of Sciences
Eric J.A. Wolanski	e.wolanski@aims.gov.au	Australian Institute of Marine Science PMB No 3, Townsville MC Queensland 4810, Australia
Gao Shu	shugao@nju.edu.cn	MOE Laboratory for Coast and Island Development, Nanjing University, Nanjing, China, 210093
Gholamreza Lashkaripour	lashkarg@hamoon.usb.ac.ir	Department of geology, University of Sistan and Baluchestan, Zahedan, Iran
Gordon E Grant	Gordon.Grant@oregonstate.edu	USDA Forest Service, Pacific Northwest Research Station, Corvallis, Oregon, USA, 97331
Gupta Avijit	avijit@foxhill.demon.co.uk	School of Geography, University of Leeds, Leeds LS2 9JT, UK
Hi Il Yi	hilee@kordi.re.kr	Marine Geoenvironments and Resources Research Division, Korea Ocean R&D Institute, 1270 Sa2Dong Ansan 426-744 South Korea
Jiang Tong	jiang.t@niglas.ac.cn	Nanjing Institute of Geography and Limnology, CAS, Nanjing, China, 210008

Name	email	address
John Chappell	john.chappell@anu.edu.au	Research School of Earth Sciences, Australian National University, Canberra
Joseph Lee	hreclhw@hkucc.hku.hk	Department of Civil Engineering The University of Hong Kong, Hong Kong, China
Kale Vishwas Shripad	yskale@unipune.ernet.in	Department of Geography, University of Pune, Pune, India, 411007
Kinga Krauze	kingak@biol.uni.lodz.pl	International Centre for Ecology Polish Academy of Sciences Konopnickiej Str.1, 05-092 Lomianki, Walsaw, Poland
Kunikatsu Nakajima	k-nakajima@emecs.or.jp	International EMECS Center, Japan
Li Luqian	g0203449@nus.edu.sg	Department of Geography, National university of Singapore, Singapore, 117570
Lichang'an	chanli@cug.edu.cn	China University of Geosciences, WuHan Hubei, China, 430074
Lu Xixi	geoluxx@nus.edu.sg	Department of Geography, National University of Singapore, Singapore 119260
Masataka Watanabe	masawata@nies.go.jp	National Institute for Environmental Studies, Tsukuba 305-8506, Japan
Matti Kummu	matti.kummu@hut.fi	Laboratory of Water Resources, Helsinki University of Technology, P.O. Box 5200, FIN-02015 HUT, Finland
Md Badrul Islam	badrul@librabd.net	Department of Geology and Mining, University of Rajshahi, Rajshahi 6205, Bangladesh
Mohammad Ghafoori	mohammad.ghafoori@science1.um.ac.ir	Department of geology, University of Ferdowsi, Mashhad, Iran
Muhammad Tahir	tahir_gexp@hotmail.com	Fugro Geodetic Limited, 28-B, KDA Scheme No.1, Karachi-75350, Pakistan
Nguyen Van Lap	sedlap@hcm.vnn.vn	Sub-Institute of Geography, Vietnam National Center for Natural Science and Technology, Mac Dinh Chi Str., 1 Dist., Ho Chi Minh City, Vietnam
Nobuo Kumamoto	kumamoto@wise.hokkai-s-u.ac.jp	International EMECS Center, Japan
Qi Yanping	qianping@hotmail.com	State Key Laboratory of Estuarine and Coastal Research, East China Normal University, Shanghai, China, 200062

Name	email	address
Ryusuke Kitamura	kitamura@emecs.or.jp	International EMECS Center, Japan
Shen Fang	fshen@sklec.ecnu.edu.cn	State Key Laboratory of Estuarine & Coastal Research, East China Normal University, Shanghai, China, 200062
Shen Huanting	htshen@sklec.ecnu.edu.cn	State Key Laboratory of Estuarine and Coastal Research, East China Normal University, Shanghai, China, 200062
Shi Yafeng	zhangq@niglas.ac.cn	Nanjing Institute of Geography and Limnology, Chinese Academy of Sciences (CAS), Nanjing China, 210008
Shogo Murakami	murakami@nies.go.jp	National Institute for Environmental Studies, Tsukuba, 305-8506, Japan
Siew Ruyan, Joanne	heehahoo@singnet.com.sg	The National University of Singapore, NUS
Steven Lee Goodbred	steven.goodbred@sunysb.edu	Marine Sciences Research Center, Stony Brook University, Stony Brook, New York, USA, 11794-5000
Takashi Oguchi	oguchi@csis.u-tokyo.ac.jp	Center for Spatial Information Science, The University of Tokyo, 4-6-1, Komaba, Meguro-ku, Tokyo 153-8904, Japan
Tran Duc Thanh	tdthanh@hio.ac.vn	Haiphong Institute of Oceanology, 246 Danang Street, Haiphong City, Vietnam
Velozzi David Michael	dmvelozz@ncsu.edu	Dept. of Marine, Earth and Atmospheric Sciences Campus Box 8208, R3147, 3148, Jordan Hall North Carolina State University Raleigh NC 27695, USA
Wang Houjie	hjwang@mail.ouc.edu.cn	Corresponding author, Houjie Wang, College of Marine Geosciences, Ocean University of China, Qingdao, China, 266003
Wang Suiji	wangsj@igsnr.ac.cn	Institute of Geographical Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing, China, 100101
Wang Yonghong	yonghongw@hotmail.com	Department of Marine Geoscience, Ocean University of China, Qingdao, China, 266003
Wu Chaoyu	eeswcy@zsu.edu.cn	Center for Coastal Ocean Research Zhongshan University, Xiaogangxi Road 135 Guangzhou, China 510275
Wu Jiaxue	jesse-wu@mail.tongji.edu.cn	Key Laboratory of Marine Geology, MOE, Tongji University, Shanghai, China 200092
Wu Ying	wuying@sklec.ecnu.edu.cn	State Key Laboratory of Estuarine and Coastal Research, East China Normal University, Shanghai, China, 200062

Name	email	address
Xiang Fang	xf@cmail.cdut.edu.cn	Sedimentary Institute of Geoscience College, Chengdu University of Technology, Chengdu City, Sichuan Province, China, 610059
Xie Shiyu	xiesy@mail.swnu.edu.cn	Department of Geography, Southwest Normal University, Chongqing, China, 400715
Xie Xiaoping	xp.xie@263.net	State Key Laboratory of Estuarine and Coastal Research, East China Normal University, Shanghai, China, 200062
Xu Chongyu	Chong-Yu.Xu@hyd.uu.se	Department of Earth Sciences, Uppsala University, Villavagen 16, S-75236 Uppsala, Sweden
Xu Jiongxin	xujx@igsnr.ac.cn	Institute of Geographical Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing, China, 100101
Xu Kaiqin	joexu@nies.go.jp	Watershed Management Research Team, National Institute for Environment Studies, Tsukuba 305-8506, Japan
Yang Dayuan	yangdy@nju.edu.cn	Department of Geography, Nanjing University, Nanjing, 210093
Yang Shouye	syyang@online.sh.cn	Laboratory of Marine Geology, Tongji University, Shanghai, China, 200092
Yin Hongfu	hfyin@mail.cug.edu.cn	China University of Geosciences, WuHan Hubei, China, 430074 China University of Geosciences, WuHan Hubei, China, 430074
Yoshiki Saito	yoshiki.saito@aist.go.jp	Geological Survey of Japan, AIST, Central 7, Higashi 1-1-1, Tsukuba, 305-8567, Japan
Zhang Qiang	zhangq@niglas.ac.cn	Nanjing Institute of Geography and Limnology, Chinese Academy of Sciences, 73 East Beijing Road, Nanjing, China 210008
Zhang Yufen	xqzhang@cug.edu.cn	China University of Geosciences, WuHan Hubei, China, 430074
Zhao Yan	yanzhao@lzu.edu.cn	CAEP National Laboratory of Western China's Environmental Systems, Lanzhou University, Lanzhou, Gansu province, China, 730000
Zheng Hongbo	zhenghb@online.sh.cn	School of Ocean and Earth Science, Tongji University, Shanghai, China, 200092
Zhou JunLi	junlizh@hotmail.com	State Key Laboratory of Estuarine and Coastal Research, East China Normal University, Shanghai, China, 200062
Zhu Jianrong	jrzhu@sklec.ecnu.edu.cn	State Key Laboratory of Estuarine and Coastal Research, East China Normal University, Shanghai, China, 200062

Name	email	address
Zhu Lidong	<u>Zhuld@cmail.cdut.edu.cn</u>	Chengdu University of Technology, Chengdu, Sichuan, China, 610059
Zhu Yurong	<u>yrzhu@sjtu.edu.cn</u>	School of Environmental Science and Engineering, Shanghai Jiaotong University, Shanghai, China, 200240
Zhuang Kelin	<u>klzhuang@hotmail.com</u>	Qingdao Institute of Marine Geology, Qingdao, Shandong, China, 266071
Zong yongqiang	<u>y.q.zong@durham.ac.uk</u>	University of Durham, UK

2nd IAG Yangtze Fluvial Conference
EMECS/NIES Session
Conference Report

Published in January, 2005

by

International EMECS Center

IHD Building, 5-1 Wakinohama-kaigandori 1-chome
Chuo-ku, Kobe, 6510073 Japan
TEL: +81-78-252-0234
FAX: +81-78-252-0404
URL: <http://www.emecs.or.jp>
E-mail: secret@emecs.or.jp