Asia-Pacific Network for Global Change Research

Integrating Support System for Managing Environmental Change and Human Impact on Tropical Ecosystems in East Asia and the Pacific

Final report for APN project: ARCP2007-03CMY

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Integrating Support System for Managing Environmental Change and Human Impact on Tropical Ecosystems in East Asia and the Pacific

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Final Report submitted to APN

Overview of project work and outcomes

Non-technical summary

The coastal zones in East Asia and the Pacific have been subjected to various pressures resulting from natural climate variability and anthropogenic activities. Increased environmental loads (e.g. sediments, nutrients) from adjacent watersheds are of particular concern because of their deleterious effects on coastal habitats (e.g. seagrasses, coral reefs). Timely and accurate detection, understanding and prediction of coastal environmental changes are crucial for management and decision-making to address possible resource conflicts and value trade-offs. However, information and analysis tools are still far from ideal. In managing coastal resources, the complex interactions between social, economic and environmental systems comprising the coastal zone must be considered. Global/regional phenomena (e.g. global climate change) should also be considered to achieve sustainability in the management and utilization of coastal resources in the short term and long term. Effective management also requires collaboration between researchers, policy makers and the community. A need exists to link science and decision-making stressing the continuum of expertise from basic science to applied science to policy, governance and management. This Project aims to strengthen present and future coastal observational (in-situ & space-based) and modelling capabilities and decision-making process by developing a region-wide, collaborative strategy for data exchange and analysis among coastal scientists and managers.

Objectives

The overall goal of this Project is to apply understanding of the causes and consequences of present and future environmental change in tropical coastal ecosystems in management decisions. The specific objectives of the Project are to:

1. Produce an accurate set of multi-date coastal resource information within the region particular to needs of managing coastal zone changes and sufficiently consistent to allow for comparison among systems in the East Asia and Pacific Region;
2. Provide an understanding of the driving/forcing effects of socio-economically-induced changes (urbanization, population) on environmental loads to the tropical coastal ecosystems;
3. Assess human welfare impacts of changes in coastal resource systems in terms of social costs and benefits with respect to different management strategies.
4. Strengthen the network of, and reinforce linkages among coastal scientists and managers thru shared expertise and resources; and
5. Develop capacity building through workshops on standardized methods of processing various data (e.g. remotely-sensed data, socio-economic surveys).

Amount received and number years supported

2006/07 and 2007/08: USD 45,200 (80% of the Total Grant for two years). The remaining 20% will be given after completing all project requirements.

Activities undertaken

<u>Ishigaki Island (Okinawa, Japan):</u>

Several field surveys have been conducted in Ishigaki Island, more specifically in Shiraho Reef and in the adjacent watershed area, the Torodoki watershed. Various types of sensors were deployed in the reef flat to characterize reef hydrodynamics and to investigate and model the fate of sediments and nutrients, especially during typhoon period. Water samples were collected and analyzed both in the reef and in several stations in the river for suspended sediments, chlorophyll-a and nutrient concentrations. The spatial and temporal distributions of microalgae in the reef were also assessed. For longer-term study, turbidity and other sensors were deployed at two stations in the reef. Sediment and nutrient discharge from Todoroki River are continuously being monitored together with meteorological variables (e.g. rainfall, solar radiation). An in situ nutrient analyzer for continuous monitoring of dissolved nutrients (i.e. nitrate, phosphate). Satellite images (e.g. Landsat TM) covering a period of about 20 years (around early 1980s to 2003) were processed to produce land cover maps covering Ishigaki Island (and other nearby islands) and benthic habitat maps of Shiraho Reef and Sekisei Lagoon. A socio-economic survey using questionnaires and interviews was conducted to ascertain demographic characteristics and migration patterns. For understanding sedimentation history and for estimating long-term rates of sediment discharge, several sediment core samples were taken.

Puerto Galera (Philippines):
Field surveys on hydrodynamics and water quality were conducted in Puerto Galera to characterize flow regimes in the bay and adjacent open waters and also changes in water quality (e.g. nutrients, turbidity/suspended sediments). Several data-logging type sensors were deployed throughout the bay and in stations outside the bay. Numerical modelling and simulation have been performed using the collected data for calibration and validation. Long-term continuous monitoring of chlorophyll-a, turbidity, water level, and temperature was also performed. A meteorological station was set up to monitor rainfall, wind velocity, solar radiation, atmospheric pressure, air temperature and humidity. This is crucial in understanding long-term and seasonal variations of these parameters in the bay. A social survey was also conducted to assess the local community's perception of water quality and its management in Puerto Galera. This is important in formulating socially-acceptable measures for the improvement of water quality that can potentially lead to more effective programs. The data collected through the aforementioned activities are critical for the integrated modeling of coastal ecosystem. Satellite images (i.e. ASTER, Landsat and IKONOS imagery) have been processed to ascertain land cover change and the spread of built up areas in Puerto Galera. This is valuable in assessing human impacts in this rapidly growing tourist destination. Benthic cover information was extracted from these images but only for relatively shallow areas. To obtain sufficient spatial coverage, results from habitat mapping using video towing technique will be used.

Bolinao, Pangasinan (Philippines):
Last November 2007, a field survey was conducted in the Bolinao Reef Complex to characterize hydrodynamic and water quality in the area. Of particular interest is the influence of the dense fish cage structures (located in a narrow channel) on the water quality in the channel and in the nearby reef areas.

Fiji and Samoa:
An intensive field survey was conducted in Votua Reef (Coral Coast, Fiji) to characterize the fate and transport of sediments from the adjacent Votua watershed using data-logging sensors and sampling techniques. Monitoring of water and sediment discharge in Naboutini and Votua watersheds in Fiji Islands and in Letogo watershed in Samoa were carried out. Spectral surveys to characterize reflectance properties of benthic habitats in the Coral Coast in southern Viti Levu, Fiji and in some reef area in Upolu, Samoa were also conducted. The data obtained will be used for deriving benthic cover information from satellite images. Sediment core samples were taken from major watersheds in Viti Levu, Fiji and Upolu, Samoa. Data from the analysis of these samples are needed for fine-tuning a regional sediment discharge model coupled with climate change model.

Regional Sediment Discharge Model:
A sediment discharge model applicable for regional scales and large basins has been developed. The model tentatively called RSDM (Regional Sediment Discharge Model) incorporates the effects of land cover, soil type, rainfall and topography on the sediment discharge. The model was coupled with a global climate change model to investigate potential impacts of the global phenomenon on sediment discharge characteristics.

Dissemination:
For disseminating activities and sharing research findings, several workshops were held:

- Fiji's Coral Reefs: Systems Approaches to Research and Management (University of the South Pacific, 30 October 2006). This was co-organized by the Marine Studies Programme of the University of South Pacific and the Nadaoka Laboratory in the Tokyo Institute of Technology.
- A local workshop held in Puerto Galera (22-23 Feb 2007)
- 2 Regional Workshops held in the Philippines
  - Developing an Integrated Support System for Managing Coastal Ecosystem Change in Tropical East Asia and the Pacific (Marine Science Institute CS, University of the Philippines, 24 -25 January 2008)
  - Asia-Pacific Regional Training Course/Workshop on the Utilization of an Integrated Decision Support System in Managing Tropical Coasts (Puerto Galera Biosphere Reserve, Philippines, 26-30 May 2008)

In addition, the Project participated in the following conferences/symposiums:

- Japan Geoscience Union Meeting 2007 (May 2007, Tokyo, Japan)
- 21st Pacific Science Congress (12-18 June 2007, Okinawa, Japan)
- 9th and 10th Japan Coral Reef Society (JCRS) Symposium (Okinawa, Japan)

Results

The Project has collected useful data, providing needed information in understanding reef hydrodynamics and water quality, watershed discharge dynamics, long-term connectivity between reef and watershed considering the influence of socio-economic environment. These data serve as baselines for the sites studied. The Project demonstrated how various data can be processed and integrated using geo-spatial technologies and modelling techniques. For example, various scenarios on how water quality in Puerto Galera Bay can be improved were investigated using hydrodynamic and water quality modeling. The socio-physical survey in Puerto Galera indicated the people's varying perception of environmental quality. The RSDM model has a very good predictive power and is a significant improvement over other regional sediment discharge models. The model predicted an increasing trend in sediment discharge in the future as a result of increasing number of heavy rainfall days (>100mm/day).

Relevance to APN's Science Agenda and objectives

Through collation of historical data and additional field observations, the Project integrated information from the physical, natural and social disciplines into a cohesive analytical framework (i.e. spatial analysis and numerical modelling) to establish major environmental changes, linkages, patterns, and short- and long-term trends within and among the human and natural systems of tropical coastal environment in East Asia and the Pacific. Specifically, the Project focused on sediment and nutrient regime in inland and shallow marine coastal systems. The framework included a global and regional component in order to understand the influence of global climate change on local conditions affecting sedimentation and nutrient delivery.

Self evaluation

The project have conducted activities covering both physical-chemical-biological and socio-economic aspects of the coastal environment. The Project has brought together a number of collaborators, forming an initial network for further studies. Results of various component research were disseminated in workshops participated in by researchers, managers and local community representatives. Overall, this Project enhanced and promoted a better understanding of the tropical coastal environments.

Potential for further work

The environmental issues tackled by the Project are issues needing particular attention in most coastal environments. The methodological framework developed is applicable in most if not all coastal areas in the West Pacific region. The collaboration resulting from this Project is continuing and the prospects of collaboration with other research institutions are promising.

Publications

Journals:

Ashikawa K, Nadaoka K (2008) Field observation and analyses of water quality characteristics in a dense aquaculture area adjacent to a coral reef in Bolinao, Philippines. Proc. of Coastal Eng., JSCE, Vol.54 (*In press; In Japanese*)

Nadaoka K, Yamamoto T, Arisaka K (2007) Analysis of hydrodynamics characteristics of s fringing reef and their formation mechanism under typhoon condition, Proc. of Coastal Eng., JSCE, Vol.54, No.2, pp. 1066-1070 (*In Japanese*)

Badira V, Nadaoka K. Geochemical baseline profile of sediment core taken from a tropical South Pacific island mangrove forest, Letogo watershed, Samoa. Science of the Total Environment (*Submitted*)

Badira V, Nadaoka K. Development of a new regional sediment load predictor with GCM rainfall coupling for the South East Asia - West Pacific regions. Sedimentary Geology (*In submission process*)

Blanco A, Nadaoka K, Yamamoto T. Planktonic and Benthic Microalgal Community Composition as Indicators of Terrestrial Influence on a Fringing Reef in Ishigaki Island, Southwest Japan. Marine Environmental Research (*Submitted*)

Paringit EC, Nadaoka K. Simultaneous estimation of benthic fractional cover and shallow water bathymetry in coral reef areas from high-resolution satellite image. International Journal of Remote Sensing (*Submitted*)

Paringit EC, Nadaoka K. Morphology-based reflectance models for corals and their measurements from reef environments. Remote Sensing of Environment (*Submitted*)

Pokavanich T, Nadaoka K. Field observation and Modeling of hydrodynamic and biochemical characteristics at Puerto Galera, The Philippines: Towards the development of DSS for Water Resources Management. Marine Pollution Bulletin (In preparation)

Rubio-Paringit MCD, Nadaoka K. Socio-environmental monitoring in Puerto Galera. Coast and Ocean Management (*In preparation*)

Symposium/conference:

Badira V, Nadaoka K (2007) Proposing a new regional sediment discharge predictor based on observed data from Taiwan, Abstracts of the Japan Geoscience Union Meeting 2007 [CD]

Blanco AC, Nadaoka K, Yamamoto T (2007) Spatial and temporal distribution composition of nutrients, microalgae and CDOM in Shiraho Reef, Ishigaki Island, Abstracts of the Japan Geoscience Union Meeting 2007 [CD]

Pokavanich T, Nadaoka K, Blanco AC, Rubio MCD (2007) Integrated Socio-Environmental Investigation of Water Quality Condition in Puerto Galera: The Decision Supported System Development, Abstract, 21st Pacific Science Congress, Okinawa, Japan, p. 78

Blanco AC, Nadaoka K, Yamamoto T, Rubio MCD and Paringit EC (2007) A multi-scale investigation of environmental controls on Shiraho Coral Reef through Field Measurements, Remote Sensing and GIS. Abstracts, 21st Pacific Science Congress, Okinawa, Japan, p. 91

Matsuura S, Kumagai W, Nadaoka K, Blanco AC, Tsukamoto E (2007) Social Structure Change Analysis in Yaeyama Islands based on Social Statistics and Interview Surveys for Evaluation of Anthropogenic Impact to Coral Reef Ecosystem, Abstracts, 21st Pacific Science Congress, Okinawa, Japan, p. 384

Yamamoto T, Nadaoka K, Nishimoto T, Blanco AC, Ishimaru T (2007) Dynamic Process of Current and Water Quality Fluctuations in a Coral Reef due to Episodic Atmospheric Disturbances, Abstracts, 21st Pacific Science Congress, Okinawa, Japan, p. 347

Blanco AC, Nadaoka K, Yamamoto T (2006). Analysis of nutrients, algal and other related measurements in Shiraho Reef area and Todoroki River: Implications for monitoring and modeling of watershed-reef connectivity. Abstracts of the 9th Japan Coral Reef Society (JCRS) Symposium, p.107

Matsuura S, Nadaoka K, Kumagai W, Tsukamoto E (2006) Social Structure Change Analysis in Yaeyama Islands based on Social Statistics for Evaluation of Anthropogenic Impact to Coral Reef Ecosystem. Abstracts of the 9th Japan Coral Reef Society (JCRS) Symposium, p.128

Rubio MCD, Nadaoka K, Pokavanich T, Iizuka H, Blanco AC, Paringit EC (2006) Complimentarity of sensor-based measurements and community perception for monitoring and management of seawater quality, Proc. of the Symposium on Infrastructure Development and the Environment (SIDE2006): Compilation of Abstracts, p. B-10

Yamamoto T, Nadaoka K, Nishimoto T, Blanco AC, Ishimaru T, Arisaka K, Tamura H (2006) Influence of atmospheric disturbances on hydrodynamics and water quality in a fringing coral reef. Abstracts of the 9th Japan Coral Reef Society (JCRS) Symposium, p.107 (In Japanese), p.108 (In Japanese)

Acknowledgments

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Technical Report

Preface

The coastal environment, being home to majority of the population, is continuously beset by various threats including sedimentation and eutrophication. These processes are aggravated by anthropogenic activities. They are also occurring against the backdrop of global climate change, which exerts significant influence on the processes. To properly address coastal environmental problems, it is necessary aims to strengthen present and future coastal observation (in-situ and space-based), modeling capabilities in support of decision-making process. In this light, the project was conceptualized to provide decision support tools for managing the complex tropical coastal environment. The project emphasizes the importance of environmental monitoring and modelling of developing a region-wide, collaborative strategy for data exchange and analysis among coastal scientists and managers. This report presents the case studies demonstrating the utility of various tools such as bio-physical surveys, numerical modeling, remote sensing and geographical information systems for aiding the decision-making process.

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1. Introduction

The natural and human elements of coastal zones in the East Asia and Pacific (mostly archipelagic or small island countries) are extremely vulnerable to disturbances associated with natural climate variability, especially in symphony with anthropogenic forcing. These disturbances, either as long-term pressures or short-term perturbations, impact the capacity of the coastal zone to support goods and services. Increase in environmental loads from adjacent watersheds such as **nutrients and sediments** are of particular concern because of their deleterious effects on coastal habitats (mangroves, seagrasses and coral reefs). Increased soil runoff and nutrient mobility is aggravated by expanded habitation and by various resource exploitation practices (agriculture, forest-cutting, industries, infrastructure) that diminish their natural retention or elimination during their downstream passage from **hydrologic** (river networks or underground) to **hydrodynamic** pathways. Therefore, the ability to detect, understand and predict changes in the coastal environment in a timely and accurate manner is crucial for management and decision-making, which seeks to address possible resource conflicts and value trade-offs. However, information and corresponding analysis tools to accomplish this forecasting task is still far from ideal.

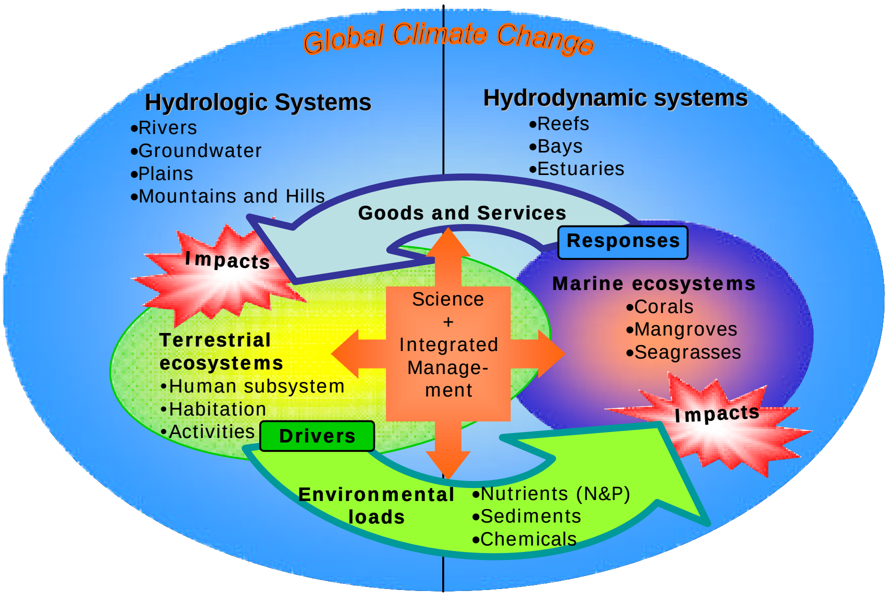

Figure 1. **Concept of linkages among tropical ecosystems in a changing coastal environment: in terms of drivers, impacts and responses and role of science and local management.**

Coastal zones contain complex interactions between social, economic and environmental systems (see **Figure 1**). Management of coastal resources requires consideration of these complex interactions including the impacts of use and management decisions on the overall sustainability of the coastal resource utilization. Effective management also requires collaboration between researchers, policy makers and the community. While numerous national and international organizations have already established research and monitoring programs that involve acquisition of physical, natural and socio-economic data by way of in-situ measurements, remote sensing observation and social weather surveys, most of these programs target either marine, coastal or terrestrial environments and communities or any combination, but rarely encompassing all. Thus, present investigative efforts are narrow, lacking or produce results that are incompatible for enabling understanding of interrelationships across systems. There is a need therefore to link science and decision-making stressing the continuum of expertise from basic science to applied science to policy, governance and management.

Objectives

This Project aims to strengthen present and future local coastal observational (in-situ & space-based) and modelling capabilities and decision-making process by developing a region-wide, collaborative strategy for data exchange and analysis among coastal scientists and managers. The Project envisions production of user-friendly tools capable of hind-casting development patterns and for building scenarios to explore various management options.

The overall goal of this Project is to apply understanding of the causes and consequences of present and future environmental change in tropical coastal ecosystems in management decisions. The specific objectives of the Project are to:

a. Produce an accurate set of multi-date coastal resource information within the region particular to needs of managing coastal zone changes and sufficiently consistent to allow for comparison among systems in the East Asia and Pacific Region;

b. Provide an understanding of the driving/forcing effects of socio-economically-induced changes (urbanization, population) on environmental loads to the tropical coastal ecosystems;

c. Assess human welfare impacts of changes in coastal resource systems in terms of social costs and benefits with respect to different management strategies.

d. Strengthen the network of, and reinforce linkages among coastal scientists and managers thru shared expertise and resources; and

e. Develop capacity building through workshops on standardized methods of processing various data (e.g. remotely-sensed data, socio-economic surveys).

2. Materials and Methods

In line with the project's objectives, several studies were carried out in several study sites in Japan, Fiji and the Philippines. These sites together with the specific research objectives are described in section 2.1 Study Site and Objectives.

In the section Methodological Framework (section 2.2), the overall methodology generally adapted for each study site is presented. This includes brief descriptions of the specific tools comprising the methodological framework. As a particular study site is different from another, particularly in terms of the existing environmental conditions and issues addressed by the corresponding study, detailed descriptions of methodology for each study site are also presented in subsequent sections.

2.1 Study Sites and Objectives

2.1.1 Puerto Galera (Oriental Mindoro, Philippines)

Puerto Galera Bay is located in the northern tip of Mindoro Island, Philippines, as shown in **Figure 2**. A natural harbor with an area of 4.2 km^2, it abounds with rich biodiversity in tropical marine flora and fauna including coral reefs, seagrasses and mangroves. It has attracted much attention as a biological study site and is regarded as one of the most attractive dive spots in the Philippines. In mid-1930's, a marine biological station was established here by the University of the Philippines. Since then, scientists have recorded 121 reef fish species belonging to the families *Pomacentridae* (140 species), *Pomacanthidae* (five species) and *Chaetodontidae* (15 species). It harbors nine of 16 seagrass species in the Philippines, 19 of the 40 mangrove species in the country (dominated by *Rhizopora apiculata, Avicennia officinalis* and *Avicenia* *marina*) and 152 of its 400 coral species, including the rare hard coral, *Anacropora puertogalerae*. The bay houses a giant clam garden which at present is a tourist destination. In 1977, this area was designated as a Man and Biosphere (MAB) Reserve, an international recognition given by the United Nations Educational, Scientific, and Cultural Organization (UNESCO) for its priceless importance worldwide in the preservation of the natural environment and conservation of biodiversity. Recently, Puerto Galera Bay has been declared the 32nd most beautiful bay in the world by a European–based advocacy group. The location of Puerto Galera Bay is in the middle of Verde Passage that connects two seas, namely, the South China Sea on the West and Sibuyan Sea on the East side (**Figure 2**). Recently, many environmentalists claimed that the passage owns a variety of marine inhabitants and can be called "the center of the center" of global marine diversity (Carpenter, 2005). This fact draws attention from both national and international tourists to frequently visit that boost up the tourism industry replacing the traditional fishing as a livelihood of the locals (Cola and Hapitan, 2004).

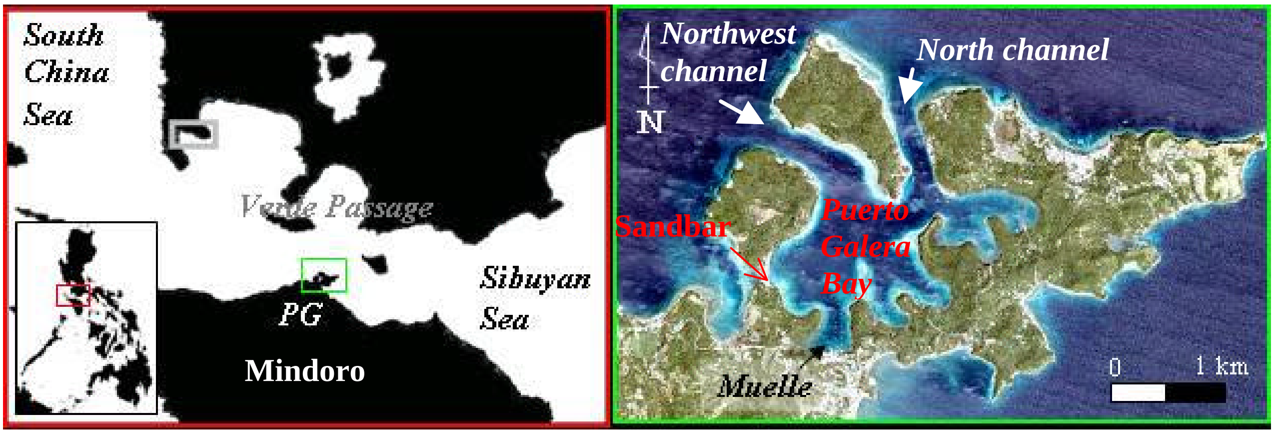

Figure 2. Location of Verde passage and Puerto Galera, The Philippines.

To accommodate development of tourism industry, the local populations also sharply increase due to migration from nearby towns. Demands of growing population and influx of visitors in the recent years have compelled citizens to resort in unregulated development activities (Fortes, 1997). Along shore establishments without waste and wastewater treating system are common in this area. (Bio-social survey of the coastal waters of Puerto Galera, Mindoro Oriental, 1984). There are 13 villages, 12 of which are coastal, in Puerto Galera. Half of the coastal villages rely on tourism-based activities for sustenance (Cola and Hapitan, 2004). Among numbers of scattering groups of establishments, there are three big communities situated at the sea front i.e. White Beach, Sabang, and Muelle, see Figure1. White Beach located on the west side of the lagoon is famous for long straight beach and affordable accommodations. Sabang, located next to the lagoon, is famous among foreign tourists for its night life activities, lineup of restaurants and diving shops along the beach. Muelle, dominated by the residential area of local people, is the only big community inside the lagoon (Book of Puerto Galera Facts, 2002). Since Muelle cove, the inner most part of Puerto Galera lagoon, is a wave-hindered area and almost current-free, it is the oldest and busiest port around this area. There are number of yachts anchored in this area through out the year. The weak current around Muelle was thought to be insufficient for the self purification from the water pollution, coupled with the anthropogenic environmental loads, this make Muelle cove to be the most vulnerable place subjected to water quality degradation. It has been discussed recently that the water quality here has been severely deteriorated. Since the 1970's, studies undertaken in the bay have largely been biological in nature (Fortes 1986; Licuanan 1991; Rollen and Fortes 1991; Atrigenio and Alino 1996). On the other hand, studies on physical environmental studies are few, although physical processes are essential in the functioning of geological and biological processes in reef environments (Robert 1975;

Wolanski et al. 1983; Roberts et al. 1988, 1992; Yoshioka and Yoshioka 1989; Black 1993; Kench 1998), and hence in addressing the environmental conservation and development issues.

In recent years, however, there has been an increase in polluted water inflow into the bay brought about largely by: (1) poorly constructed sanitation and household facilities, (2) natural runoff from the hillsides associated with the tourism development and (3) closure of the sand bar (**Figure 2**). The environmental deterioration, evident in the significant decrease in water quality within the bay, is aggravated by its geographic characteristic, which limits seawater exchange inside the bay with the open sea. San Diego-Mcglone et al. (1995) describes the flow field within the Puerto Galera bay as tidally dominated, particularly in its northern half portion. During flood conditions, seawater enters the lagoon through the Northwest Channel and simultaneously flows out through the North Channel; during ebb conditions, the flow direction is reversed **(Figure 2)**. Also the rate of seawater exchange at the interior part of the bay is extremely low as compared with that of northern portion. However, the main topic of their research is temporal and spatial variability of the nutrients within the bay, and it is difficult to find studies dealing with the detailed mechanism of tidal flow circulation in the bay. There may have been a few studies undertaken in the bay but these are largely undocumented.

Concerned about the seriousness of this problem, the local government is currently preparing a coastal management plan, which includes water quality improvement especially in the bay, with the possibility of re-opening the sand bar. To mitigate the foreseeable water quality problems, the final target of this research is to develop a decision support tool to promote proper management by local government units based on scientific study. As part of the study, the Project has attempted to clarify the hydrodynamic and bio-chemical environments of Puerto Galera lagoon and its relationships with the adjacent coastal waters. For this purpose, we conducted a field observation coupled with state-of-the-art numerical model to reproduce the circulation inside and outside PG lagoon. Water quality model describing the bio-chemical conditions of the lagoon water were computed using the data from hydrodynamic model. The model was run in various scenarios to find the most effective way to mitigate water quality problem at area close to Muelle pier.

2.1.2 Bolinao (Pangasinan, Philippines)

Bolinao is located along the northwestern coast of Luzon Island in the Philippines (**Figure 3**). It is one of the 16 municipalities surrounding the entire water body of Lingayen Gulf. It is connected to the South China Sea through the western part of the Luzon Sea. Bolinao is known as one of the top producers of milkfish which is an important food fish and aquaculture commodity in the Philippines. The culture of milkfish in Bolinao started in the early 1970's through brackish-water fishponds. In 1995, the culture of milkfish on brackish-water fishponds was expanded to coastal water through the use of fish pens and fish cages. Since then, fish pens and fish cages have increased around the south part of the Santiago Island, Bolinao.

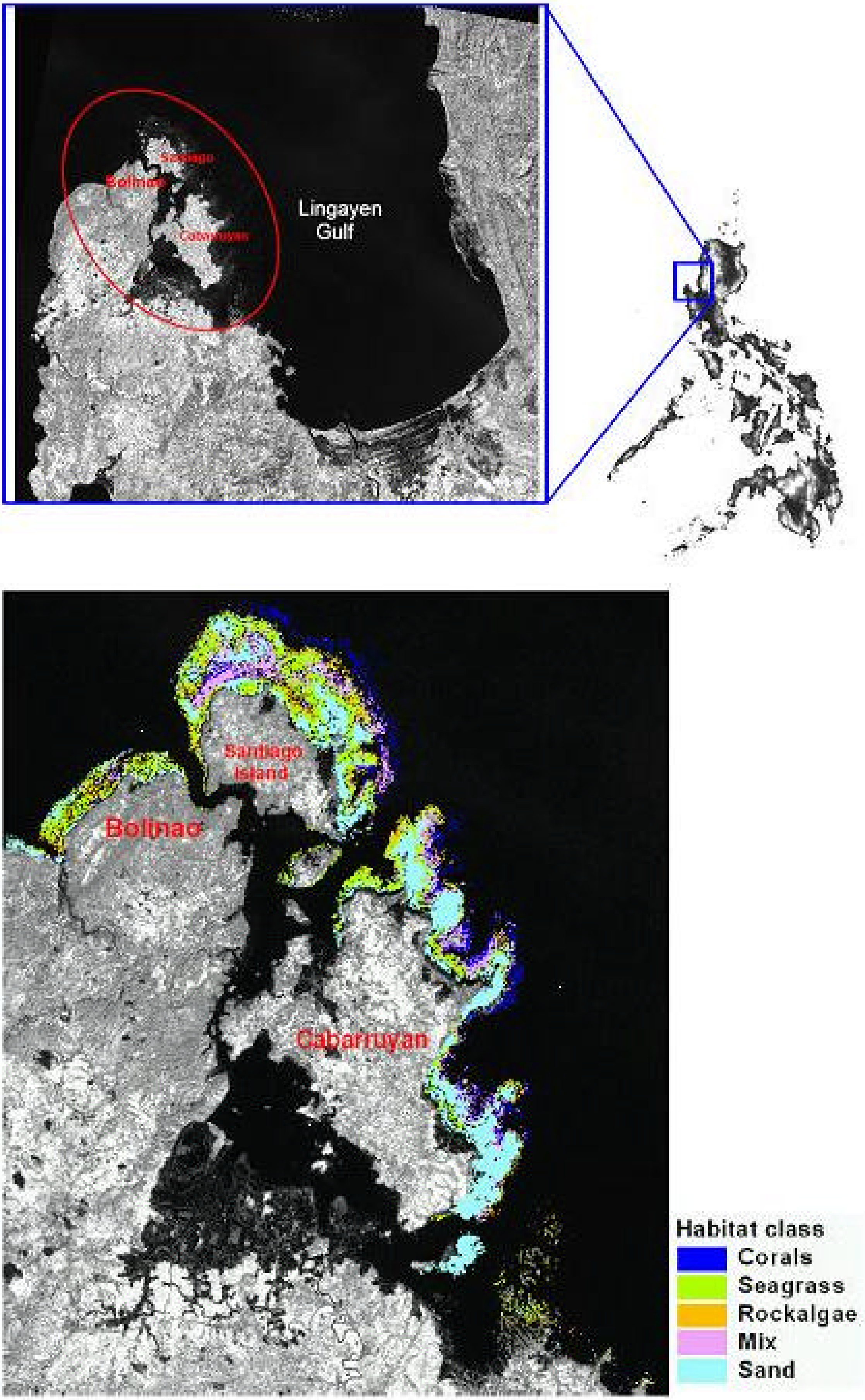

Figure 3. Location of study area (blue square- Lingayen Gulf, red oblong- Bolinao Reef Complex) and benthic habitat map of the Bolinao Reef Complex.

The north part of Santiago Island, on the other hand, is surrounded by typical fringing reefs. The reef flat along Santiago Island was approximated to occupy an area of 32 km2. The habitat map of the reef complex is shown in **Figure 3**. The back reef areas are dominated by seagrass beds and sandy substrate. Most of the corals and rocky substrate are found on the outer fringes of the reef. There are three channels in the west, north and east of the reef area connecting the reef area to the outer sea, and these channels may govern water exchange between areas. The reef is considered as one of the major open fishing grounds in Bolinao and provides a resource and livelihood base to coastal inhabitants.

The uncontrolled milkfish culture such as the high feeding input and the proliferation of fish cages and pens have contributed to the deterioration of the water quality. The number of fish pen and cage structures in the area increased from 242 in 1995 to 1170 in 2001, contributing to the nutrient enrichment in the area. The nutrient enrichment leads to the excessive growth of algae at the water surface and the onset of hypoxic and anoxic conditions in the bottom water. As a consequence of the depletion of dissolved oxygen, a massive milkfish kill took place, incurring a loss of approx P500 million in 2002. To date, a recent fish kill incident happened again in the area in June 2007. At least P100 million worth of milkfish went belly up during the recent fish kill. Also, exposed to various anthropogenic disturbances and exploitations, it was estimated that about sixty percent of corals in Bolinao reef complex had been destroyed and some of which are already far beyond recovery. Milkfish culture is also considered as one of the major causes of the destruction of corals, since it had contributed to the deterioration of the water quality not only in the aquaculture area but also in the reef area.

Previous Research

Many studies have been done on hydrodynamic and water quality characteristics around Santiago Island over the years.

- Nutrient concentration in Bolinao waters has been increasing which has been attributed to the increase in fish pens and fish cages. However, significant decrease in nitrate and nitrite has been observed between 2002 and 2003 which was parallel to the decrease in fish pens and fish cages due to a massive milkfish kill. On the other hand, ammonia, a more reduced form of nitrogen was higher in 2003 which implicates a low oxygenated environment that favors its formation that can be contributed to continued build up of decomposing products (fish feeds) and other organic materials. (Azanza et al. 2006)

- The death of milkfish was clearly the result of lack of oxygen mostly from the collapse of the algal bloom. The optimal level of dissolved oxygen is about 5 mg/l for milkfish growth in tropical waters. The observed dissolved oxygen during the fish kill was 2.1 mg/l in 2002. (Azanza et al. 2005)

- Inflow into the reef flat is through a number of surge channels cutting across the outer reef crest although a significant volume of water spills over the reef crest driven by the wind and spilling waves (Villanoy 1998).

- The circulation around the Bolinao reef system results from the interactions of several significant factors including wind, tidal forces and complex bathymetry. The combined wind and tide driven circulation patterns show areas with persistent current directions even with the changing tides. During the flood and ebb cycle, some areas within the reef system do not exhibit complete current reversals. (Salamante 2007)

- Areas along the eastern side of Santiago Island reef flat is a potential site for breeding ground. With the area being dominated by dense seagrass beds and its high probability of retaining the larvae for more than a week makes the area an effective candidate for establishment of marine protective zone. (Salamante 2007)

Research Objectives

This research encompasses various aspects (e.g. physical, chemical, biological) of the coastal environment around Santiago Island to identify milkfish culture impacts on the coastal ecosystem and mechanism of massive milkfish kills.
The specific objectives of this study are:

1. To collect substantial field data for a subsequent numerical simulation of hydrodynamic and water quality in order to assess the carrying capacity of marine water around Santiago Island.
2. To identify physical environmental characteristics of the marine water around Santiago Island in order to describe the hydrodynamic and polluted water transport processes.
3. To identify temporal and spatial variation of water quality and evaluate impacts of milkfish culture on water quality around Santiago Island.

2.1.3 Shiraho Reef and Todoroki Watershed (Okinawa, Japan)

Shiraho Reef is a well-developed fringing reef with typical topographic features such as moat, reef pavement, reef crest and reef edge (Kayanne et al. 1995). The average water depth in the moat is about 2 meters. Four channels exist in the reef area, namely, 'Tooru-guchi', 'Ika-guchi', 'Moriyama-guchi' and 'Bu-guchi' (**Figure 4**). Tooru-guchi, the biggest channel, has an average depth of 20 meters and penetrates deeply into the reef. Tooru River drains towards Tooru-guchi channel. The typical flow circulation pattern (tide-averaged velocity) in the reef was described in detail in the work of Tamura et al. (2007). Flow pattern near Todoroki River mouth indicates that current is directed northward and water flows towards Moriyama-guchi and also further northwards to Tooru-guchi. The influence of Tooru on the reef is spatially-limited due to the strong converging currents toward Tooru-guchi in the northern part of the reef and subsequent flow offshore. Flows in and near Moriyama-guchi and Ika-guchi are mostly directed offshore. Suspended particles from Todoroki River mouth can be transported towards Tooru-guchi based on particle tracking simulation results (Tamura et al. 2007). These flow characteristics can also have significant influence on nutrient transport in the reef area. In addition to sedimentation and increased nutrient concentrations attributable to discharge from Todoroki River, there is also significant contribution of dissolved nutrients delivered through groundwater discharge into the coral reef. Based on estimates, land-derived nitrogen through groundwater contributes about 35% of the total nitrogen inputs in Shiraho Reef (Umezawa et al. 2002).

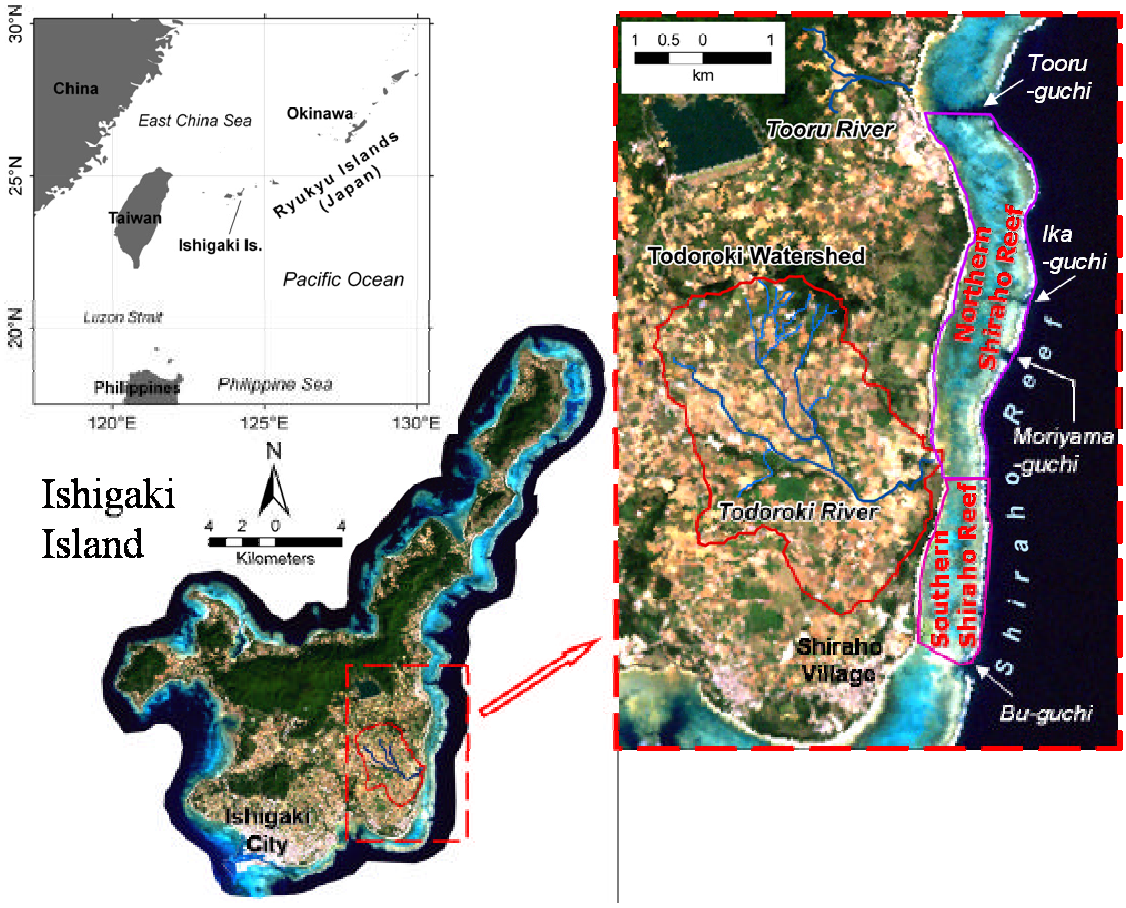

Figure 4. The study area: Shiraho Reef (a fringing reef) and Todoroki watershed (a small agricultural watershed) in the southeastern part of Ishigaki Island, Okinawa, Japan. Shiraho Reef is divided into northern and southern parts for analysis purpose. (Image: Landsat-7 ETM+ dated 23 February 2002)

Todoroki watershed is a small (about 10.82 km^2) watershed devoted to intensive agriculture, including livestock farming. Farmland development started in 1979 and was active until 1982 and after 1984 (Ohgaki and Koike 1992). By 1989, almost half of watershed had been transformed into farms. To date, the watershed is largely dominated by farmlands with only minimal ‘forest’ or treed areas remaining. These farmland developments have fragmented the landscape of Todoroki watershed. Sugarcane and rice are the main agricultural crops, though pineapple and tobacco can also be found in some plots. In Ishigaki Island, sugarcane is planted during the Spring and Summer planting seasons. Grassland and pastureland occupy a considerable portion of the watershed due to active livestock farming. Fertilizers and animal wastes are the two prime sources of nutrients discharged from the watershed. Rainy season in Ishigaki starts in early or mid-May and lasts for about one month, followed by typhoon occurrences in July to October. During these periods, soil erosion and potentially excessive discharge of sediments and nutrients onto the adjacent reef area occur. Todoroki River discharges about 2,240 tons of suspended solids, 71.5 tons of nitrogen and 6.6 tons of phosphorus annually (Nakasone et al. 2001). Estimates based on numerical simulation indicated that about 47% (24.13 tons) of detached sediments (51.34 tons) were discharged through the river outlet considering four rainfall events in June 2000 (Paringit and Nadaoka 2003).

2.1.4 Coral Coast watersheds and Votua Reef (Fiji)

In Fiji Islands, two watersheds in the Coral Coast region (southwestern part of Viti Levu Island) have been monitored: Naboutini watershed and Votua watershed (**Figure 5**). Naboutini watershed, which drains into the Somo-somo Bay, is largely a forested watershed where logging activities are ongoing. Votua watershed is also forested, however, logging activities stopped more than 25 years ago, though there are some illegal logging in the upper part of the watershed. Subsistence farming on slopes can be seen in Votua watershed. Monitoring in Votua Watershed is ongoing. As an initial step in investigating sediment fate and transport in the Coral Coast fringing reef, Votua Reef was selected as the site for an intensive survey on reef hydrodynamics and water quality.

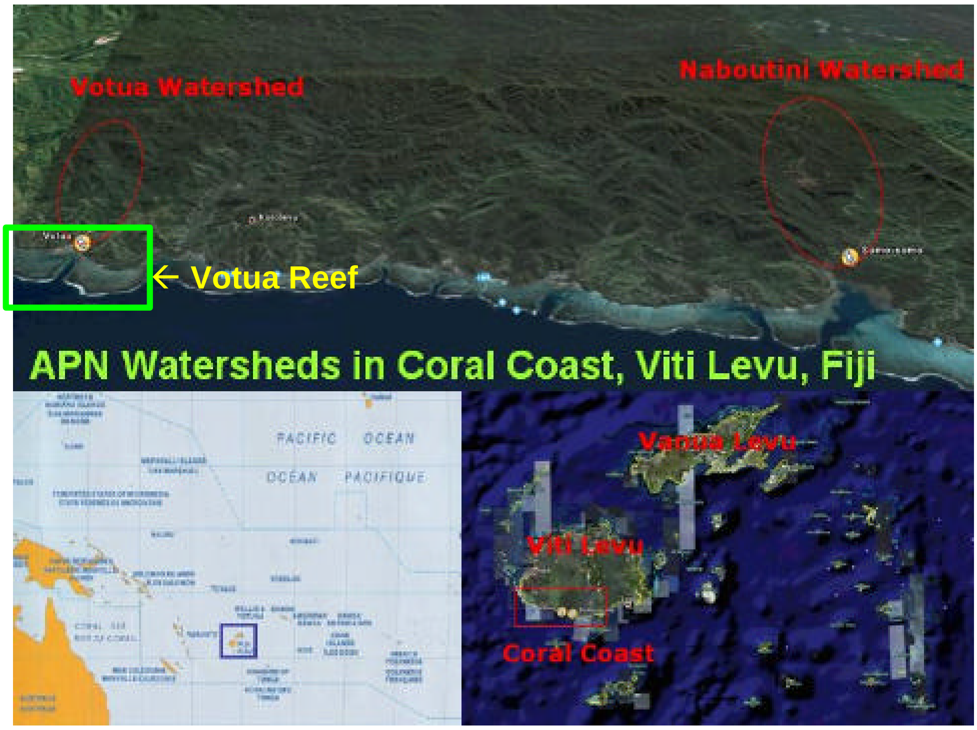

Figure 5. Study sites in Coral Coast, Fiji Islands: Votua Reef, Votua watershed and Naboutini watershed

2.1.5 Sites for Regional Discharge Assessment

Data from parts of Indonesia, Papua New Guinea and the Philippines were used to parameterize the formulated regional sediment predictor model. Data includes rainfall, land cover, soils data, topographic characteristics of the basins and sediment load data. In addition, sediment core samples were taken from around Ishigaki Island in Okinawa, Japan, from Pampanga River and Laguna Lake in the Philippines and from Viti Levu and Upolu Island in Fiji and Samoa, respectively.

2.2 Methodological Framework

With the objective of aiding the decision-making process in the coastal environment, an overall methodological framework (**Figure 6**) was formulated, bringing in together a range of tools including geo-spatial technologies and numerical modeling. It must be emphasized that it is not a requirement that all this tools be used in supporting the decision-making process. Depending on the problem at hand, decision to be made and considering limitations in the available resources, some parts may be skipped or substituted with simpler methods. Furthermore, the importance of networking among stakeholders in implementing the methodology must be given prime consideration. The project promotes networking among various sectors in the locality and also with external agencies and institutes so that expertise and experiences can be shared and capacity-building can be enhanced.

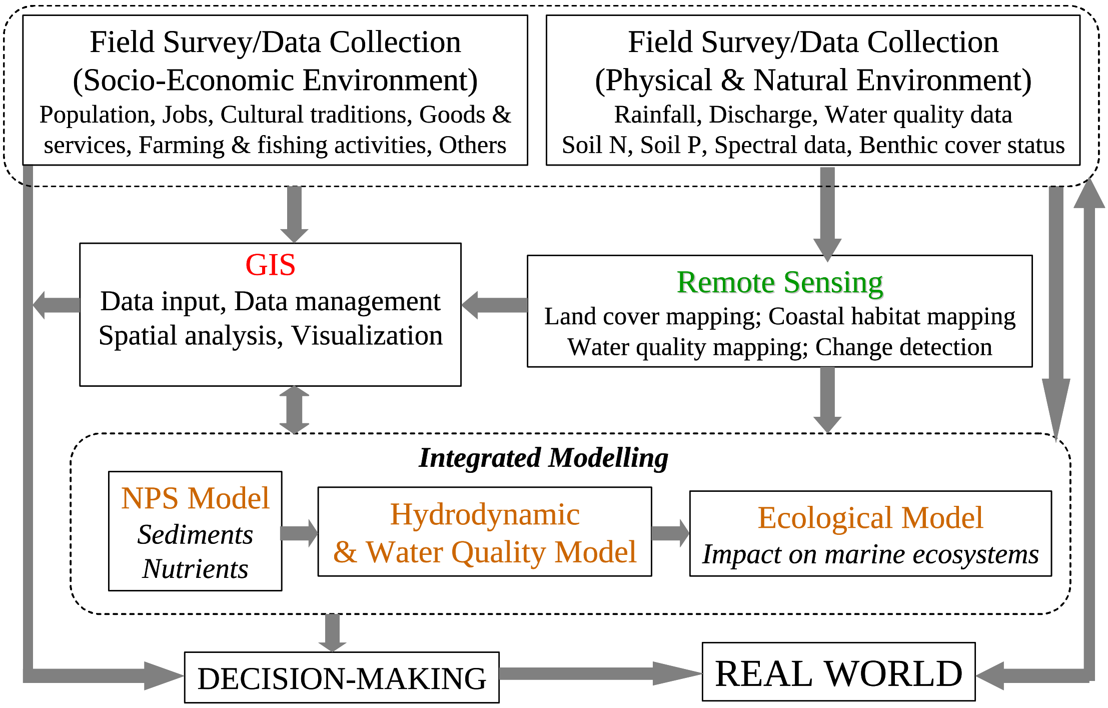

Figure 6. Overall methodological framework of the decision support tool

2.2.1 Field survey/Data collection and analysis

Field surveys conducted under this Project focused on collecting continuous monitoring data on several hydrodynamic, hydrologic and water quality parameters. Hydrodynamic variables include water level, wave height, two-dimensional velocity, and velocity profiles. On the other hand, the water quality sensors monitor temperature, turbidity, chlorophyll-a, salinity, conductivity, and dissolved oxygen. The Project utilized an integrated survey methodology consisting of continuous monitoring using data-logging sensors, water column profiling for water quality and water sampling. For the vertical profiling of water quality, a multi-sensor instrument is used, measuring pH in addition to the parameters previously stated. Where needed, bathymetry surveys are also conducted to produce an accurate bathymetry map of the study site.

As data on meteorological conditions are very important, the Project set up weather stations in key study sites (i.e. Puerto Galera, Bolinao, and Votua). These weather stations continuously log measurements of rainfall, wind speed and direction, air temperature, relative humidity, solar radiation and atmospheric pressure.

Secondary data are also collected in the form of maps and tables. Socio-economic data are also collected using questionnaire and interview surveys. This part of the methodological framework is exemplified by the socio-physical environmental survey conducted in Puerto Galera as described later.

2.2.2 Remote sensing and GIS

In assessing environmental status, determining how the bio-physical environment has changed in both time and space is indispensable. Remote sensing and geographic information systems (GIS) enables the assessment of environmental changes through the analysis of synoptic images and related data. In this project, remote sensing was primarily used in the creation of land cover and benthic cover maps from satellite images (e.g. Landsat, IKONOS and Quikbird images). Where available, images covering several years (e.g. up to about 20 years) were processed to determine temporal and spatial changes in both land and benthic cover. Products resulting from image analysis (e.g., cover maps) are organized and examined within a GIS environment. GIS organizes data from various sources and employs statistical and spatial analysis techniques to examine relationships of variables considering geographic attributes. GIS is also used to visualize data and analysis results. Field data, remote sensing and GIS outputs serve as inputs to the modelling stage.

2.2.3 Watershed monitoring and modelling

Watershed monitoring has been conducted in several coastal watersheds under the APN Project: Todoroki watershed (Ishigaki Island, Okinawa, Japan), Naboutini and Votua watersheds (Coral Coast, Viti Levu, Fiji) and Letogo watershed (Upolu Island, Samoa). Rain gages were deployed in the watershed. Water and sediment discharges were monitored by continuously measuring water level and turbidity using data-logging type sensors. In Todoroki, discharge of nutrients from the watershed was monitored by measuring nutrient concentrations in addition to water level and turbidity. The Project used 2 units of MicroLAB, an in-situ nutrient analyzer, to monitoring dissolved nutrients (nitrate and phosphate). Periodic grab sampling of water is performed and samples are analyzed for total suspended sediments, total nutrients (i.e., TN, TP) and dissolved nutrients (i.e., NO_3, NO_2, NH_4, PO_4, and SiO2). Watershed modeling is carried out using the Gridded Surface-Subsurface Hydrologic Analysis (GSSHA) model.

2.2.4 Hydrodynamic and water quality modelling

Modeling of hydrodynamic and water quality in the study sites using Delft3D model. The Delft3D-FLOW is the hydrodynamic program of Delft3D developed by the Delft Hydraulics in the Netherlands. This FLOW module calculates non-steady flow and transport phenomena that could predict water levels, tidal currents and waves resulting from tidal, meteorological and density forcing. The system of equations in Delft3D-FLOW comprise of the shallow water equations derived from the 3D Navier-Stokes equations for an incompressible fluid using the shallow water and Boussinesq assumptions. The vertical momentum equation is reduced to the hydrostatic pressure relation. Vertical accelerations are assumed to be small compared to the gravitational acceleration and are not taken into account. In three-dimensional models the vertical velocities are computed from the continuity equation to insure that mass is conserved. The computational scheme is solved on a finite difference grid through equating a set of partial differential equations with an appropriate set of initial and boundary conditions. The velocity fields calculated from the hydrodynamic model were used to simulate the dispersal pattern of particles released from different point sources within the reef complex. The PART module of Delft3D was the one used for simulation. This transport model involved tracking the paths of individual particles as they are carried by the moving fluid. The dispersal of substances in a fluid medium is influenced by three processes namely: transport by water flow (advection); turbulent diffusion/ dispersion; and, decay.

For relatively shallow waters like in Shiraho Reef, the SDS-Q3D model, a shallow water turbulent model, was used. This model consists of an SDS turbulence model (Nadaoka and Yagi 2003) and quasi 3-D shallow water equations. By applying SDS turbulence model, SDS-Q3D model enables to simulate hydrodynamic accurately with a low computing cost (Nadaoka and Tamura 2001).

2.3 Puerto Galera: Field Observation and Modeling of Hydrodynamic and Biochemical Characteristics

The field observation was performed from February 22 to March 8 in 2007 at Puerto Galera Bay in Mindoro Island, The Philippines. The bay is at the middle of Verde Passage Sea, which connects South China Sea and Sibuyan Sea. The total field observation time is 15 days, covering 1 lunar cycle from neap to neap tide. The bay is a typical coastal lagoon adjacent to an outer sea. It has two openings, namely, the Manila Channel on the Northeast and Batangas Channel on the Northwest (see **Figure 2**). The Batangas Channel is relatively deeper compared to the Manila Channel. The lagoon is surrounded by the topographic terrain of Mount Malasimbo. The peak area is 1,400 m above mean sea level and often cloud-covered, which extends into the sea. This topographic feature creates the Puerto Galera coast line with three main coves. The innermost cove is Muelle Cove being an oldest and busiest pier for transportation of locals and tourists. The deepest area of the bay has a depth of about 25 m and is at the center of the bay. The bay has an opening area of about 3.47×10^6 sq. m. There is no river discharge into the bay so that its water to a certain extent has a level of transparency. The average suspended sediment concentration during field observation is about 2mg/L. There are three submerged sand bar-like projections, locally called “plateau”, which are inhabited by a diverse set of coral communities.

2.3.1 Field survey methodology

The field survey was conducted based on three methodologies i.e. 1) the monitoring at nine stations using bottom fixed deployment and taut-wire moorage system; 2) the synoptic survey for water sampling and vertical profiling of water properties using STD-type sensor and Fluoroprobe (an algal fluorometer); and 3) bathymetric survey using echo sounder. The first methodology was conducted for 15 days to cover one lunar cycle from 22 February and 8 March, 2007. The second methodology was carried out once a day for 7 consecutive days between 25 February and 3 March, 2007. The last survey was performed on 4 March to 5 March, 2007. The overall data available for this time field campaign are given in **Table 1**.

Table 1. Summary of data available from the field survey

	Items	FEB														MAR
		22	23	24	25	26	27	28	1	2	3	4	5	6	7	8
Memory-type sensors	Meteorological condition	←	—	—	—	—	—	—	—	—	—	—	—	—	—	→
	Flow velocity	←	—	—	—	—	—	—	—	—	—	—	—	—	→	
	Water level	←	—	—	—	—	—	—	—	—	—	—	—	—	—	→
	Water temperature	←	—	—	—	—	—	—	—	—	—	—	—	—	—	→
	Salinity	←	—	—	—	—	→									
	Chlorophyll-a concentration	←	—	—	—	—	—	—	—	—	—	—	—	—	—	→
	Dissolved oxygen concentration	←	—	—	—	—	—	—	—	—	—	—	—	—	—	→
Daily synoptic survey	Nutrient concentration from water sample analyses				←	—	—	—	—	—	→					
	AAQ1180 water properties profile				←	—	—	—	—	—	→					
	Fluoroprobe profile				←	—	→									

Nine (9) measuring stations were set at the locations indicated in **Figure 7** for 15-day continuous monitoring. Among them, four stations are located close to the shoreline inside the bay (B1-B4), three stations are at the strong current zone near the channel (C1-C3) and two stations are outside the lagoon at the northern most and Western most point. At these measuring stations, except station O3, we deployed moored buoys for installing various memory-type sensors. The schematic diagram showing the sensor deployment technique and synoptic survey is given in **Figure 8**. The water flow velocities were monitored using electromagnetic current meter deployed at the sea bottom at stations C1, C2, C3, O2, O3 and, for near sea-surface at station C2. Salinometers were deployed at stations B2, C2, C3 and O2, close to the surface and bottom. Thermometers were deployed in every station at sea-surface, 3-meter from the water surface and half a meter from the sea floor. At about half a meter close to the sea surface, the chlorophyll-a and turbidity concentration were monitored using COMPACT-CLW at stations B2, C2, B4 and O2. This instrument measured reflected fluorescent light and infrared back scattering to convert to chlorophyll-a concentration and turbidity level, respectively. Dissolved oxygen concentrations at half a meter from the seabed were monitored from station B2 and C2.

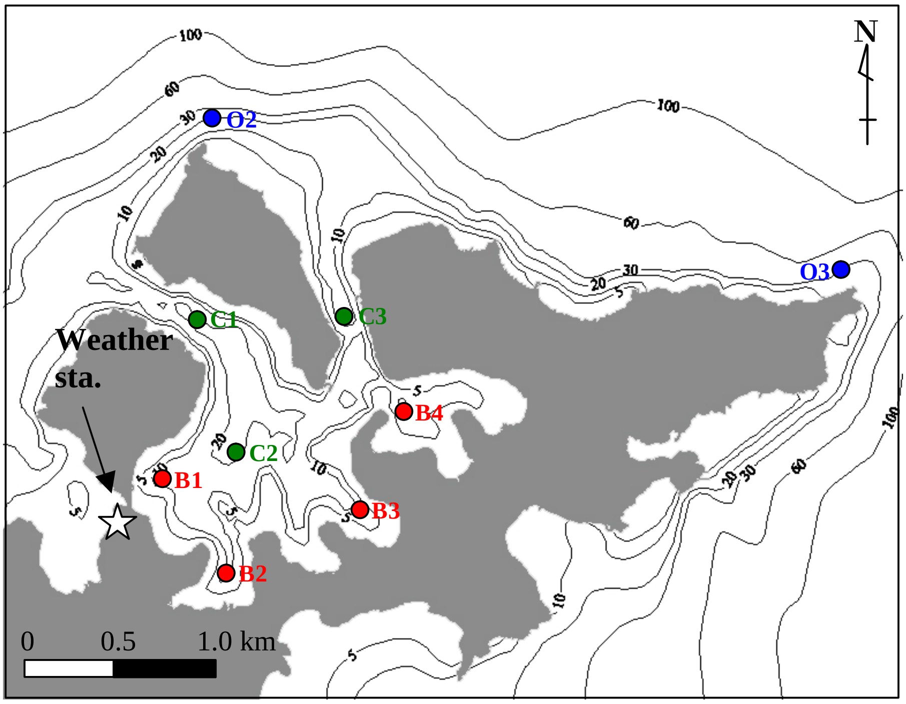

Figure 7. Locations of nine monitoring stations. The stations can be categorized by their locations; B stations are inside the bay area, C stations are at the channel and O stations are outside. Depth contours are in meters

For seven consecutive days, from 25 February to 3 March 2007, synoptic surveys were performed to collect water samples and to profile the water properties using STD type sensor and Fluoroprobe. The STD-type sensor used was AAQ1180 (Alec electronics). The sensor can simultaneously probe the water temperature, salinity, chlorophyll-a, turbidity, and dissolved oxygen. Fluoroprobe is an instrument that measures the back scatter of fluorescence of different class of algae after light excitation. The data obtained show the total concentration of a specific algae class, as well as the total concentration of algae. In this field survey, the instrument was set to monitor 4 species of algae (green algae, blue algae, diatom, and cryptophyta) and yellow substance. The water samples were collected from 0.5 meter from the sea surface, and 0.5 meter from the sea bottom using a 1 liter modified Niskin sampling bottle (Yoshino Keisoku Co., Ltd., Japan). After retrieval of the samples from the sea, the water samples were transferred to the acid-washed bottles and stored in light-free ice crest.

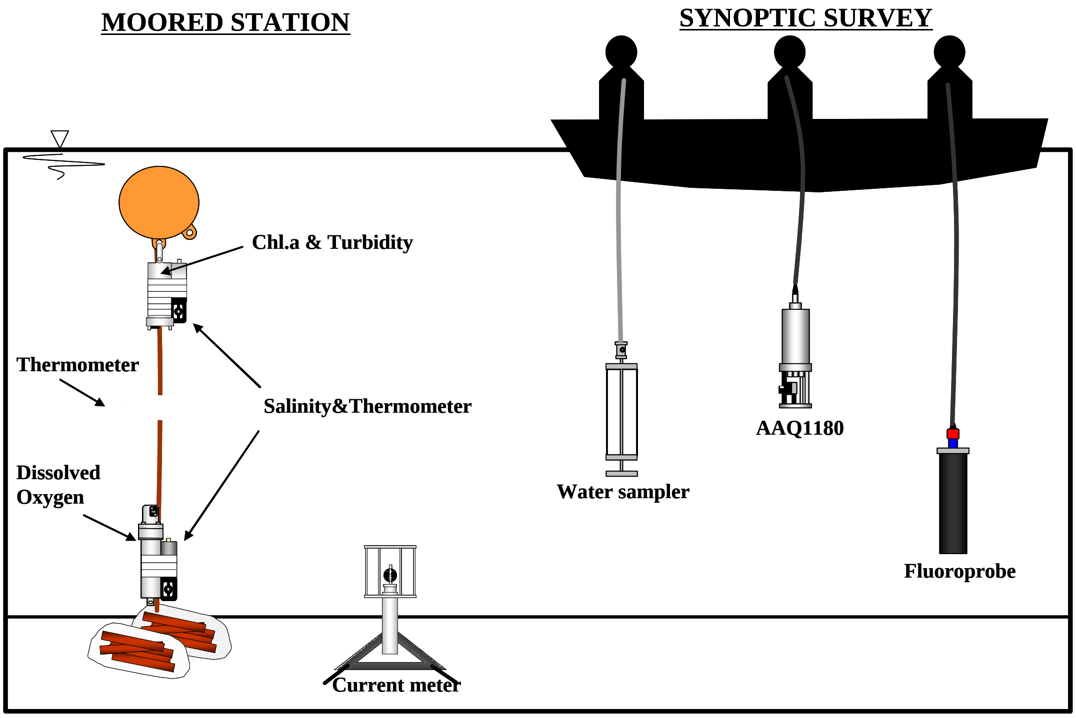

Figure 8. Example illustration of a Taut-wire moorage, bottom fixed deployment, water sampling and water properties profiling.

2.3.2 Water sample analysis

After the daily synoptic survey, samples for dissolved nutrient (ammonium, nitrite, nitrate, phosphate, silicate) determination were filtered using Whatman GF/C glass micro-fibre filters (0.4 micrometer), and then were frozen. The water samples were brought back for analysis in the laboratory in Japan. The analysis of nutrient concentrations was conducted using a continuous flow wet chemistry analyzer (TRAACS 2000) that uses a colorimeter to detect changes in color produced by the presence of the analytes. The nutrient concentration detection range were set to be between 0.4 and 0.002 mg/L for NH4, NO3+NO2 and PO4; between 0.08 for 0.0004 for NO2; and between 4 for 0.02 for SiO2.

Fifty milliliters of samples for chlorophyll-a analysis were filtered using Whatman GF/C glass micro-fibre (0.4 micrometer). The chlorophyll-a extraction from the filter follow the methodology recommend by Suzuki R. and Ishimaru T. (1990), where the extracting media is N-dimethylformamide (DMF). After the extraction, the samples were stored in a light-free container and at refrigerated temperature, before being back for analysis in the laboratory in Japan. Concentrations of chlorophyll-a and pheopigments in the extracts were determined by the fluorometry suggested by Strickland and Parsons (1972) using a fluorometer (Tuner Design 10R) equipped with color filter of 5-60 for excitation and of 2-64 for emission. The chlorophyll-a concentration detection limit was 0.05 mg/L.

2.3.3 Hydrodynamic simulation

The simulation was carried out using a sigma coordinate system with horizontal orthogonal curvilinear grid **(Figure 9)**. A well established three-dimensional density driven flow model, Delft3D-Flow, from Delft Hydraulic-Netherlands, was used in this study (Delft3D-Flow User Manual, 2004). **Table 2** shows the computation conditions of the hydrodynamic model. **Figure 9** shows the horizontal computational grid and bottom topography derived from the bathymetric survey and additional depth points outside the lagoon from base map. The meteorological concerned data (e.g. solar radiation, air temperature, relative humidity, wind) obtained from weather station, the location of which is shown in **Figure 7**. The simulation period was in summer and for two weeks to cover a cycles of neap and spring tide, from 21 February to 9 March, 2007. At the water surface, the heat exchange is modeled by taking into account the separate effects of solar (short wave) and atmospheric (long wave) radiation, and heat loss due to back radiation, evaporation and convection (Murakami et al. 1985). The bed stress formulation is related to the current just above the bed. There is no transported flux across the bottom. There is no flow through all close boundaries.

The model was calibrated and validated against hydrographic data from the field observations. **Figure 10** shows the overall agreement between field and simulated data showing that the numerical model can acceptable reproduce the circulation as well as water temperature feature of the lagoon.

2.3.4 Water quality simulation

Water quality model was developed in Delft3d-WAQ modeling system environment (Delft3d-WAQ user manual, 2005). The model composed of 4 compartments i.e. dissolved oxygen, phytoplankton, detritus nitrogen, detritus carbon. **Figure 11** is the conceptual diagram of the water quality model of Puerto Galera showing the linkage between each compartment. The transportation of matter and necessary hydrographic conditions were derived from the calibrated hydrodynamic model. The initial and boundary condition of the substance in each compartment were obtained from field observation data. Since there is no available data for nutrient influx from coastal community, the amount are derived from calibration in order to get the good agreement of dissolved oxygen, and phytoplankton concentration between surveyed and simulation. **Figure 12** shows model validation with observational data at the location close to Muelle pier. The detailed of the concerned processes are described in the Delft3d-WAQ user manual.

Table 2. Computation condition of hydrodynamic model

Item	Condition
Simulation period	21 February – 9 March 2007 (Summer)
Initial condition	Constant temperature, salinity (26Celsius)
Horizontal grid	Orthogonal curvilinear grid 74x118
No of vertical layer	Sigma coordinate with 18 layers
Offshore Boundary condition	Observed water level and flow velocity, water temperature at two channels
Wind	Temporal variation uniform wind from weather station.
Meteorological data	Air temperature, cloud fraction, humidity from weather station
Horizontal Eddy	Smagorinsky model with zero background
Vertical Eddy	k-epp model with zero background
Bottom roughness	Chezy 150
Surface heat flux	Murakami model

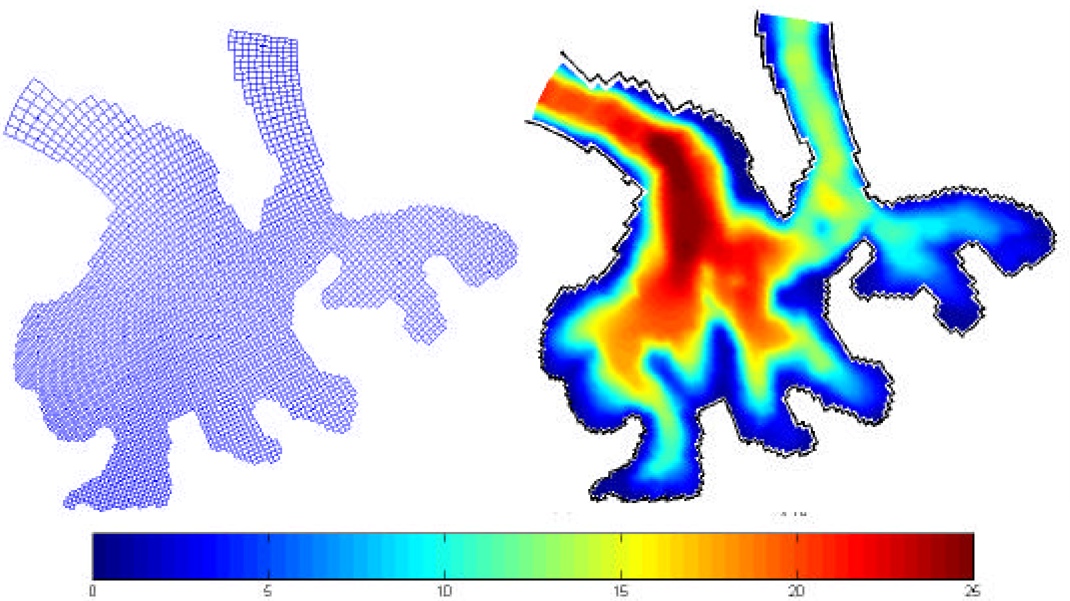

Figure 9. Horizontal computational grid and bottom topography of PG

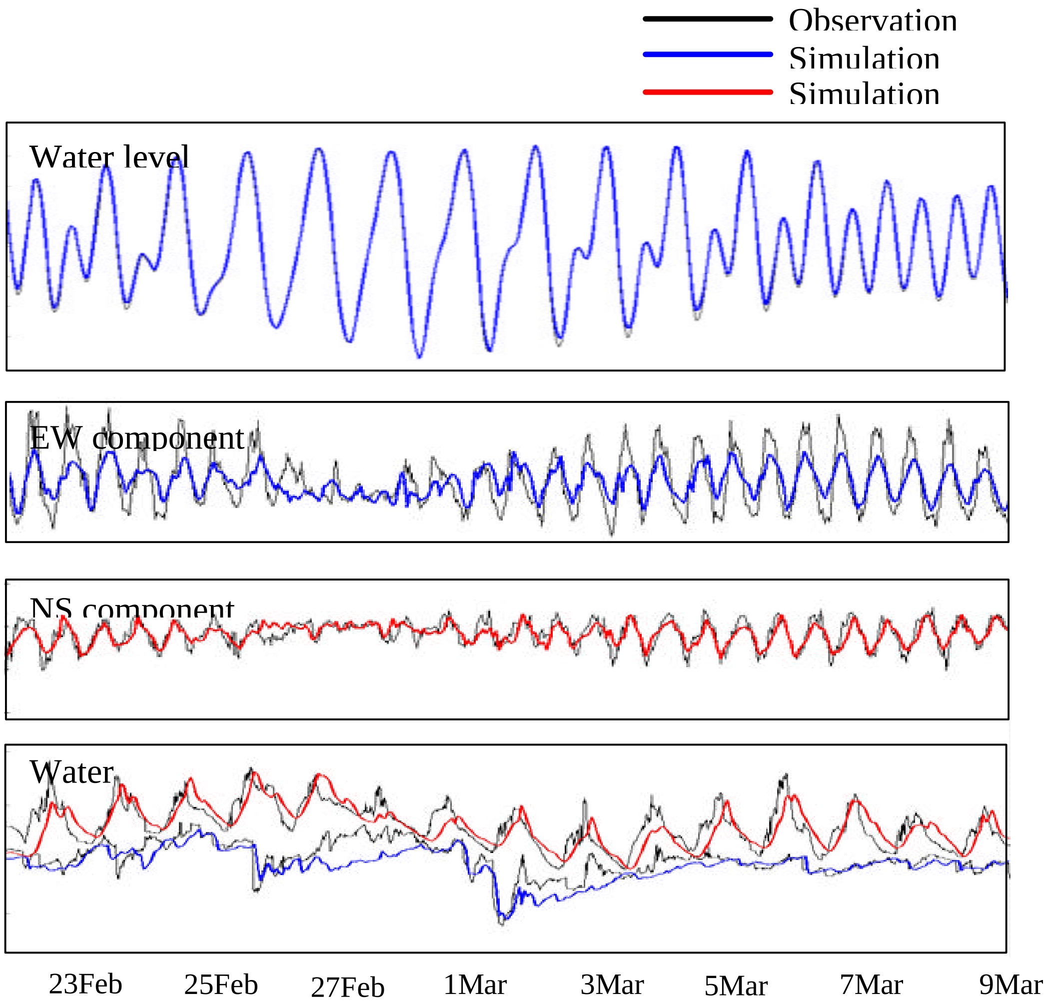

Figure 10. Results of model validation showing comparison between observed and simulated water level, flow velocity at station C1 and water temperature at station B1.

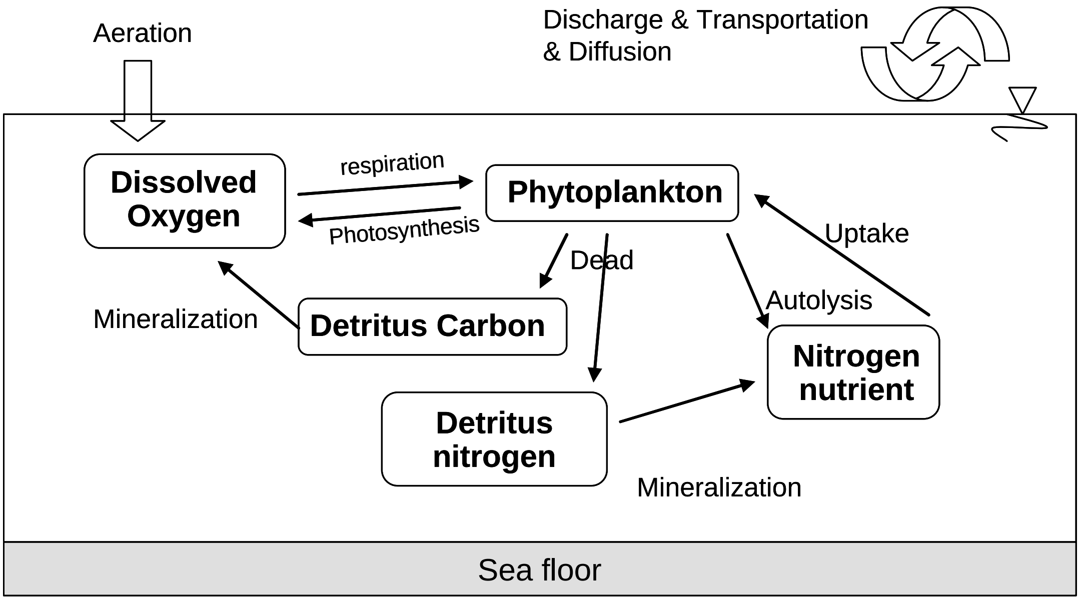

Figure 11. Water quality model conceptual diagram

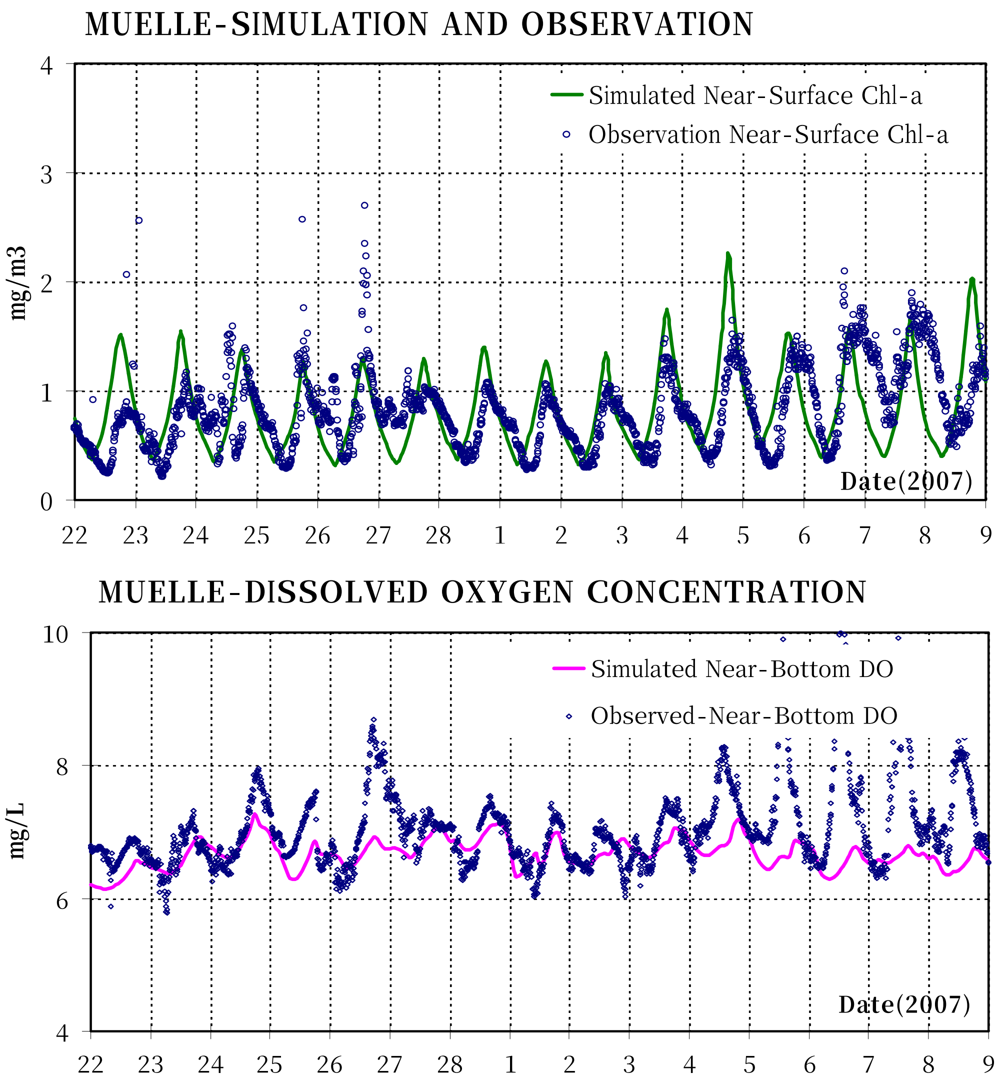

Figure 12. Water quality model validation showing the comparison of dissolved oxygen (upper figure) and chlorophyll-a concentration between observation (black color) and numerical simulation

2.4 Socio-physical monitoring in Puerto Galera

Puerto Galera, being a popular tourist spot, has rich and diverse marine resources, such as the healthy coral reefs, and the extensive beaches as its main selling points. These resources offer recreational and scenic values for tourists, generate revenues for the tourism-oriented businesses and provide food and sources of livelihood for the local people. There exist the enormous needs of the growing population and of the great influx of visitors in the recent years; and the unregulated type of development seems to be the current coping means (Fortes, 1997). However, this type of development fails to protect the coastal and marine resources from degradation and water pollution brought about by improper sewage and waste water discharges. Maintenance of high water quality is essential to sustain the beauty and health environment but it requires proper management based on thorough and continuous monitoring of both the water quality conditions and the existing sewage and wastewater disposal practices of the people.

The people and government of Puerto Galera have relied on occasional water quality analysis performed by academic researchers and by the national government agencies; and worst, these analysis results were often not provided to Puerto Galera. Some research results on water quality and recommendations fail to appeal the local people probably due to the following reasons:

a) Since most researchers are not local residents, local people's trust is difficult to obtain.
b) The results of those researches are not effectively disseminated to the local people in a language understandable to them.
c) The linkage between the water quality and local people's activities are not clearly defined.

Also, the physical conditions with which the tourism sites in Puerto Galera are exposed vary for each site. Mitigation efforts toward water quality deterioration depend on local people's cooperation, which is based on their understanding of the process. Recently, the local residents are divided on the proposed plan (which is not based on scientific study result) to re-open the sandbar as a means to improve water quality in Puerto Galera Bay. Thus, dealing with seawater quality improvement would require socio-physical integrated approach.

The aims of this research are to relate the impact of human activities in some tourism areas to seawater quality and to show that socio-physical integrated approach to water quality can highlight the local people's role in water quality improvement efforts.

2.4.1 Tourism area clustering for comparison

There are 13 villages (12 of which are coastal) in Puerto Galera. Half of the coastal villages relies on tourism-based activities for livelihood sustenance (Cola and Hapitan, 2004). However, for this research, the focus is on the specific clusters of tourism-related establishments and household communities situated along the coastline. The basic assumption is that those communities closest to the bay have greater impact to seawater quality and have better knowledge on the water quality conditions. The major tourism-related clusters considered in this research are Muelle, Sabang and White Beach. Most social and infrastructure data available are either in municipal or village scale. However, a cluster of establishments and households covers only a portion of the entire village extent and may traverse two villages, as in the case of Muelle. In this regard, social data used to describe these clusters are referred from the related village.

The common characteristics of these there clusters are the following:

1) being ferry arrival points for tourist (but only Muelle has pier structure)

2) high concentration of hotel and restaurant establishments,
3) highly-dense communities and
4) strong population growth (see **Figure 13**)

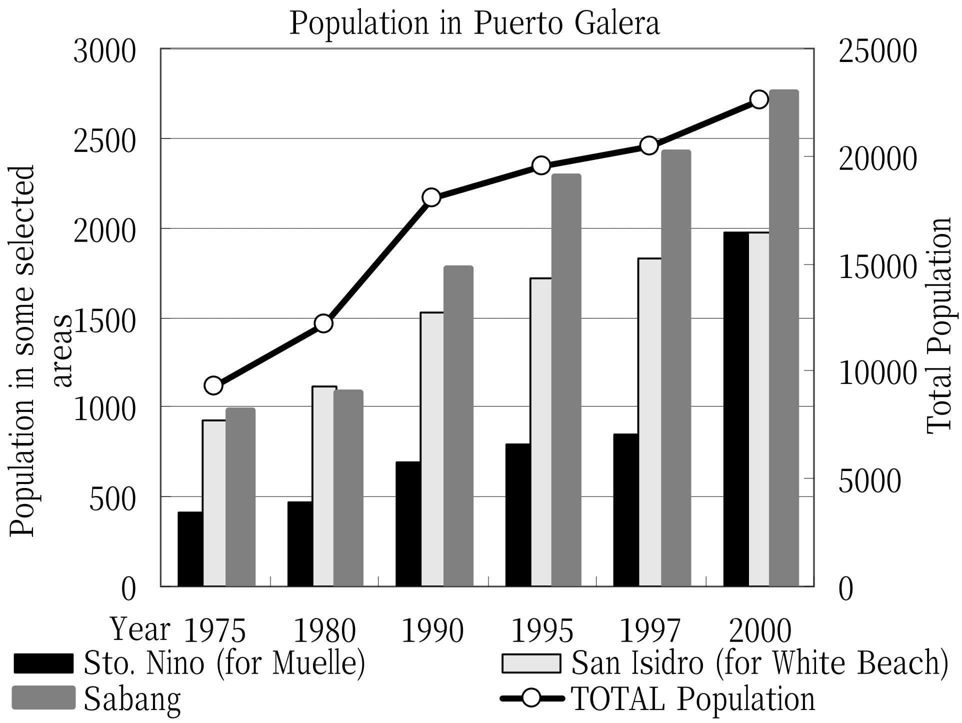

Figure 13. Population growth in Puerto Galera

The following description of the three tourism sites was taken from the 'Book of Puerto Galera Facts (2002)'.

Muelle (Poblacion and Sto. Niño)

It is where the busiest and oldest of the three ports in Puerto Galera is located. This tourism site is situated within a natural harbor. Its still bay water serves as safe haven to more than 20 yachts that are moored there. Commercial establishments such as small eateries, T-shirt and garment shops, groceries, restaurants and lodging facilities, mostly catering for the daily tourist needs, are lined up along the port. Being at the heart of Puerto Galera, this is the preferred take-off point to other popular tourist destinations. As shown in **Fig. 13**, the household communities residing in Muelle belong to Sto. Niño village. Its population got the highest annual growth rate of 6.41 against the national growth rate of 2.3 and Puerto Galera growth rate of 2.4. Sto. Niño absorbs the expansion of the town's center.

Muelle Bay has the least anthropogenic activities influence over water quality but due to its physical environment characteristics, its carrying capacity for waste water is quite low. The seawater here is highly turbid because this is an enclosed bay with a very low open sea water exchange and is a port area. Nutrient loads come from small freshwater creeks discharges during the rainy season and from direct inputs of wastewater and sewage (San Diego-McGlone, 1995). There is no sewerage system and sewage effluents are normally discharged in open canals leading to natural waterways, like rivers and streams eventually ending up to the bay (Bio-social survey of the coastal waters of Puerto Galera, Mindoro Oriental;1984).

Sabang

Sabang (in Sabang village) is best-known for its nightlife facilities, as well as, its scuba-diving opportunities. It is where most of the upper-class hotels and better restaurants in Puerto Galera are situated. Though the actual beach is quite narrow (gone during high tide) but it has been the favored spot of the majority of foreign tourists. Foreigners are attracted by the presence of numerous diving centers, hotels, restaurants, discos, nightclubs and versatile shops lying along its shoreline. These establishments are mainly managed by Filipino-foreigner couples. Over a 100 hotels and lodging facilities here are ready to accept visitors.

The seawater quality in Sabang may suffer from severe eutrophication and algal bloom, if the discharge of untreated sewage persists. The untreated wastewater discharges from commercial establishments and households are directly drained to beach waters through open canal and over the beach sand.

White Beach (in San Isidro village)

White Beach is the economical version of Sabang and has been mostly patronized by local Filipino tourists. It has a long and extensive beach that stretches up to 30m in width and 800m in length and is pleasant venue for beach-combing, swimming, beach valley, disco, massage, drinking and camping activities. The establishments here are mostly managed by local residents. There are more than 30 hotels and lodging facilities in this area.

As compared to the previous two sites, White Beach has relatively the cleanest water due to better wastewater facilities and effluent discharge practices. It has well-constructed canal system for wastewater leading to a retention pond.

2.4.2 Questionnaire survey for tourism and household sectors

The purpose of this survey is to determine the local people's activities and perception of Puerto Galera regarding seawater quality in the three tourism areas. The survey was conducted on the first week of March 2006. A structured questionnaire was used survey was divided into two main parts: behavior/activities related to water quality and perception to seawater quality. The first part includes questions related to availability of sanitation facilities and local peoples' sanitation practices. Two sectors of the community were considered, as shown in **Table 3**, namely:

1) household – They were represented by household heads. In most areas, except in Muelle, respondents were only taken at every four household due to large number of households. This sector was mostly located behind those of tourism-related business establishments. A total of 301 households were interviewed.

2) tourism - They were represented by either the hotel/resort/restaurant owners or managers. Their presence in those tourism areas closest to the shore was profit-driven and this sector was directly involved in tourism. There is a total of 66 respondents.

The division of respondents is necessary for differentiating the influences and perceptions on seawater quality between of household (may or may not be involved in tourism) and tourism (directly involved in tourism) sectors. The questions were written in English for tourism sector and in Tagalog for household sector.

Table 3. Number of respondents.

	tourism	household
Sabang	32	74
White beach	24	91
Muelle	10	96
Batangas Channel*		40*

Availability of sanitation facilities

Having poor sanitation facilities are being blamed as one of the main reasons for increased in nutrient loading on the bodies of water. The following questions were solicited to determine the existing sanitation and waste disposal facilities in each tourism area. The types of toilet and septic tank were particularly asked.

The type of toilet facility indicates socio-economic status of the people using it. The advance type of toilet facilities such as flush-type provides convenience to users. A flush-type toilet is one in which water carries the waste down pipes and a pour-type toilet functions the same way, but water is poured in by buckets and not piped into the toilet. Waste from these toilet types ends up either in septic tank (sealed or open-type), pit or elsewhere through rivers. A latrine or antipolo-type of toilet, do not use water at all to flush waste which goes directly to a pit.

The type of fecal waste disposal facility indicates the level of waste control management. The old type of septic tank in Puerto Galera is an open-type (**Figure 14**). Here, solid waste and greases for sewage are filtered. The waste water comes out from the sanity tee outlet and should go to sanitary sewage treatment system but there is no such system in Puerto Galera, the sewage effluent instead is directed into open canal or bodies of water. The sealed-type septic tank (**Figure 15**) is recently recommended by the local government for all newly constructed houses and establishments built from year 2002. This does not have sewage effluent outlet but instead allows effluent to leach on its second chamber. Pit is the least environment-friendly among fecal waste disposal facilities.

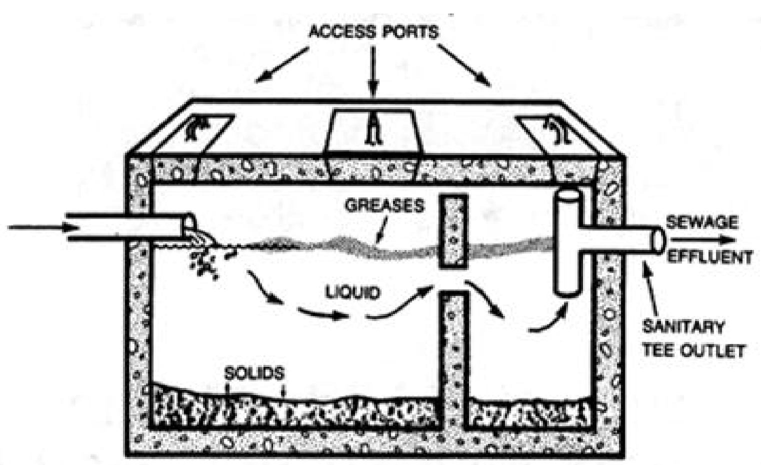

Figure 14. Open-type septic tank.

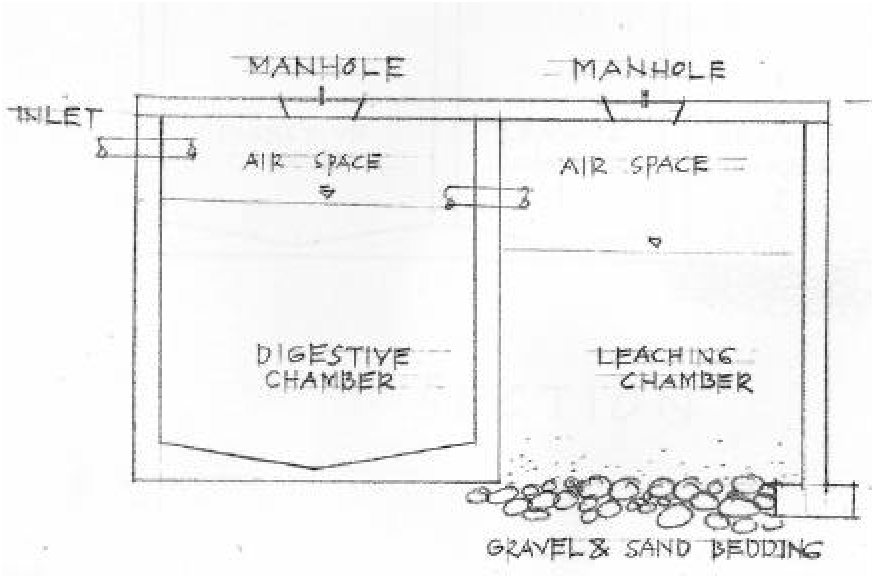

Figure 15. Sealed-type septic tank.

Local peoples' sanitation practices

This part of the questionnaire focuses on how individuals may have contributed to water quality deterioration. The respondents were asked where do they dispose their waste water and what activities do they engaged involving the use of clean water. The respondents were also asked if they think that have polluted the water.

Perception toward seawater quality

The last part of the questionnaire would like to bring out environmental awareness among local people. Local people's opinions were obtained about the current state of seawater quality and some water quality management issues. Aside from inquiring about the existence of polluted water, the indicators, duration, causes, sources, impacts and effects of personal health of polluted water were asked. In the search of finding solution to water quality deterioration, their opinion on pollution mitigation is highly important for consideration. The people's acceptability of recommendations lies on the compatibility of their opinion with the basis of recommendations.

2.4.3 GPS mapping of household, tourism infrastructure and facilities

Using a hand-held GPS, location of households and tourism establishments were surveyed. By walking around the extents of residential buildings and tourism establishments, the relative locations of these areas with respect to the shoreline were noted. And also, some open canal and outlets of natural waterways were also mapped. This location data could be used in verifying data generated by image classification through GIS.

2.4.4 Monitoring by remote sensing

Five Aster and one Quickbird satellite image datasets were acquired. Image acquisition dates for Aster are as follow: Jan 3, 2001; Nov. 3, 2001; Sept., 3, 2002; Feb. 17, 2003 and Feb. 22, 2005. The Quickbird image was taken on Feb., 28, 2006. These images were geo-referenced and were calibrated using empirical line to have common spectral range values for all images. Spectral unmixing technique was used to classify basic land cover, such as built-up, grassland and forest.

2.4.5 Tourism and household area expansion

The tourism and household area expansion for the three tourism sites were analyzed from the increase of built-up area from the classification results of 2001 to 2005 Aster images. The rate of increase and the spatial growth distribution were investigated.

2.4.6 Land cover change detection

From the results of the image classification of the Aster images, the historical land cover changes were determined by comparing Aster images taken at various dates. Forest, grass and built-up were the land covers being examined. This information on cover change is important for building up a spatial information database for understanding physical environment dynamics.

2.4.7 Creation of GIS for household, tourism infrastructure and facilities

A GIS database was set up to demonstrate how various data can be compiled to provide useful information for monitoring and management. It was implemented under ArcGIS platform. The tourism establishment data obtained from Puerto Galera council were encoded and overlaid on Puerto Galera map derived from Quickbird dataset. The name of the hotel, number of rooms, restaurants and other details were included in the list of input details and could be updated anytime. Other results from remote sensing classification, such as built-up and forest covers, were added. In GIS, it is also possible to incorporate other data from water quality simulation and measurements. Understanding the relationships among various data and comparison among different sites in Puerto Galera could be realized through GIS setting up.

2.5 Bolinao: Methods for Assessing Environmental Impacts of Fish Cage Aquaculture

2.5.1 Field Observations

Intensive and extensive field observations were conducted from November 14 to December 2, 2007 around Santiago Island, Bolinao in collaboration with Marine Science Institute, the University of the Philippines. The aim of the field observations is to collect physical, biological and chemical data essential for understanding significant temporal and spatial variations in hydrodynamic and water quality processes in the area. The filed observations were conducted based on the following methodologies:

1. Sensor deployment: Monitoring by data-logging senor using bottom fixed deployment and taut-wire moorage system.

2. Water quality Survey: Water sampling and vertical profiling of water quality using a multi-quality meter at eleven stations.

As shown in **Figure 16**, there were 12 stations for sensors deployment and water quality survey. Among the stations, three stations were located in the aquaculture area (Station 1, 11, 12), two stations were outside the reef (Station 3, 7) and four stations were inside (Station 4, 5, 6, and 10).

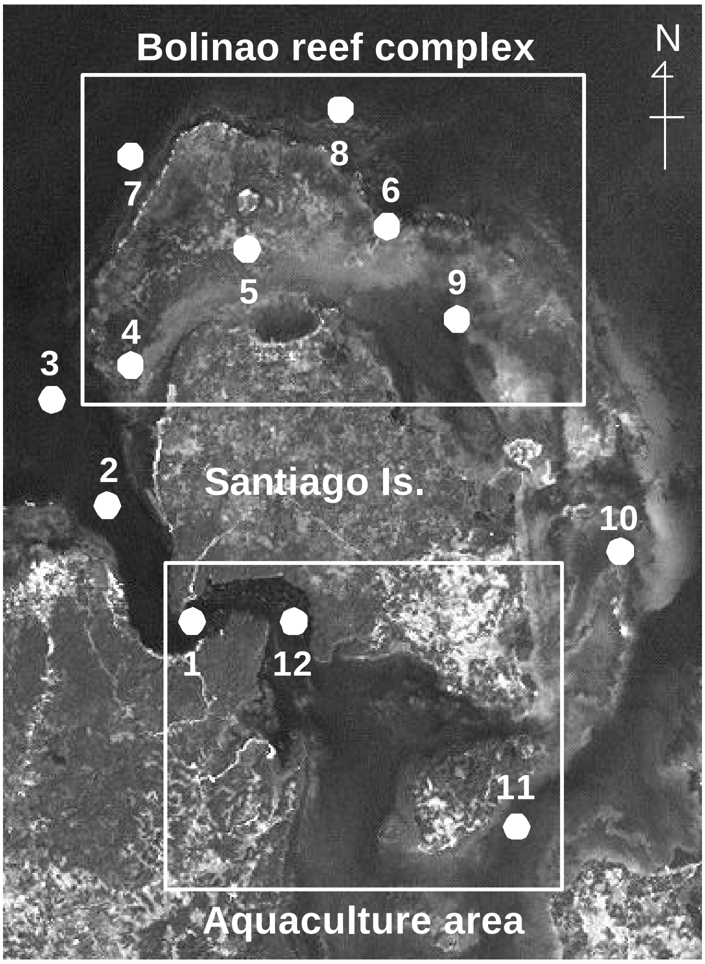

Figure 16. Map of study site showing stations for sensor deployment and water quality survey

2.5.2 Sensor Deployment

19-day continuous measurements at nine stations (Stations 1, 3, 4, 5, 6, 7, 10, 11, and 12) by various data-logging sensors were conducted from November 14 to December 2 to collect hydrodynamic and water quality data around Santiago Island. Monitoring parameters were hydrodynamic quantities (velocity, wave) and water quality quantities (temperature, salinity, turbidity, chlorophyll-a, light intensity, dissolved oxygen). Each station's monitoring parameters are indicated in **Table 4**. **Table 5** summarizes names, locations and setting of the sensors deployed. Sensors were either attached to moored buoys or mounted at the bottom, or both.

2.5.3 Water Quality Survey

Water sampling and vertical profiling of water quality were conducted at ten stations (Stations 2, 3, 4, 5, 6, 8, 9, 10, 11, 12) on 16 am, 17 pm, 18am, 18pm, 20pm, 21am, 30am November (**Table 6**)

(a) Water sampling

Water samples were collected using a 1 liter modified Niskin sampling bottle (Yoshino Keisoku Co.,Ltd., Japan) from surface layer at station 4, 5, 6, 8, 9, 10 and from surface, middle and bottom layer at station 2, 11, 12. Water samples were used to analyze concentration of nutrient and chlorophyll-a.

Samples for analysis of dissolved nutrient such as ammonium, nitrite, nitrate, phosphate and silicate were filtered using Whatman GF/C glass micro-fibre filters

(0.45 micrometer), and then frozen. The analysis of nutrient concentrations was conducted using a Bran + Luebbe Autoanalyser.

Samples for chlorophyll-a analysis were filtered using Whatman GF/C glass micro-fiber (0.45 micrometer). The chlorophyll-a extraction from the filter follow the methodology recommended by Suzuki and Ishimaru (1990), where the extracting media is N-dimethylformamide (DMF). After the extraction, concentrations of chlorophyll-a and pheopigments in the extracts were determined by the fluorometry suggested by Strickland and Parsons (1972) using a fluorometer (Tuner Design 10R).

(b) Vertical profiling of water quality

Vertical profiling of water quality using AAQ1183 (Alec electronics), an STD-type instrument for measuring various water quality parameters were conducted in order to describe water quality variation along the vertical water column with the changing physical environment. The sensor can measure water temperature, salinity, chlorophyll-a, turbidity, PH and dissolved oxygen.

2.6 Methods for Shiraho Reef and Todoroki Watershed Study

2.6.1 Field Survey

The field observation was conducted in a part of the east coast of Ishigaki Island where fringing coral reefs of approximately 1km wide toward east-west direction are formed (**Figure 18**). A typical topographic feature of fringing reef can be seen with moat, reef pavement, reef crest, and reef edge. Most of the reef crests are exposed at low tide. The observation was taken place within the 8 km from the shoal called Watanji at south to the big channel called Toru-guchi at north. There are three other channels connecting the reef area to the outer sea; Ika-guchi, Moriyama-guchi and Bu-guchi. Among four channels, Toru-guchi is largest penetrating the reef deeply up to the moat with the average water depth of 20 m. The main stream that runs off toward the reef is Todoroki River, of which the river mouth is located at the middle of our observation site. Sediment discharge from adjacent land via Todoroki River causes one of the major environmental problems of this coral reef.

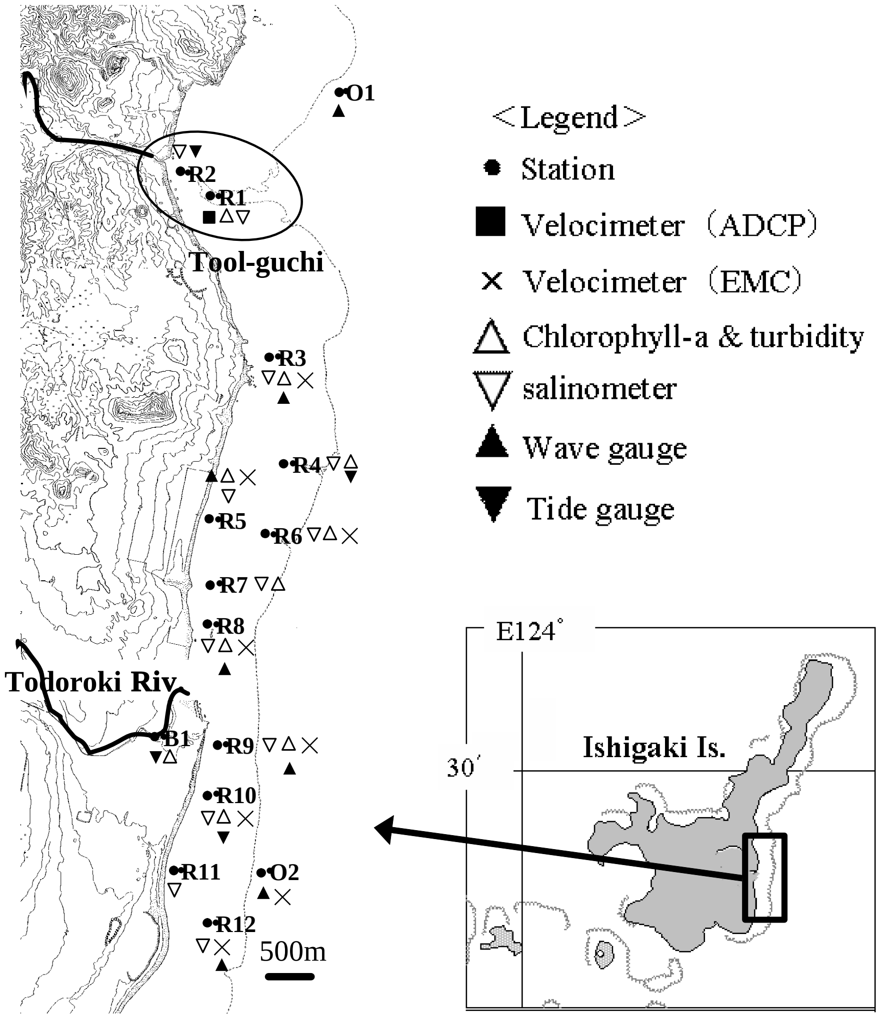

Figure 18. Location of stations and sensors deployed

(b) Sensor deployment and water sampling

Fifteen (15) stations are established at the locations shown in **Figure 18**. 12 stations (R1-12) are located inside the reef and 2 stations (O1,2) are set outside the reef at the water depth of about 12 m. One station was set up in Todoroki River, at about 1 km upstream from the river mouth. R1, R4, R6 and R12 were selected to be near the channels respectively Toru-guchi, Ika-guchi, Moriyama-guchi and Bu-guchi. All other stations inside the reef (Stn.R2, R3, R5, R7, R8, R9, R10 and R11) were located relatively close to the shoreline. The types of sensors deployed at each station are indicated in **Figure 18**. **Table 7** summarizes names and setting of the sensors (interval, numbers, and frequency). Salinometers and turbidity & chlorophyll-a meters are moored with bouys so that river plume can be observed during flood (**Figure 19**). Velocimeters, wave gauges and tide gauges are deployed on sea bed.

Water samples were collected both from surface and bottom layer at stations except for Stn.R2, R11 and B1 on 27 July, 6, 8, 19, 20 August to measure nutrients and chlorophyll concentration. Samples were filtered through 0.45-µm membrane filters and were frozen for subsequent analysis of phosphorus, nitrate, nitrite, ammonium and silicate on a Bran + Luebbe Autoanalyser. The observation period is from 24 July to 22 August in 2005.

Table 7. Sensors and their measurement setup. ADCP Acoustic Doppler current profiler. Manufacturers: A: ALEC Electronics; B: Van Essen; C: RD Instruments

Instrument	Product name (manufacturer)	Interval	Number	Frequency
Velocimeters (EMC)	Compact-EM (A)	30 min 120 min (O2 only)	120 300	1Hz 1Hz
Wave gauges	Compact-WH (A)	120 min	2400	2Hz
Tide gauges	Diver (B)	10 min 15 min (B1 only)	1 1	- -
Salinometers	Compact-CT (A)	1 min	1	-
Chlorophyll-a & Turbidity	Compact-CLW (A)	15 min	60	1Hz
ADCP	Workhorse (C)	30 min	600	1Hz

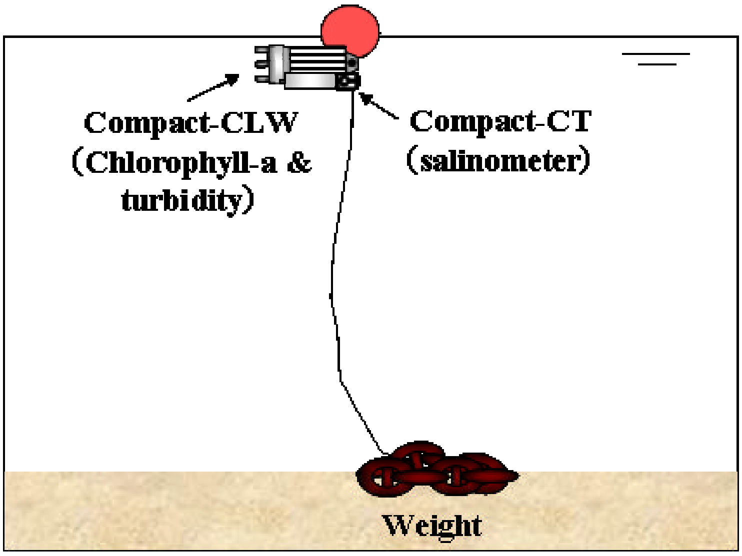

Figure 19. Installation of Chlorophyll-a & turbidity and salinometer with moored buoy

2.6.2 Numerical simulation

(a) Outline of the model for current simulation

For the computing currents of relatively shallow waters like the coral reef concerned, a shallow water turbulent model, the SDS-Q3D model was applied in this study. This model consists of an SDS turbulence model (Nadaoka and Yagi 1993) and quasi 3-D shallow water equations. By applying SDS turbulence model, SDS-Q3D model enables to simulate hydrodynamic accurately with a low CPU cost (Nadaoka and Tamura 2001).

(b) Model improvement for application to simulation during typhoon period

Although SDS-Q3D model can simulate current of shallow waters effectively, it can not directly be applied to period during a typhoon since the model does not include effect of wind. Wind stress term has been incorporated into the calculation of momentum. Conventionally, wind stress is parameterized by a bulk formula

$$t = r \quad C_s U_{10}^{2} \qquad (1)$$

where τ is wind stress; ρ is the air density; C_s is drag coefficient, and U_{10} is the horizontal wind velocity at 10 m above the sea surface.

Quantification of drag coefficient has been proposed by many researchers (Geernaert et al. 1987, Tanaka et al. 2001). In this study, drag coefficient proposed by Honda and Mitsuyasu was applied.

$$C_s = (1.28 - 0.0242U_{10}) \times 10^{-3} \quad U_{10} \le 8m/s \qquad (2)$$
$$C_s = (0.581 + 0.0626U_{10}) \times 10^{-3} \quad U_{10} \ge 8m/s$$

For wind stress calculation, 10 minutes averaged wind velocity observed by Japan Meteorological Agency was used.

(c) Computational conditions

The computational domain is shown in **Figure 20**, which also indicates the bathymetry of the reef obtained from a spectral inversion technique for a remote sensing image (Paringit and Nadaoka 2003). This method provides bathymetry with a high spatial resolution; this is one of the critical points for accurate numerical simulations of currents in shallow waters. For the outer sea, where spectral inversion technique can not be applied since it is too deep, a sea chart was used. Therefore the bathymetry was defined by combining of digitized data obtained from sea chart and the bathymetry extracted from satellite image.

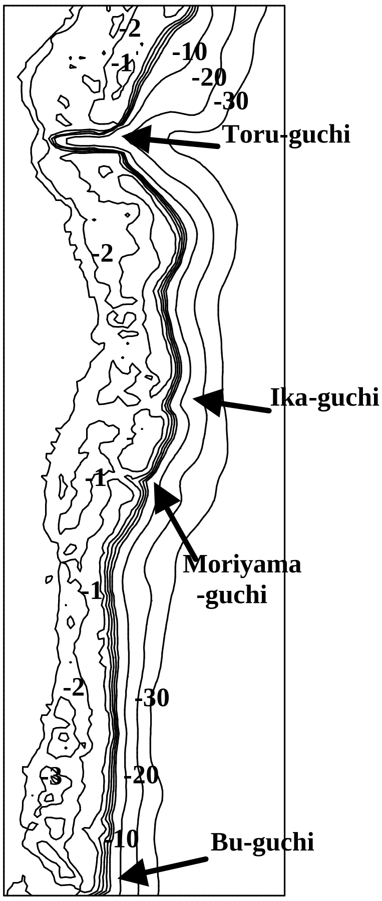

Figure 20. Bathymetry and computation domain

Table 8. Parameters for current and wave computation

Current computation	
Time increment (s)	1
Spatial resolution for east-west direction (m)	50
Spatial resolution for north-south direction (m)	50
The number of	1
Critical depth for moving boundary conditions (cm)	2
Drag coefficient of the sea bottom	0.035
Coriolis parameter (1/s)	6.02×10^{-5}
Wave computation	
The total number of frequency components	10
The number of angular components	35
Spreading parameter	75
Incident wave direction (°)	53.8

The computation was performed from 3 to 7 August 2005 when typhoon no.9 struck Ishigaki Island. At the offshore side of the domain, an open boundary condition was applied where tidal fluctuation of the sea level obtained by harmonic analysis of the observed tidal data was given. Significant wave height and period obtained from field observation were imposed every two hour for simulating waves. The spatial resolutions in the x and y direction were both 50 m and the time increment was set at 1 s. **Table 8** lists the other parameters used in the computation. The bottom friction coefficient was set at 0.035 to fit the computation result to the field survey results (Lugo-Fernandez et al. 1998).

2.6.3 Assessment of Cover Dynamics

Satellite images (Landsat TM and ETM+) were analyzed to generate land cover and benthic cover maps. Cover statistics were calculated and change analysis was then performed. Cover change analysis was performed for Todoroki watershed and the entire Shiraho Reef. For further analysis, Shiraho Reef was divided into northern Shiraho Reef and southern Shiraho Reef, considering the differential influence of riverine discharge on the reef.

Land cover mapping

Landsat images covering a period of 20 years (1984-2003) (**Table 9**) were used to generate land cover maps. Images with clouds over Todoroki watershed were excluded so that landscape composition and configuration can be evaluated over the whole watershed. The images were radiometrically corrected. Atmospheric correction was performed using the 6S algorithm (Vermote et al. 1997). Images were then classified using spectral unmixing technique. This method requires the spectral signatures of various land cover classes that can be found in the watershed as input. Based on these signatures, the algorithm estimates the proportion or percentages of the classes comprising a pixel, i.e., within a 30 x 30 meter area in the case of Landsat TM and ETM+. The resulting classified images were then subjected to a generalization procedure to assign each pixel to a cover class. The class with the highest percentage occurrence in a pixel is assigned as the class for that pixel. The land cover classes are Forest (or Trees), Sugarcane, Grass, Mulch (i.e., plots with mulching), Bare areas, Wet paddy, and Shallow water. Bare areas are generally transitional areas (i.e., before planting and after harvesting of sugarcane).

Table 9. Landsat images used for land cover mapping of Todoroki watershed and benthic cover mapping of Shiraho Reef. (Note: *X denotes exclusion due to cloud cover.*)

ID	Landsat type	Date of acquisition	Season	Used for land cover?	Used for benthic cover?	Tide level (m)
S84	Landsat-5 TM	08/24/1984	Summer	√	√	0.59
S85	Landsat-5 TM	07/10/1985	Summer	√	√	1.36
W86	Landsat-5 TM	01/18/1986	Winter	√	√	1.25
A87	Landsat-5 TM	09/02/1987	Autumn	√	√	1.25
A89	Landsat-5 TM	10/25/1989	Autumn	√	√	0.87
S90	Landsat-5 TM	07/24/1990	Summer	X	X	0.51
S91	Landsat-5 TM	07/11/1991	Summer	X	X	0.11
S92	Landsat-5 TM	07/13/1992	Summer	X	√	0.39
S93	Landsat-5 TM	08/17/1993	Summer	√	√	0.20
A94	Landsat-5 TM	09/05/1994	Autumn	√	X	0.27
S95	Landsat-5 TM	08/07/1995	Summer	X	√	0.78
S96	Landsat-5 TM	08/25/1996	Summer	X	√	0.80
W96	Landsat-5 TM	12/31/1996	Winter	√	X	1.13
S97	Landsat-5 TM	07/27/1997	Summer	X	√	1.46
S98	Landsat-5 TM	06/28/1998	Summer	√	X	0.88
S99	Landsat-5 TM	07/01/1999	Summer	X	√	0.47
S00	Landsat-5 TM	08/20/2000	Summer	X	√	1.04
W01	Landsat-7 ETM+	01/19/2001	Winter	X	X	1.31
A01	Landsat-7 ETM+	11/19/2001	Winter	√	√	1.03
W02	Landsat-7 ETM+	02/23/2002	Winter	√	X	1.33
S02	Landsat-7 ETM+	07/01/2002	Summer	X	√	1.20
W03	Landsat-7 ETM+	02/26/2003	Winter	√	X	1.33

Benthic cover mapping

The same set of Landsat images were used for mapping benthic cover in Shiraho Reef except those images with clouds over reef areas (**Table 9**). Water column correction was carried out to account for the attenuation effects of the water column using the method developed by Lyzenga (1978). Depth-invariant index images were generated from the images previously subjected to radiometric and atmospheric corrections. The Iterative Self-Organizing Data Analysis (ISODATA) method, an unsupervised classification algorithm, was then used to detect spectral groupings of image pixels in the depth-invariant index images. The algorithm was set to detect 5 to 15 spectral groups, which are then categorized into 4 benthic cover classes, namely, Coral, Cay sand, Algae/seagrass, and Pavement/exposed areas. The benthic cover class Coral consists of areas with live coral as the dominant cover. The categorization was accomplished by visually analyzing both the Landsat images and corresponding depth-invariant index images. Contextual editing was also employed at this stage.

2.6.4 Monitoring and Modeling of Todoroki Watershed

Four rain gauges are currently deployed in Todoroki watershed to capture the spatio-temporal variation of rainfall. Water and sediment discharge by Todoroki River is monitored using a turbidity meter and a pressure gauge for water level measurement. Pressure readings are compensated for atmospheric pressure to obtain accurate water level data. River discharge is computed using an L-Q curve or equation developed for Todoroki River. On the other hand, turbidity readings are converted to TSS concentrations using TSS measurements and calibration of the turbidity meter used. Nutrient monitoring was carried out by deploying 2 in-situ nutrient analyzers (MicroLAB) and periodic sampling of water from several stations along the Todoroki River (**Figure 21**). Modeling was carried out using the GSSHA model.

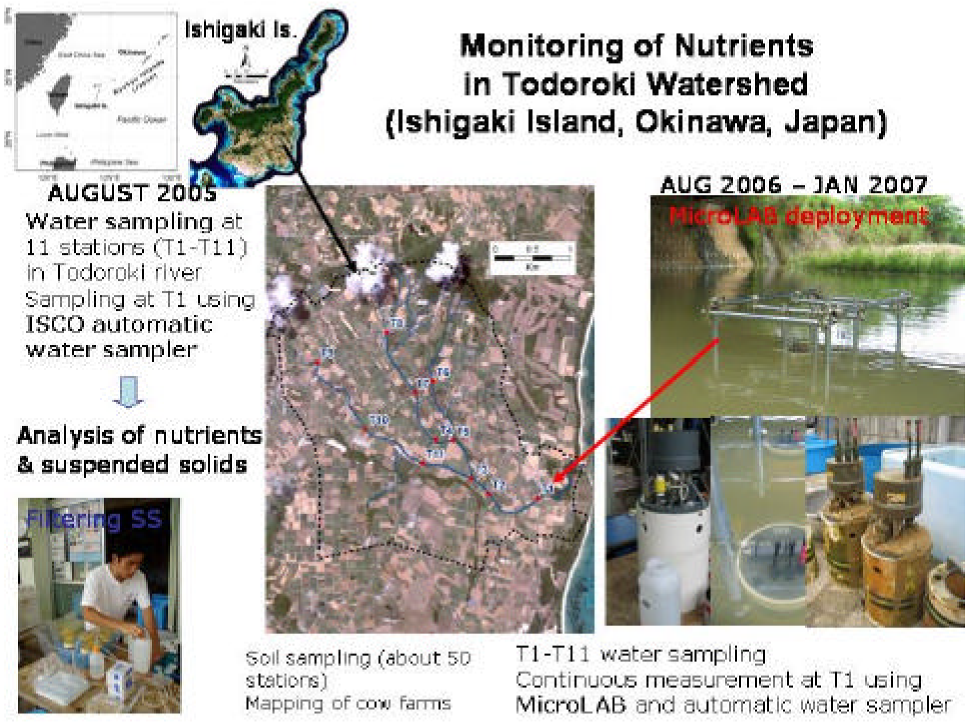

Figure 21. Scheme of nutrient monitoring in Todoroki watershed

2.7 Coral Coast watersheds/Votua Reef Study Methodology

2.7.1 Watershed monitoring

Watershed monitoring in Fiji is carried out similar to the approach used for Todoroki watershed. Two rain gauges were deployed in the watershed, one in the upper part and another in the lower part of the watershed. Near the stream or creek mouth, a turbidity meter (Compact-CLW, Alec Company, Japan) and a water level logger (Diver or Hobo Water Level Logger) were deployed by attaching to a triangular prismatic frame or to a long iron pipe driven into the stream or creek bed. The Compact-CLW measures turbidity, chlorophyll-a and temperature every 20 minutes, taking 30 readings at 1-secon interval. The water level logger was set to read pressure every 10 minutes.

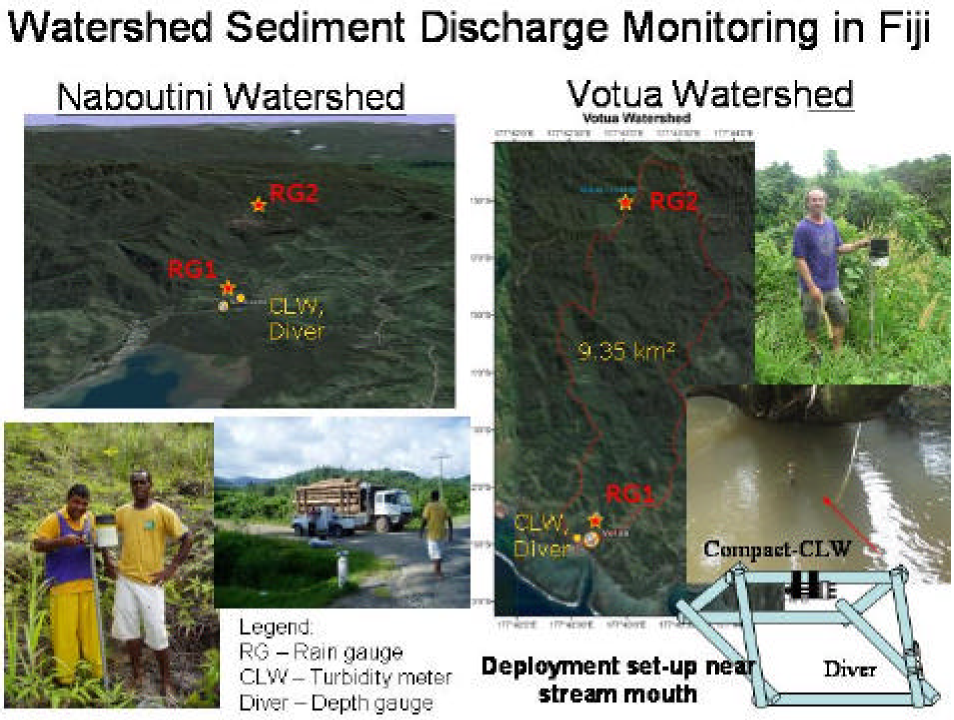

Figure 22. Monitoring set-up for Naboutini and Votua watersheds in Fiji

2.7.1 Votua Reef monitoring

A survey was conducted in Votua Reef for almost three weeks (2-20 March 2008). The objectives of the survey was to characterize reef hydrodynamics, particularly its effects on the fate and transport of sediments and nutrients from Votua watershed. Continuous monitoring of hydrodynamic and water quality parameters was made using data-logging sensors measuring turbidity, chlorophyll-a, wave height, 2D-velocity, salinity/conductivity, temperature and dissolved oxygen (DO). **Figure 23** shows the location of stations in Votua Reef. Typical deployment schemes for various sensors are shown in **Figure 24**. Similar to surveys in Ishigaki and the Philippines, profile measurements were carried out using an STD-type multi-parameter instrument to measure turbidity, chlorophyll-a, salinity, pH, temperature and dissolved oxygen. During profile measurement, water samples were collected at selected locations and at different depths (particularly for the channel and outer sea stations). The samples were analyzed for SS, TN, TP, dissolved nutrients (nitrate, nitrite, ammonium, phosphate, silicate) and chlorophyll-a. Water samples were also collected 1m from low water line at several stations along the Votua coast. Samples were analyzed for dissolved nutrients.

Since no reef bathymetry data are available, a bathymetric survey was performed. Bathymetric measurements will be input to a model to general bathymetry from satellite image.

Reef Hydrodynamics and Water Quality Monitoring using Data-logging Sensors

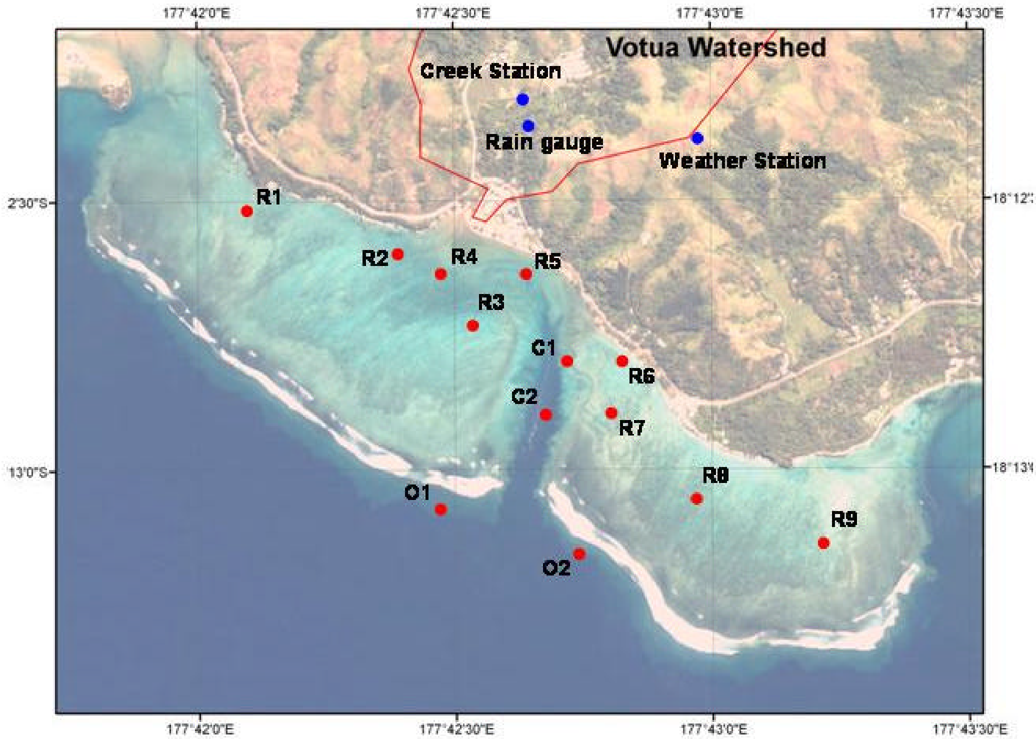

Figure 23. Location of stations during the Votua Reef survey (March 2008)

Typical Sensor Deployment

(Reef flat stations: R1-R9)

Water Depth : around 2.00 m

Sensor Deployment at Channel Station C2

Water Depth : around 20.00 m

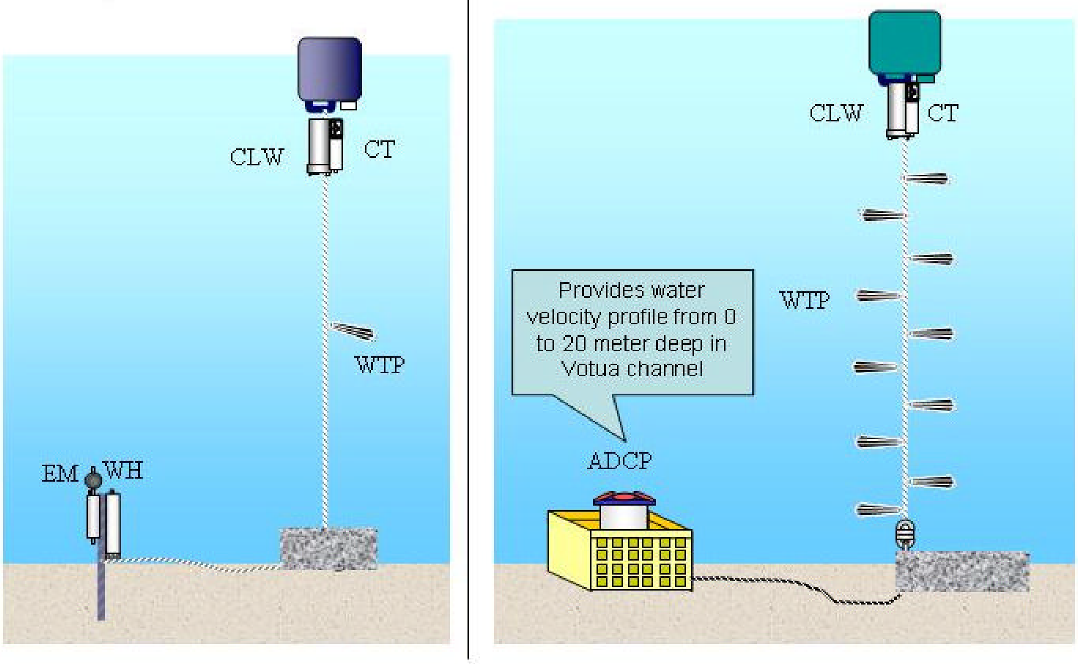

Figure 24. Location of stations during the Votua Reef survey (March 2008)

2.8 Regional sediment discharge modeling

Prediction of regional sediment load into the coastal environment is an important undertaking as 90% of the global rivers are unmonitored for. For this reason the International Association of Hydrological Sciences (IAHS) declared year 2003 to 2013 as the decade for prediction in ungauged basins (PUB).

Monitoring of global and regional sediment discharge is an extensively laborious undertaking due to the myriad number of rivers worldwide. Sediment load is measure in various spatio-temporal scales, ranging from hours to decades and from catchment size to regional drainage basins, the sizes of the Amazon basin. Many numerical models have been developed to assess sediment load such as the soil conservation service curve number (SCN-CN) method[1], the universal soil loss equation USLE (Wischmeier and Smith 1978), the water erosion prediction project (WEPP) model (USDA 1995) and others (de vente et al. 2005) for catchment scale, which, however, are all reliant on hydrometric data. Considering that 90% of the global rivers are ungauged for (Syvitski et al. 2005), it is a tremendous challenge to develop predictors that are transferable and require minimum or at best no hydrometric data. Numerous regional scale sediment load models have also been developed for prediction of regional scale ungauged rivers (Hay 1998, Hovius 1998, Milliman 1992, Syvitski 2005) (**Table 10**).

This study develops a new regional scale sediment load predictor. It improves from conventional regional scale sediment load models, which are typically based on area-elevation-slope relationships, to a predictor which is based on vegetation cover, soil moisture content and rainfall. The new regional sediment discharge model is named RSDM. RSDM is also couple to the General Circulation Model (GCM) predicted rainfall of the South East Asia - West Pacific regions to predict future trend of sediment load. A new novelty method of hind casting sediment load in ungauged watersheds to further improve RSDM is also investigated.

2.8.1 Model Development

The sediment load model is developed using empirical relationships and is based on the relationships between sediment load *Qs* [MT/yr] to basin drainage area *A*[km2], maximum basin elevation *E* [km], average basin slope angle *S* [^{o}], percentage vegetation cover per square kilometer *V*[/km2], soil moisture content *M*, and average basin rainfall *R* [m]. It is developed to describe the temporal variations of sediment load due to vegetation cover, soil and climate. The model uses five relationships which are all similar to the sediment rating curve developed by power regression. These are shown as below.

Area, *A*:	$Qs_1 = a_1 A^{a_2}$	(1)
Elevation, *E*:	$Qs_2 = a_3 E^{a_4}$	(2)
Slope, *S*:	$Qs_3 = a_5 S^{a_6}$	(3)
Rainfall, *R*:	$Qs_4 = a_7 R^{a_8}$	(4)
%Vegetation Cover (per km2), *V*:	$Qs_5 = a_9 V^{a_{10}}$	(5)
Soil Moisture Content, *M*:	$Qs_6 = a_{11} M^{a_{12}}$	(6)

For $Qs = Qs_1 = Qs_2 = Qs_3 = Qs_4 = Qs_5 = Qs_6$, the empirical relationships can be extended to the form:

$$Qs = b_1 \left(\left(a_1 a_3 a_5 a_7 a_9 a_{11} \right) \left(A^{a_2} E^{a_4} S^{a_6} R^{a_8} M^{a_{10}} V^{a_{12}} \right)^{b_2} \right)^{1/6} \quad (7)$$

The empirical model needs 12 sets of coefficients that need to determined using multiplicative regression model. The respective coefficients are deduced by fitting power relationships for all values of sediment load data and the variables. A predictive model is obtained that describes the relationships of sediment load to specific drainage basin features of climate, vegetation cover, soil characteristics and the size factor.

Table 10. Sediment discharge model by various authors

Ahnert (1970)	$Qs = A[D \times d \times 10^3]$ where $D = H_{ave} \times 0.1535 \times 10^{-6}$
Hay (1998)	$Qs = (H_{ave} - B_s) \times k_{ms}$
Hovius (1998)	$Qs = A \times Y$ where
	$\ln Y = -0.416 \ln A + 4.26 \times 10^{-4} H_{max} + 0.15T + 0.09 T_{range} + 0.0015R + 3.585$
Milliman&Syvitski (1992)	Qs=*A´Y where Y= c´A* $Qs = A\acute{}Y$ *where* $Y = c\acute{}A^f$ *and f & c vary from different elevation as shown below*

Maximum Elevation of Drainage Basin	c	f
>3000m	280	-0.54
1000-3000m	210	-0.46
500-3000m	12	-0.59
100-500m	8	-0.34
<100	5	-0.20

2.8.2 Data

Equation (7) is solved empirically by using sediment load data, elevation data, slope data vegetation data, soil moisture content and climatic data from parts of Indonesia, Papua New Guinea and Philippines. Summary of the data used is shown in **Table 11** below. Addition data source are as follows;

Rainfall:	Intergovernmental Panel on Climate Change (IPCC) (http://ipcc-ddc.cru.uea.ac.uk/)
Elevation and slope:	Hydro1K (http://edc.usgs.gov).
Vegetation cover:	Global Land Cover Facility GLFC (http://glcf.umiacs.umd.edu/index.shtml).
Soil moisture content:	National Climate Prediction Center (US) http://www.cpc.ncep.noaa.gov/soilmst/leaky_glb.htm

Table 16. Summary of Data

River	Observed (Mt/yr)	Source	Area (km^2)	Vege (%)	Rainfall (m)	soil moisture	Slope (%)	Veg/A (%/km^2)	Elevation (km)
Fly	237.9	Haris (1993)	58053	76	7	0.73	6	0.0013	3.82
Markham	51.9	Nedco (1980)	13163	65	4	0.50	4	0.0049	2.1
Mamberamo	304	Milliman (1995)	71195	61	8	0.70	4	0.0009	3.08
Digul	16	Milliman (1995)	023000	77	4	0.24	2	0.0033	1.75
Palau-palau	151	Milliman (1995)	25000	70	4	0.47	6	0.0028	2.9
Cijolang	7.2	Walling, (1982)	380	13	2	0.38	3	0.0342	1.265
Cikeruh	28	Walling (1982)	250	14	1	0.60	4	0.0560	2.326
Cilutung	7.2	Walling (1982)	600	22	2	0.32	1	0.0367	1.5
Cimanuk	25	Walling (1982)	3200	16	2	0.25	2	0.0050	1.22
Cimuntur	1.9	Walling (1982)	580	13	2	0.13	2	0.0224	1.3
Citanduy	13.1	Walling (1982)	2500	22	2	0.25	3	0.0088	2.1
Kali Brantas	8.1	Hoekstra (1985)	8500	23	2	0.33	3	0.0027	2.3
Porong	20.9	Hoekstra (1985)	12000	20	2	0.35	4	0.0017	2.575
Solo	19	Nippon Koae/FAO (1973)	16000	18	2	0.33	3	0.0011	3.1
Komering	33	Pickup (1983)	4474	54	3	0.54	5	0.0121	1.2
Purari	80	Chappell (1993)	21848	15	4	0.45	5	0.0007	3.3
Sepik	261	Haris (1993)	101821	77	11	0.71	4	0.0008	3.2
pampanga	10	Miner & Gulcur, (1971)	8400	5	3	0.24	2	0.0006	1.03
agno	51	Miner & Gulcur, (1971)	7460	15	4	0.24	3	0.0020	2.1
Mahakam	243	Milliman (1995)	98194	74	5	0.61	5	0.0008	4.095

3. Results & Discussion

3.1 Hydrodynamic and Biochemical Characteristics of Puerto Galera

3.1.1 Meteorological state

Figure 25 shows the time variations of the wind vector, solar radiation, air temperature, relative humidity and precipitation rate during the observation period from 22 February to 8 March 2007. The wind field was dominated by a Southeast wind which seldom changes to a Northeast wind. The prevailing wind blew almost continuously at about 5 m/s except on 26 February when there was no wind. Since the survey was conducted in summer, the precipitation rate is very small (maximum of 7 mm/hr). The highest rate of precipitation during the field survey occurred on 3 March and the much smaller rain occurred on 2 February and 7 March. Air temperature and relative humidity show clear diurnal fluctuation between 25 and 27 degree centigrade, and between 60 and 95 percent, respectively. The solar radiation data shows that it was sunny almost everyday except 27 February, 2 March and 7 March.

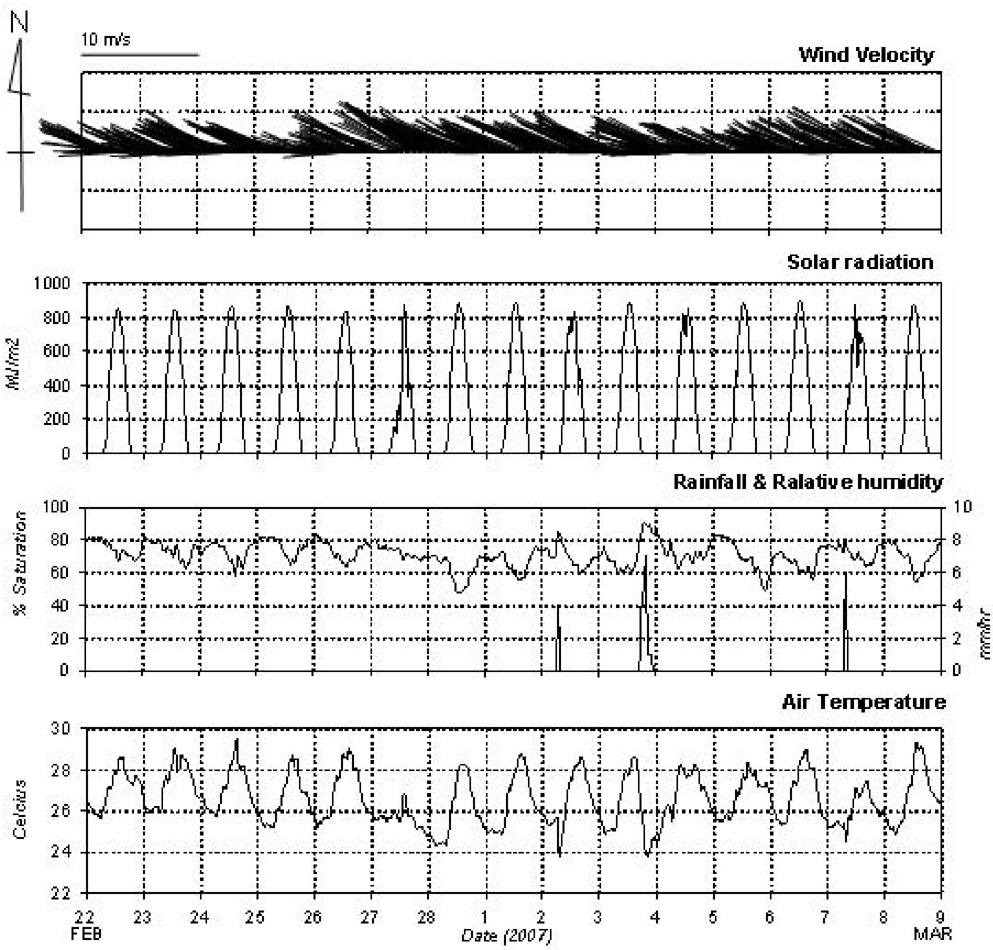

Figure 25. The record meteorological parameter from weather station showing wind velocity vector, solar radiation, rainfall, relative humidity and air temperature during survey period.

3.1.2 Oceanographic State

Figure 26 shows the observational tidal fluctuations, and current velocities recorded from the outer sea area at O2 sta. and O3 sta. The velocity records are expressed as 1hr-averaged and 25hr-averaged values. The current velocity is highest during neap tide, and lowest during spring tide. Moreover, flow velocity fluctuations show a semi-diurnal fluctuation pattern even in the diurnal tidal fluctuation period. This tells us that the hydrodynamics here is not simply governed by lunar water level changes. The measured velocities at O2 sta. and O3 sta. also suggest that the majority of flow directions are toward the East direction. The 25hr-averaged mean flows have non-zero values in both stations. The mean flow velocity magnitudes approach zero at diurnal spring tide and increase at semi-diurnal neap tide.

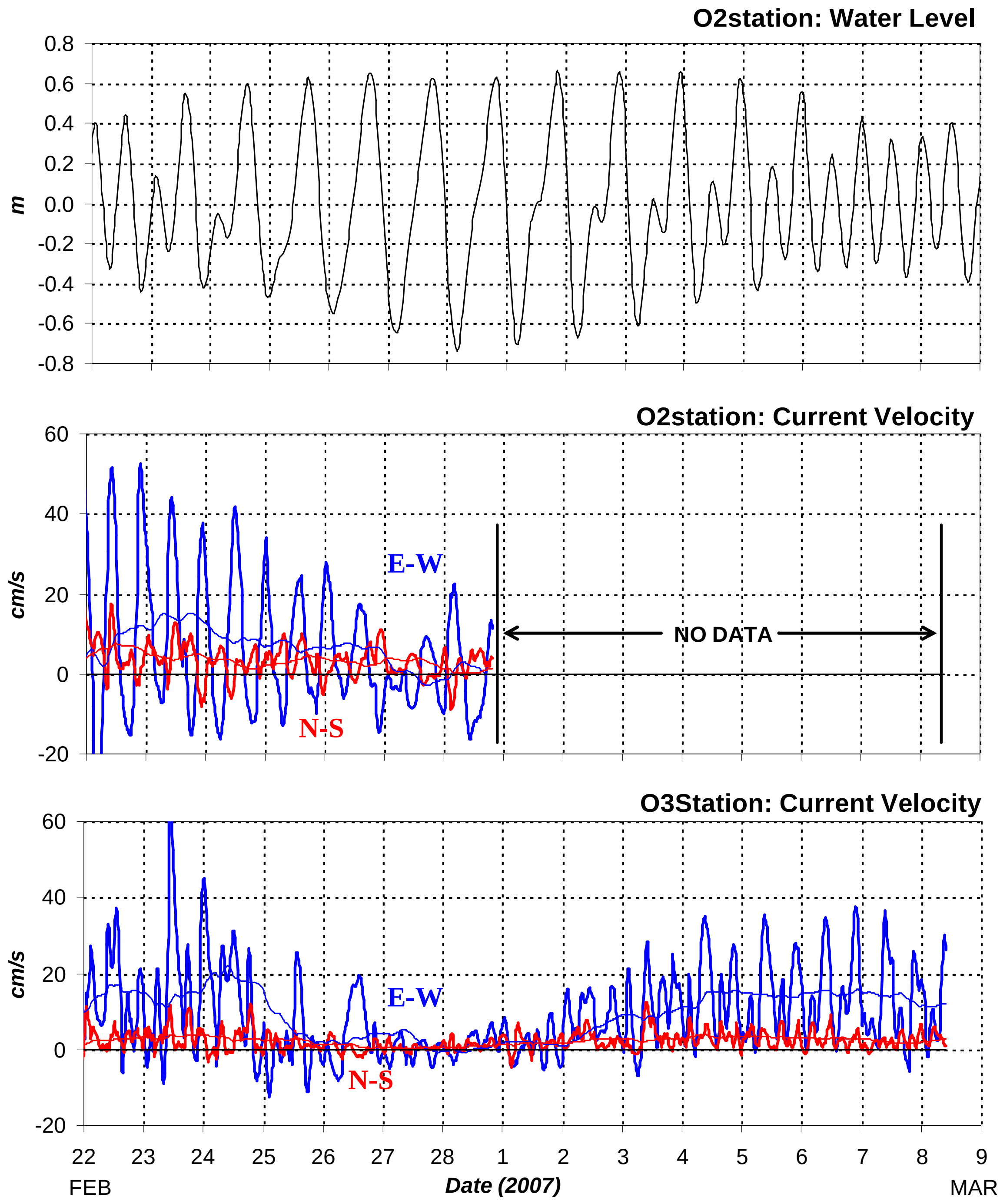

Figure 26. The water level and measured near-bottom current velocities in the North-South (N-S) and East-West (E-W) components outside the lagoon. The bold lines are 1-hr averaged flow velocity while the thin lines show residual current from 25-hr averaged flow velocity.

Data from both field survey and simulation of currents at channels demonstrate the close relationship with the outer sea. **Figure 27** presents the 1hr-averaged and 25hr-averaged flow velocity at lagoon interior from C1 sta., C2 sta., C3 sta. and water level at B2 sta. Comparing **Figure 26** and **Figure 27**, it can be seen that the current fluctuation at channels are almost identical to the outer sea. However the magnitudes of flow fluctuations are slightly smaller. The 25hr-average mean current at C1 sta. and C3 sta. show non-zero values with unidirectional flow direction to the East. The similar water moving pattern between the outer sea and at the channels implies that the water in these locations may be governed by the same factor. In contrast with the adjacent strong current at the channel, the current recorded at C2 sta. is much more sluggish. It shows the maximum current of about 5 cm/s and almost no notable fluctuation pattern as the one at the channel stations (C1, C3). Water level record at station B2 and O2 (not shown here) shows that the water level in and outside the Puerto Galera lagoon are about the same at all time during the observation period. The overall circulation patterns from numerical model are shown in **Figure 28**.

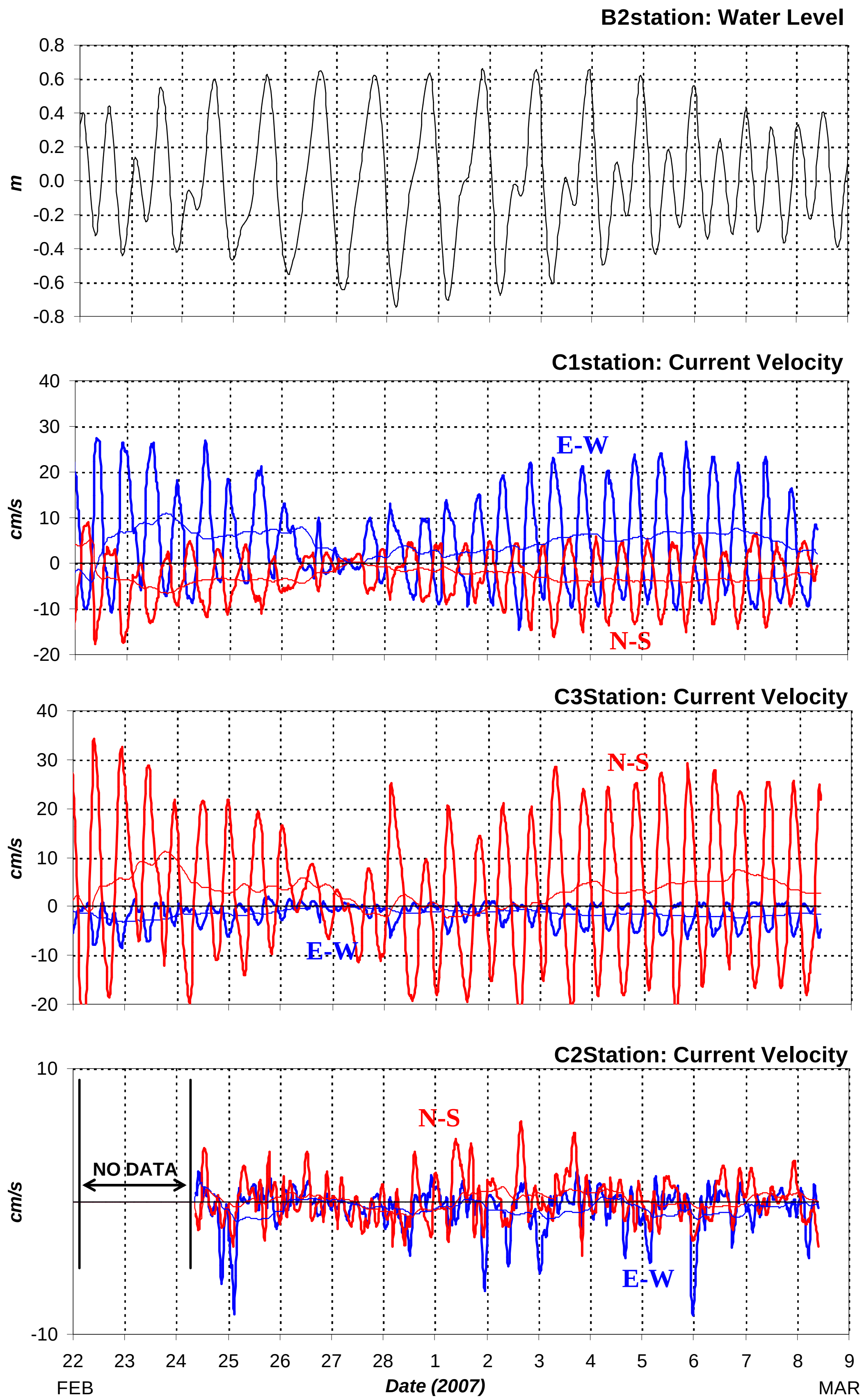

Figure 27. The water level and measured near-bottom current velocities in the North-South (N-S) and East-West (E-W) components inside the lagoon. The bold lines are 1-hr averaged flow velocity while the thin lines show residual current from 25-hr averaged flow velocity.

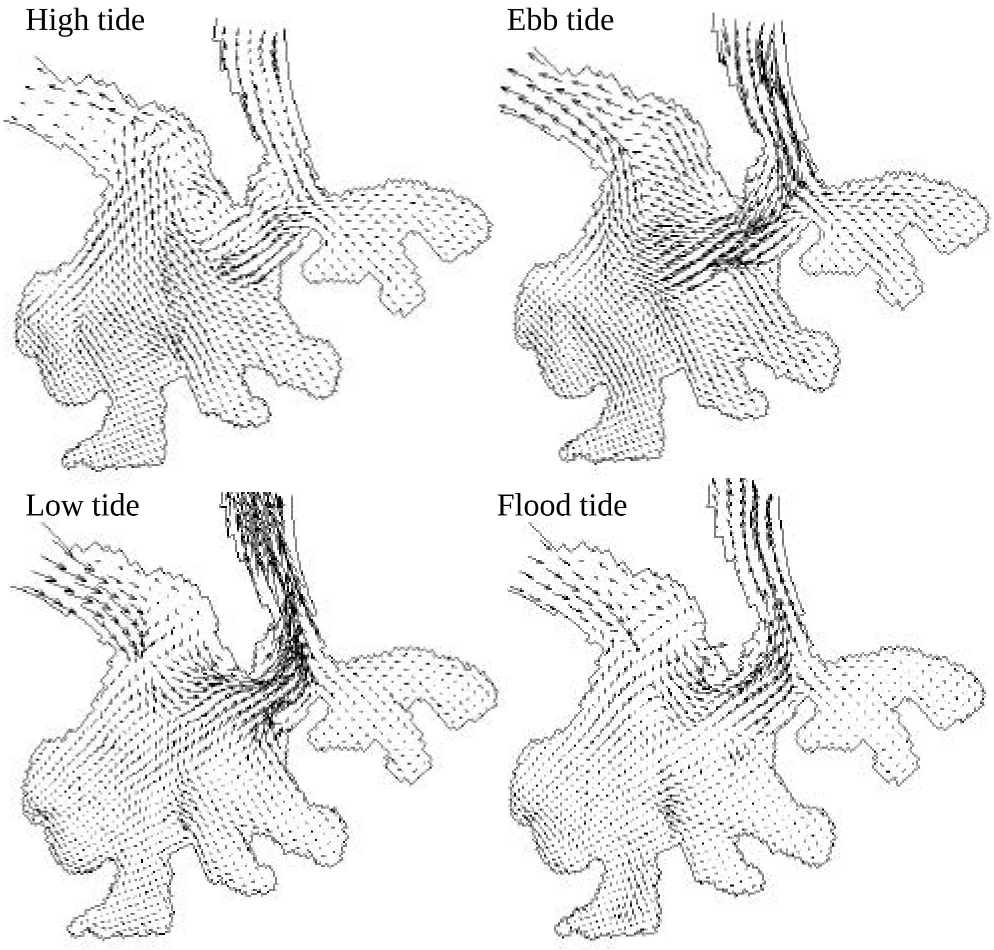

Figure 28. Flow velocity field of near-to-the-surface circulation of PG during neap semi-diurnal tide showing two current regime inside the lagoon.

Aside from tidal fluctuation circulation feature, PG hydrographic condition also of depict close relationship with the water temperature. **Figure 29** shows the time variation of water temperature at outer sea, channels and lagoon interior at O2 sta., C2 sta. and B2 sta., respectively from the observational data. The upper layer water appears to be always warmer than the lower layer wherein the average deviation range is 0.2 to 2 centigrade at C2 sta. and B1 sta. and less than 0.1 to 2.5 centigrade for O2 sta. There is a prominent diurnal pattern for the water temperature fluctuation of the upper layer following the meteorological condition. This temperature variation can be observed at every station. However, the stations inside the lagoon tend to have a bigger fluctuation. In contrast with the upper layer, the lower layer water temperature tends to maintain a colder constant temperature as can clearly be notice from 4 March to 9 March. The water temperature difference between the upper and lower layers at O2 sta. is relatively smaller. Moreover, the frequency of abrupt change in water temperature is much higher than the other stations. These might be attributed to the fact that O2 station is located at a highly unstable flow area. The turbulence created by strong currents horizontally and vertically mixes the water column very well resulting in the smaller water temperature deviation and higher frequency of abrupt temperature changes. Notice that during the period of weak current at offshore stations (between 26 February and 27 February); the water temperature difference is higher than the period of strong current. In general water temperature inside Puerto Galera bay is warmer than at the outer sea (not shown here), and the mismatch of water temperature from layers are larger. Furthermore, it is seen that the differences of water temperature between the upper and lower layers tend to be higher at stations which have slower current (B1, B2, B3, B4, C2) than the stations which have stronger current (C1, C3, O2).

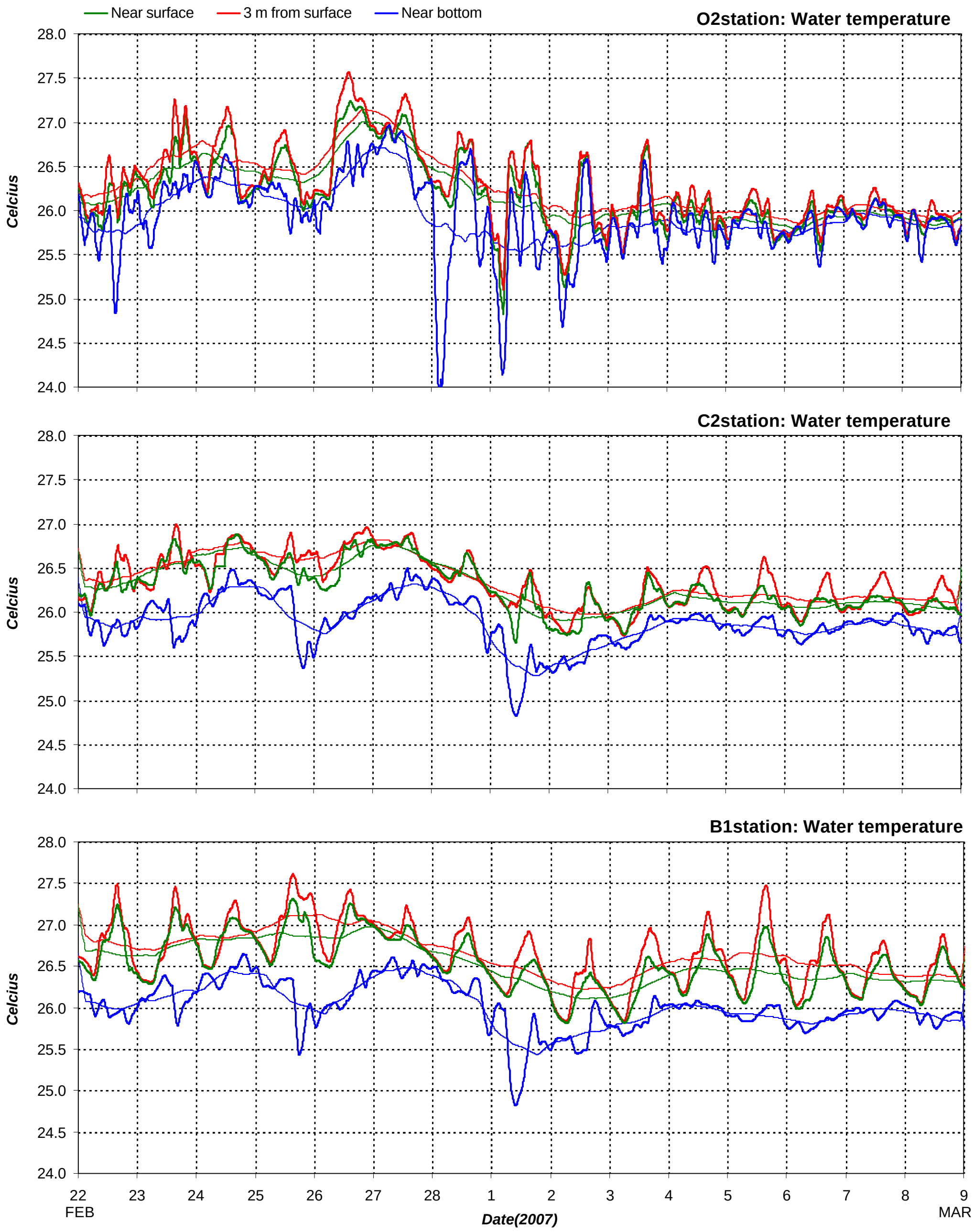

Figure 29. The water temperature of near-surface, 3m and near-bottom measured at B1, C2 and O2 sta. The 1-hr averaged and 24-hr averaged are shown as bold and thin lines.

On 23 February, 25 February and 1 March, the water temperature show abrupt changes making the water temperature difference between the upper and lower layers to be highest. This intermittent drop of lower layer water temperature could also be reproduced in the simulation showing that the cold water were supplied from outer sea through mainly Manila channel. The sporadic intrusion of cold water based on numerical simulation is shown in **Figure 30**. Notice that the clean cold water from intrusion can reach the inner most part of the lagoon. This hydrodynamic feature can greatly enhance the water exchange and mitigate water quality problem at Muelle cove.

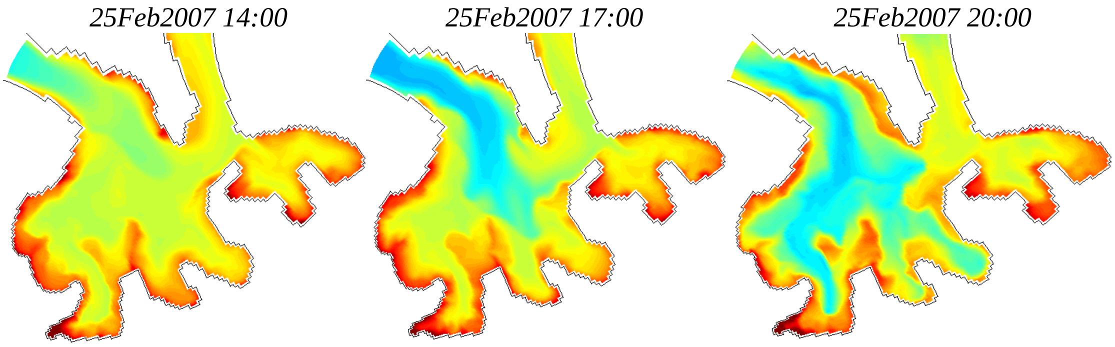

Figure 30. Near-bed water temperature distribution from numerical simulation. Blue and red colors indicate the cooler and warmer water, respectively.

Spatial variability of the lagoon biochemical properties

The spatial distribution of 7-day-temporal&depth averaged concentration from water sampling analysis of ammonium, nitrate, nitrite, phosphate, silicate, chlorophyll-a and turbidity from water are shown in **Figure 31**. The ranges and average concentrations of the measuring parameters are given in **Table 12**. The distribution of Chlorophyll-a and dissolved oxygen concentration from numerical simulation are given in **Figure 32**. The spatial variation of chlorophyll-a concentration between simulation and field observation agree well showing the area close to Muelle cove have highest concentration. This area is perceived to receive the largest nutrient influx from community and pier activities. The turbidity and chlorophyll-a concentrations display similar distributions which their concentration tend to be higher along the coastline inside the lagoon, and highest at Muelle Cove. The distributions suggest their close relationship. It implies that the algal biomass might be the main contributor to the water turbidity in this area. There is no big river in Puerto Galera bay's vicinity to supply suspended sediment. During the survey, the suspended sediment concentrations were in the range of 1-3 mg/L. For the distribution of nutrients, most of the nutrients (except ammonium) have higher concentrations in the bay interior compared to the channel and outer sea areas. This may be due to the lagoon being a source of algal biomass and nutrients to the adjacent coastal waters.

Table 12. Ranges of nutrient concentration observed during 25February to 3March, 2007. Number with and without parenthesis mean the concentration bottom and surface respectively.

Component	**Range**	**Average value**
Chlorophyll a (mg m-3)	0.103-1.618 (0.210-1.688)	0.572 (0.667)
Ammonia (mg/L)	0.010-0.021 (0.012-0.023)	0.016 (0.016)
Nitrate (mg/L)	ND-0.086 (0.006)	ND-0.103 (0.014)
Nitrite (mg/L)	ND-0.022 (0.001-0.008)	0.004 (0.003)
Phosphate (mg/L)	0.004-0.034 (0.007-0.036)	0.023 (0.025)
Silica (mg/L)	0.097-0.427 (0.105-0.615)	0.157 (0.178)
*ND, non-detectable		

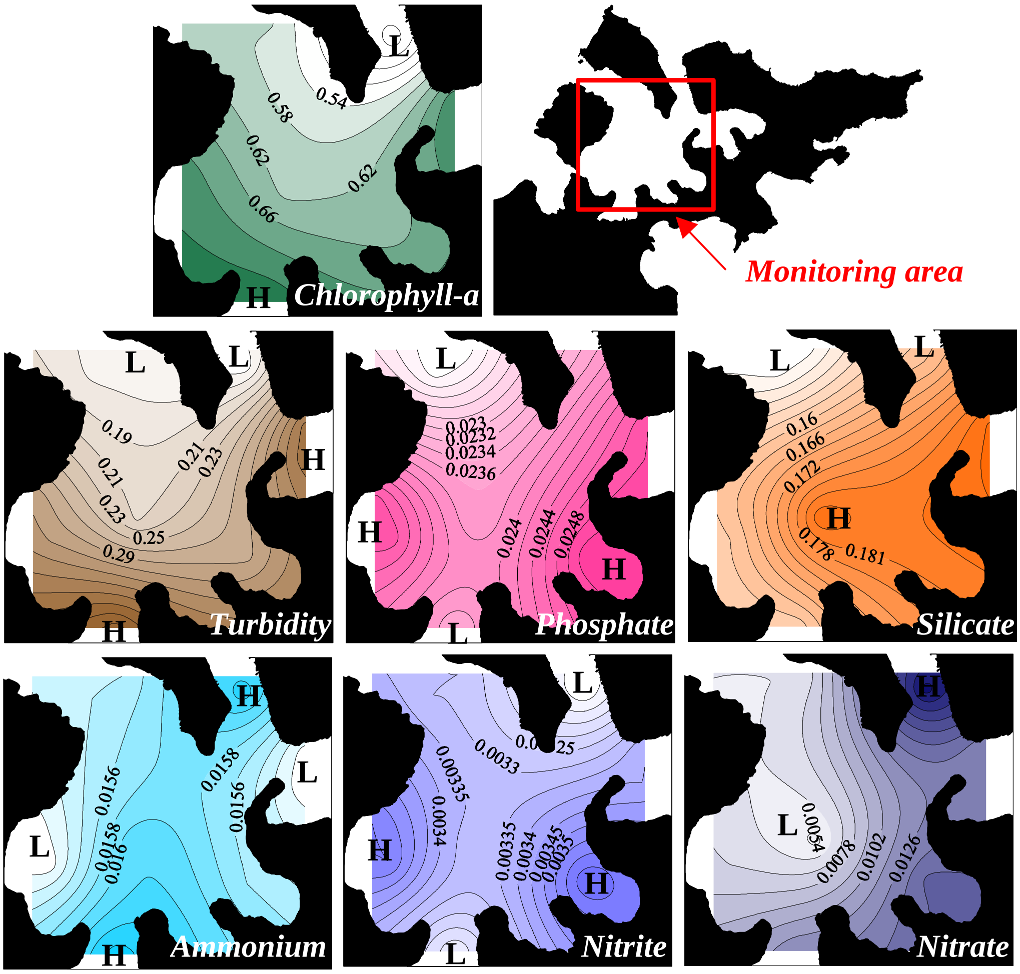

Figure 31. 7-days depth-averaged chlorophyll-a, turbidity and nutrient concentrations. The data is derived from laboratory analysis of water samples. The contours are derived from spatial interpolation of data from seven fixed observation stations reside in the bay.

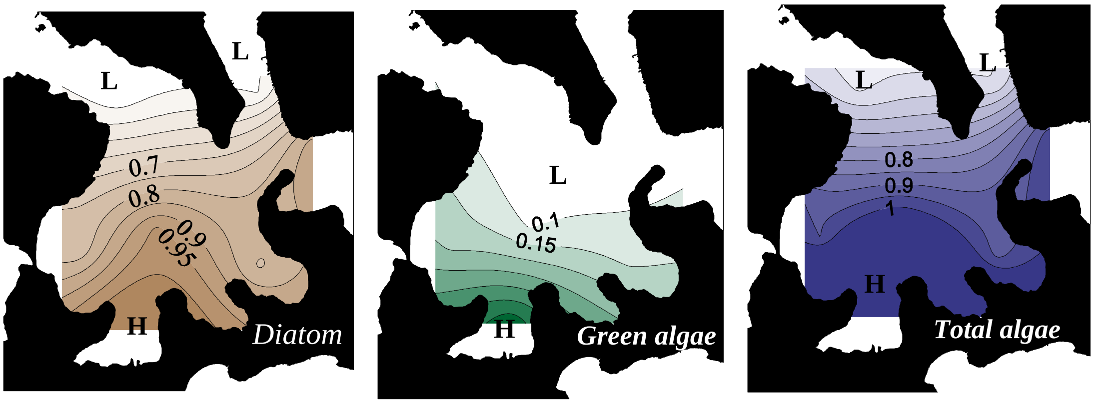

Figure 32. Spatial distribution of the depth-averaged total algae, diatom and green algae classified by Fluoroprobe. The sensor was set to measure five different types of parameter i.e. diatom, green algae, blue algae, cryptophyta and yellow substance. However, only diatom and green algae have detectable concentrations.

Table 13 gives the results of algal classification for three consecutive days from 25 February to 28 February 2007 by the fluorometry technique using Fluoroprobe instrument. The measurement data reveals that only two kinds of algal species are dominated in the Puerto Galera lagoon i.e. diatom (83%) and green algae (16%). The presence of other algae (blue algae, cryptophyta) and yellow substances are negligibly small. The overall distribution of diatom, green algae and total concentrations are shown in **Figure 32**. Green algae appear to have high concentration around the Muelle Cove. The concentration decreases rapidly toward the channels. Diatom concentrations also elevate close to Muelle Cove. The higher concentrations of diatom appear at the area of relatively slow flow velocity. **Figure 33** is the time history of dissolved oxygen and chlorophyll-a at the monitoring stations. The chlorophyll-a concentration measured by the memory-type sensors (COMPATCT-CLW, Alec) agree well with the laboratory analysis of water samples showing that the higher concentrations can be found at the lagoon interior. The chlorophyll-a concentrations fluctuate between 0.5 to 2.0 mg/L during the biomass production peak period and between 0.25-1.00 mg/L during other period. The highest daily chlorophyll-a concentration at the water surface was around 6p.m. and the lowest was around 12a.m. Dissolved oxygen concentrations vary between 7 to 8 mg/L (super saturated) during the biomass production peak period and between 6 to 7 mg/L during other period. Figure17 also shows the similar behavior of the time history of chlorophyll-a and dissolved oxygen, revealing the role of phytoplankton to modify oxygen concentration of the surrounding water. However, the 7day-averaged concentration of dissolved oxygen during synoptic survey indicates that the amount of dissolved oxygen inside the lagoon were smaller than that at the outer sea. This might be attributed to the higher biological consumption of oxygen and demand of oxygen to decompose wastewater load from the surrounding communities inside the lagoon. The spatial distributions of dissolved oxygen and chlorophyll-a concentration from the numerical simulation are shown in **Figure 34**

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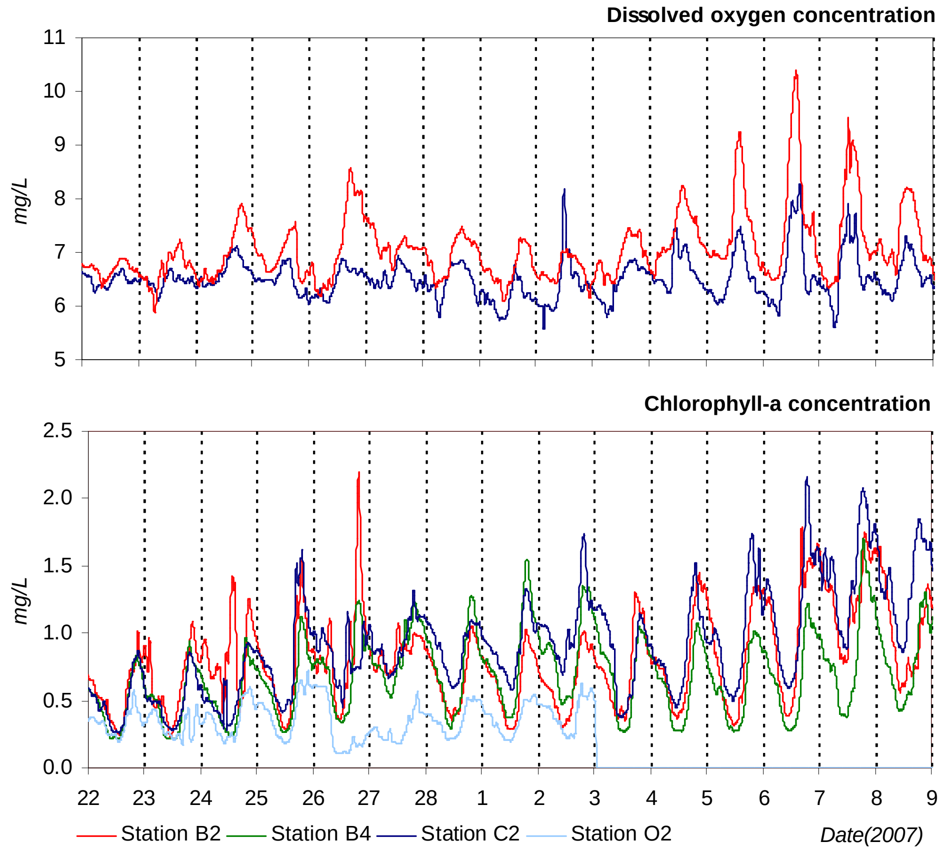


Figure 33. The time history of chlorophyll-a and dissolved oxygen concentration measured at near-surface and near-bottom respectively.

Table 13. Ranges of algae concentration observed during 25 to 28February, 2007.

Component	Range	Average value	Percent
Diatom	0.20-1.53	0.64	83.12
Green algae	0.01-0.67	0.12	15.58
Blue algae	0.000-0.045	0.004	0.52
Cryptophyta	0.000-0.245	0.003	0.39
Yellow substances	0.000-0.035	0.009	1.17
Total	0.23-2.28	0.77	100

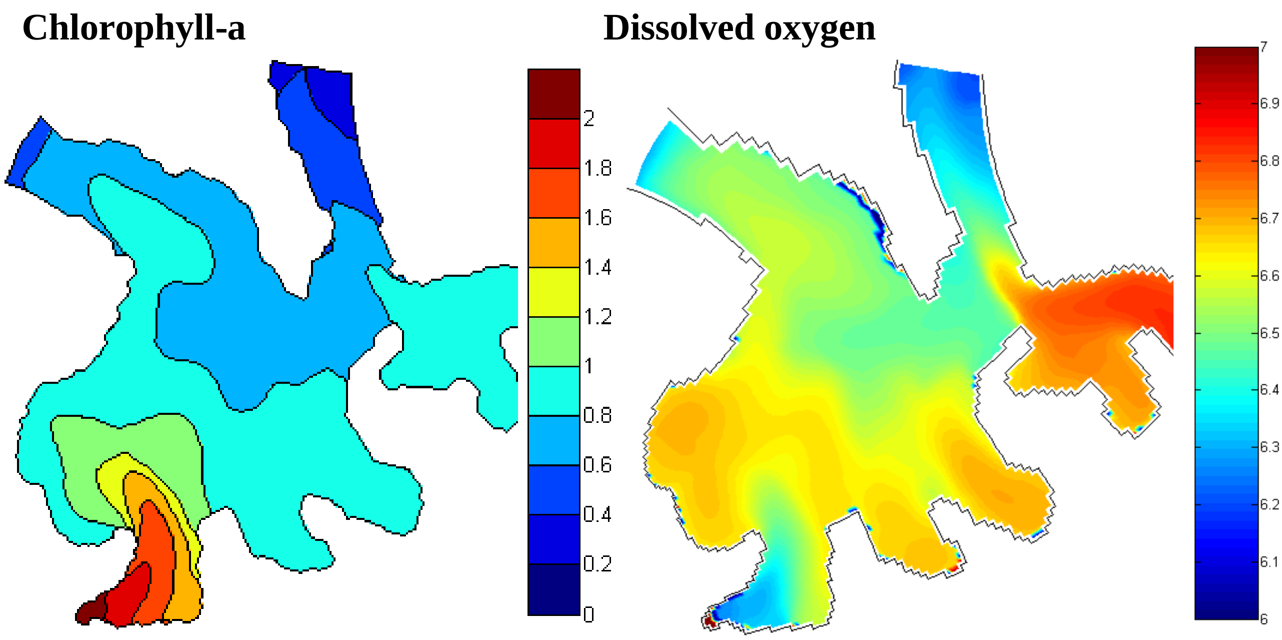


Figure 34. Spatial distribution of dissolved oxygen and chlorophyll-a from the water quality model

DISCUSSIONS

Offshore circulation from tide and topographical effects

As can be seen from **Figure 26**, the fast moving offshore currents appear during diurnal spring tide in both stations O2, O3. Moreover, the current persistently exhibit semi-diurnal fluctuations even in the diurnal turnover change of the water level. We found that the water levels at the two ends of the Verde Passage, within which Puerto Galera is situated, have different patterns in fluctuation. **Figure 35** shows the tidal fluctuation pattern map around the Philippine region. The water level differences between the two ends display a semi-diurnal fluctuating pattern having the highest value during neap tide. The developed water level gradient in the passage induces current which moves Eastward during low and flood tides, and Westward during high and ebb tides. The gradients are mild during diurnal tide and correspondingly generate slower flow in this period. **Figure 36** shows the relationship of water level difference and current speed at stations C1, C3, O2, and O3. The persistent Easterly flow is attributed to the separated flow created by eddies. During low and ebb tide, the water moves from the South China Sea toward Sibuyan Sea. The Westerly current slowly moves towards the west side of Puerto Galera lagoon where the cross-sectional area of the passage is wide. The currents flow faster when a large volume of water is force to flow through a narrower cross-section in the North and East side of Puerto Galera. At these times the overall Westward flow pattern is dominant. **Figure 37** shows the overall flow pattern from preliminary numerical simulation. When the current reverses its direction and flows in the opposite direction during flood and high tides, the fast-moving current moves from Sibuyan Sea toward South China Sea. When this current moves into or through slower-moving water on the North and West side of Puerto Galera, its force displaces the quieter water and captures additional water. The current oscillates and develops waves along its boundary that are known as meanders. The meanders break off to form eddies, or pockets of water moving with a circular motion; eddies take with them energy of motion from the main flow and gradually dissipate this energy through friction. This locally generated eddies are responsible for the overall observed semi-diurnal pattern with non-zero unidirectional mean flow to the East at the offshore and channels. These eddies may stir the water column right down to the ocean floor, agitating large amounts of sediment. The strong eddies cause very well mixing of the algae-rich warmer upper layer with the nutrient-rich cooler lower layer, thus high productivity and homogenous water properties over large areas. This process may be an essential process to maintain high biological productivity in Verde Passage as well as Puerto Galera bay.

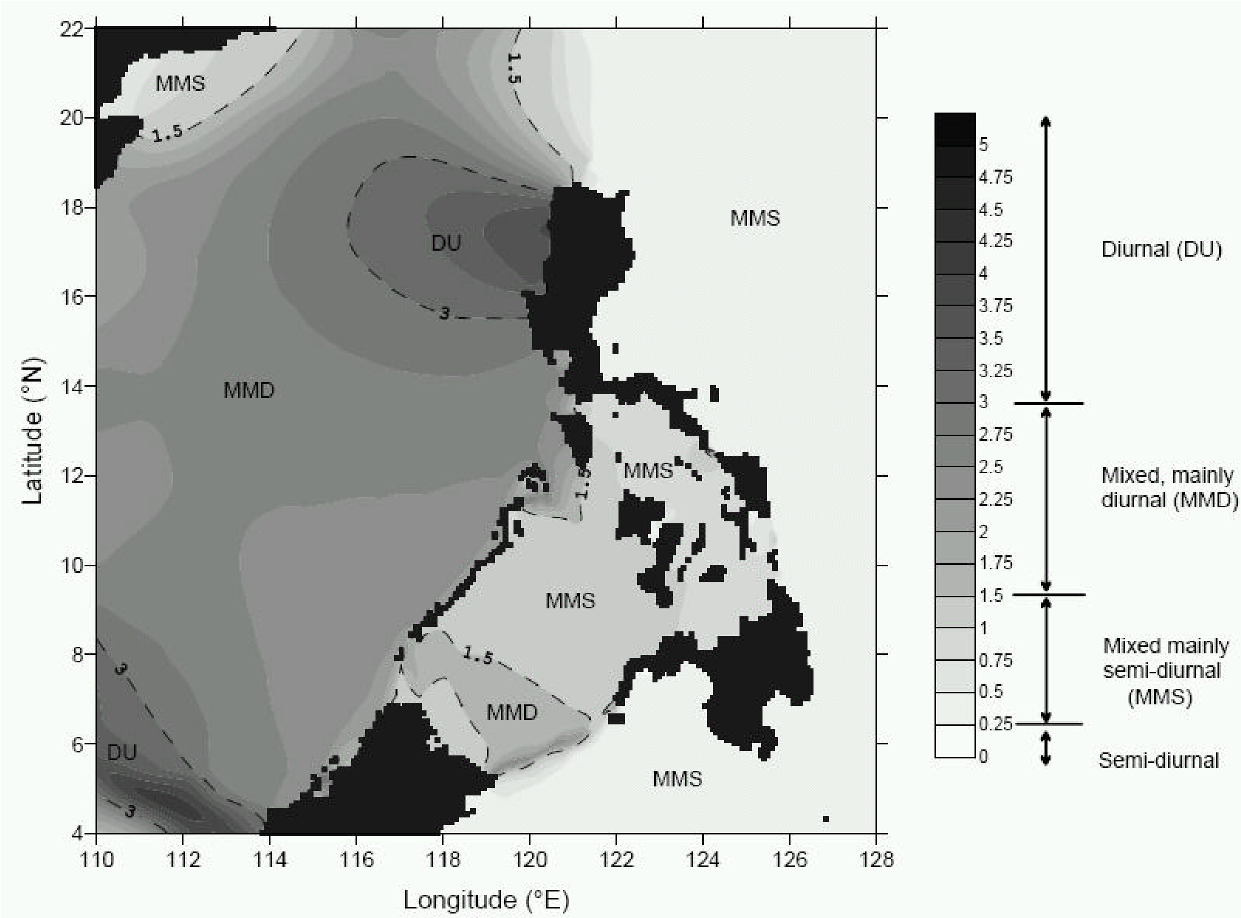


Figure 35. Geographical distribution of tidal types obtained from the ratio of the dominant diurnal components with the dominant semi-diurnal components (Magno, 2005).

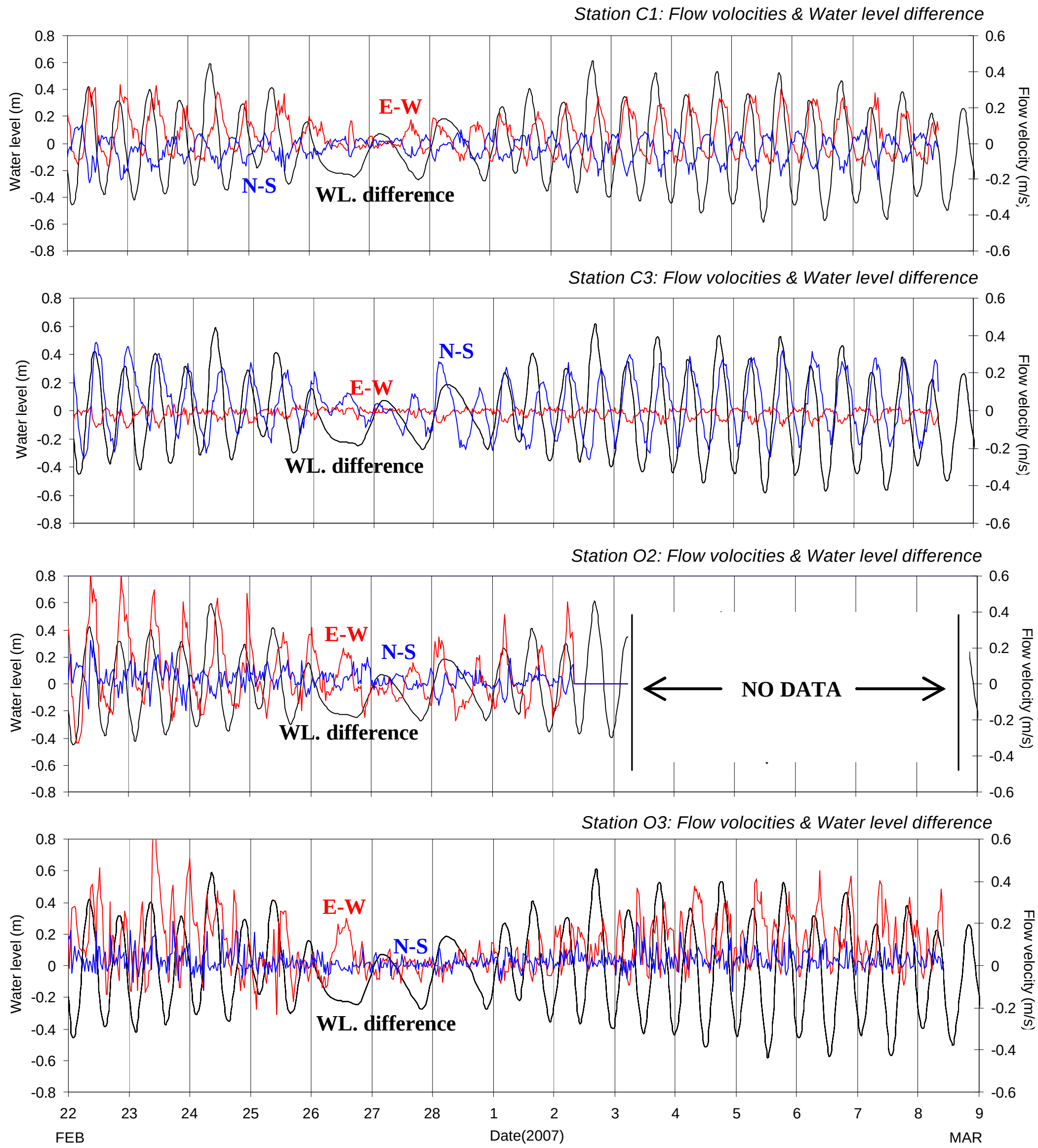


Figure 36. Relationship of water level difference between two ends of Verde passage and flow velocities in North-South (N-S) and East-West (E-W) components at C1, C3, O2, O3 station.

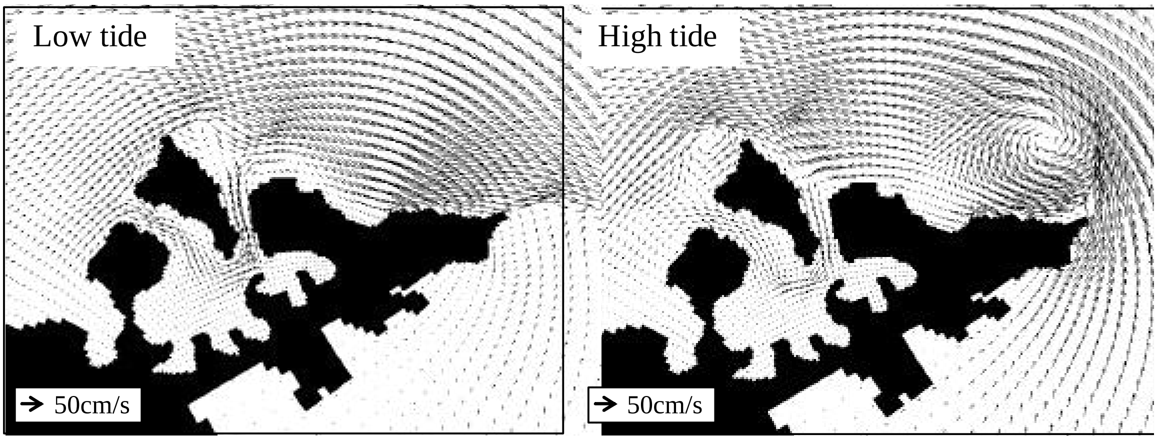


Figure 37. Snapshots of hydrodynamic simulation showing two current regimes at PG vicinity. The large counter-clockwise eddies locally modified the general west-ward flow and create a non-zero mean current at various locations.

Effect of wind and gravity current on the lagoon interior circulation

The currents are much weaker inside the Puerto Galera lagoon compare to the outer sea. The offshore strong currents enter the lagoon through the Manila Channel during ebb and low tides and Batangas Channel during flood and high tides. Most of the waters infiltrated immediately exit the lagoon at other channel. As a result, the current velocity inside the lagoon is characterized by slow circulation, which has a different flow pattern compared with the channel stations and the offshore. The sluggish circulation of the lagoon interior make it one from wind-driven current and density-driven current to be more evident. **Figure 38** shows the 1hr-averaged flow velocities measured from the near surface and close to the bottom at station C2. At almost all times, the current at the near surface (upper layer) and close-to-the-bottom (lower layer) flow in different directions. This suggests that the current in the lagoon might have changed from the barothophic mode (vertically uniform) to baroclinic mode (two-layer flow). **Figure 38** also shows the 25hr-averaged flow in two layers in compared with wind. It can be seen that the surface current moves Northward due to the Southeast wind. In the absence of wind, specifically the 26 February, the mean current switches its flow direction from the North. Comparison between wind and surface flow velocity in North-South and East-West components (not show here), shows that the stronger wind can speed up the surface water. It can also be noticed that the time lag of surface flow velocity in response to the wind condition is approximately one day.

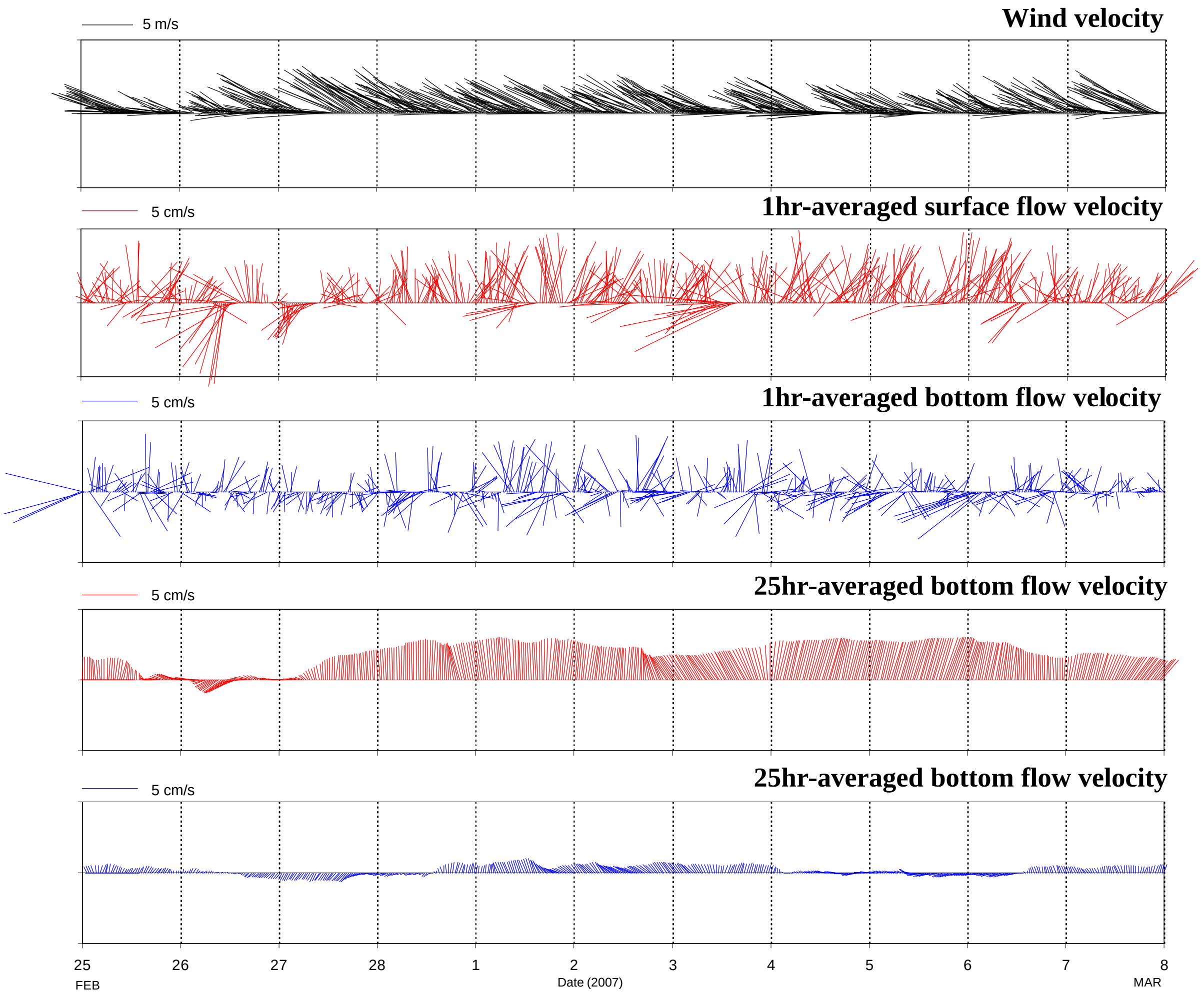


Figure 38. The stick diagram of wind velocity, near-surface and near-bottom flow velocity measured from C2 station.

The density of the coastal water is generally controlled by salinity and water temperature. Due to a negligible change in time and space of the salinity at the lagoon, the larger water temperature fluctuation seems to be the main density modifier and controls the density-driven circulation. As the cool waters from the outer sea approach the warmer waters in the lagoon, the cool waters infiltrate in to the lagoon interior along the sea bottom. This makes the near-surface and close-to-the-bottom water temperature to be different almost at all time. The surface water temperature is mainly controlled by the meteorological condition. Close to the bottom of the sea, the temperature is controlled by of cool waters from the outer sea. It seem that there are 2 regimes of cold water supplies: large amount of cold water infiltration producing large temperature drop, and small amounts of cold water infiltration for a continuous yet small decrease in temperature. The 2nd regime may be the main contributor in keeping the difference in water temperature between the upper and lower layer. The 1st regime massive supply of cool water can be noticed at 23 February, 25 February and 1March. This regime can bring cool water to the inner most part of the lagoon at Muelle Cove. Its flow characteristics may prove to be very important in enhancing the renewal of water at the innermost part of the lagoon where the water exchange ability is thought to be insufficient. **Figure 30** and survey data also suggests that the massive intrusion occur through the Manila channel with a time lag of about 3 hours for the cool water to travel to the innermost part of the lagoon at B2 station. This implies that the source of cool water for massive intrusion is from the deep basin in front of Manila Channel. The deep cool water may approach the lagoon vicinity and then further move into the lagoon. Interestingly, not every time the approached cool water may further intrude into the bay, (for example as 28 February in **Figure 38**).

The controlling mechanism to trigger the massive intrusion is subject to further research.

It seems that the wind-driven circulation and density-driven circulation have similar flow patterns; the surface water flows outward while the bottom water flows inward to the lagoon. Therefore, this may imply that the wind and density difference in this area have an additive effect, thus, increasing the intensity of the two-layer circulation. Both of them contribute to the circulation that enhances the water exchange ability of lagoon water.

Roles of sporadic gravity current and sandbar to the in-lagoon water conditions

The residence time of pollution is usually considered to affect a lot the water quality condition of coastal water. The longer the residence time, the more vulnerable the coastal water to be degraded in quality. The study employed particle tracking analysis technique to monitor water residence time from three hydrographic scenarios i.e. present circulation, the circulation with out gravity current and circulation after re-opening the sandbar. Muelle cove is chosen to be the area to release 8,000 particles. The calculations run for two weeks. **Figure 39** shows close-to-the-surface distribution of concentration of released particle in various elapse times of each scenario. If treat particle as pollution from wastewater loaded into the lagoon, it is clear that the pollutant residence times between case with and without gravity current are very much different. Wastewater tends to stay much longer without the intermittent intrusion of cool water from outer sea. This emphasizes the important of the intrusion to maintain water exchange and water quality inside the lagoon especially at the inner most part Muelle cove. Minor differences in wastewater residence time can be noticed between present circulation case and circulation after reopening the sandbar. This might because the relatively shallow topography of the sea floor at another side of the sandbar. Although the simulation re-opened the sandbar with about 20 m. width and 3 m. depth, ability of pollutant to flush out through this channel was limited.

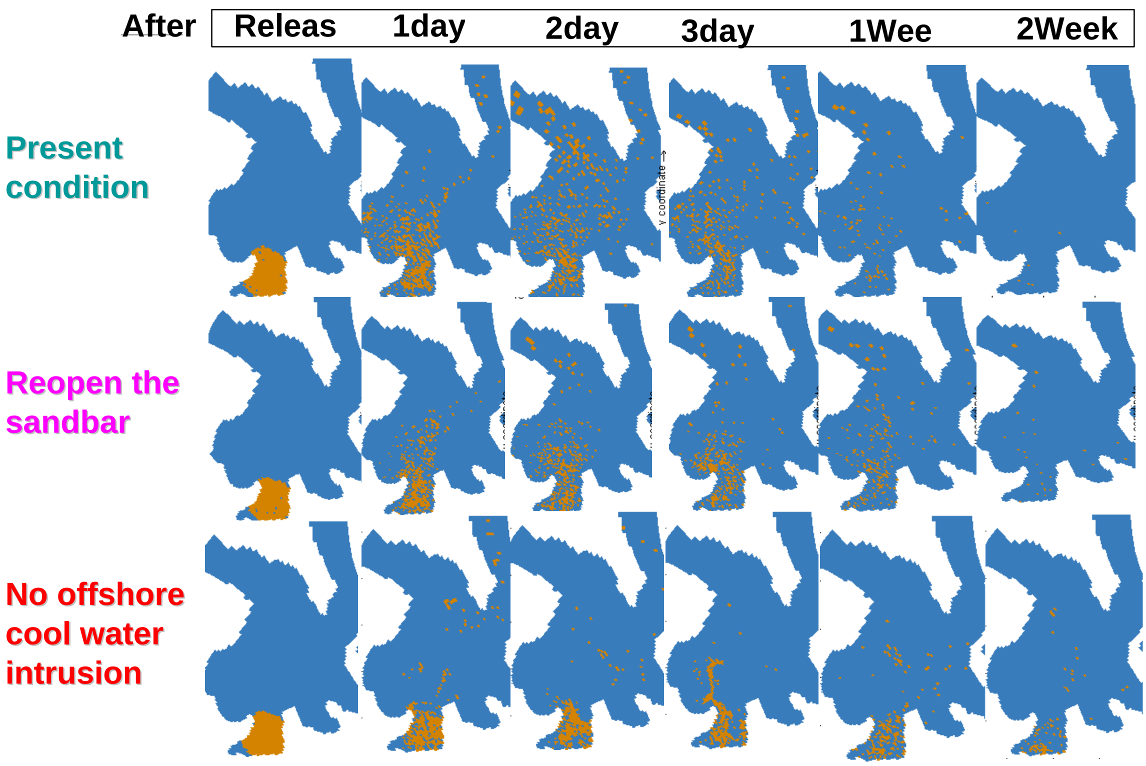


Figure 39. Close-to-the-surface distribution of concentration of released particle in various elapse times of each scenario.

Anthropogenic nutrient loads and biochemical properties

Euthophication is a well known environmental problem caused by over nutrition from wastewater discharged from human activities along the coastal zone. The problem has recently doomed the natural coastal ecosystem including Puerto Galera lagoon. The gradual decline in its water quality in the lagoon has become an important public concern and is considered to be a result of various factors, e.g., increase in tourist activities, deforestation and urbanization with poor wastewater management. To mitigate the foreseeable water quality problems, the studies employed developed water quality model running three scenarios in which nutrient influx are different. The location of to discharge various environmental load is at Muelle pier.

The results of simulation are shown in **Figure 40**. It can be seen that the water quality in term of dissolved oxygen concentration are different in each cases. Halved the wastewater load can increase dissolved oxygen concentration. In contrast three times increase in wastewater load will further reduce concentration of dissolved oxygen. In term of phytoplankton biomass the more wastewater load, the higher concentration of phytoplankton biomass. As discussed earlier, in PG lagoon the availability of phytoplankton in water column govern turbidity and can further block the sunlight to reach sea floor. Although, have not yet include in the calculation, this characteristic can further deteriorate to the benthic communities fating out dissolved oxygen production. Furthermore, the phytoplankton detritus after they die can settle down easily to the sea bed in the sluggish circulation in side the lagoon especially at Muelle. Decomposition will take place and consume large amount of dissolved oxygen. Therefore, large area of high chlorophyll-a concentration is greatly vulnerable to the degradation of the benthic ecosystem and appearance of hypoxic water in future.

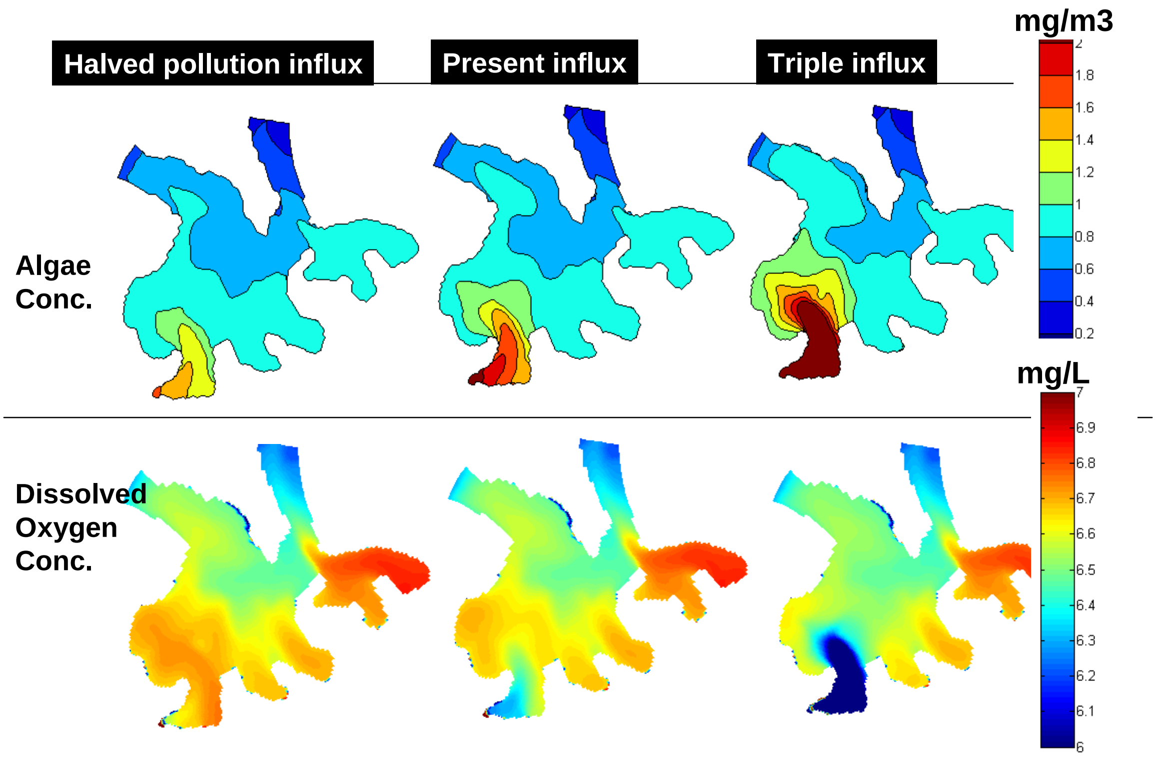


Figure 40 Water quality simulation results from three different rate of wastewater discharge in Muelle cove.

PG lagoon water is also sensitive to the nitrogen nutrient addition which is a common substance from anthropogenic sources. The average Si:NO3:PO4 value during the synoptic survey was determined to be 7:2:1; much lower than the modified Redfield ratio of 15:16:1. This is an indication of nitrogen limitation. Since concentration of the nutrients in seawater changes in relation to the fixed concentration ratio in the organisms, the ratio in the organisms obtained indicates that the system (i.e. the bay and associated primary producers) would be very sensitive to any significant increase in nitrogen. However, the absence of any temporal or spatial variation trend for phosphate and silicate seems to be associated with the less sensitive response of the system to nitrogen as implied by the observed ratio.

3.1.2 Socio-physical monitoring for mitigating water quality deterioration in Puerto Galera's tourism areas

The results of the interview survey in percentage were plotted in a uniform way following the convention and legend as shown in **Figure 41**. All the corresponding data for tourism sector were placed on the left side while those for household sector were placed on the right. Through this way, comparisons between household and tourism sectors and among the three tourism sites are possible.

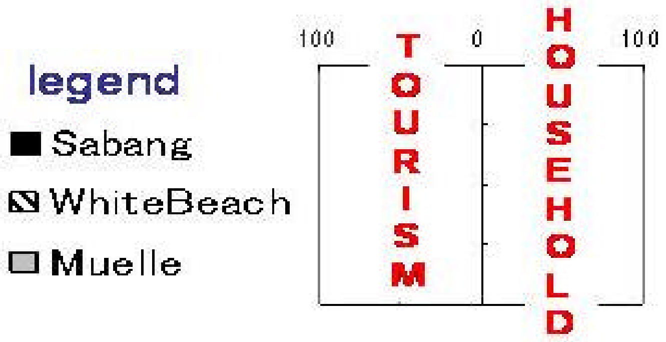


Figure 41. Legend and convention used in showing the interview survey results.

Availability of sanitation facilities

In **Figure 42**, advance toilet facilities as indicated by flush-type toilet were found in all tourism establishments in White Beach and in most establishments and households in Sabang and Muelle. However, most households in White Beach had pour-type toilets.

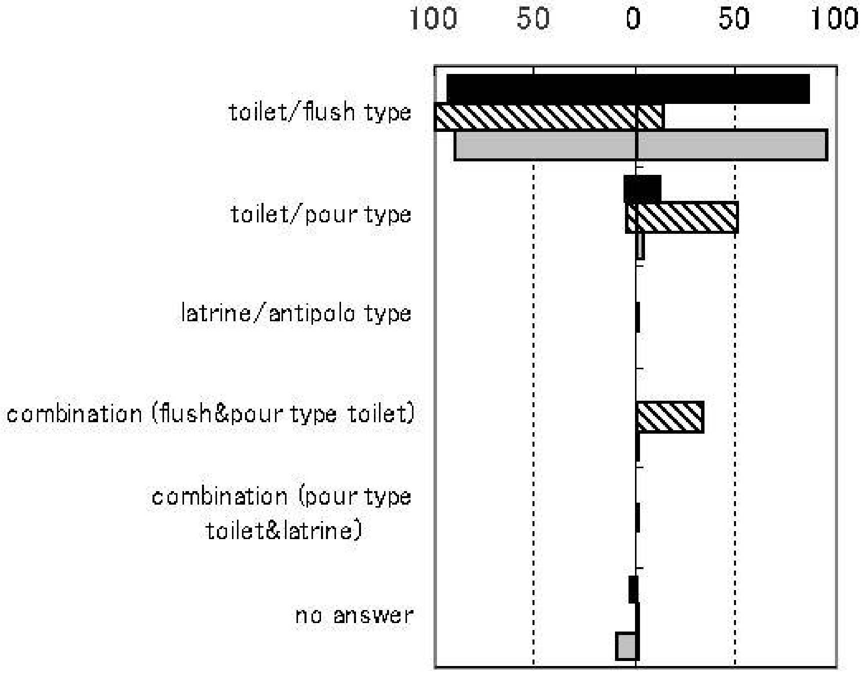


Figure 42. Type of toilet facilities.

It does not mean that if a house or an establishment is equipped with advance type of toilet, the sewage disposal facility is also of good quality. In **Figure 43**, the sewage from toilet ended up sealed-type septic tanks in most establishments located Sabang and in majority of households in Muelle and White Beach. All establishments in White Beach and most establishments in Muelle had open-type septic tanks. Despite most households in Sabang had flush-type toilets, they did not have septic tanks and disposed wastes into individual pit.

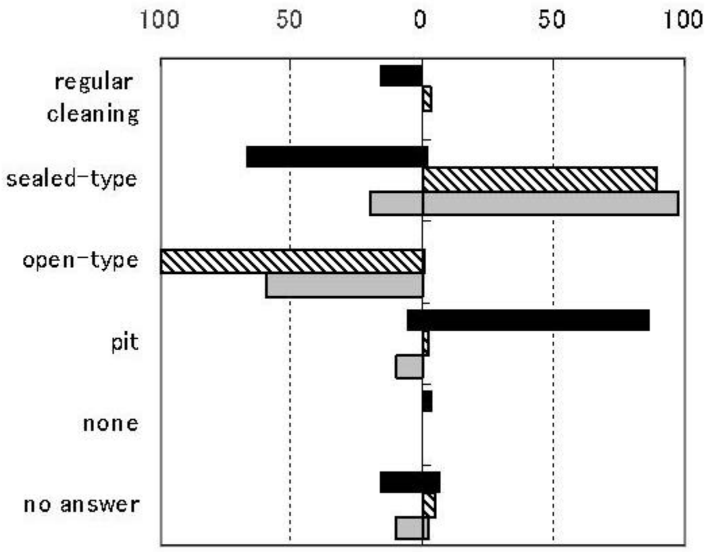


Figure 43. Type of sewage disposal.

Generally, flush-type toilet consumes more water to carry down the waste than other types. The combination of flush-type toilet and pit as sewage disposal means may result to greater load of waste to end up into the bodies of water. This is the case of Sabang household sector. The household sectors of White Beach and Muelle and tourism sector of Sabang got better facilities to control pollution in terms of toilet and sewage disposal facilities.

Local peoples' sanitation practices

As of activities involving the use of water shown in **Figure 44**, the household sector claimed that water usage was dominantly for food preparation, cleaning/laundry and bathing activities. In contrast, responses from tourism sector varied among the sites. For White Beach, bathing was the leading activity using water, followed by cleaning/laundry and food preparation. For Sabang and Muelle (though much lesser in degree), cleaning/laundry was the main use of clean water. Among the three tourism sites, Muelle had the least amount of activities related with water usage.

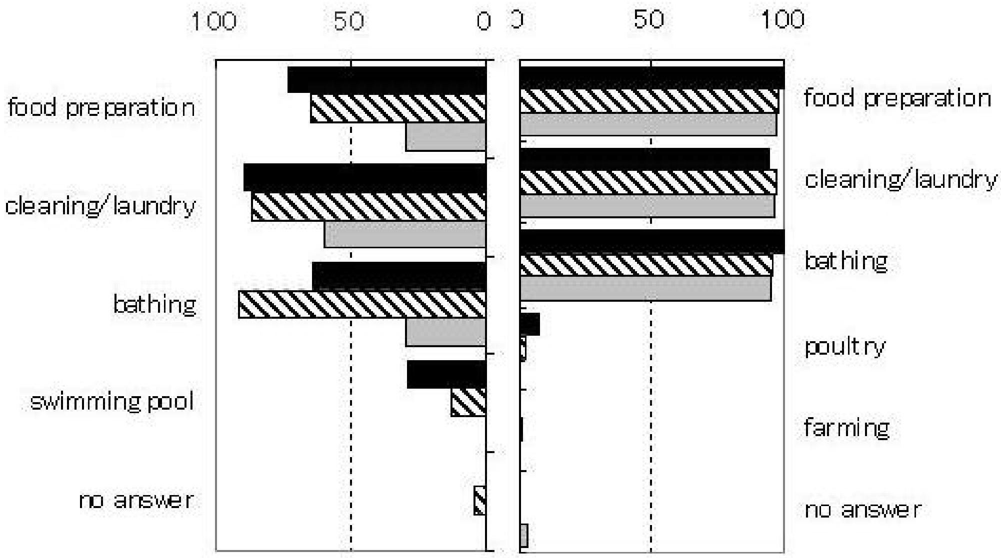


Figure 44. Activities related with water usage.

In White Beach, regardless of sector, the discharge of waste water, refer to **Figure 45**, was directed toward the soil. This was also true for the tourism sectors of Sabang and Muelle. But since the location of the business establishments was along the shoreline, waste water almost directly discharged into the sea. On the other hand, the household sectors in Muelle and Sabang discharged waste water into either open canal or bodies of water.

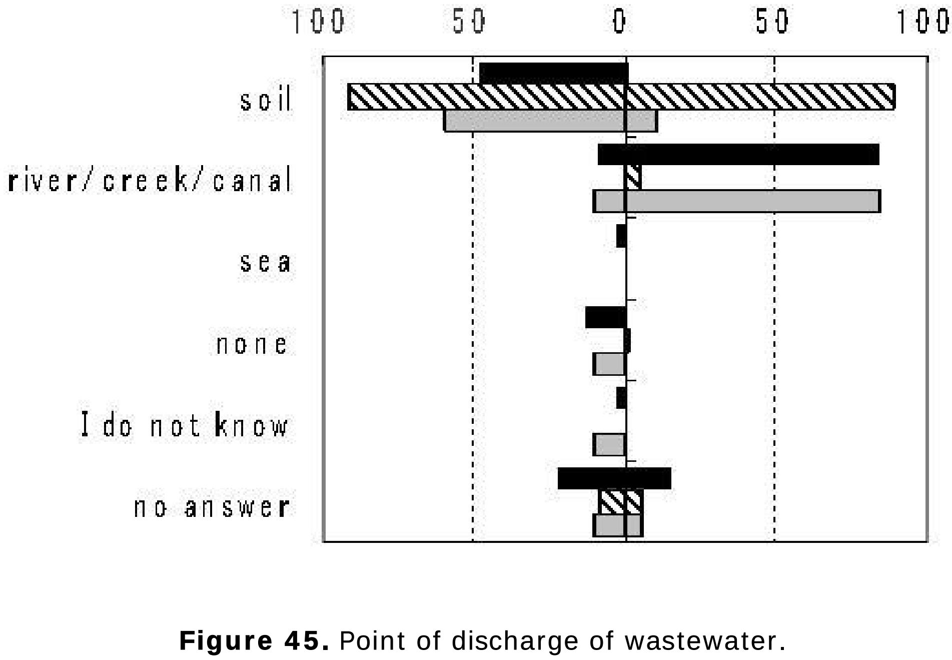


Figure 45. Point of discharge of wastewater.

As plotted in **Figure 46**, most establishments from all tourism sites and most people residing in White Beach denied contributing to water pollution. The residents in Muelle and Sabang admitted to have contributed to seawater deterioration.

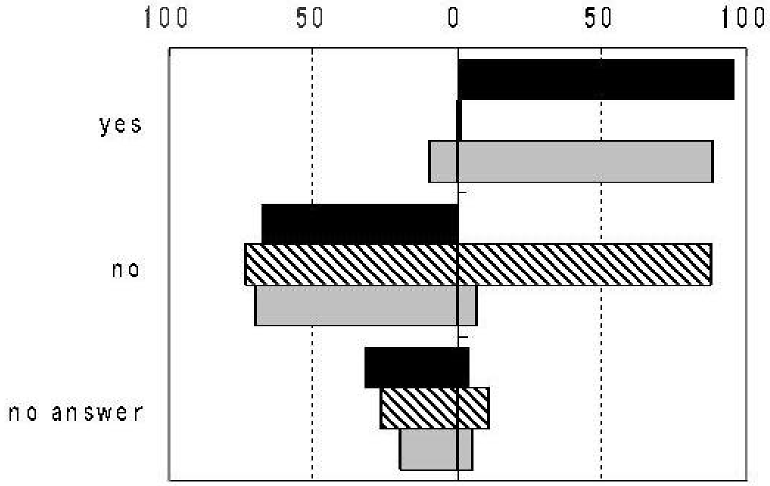


Figure 46. Do people regard themselves as contributor polluted water?

Generally, those people who discharged waster water into the open canal / bodies of water were aware that they had taken part in polluting seawater. However, most respondents, especially those from the tourism sector, denied polluting the seawater.

Perception toward seawater quality

Shown in **Figure 47**, most people in Sabang recognized that seawater had deteriorated while most people in White Beach claimed that seawater had remained clean. The people in Muelle had divided opinion, those from household sector observed that seawater became polluted while those from the tourism sector think that seawater had not deteriorated.

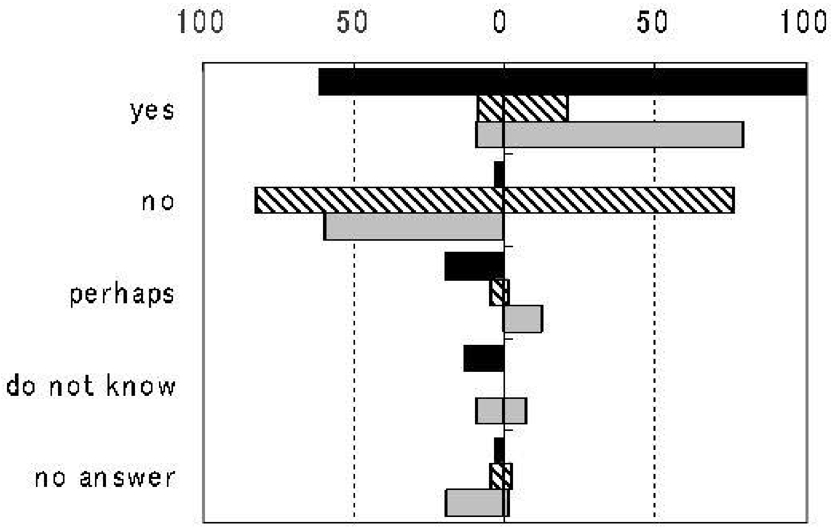


Figure 47. Perception on seawater quality deterioration.

In **Figure 48**, color, followed by algae and turbidity, was the leading indicator of water pollution according to Puerto Galera people. Between the two sectors, the household sector seemed to be more sensitive to recognizing polluted water. Apparently, the duration of water pollution (refer to **Figure 49**) in Sabang as detected by the people was the longest.

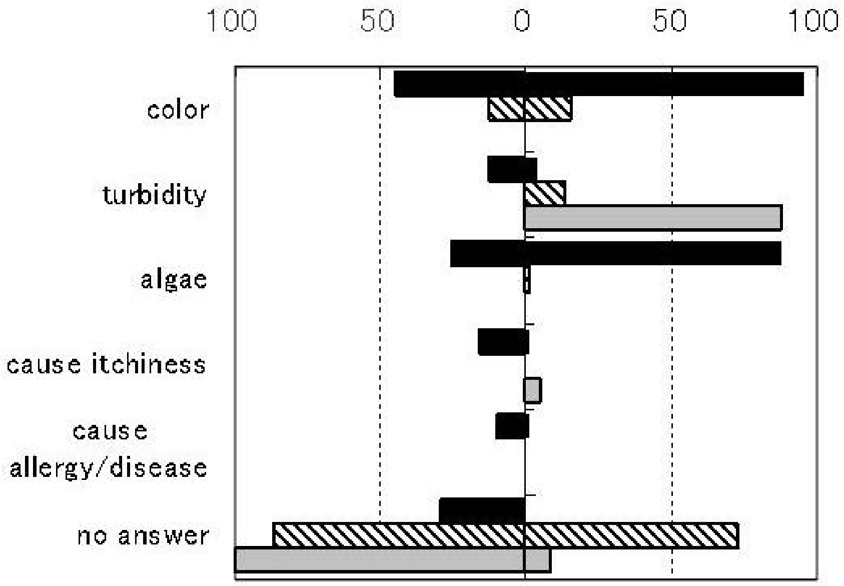


Figure 48. Indicators of seawater quality deterioration.

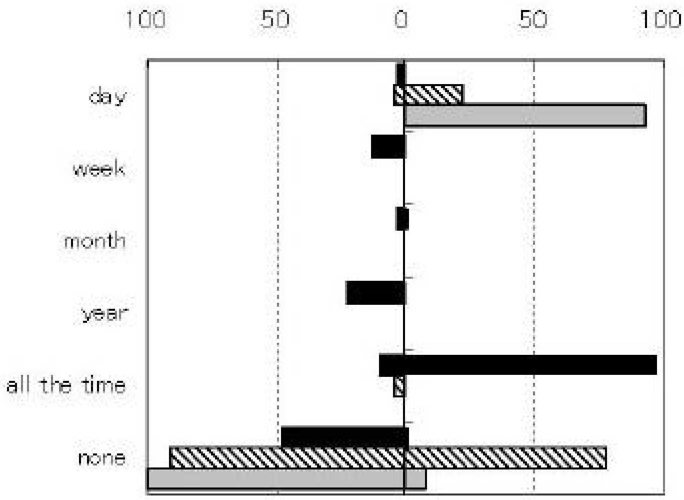


Figure 49. Duration of polluted water.

In **Figure 50**, the seawater quality parameters, as measured using data-logging sensors (as discussed in the previous chapter) were plotted in their normalized values. Noticeably, White Beach got the cleanest water among the three sites. Muelle was highly turbid and Sabang got highest bluegreen algae value. The results of water quality measurements and the observations of the local residents in terms of algae and turbidity showed a positive correlation as plotted in **Figure 51**. The survey results along Batangas channel were added just to increase the number of samples. This figure confirmed that even without water quality measuring devices, people are capable detecting pollutions either through observations. However with the presence of a strong indicator such turbidity in Muelle and bluegreen algae in Sabang, the weaker indicator, such as bluegreen algae in Muelle and turbidity in Sabang, was overlooked by the respondents.

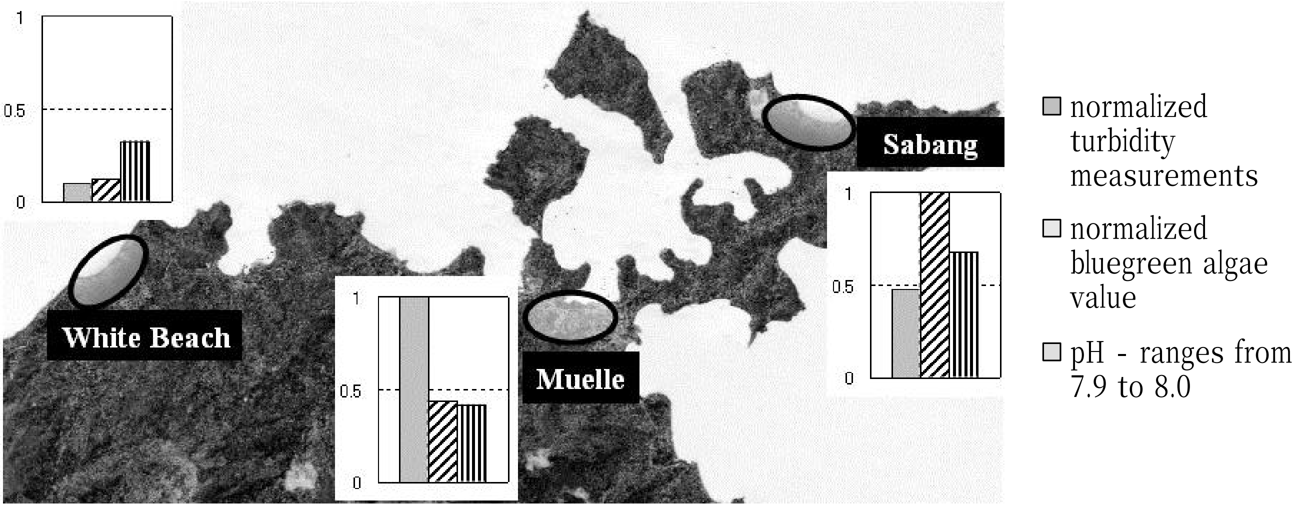


Figure 50. Measured seawater quality parameters (normalized values).

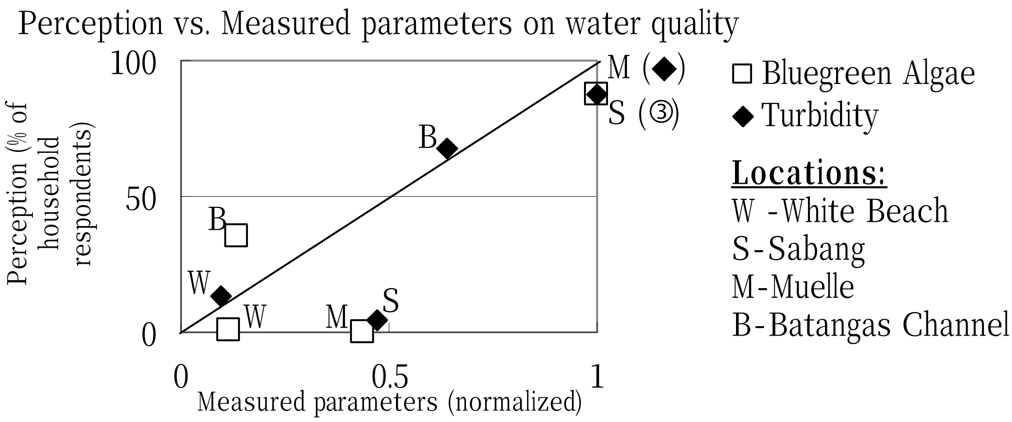


Figure 51. Correlation between perception and measured parameters on water

In **Figure 52**, those interviewed in Sabang attributed the seawater pollution to themselves. While people in White Beach, blamed the boat/ship and tourist. Households in Muelle attributed pollution to themselves and to hotel/restaurant/resort, but those from business establishments pointed to boat/ship, tourist and yacht as causes of pollution. There was the tendency of the respondents to blame others for seawater deterioration as in the case of the tourism sector.

In **Figure 53**, most people in Sabang recognized the negative effects of water pollution to health and safety, and tourist attraction. In Muelle, majority of those from tourism sector did not see any problem with pollution and those from household sector could only identify aesthetics as main impact of water pollution. In White Beach, loss of tourist was considered as the main problem pointed out by the household sector, while the effect on biota was identified by the tourism sector. It seemed that the tourism sector in Sabang is aware of the various impacts of pollution to environment and society. However those from the household sector recognized few impacts of pollution.

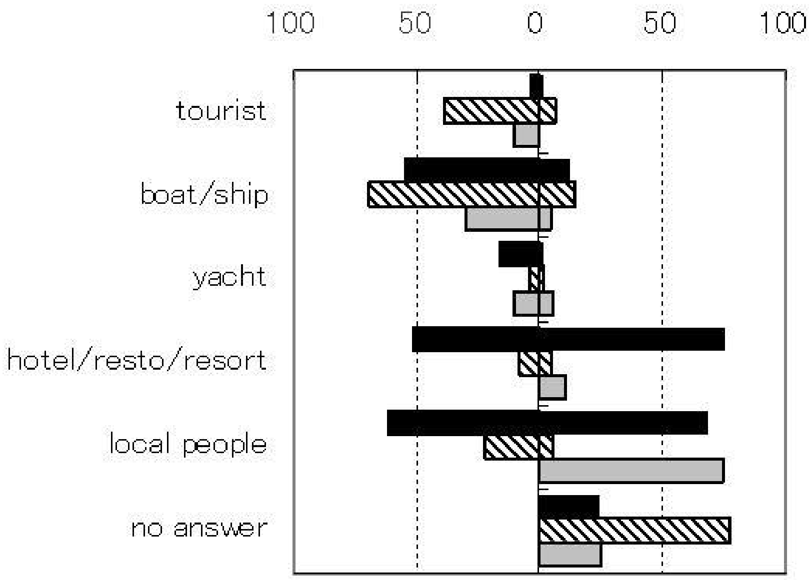


Figure 52. Causes of seawater quality deterioration.

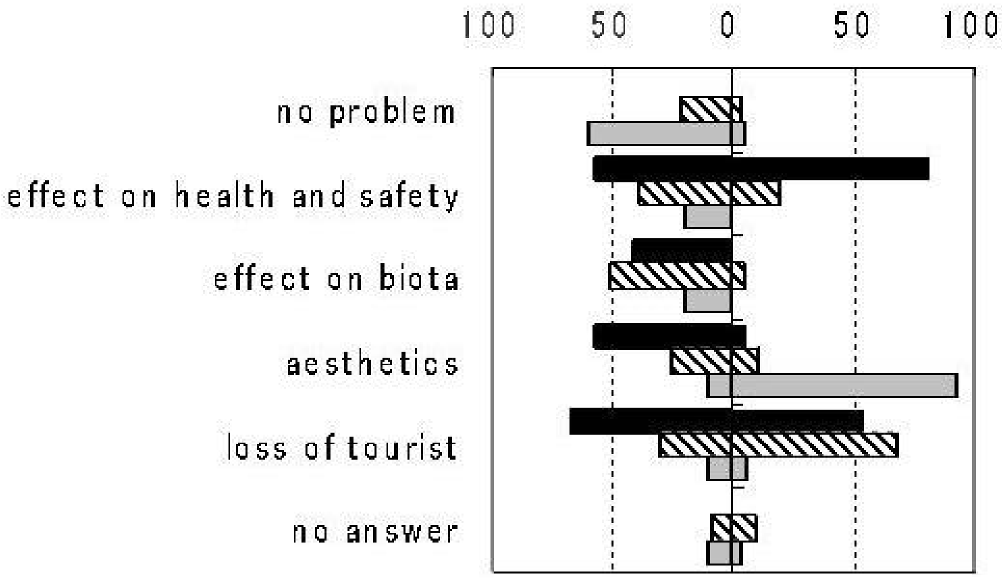


Figure 53. Effects of seawater quality deterioration.

In **Figure 54**, most people residing in Muelle and White Beach, had no untoward experience with the current seawater quality condition. However in Sabang, many had suffered from diseases/ allergies due to polluted water. Thus, the people of Sabang gained awareness of water pollution and its negative impacts based on personal experience.

In **Figure 55**, many people, especially the household sector from Sabang, believed that water quality management is a joint effort among local government, various government agencies, resort/hotels, local people and some NGO's. Cooperation among various interest groups with guidance and support of government seemed to be the accepted seawater management type.

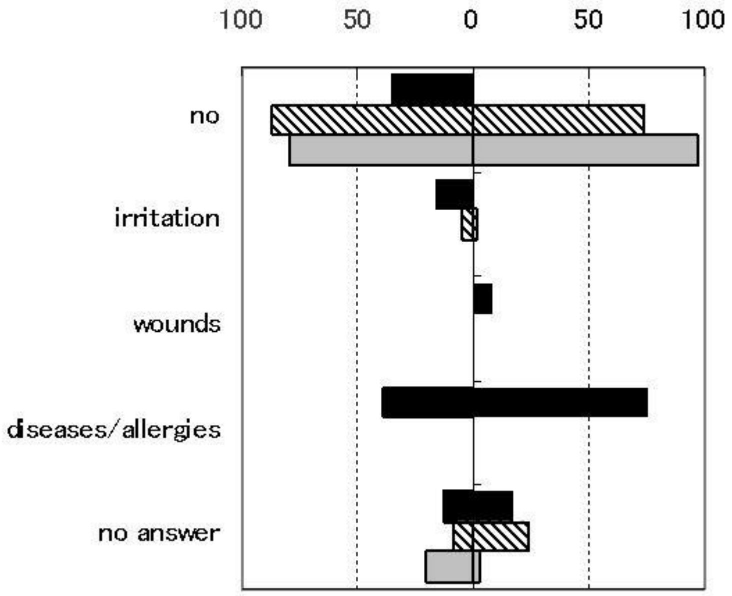


Figure 54. Effects on personal health of seawater quality deterioration.

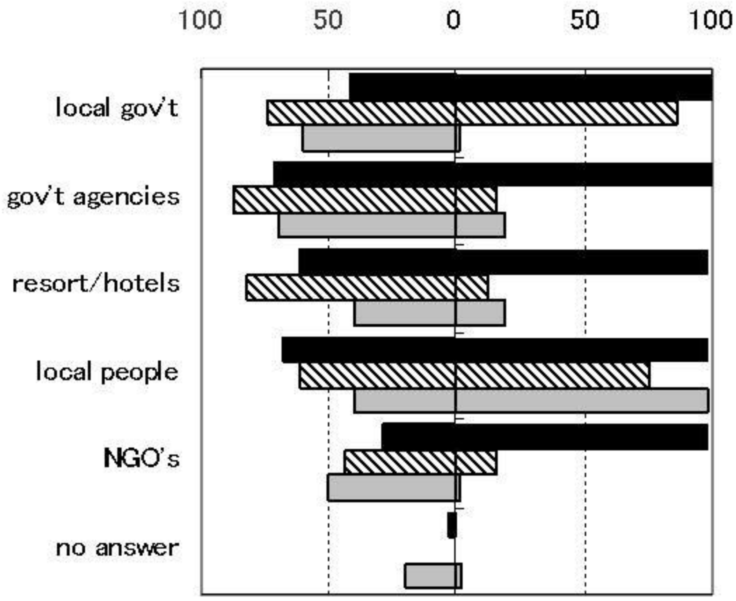


Figure 55. Actors of seawater management.

In terms of possible ways to help improve water quality, the responses varied between household and tourism sectors among the three sites as plotted in **Figure 56**. Apparently, information campaign got the highest response among the household sector.

As shown in **Figure 57**, the people in Muelle, particularly from the household sector, were not willing to pay some fees for improving facilities intended for maintaining good water quality. On the other hand, the people in Sabang were more willing to contribute. Seemingly, those people who had an awful experience with water pollution were the ones who are more willing to contribute for water quality improvement.

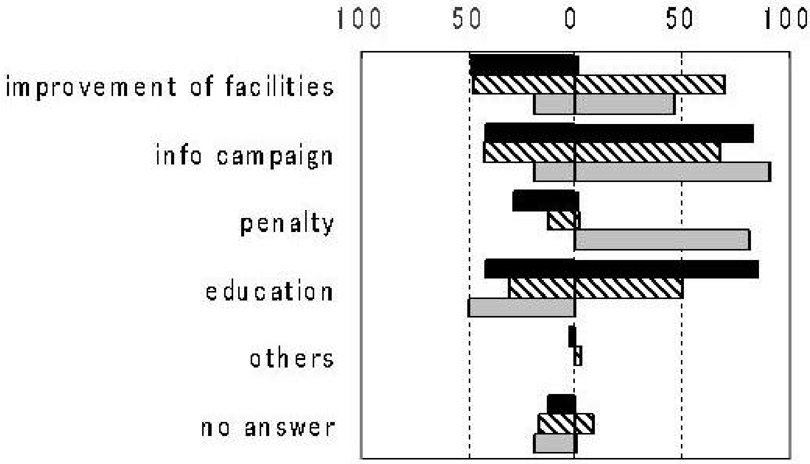


Figure 56. Tools of seawater management.

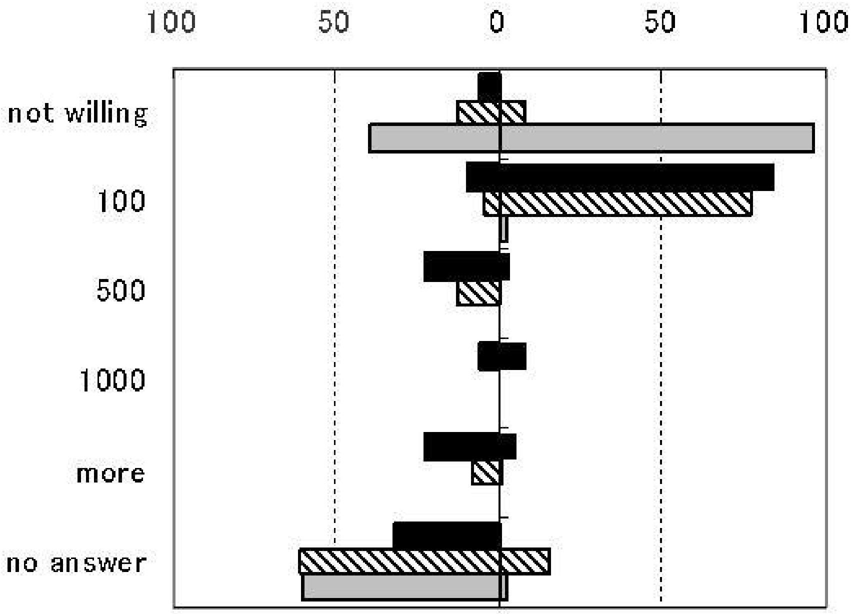


Figure 57. "Willingness to pay" for seawater management.

3.1.3 Monitoring by remote sensing

In **Figure 58**, the classification results of Aster image datasets were combine to show the pattern of land cover change, including built-up expansion. The increase in area covered by built up, whether household or tourism, from 2001 to 2005, were plotted in **Figure 59**.

The development in Muelle was scattered and the increase in area was minimal, about one hectare in four years. While in White Beach, there was almost 100% increase in four years, however, new built up areas were dispersed further from the shoreline. In contrast, the expansion of development was concentrated along the shoreline. Assuming that accessibility or proximity to the sea is proportional to its impact, then, Sabang can pose greater threat to water quality.

In terms of other land cover, **Table 14** shows the area covered by built-up, forest and grass in 2001 and 2005, respectively. Land conversion occurred in White Beach, wherein as built-up and grass coverage had about 100% spatial growth but forest got 20% reduction. On the other hand, Sabang had the least land use change. The probable cause for the variances in the change pattern is the dependency of the local people to tourism as sources of livelihood. The people of Sabang are inclined to get closer to the coastline and get involve in business related to tourism. While the people of Muelle and White Beach, have other economic activities beside tourism.

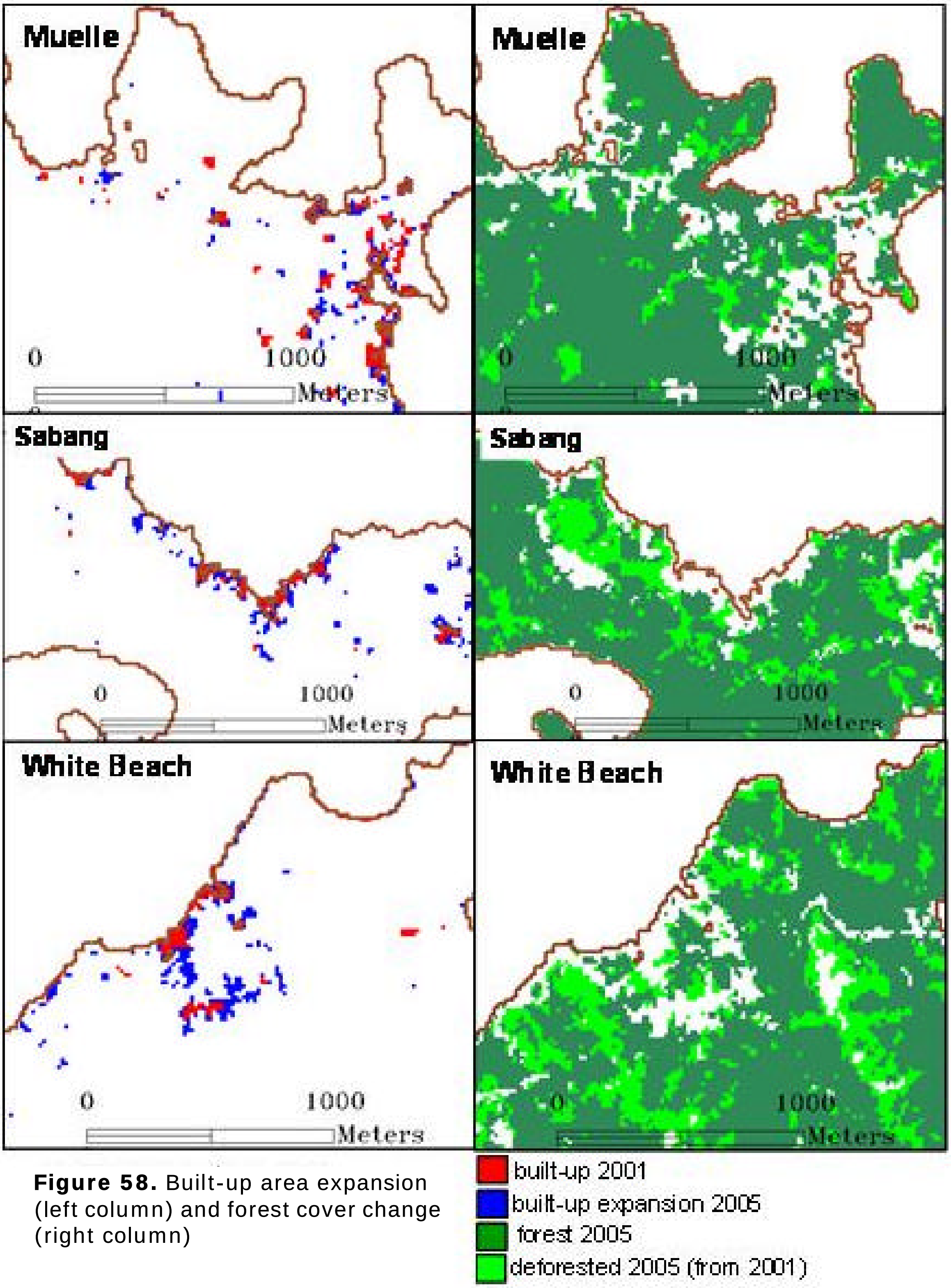


Figure 58. Built-up area expansion (left column) and forest cover change (right column)

Table 14. Land cover change (in hectares)from 2001 to 2005 based on Aster image classification.

MUELLE	***built***	***forest***	***Grass***
New (2005)	6.8	30.1	19.2
Old (2001)	2.61	35.4	16.8
unchanged	2.2	25.5	9.4
SABANG	***built***	***forest***	***Grass***
New (2005)	2.2	30.7	14.3
Old (2001)	1.8	29.2	14.3
Unchanged	1.0	24.1	7.3
WHITE BEACH	***built***	***forest***	***grass***
New (2005)	6.7	55.2	31.4
Old (2001)	3.1	70.8	16.9
unchanged	2.4	50.0	9.8

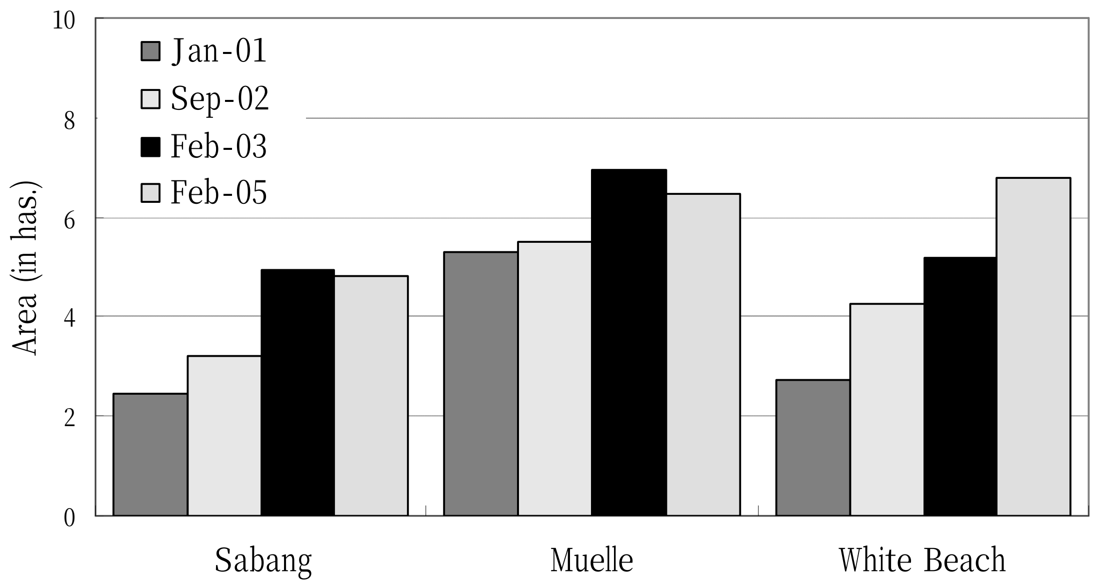


Figure 59. Built-up area expansion

3.1.4 Creation of GIS for household, tourism infrastructure and facilities

The GIS enabled various data to be spatially connected and be viewed simultaneously. The results of the tourism establishment survey, GPS mapping, water quality measurements and remote sensing classification were just some of the data incorporated in the set-up. In **Figure 60**, an example of the data incorporated in the GIS is shown. Tourism establishment details can be viewed instantly by simply pointing into a particular location. These data is overlaid against the Quickbird satellite image to allow reference to other coastal resources surrounding the point of concern.

Further analysis could be derived in the light of all available data through GIS, such as of statistical- and spatial-types. Thus, it is possible to maximize the utilization of all existing data for more understanding of the physical and social environment.

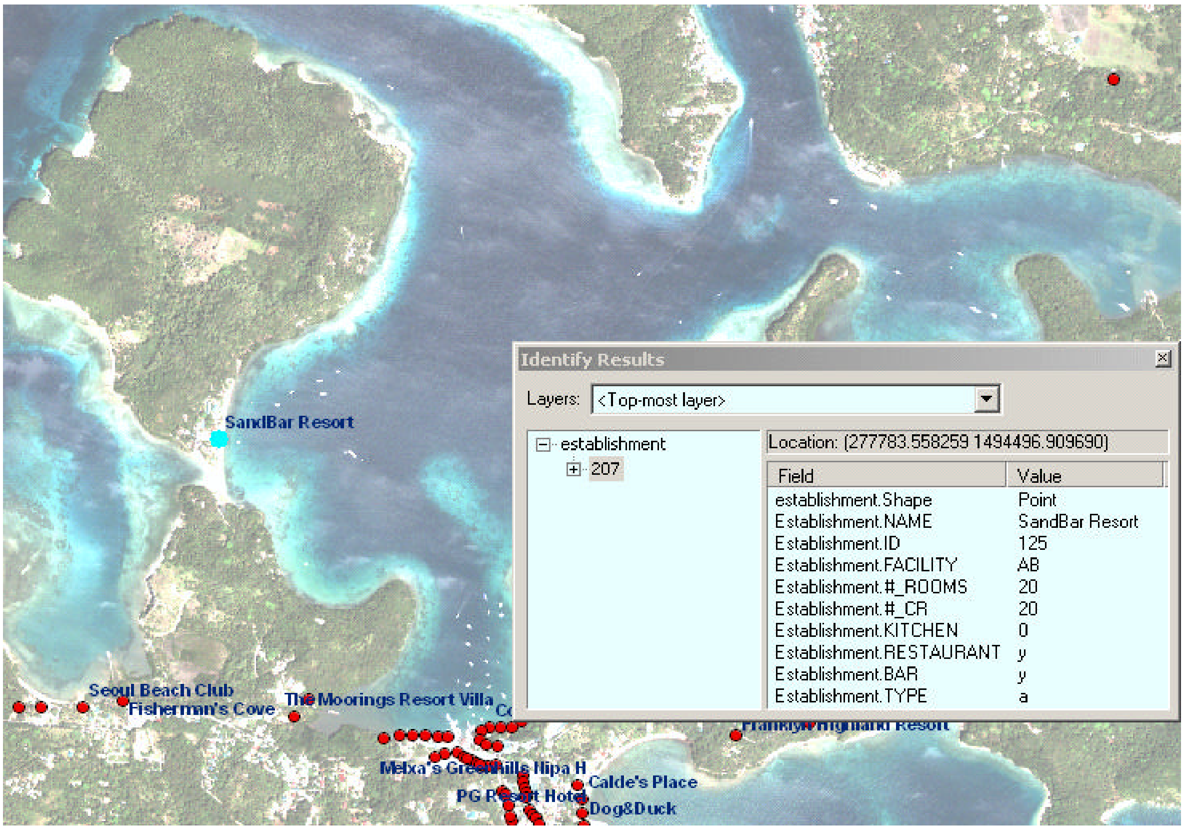


Figure 60. A GIS set up for Puerto Galera.

3.1.5 Analysis and implications for management

With the continuing growth of tourism and population, the construction of new hotels and modern houses are coping with the demand but not in the case of sewage collection and treatment facilities. Still, there is no existing sewage collection and treatment facility in Puerto Galera, and also, a number of houses do not have septic tanks. Effluent loads to the sea come from the open canal, except for White Beach, through which most households put in their waste water. This sector admitted to have contributed to seawater deterioration. On the other hand, the location of the tourism establishments is so close to the shoreline, as in the case of Sabang, thus, additional sewage effluents from them directly pollute the seawater but they denied polluting the sea. Admission of the problem and environmental awareness are the fundamental steps in solving water deterioration problem.

The household sector seemed more sensitive in detecting polluted water probably due to their infrequent visits as compare with those from the tourism sector who got immune because of their daily exposure to the sea. Nonetheless, ordinary people can spot pollution through some indicators. Through information campaign and training, these people can do water quality monitoring and can supplement additional information those provided by sensors.

With the preference to information campaign as a tool to solve water quality, it reflects the inadequacy of information about environmental condition and its impact, and the people's desire to acquire knowledge about the environment. This is a preventive way of addressing a problem. Through this, it is possible to avoid experiencing the harsh consequences, such as spread of diseases and loss of tourist, before the realization of the consequences of seawater deterioration.

Devising a monitoring scheme (whether involving data-logging sensors and people's perception) and developing a good spatial information database through various sources would serve as a start of point for assessment of environmental condition and would help determine areas needing immediate measures. A collective participation of all sectors in the process of monitoring and planning would facilitate acceptance of environment program.

3.1.6 Summary

There is inadequate facility for sewage collection and treatment in Puerto Galera. However, differences in peoples' sanitation practices, as in the cases of White Beach and Sabang, show variation in the amount of pollutants to the seawater. And also, the carrying capacity of the sea to absorb waste water in the three tourism site is affected by the governing hydrodynamic circulation. Monitoring of the seawater quality is necessary to know the various factors involve in water quality deterioration.

The people are capable of monitoring. They have the desire to learn more about their environment through information campaign. Best of all, they are willing to contribute for the improvement of the water quality condition.

There were not enough information about the physical environment and the spatial distribution of social and tourism data. Through mapping and creation of GIS, the assimilation of available data into a more comprehensible can help maximize the utilization of data for uplifting environmental awareness and for proper management of the coastal ecosystem.

3.2 Bolinao, Pangasinan (Philippines)

This section on the Bolinao study describes the results of field observations and analysis of collected data and samples, and identifies milkfish culture impacts on the coastal ecosystem and mechanism of massive milkfish kills.

3.2.1 Nutrient Distributions

High feeding input from fish cages and pens contributes significantly to high nutrient levels in the aquaculture area (**Table 15**). Nutrient concentrations in the reef area, on the other hand, were quite low compared to those in the aquaculture area. However, even those levels were way beyond the optimal levels (TN: 0.1µmg/l, TP: 0.01µmg/l) for corals, implying that water which have high nutrient concentrations may drift in to the reef area from the aquaculture area. In addition, high nutrient level can be considered as one of the major causes of destruction of the ecosystem in Bolinao reef complex.

Table 15. 6-day-averaged concentration of dissolved nutrients from water sampling analysis

Station	TDN	PO4	Si(OH)4
2	11.59	1.42	6.62
4	0.98	0.18	4.58
5	1.19	0.18	4.47
6	0.97	0.16	4.72
8	1.31	0.16	4.25
9	1.20	0.17	6.45
10	4.43	0.58	8.58
11	12.82	1.50	11.78
12	15.05	1.75	10.20

TDN: Total Dissolved Nitrogen (NH_4, NO_3, NO_2)

3.2.2 Current Structure in the Aquaculture Area

Tide-averaged flows in east channel were in the direction of the aquaculture area, while those in the north channel were directed offshore, suggesting that outer sea water mass comes into the aquaculture area through east channel and go out to outer sea through north channel (**Figure 61**). Therefore, it can be said that polluted water disperse to reef area mainly through the north channel. Also, fish structures along the channel should be demolished to allow water flow freely and flush out pollutants to outer sea effectively.

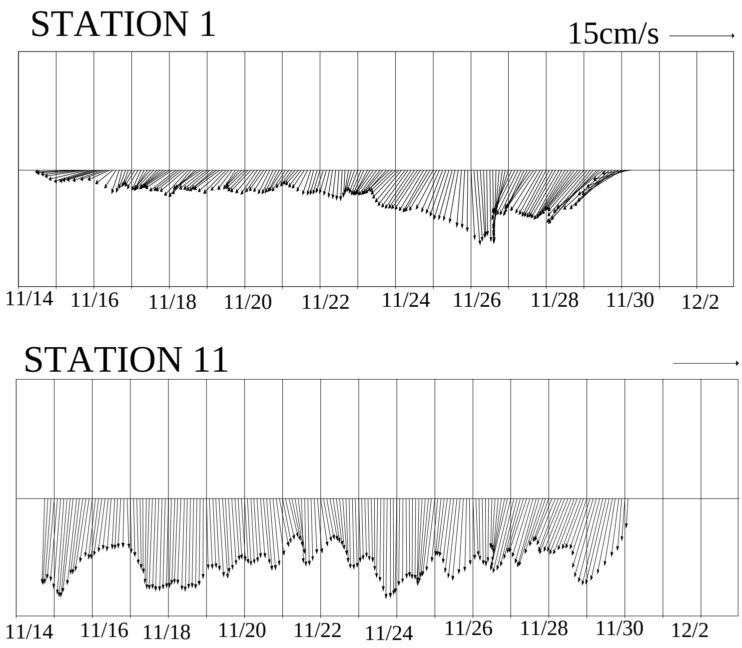


Figure 61. The 25-h-averaged velocity vectors at Station 1 in the north channel and Station 11 in the east channel

3.2.3 Spatial and Temporal Variation in Chlorophyll-a Distributions

As consequence of high nutrient levels around fish cages and pens, chlorophyll-a concentrations in the area have much higher value compared to in the reef (**Table 16**).

Table 16. 6-day-averaged chl-a concentration from water sampling analysis

Station	2	4	5	6	8	9	10	11	12
Chl-a (μ mg/l)	9.42	0.40	0.40	0.39	0.37	0.71	3.29	7.13	16.33

Observed data revealed that chl-a value tend to increase drastically in the aquaculture area (Stations 11, 12) during neap tide (**Figure 62**). Relatively low velocities during that period cause the weak vertical mixing and low tidal exchanges between the outer sea and aquaculture area. Consequently, phytoplankton blooms tended to occur during neap tide.

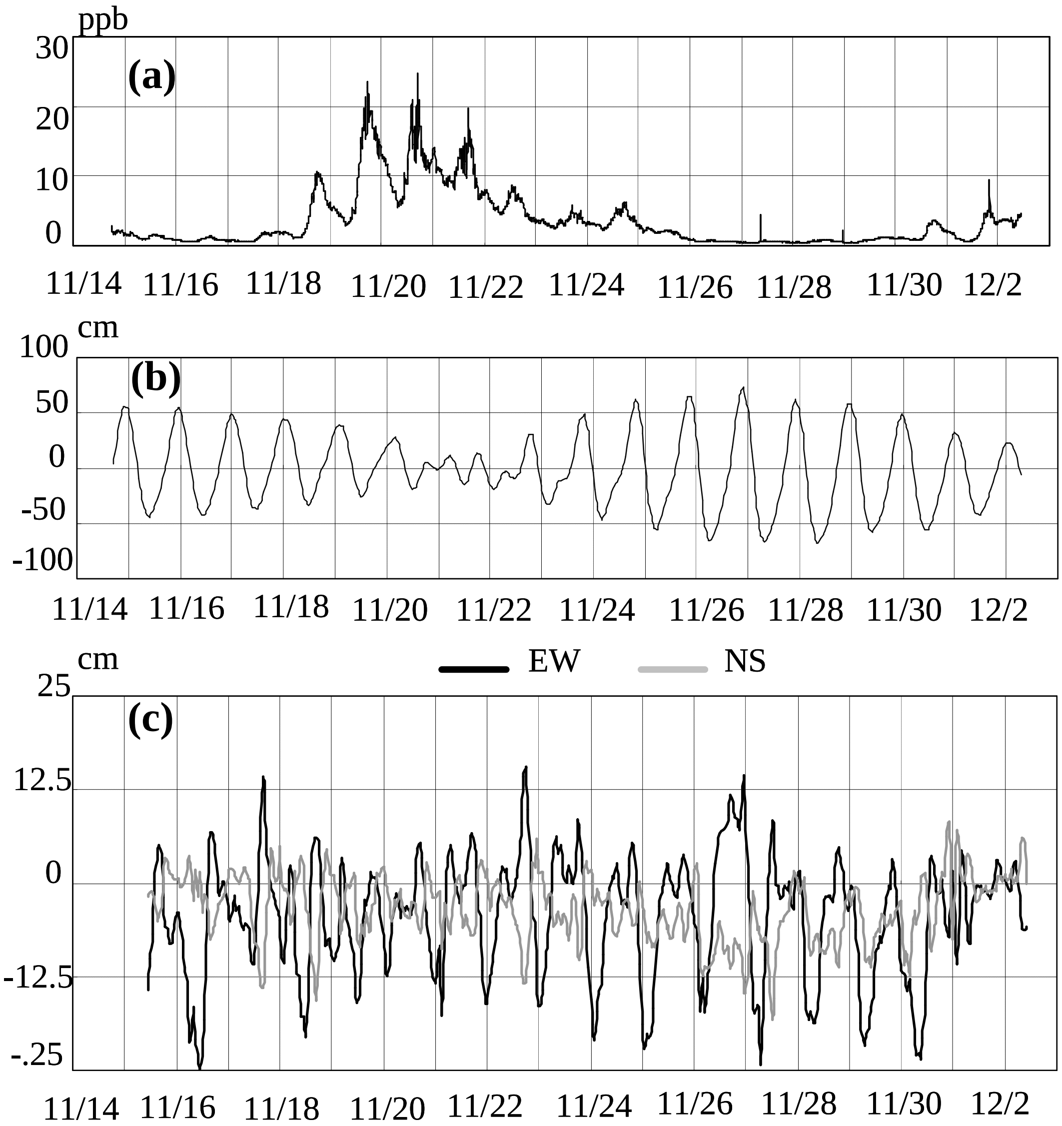


Figure 62. Time series of (a) Chl-a at Station 12, (b) water level in the outer sea, (c) flow velocity at Station 1

3.2.4 Spatial and Temporal variation in Dissolved Oxygen

High dissolved oxygen levels were observed in the reef area (Stations 4, 5) due to high oxygen productivity by the photosynthesis of abundant seagrass (**Figure 63**). Boyd and Lichtkoppler (1979) gave optional levels of dissolved oxygen (about 5 mg/L), for milkfish growth in tropical waters. Based on the observed data, dissolved oxygen near fish cages (Stations 11, 12) were less than the optimal level due to oxygen consumption by decomposition of organic matter, suggesting that the fundamental cause of the massive fish kills was the lack of dissolved oxygen in the cages and pens.

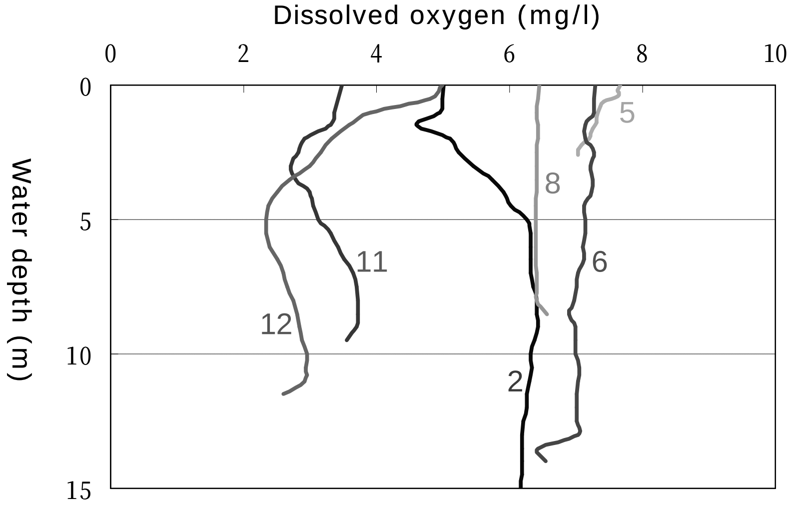


Figure 63. 6-day-averaged vertical levels of dissolved oxygen

Looking at time variation of dissolved oxygen near the bottom at Station 12, in a lunar period, dissolved oxygen reached near-zero level during neap tide, especially on November 20 (**Figure 64**). Dissolved oxygen is replenished via plant photosynthesis and diffusion across the air-sea interface, both of which are limited to the surface water. Dissolved oxygen near bottom layer is enhanced by vertical mixing regimes. However, during ebb tide, flow current is quite calm and vertical mixing is weak. Therefore, dissolved oxygen levels tend to be low during ebb tide. Also, increase in oxygen consumptions by decompositions of organic matter corresponding to phytoplankton blooms during ebb tide is another critical factor for dysoxic environment.

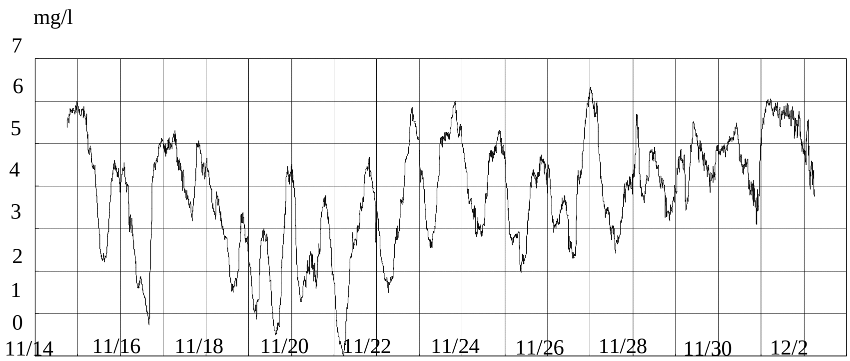


Figure 64. The time variation in dissolved oxygen near bottom at Station 12

3.3 Shiraho Reef and Todoroki Watershed (Japan)

Field observation

3.3.1 Meteorological state

Figure 65 shows the time series of the wind velocity, atmospheric pressure at sea level and precipitation during the observation period. For wind velocity, north- and eastward wind is defined positive. During period of 3 to 7 August 2005, typhoon no.9 struck Ishigaki Island and wind direction showed drastic change around 20 pm on August 4 as the typhoon passed over the island. The maximum 10 minutes average wind velocity during the typhoon was 27.9 m/s. The atmospheric pressure at sea level declined down to 960 hPa. Total amount of precipitation by this typhoon was 215 mm. There was another precipitation on 19 to 20 August during observation period with 45 mm in total amount with relatively week wind less than 10 m/s

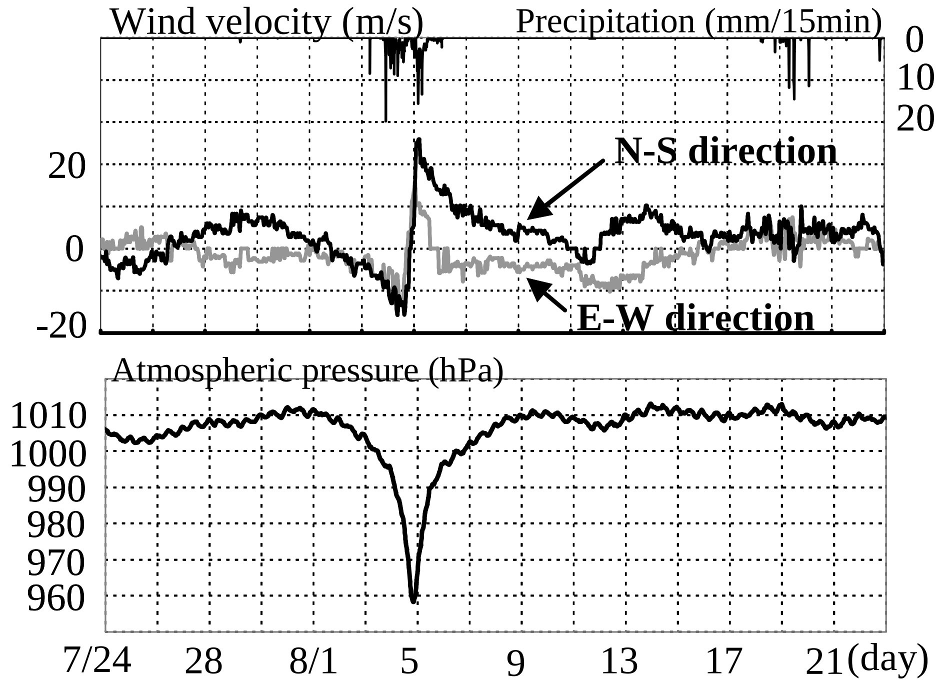


Figure 65. Time variation of wind velocity, precipitation and atmospheric pressure. For wind velocity, north and east direction is positive.

3.3.2 Oceanographic state

Figure 66 shows the time variation of mean water level observed at Stn.O2 indicating the tidal range was about 1.5 m at the spring tide and about 0.9 m at the neap tide. Effect of storm surge on the water level was observed during typhoon period in correspondence with the decrease in the atmospheric pressure and the increase in the shore-directed component of wind.

Figure 67 shows the variation of significant wave height and period at Stn.O2. High wave condition was observed during 25 to 27 July, 3 to 7 August, 11 to 14 August with significant wave height more than 1 m. At the same time, the significant wave period was relatively long from 9 s to 12 s representing dominance of swell. Especially during typhoon period, from 3 to 7 August, the significant wave height attained 4.5 m.

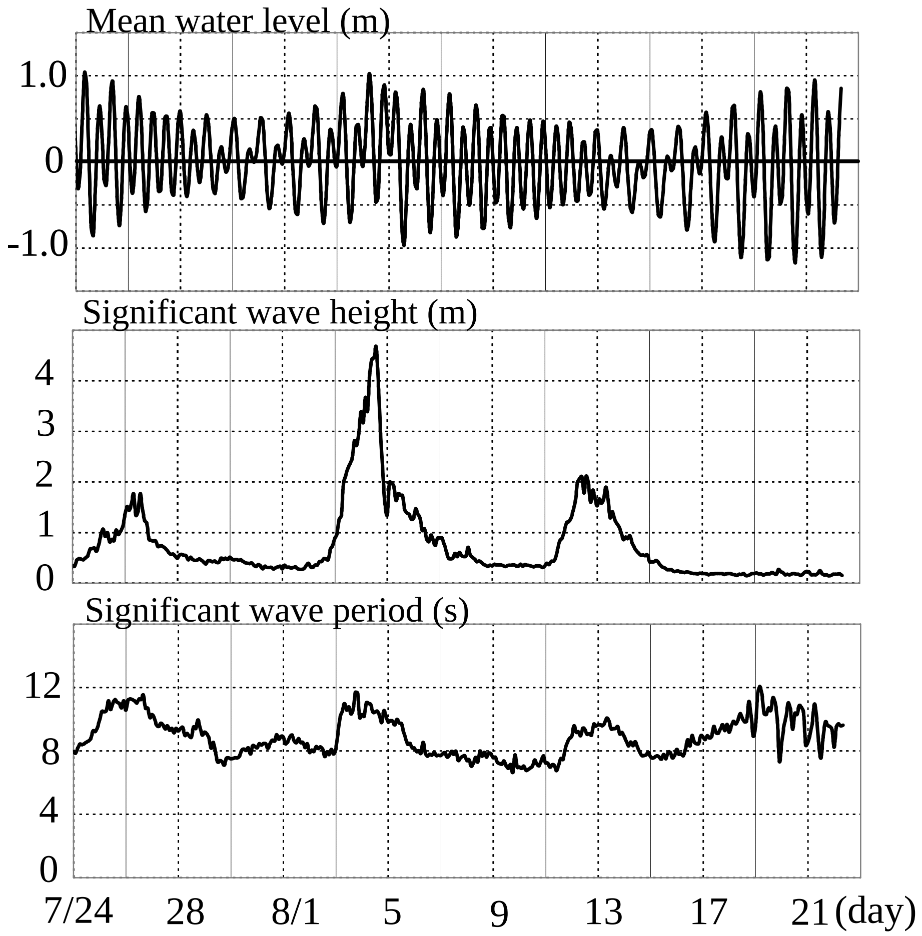


Figure 66. Time series of mean water level, significant wave height and significant wave period observed at Stn.O2.

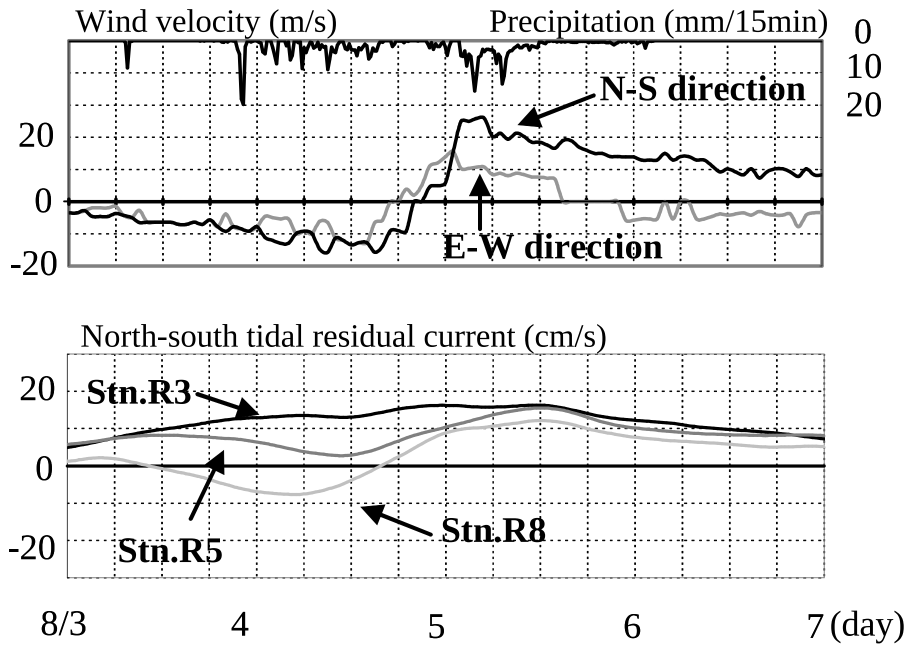


Figure 67. Time variation of wind velocity, precipitation and tidal residual current at Stn. R3 and R8 during typhoon period. North and east direction is positive, respectively.

3.3.3 Current characteristics during typhoon

Precipitation, north-south wind velocity and north-south tidal residual current at Stn.R3 and R8 during typhoon are given in **Figure 67**. Northward components both of wind velocity and current are taken positive. With the passage of the typhoon, wind changed drastically in its direction from south to northward as described before. Corresponding to the change in the wind direction, the tidal residual current at Stn.R5 and R8 became stronger toward north. **Figure 68**, which plots the north-south tidal residual current at Stn.R5 against the significant wave height at Stn.O2 in outer reef, shows the magnitude of tidal residual current was different according to the wind condition even though the significant wave height was almost the same. Tidal residual current during the period with strong south wind was nearly two times larger than that during period with weak wind. Obviously the differences of velocity between two cases were due to wind indicating importance of wind-induced current effect.

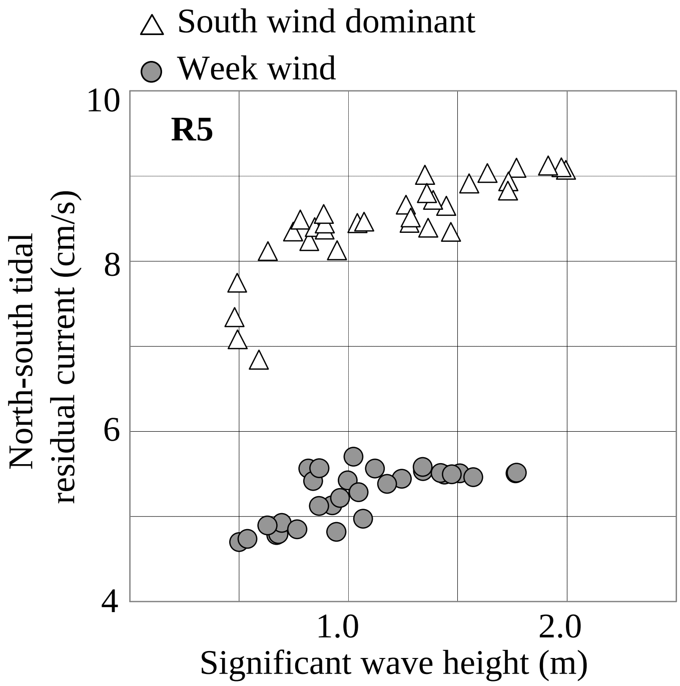


Figure 68. Relationship between significant wave height and tidal residual current at Stn.R5. Rectangle plots show when south wind was dominated and circle plots show when wind was weak. North direction is positive.

Effect of the current induced by strong wind, however, did not uniformly appear in the reef. There are clear differences in the tidal residual currents between Stn.R3, R5 and R8 during the period dominated by north wind. The velocity was stronger at Stn.R3, R5, R8 in increasing order (**Figure 69**). This indicates that as northern the station is, or to be more precise, nearer to the Toru-guchi the station is, the northward current became stronger. A current pattern of the reef has been observed by previous research[13)] which shows flow toward Toru-guchi is predominant during fine weather. Fig.8 indicates contribution of topographic circulation flow generated by Toru-guchi to hydrodynamic of the reef is dominant even in condition with strong wind like typhoon period.

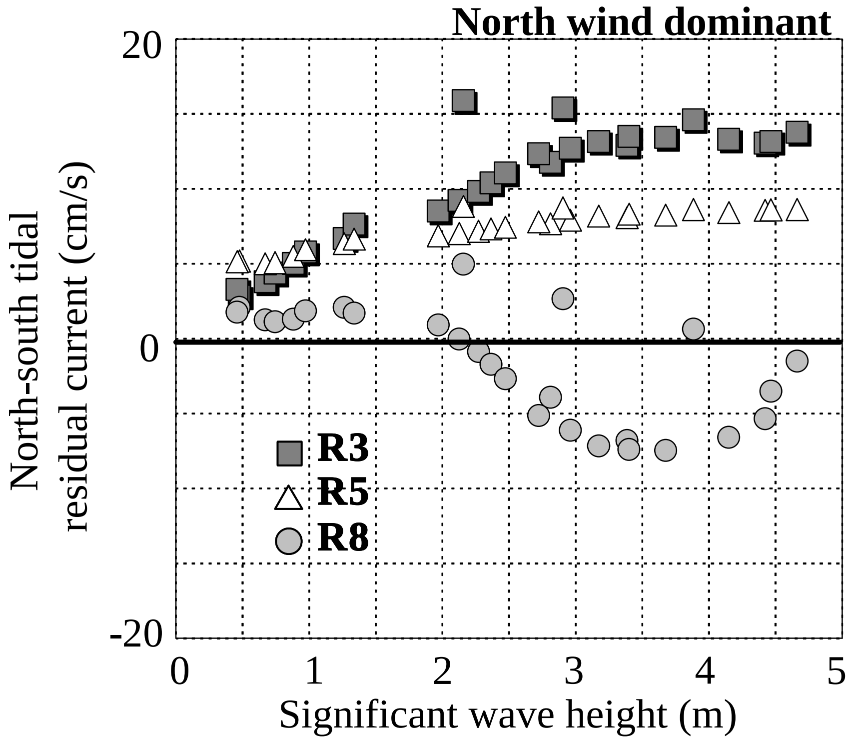


Figure 69. Relationship between significant wave height and tidal residual current at R3, R5 and R8.

3.3.4 Sediment discharge during the typhoon

Chlorohyll-a and turbidity sensor and depth gauge were installed at Stn. B1 for the entire period of observation. However due to failure of the sensor, turbidity data could not be obtained. Alternatively *L-Q* equation below was derived to estimate the total sediment discharge during typhoon.

$$L = aQ^b \qquad (3)$$

in which L is total sediment loads; Q is total river discharge; a, b are coefficients. For determination of the coefficients, sediment discharge data monitored by the authors at Stn.B1 were used giving,

$$a = 0.0001,\ b = 2.7045,\ r = 0.673$$

The total river discharge *Q* was calculated by integrating river discharge, from 7am 3 to 2am 6 August when rain started and finished (**Figure 70**). From equation (3), total sediment discharge was estimated as 145 tons. This is even equal to the total sediment discharge of about 160 tons during rainfall of 31 May to 1 June 2001 when corals were heavily damaged. This indicates that relatively large sediment discharge occurred during the typhoon.

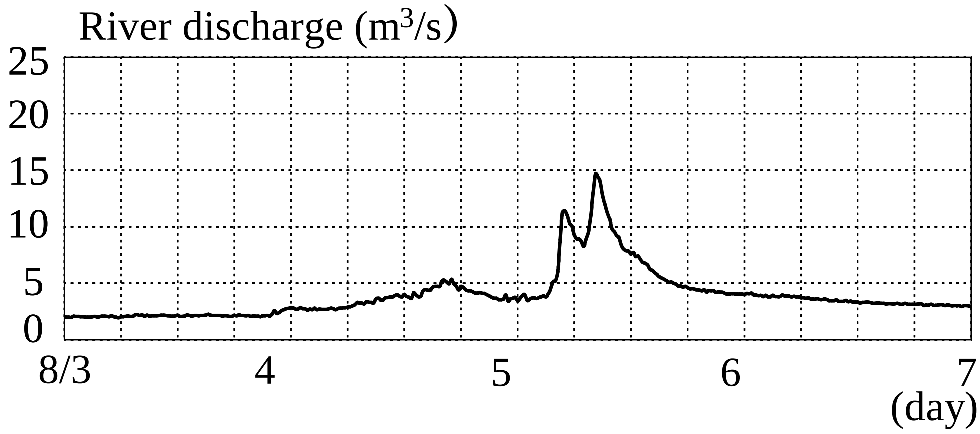


Figure 70. Time variation of river discharge at Stn. B1

3.3.5 Factors affecting turbidity increase during typhoon

Figure 71 shows time variation of salinity, turbidity at Stn.R5, R8, and significant wave height at Stn.O2. Salinity at Stn.R5 and R8 remarkably declined at second half of typhoon period. At the same time turbidity at both stations increased correspondingly. As Stn.R8 is located near the Todoroki river mouth, the fluctuations of salinity and turbidity were to be effect of river plume from Todoroki River. In the same way the decrease in salinity at Stn.R5 is likely due to the effect of river plume that was transported by wind-induced current during south wind.

Meanwhile there occurred an appreciable increase in turbidity at Stn.R5 in the first half of typhoon period. Unlike the case of turbidity increase at the second half of typhoon period, salinity at Stn.R5 remained high while turbidity decreased. This means turbidity increase in the first half of typhoon period was not due to the river plume. The nature of turbidity increase against salinity fluctuation at Stn.R5 was completely different between first half and second half of typhoon period (**Figure 72**). In the second half of typhoon period, salinity decreased as turbidity increased. On the other hand, salinity did not fluctuate even when turbidity increase in the first half of typhoon period. Significant wave height was high at the first half of typhoon period and was low at the second half of typhoon period. This suggests that turbidity increase at the first of typhoon period was caused by resuspension of sediments from the sea bed. Thus, turbidity may increase not only by sediment discharge from adjacent land, but also by re-suspension of sediments deposited on the sea bed. This mechanism controlling water quality in the reef is not negligible.

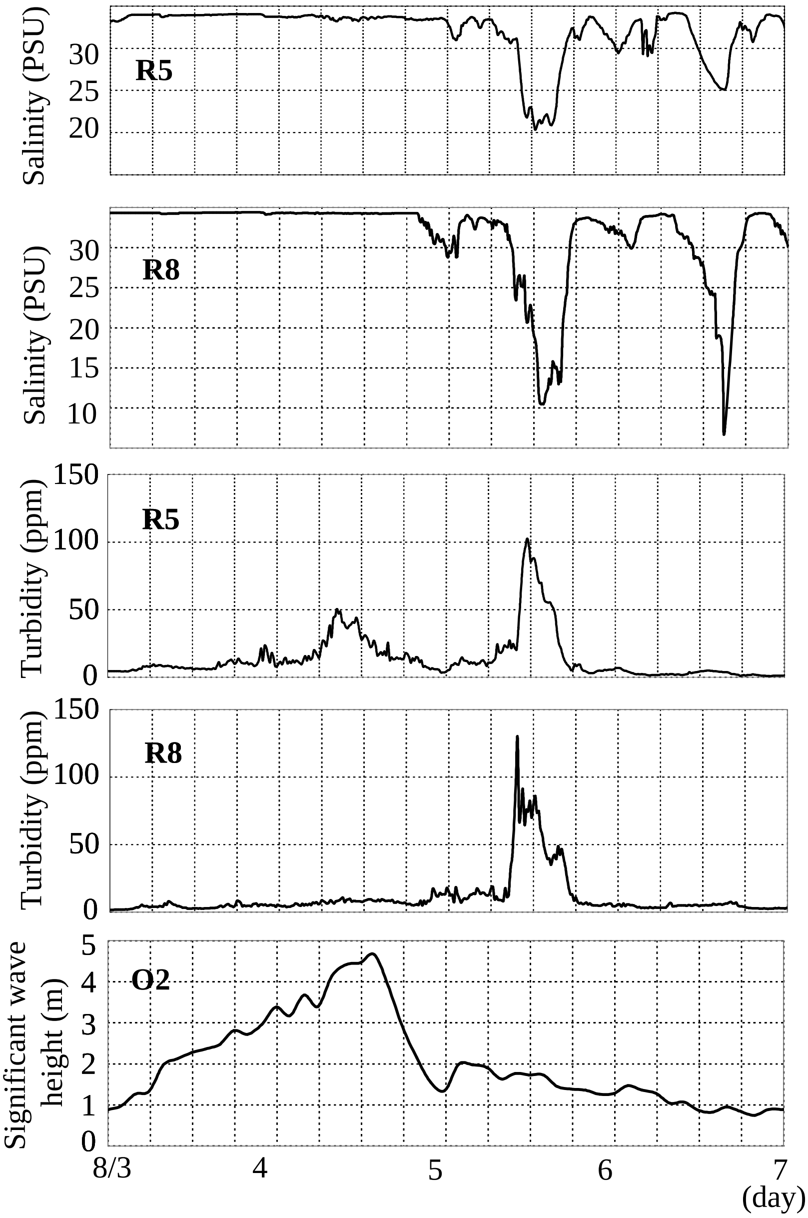


Figure 71. Time series of salinity, turbidity at Stn.R3, R8 and significant wave height at Stn.O2 during typhoon.

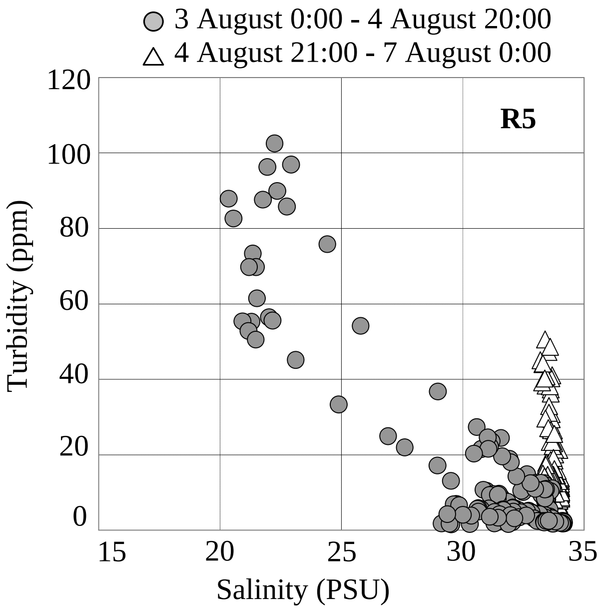


Figure 72. Relationship between salinity and turbidity at Stn.R5 during typhoon period

3.3.6 Water quality in the reef after passage of typhoon

Figure 73 shows concentrations of phosphorus in the reef at 26 July and 8 August which correspond to the concentrations before and after typhoon passage, respectively. The concentration of phosphorus increased after typhoon. Especially in

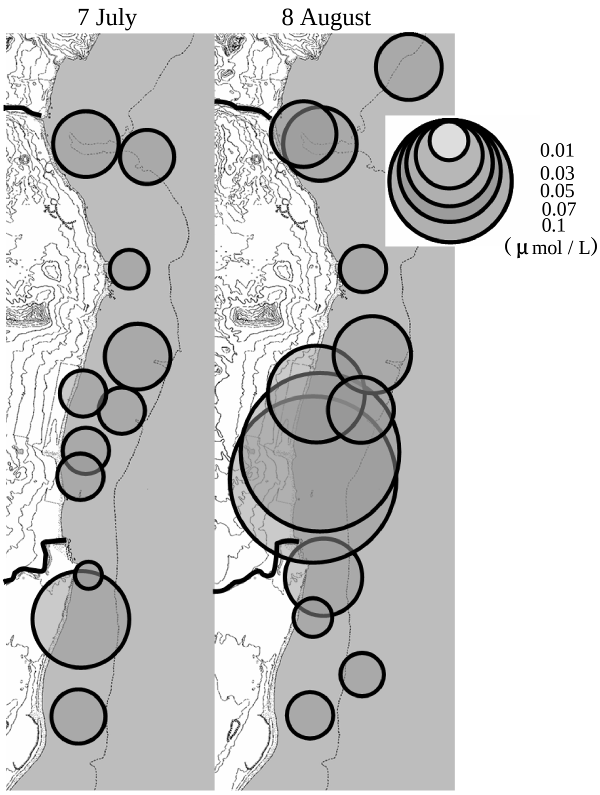


Figure 73. Difference of dissolved inorganic phosphorus (DIP) concentrations between the day before typhoon and day after typhoon

area north of Todoroki river mouth, concentration of phosphorus was relatively large, probably because river plume with large amount of nutrients from Todoroki river was transported by the northward current during typhoon.

Concentration of chlorophyll-a gradually increased as solar radiation became stronger after typhoon passed (**Figure 74**). Finally the concentration of chlorophyll-a became 3 to 4 times larger compared to the concentration before typhoon. This indicates that primary production in the reef may be promoted by concentrated supply of nutrients during atmospheric disturbance.

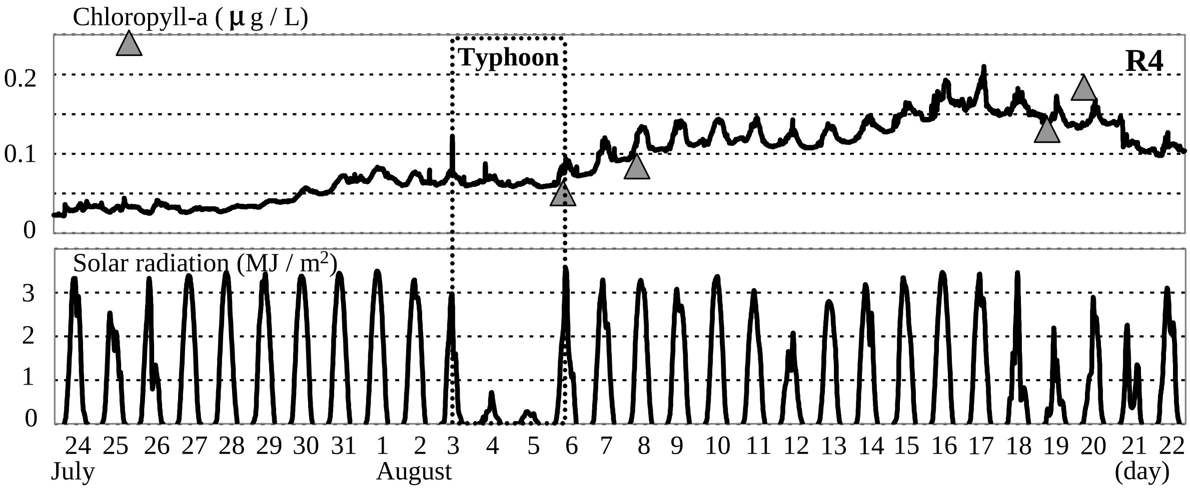


Figure 74. Time series of chlorophyll-a and solar radiation per day. Rectangle plots are chlorophyll-a concentration obtained from sampling analysis.

Numerical simulation

3.3.7 Reproducibility of current during typhoon

Figure 75 is an example of the computational results of current and time variation of wind during the typhoon. The results show the trend of characteristic pattern of flow during the typhoon in which current is directed south during the period with northwind and is directed north after northwind changed to southwind. Comparing time series of computational results with observation results for the velocity of tidal residual current (**Figure 76**), computational results agree relatively well with the observation data for N-S direction. For E-W direction, the computational velocity at Stn.R8 has some difference with the observed velocity. **Figure 77** shows computational and observation results on the water depths at Stn.R3 and R8. As the computation does not take account of the effects of storm surge, the water level is lower than the actual water level when the effect of depression of suction and eastwind toward shore was strong.

3.3.8 Contribution of wind stress to current in the reef under strong wind

Figure 78 shows tidal residual current computed for two different cases; the case1 is computed including wind term and the case2 is computed excluding wind term. As the results of case1 show, changes in current direction correspond to the wind variation, while the results of case2 do not show correlation with wind characteristic. The difference of velocity between the results of these two cases shows similar trend of fluctuation to the wind velocity fluctuation which indicates clear influence of wind stress to current in the reef (**Figure 79**). In addition the difference of velocity between two cases is not homogeneous in the reef. The maximum difference is 14 cm/s at Stn.R8, while 13cm/s at Stn.R5, and 8cm/s at Stn.R3. This shows that the effect of wind stress become stronger as the station move to north. Meanwhile field observation data indicates intensive flow toward Toru-guchi caused by circulation flow and the degree of influence by the circulation flow was larger near the Toru-guchi. Consequently it can be said that effect of wind stress become weaker and instead effect of circulation flow become dominant as it get closer to Toru-guchi.

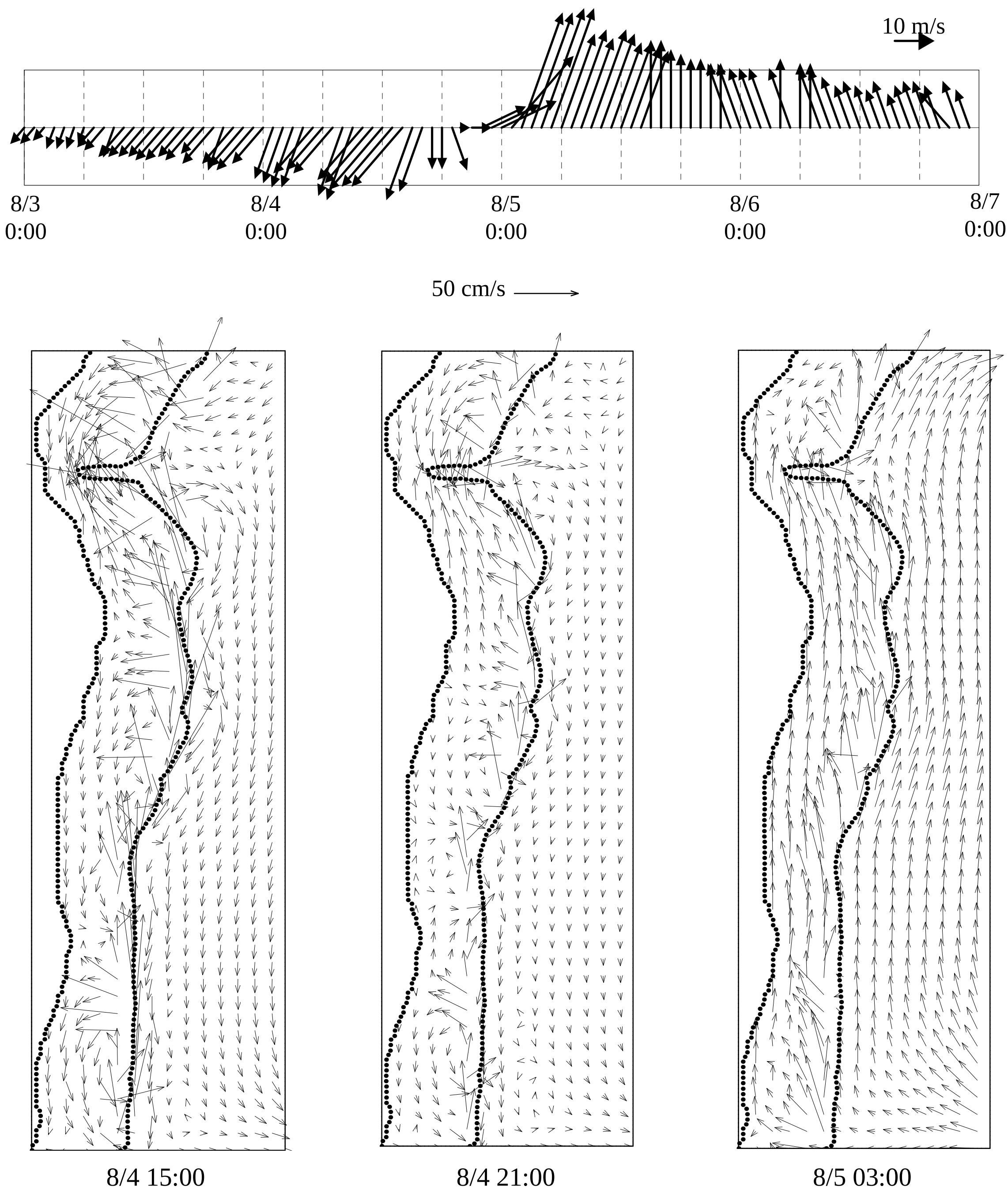


Figure 75. Time series of wind velocity and snapshots of computed current distribution in the reef before and after typhoon passes.

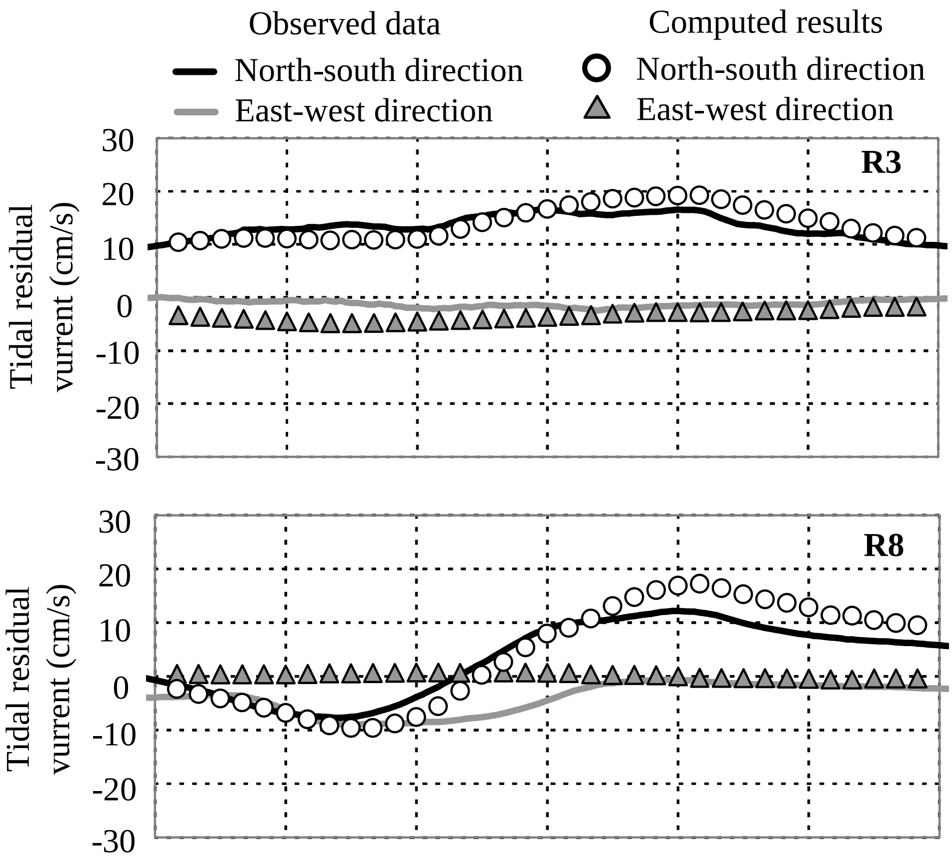


Figure 76. Time variation of tidal residual current derived from computation and field observation at Stn.R3 and R8.

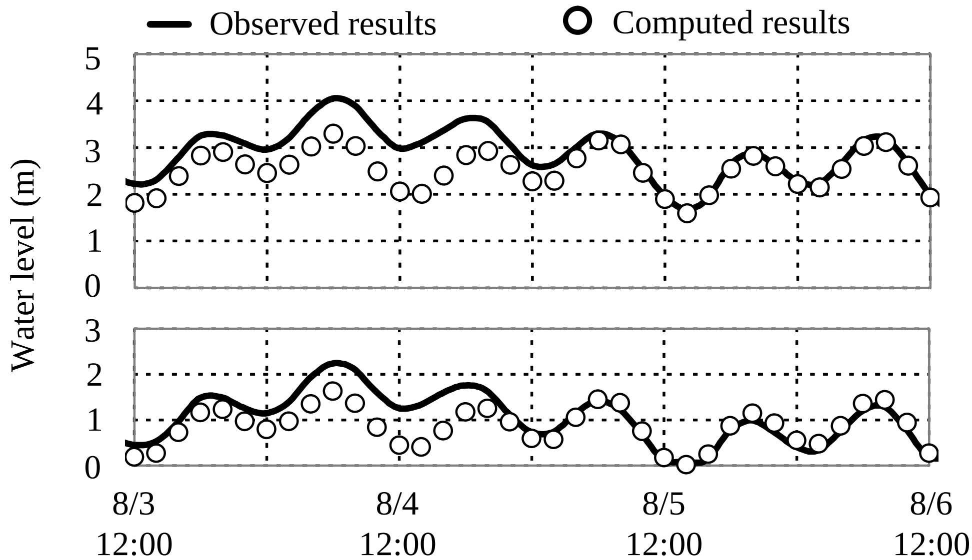


Figure 77. Time variation of water level derived from computation and field observation at Stn.R3 and R8.

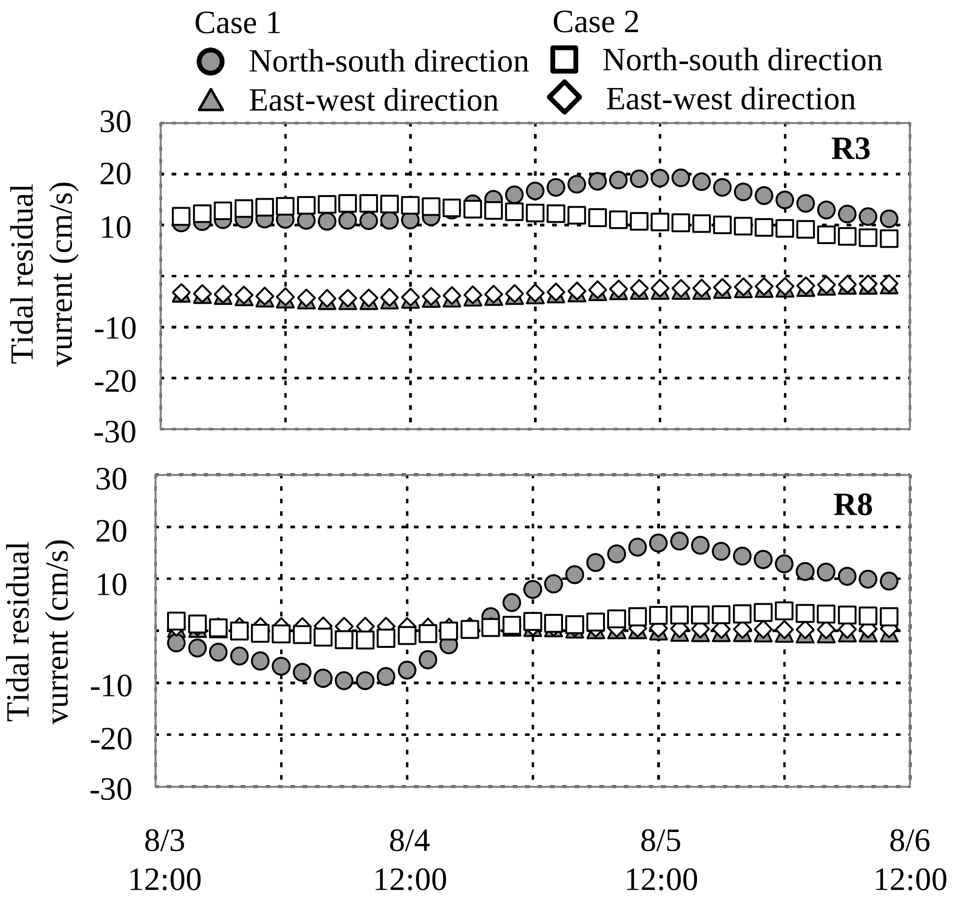


Figure 78. Time variation of computed velocity for tidal residual current derived from two different cases at Stn.R3 and R8. Case1: computation with wind. Case2: computation without wind

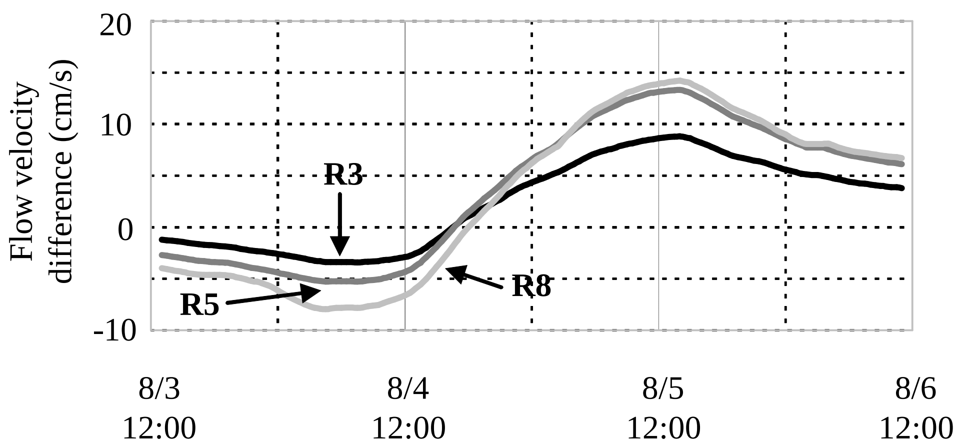


Figure 79. Flow velocity difference between computation with wind stress and computation without wind stress at Stn. R3, R5 and R8.

3.3.9 Historical land cover change (Todoroki watershed)

The time history (1984-2003) of land cover of Todoroki watershed (**Figure 80**) based on Landsat satellite image analysis showed dynamic changes. Each land cover map is a snapshot in time, thus, affected by a range of factors including cultivation activities. Land cover in the watershed has changed as a result of farm development in the earlier years and due to seasonal dynamics of agricultural crops as affected by planting and harvesting activities. A general decline in forest or 'trees' areas and an increase in bare and sugarcane areas were notable (**Figure 81a**). Most bare areas in a land cover map were actually sugarcane areas when compared with previous or succeeding land cover maps. A significant portion remains as grassland over the years, serving as pasture areas or source of grass for feeding cows being raised in the watershed and nearby areas. Sugarcane coverage showed progression through the seasons (**Figure 81b**). Coverage was lowest during summer (a planting season) and increased through the autumn period. Highest coverage occurred during winters, presumably prior to the harvesting of the crop. Note the declining forest coverage over the summer and autumn years.

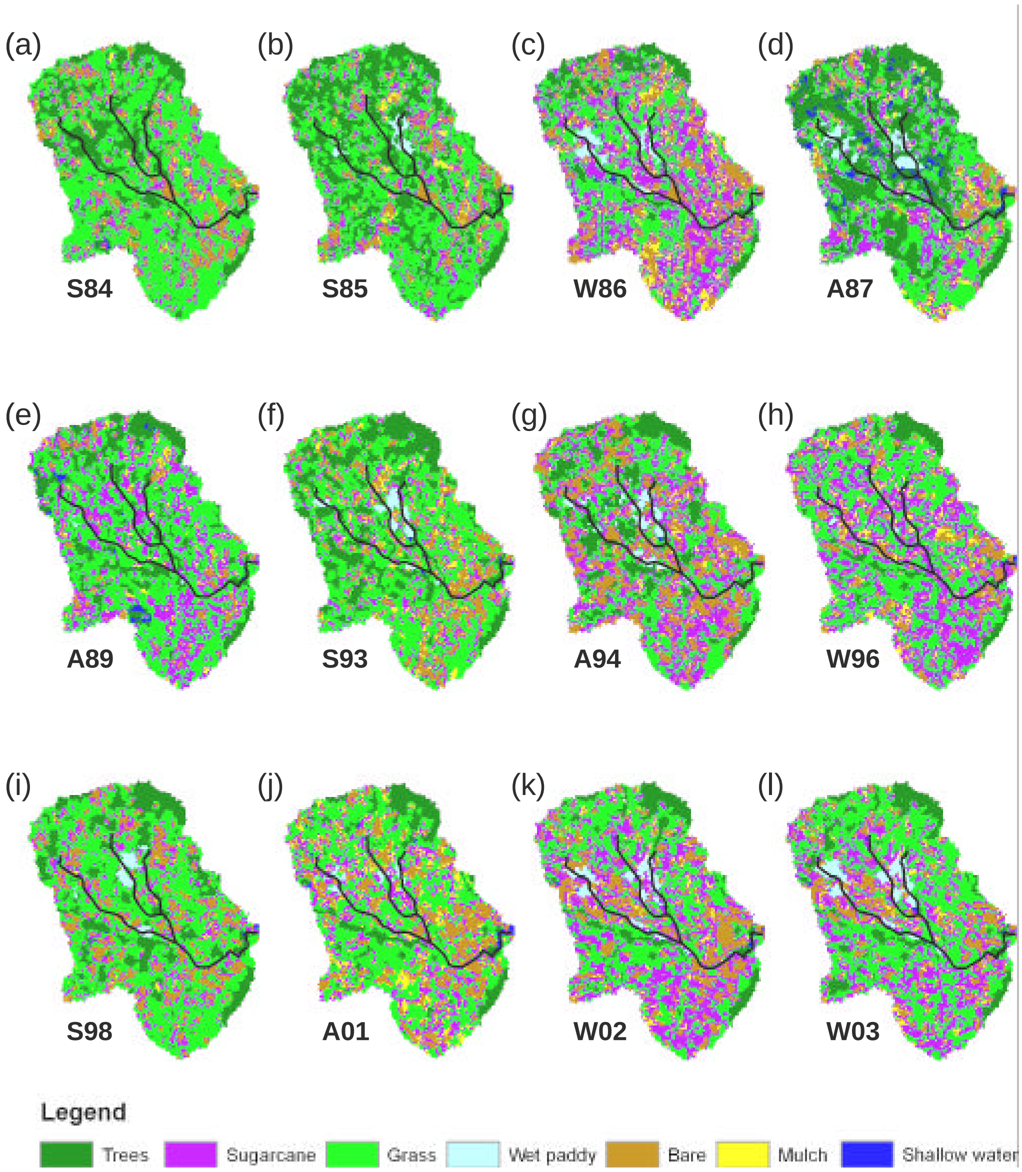
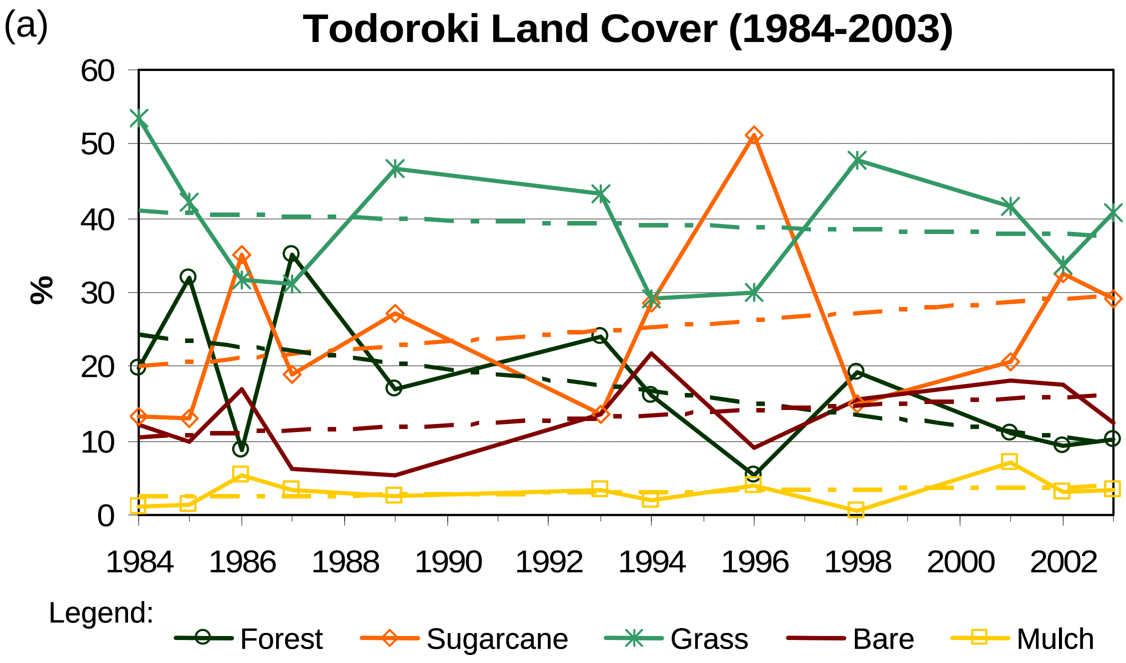


Figure 80. Land cover (1984-2003) of Todoroki watershed (Ishigaki Island, Okinawa, Japan) derived from Landsat-5 TM and Landsat-7 ETM+ images. (Todoroki River is shown in black lines. Labels indicate season and year, e.g. S84 – Summer 1984)



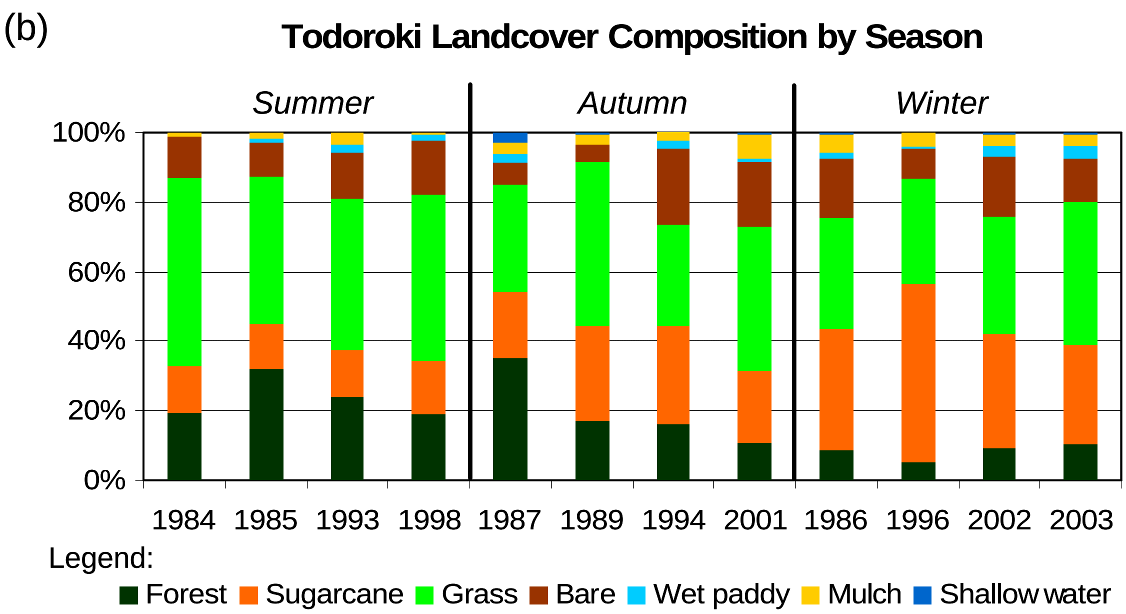


Figure 81. Land cover of Todoroki watershed based on the analysis of 12 Landsat images: (a) time history (1984-2003) and (b) land cover composition by season. Broken lines indicate linear trend for each cover class.

3.3.10 Historical benthic cover change (Shiraho Reef)

Benthic cover of Shiraho Reef changed dynamically with coral coverage generally decreasing and algal coverage increasing (**Figs. 82, 83**). Coral cover was greatly reduced in areas close to the Todoroki River mouth. In the nearshore areas of the reef, coral cover generally decreased more compared to coral cover close to the reef edge. Coral cover was evidently minimal in 1999, primarily due to the mass coral bleaching in 1998. Declines in coral cover were usually associated with increasing dominance of algal cover (**Figure 83**). In contrast to corals, macrophytes were almost always present in nearshore reef areas. Algae were abundant in areas adjacent to Todoroki River mouth. They even colonized significant portions of pavement rock in these areas. Algal coverage peaked in 1999 after the corals have been greatly diminished due to bleaching coupled with other stresses.

For the entire Shiraho Reef, a decreasing trend in coral cover is evident (**Fig. 83a**). In 1984, about 32% of the reef area is dominated by corals. By 1997, prior to the 1998 coral bleaching, coral cover was down to just 21%. Lowest coral coverage was detected in 1999 at 12% accompanied by maximum algal coverage at 65%. Coral coverage can be much lower than this percentage immediately after the bleaching event. From 1999 to 2002, coral cover increased, signifying recovery of corals from the effects of bleaching.

Northern Shiraho Reef exhibited a decreasing trend in coral cover and increasing trend in algal cover (**Fig. 83b**) over the pre-bleaching period. As before, coral recovery from bleaching was detected from 1999 onwards. On the other hand, coral cover in southern Shiraho Reef for the pre-bleaching period did not manifest significant trends, though there were considerable fluctuations in percentage cover (**Fig. 83c**). However, the increasing trend in algal cover appeared to be more pronounced than in the northern Shiraho Reef. As a result of the 1998 mass coral bleaching, coral cover in southern Shiraho Reef dropped from 22% in 1997 to just around 9% in 1999. This was followed a period of recovery until coral coverage reach about 20% in 2001 and 2002.

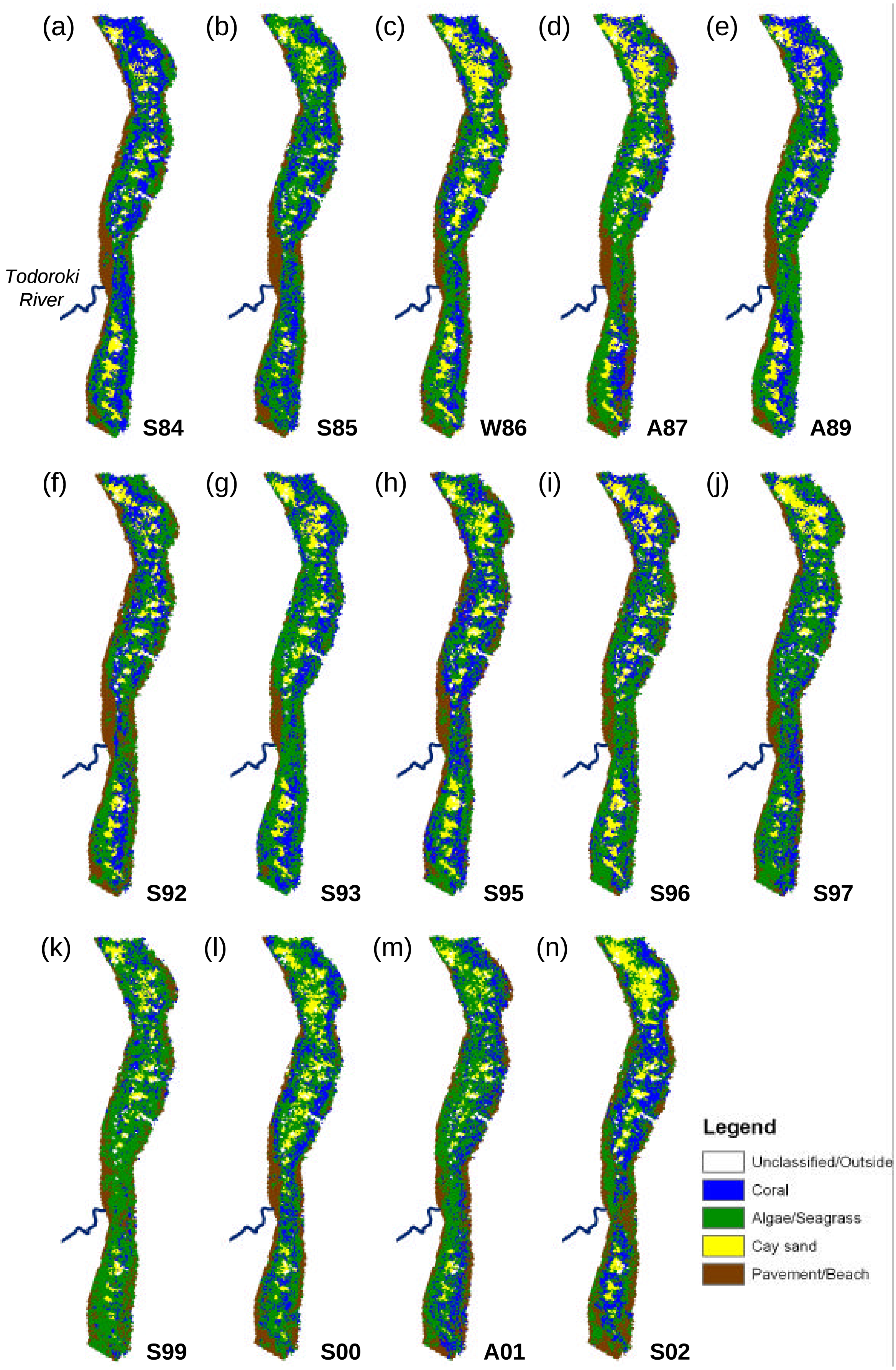


Figure 82. General benthic cover (1984-2002) of Shiraho Reef (Ishigaki Island, Okinawa, Japan) derived from Landsat-5 TM and Landsat-7 ETM+ images,

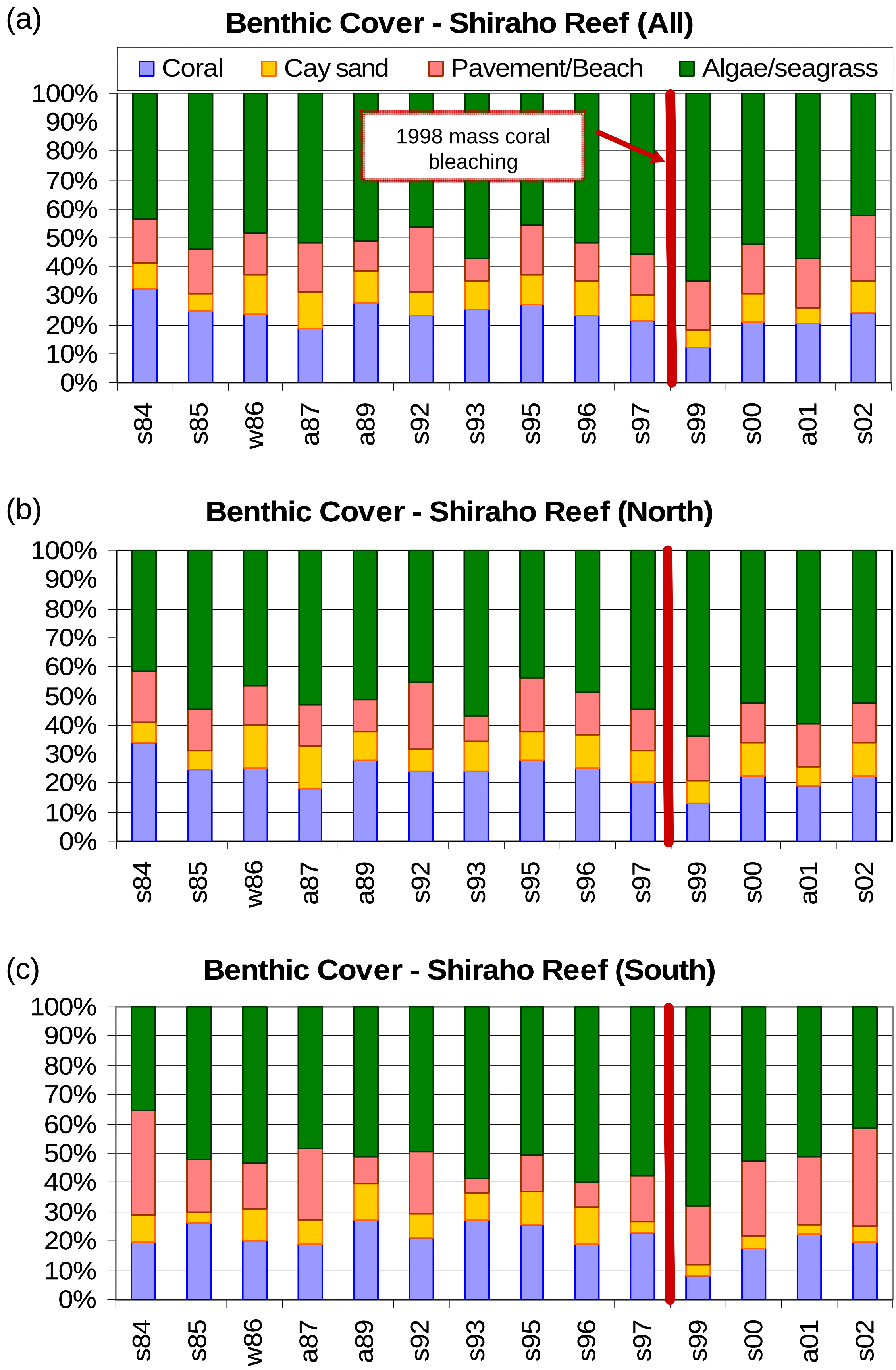
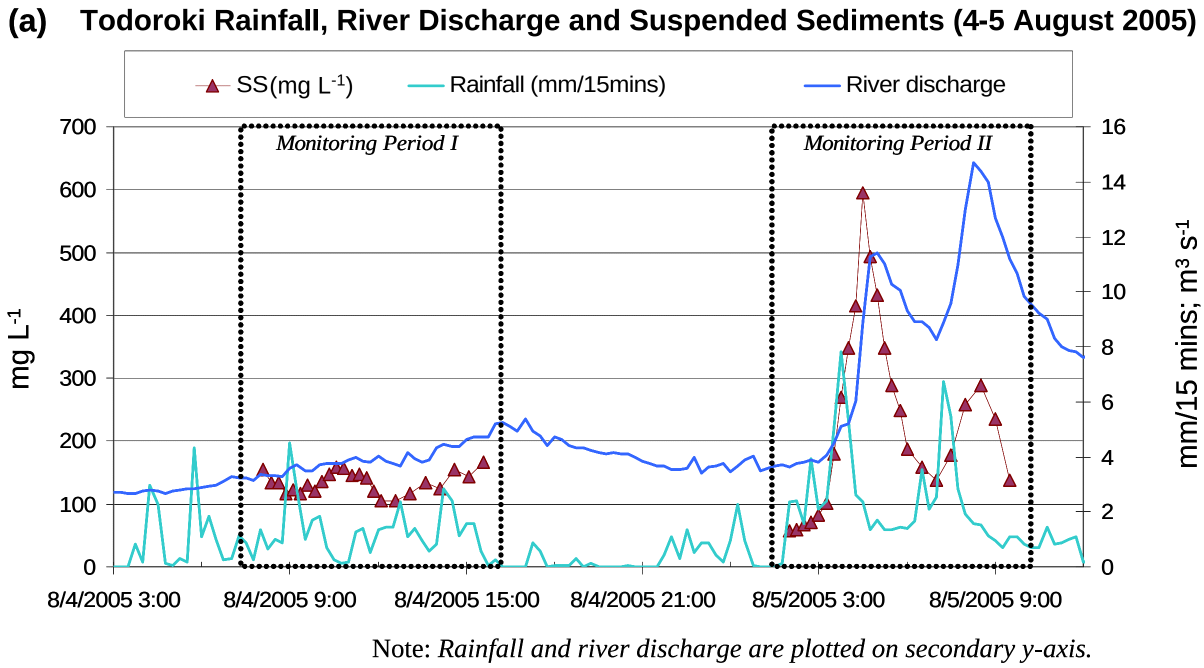


Figure 83. Time history of benthic cover (1984-2002) in Shiraho Reef: (a) whole Shiraho Reef, (b) northern Shiraho Reef and (c) southern Shiraho Reef

3.3.11 Time change of nutrient concentrations near Todoroki River mouth

Nutrient and suspended solid (SS) concentrations monitored at station T1 during a typhoon in summer 2005 are shown in **Figure 84**The almost continuous rains on 4 August resulted in a gradual increase in river discharge. Stronger rains on 5 August resulted in higher river discharge and rapid increase thereof. SS concentrations dramatically increased particularly after intensive rainfall events, with SS peaks nearly coinciding with high river discharges (**Fig. 84a**). This indicates the combined influence of erosive power of strong rains and transport capacity of resulting surface runoff. TP was directly proportional to SS and total dissolved P (TDP) constituted only a small percentage (<10%) of TP (**Fig. 84b**). Phosphorus readily absorbs to fine sediments and thus mostly occurs in particulate form in this watershed. In addition, TDP exhibited greater variability. A decreasing trend of TDP was observed during monitoring period I while an increasing trend was evident during second monitoring period II. TN (4-7 mg l^{-1}) did not exhibit a clear trend during monitoring period I but showed a decreasing trend during period II. N occurs mostly in dissolved form with total dissolved N (TDN) accounting for about 67% on the average and as much as 87% of TN. A gradual increase in river discharge (period I) gave rise to an increasing trend or 'concentration effect' (Webb and Walling 1985) in TDN (**Fig. 84b**). However, abrupt increase in river discharge (period II) led to a 'dilution effect' (Webb and Walling 1985) on TDN, with the lowest TDN concentration (2.2 mg l^{-1}) nearly coinciding with the first river discharge peak. In both cases, TDN tended to reach near equilibrium after the preliminary increase or decrease in concentration. Total particulate N (TPN) did not manifest a clear relationship with SS nor with river discharge and had greater variability compared to TDN.

Two major rainfall events were captured during the deployment of the MicroLAB instruments (**Fig. 85a**). Rainfall event A is relatively stronger but of shorter duration compared to event B. As a result, the increase in river discharge is much higher during event B. The rainfall events caused turbidity increases (**Fig. 85b**) in Todoroki River with turbidity being directly proportional to rainfall intensity. Chlorophyll-*a* concentration changes in accordance with changes in turbidity. A general increase in nitrate concentration was observed (**Fig. 85c**). During periods of relatively higher river discharge, NO_3-N concentration drastically decreased in direct proportion to river discharge, indicating dilution effect especially for events A and B due to the dominance of surface runoff. However, as the water level subsides, NO_3-N concentration tends to increase gradually over a period of days during low flow conditions. This is attributed primarily to groundwater contribution resulting from previous rainfall events. River discharge shifted from being surface runoff-dominated during storm events to baseflow-dominated during low flow periods. Indeed, strong rains produce surface runoff but at the same time cause leaching of nutrients and increase groundwater flow, hence, the increasing trend in NO_3-N concentration. Both NO_3-N and PO_4-P fluxes (**Fig. 85c**) correspond to changes in river discharge though increase rates during high flow condition were different. PO_4-P flux increased a hundred fold while NO_3-N increased about 10 times only. The average NO_3-N fluxes for the flow periods considered in **Table 17** did not vary much. On the other hand, average PO_4-P fluxes were higher during high flow conditions. Event A and event B discharged about 150 and 900 kg NO_3-N, respectively. During low flow periods, the river also outputted considerable loads of NO_3-N. For example, between events A and B, 670 kg of NO_3-N were discharged over a period of around ten days. The actual total P discharged can be considered to be more than 10 times the computed discharged amount of dissolved PO_4-P, based on findings from nutrient monitoring in summer 2005. These observations underscore the importance of continuous monitoring of nutrient discharge.



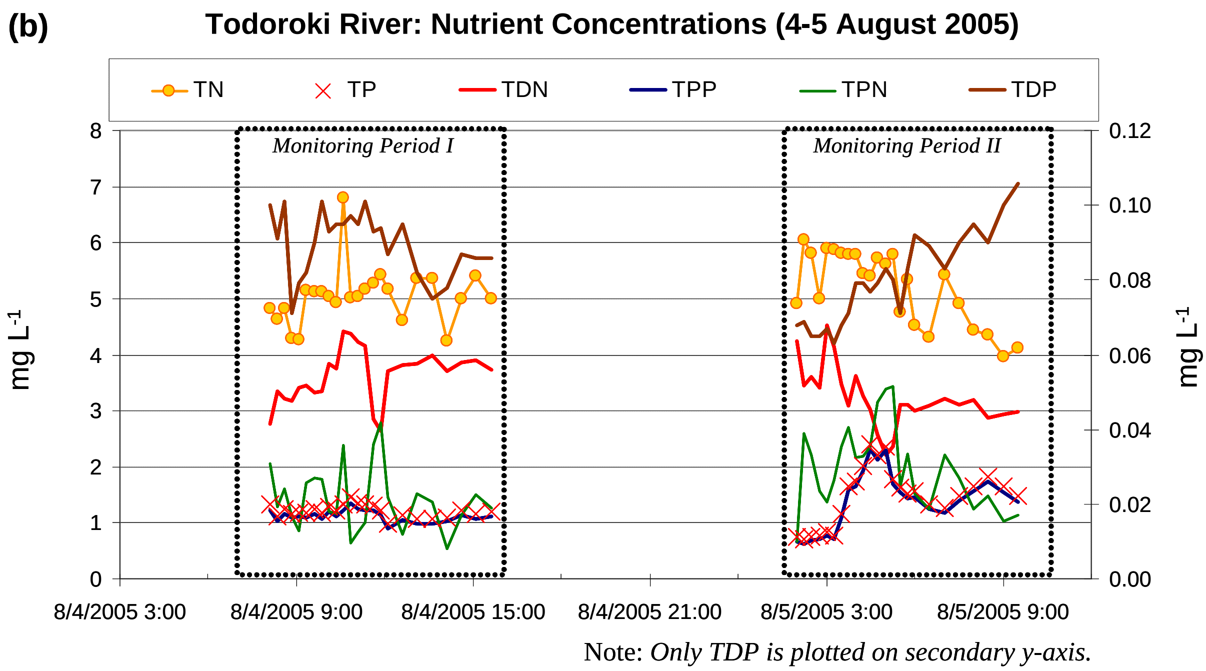


Figure 84. Concentrations of (a) suspended solids and (b) nutrients at Station T1 (near Todoroki River mouth) analyzed from water samples collected on 4-5 August 2005

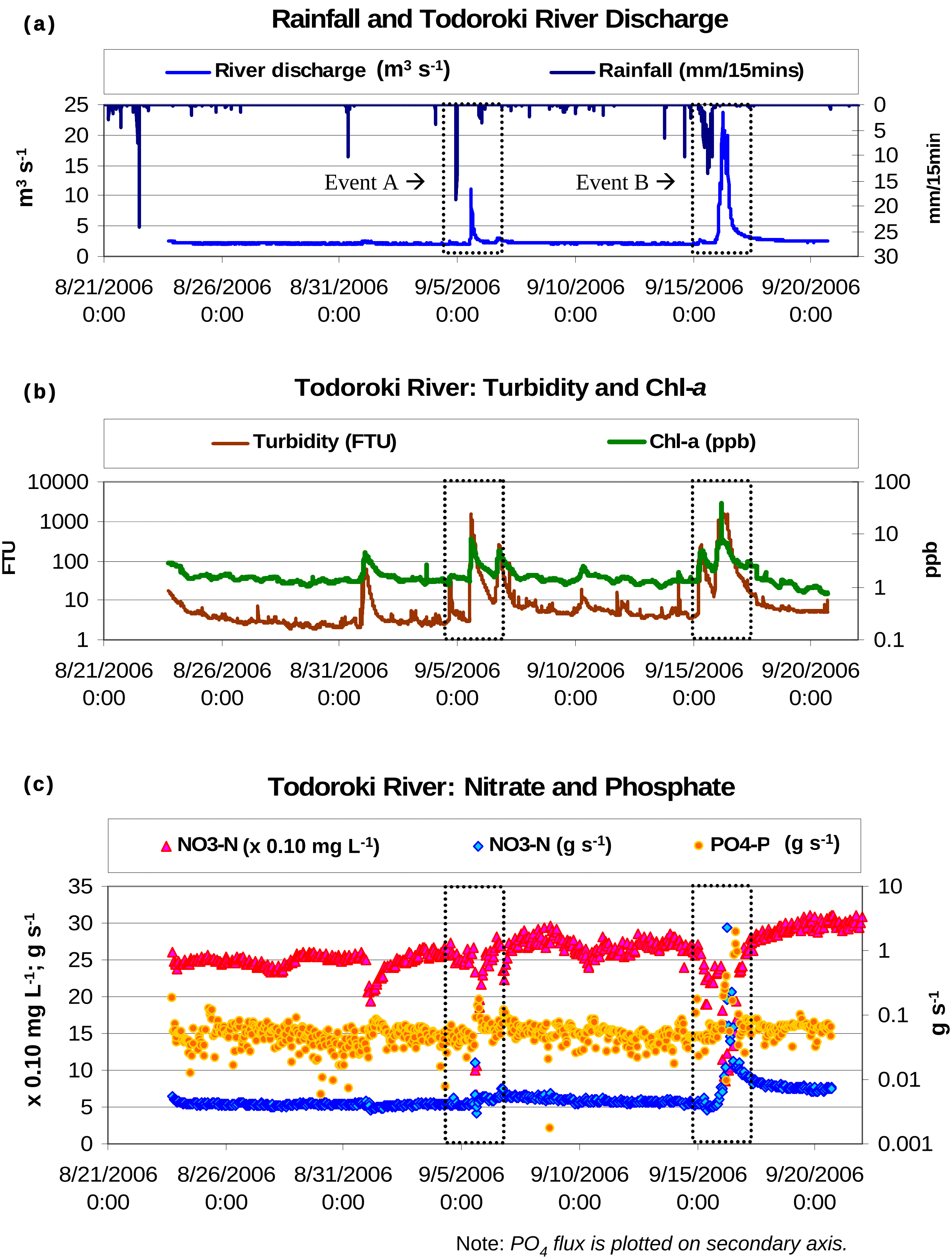


Figure 85. Todoroki monitoring data (Summer 2006): (a) Rainfall and river discharge, (b) Turbidity and chlorophyll-a and (c) Time history of NO_3-N concentration (mg/L) at Station T1 (near Todoroki River mouth) obtained using an in-situ nutrient analyzer (MicroLAB). Shown also in (c) are the discharge rated for NO_3-N and PO_4-P.

Table 17. Nitrate and phosphate fluxes from Todoroki River during low and high flow conditions shown in Figure 80

Dissolved nutrient fluxes from Todoroki River (23 August – 22 September 2006)				
Time Period *(Calculation period)*	**Dissolved NO_3-N**		**Dissolved PO_4-P**	
	Discharged amount (kg)	*Average flux (kg hr^{-1})*	*Discharged amount (kg)*	*Average flux (kg hr^{-1})*
Before event A *(over 12 days 18 hrs)*	703.9	2.472	6.3	0.021
Event A *(22 hrs)*	149.7	2.136	1.8	0.078
Between event A and B *(9 days 11 hrs)*	674.9	2.146	6.2	0.027
Event B *(over 1day 17 hrs)*	900.5	2.069	17.5	0.456

3.4 Regional sediment discharge modeling

3.4.1 Empirical relationships

Analysis of sediment discharge against basin area (**Figure 86a**) shows a strong correlation in support to similar relationships establish in numerous other studies (Chorley et al. 1984, Milliman et al. 1992). It is also noted that as the basin slope increases the sediment load also increases (**Fig. 86b**), this follows on by discussions by other researchers on the role of slope angle for increased erosion

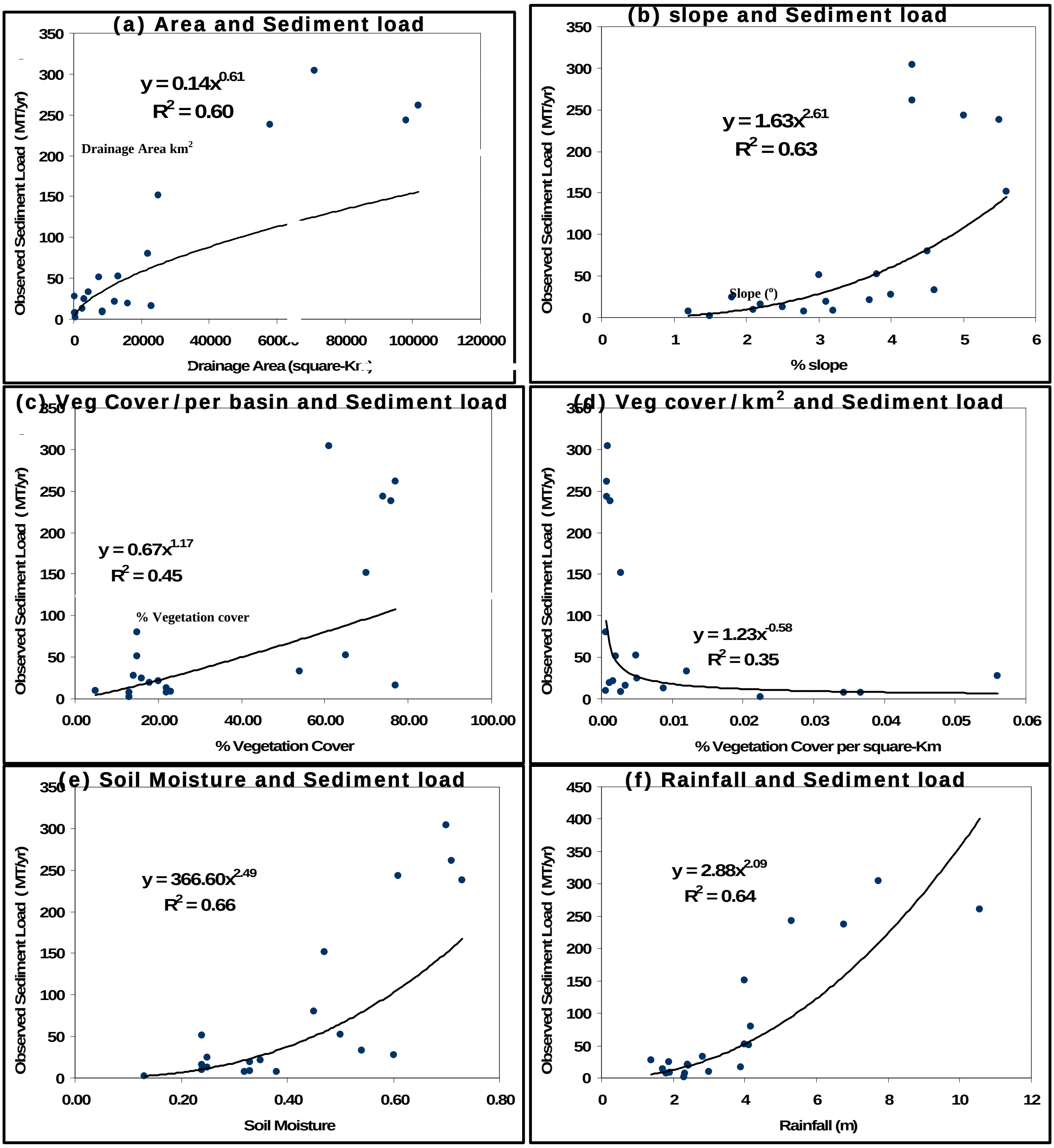


Figure 86. Empirical relationship between basin area, slope, vegetation cover, soil moisture, rainfall and elevation to sediment load for the 22 drainage basins in the South-East Asia and West Pacific Region

Figure 86c shows the relationship of sediment flux and average basin percentage vegetation cover. The relationship shows a weak positive correlation factor R^2 of 0.45. It can be interpreted as when vegetation cover increases, sediment load also increases, however, in the physical senses this is not the case. Naturally sediment load from a basin should increase due to more bare soil exposed to rainfall and wind. Therefore, it is important to understand that this figure shows the percentage vegetation cover per basin regardless of the size.

Figure 86d shows the ratio between percentage-vegetation cover and area in square-kilometers. This figure gives a more appropriate representation of sediment discharge due to vegetation cover. It shows that as vegetation cover per-square kilometer increases, the sediment discharge decreases (Lukey et al. 1995).

Figure 86e shows the relationship between sediment discharge and average basin soil moisture content in each watershed. The relationship between soil moisture content and sediment discharge has been established to be vital for overland erosion processors (Pappas et al. 2008). Rainfall and sediment discharge was found to have a positive correlation factor R^2 of 54% as shown in Figure 1f. This is good agreement with previous other studies as high rainfall normally result in large sediment discharge signal.

3.4.2 Regional Sediment Discharge Model (RSDM)

The following empirical relationship between basin drainage area, *A*, maximum elevation in basin drainage area, *E*, average slope angel per-km, *S*, average basin rainfall, *R*, %vegetation cover per-square kilometer, *V*, and average soil moisture content per-square kilometer, *M*, and sediment discharge *Qs* were obtained;

Area, *A*: $Qs = 0.15A^{0.61}$ $R^2=0.60$

Elevation, *E*: $Qs = 4.98E^{2.49}$ $R^2=0.54$

Slope, *S*: $Qs = 1.63S^{2.61}$ $R^2=0.63$

Rainfall, *R*: $Qs = 2.88R^{2.09}$ $R^2=0.64$

%Vegetation Cover (per km2), *V*:

$Qs = 1.23V^{-0.58}$ $R^2=0.35$

Soil Moisture Content, *M*:

$Qs = 366.60M^{-2.49}$ $R^2=0.35$

Hence the new sediment model named RSDM developed by multi-regression analysis is shown below.

$$Qs = 0.092\frac{A^{0.17}R^{0.60}S^{0.74}M^{0.71}E^{0.73}}{V^{0.164}}$$

RSDM is compared with observed sediment load. The results show a small bias with R^2 of 0.93 as shown in **Figure 87**.

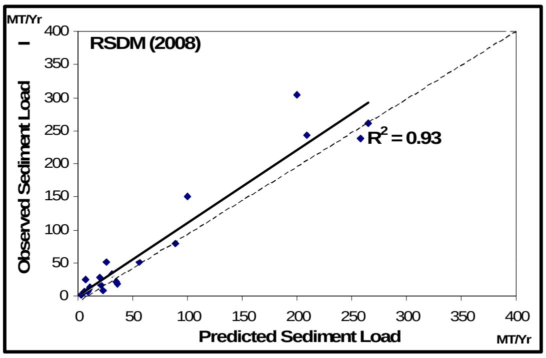


Figure 87. Predicted sediment load and observed.

3.4.3 Model Comparison with QART Model

RSDM is compared with the QART (Syvitski et al. 2005) sediment load predictor. The results are summaries in **Table 18**. It shows RSDM has a mean maximum error reading of 0.75, a reduction by 1.15 when compared to the ART sediment flux model output. This is a significant improvement by 150% in the accuracy of the prediction when compared to the ART sediment discharge model.

Table 18. Comparison of observed, RSDM and ART annual sediment discharge values (Mt/yr) with Maximum Error Analysis

River	ART Model Mt/yr	RSD Model Mt/y	Observed Sediment Discharge Mt/y	Max Error RSDM	Max Error ART Model
Fly	237.9	108	115	0.06	1.07
Markham	51.9	31	5	5.2	9.38
Mamberamo	40.9	96	94	0.02	0.57
Digu	68	97	75	0.09	0.29
Palau-palau	110	138	270	0.59	0.49
Cijolang	7.2	3	1.73	3.16	0.73
Cikeruh	3.4	7	5.9	0.42	0.19
Cilutung	14.1	23	7.2	0.96	2.19
Cimanuk	28.7	45	25	0.15	0.80
Cimuntur	2.4	11	1.9	0.26	4.79
Citanduy	13.1	15	10	0.31	0.50
Kali Brantas	12.3	21	8.1	0.52	1.59
Porong	17.1	37	20	0.15	0.85
Solo	13.1	16	19	0.31	0.16
Komering	1	10	1.2	0.17	7.33
Purari	169.9	60	105	0.43	0.62
Sepik	25.9	115	115	0	0.78
			Mean Max Error	**0.75**	**1.90**

3.4.4 RSDM and Other models

The RSDM bias and variance was compared with other known global and regional scale sediment load models. Models suggested by several different authors Hay 1998, Hovius 1998, Milliman et al. 1992, Ahnert 1970) were used for this purpose (**Table 10**). Obvious draws back for these equations are the lack factors to describe vegetation cover, soil moisture characteristics, and rainfall parameters.

The equations proposed by these authors can be conclusively referred to as “steady” or “unchanging” parameters with respect to the temporal scale. With global warming, subsequently, climate change, as a crucial factor in vegetation shifts and rainfall intensity and frequency, it is apparent that more appropriate factors capable to capture the influence due to climate change are needed to model regional and global scale sediment discharge. **Figure 88** shows the bias and variance assessment of the five other regional scale sediment load predictors.

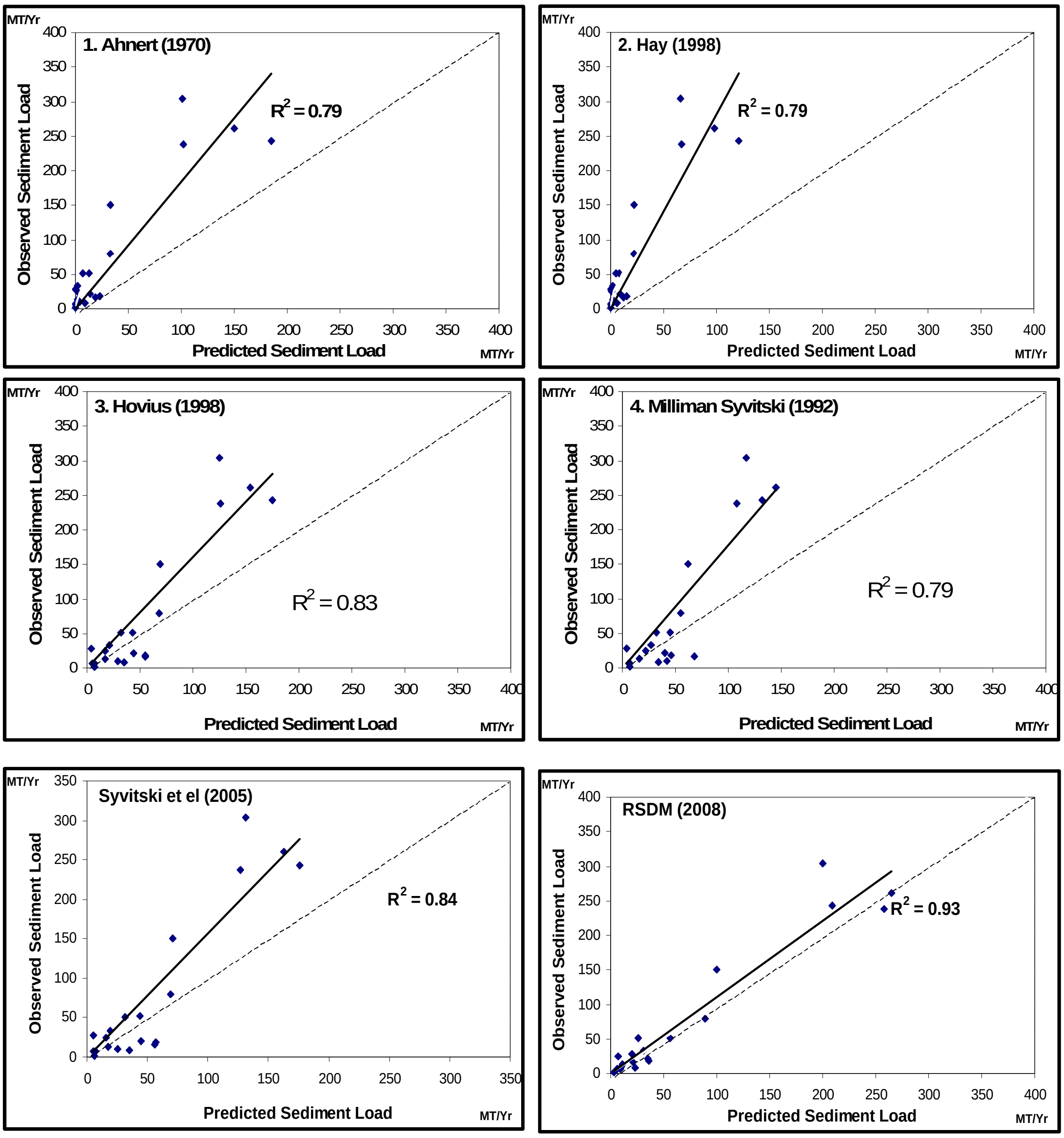


Figure 88. Comparison of RSDM with 5 regional/global sediment discharge models

3.4.5 RSDM application to SEA-WP regions

RSDM was used to calculate sediment budget for the SEA-WP regions. **Table 19** and **Figure 89** shows the sediment load budget comparison.

RSDM was than coupled to GCM Precipitation data obtained from the Center for climate research/National Institute of Environmental Studies (CCR/NIES) Japan (http://www.ipcc-data.org/). The rainfall data for future prediction was for scenario B1, which projects the most conservative future emission of greenhouse gases, and A1B, which describes a balance between fossil and non-fossil energy usage, are used to show the sediment trends in future using RSDM. **Figure 90** shows the future trend for heavy rainfall days. Future sediment load trend for the GCM rainfall predictions are shown in **Figure 91**.

Table 19. Sediment load calculated for the SEA-WP from various models

Authors	Sediment Load
Hay (1998)	1068 x 10^6 t/yr with an erosion base level of 200m
Milliman et al. (1999)	2950 x 10^6 t/yr

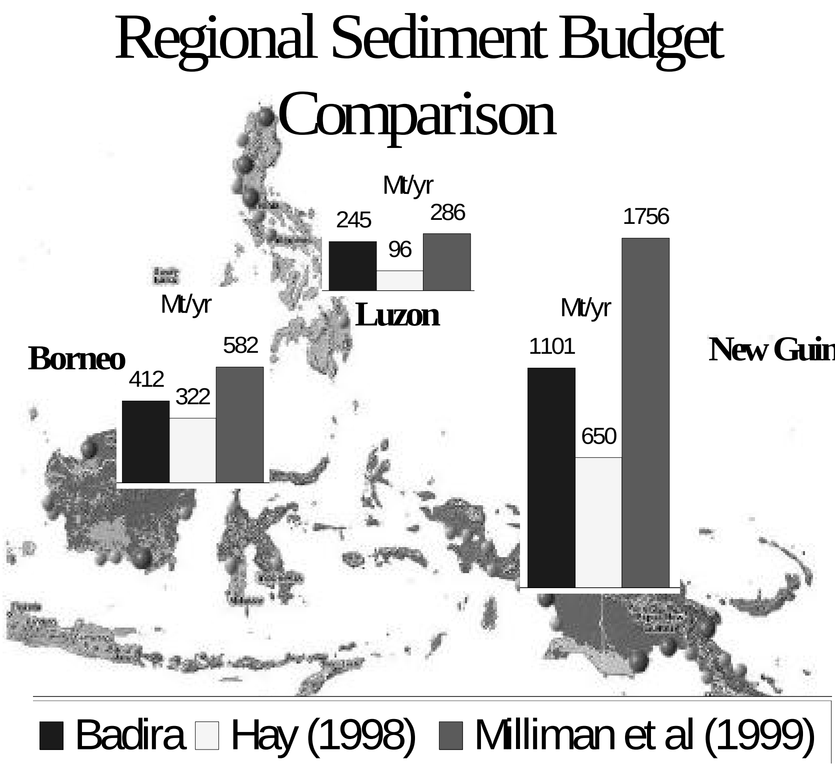


Figure 89. Sediment load in the SEA-WP region

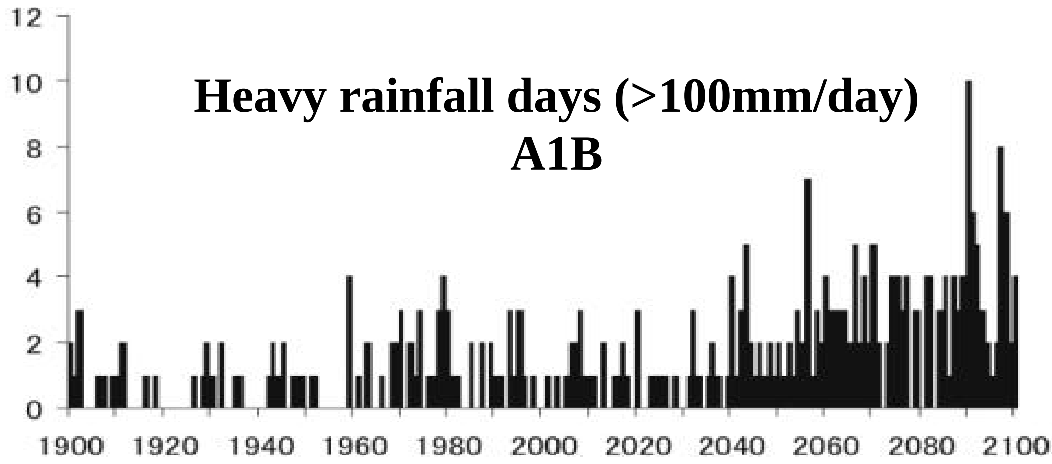


Figure 90. Future Heavy rainfall trends in the SEA-WP region

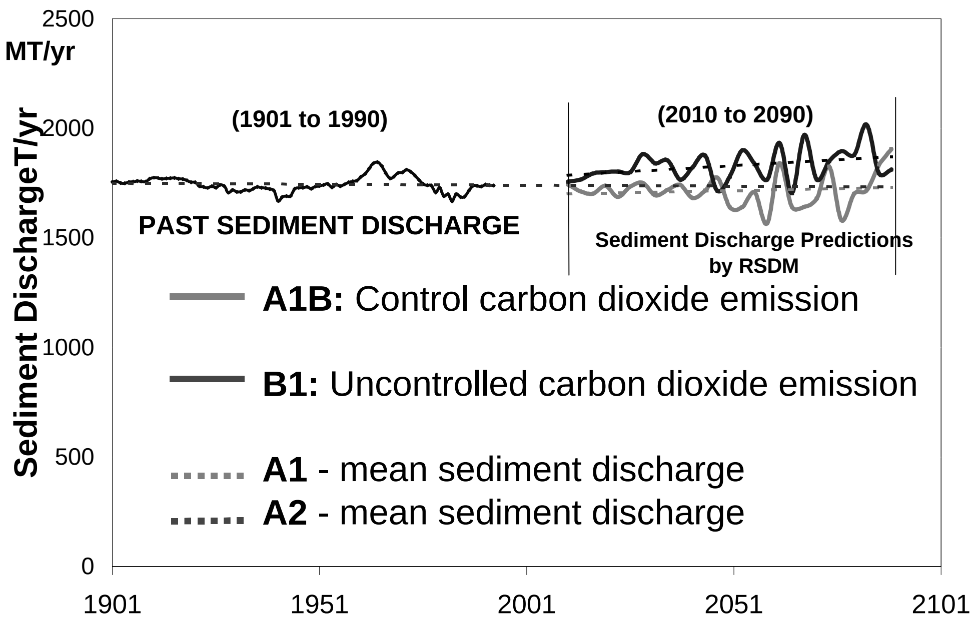


Figure 91. Future sediment load trend in the SEA-WP

The model also showed that in 2100 period the range of sediment load change is from 27% to 39% in the SEA-WP region. Average New Guinea sediment Load is suggested to change by 16%, 22% in the Borneo, and 13% in Philippines in 2050 compared to the 2010 levels. The change in load is subject only to precipitation change with both % vegetation cover and soil moisture contents remaining unchanged.

4. Conclusions

Puerto Galera Study

The current around Puerto Galera area can be divided into a strong current at the outer sea and the channels and a weak two-layer flow at the lagoon interior. The circulation outside the lagoon and at the channels is controlled by the water level difference between South China Sea and Sibuyan Sea. The sluggish circulation inside the lagoon is controlled by the wind and temperature-governed gravity current. Even though the current is extremely weak at the innermost part of the bay, the ability of renewal of its waters is maintained by the wind and density-driven circulation, which drives out the polluted water from surface water. Moreover, from time to time, the immediate massive intrusion of the cool water could rapidly renew the water at the innermost part of the bay at Muelle pier. During low flushing periods, the algae concentration inside Puerto Galera lagoon has higher magnitude and higher nutrient concentration. The always higher concentration of chlorophyll-a inside the bay implies that the lagoon works as a source of primary producer for the Verde Passage. The nutrient concentrations inside the lagoon fluctuate quite rapidly, indicating the limited nutrients in the system. Since the nutrient concentration may be higher or lower compared to the outer sea, the lagoon works as both a source and a sink of nutrients for the passage. Re-opening sand bar can deliver positive improvement of water quality at area very close to sandbar. The improvement of water quality at Muelle cove is limited. The most effective way to mitigate the water quality problem at Muelle cove is to reduce the amount of input pollution.

Bolinao Study

The intensive and extensive field observations were conducted from November 14 to December 2, 2007 around Santiago Island, Bolinao to collect physical, biological and chemical data. The main conclusions are as follows:

- The currents in the Bolinao reef complex have an appreciable magnitude of tide-averaged velocities, even during neap tides, which are governed mostly by wave set-up effect due to radiation stress of wave. A significant volume of water go out from the reef flat through channels cutting across the outer reef crest, while inflow into the reef flat spills over the reef crest.

- Water of outer sea come into the aquaculture area through east channel and go out to outer sea through the north channel. Since the north channel is an exit point of water that goes around the aquaculture area, fish structures along the channel should be demolished to allow water flow freely and flush out pollutants to outer sea effectively.

- High feeding input from fish cages or pens contributes significantly to high nutrients concentrations in the aquaculture area. Consequently, phytoplankton blooms tend to occur especially during neap tide.

- Nutrient concentrations in the reef area were way beyond the optimal levels for corals, since water which have high nutrient concentrations drift in to the reef area from the aquaculture area. Therefore, it can be said that high nutrient concentration is one of the major causes of destruction of corals in Bolinao reef complex.

- Concentrations of dissolved oxygen in the aquaculture area were less than optimal levels for milkfish. Especially during neap tide, dissolved oxygen reached almost 0 mg/l near the bottom. It was implied that the fundamental cause of the massive fish kill in 2002 and 2007 was lack of dissolved oxygen in the cages and pens.

- Concentrations of dissolved oxygen in the reef area were high enough for marine life due to high oxygen productivity by the photosynthesis of abundant sea grasses. Areas along the eastern side of the reef flat are dominated by dense seagrass beds and thereby the highest dissolved oxygen concentrations were observed in the area.

Shiraho Reef Study

A field survey was conducted in a fringing reef at Ishigaki Island, Okinawa from 24 July to 22 August 2005 by deploying velocimeters, wave gauges, tide gauges, salinometer and turbidity & chlorophyll-a meters at 14 stations including the outer reef and the river mouth. Also water sampling was taken place to analyze nutrients and chlorophyll-a concentration. Numerical simulation was conducted to reproduce currents in the reef based on data obtained by the field survey. The main conclusions are as follows:

- During typhoon, contribution of wind stress to current was dominant and tidal residual currents under strong southwind became twice as large as those under weak wind condition.

- Hydrodynamic condition during typhoon, however, is not simply governed by wind-induced currents but also by the circulating flow, which is strongly affected by topography of the reef. The effect of the wind-induced currents became weaker and the influence of circulation flow, instead, became stronger, in the area closer to the big channel, Toru-guchi.

- There was considerable sediment discharge during the typhoon which increased turbidity in the reef. However the turbidity of sea water was increased not only by the turbid river plume but also by re-suspension of bottom sediments due to high waves.

- Supply of nutrients during typhoon promoted primary production in the coral reef drastically. The concentration of chlorophyll increased after typhoon and became 3 to 4 times larger than the concentration before typhoon.

Regional Sediment Discharge Modeling

RSDM and the subsequent verification of the new sediment flux predictor against observed annual sediment load data showed a correlation factor R2 of 93% and shows small bias and small variance against other regional sediment discharge models. The potential to couple to Global Circulation Models is a tremendous boast to calculate sediment load trends in the future.

The application of the new model to predict future sediment load showed an increasing trend in the future for mean sediment load from the years 2010 to year 2100 for the SEA-WP region due to anthropogenic global warming.

Geochemistry study of vertical mangrove sediment profile can be used to tune and further improve sediment discharge models. Upon differentiating between various sediment sources, the terrigenous sediments can be used to estimate sediment loads based from the sediment cores analysis. Estimates of accumulation rates and trapping efficiencies of mangroves are important to come up with sediment load estimates, which can be used to develop more accurate long term prediction models for ungauged drainage basins.

Overall Conclusions of the Project

The coastal environment is beset by increasing pressure from humans. Add to this the effects of the changes in the global climate. Environmental threats such as sedimentation and eutrophication remain to be two of the environmental concerns despite headways in the management of the coastal zone. However, to properly address these environmental concerns, understanding of the processes at work and their interactions must be improved. Management and socio-economic aspects of an integrated coastal zone management must be supplemented with scientific data on the bio-physical environment. Monitoring of key environmental variables is critical in the protection of the fragile coastal ecosystem. Loadings of sediments, nutrients and other materials into rivers and streams and subsequently to the reefs and bays need to be quantified. As shown through the case studies presented in this report, the effect of sediment and nutrient discharges from the watershed and point sources in the water body itself (e.g. fish cages) is largely affected by hydrodynamics. Modelling of hydrodynamics and water quality is an effective tool for assisting managers make informed decisions for protecting and conserving the coastal environmental resources. It is also essential to incorporate into the decision-making process the potential influence of global climate change such that decisions are made not only to address the need of the present generation but also of the future generations to come.

5. Future Directions

From the component studies carried out under this Project, it is clear that monitoring and modelling efforts should continue, particularly because coastal ecosystems are facing sustained and increasing threats from humans and from the effects of global climate change. The Project identified the following as potential future undertakings:

- In the modelling of the coastal environmental fluxes, submarine groundwater discharge needs to be considered also, especially because of the nutrients they deliver into the receiving water bodies. Subsequent monitoring and modelling efforts are geared towards this direction.

- The development of indicators based on field observations and modelling results should be looked into. Considering that most coastal communities cannot afford expensive high-technology monitoring sensors, these indicators may be used for supplementary routine monitoring of the coastal environment.

- The linkage of hydrodynamic/water quality modelling with ecological modeling will be pursued. The results of hydrodynamic/water quality simulations needs to be translated into equivalent effects or impacts on the biota or the ecology of reefs and bays as a whole. In this way, scientific findings can easily be communicated with the environmental managers and policy-makers.

- The potential effects of environmental and meteorological changes (e.g. rainfall intensity, frequency and strength of typhoon) predicted by global or regional circulation models needs to be investigated. The Regional Sediment Discharge Model (RSDM) must be extended to include capability for estimating nutrient discharge as well.

- Collaborative networking should continue and actual research collaboration needs to be pursued with the aim of facilitating the sharing of expertise and experience and building the capacity of local research centers. A database of hydrodynamic and water quality observations needs to be set up to serve as repository of data collected by various research groups in the West Pacific region.

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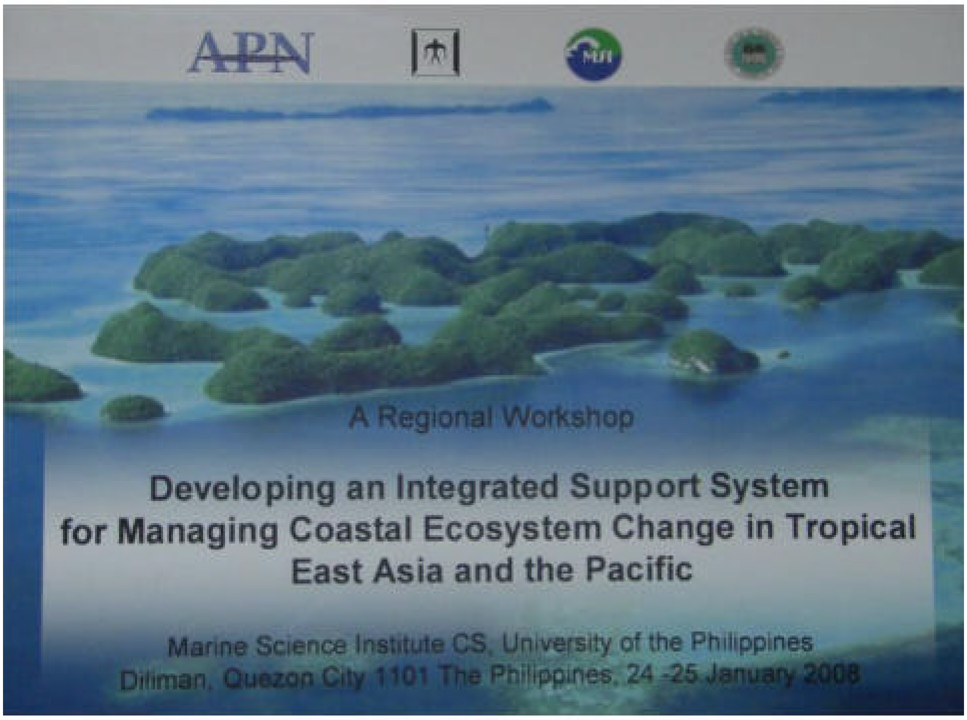
APPENDIX A

A Regional Workshop
Developing an Integrated Support System for Managing Coastal Ecosystem Change in Tropical East Asia and the Pacific

Marine Science Institute CS, University of the Philippines
Diliman, Quezon City 1101 The Philippines, 24 -25 January 2008



Appendix A.1 Programme and List of Participants

A Regional Workshop
Developing an Integrated Support System for Managing Coastal Ecosystem Change in Tropical East Asia and the Pacific
Marine Science Institute CS, University of the Philippines
Diliman, Quezon City 1101 The Philippines, 24 -25 January 2008

Rationale

The tropical coasts of East Asia and the Pacific are fragile ecosystems that are subjected to increasing pressures from human activities and natural events. To achieve sustainable use of coastal resources, management decisions must be founded on sound scientific basis. Hence, physical and biological data must be collected using a methodology, which can yield comparable results across regions in the Asia-Pacific. Efforts must move forward from 'detecting' to 'forecasting' the consequence of changes in sediment and nutrient loads and thresholds of impact for different species and habitats in order to identify sustainable management strategies (Airoldi, 2004). Thus, by integrating numerical modeling, remote sensing and geographic information systems, while considering socio-economic drivers, a Decision Support System (DSS) can be developed to explore change scenarios and which can give reliable results, making use an operational basis highly probable.

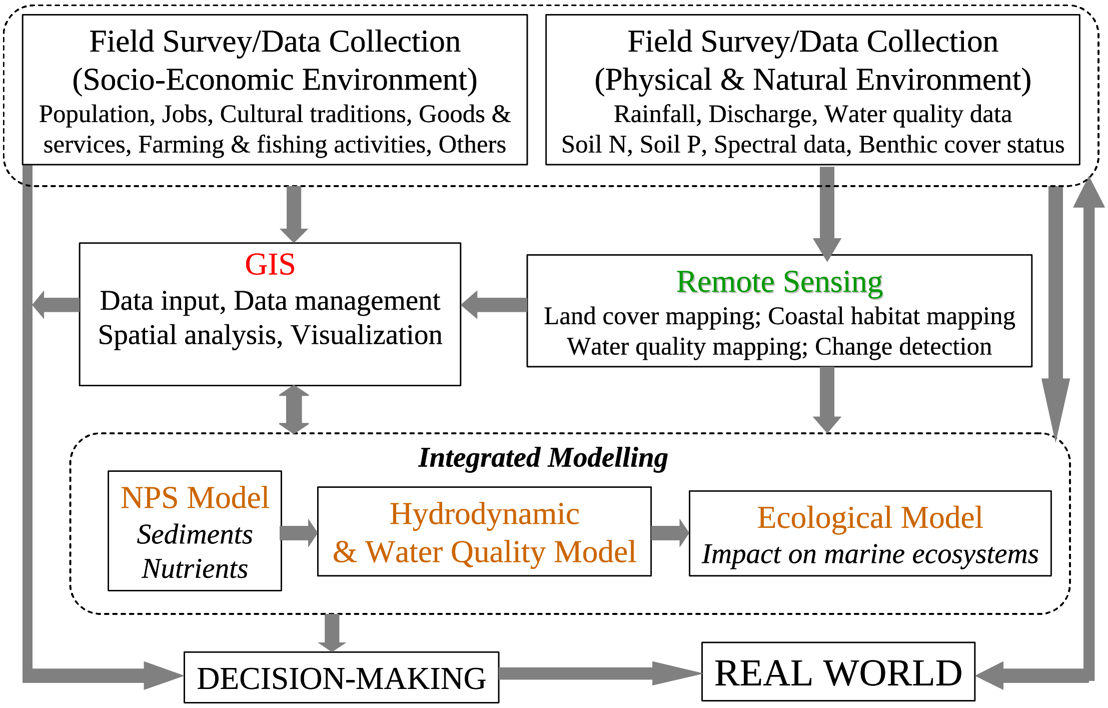
Several studies have been conducted in various coastal study sites with the framework of an integrated support system being promoted by the APN Project "*Integrated Support System for Managing Environmental Change and Human Impact on Tropical Coastal Ecosystems in East Asia and the Pacific*". These studies encompass different aspects (e.g. physical, biogeochemical, socio-economic) of the coastal environment. It is high time to put the pieces together to reap the benefits of these studies and improve understanding of the complexities of coastal ecosystems in the Asia-Pacific region. Thus, this workshop aims to synthesize the results of various research work conducted in the Philippines, Japan and other countries and come up with an integrated model of tropical and sub-tropical coastal environments. It also aims formulate a decision support system, within the framework of research collaboration and community participation, for studying such environments and for proposing solution alternatives to address coastal environmental problems. Furthermore, this workshop also aims to solicit the participation of a group of coastal scientists in the region to exchange data and experiences in developing local DSS in order to improve their proficiency in evaluating environmental change in tropical coastal environments.

Focus

Through collation of historical data and additional field observations, the workshop aims to combine information from the physical (e.g. changes in coastal zone physiography, composition, dynamics), natural (changes in flora and fauna) and social (e.g. population growth and human activities) disciplines into a cohesive analytical framework (i.e. spatial analysis and numerical modelling) to establish major environmental changes, linkages, patterns, and short- and long-term trends within and among the human and natural systems of tropical inland and shallow marine coastal systems in East Asia and Pacific.

Framework of Activities

The overall framework of the DSS is shown below. Hence, the workshop topics include data generation, processing, analysis, application of physical and socio-economic modeling and development of a system to support the decision making process:



Expected Outcomes/Products

The expected outcomes/products of the workshop include the following:

1. A collection of standardized *in-situ* data and methods for processing remotely-sensed data and socio-economic surveys;

2. Development of an integrated physical and ecological model specific to assessment of environmental changes in tropical ecosystems; and
3. Formulation of a science-based, user-driven practical decision support system (DSS) suited for management concerns of coastal zones.
4. Participants are expected to gain knowledge and improve their understanding of:
    a. Processing of satellite imagery
    b. Mobilization and deployment of instruments to measure physico-environmental parameters on site
    c. Assessment of the biological aspects of coastal ecosystems, valuation of resources and formulation of the DSS models.

Participants and Resource Persons

Participants will be invited from countries in East and Southeast Asia and the South Pacific regions. They are expected to have working knowledge in either the physical or natural sciences or on policy, planning and community resource management.

The Resource Persons will be mostly the collaborators of the Asia-Pacific Network for Climate Change Research Project spearheaded by the Tokyo Institute of Technology in Tokyo, Japan. They include the following:

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A Regional Workshop
Developing an Integrated Support System for Managing Coastal Ecosystem Change in Tropical East Asia and the Pacific
Marine Science Institute CS, University of the Philippines
Diliman, Quezon City 1101 The Philippines, 24 -25 January 2008

PROGRAMME OF ACTIVITIES

Date/Time	Activities	Responsible Person/s
Day 1 (Thursday, 24 Jan) **0830 – 0900**	**REGISTRATION & COFFEE*** * 'flowing' coffee, available beside the hall during the sessions	**Secretariat**
0900 – 0920	**OPENING CEREMONIES**	
0900 – 0910	*Opening Remarks*	**Dr. M. McGlone** Professor & Director, UPMSI
0910 - 0920	*Welcome Address*	**Dr. Kazuo Nadaoka,** Professor, Tokyo Institute of Technology & APN Project Leader
0920 – 0925	*Introduction of Participants*	**Ms. Karen Uy (**EMCEE**)**
0925 - 0935	*Overview and Expectations of the Workshop*	**Dr. Miguel D. Fortes** Professor, UPMSI & Local Workshop Coordinator
0935 – 1000	**PICTORIAL**	**Secretariat**
	PRESENTATIONS **Session 1: Keynote Address**	
1000 – 1030	*"Highlights of the APN Project & Current Japanese Research Initiatives and Their Relevance to Asia-Pacific"*	**Professor Kazuo Nadaoka**, TOKYO TECH
1030 – 1210	**Session 2: Plenaries**	
1030 – 1055	*"The Coastal Environment of Asia-Pacific: Status, Issues & Management Perspectives"*	**Dr. Miguel D. Fortes,** UPMSI
1055 – 1115	*"Satellite Remote Sensing of Coastal Ecosystems Changes Related with Human Activities"*	**Dr. Dan Ling Tang,** RSMEE
1115 – 1135	*"Integrating Science and New Technologies To Enhance Community-based Resource Management in Fiji"*	**Dr. Victor Bonito,** IAS/USP
1135 – 1155	*"Mapping Benthic Habitats on Fijian Coral Reefs: Evaluating Combined Field and Remote Sensing Approaches"*	**Dr. James Comley,** IAS/USP
1155 – 1315	**LUNCH**	
1315 – 1400	**Session 3: Conditions & Trends**	
1315 – 1330	*"Regional Sediment Discharge Model and the Future Trends of Sediment Load Due to Climate Change in the Asia-Pacific Region"*	**Mr. Varigini Badira et al.,** TOKYO TECH
1330 – 1345	*"Temporal Changes in the Cyst densities of*	**Dr. Fernando Siringan** et

	Pyrodinium bahamense var. compressum and Other Dinoflagellates in Manila Bay, Philippines"	al., Proferssor, UPMSI
1345 – 1400	*"Social and Environmental Assessment of Puerto Galera, Philippines"*	**Dr. Ma. Cecilia Rubio-Paringit,** UPCE
1400 – 1515	**Session 4: Monitoring & Modeling**	
1400 – 1415	*"Studies of the Circulation and Bio-chemical Characteristics of the Coastal Lagoon at Puerto Galera, The Philippines"*	**Mr. Tanuspong Pokavanich et al.,** TOKYO TECH
1415 – 1430	*"Hydrodynamics and Water Quality Monitoring Around Santiago Island, Bolinao"*	**Mr. Kota Ashikawa et al.**, TOKYO TECH
1430 – 1445	*"Collaborative Monitoring and Study of Laguna Lake Hydrodynamics and Water Quality"*	**Mr. Eugene C. Herrera** et al**.,** TOKYO TECH
1545 – 1500	*"Monitoring and Modeling of Sediment and Nutrient Discharge from Coastal Watersheds in Ishigaki Island (Okinawa, Japan) and Coral Coast (Viti Levu, Fiji Islands)"*	**Mr. Ariel C. Blanco et al.,** TOKYO TECH
1500 – 1515	*"Satellite Data Processing Techniques for Tropical Coastal Ecosystem Mapping and Monitoring; Overview of Some Selected Remote Sensing Study in Indonesia"*	**Mr. Muhammad Helmi** et al., Diponegoro Univ.
1515 – 1535	**COFFEE BREAK**	
1535 – 1625	**Session 5: Coastal Resources Management & MPAs**	
1535 – 1550	*"Inter-Local Government Unit Partnership for Coastal Resources Management of Banate Bay"*	**Ms. Mary Lou B. Larroza,** BBRMCI
1550 – 1605	*"Best Practices in MPA Management: Case Study of the BSDS in Bolinao, Pangasinan"*	**Ms. Tutu Almonte,** CAO-PPC
1605 - 1625	*"Coral Reef MPAs in Okinawa and Asia-Pacific: Considerations for Designing Effective Co-managed MPAs"*	**Dr. Shinishiro Kakuma**, Fisheries Division, Okinawa Prefectural Government
1625 – 1700	**OPEN FORUM**	**Dr. Enrico Paringit,** UPCE, Moderator
1700 – 1730	**WORKSHOP PREPARATION (Discussion on essential elements to develop the DSS e.g. themes, topics, approach, groupings, etc.)**	**Professor Kazuo Nadaoka & Dr. James Comley,** Facilitators
1730 – 1900	**OPEN**	
1900 – 2100	**HOSTED WELCOME DINNER**	**Secretariat**
Day 2 Friday, 25 Jan 0830 - 1200	**WORKSHOP PROPER**	Facilitators
1200 - 1400	**LUNCH**	
1400 – 1600	**WORKSHOP PROPER (con't)**	

	Preparation for the DSS utilization Workshop in May 2008	
1600 – 1630	*Presentation of Outputs; Plenary Discussion*	**Focal Persons**
1630 – 1645	*Summarization*	
1645 - 1700	**CLOSING**	

Appendix A.2 Abstracts

Integrating science and new technologies to enhance community-based resource management in Fiji

Victor Bonito
Reef Explorer Fiji Limited

Bill Aalbersberg
USP Institute of Applied Science

Fiji's coral reefs are hot spots of marine biodiversity that support the subsistence and economic needs of the nation's nearly one-million citizens. Noticeable declines in coastal resources due to overfishing, coastal development and global climate change have prompted over 200 Fijian communities to include almost 30% of nearshore areas under community-based resource management plans. Supporting these efforts, the Fiji Locally-Managed Marine Areas (FLMMA) Network was formed in 2000 by the University of the South Pacific (USP), government departments, NGOs, and numerous stakeholder groups to engage communities in coral reef conservation and coordinate marine resource management in Fiji. Exemplified worldwide as a model for engaging Pacific island communities in marine conservation, FLMMA's participatory approach assists traditional resource owners to a) develop and implement resource management plans that address resource threats and provide economic alternatives to destructive practices, and b) conduct biological and socioeconomic monitoring to evaluate impacts of changes in management.

Building upon the strong community involvement in and established foundation for resource management in Fiji, USP's Institute of Applied Sciences (IAS) is collaboratively working to integrate science and new technologies to address critical gaps in knowledge and improve local capacity for and involvement in resource management. Specifically, the aim is to: 1) Evaluate marine management effectiveness and facilitate the design of a marine protected area (MPA) network meeting local and national fisheries and conservation objectives; 2) Provide educational opportunities and tools to improve local capacity for resource management; 3) Promote community health and well-being; 4) Develop sustainable economic opportunities that promote resource conservation; 5) Monitor and evaluate the effectiveness and cost/benefits of management and development strategies and approaches; and 6) Engage a broader audience in marine conservation efforts.

Votua village and the Korolevu-i-wai district lie in the heart of tourism on Fiji's Coral Coast, and began their current resource management efforts with the assistance of IAS in 2002. Active participation in and contribution to these efforts was complimented in 2005 by the addition of a village-based coral reef ecologist who is undertaking and assisting with the implementation of a suite of pilot research, development, and educational activities. Biodiversity and connectivity studies, ecological and environmental monitoring, socioeconomic monitoring, the development of sustainable economic opportunities, and projects improving community health and environment standards are being conducted and learning tools, programs, and products created to support and build capacity for national and local resource management efforts. Further collaborations would be beneficial, particularly with efforts to create benthic habitat and oceanographic maps, improve GIS and remote sensing capacity in Fiji, and ultimately create monitoring and predictive tools to improve national and community-based resource management.

STUDIES OF THE CIRCULATION AND BIO-CHEMICAL CHARACTERISTICS OF THE COASTAL LAGOON AT PUERTO GALERA, THE PHILIPPINES

Tanuspong POKAVANICH[1], Kazuo NADAOKA[2], Ariel C. BLANCO[1]

[1]*Graduate Student, Dept. of Mechanical and Environmental Informatics,TokyoTech, Japan*
[2]*Professor, Dept. of Mechanical and Environmental Informatics, TokyoTech, Japan*

Puerto Galera (PG), a semi-enclosed coastal lagoon forming by three small coves, is connected to the Verde Island Passage through two channels. The passage links South China Sea and Sibuyan Sea. The PG lagoon and its vicinities are renowned for their attractive recreational and diving spots, which are composed of various types of rich coastal ecosystem such as coral reefs, mangroves and seagrass beds. The recent drastic water quality degradation, generally due to poorly constructed sanitation and household facilities and runoff from the hillsides associated with the tourism development, forewarns the public about the possible irreversible unfavorable effects on these ecosystems. This study attempts to provide sufficient understanding of the lagoon's circulation and water quality characteristics to the local communities and governmental unit to promote the conservation and restoration of the coastal ecosystems. Hydrodynamic and bio-chemical aspects were examined by means of intensive field observations coupled with numerical models. The field observations are composed of various programs setting out to monitor the meteorological, hydrographic and bio-chemical conditions of the lagoon. Annual variation of wind, rainfall, air temperature, relative humidity and solar radiation were collected from the meteorological observations at an in-situ long-term monitoring platform. An intensive field survey was conducted during February 22 to March 8, 2007 in which data on water level, flow velocity, water temperature, salinity, phytoplankton (chlorophyll-a) concentration and water samples were collected at many stations at various depths. In addition, the water samples were collected at June, September, and October 2007. The water samples were subsequently analyzed for nutrients (NH4-N, NO3-N, NO2-N, PO4-P, SiO2-Si) and Chlorophyll-a (Chl-a) content. State-of-the-art numerical simulations were performed to reproduce three-dimensional flow structure as well as bio-chemical properties of the lagoon. The results of the studies indicate that the circulation of the lagoon is composed of two current regimes, strong currents at the outer sea and channels and weak currents in the lagoon. The strong currents are driven controlled by the differences in the water level between the two ends of Verde Island Passage. The simple alternately varying west- and eastward flow pattern in the main parts of the Passage is modified by the local complicated topography around Puerto Galera to produce asymmetrical westward residual currents at the channels. Inside the lagoon, where the strong tidal currents cannot reach, the sluggish circulation was observed. The temporal variation of the surface velocity in the lagoon was correlated well with that of the wind. The water resident time was much higher at the lagoon interior where most of the pollutants are discharged from surrounding communities. This implies that the water body at Muelle cove, the innermost part of the lagoon, might be vulnerable to euthophication. However, the field data analysis and numerical simulation results showed that even into this area the water mass from the outer sea with lower temperature may sporadically intrude as the density currents. This intrusion greatly reduced the residence time of the polluted water and kept dissolved oxygen concentration at high level hence mitigating the water quality deterioration. The results from water sample analysis indicated that the nutrients and Chl-a concentration of PG are relatively low through out the year. Highest Chl-a concentrations (around 1.5 mg/L) were found in samples collected in June when nitrogen-nutrients runoff were highest due to high rainfall intensity. The numerical model was also used to predict the water conditions for several management scenarios from the local government unit in attempt to improve the lagoon water condition, e.g., by making the third connection between the lagoon and the outer sea by re-opening a sandbar.

Collaborative Monitoring and Study of Laguna Lake Hydrodynamics and Water Quality

Eugene C. Herrera[1], Kazuo Nadaoka[2], Ariel C. Blanco[1] and Emiterio C. Hernandez[3]
[1]Graduate Student, Department of Mechanical and Environmental Informatics, Tokyotech, Japan
[2]Professor, Department of Mechanical and Environmental Informatics, Tokyotech, Japan
[3]Integrated Water Resources Management Division, Laguna Lake Development Authority, Philippines
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ABSTRACT: Laguna de Bay (Laguna Lake), strategically located in the midst of the country's center of urban and industrial development of over 13 million inhabitants, with vast development potentials for multipurpose use and substantial environmental significance, is the most important inland water body in the Philippines. Unmitigated anthropogenic watershed and lake practices however have led to its rapid degradation, particularly siltation, eutrophication and pollution. Its interaction with Manila Bay through Pasig River makes it a brackish water lake that is ideal for fishery and aquaculture, but at the same time discharges polluted seawater from greater Metro Manila and surrounding coastal towns. In the face of the massive environmental stress, sustainable and effective management of Laguna de Bay requires constant and reliable monitoring and decision support system based on sound scientific studies. This paper discuses the foundation and framework of the on-going collaborative monitoring, field surveys, data sharing, and numerical modeling of Laguna de Bay between Nadaoka Laboratory, Tokyotech and Laguna Lake Development Authority (LLDA) as part of an Integrated Manila Bay-Laguna Lake and Surrounding Watersheds Environmental Study (IMSWES). The collaboration has proven to be mutually beneficial for both parties with LLDA further improving its monitoring and decision support system and Nadaoka Laboratory able to pursue its research on Laguna de Bay and surrounding watershed more effectively with the assistance of LLDA. The joint undertaking has set a firm foundation for research collaboration to provide deeper and better understanding of the lake dynamics essential for its optimal and sustainable use as a multi-purpose resource, while preserving its environmental integrity at the same time. Monitoring and research activities will proceed to cover the surrounding watersheds as well, aimed at comprehensively understanding the impact of environmental loads to the lake ecosystem. Continuous long term measurement of hydrodynamic and water quality variables, vital for detailed studies, is facilitated by a monitoring platform constructed at the west lobe of the lake. The platform provides an ideal location for designed measurement schemes of various scientific studies as well. A diurnal-intensive field survey conducted at the platform location reveals significant and dynamic temporal and vertical variation in physical, chemical, and biological processes. Analyses suggest meteorological and hydrodynamic forces significantly influence the reaction of chemical nutrients and behavior of aquatic organisms in the lake.

Keywords: Laguna de Bay, Tokyotech, LLDA, collaboration, intensive study

Monitoring and Modeling of Sediment and Nutrient Discharge from Coastal Watersheds in Ishigaki Island (Okinawa, Japan) and Coral Coast (Viti Levu, Fiji Islands)

Ariel C. Blanco[1], Kazuo Nadaoka[1*], Takahiro Yamamoto[1], Koichi Kinjo[2]
Victor Bonito[3], Bale Tamata[4], and Batiri Thaman[4]

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Tokyo Institute of Technology, Tokyo, Japan
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Okinawa Prefectural Institute of Health and Environment, Okinawa, Japan
[3]Reef Explorer (Fiji) Ltd., Korolevu, Fiji Islands
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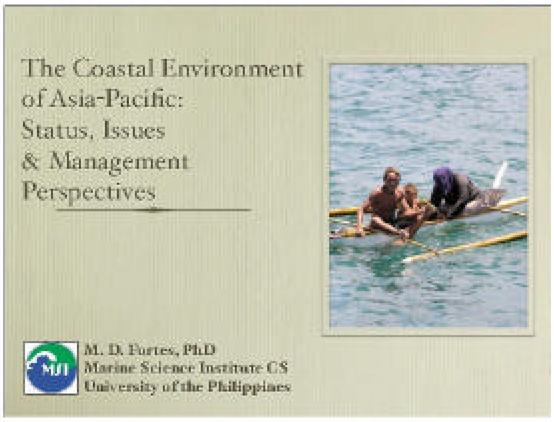
University of the South Pacific, Suva, Fiji Islands
**E-mail address: nadaoka@mei.titech.ac.jp*

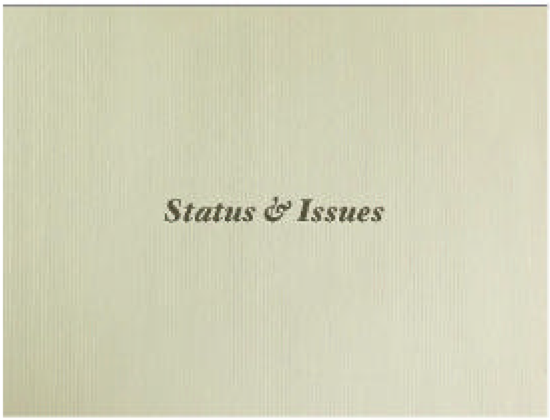
Terrestrial runoff has different adverse effects on the ecology of coral reefs such as decreased coral cover, changes in coral community and increased algal growth resulting from excessive nutrients and sedimentation. It becomes imperative to assess and model the export of materials from the watershed onto the adjacent coral reefs in order to formulate effective reef conservation measures. In line with this, sediment discharges have been monitored in three watersheds, namely the agricultural Todoroki watershed which drains into Shiraho Reef (Ishigaki Island, southwest Japan) and the forested Naboutini and Votua watersheds, both draining into the Coral Coast reef (southern Viti Levu Island, Fiji). For Todoroki watershed, nutrient concentrations were measured in Todoroki River with continuous (hourly) monitoring of nitrate (NO_3^-) and phosphate (PO_4) concentrations at a station near the river mouth using in-situ nutrient analyzers. Turbidity, suspended solid and total phosphorus concentrations in Todoroki River (discharging onto Shiraho Reef) increased with increasing rainfall intensity and river discharge. Nitrate concentration tends to decrease during stages of flood events dominated by surface runoff but showed increasing trend when baseflow starts to dominate. Considerable loads of NO_3^- and PO_4 were also discharged during low flow conditions, underscoring the importance of continuous nutrient discharge monitoring and adapting measures to effectively use nutrients and minimize nutrient leaching. Nutrient analysis of water samples periodically taken at 11 stations in Todoroki River indicated the combined influence of agricultural plots and cow farms, potentially exacerbated by groundwater discharge into the river. Sediment and nutrient discharge from Todoroki watershed were modeled using the Gridded Surface-Subsurface Hydrologic Analysis (GSSHA) model. Initial results indicate the ability of the model to capture the variability of sediment and nutrient discharge from Todoroki watershed. Monitoring data for Naboutini watershed, a forested watershed with ongoing logging activities, indicate excessive export of sediments sourced from logged areas and unpaved logging roads. On the other hand, in Votua watershed where logging operations had stopped many years ago, sediment discharge is interestingly comparable with that from Naboutini. Votua watershed discharges high loads of sediments primarily due to slash-and-burn farming, which is becoming pervasive. Monitoring and modeling of sediment and nutrient discharges is crucial considering the differences in watershed characteristics (e.g. land use/land cover, soil, rainfall).and the varying capacity of the adjacent coral reef to withstand sediment and nutrient loadings.

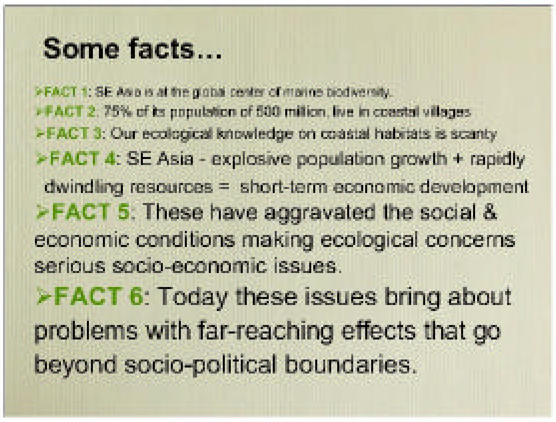
Keywords: watershed, sediment discharge, nutrients, monitoring, GSSHA model

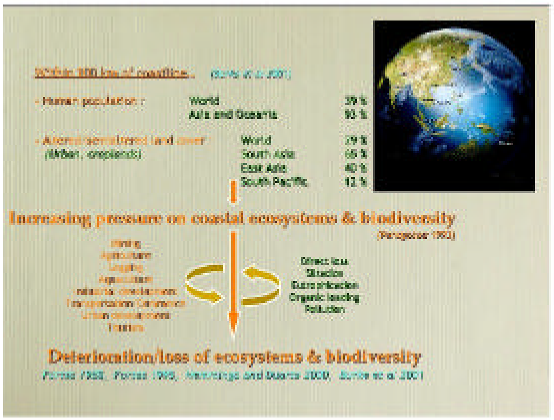
A.3 Workshop Presentation Slides

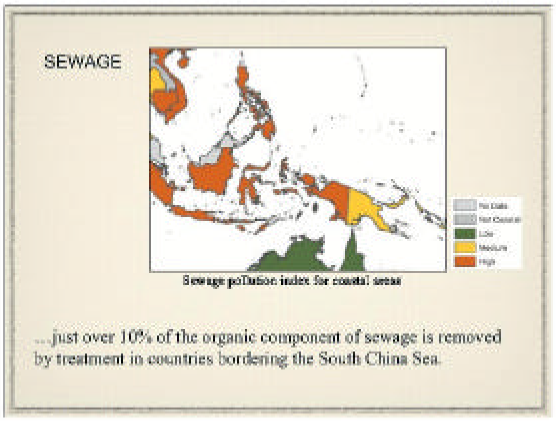
(1) The Coastal Environment of Asia-Pacific: Status, Issues & Management Perspectives

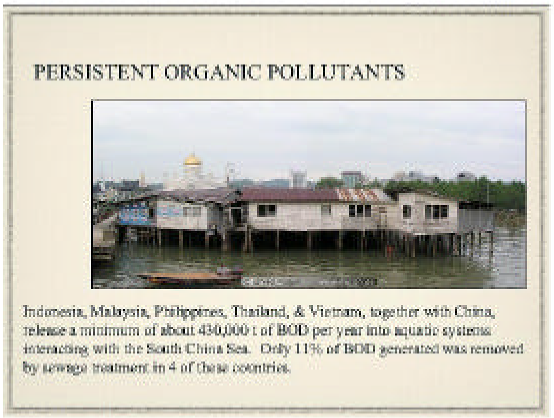


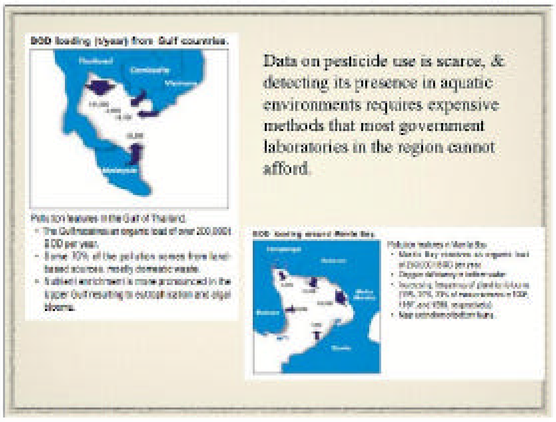


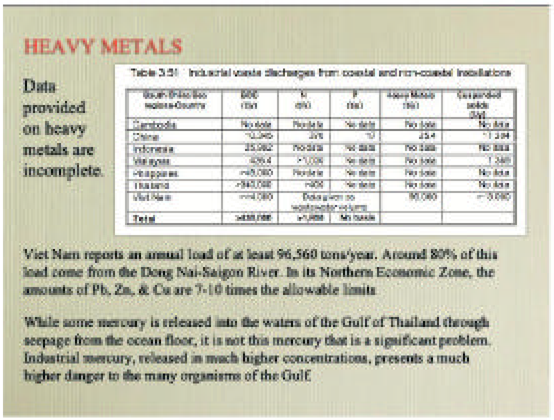


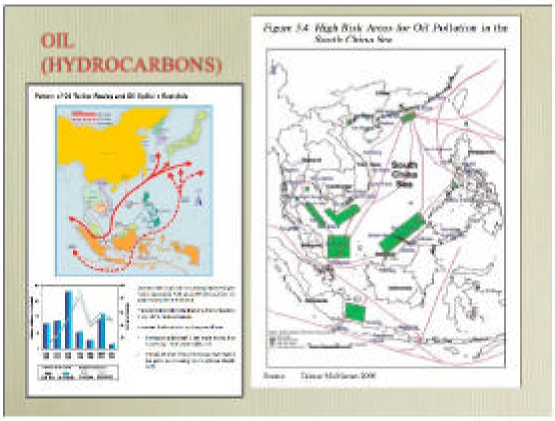


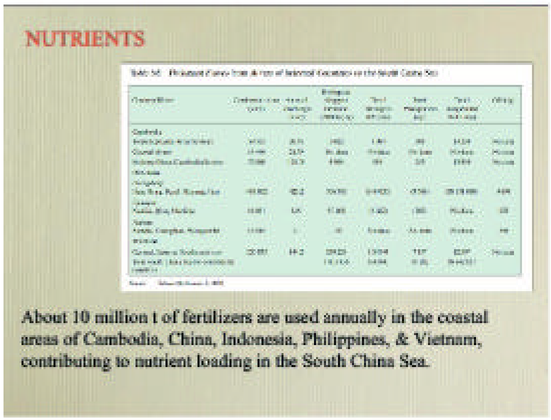


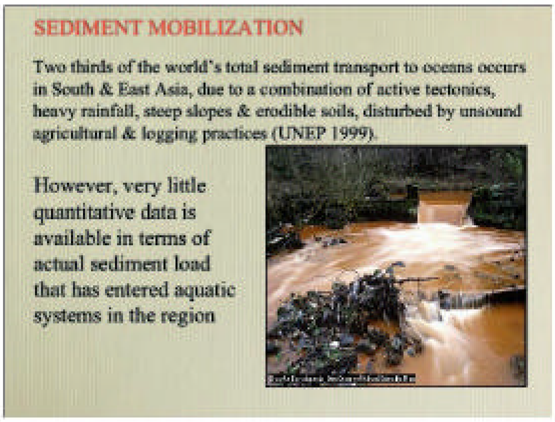




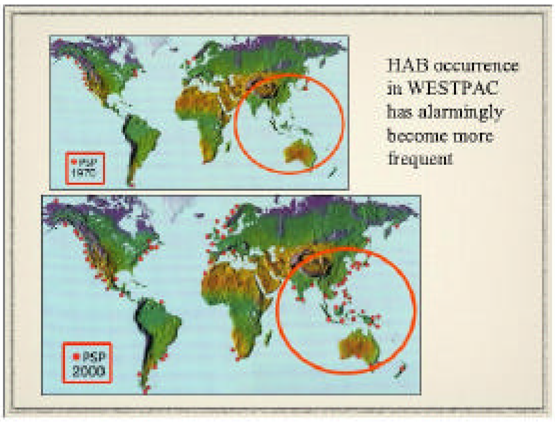


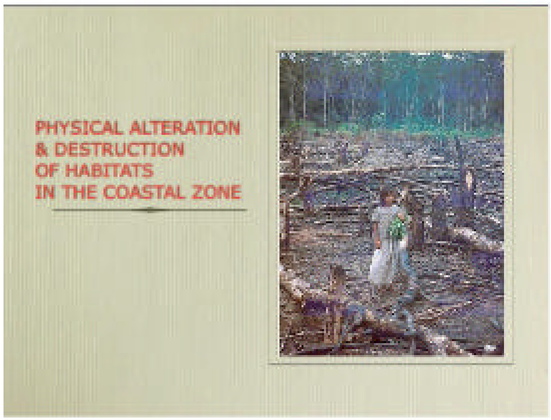

OIL
(HYDROCARBONS)
Figure 5.4 High Risk Areas for Oil Pollution in the South China Sea
South China Sea

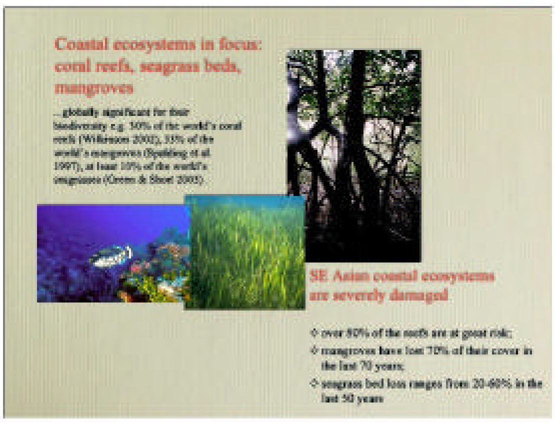

NUTRIENTS
About 10 million t of fertilizers are used annually in the coastal areas of Cambodia, China, Indonesia, Philippines, & Vietnam, contributing to nutrient loading in the South China Sea.

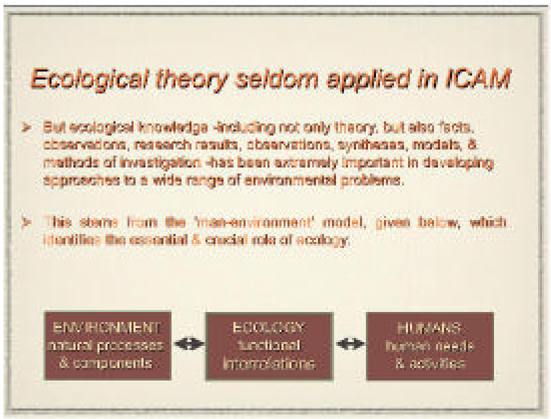

SEDIMENT MOBILIZATION
Two thirds of the world's total sediment transport to oceans occurs in South & East Asia, due to a combination of active tectonics, heavy rainfall, steep slopes & erodible soils, disturbed by unsound agricultural & logging practices (UNEP 1999).
However, very little quantitative data is available in terms of actual sediment load that has entered aquatic systems in the region

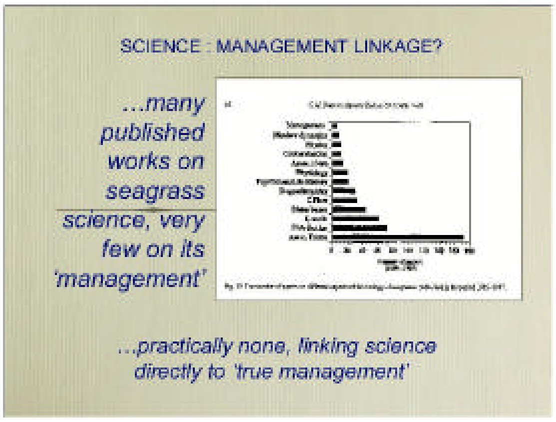

MARINE LITTER
The coastal population of South China Sea in Cambodia, China, Indonesia, Malaysia, Philippines, Thailand, & Vietnam generates a total of over 66 million t of solid wastes per year. A significant portion of the solid wastes is composed of plastics, metals, & glass that are not readily biodegradable.

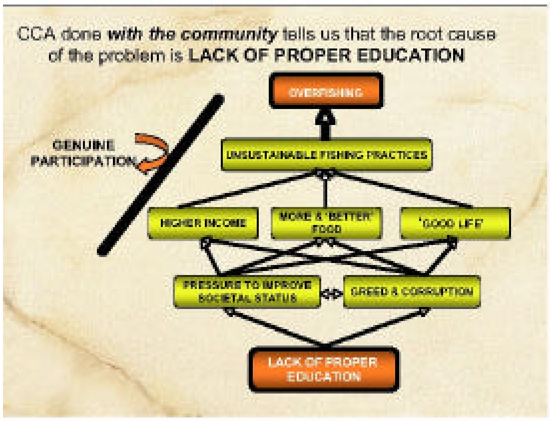

PSP
1970
PSP
2000
HAB occurrence in WESTPAC has alarmingly become more frequent


PHYSICAL ALTERATION
& DESTRUCTION
OF HABITATS
IN THE COASTAL ZONE


Coastal ecosystems in focus: coral reefs, seagrass beds, mangroves
...globally significant for their biodiversity e.g. 30% of the world's coral reefs (Wilkinson 2002), 35% of the world's mangroves (Spalding et al. 1997), at least 10% of the world's seagrasses (Green & Short 2003).
SE Asian coastal ecosystems are severely damaged
over 80% of the reefs are at great risk;
mangroves have lost 70% of their cover in the last 70 years;
seagrass bed loss ranges from 20-60% in the last 50 years


Ecological theory seldom applied in ICAM
But ecological knowledge -including not only theory, but also facts, observations, research results, observations, syntheses, models, & methods of investigation -has been extremely important in developing approaches to a wide range of environmental problems.
This stems from the 'man-environment' model, given below, which identifies the essential & crucial role of ecology.
ENVIRONMENT
natural processes
& components
ECOLOGY
functional
interrelations
HUMANS
human needs
& activities

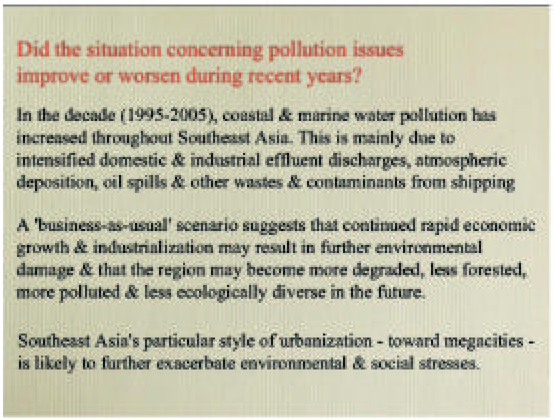

SCIENCE : MANAGEMENT LINKAGE?
...many published works on seagrass science, very few on its 'management'
...practically none, linking science directly to 'true management'

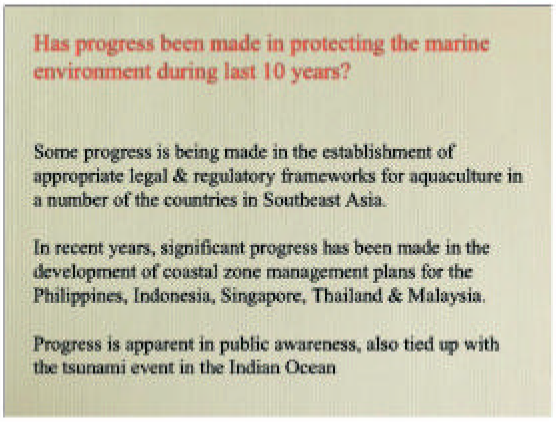

CCA done ***with the community*** tells us that the root cause of the problem is **LACK OF PROPER EDUCATION**
OVERFISHING
GENUINE PARTICIPATION
UNSUSTAINABLE FISHING PRACTICES
HIGHER INCOME
MORE & 'BETTER' FOOD
'GOOD LIFE'
PRESSURE TO IMPROVE SOCIETAL STATUS
GREED & CORRUPTION
LACK OF PROPER EDUCATION

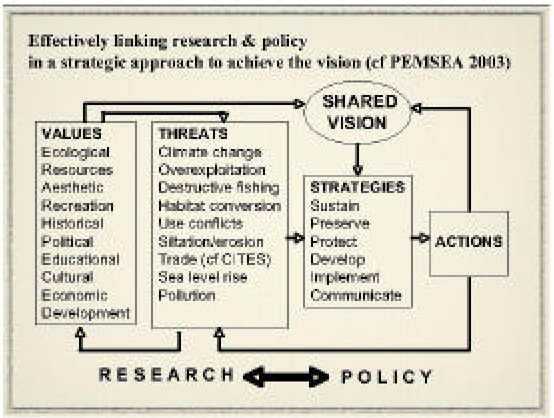

Management Perspectives


What will happen if the trends are not reversed?
Unless managed, the reefs will collapse within 20 years, all mangroves will be lost by 2030, & seagrass beds will follow suit, so will the resources & revenues derived from them (PEMSEA 2003)
Global fisheries will collapse in 2048 (Science 2048)

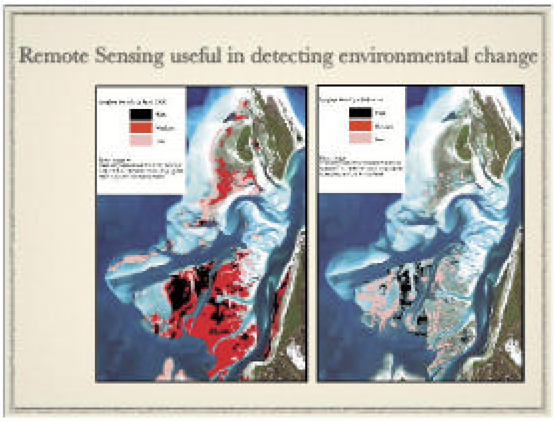

VALUABLE LESSONS FROM PAST MISTAKES
Government
(has power; political will?)
NGOs, POs
(with resources; with own priorities?)
Community
(has time, muscle, nothing to eat)
Support Agencies
(with resources, insensitive (?) to local needs)
Academia
(with ideas, know-how, no resources)
?
?
?
?
?


Did the situation concerning pollution issues improve or worsen during recent years?
In the decade (1995-2005), coastal & marine water pollution has increased throughout Southeast Asia. This is mainly due to intensified domestic & industrial effluent discharges, atmospheric deposition, oil spills & other wastes & contaminants from shipping
A 'business-as-usual' scenario suggests that continued rapid economic growth & industrialization may result in further environmental damage & that the region may become more degraded, less forested, more polluted & less ecologically diverse in the future.
Southeast Asia's particular style of urbanization - toward megacities - is likely to further exacerbate environmental & social stresses.

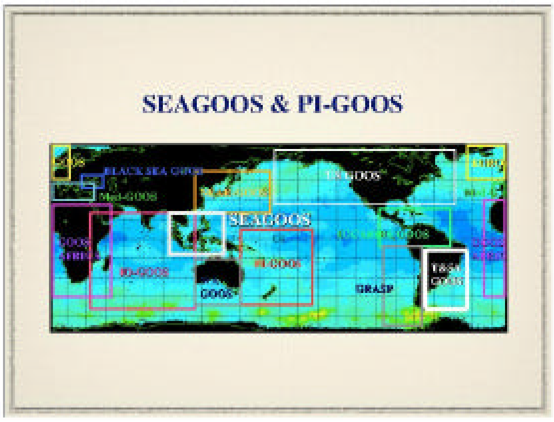

Has progress been made in protecting the marine environment during last 10 years?
Some progress is being made in the establishment of appropriate legal & regulatory frameworks for aquaculture in a number of the countries in Southeast Asia.
In recent years, significant progress has been made in the development of coastal zone management plans for the Philippines, Indonesia, Singapore, Thailand & Malaysia.
Progress is apparent in public awareness, also tied up with the tsunami event in the Indian Ocean

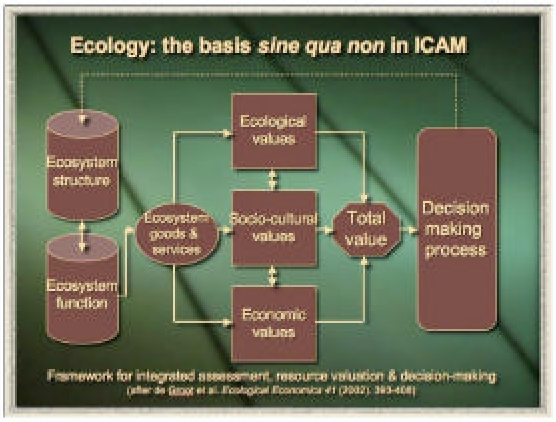

Effectively linking research & policy in a strategic approach to achieve the vision (cf PEMSEA 2003)
SHARED VISION
VALUES
Ecological
Resources
Aesthetic
Recreation
Historical
Political
Educational
Cultural
Economic
Development
THREATS
Climate change
Overexploitation
Destructive fishing
Habitat conversion
Use conflicts
Siltation/erosion
Trade (cf CITES)
Sea level rise
Pollution
STRATEGIES
Sustain
Preserve
Protect
Develop
Implement
Communicate
ACTIONS
RESEARCH
POLICY

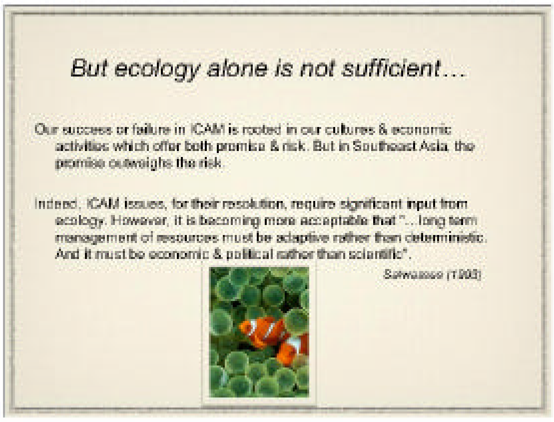

We need to shift towards environmental problem solving
Observation Revolution
Data gathering capabilities dramatically increasing
Information Generation
Capacity for data analysis increasing
Knowledge Building
Synthesis and visualization techniques not utilized enough
Problem Solving
Need integrated and applied approach
Management
Monitoring
Research

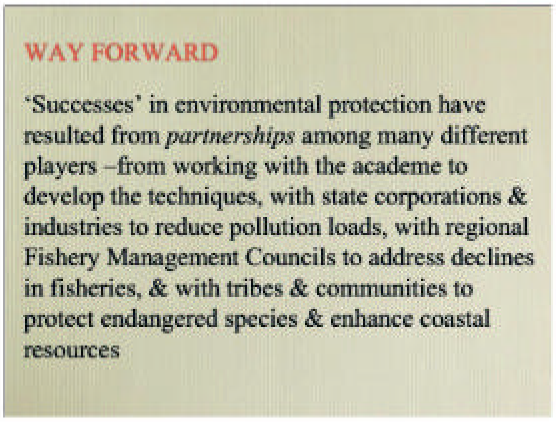

Remote Sensing useful in detecting environmental change


...post-disaster mitigation & management
An Integrated Decision Support System needs to be place
Khao Lak, Phuket
29 Dec 2004
Area 1
Area 2
Area 3
Area 4
Area 5
Area 6

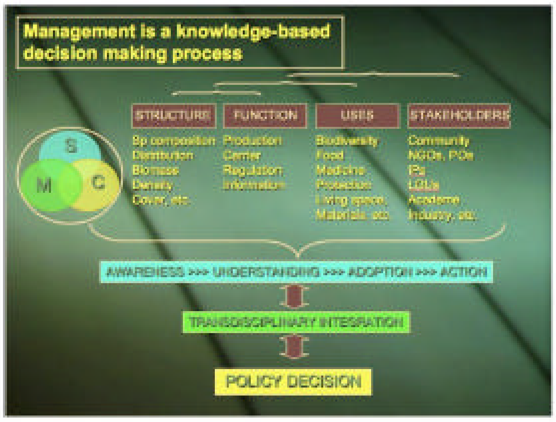

SEAGOOS & PI-GOOS
BLACK SEA GOOS
Med-GOOS
SEAGOOS
GOOS
GRASP

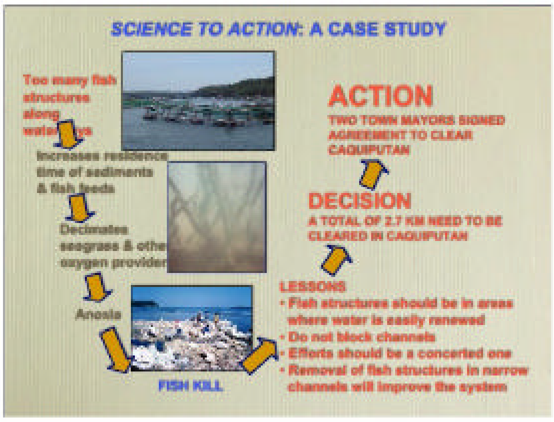

Ecology: the basis sine qua non in ICAM
Ecosystem structure
Ecosystem function
Ecosystem goods & services
Ecological values
Socio-cultural values
Economic values
Total value
Decision making process
Framework for integrated assessment, resource valuation & decision-making

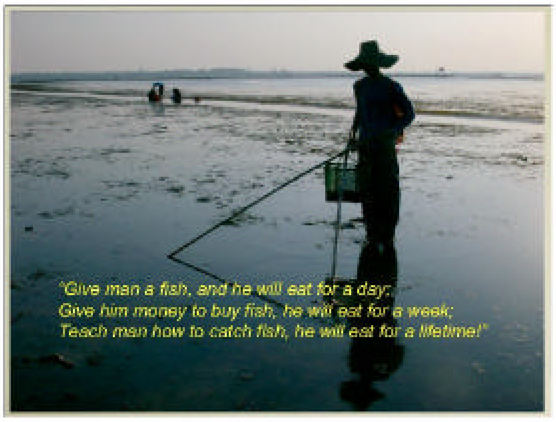

But ecology alone is not sufficient…
Our success or failure in ICAM is rooted in our cultures & economic activities which offer both promise & risk. But in Southeast Asia, the promise outweighs the risk.
Indeed, ICAM issues, for their resolution, require significant input from ecology. However, it is becoming more acceptable that "…long term management of resources must be adaptive rather than deterministic. And it must be economic & political rather than scientific".
Salwasser (1993)


WAY FORWARD
'Successes' in environmental protection have resulted from partnerships among many different players –from working with the academe to develop the techniques, with state corporations & industries to reduce pollution loads, with regional Fishery Management Councils to address declines in fisheries, & with tribes & communities to protect endangered species & enhance coastal resources

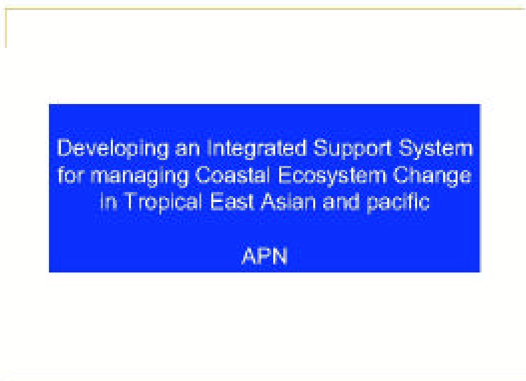

Subregional growth areas
Enhance greater Economic collaboration
Enhance partnerships in environmental management as nature protection is indispensable in social & sustainable economic development
Subregional Growth Areas

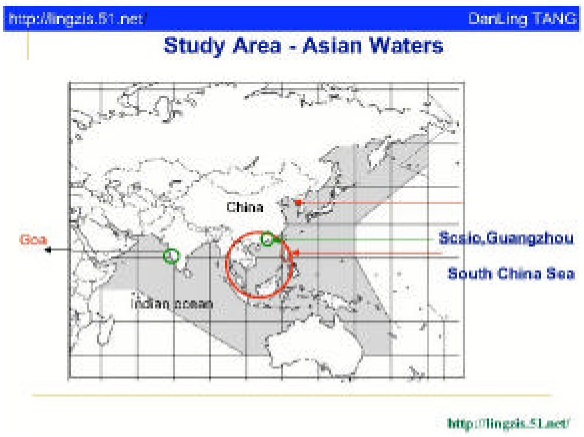


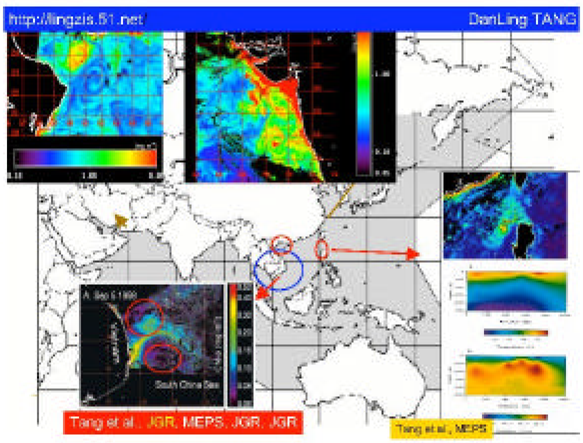




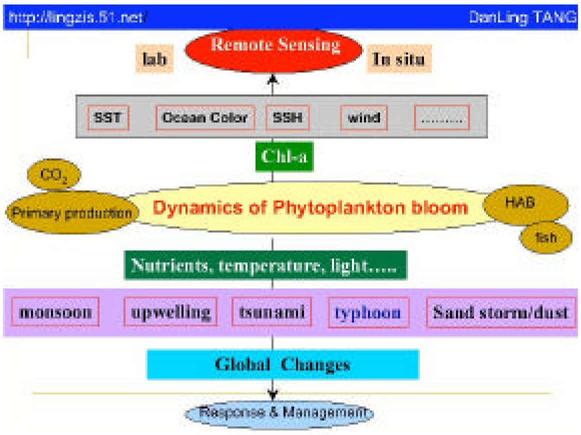
(2) Remote Sensing of Marine Ecosystem to Environmental Changes







http://lingzis.51.net DanLing TANG



PORSEC2008

Dynamics of Phytoplankton bloom

1. Nutrient
2. Water temperature
3. Water stability………..

1. Short time variation - typhoon
2. Long time change – wpwelling, El Nino
3. Special case - tsunami/ power station
4. Occasional event – sand storm

PORSEC2008

http://lingzis.51.net/

http://lingzis.51.net PORSEC2008 DanLing TANG

1. Phytoplankton increases related to typhoon

----Short term variation

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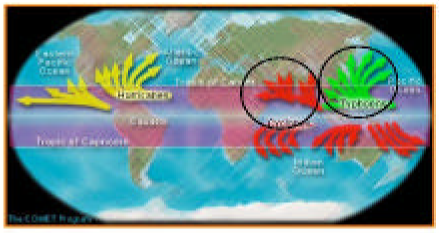
Large area coverage

SCS

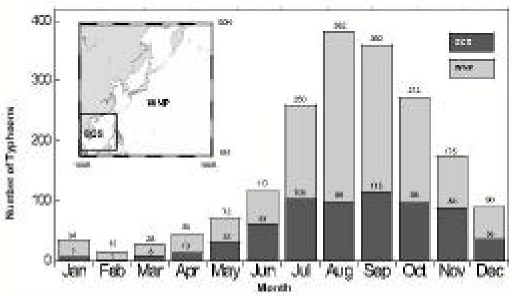


Increase with global warming

MEPS 2007

http://lingzis.51.net DanLing TANG

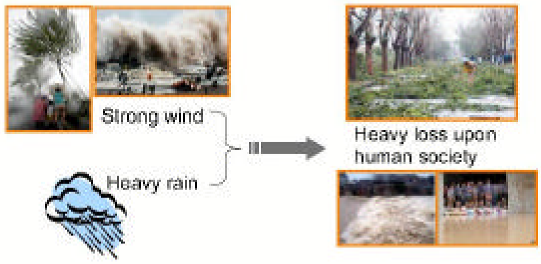
Typhoon climatology (1951-2005) in SCS and WNP



MEPS 2007

http://lingzis.51.net DanLing TANG

What is the effect upon marine ecosystem?



MEPS 2007

http://lingzis.51.net DanLing TANG

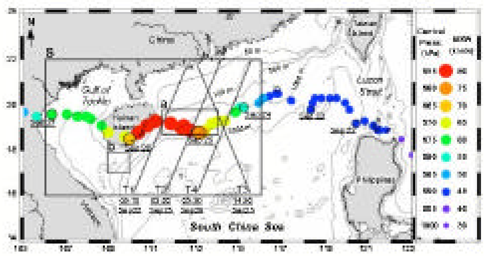
How do typhoon affect phytoplankton ?

- In situ data
  - Where
  - When
  - Winds
- Satellite remote sensing - advantages
  - Try

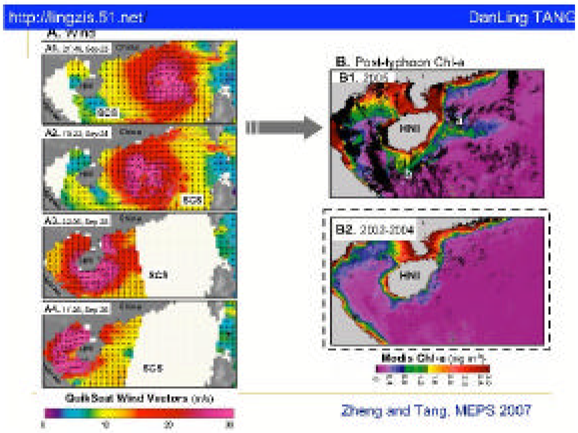
http://lingzis.51.net/

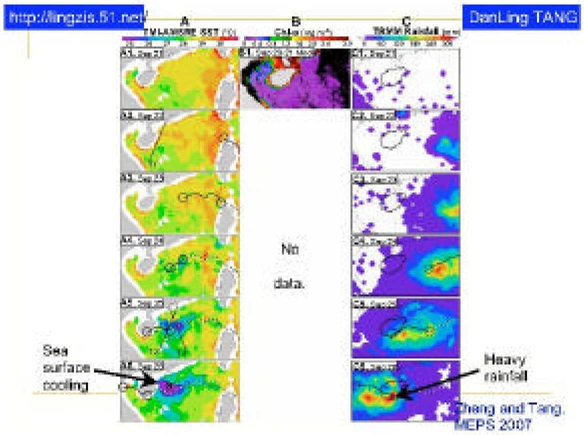
http://lingzis.51.net DanLing TANG

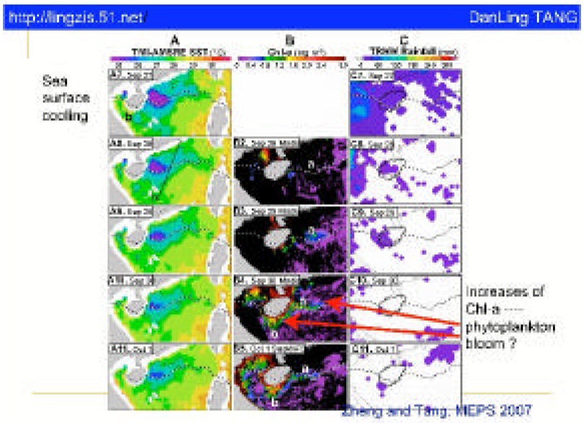
Track of Typhoon **Damrey**, Sep 2005

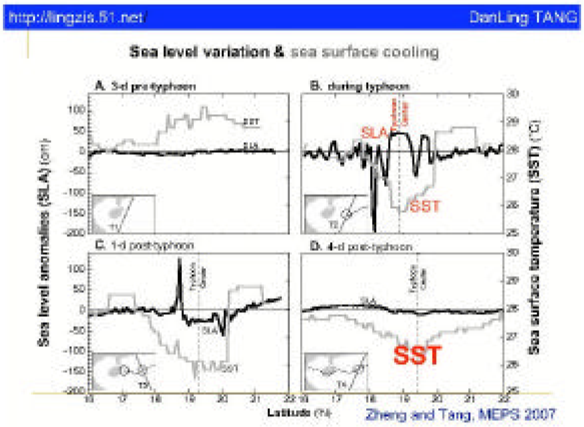


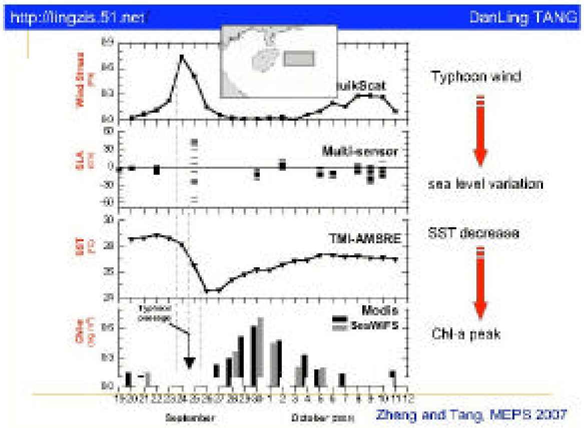
Zheng and Tang, MEPS 2007







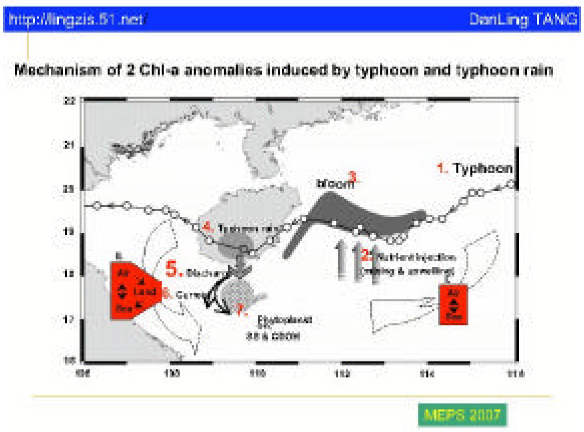




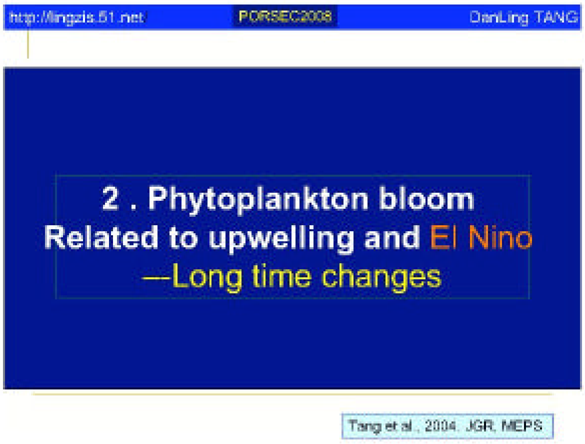
http://lingzis.51.net/ DanLing TANG

Chl-a at study water

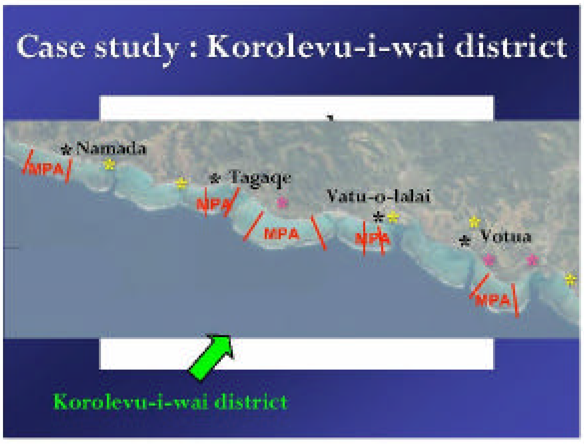
Parameters	Offshore			Nearshore		
	Before	After	After - Before (After / Before)	Before	After	After - Before (After / Before)
Chl-a (mg m^{-3})	0.129	0.626	0.497(4.9)	0.135	1.07	0.935([illegible])
$a_g(443)$ (10^{-3} m^{-1})	7.07	39.02	31.95([illegible])	7.78	49.05	41.27(6.3)
$a_d(555)$ (10^{-3} m^{-1})	1.56	2.47	0.91(1.6)	1.18	12.13	10.95(10.3)
$a_p(470)$ (10^{-3} m^{-1})	1.38	3.03	1.65(2.2)	2.59	8.98	6.39(3.5)
Increase amplitude	Phytoplankton > CDOM > SS			SS > phytoplankton > CDOM		
SST (°C)	28.9	24.5	-4.4	28.2	27.6	-0.6
SLA (cm)	-4.9	-26.3	-21.4			
Location	In the track of typhoon			Near the largest rainfall area of HNI		
Sample area (km^2)	Box a in Fig. 1A (30000)			Box b in Fig. 1A (10000)		
Mechanism	Upwelling and vertical mixing induced phytoplankton bloom.			Precipitation, runoff discharge, and advection of SS and phytoplankton		

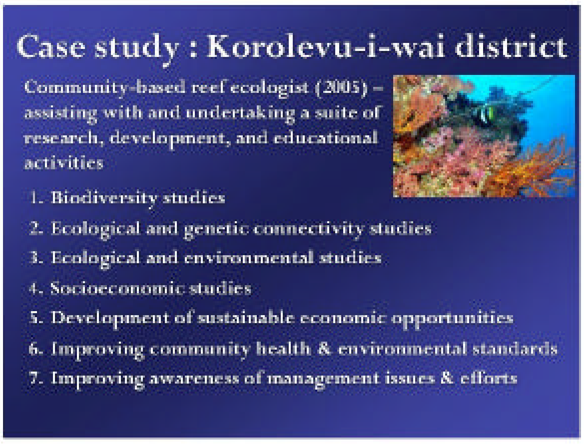


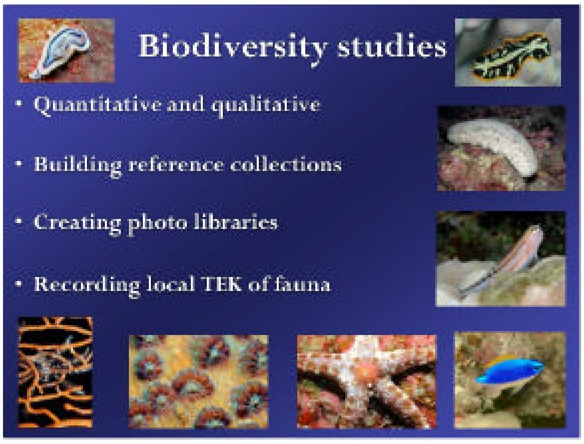
- 7 typhoons /year
- Primary production?
- CO_2 – SST?

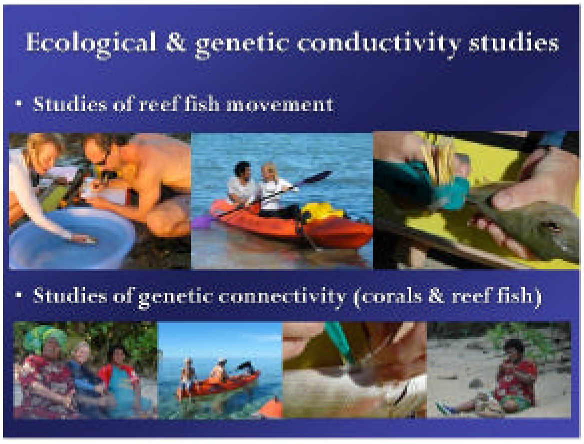


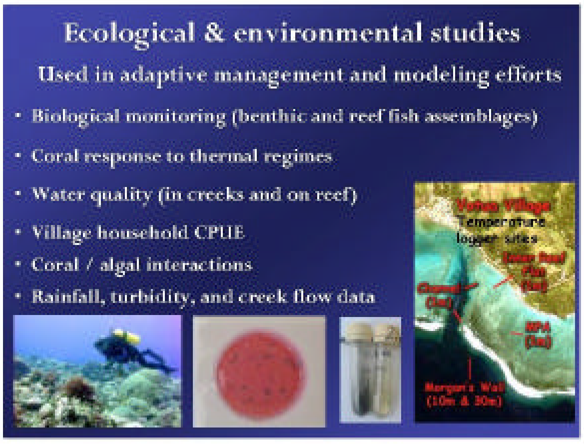
(3) Integrating Science and New Technologies to Enhance Community-based Resource Management in Fiji

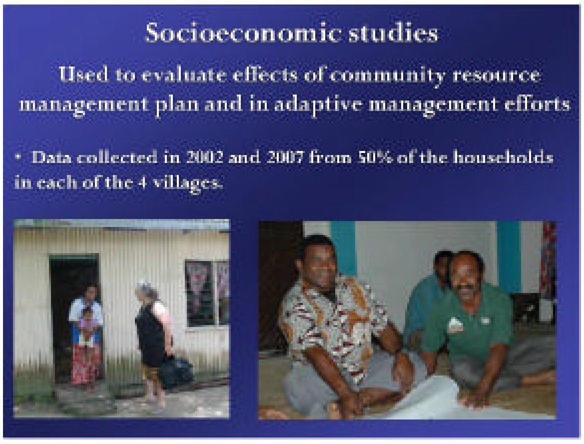





Biodiversity studies
• Quantitative and qualitative
• Building reference collections
• Creating photo libraries
• Recording local TEK of fauna


Ecological & genetic conductivity studies
• Studies of reef fish movement
• Studies of genetic connectivity (corals & reef fish)


Ecological & environmental studies
Used in adaptive management and modeling efforts
• Biological monitoring (benthic and reef fish assemblages)
• Coral response to thermal regimes
• Water quality (in creeks and on reef)
• Village household CPUE
• Coral / algal interactions
• Rainfall, turbidity, and creek flow data


Socioeconomic studies
Used to evaluate effects of community resource management plan and in adaptive management efforts
• Data collected in 2002 and 2007 from 50% of the households in each of the 4 villages.

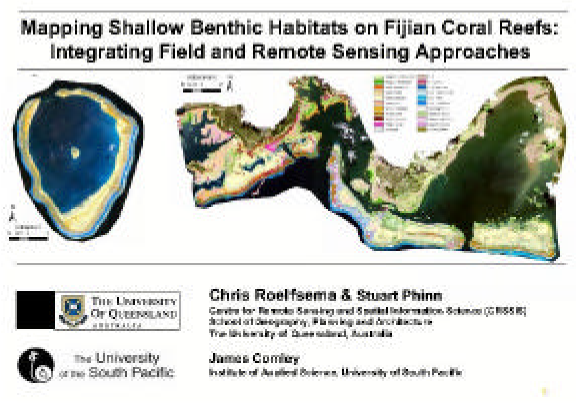

Development of sustainable economic opportunities
To improve village incomes while supporting resource management efforts and preserving local traditions and crafts
• Village-operated ecotourism activities
• Village handicrafts
• Village plantation development

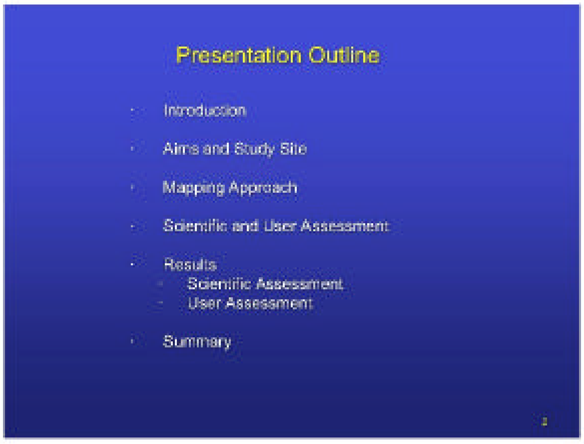

Improving community health and environmental standards
• Waste management program (solid & liquid waste)
• Upgrading village water supply
• Piggery relocation and improvement

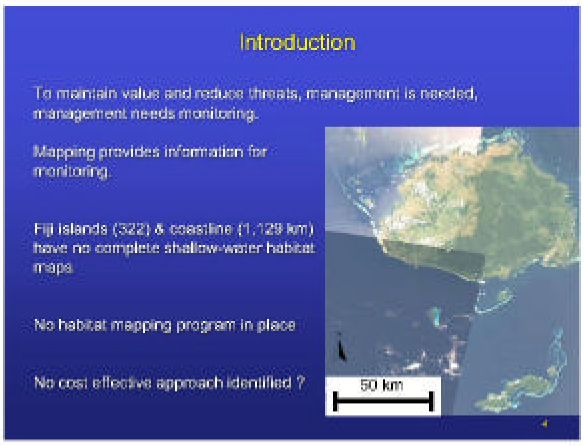

Improving awareness of management issues & efforts
• Community workshops & educational programs
• Educational materials and displays

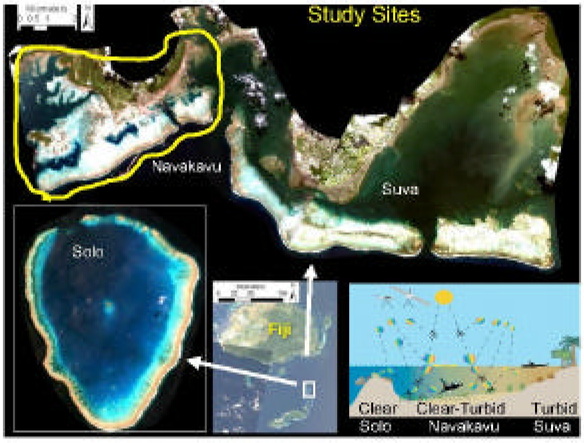

Korolevu-i-wai
• Research has active participation of community members
• Finding are presented back to the community
• Target local and national priorities
• Educational materials and tools produced
• Involve capacity-building components
• Transferable products shared with other FLMMA partners

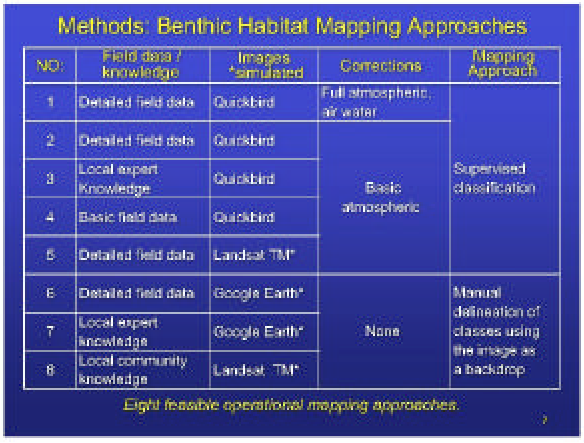
(4) Mapping Benthic Habitats on Fijian Coral Reefs: Integrating Field and Remote Sensing Approaches



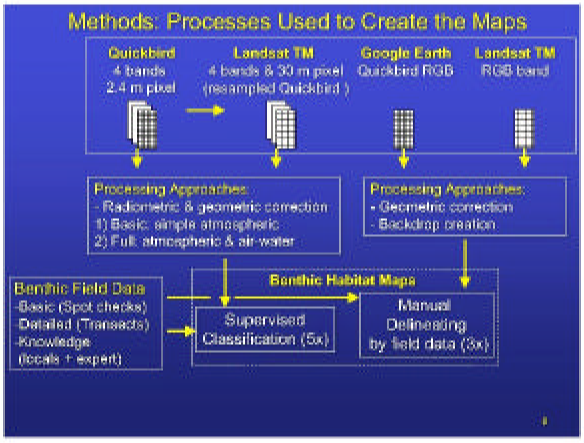


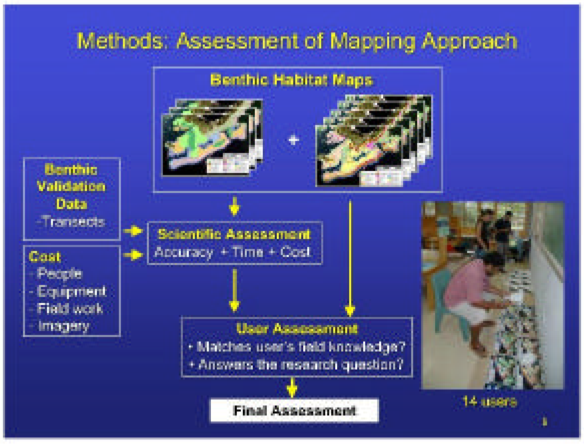


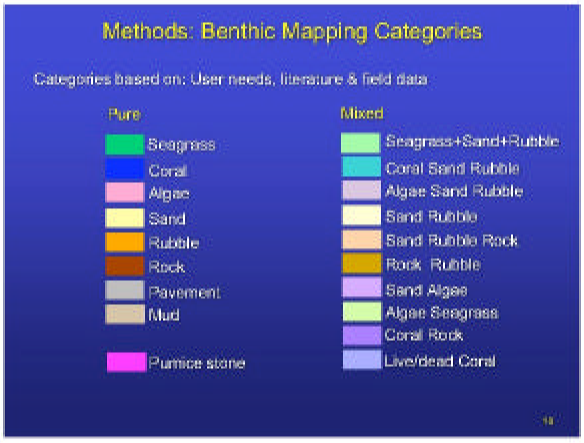


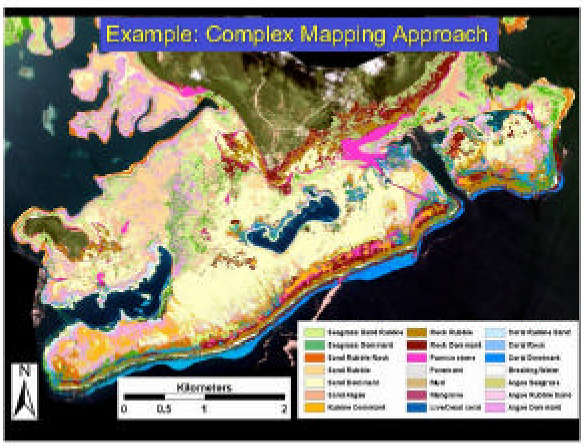


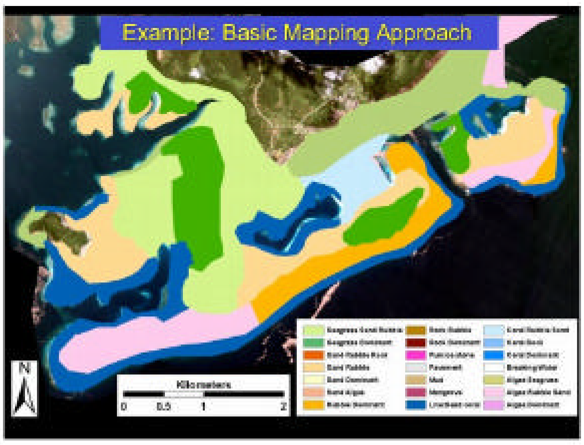
NO.	Field data / knowledge	Images *simulated	Corrections	Mapping Approach
1	Detailed field data	Quickbird	Full atmospheric, air water	Supervised classification
2	Detailed field data	Quickbird	Basic atmospheric	
3	Local expert Knowledge	Quickbird		
4	Basic field data	Quickbird		
5	Detailed field data	Landsat TM*		
6	Detailed field data	Google Earth*	None	Manual delineation of classes using the image as a backdrop
7	Local expert knowledge	Google Earth*		
8	Local community knowledge	Landsat TM*		

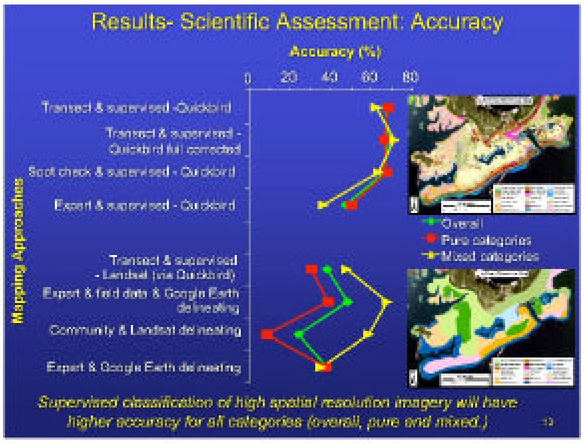


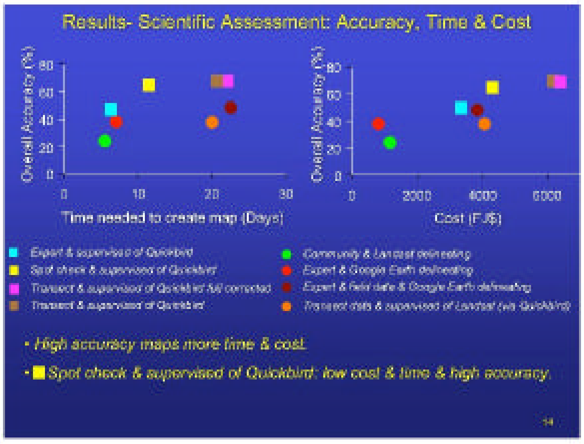


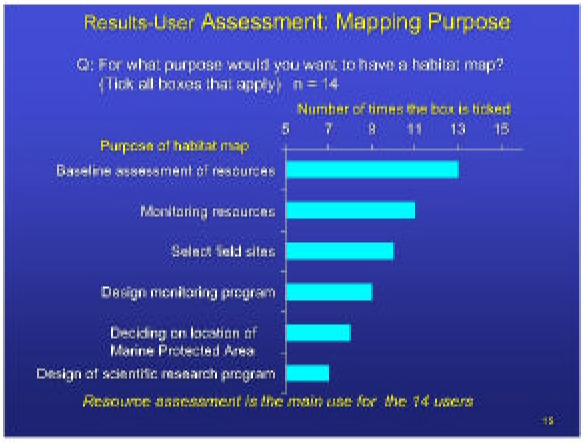


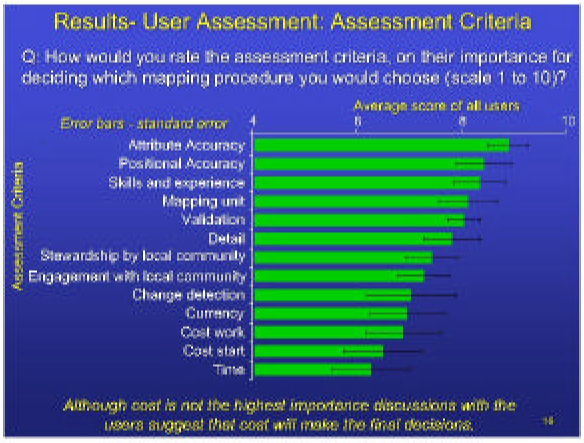


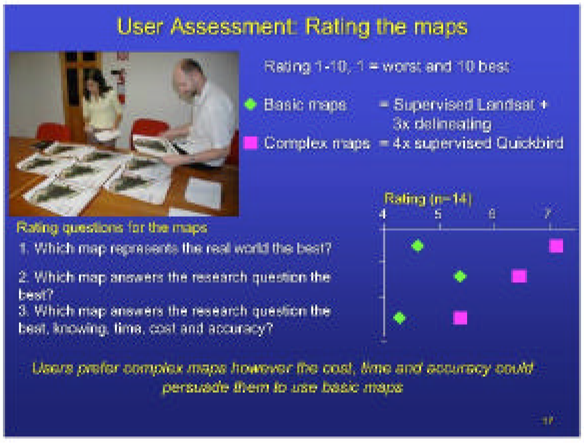


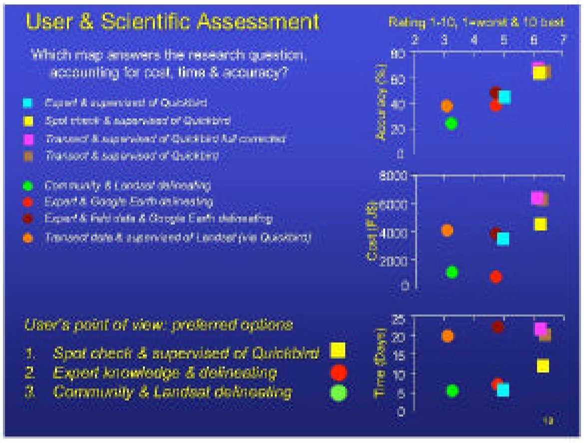












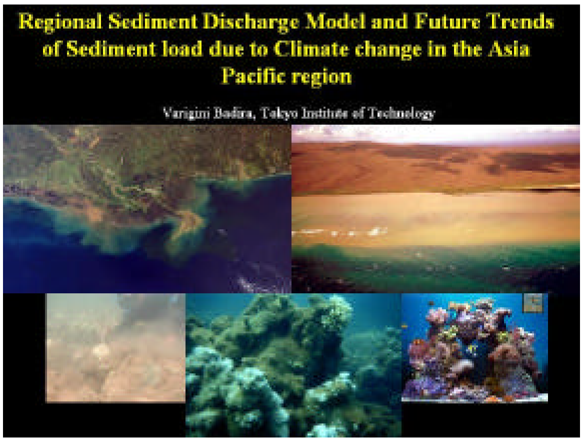
Summary

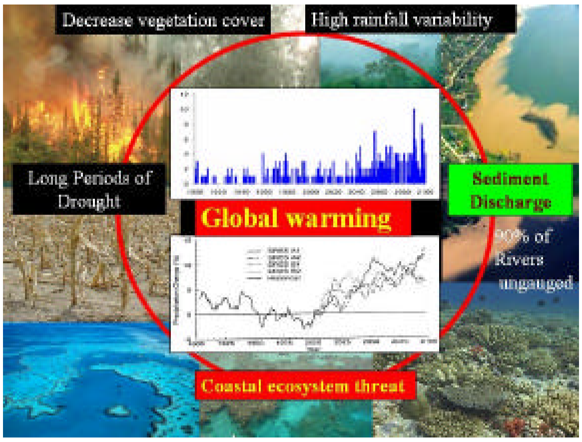
Three levels of options	Advantage	Disadvantage	Mapping purpose
Quickbird, spot check & supervised classification	Accuracy & repeatable	Cost & time high	Monitoring program
Expert knowledge & delineating	Accuracy, Cost & Time still doable	Not repeatable	Baseline
Local knowledge & delineating	Cost & time low	Low accuracy & not repeatable	Site selection

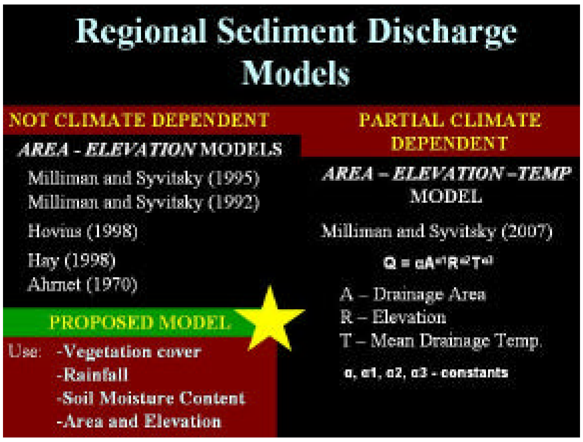
Acknowledgements

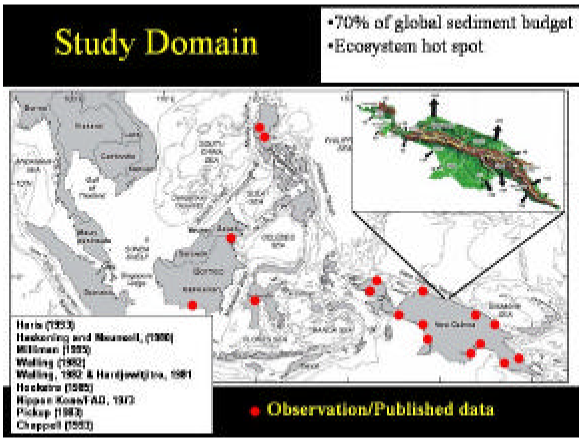
- Volunteers
- Navakavu Qoliqoli members
- Qoliqoli survey team
- Staff and Students of University of South Pacific
- CRISP
- AWARE
- WCS
- Dravuni villagers
- Dravuni research stations
- Coral Cay Conservation
- University of Queensland
- SOPAC
- World Bank GEF CRTR-Remote Sensing
- ARC Coral Reef Mapping
- D. Kleine

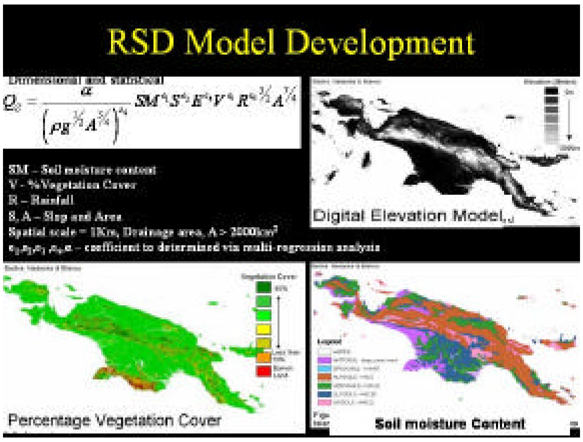
(5) Regional Sediment Discharge Model and the Future Trends of Sediment Load Due to Climate Change in the Asia-Pacific Region

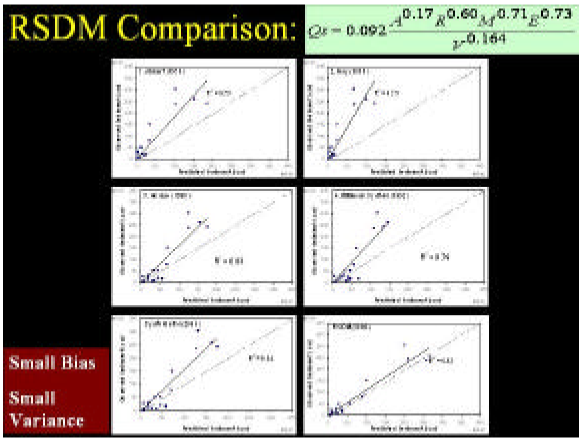


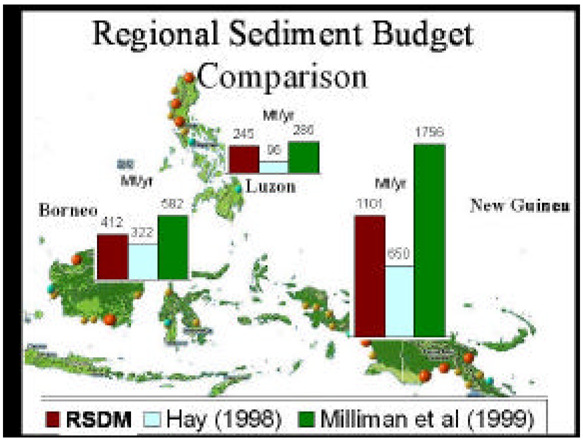


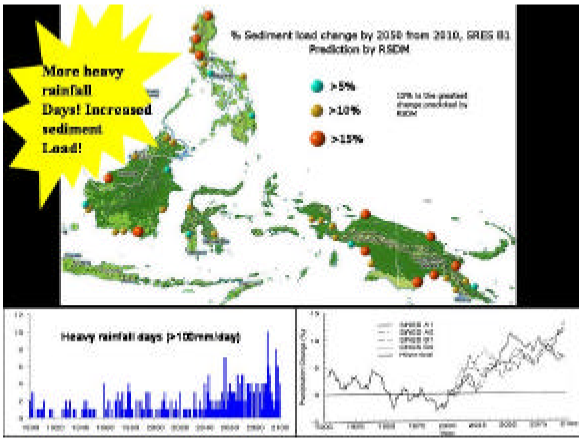


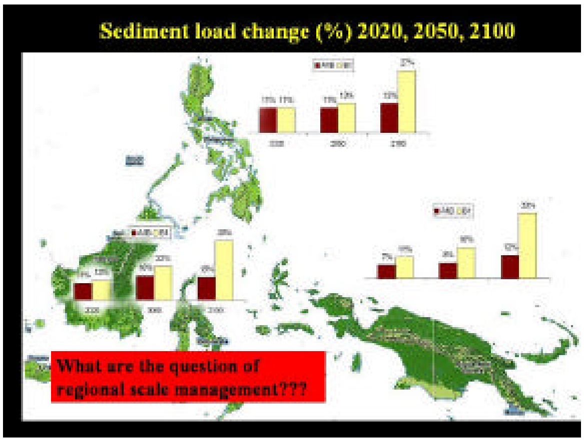


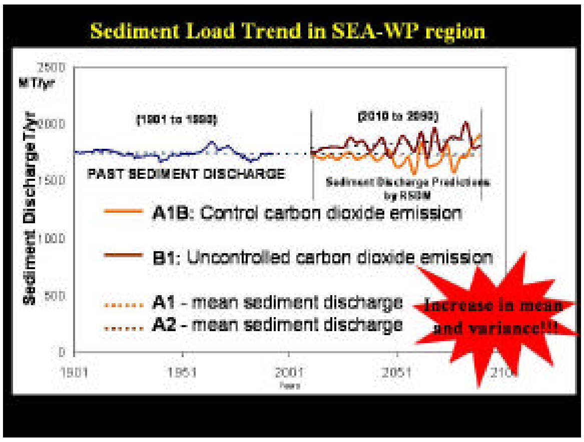


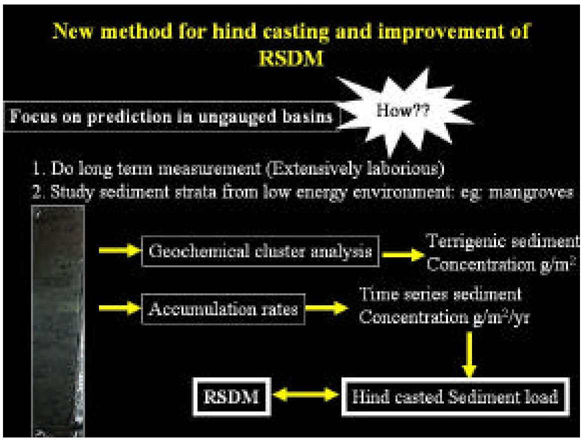


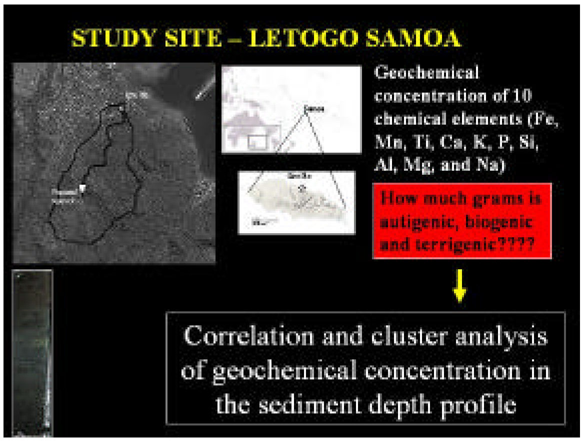


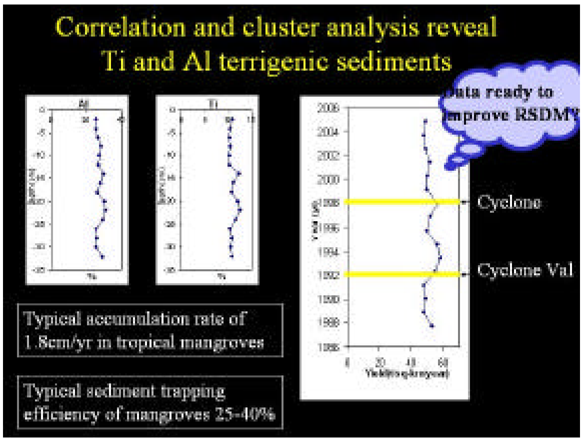


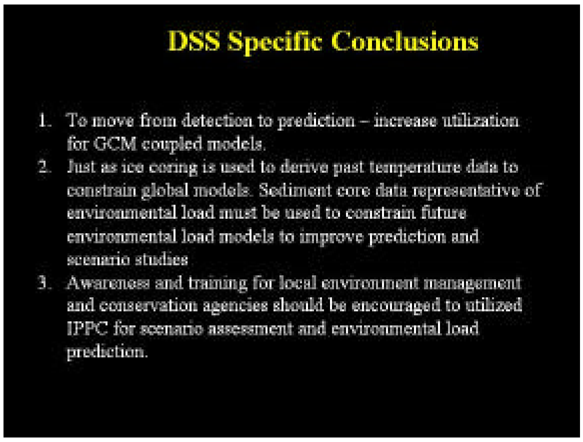

Sediment load change (%) 2020, 2050, 2100
What are the question of regional scale management???


Sediment Load Trend in SEA-WP region
MT/yr
Sediment Discharge T/yr
(1901 to 1990)
(2010 to 2090)
PAST SEDIMENT DISCHARGE
Sediment Discharge Predictions by RSDM
A1B: Control carbon dioxide emission
B1: Uncontrolled carbon dioxide emission
A1 - mean sediment discharge
A2 - mean sediment discharge
Increase in mean and variance!!!
1901
1951
2001
2051


New method for hind casting and improvement of RSDM
Focus on prediction in ungauged basins
How??
1. Do long term measurement (Extensively laborious)
2. Study sediment strata from low energy environment: eg: mangroves
Geochemical cluster analysis
Terrigenic sediment Concentration g/m²
Accumulation rates
Time series sediment Concentration g/m²/yr
RSDM
Hind casted Sediment load


STUDY SITE – LETOGO SAMOA
Geochemical concentration of 10 chemical elements (Fe, Mn, Ti, Ca, K, P, Si, Al, Mg, and Na)
How much grams is autigenic, biogenic and terrigenic????
Correlation and cluster analysis of geochemical concentration in the sediment depth profile


Correlation and cluster analysis reveal Ti and Al terrigenic sediments
Data ready to improve RSDM?
Al
Ti
Cyclone
Cyclone Val
Typical accumulation rate of 1.8cm/yr in tropical mangroves
Typical sediment trapping efficiency of mangroves 25-40%


DSS Specific Conclusions
1. To move from detection to prediction – increase utilization for GCM coupled models.
2. Just as ice coring is used to derive past temperature data to constrain global models. Sediment core data representative of environmental load must be used to constrain future environmental load models to improve prediction and scenario studies
3. Awareness and training for local environment management and conservation agencies should be encouraged to utilized IPPC for scenario assessment and environmental load prediction.

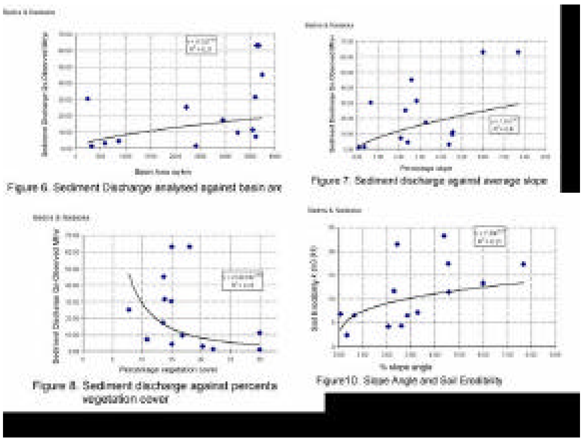
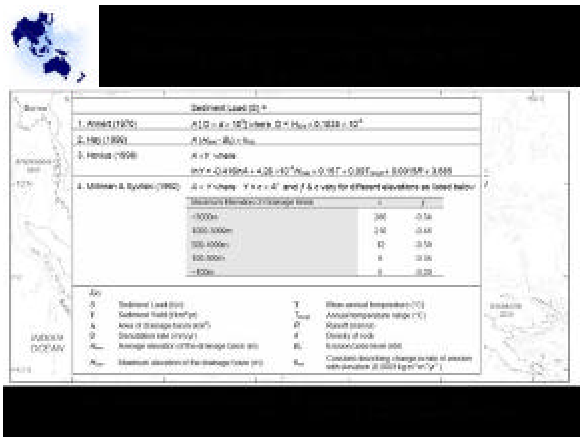
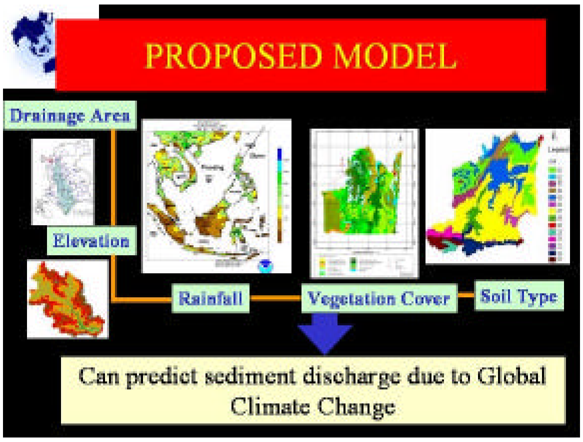
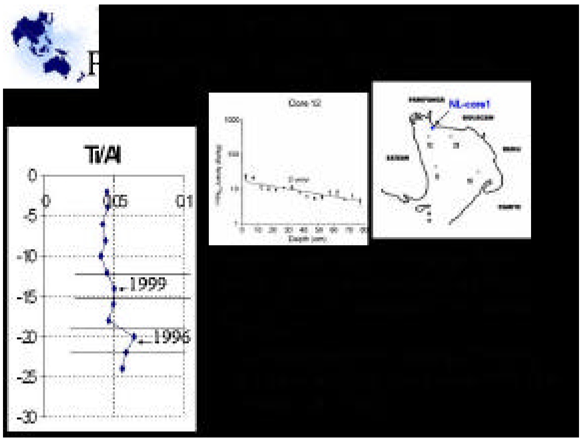


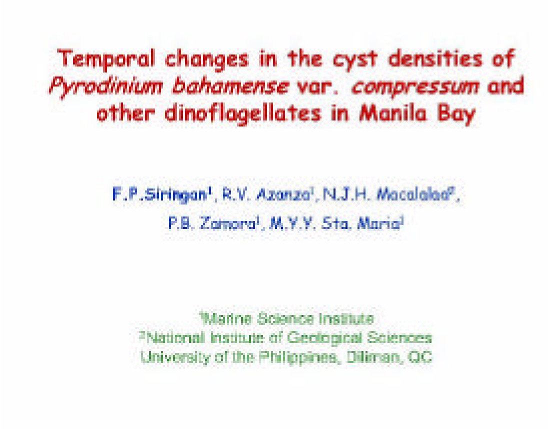
Figure 6. Sediment Discharge analysed against basin are
Figure 7. Sediment discharge against average slope
Figure 8. Sediment discharge against percenta vegetation cover
Figure10. Slope Angle and Soil Erodibility

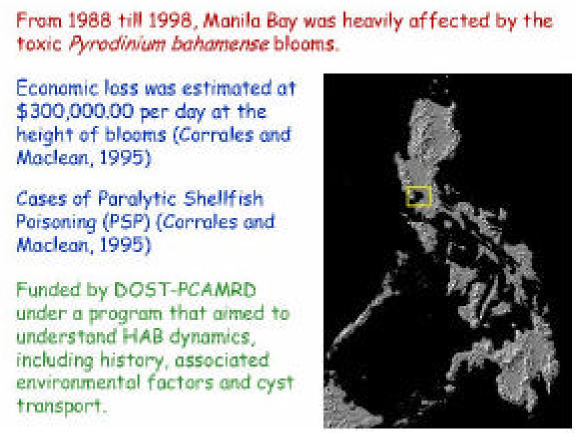


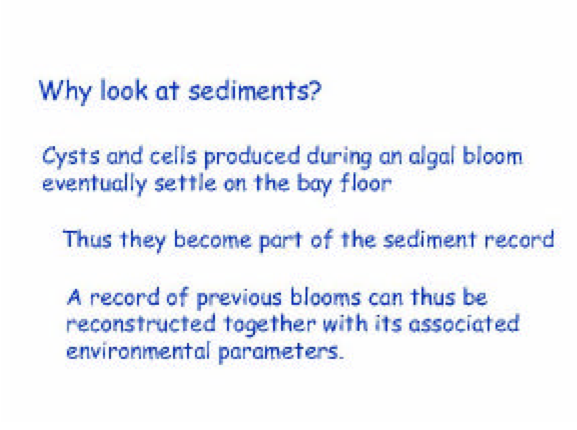


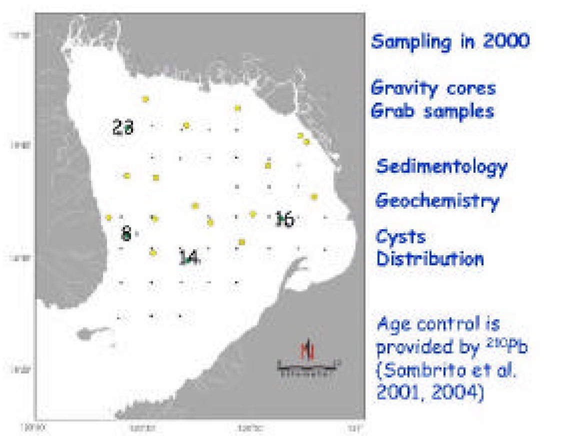


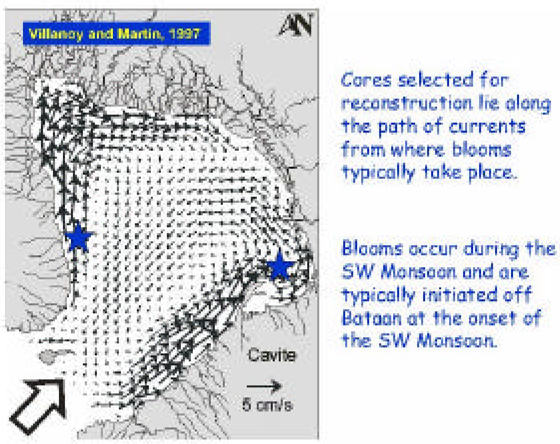
(6) Temporal Changes in the Cyst Densities of Pyrodinium bahamense var. compressum and Other Dinoflagellates in Manila Bay, Philippines

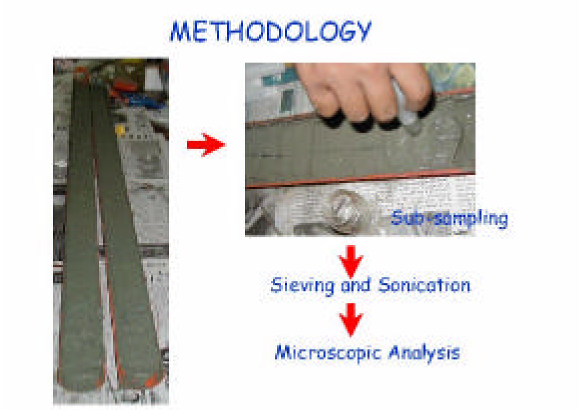


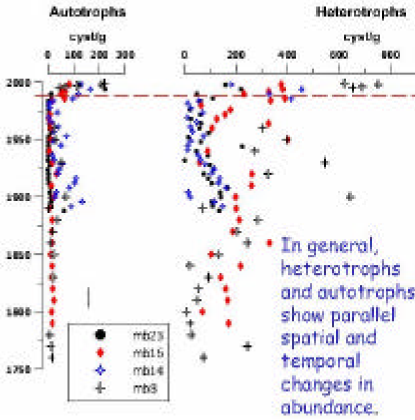


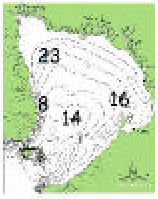






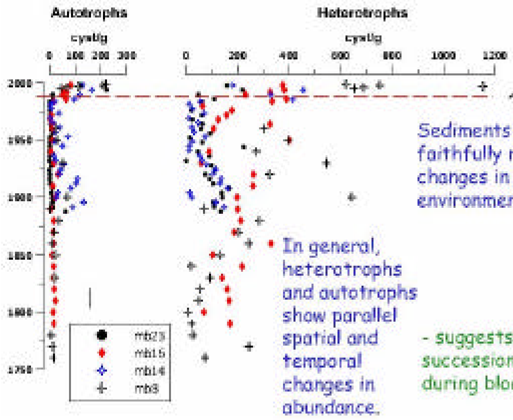






Sediments faithfully record changes in the environment.

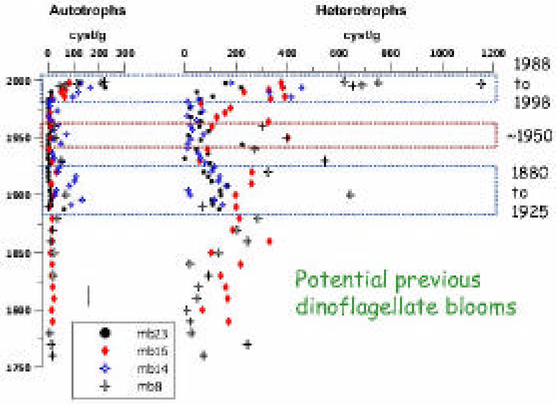
- In general, heterotrophs and autotrophs show parallel spatial and temporal changes in abundance.



Sediments faithfully record changes in the environment.

- In general, heterotrophs and autotrophs show parallel spatial and temporal changes in abundance.

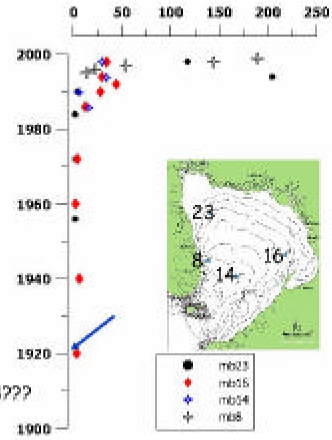
- suggests succession during blooms

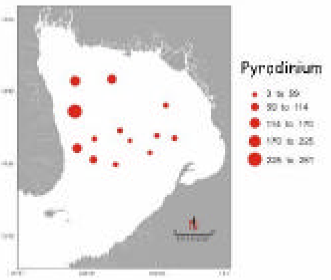


Potential previous dinoflagellate blooms

Pyrodinium bahamense var. *compressum*

- first appeared in the 1920s off Cavite side
- weakens the argument that the 1988 bloom was due to recent transport of cysts to Manila Bay
- Why the bloom in 1988???





Pbc cysts counts are higher where metal and organic (N, P, TOC) inputs are lower.

- Pbc appears to prefer relatively clean waters.

- questions the generally accepted notion that Pbc blooms are due to eutrophication ! ! !

eutrophication in Manila Bay started much earlier than 1988 (David et al. 2007)

It has been previously suggested that Pyrodinium blooms were triggered by coincidence of several climatic factors (e.g. McLean, 1989; Mudie et al. 2002);

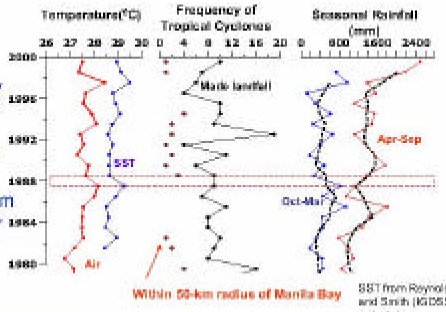
Warm waters (McLean, 1989; Usup and Azanza, 1998).

P. bahamense cells, in laboratory culture, reached optimum growth at 28°C (Usup, 1995, cited in Usup and Azanza, 1998)

Stable water column - favors cell growth and survival of seed population (Smayda 1997)

High river discharge - elevated river runoff delivers nutrient-rich waters (Phlips et al. 2004)

In 1988, Manila Bay had a high SST because it was an ENSO warm phase year



SST from Reynolds and Smith (IGOSS website)

Air temperature and precipitation (PAGASA, IGOSS)

Tropical cyclone (Joint Warning Typhoon Center)

No typhoon passed within 50 km

There was higher rainfall in preceding season.

Summary and Conclusions

Occurrence of P. bahamense dating back to 1920s weakens the hypothesis that the 1988 bloom was caused by recent introduction through ballast waters of marine vessels.

Coincidence of warm, stable waters and discharge of nutrient-rich waters in preceding season likely triggered the 1988 bloom.

(7) Social and Environmental Assessment of Puerto Galera, Philippines

Complementarity of sensor-based measurements and community perception for monitoring and management of seawater quality

Maria Cecilia D. Rubio, Kazuo Nadaoka, Tanuspong Pokavanich, Ariel C. Blanco and Enrico C. Paringit

Aims

- Impact of **human activities** in some tourism areas

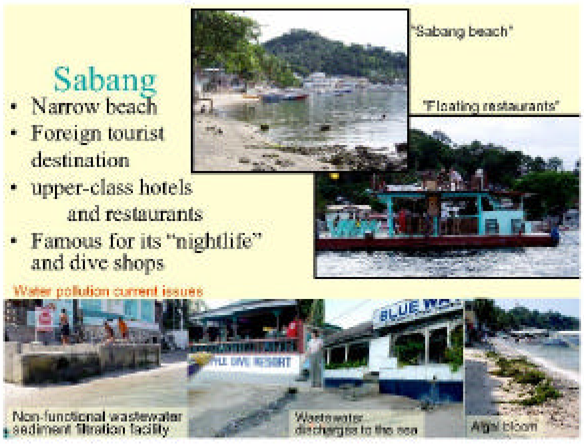
  ⇕

  seawater quality

- integrated **socio-environmental approach**

  ⇓

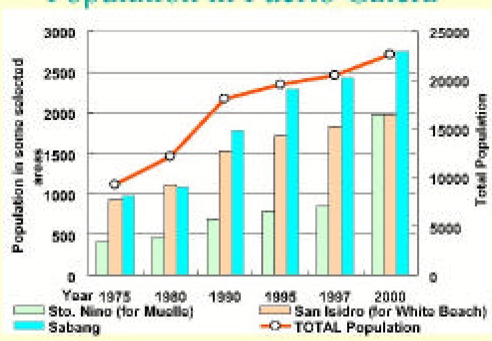
  emphasize the **community's role** in water quality improvement efforts.



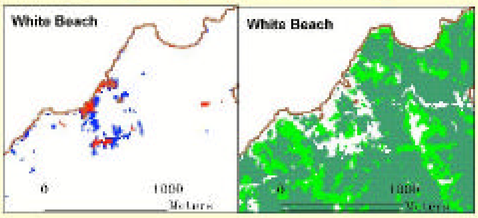
Materials used

- Social – social profiling by questionnaire& interview surveys
- Environmental – remote sensing (using ASTER imageries), GIS and GPS survey
  - Bio-physical – water quality measurement by STD-type sensor

Population in Puerto Galera

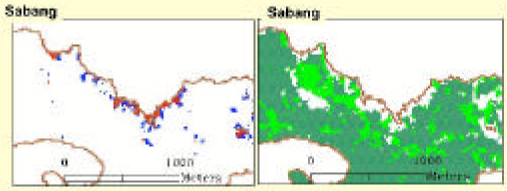


Built-up expansion and land cover change by remote sensing



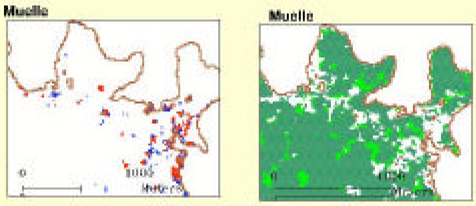
Expansion far from the beach

- built-up 2001
- built-up expansion 2005
- forest 2005
- deforested 2005 (from 2001)



Expansion concentrated along the beach

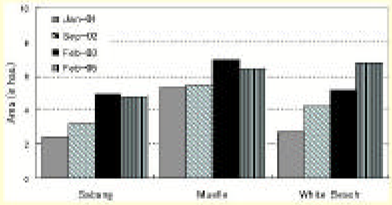
- built-up 2001
- built-up expansion 2005
- forest 2005
- deforested 2005 (from 2001)



Expansion far from the beach

- built-up 2001
- built-up expansion 2005
- forest 2005
- deforested 2005 (from 2001)

Built-up area growth



Population growth may not be the main factor of water pollution problem.

GIS set-up for organizing all data

For further analysis
For easy viewing

Outline of social survey

- Actual situation
  - Existing sanitation facilities.
  - Activities and sanitation practices.
- Perception on water quality.
  - Indicators
  - Duration
  - Negative effects
- Opinion on pollution problem

Check on environmental awareness and commitment.

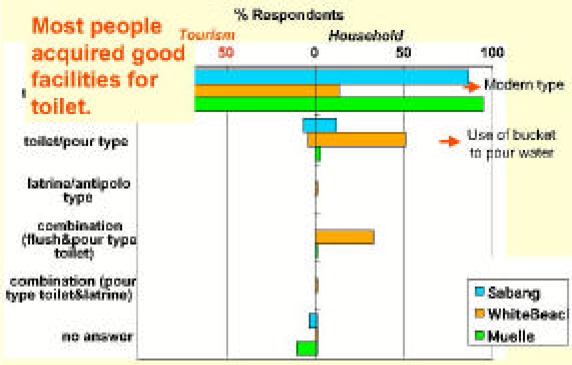
Knowing People's Perception on Water Pollution

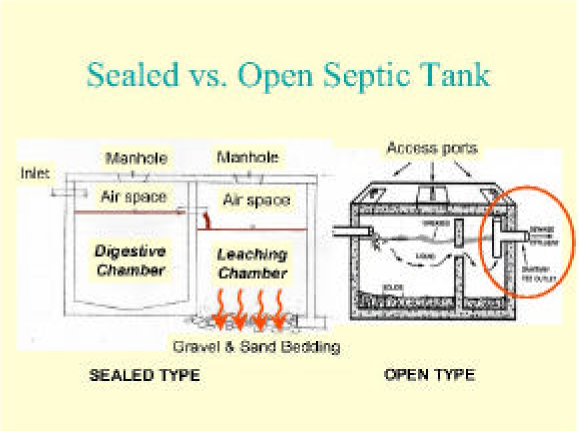
	tourism	*household*
Sabang	32	74
White beach	24	91
Muelle	10	96
Batangas Channel*		40*

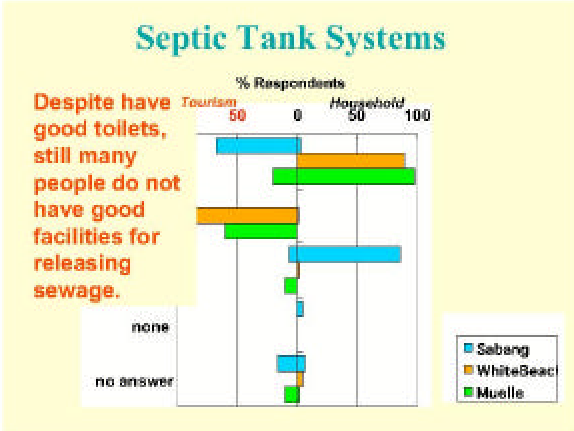
No. of respondents

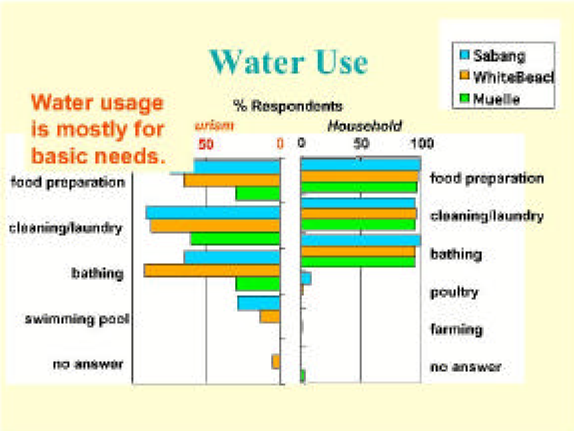
Tourism sector – as represented by hotel/restaurant owners or managers
Household sector– as represented by the head of the family

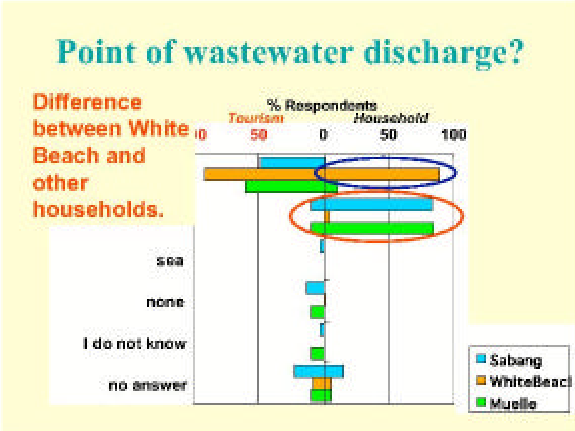
Type of Toilet

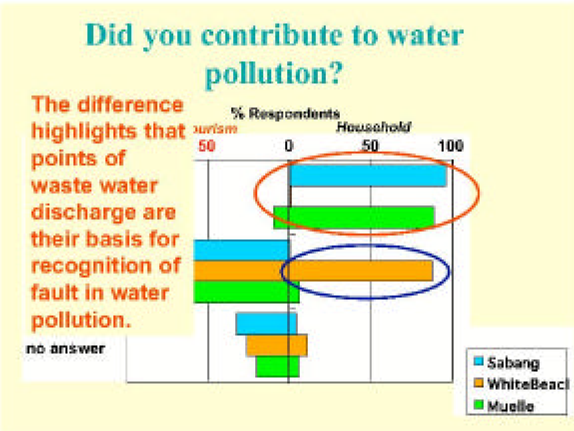


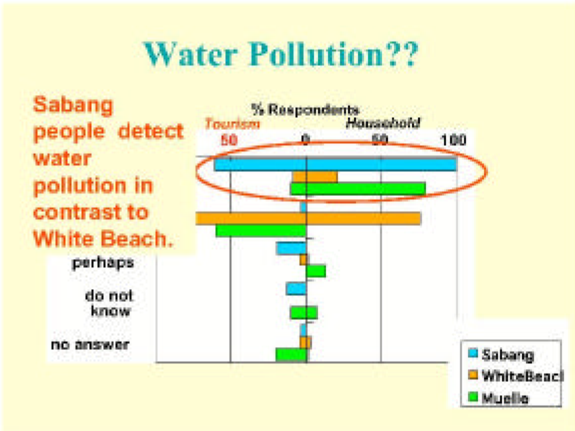

Sealed vs. Open Septic Tank
Manhole
Manhole
Inlet
Air space
Air space
Digestive Chamber
Leaching Chamber
Gravel & Sand Bedding
Access ports
SEALED TYPE
OPEN TYPE

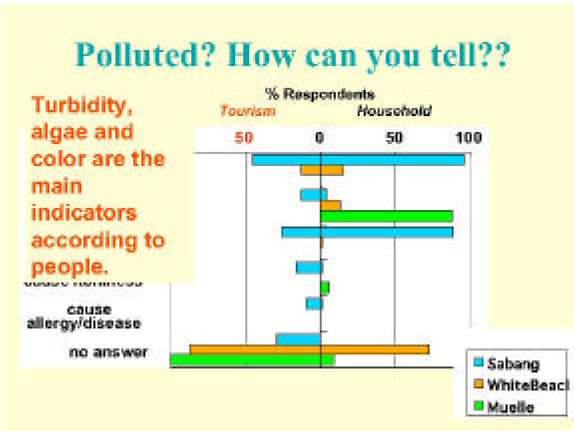

Septic Tank Systems
Despite have good toilets, still many people do not have good facilities for releasing sewage.
% Respondents
Tourism
Household
50
0
50
100
none
no answer
Sabang
WhiteBeac
Muelle

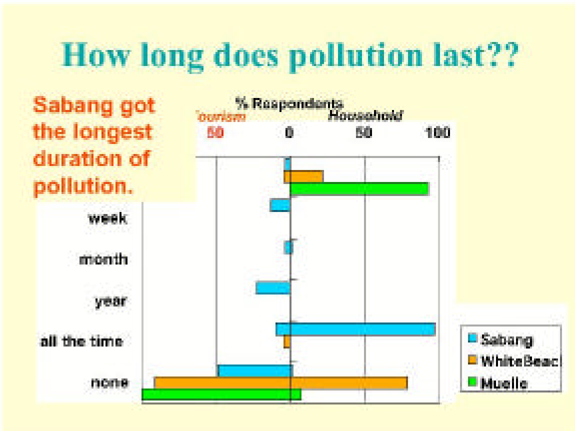

Water Use
Water usage is mostly for basic needs.
% Respondents
Household
50
0
0
50
100
food preparation
cleaning/laundry
bathing
swimming pool
no answer
food preparation
cleaning/laundry
bathing
poultry
farming
no answer
Sabang
WhiteBeac
Muelle

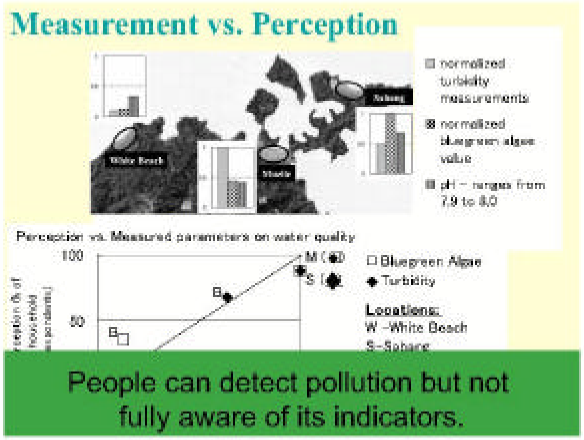

Point of wastewater discharge?
Difference between White Beach and other households.
% Respondents
Tourism
Household
50
0
50
100
sea
none
I do not know
no answer
Sabang
WhiteBeac
Muelle

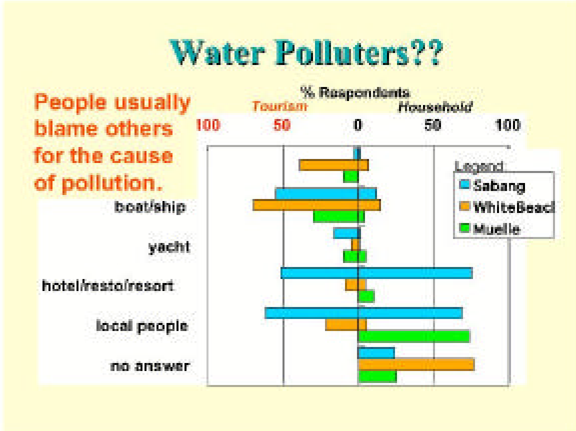

Did you contribute to water pollution?
The difference highlights that points of waste water discharge are their basis for recognition of fault in water pollution.
% Respondents
Household
50
0
50
100
no answer
Sabang
WhiteBeac
Muelle

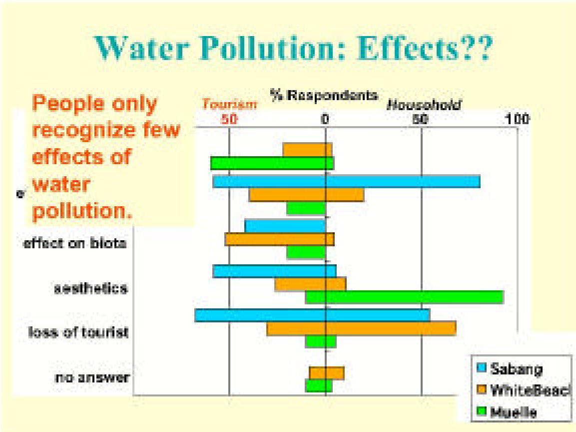

Water Pollution??
Sabang people detect water pollution in contrast to White Beach.
% Respondents
Tourism
Household
50
0
50
100
perhaps
do not know
no answer
Sabang
WhiteBeac
Muelle

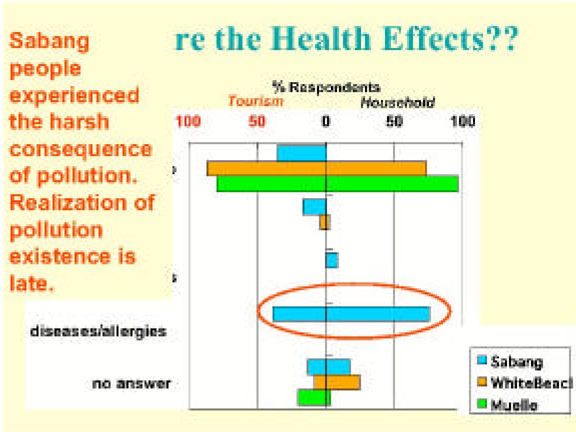

Polluted? How can you tell??
Turbidity, algae and color are the main indicators according to people.
% Respondents
Tourism
Household
50
0
50
100
cause allergy/disease
no answer
Sabang
WhiteBeac
Muelle

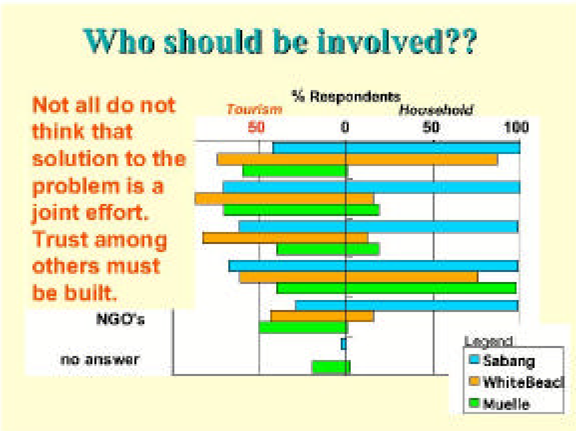

How long does pollution last??
Sabang got the longest duration of pollution.
% Respondents
Household
50
0
50
100
week
month
year
all the time
none
Sabang
WhiteBeac
Muelle

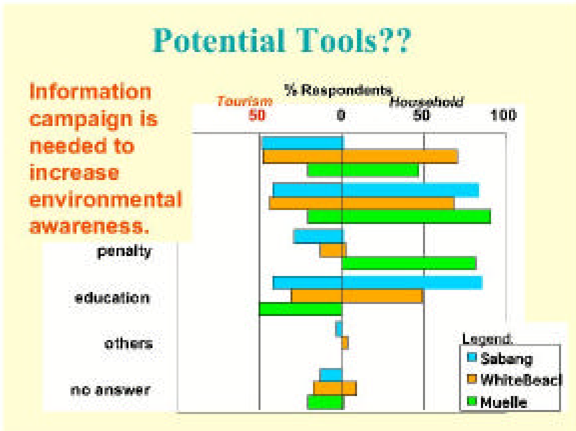


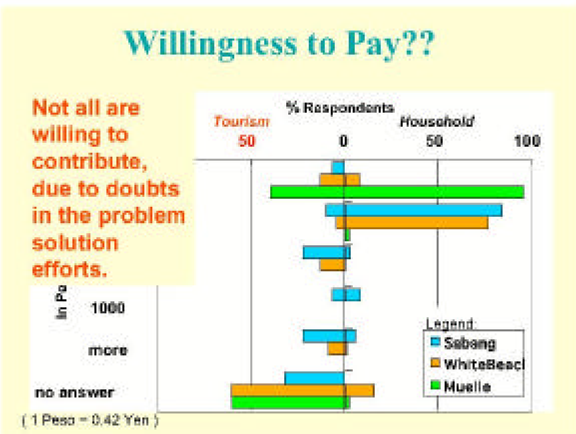








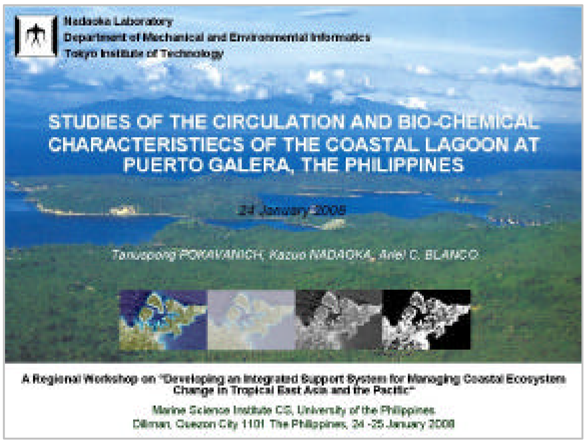


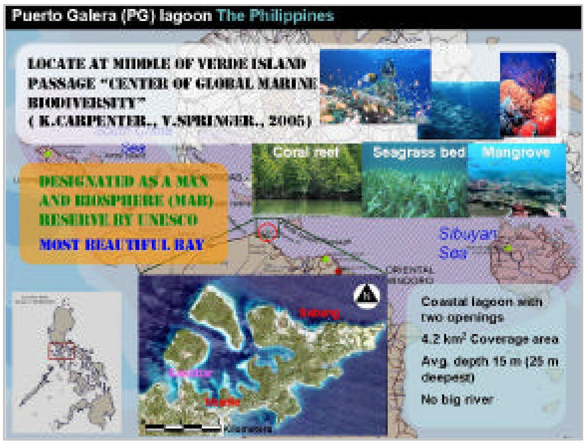


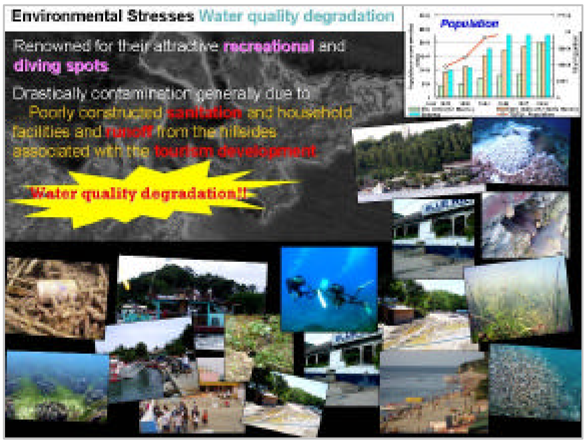
Summary of Findings

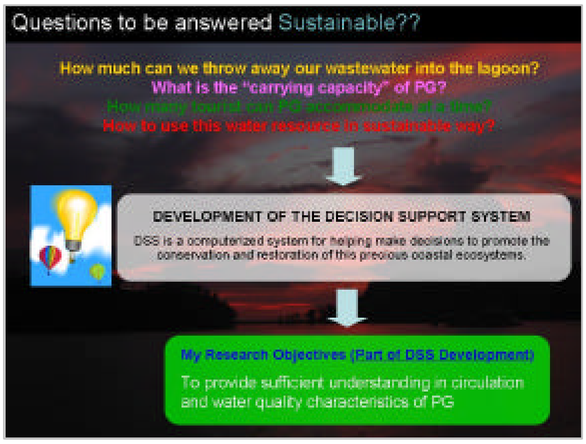
- **Social Profiling & feedback system**
  - Reveal people's activities, practices and perception
  - Perception and measurements: complementary tools for monitoring
  - Best solution to water quality is reduction of waste load and improve sanitation practices
- **Integration approach**
  - Social, physical and biological aspects of ecosystems provides clear picture of environmental problems for effective management
  - People's involvement necessary in monitoring and planning

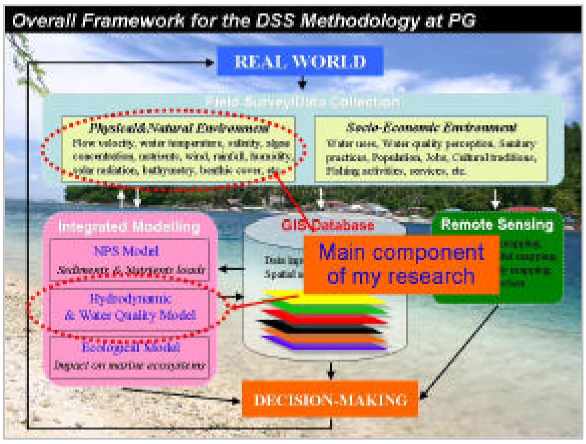
(8) Studies of the Circulation and Bio-chemical Characteristics of the Coastal Lagoon at Puerto Galera, The Philippines

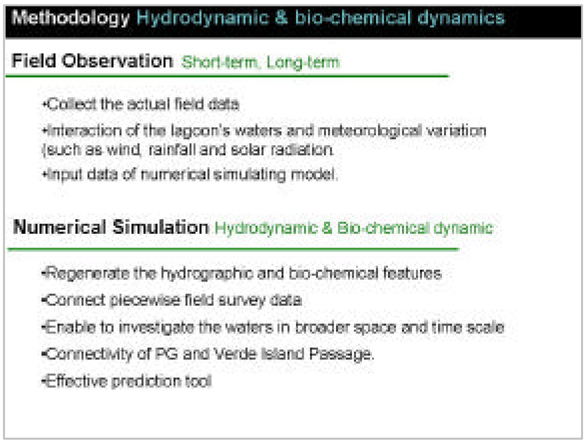


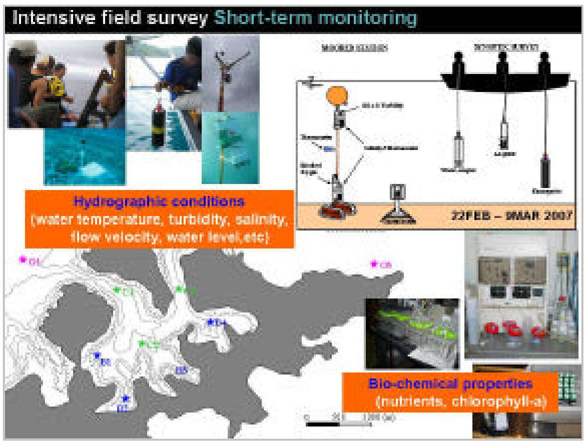


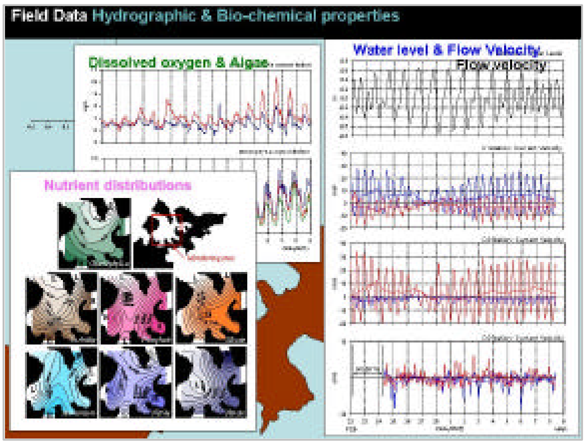


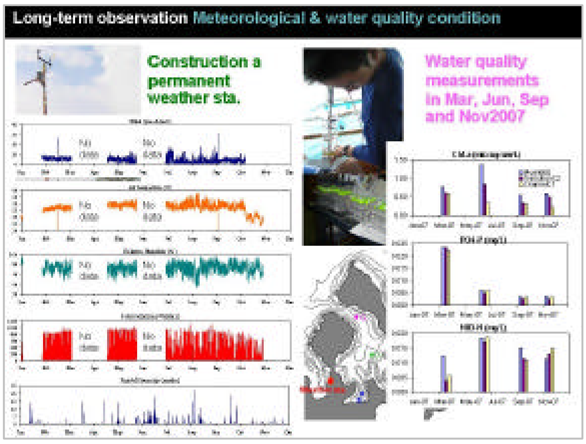


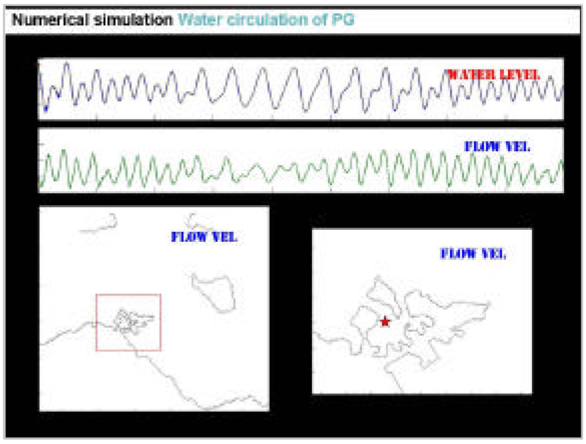


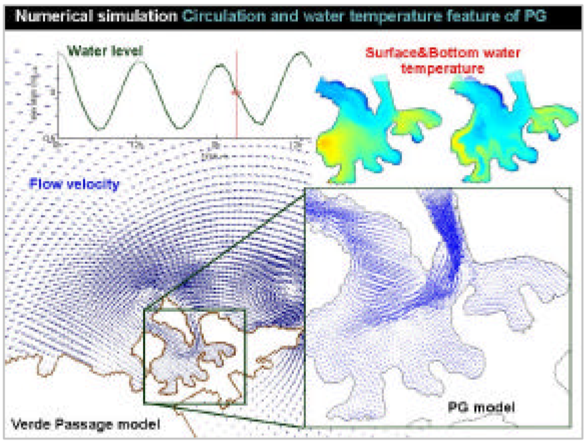


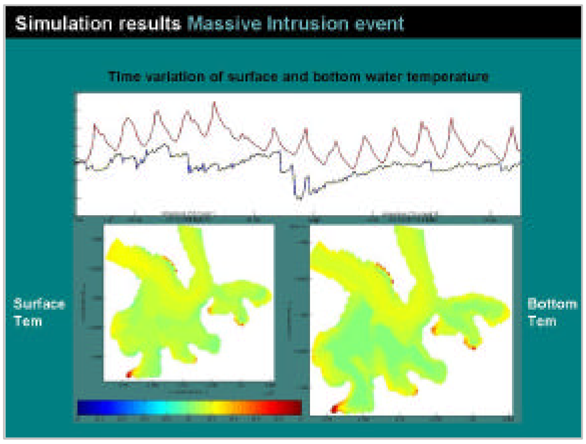


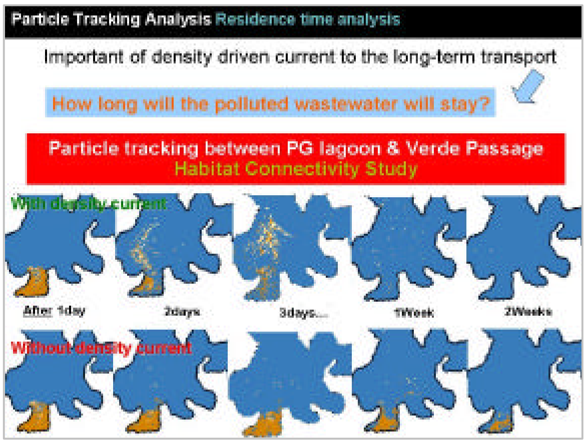


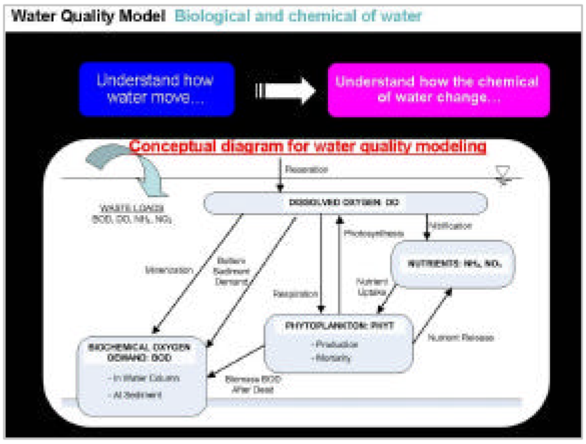

Long-term observation Meteorological & water quality condition
Construction a permanent weather sta.
Water quality measurements in Mar, Jun, Sep and Nov2007
No data
No data

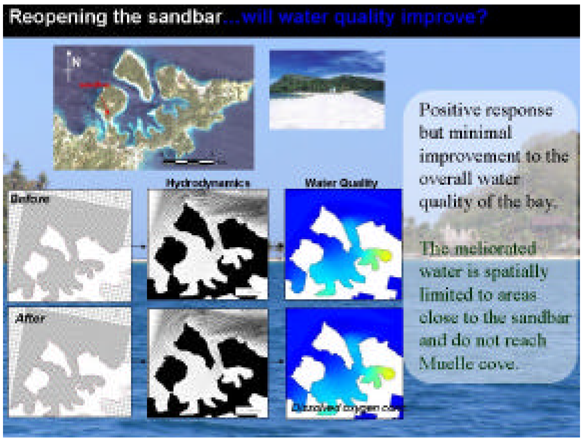

Numerical simulation Water circulation of PG
WATER LEVEL
FLOW VEL
FLOW VEL
FLOW VEL

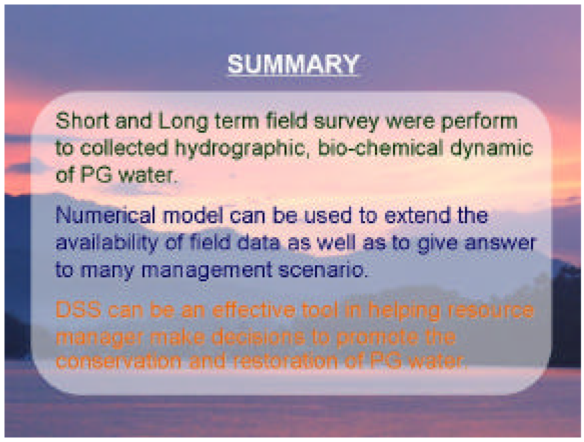

Numerical simulation Circulation and water temperature feature of PG
Water level
Surface&Bottom water temperature
Flow velocity
PG model
Verde Passage model


Simulation results Massive Intrusion event
Time variation of surface and bottom water temperature
Surface Tem
Bottom Tem

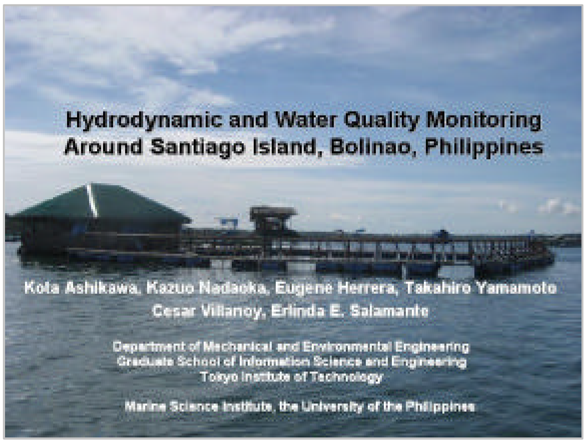

Particle Tracking Analysis Residence time analysis
Important of density driven current to the long-term transport
How long will the polluted wastewater will stay?
Particle tracking between PG lagoon & Verde Passage
Habitat Connectivity Study
With density current
After 1day
2days
3days...
1Week
2Weeks
Without density current

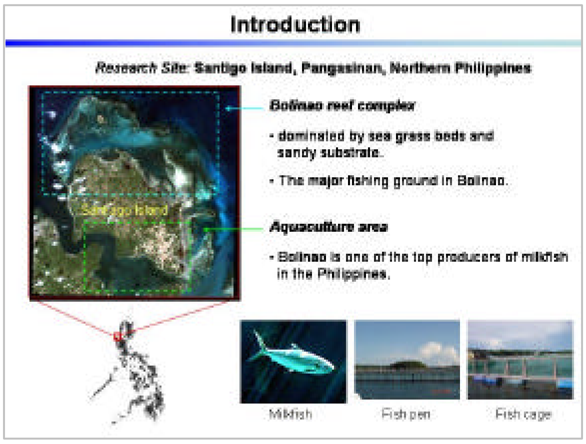

Water Quality Model Biological and chemical of water
Understand how water move...
Understand how the chemical of water change...
Conceptual diagram for water quality modeling
DISSOLVED OXYGEN: DO
NUTRIENTS
PHYTOPLANKTON: PHYT
BIOCHEMICAL OXYGEN DEMAND: BOD

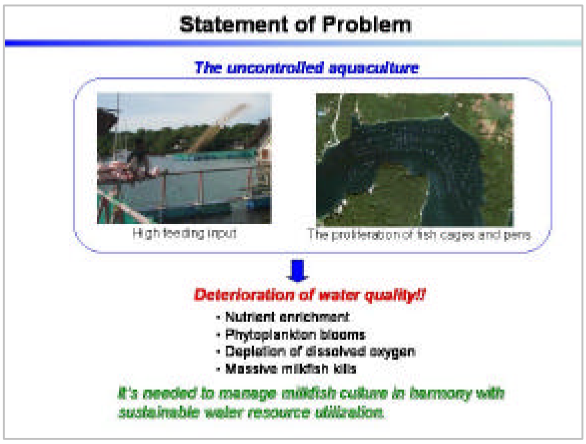

Reopening the sandbar...will water quality improve?
Hydrodynamics
Water Quality
Before
After
Positive response but minimal improvement to the overall water quality of the bay.
The meliorated water is spatially limited to areas close to the sandbar and do not reach Muelle cove.

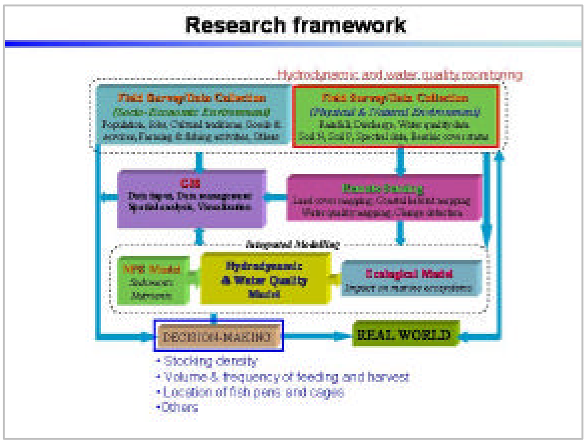

SUMMARY
Short and Long term field survey were perform to collected hydrographic, bio-chemical dynamic of PG water.
Numerical model can be used to extend the availability of field data as well as to give answer to many management scenario.
DSS can be an effective tool in helping resource manager make decisions to promote the conservation and restoration of PG water.

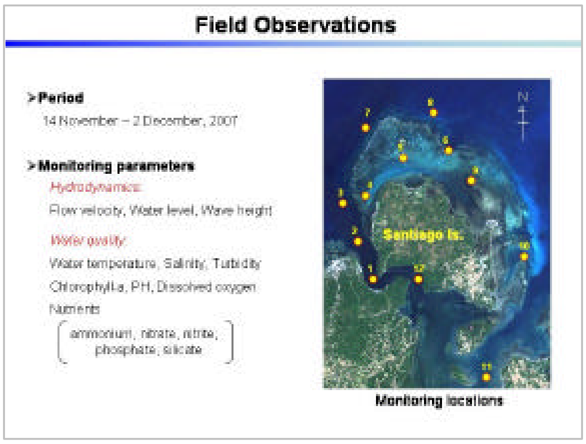
(9) Hydrodynamics and Water Quality Monitoring Around Santiago Island, Bolinao

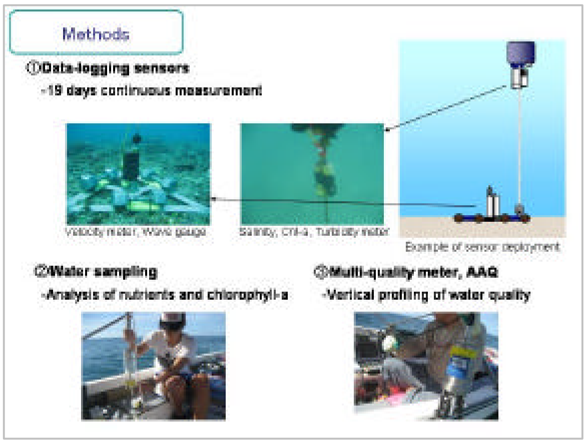


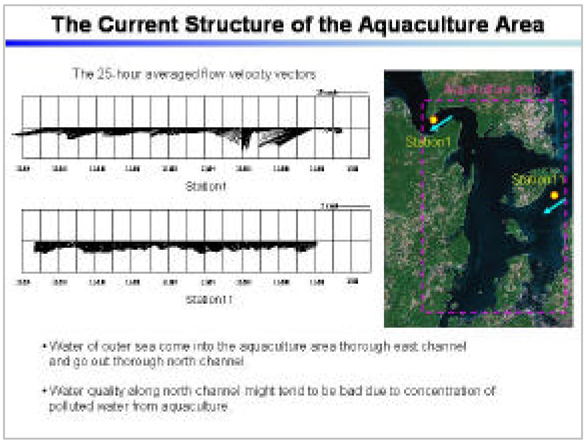


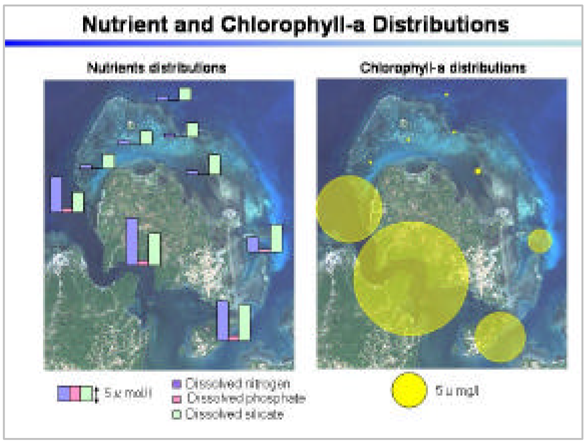


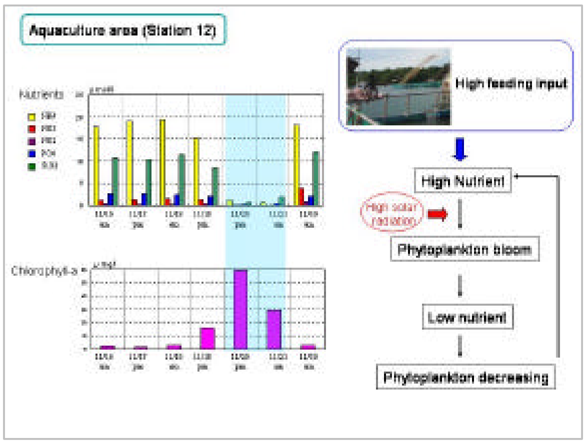


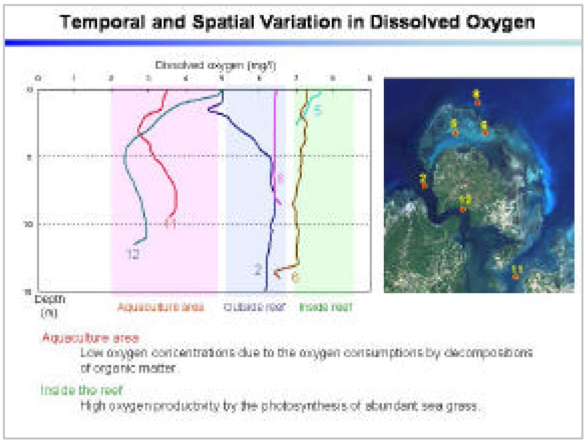


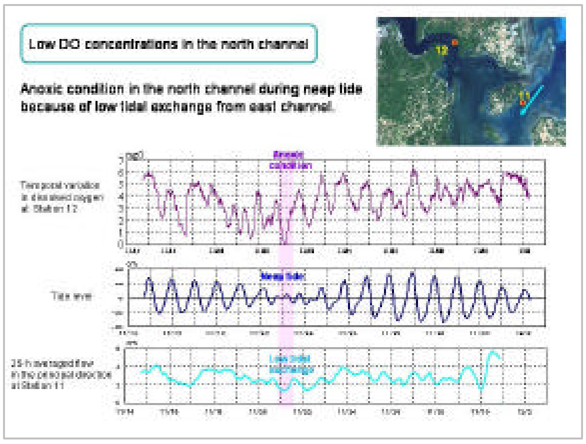


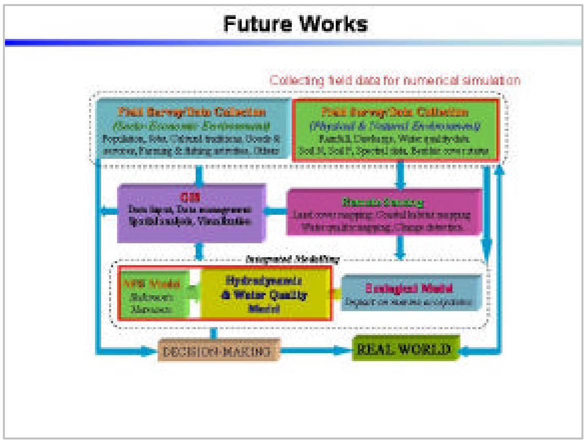


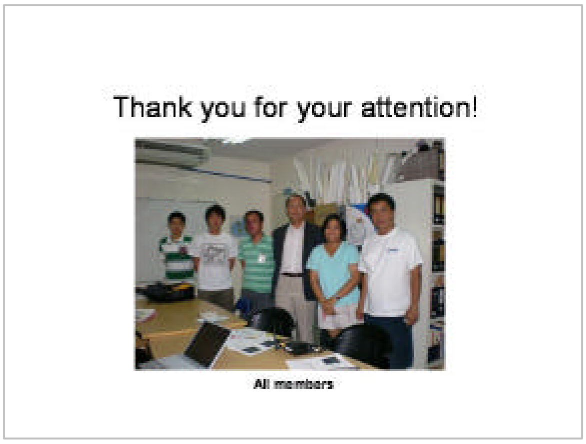

Nutrient and Chlorophyll-a Distributions
Nutrients distributions
Chlorophyll-a distributions
5 μ mol/l
Dissolved nitrogen
Dissolved phosphate
Dissolved silicate
5 u mg/l


Aquaculture area (Station 12)
Nutrients
Chlorophyll-a
High feeding input
High Nutrient
High solar radiation
Phytoplankton bloom
Low nutrient
Phytoplankton decreasing

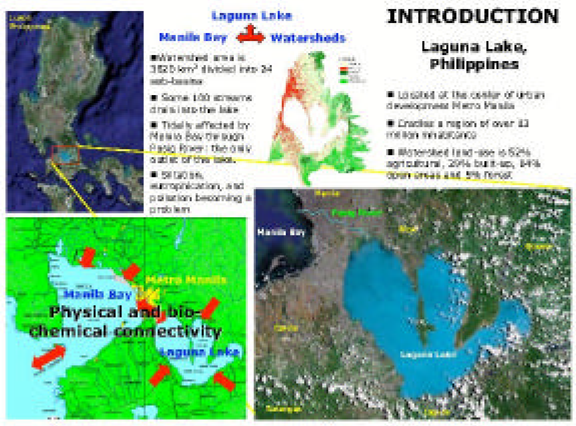

Temporal and Spatial Variation in Dissolved Oxygen
Dissolved oxygen (mg/l)
Depth (m)
Aquaculture area
Outside reef
Inside reef
Aquaculture area
Low oxygen concentrations due to the oxygen consumptions by decompositions of organic matter.
Inside the reef
High oxygen productivity by the photosynthesis of abundant sea grass.

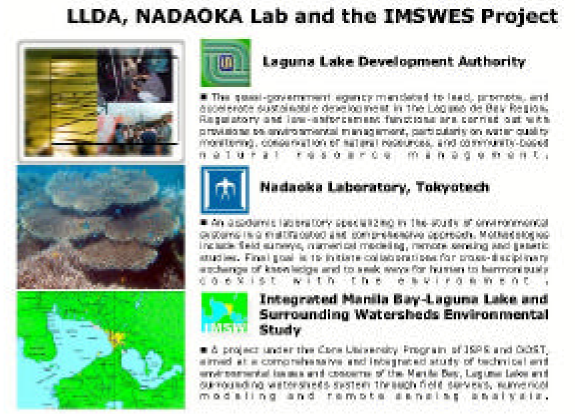

Low DO concentrations in the north channel
Anoxic condition in the north channel during neap tide because of low tidal exchange from east channel.
Anoxic condition
Temporal variation in dissolved oxygen at Station 12
Neap tide
Tide level
Low tidal exchange
25-h averaged flow in the principal direction at Station 11

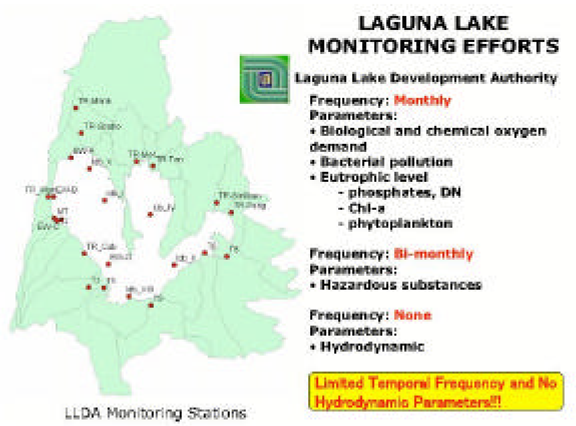

Future Works
Collecting field data for numerical simulation
Field Survey/Data Collection
(Socio-Economic Environment)
Field Survey/Data Collection
(Physical & Natural Environment)
GIS
Remote Sensing
Integrated Modelling
Hydrodynamic & Water Quality Model
Ecological Model
DECISION-MAKING
REAL WORLD

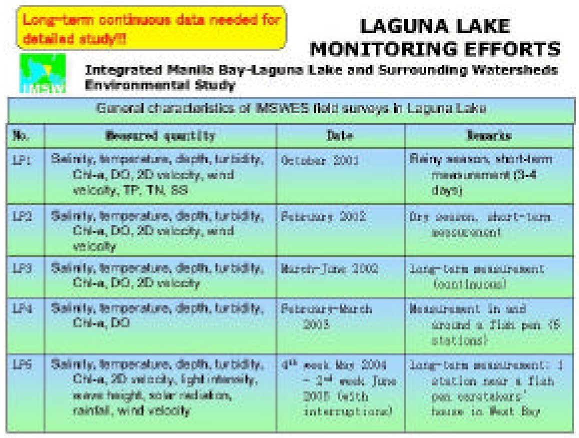

Thank you for your attention!
All members

(10) Collaborative Monitoring and Study of Laguna Lake Hydrodynamics and Water Quality



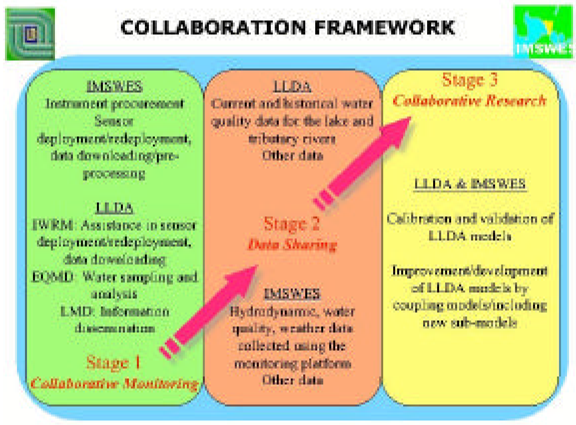


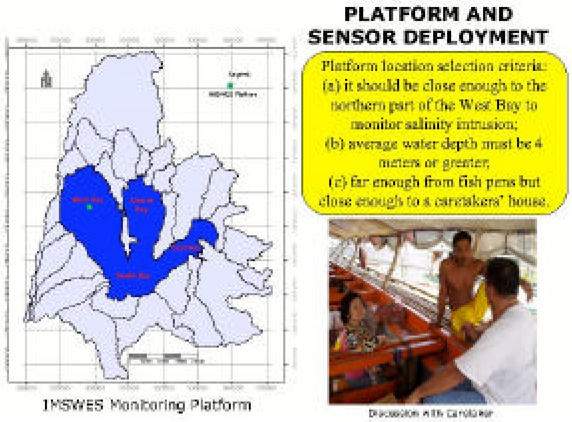


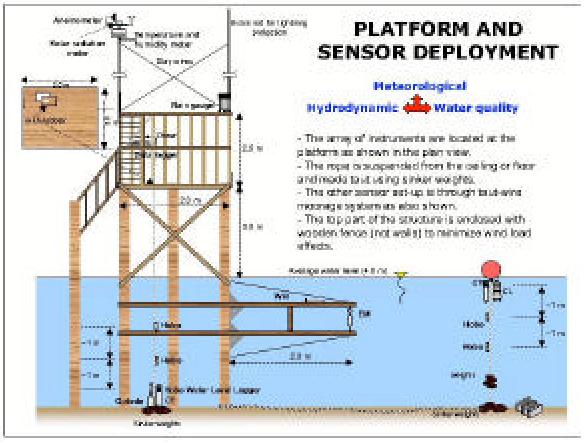


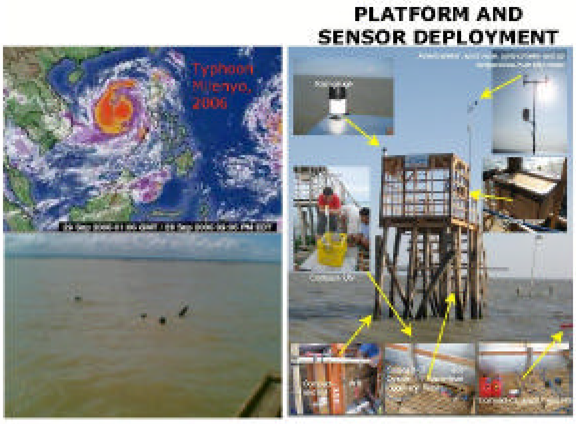
No.	Measured quantity	Date	Remarks
LP1	Salinity, temperature, depth, turbidity, Chl-a, DO, 2D velocity, wind velocity, TP, TN, SS	October 2001	Rainy season, short-term measurement (3-4 days)
LP2	Salinity, temperature, depth, turbidity, Chl-a, DO, 2D velocity, wind velocity	February 2002	Dry season, short-term measurement
LP3	Salinity, temperature, depth, turbidity, Chl-a, DO, 2D velocity	March-June 2002	Long-term measurement (continuous)
LP4	Salinity, temperature, depth, turbidity, Chl-a, DO	February-March 2003	Measurement in and around a fish pen (5 stations)
LP5	Salinity, temperature, depth, turbidity, Chl-a, 2D velocity, light intensity, wave height, solar radiation, rainfall, wind velocity	4^{th} week May 2004 - 2^{nd} week June 2005 (with interruptions)	Long-term measurement: 1 station near a fish pen caretakers' house in West Bay

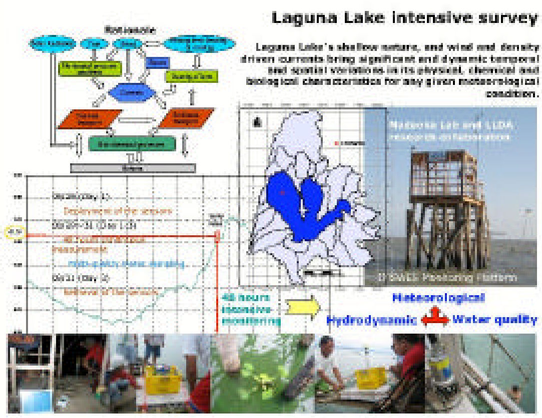

SCOPE OF COLLABORATION
Discussions between LLDA-IWRMD and IMSWES
IMSWES
Discussions for the undertaking of collaborative activities!

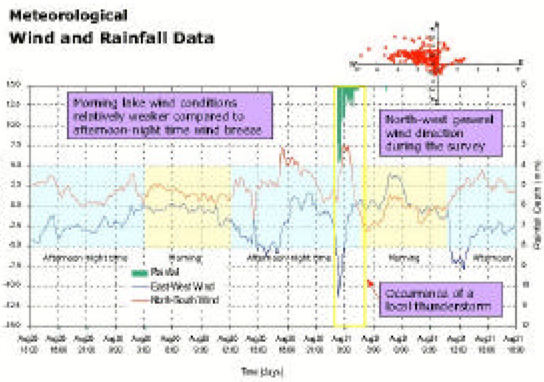

COLLABORATION FRAMEWORK
IMSWES
IMSWES
Instrument procurement
Sensor deployment/redeployment, data downloading/pre-processing
LLDA
IWRM: Assistance in sensor deployment/redeployment, data downloading
EQMD: Water sampling and analysis
LMD: Information dissemination
Stage 1
Collaborative Monitoring
LLDA
Current and historical water quality data for the lake and tributary rivers
Other data
Stage 2
Data Sharing
IMSWES
Hydrodynamic, water quality, weather data collected using the monitoring platform
Other data
Stage 3
Collaborative Research
LLDA & IMSWES
Calibration and validation of LLDA models
Improvement/development of LLDA models by coupling models/including new sub-models

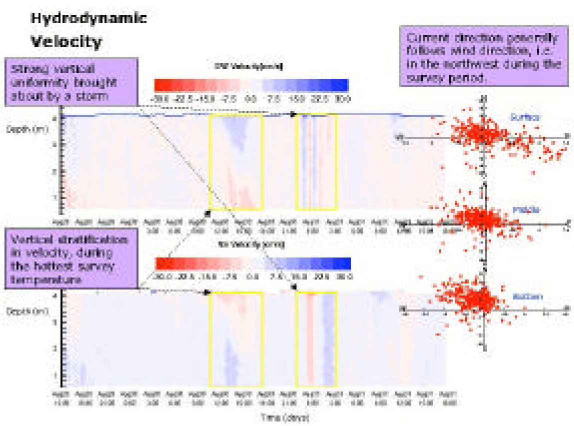

PLATFORM AND SENSOR DEPLOYMENT
Platform location selection criteria:
(a) it should be close enough to the northern part of the West Bay to monitor salinity intrusion;
(b) average water depth must be 4 meters or greater;
(c) far enough from fish pens but close enough to a caretakers' house.
IMSWES Monitoring Platform
Discussion with caretaker

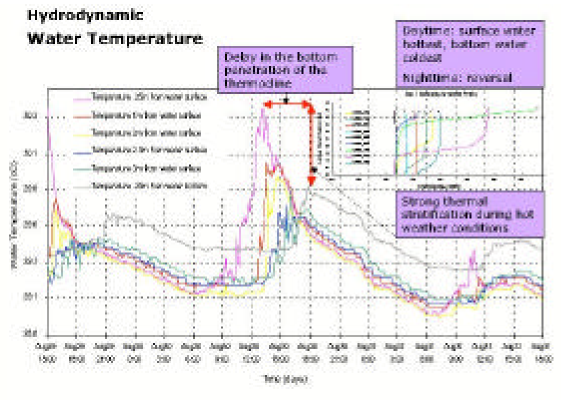

PLATFORM AND SENSOR DEPLOYMENT
Meteorological
Hydrodynamic
Water quality
- The array of instruments are located at the platform as shown in the plan view.
- The rope is suspended from the ceiling or floor and made taut using sinker weights.
- The other sensor set-up is through taut-wire mooring systems as also shown.
- The top part of the structure is enclosed with wooden fence (not walls) to minimize wind load effects.

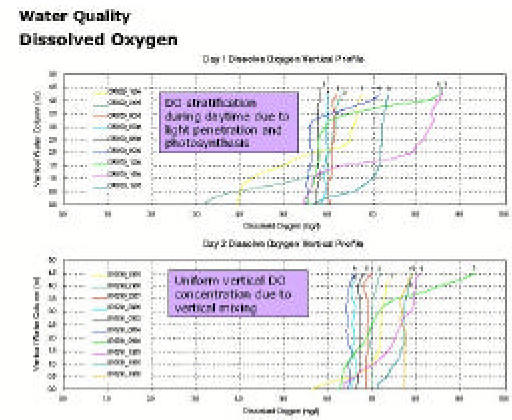

PLATFORM AND SENSOR DEPLOYMENT
Typhoon Milenyo, 2006

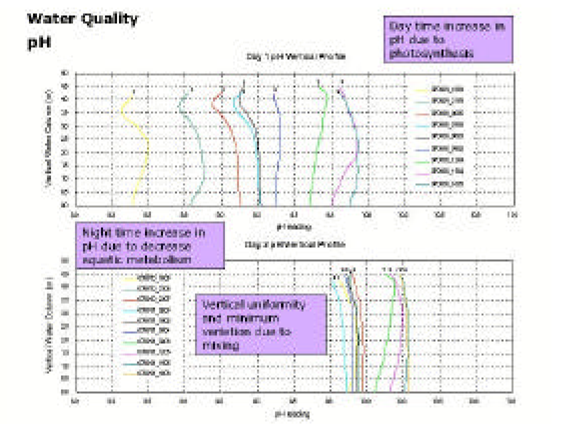

Laguna Lake intensive survey
Laguna Lake's shallow nature, and wind and density driven currents bring significant and dynamic temporal and spatial variations in its physical, chemical and biological characteristics for any given meteorological condition.
48 hours intensive monitoring
Meteorological
Hydrodynamic
Water quality
IMSWES Monitoring Platform

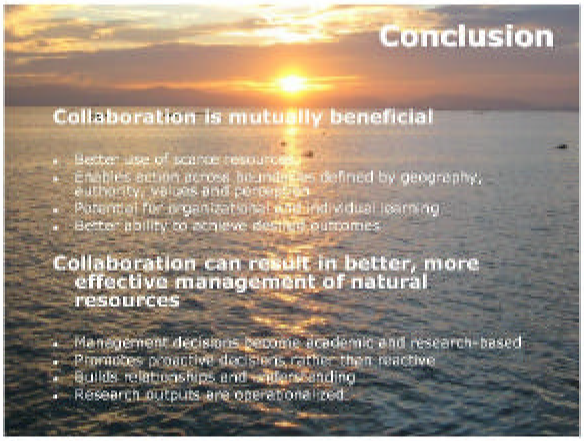

Meteorological
Wind and Rainfall Data
Morning lake wind conditions relatively weaker compared to afternoon-night time wind breeze
North-west general wind direction during the survey
Occurrence of a local thunderstorm
Rainfall
East-West Wind
North-South Wind
Time (days)


Hydrodynamic
Velocity
Strong vertical uniformity brought about by a storm
Current direction generally follows wind direction, i.e. in the northwest during the survey period.
Vertical stratification in velocity, during the hottest survey temperature
Time (days)

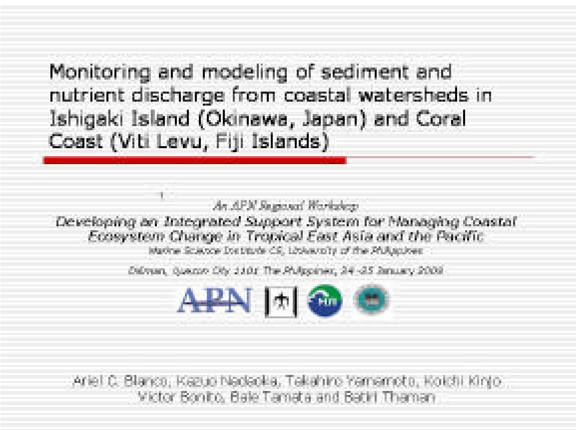


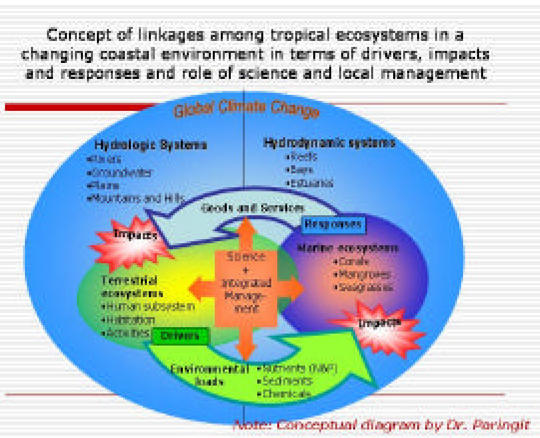




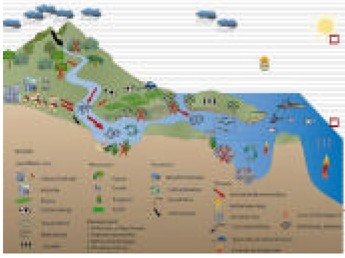


(11) Monitoring and Modeling of Sediment and Nutrient Discharge from Coastal Watersheds in Ishigaki Island (Okinawa, Japan) & Coral Coast (Viti Levu, Fiji Islands)



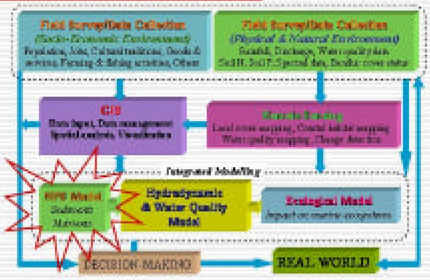


Why is watershed monitoring and modeling important?



- Each watershed is different (due to land use/cover, geology/soil, meteorology, etc.)
  - Material discharge depends on the complex interaction of these factors (dynamically changing).
- Adverse effects of excessive sedimentation and nutrification
  - Decreased coral cover, abundance of macroalgae, enhanced severity of coral diseases, etc.
- Affected coral reefs have varying capacity to withstand allochtonous inputs
  - Some can take more than the others (affected by hydrodynamics, habitat condition, herbivory, eutrophication status, etc.)

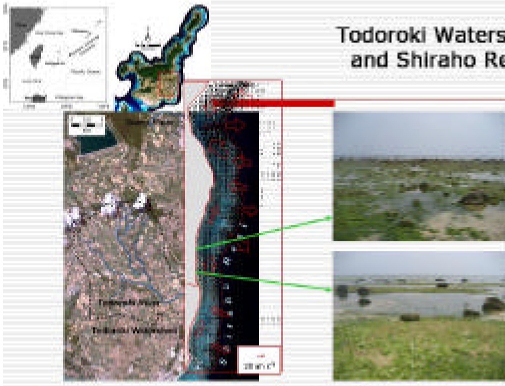
The overall DSS methodological framework of the APN-funded project "Integrated Support System for Managing Environmental Change and Human Impact on Tropical Ecosystems in East Asia and the Pacific"



In this presentation…

- Monitoring and modeling of sediment and nutrient discharge from Todoroki watershed
- Monitoring efforts in Viti Levu, Fiji
  - Naboutini watershed
  - Votua watershed

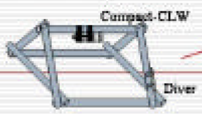
Todoroki Watershed and Shiraho Reef

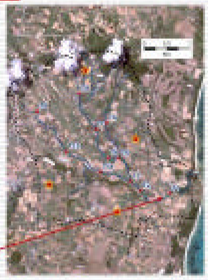


Decline in coral cover
Increased seagrass and macroalgal coverage

Monitoring of Sediments in Todoroki Watershed

- Rain gauges ★
- Compact-CLW (Turbidity, Chl-a, Temp)
- Diver (Water level)
- TSS analysis



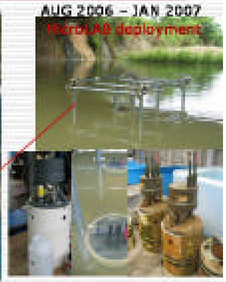


Monitoring of Nutrients in Todoroki Watershed

AUGUST 2005
Water sampling at 11 stations (T1-T11) in Todoroki river
Sampling at T1 using ISCO automatic water sampler

Analysis of nutrients & suspended solids

AUG 2006 – JAN 2007

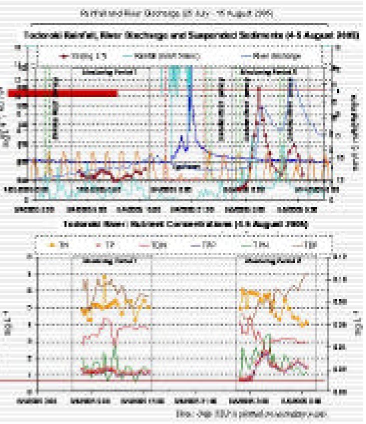


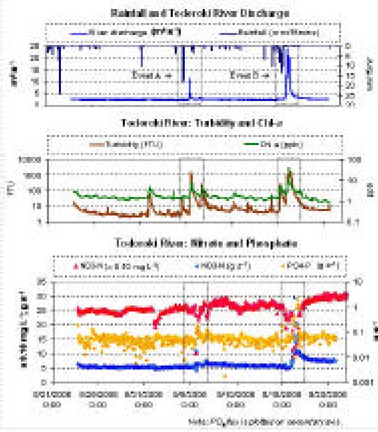
Soil sampling (about 50 stations)
Mapping of cow farms

T1-T11 water sampling
Continuous measurement at T1 using MicroLAB and automatic water sampler

Results

- SS concentrations dramatically increased particularly after intensive rainfall events
- TP was directly proportional to SS and total dissolved P (0.1 mg L-1 or less) constituted only a small percentage (<10%) of TP.
- TN showed a decreasing trend during period II.
- TDN: about 67% on the average and as much as 87% of TN.
- A gradual increase in river discharge during monitoring period I gave rise to an increasing trend or 'concentration effect' in TDN before dropping and then increasing to a fairly stable concentration. However, abrupt increase in river discharge led to a 'dilution effect' on TDN during monitoring period II





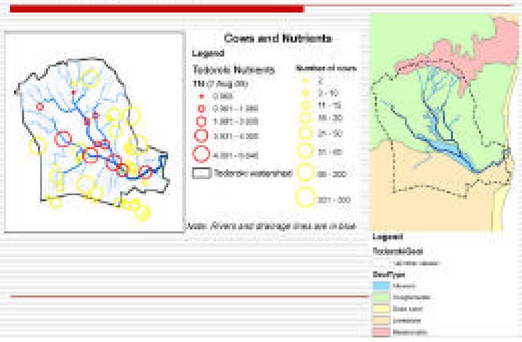
Results

- Increasing NO_3 concentration due enhanced groundwater discharge into stream after rainfall events
- Long-term nutrient monitoring data generally show similar pattern

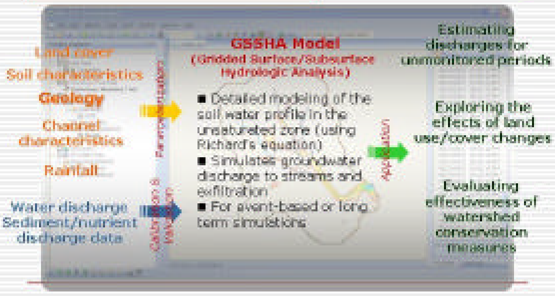
Dissolved Nutrient Discharge

Dissolved nutrients from Todoroki River (23 August – 22 September 2006)				
Time Period *(Calculation period)*	**Dissolved NO_3-N**		**Dissolved PO_4-P**	
	Discharged amount (kg)	*Average flux (kg hr⁻¹)*	*Discharged amount (kg)*	*Average flux (kg hr⁻¹)*
Before event A *(over 12 days 18 hrs)*	701.9	2.472	6.3	0.021
Event A *(22 hrs)*	149.7	2.136	1.8	0.078
Between event A and B *(9 days 11 hrs)*	674.9	2.146	6.2	0.027
Event B *(over 1day 17 hrs)*	900.5	2.069	17.5	0.456

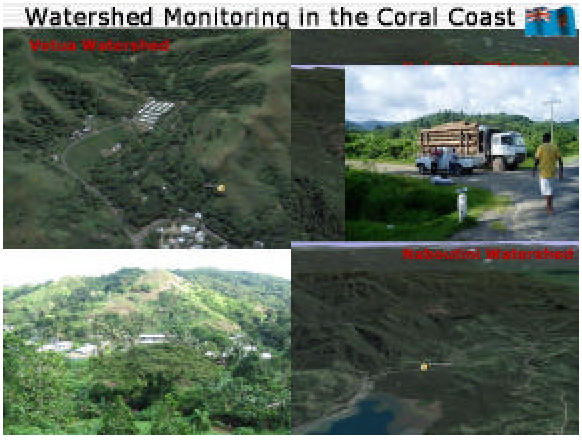
Spatial Distribution of Nutrients in Todoroki River



Watershed modeling

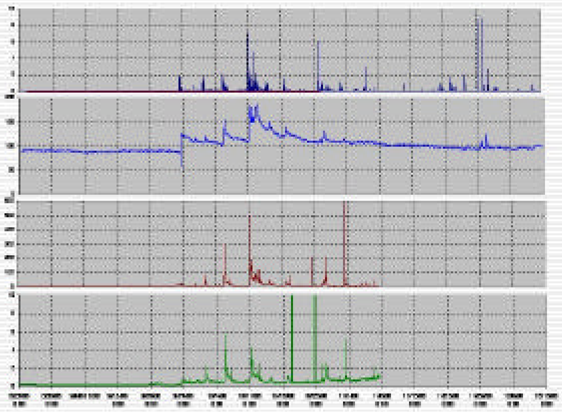


Watershed Monitoring in the Coral Coast



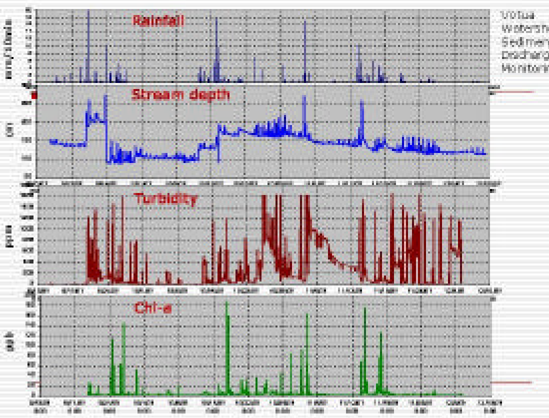
Naboutini Watershed

Regular cleaning and checking of sensors maintained by a local person.
Data downloading/sensor redeployment by USP-IAS.

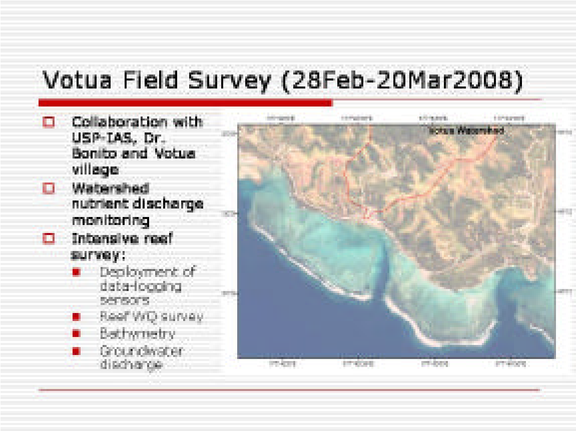


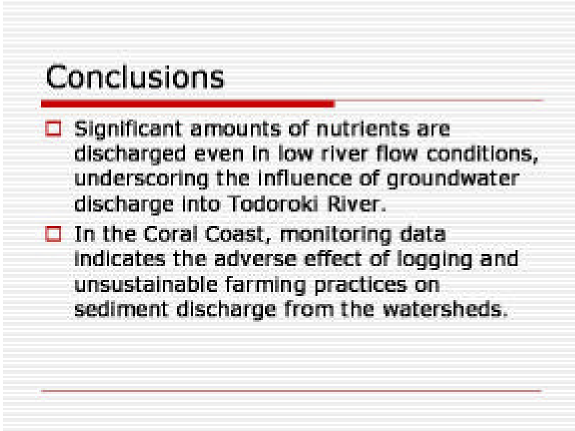
Votua Watershed

Deployment: Sept 2007 – present

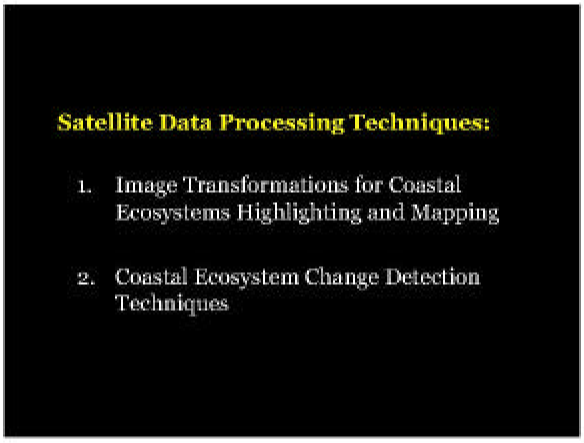


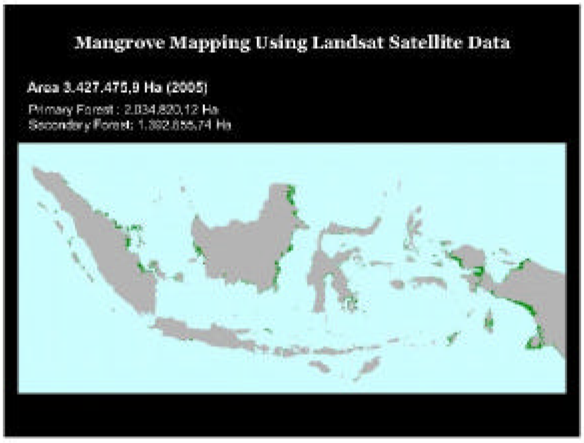
Votua Watershed Sediment Discharge Monitoring

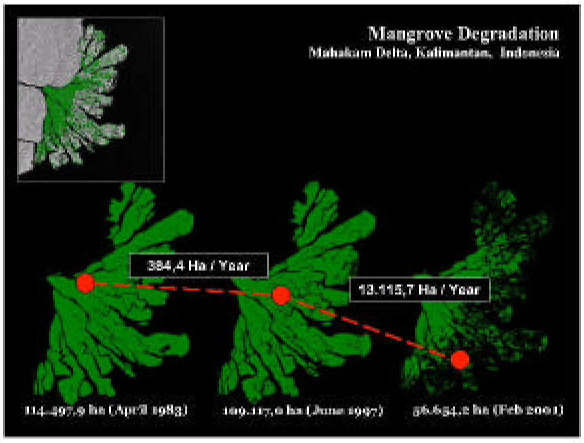


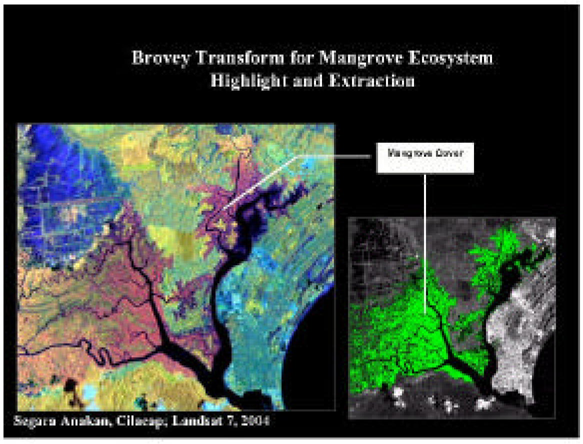


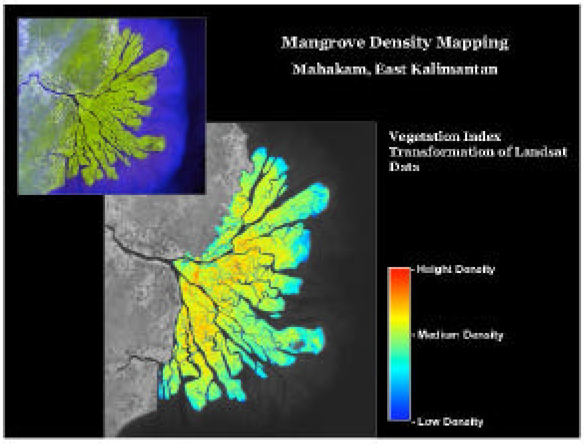
(12) Satellite Data Processing Techniques for Tropical Coastal Ecosystem Mapping and Monitoring: Overview of some selected remote sensing study in Indonesia

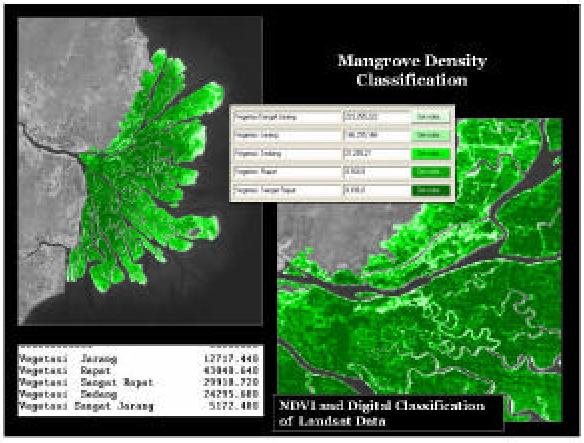


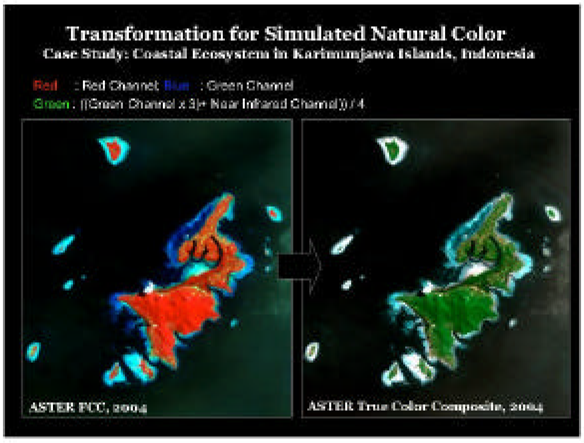


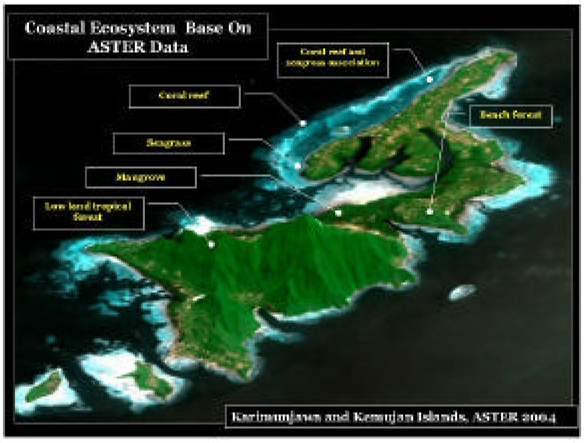


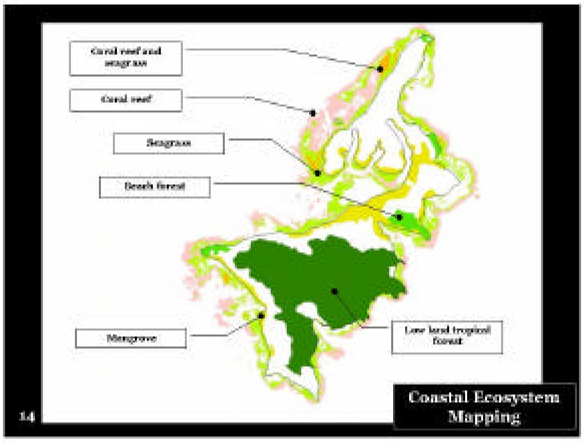


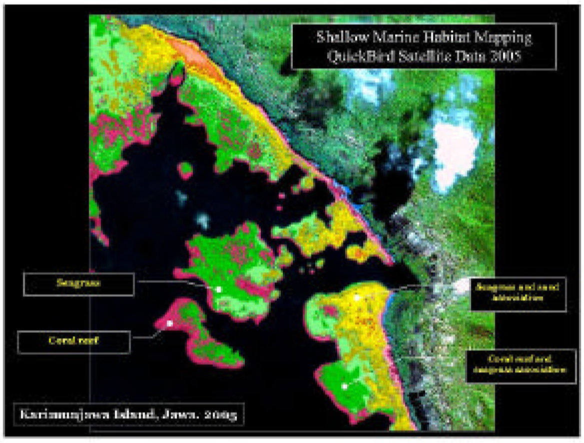

Mangrove Density Mapping
Mahakam, East Kalimantan
Vegetation Index Transformation of Landsat Data
Height Density
Medium Density
Low Density


Mangrove Density Classification
Vegetasi Jarang 12717.440
Vegetasi Rapat 43848.640
Vegetasi Sangat Rapat 29938.720
Vegetasi Sedang 24295.680
Vegetasi Sangat Jarang 5172.480
NDVI and Digital Classification of Landsat Data

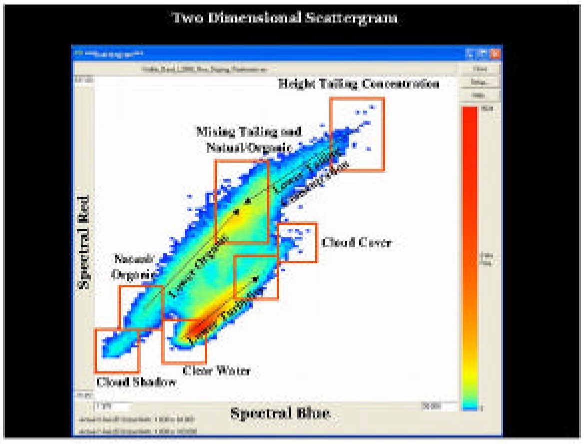

Transformation for Simulated Natural Color
Case Study: Coastal Ecosystem in Karimunjawa Islands, Indonesia
Red : Red Channel Blue : Green Channel
Green : ((Green Channel x 3)+ Near Infrared Channel)) / 4
ASTER FCC, 2004
ASTER True Color Composite, 2004

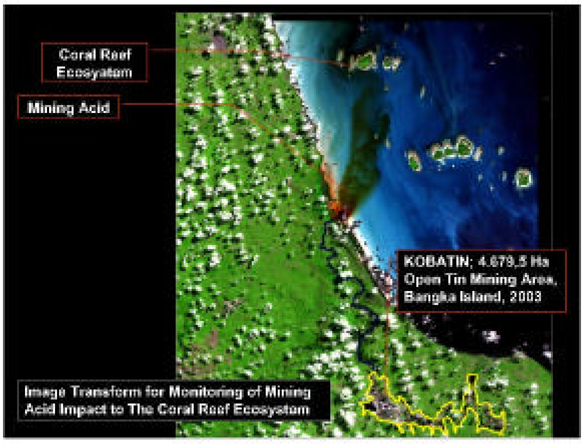

Coastal Ecosystem Base On ASTER Data
Coral reef
Seagrass
Mangrove
Low land tropical forest
Beach forest
Karimunjawa and Kemujan Islands, ASTER 2004

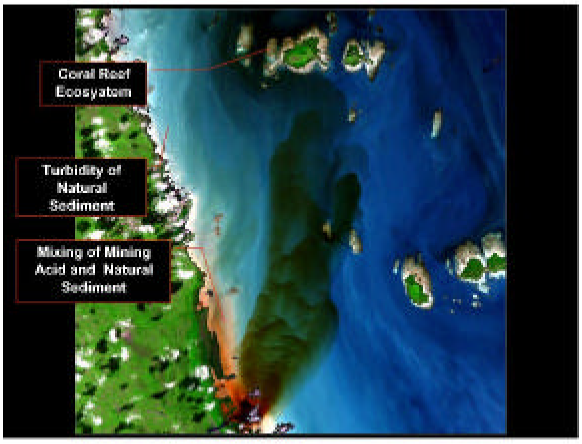

Coral reef
Seagrass
Beach forest
Mangrove
Low land tropical forest
14
Coastal Ecosystem Mapping

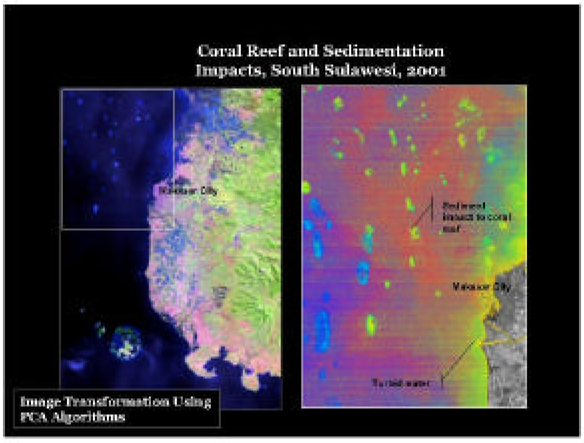

Shallow Marine Habitat Mapping
QuickBird Satellite Data 2005
Seagrass
Coral reef
Karimunjawa Island, Jawa. 2005

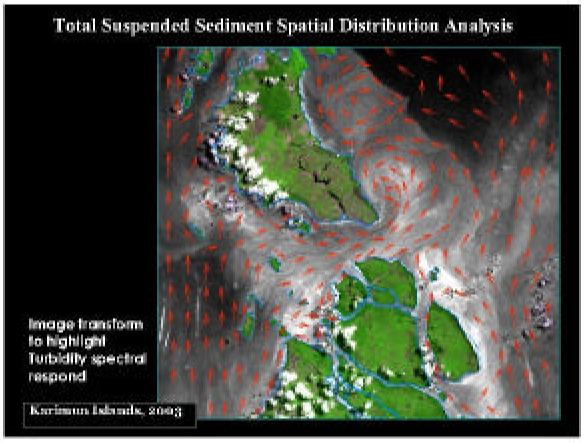

Detail Coral Reef Ecosystem Condition
Pulau Seribu, North Jakarta
SPOT5-2.5m, 2006

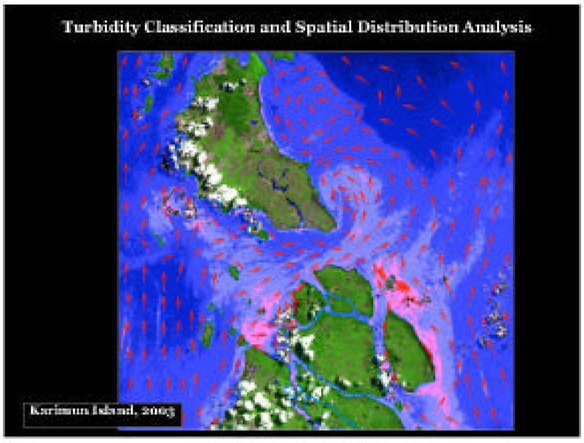

Two Dimensional Scattergram
Height Tailing Concentration
Cloud Cover
Cloud Shadow
Clear Water
Spectral Red
Spectral Blue

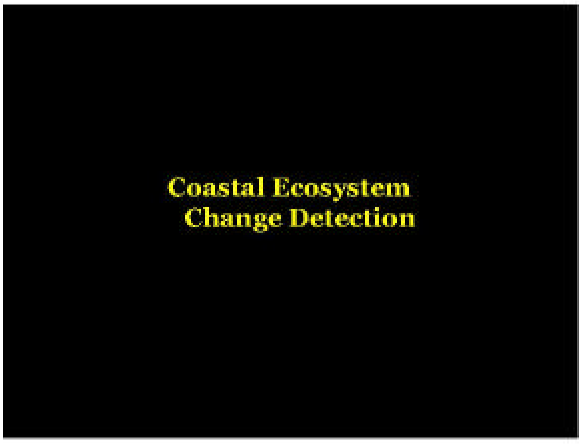

Coral Reef Ecosystem
Mining Acid
KOBATIN; 4.679,5 Ha Open Tin Mining Area, Bangka Island, 2003
Image Transform for Monitoring of Mining Acid Impact to The Coral Reef Ecosystem

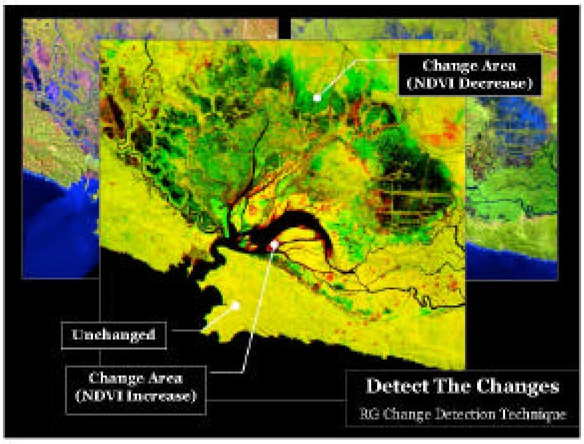

Coral Reef Ecosystem
Turbidity of Natural Sediment
Mixing of Mining Acid and Natural Sediment

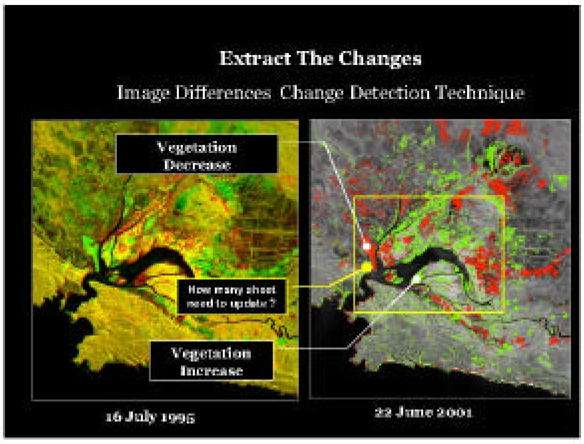

Coral Reef and Sedimentation Impacts, South Sulawesi, 2001
Image Transformation Using PCA Algorithms

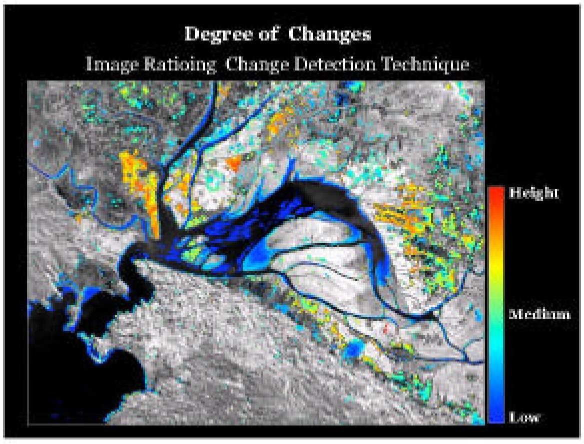

Total Suspended Sediment Spatial Distribution Analysis
Image transform to highlight Turbidity spectral respond
Karimun Islands, 2003

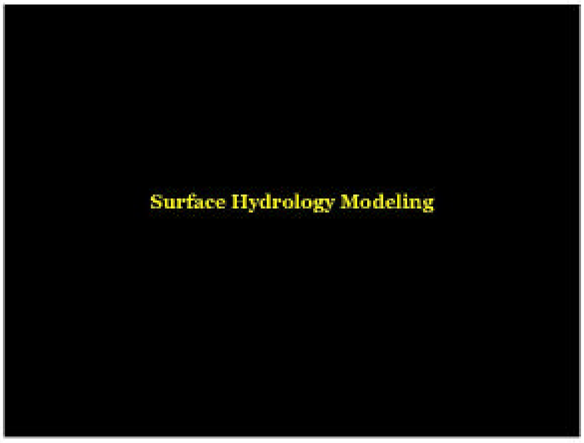

Turbidity Classification and Spatial Distribution Analysis
Karimun Island, 2003

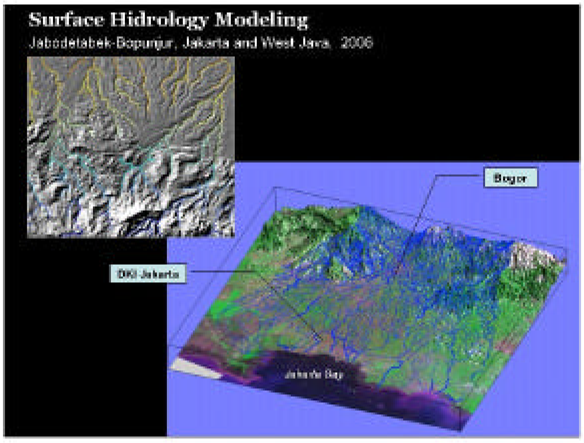

Coastal Ecosystem
Change Detection

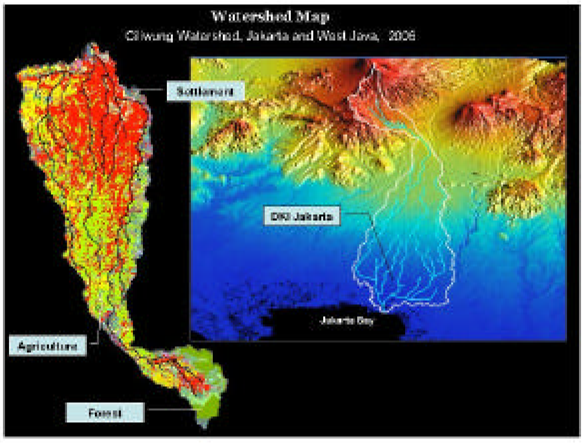

Change Area (NDVI Decrease)
Unchanged
Change Area (NDVI Increase)
Detect The Changes
RG Change Detection Technique


Extract The Changes
Image Differences Change Detection Technique
Vegetation Decrease
How many sheet need to update ?
Vegetation Increase
16 July 1995
22 June 2001

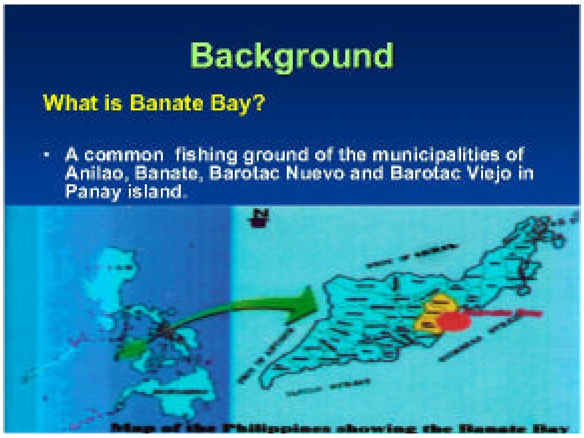


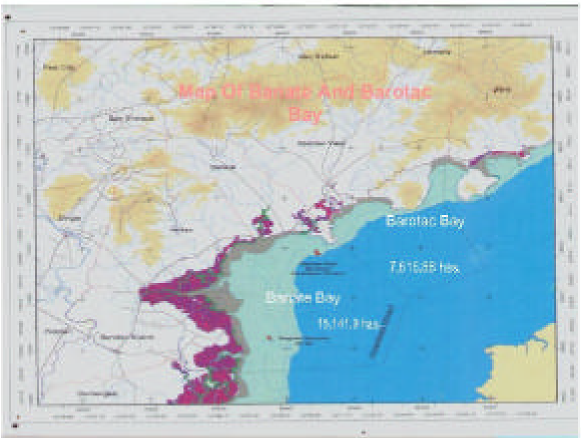






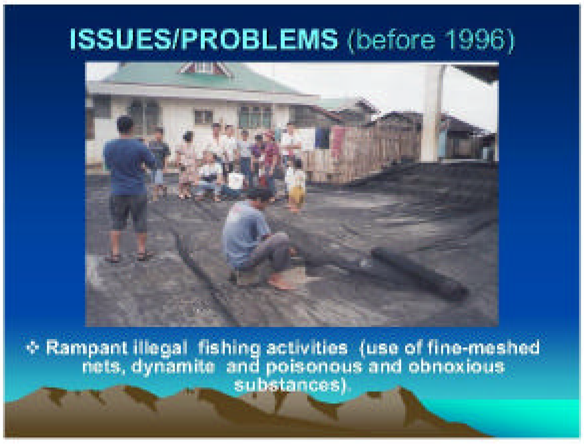
(13) Inter-Local Government Unit Partnership for the Coastal Resources Management of Banate Bay

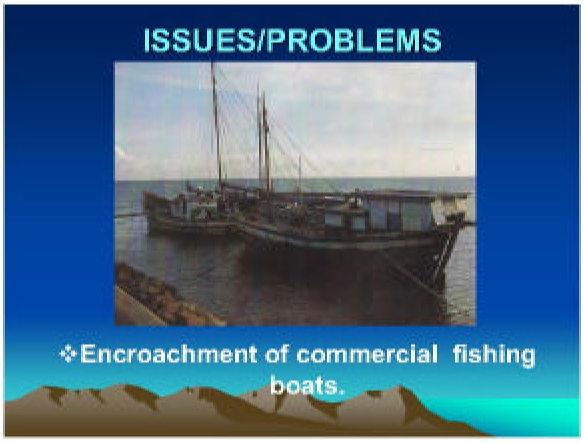




Fisheries Profile

INDICATOR	BANATE	ANILAO	BTAC. NUEVO	BTAC. VIEJO	TOTAL
Coastal Population	11,937	8,279	12,787	10,321	43,324 (33%)
Total No. of Fishermen	1,040	1,770	651	1,276	4,737 (10%)
Mangrove Cover (has)	23	16.45	94.48	17.5	151.43
Fishpond Area	420	1,180	2,061.00	342.7954	4,003
No. Of Rivers	2	2	3	2	9
Bay Area	Banate Bay = 15,141.0 ha. Barotac Bay =7,616.88 ha. (22,757.88 ha)				

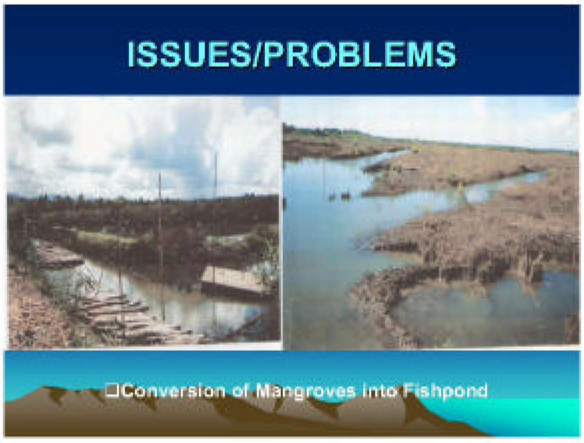

ISSUES/PROBLEMS (before 1996)
❖ Rampant illegal fishing activities (use of fine-meshed nets, dynamite and poisonous and obnoxious substances).

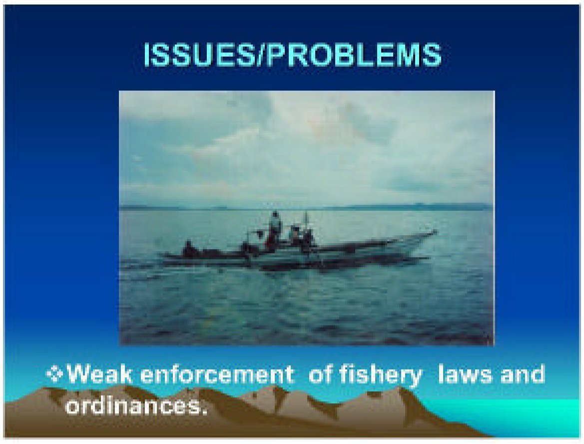

ISSUES/PROBLEMS
❖Encroachment of commercial fishing boats.

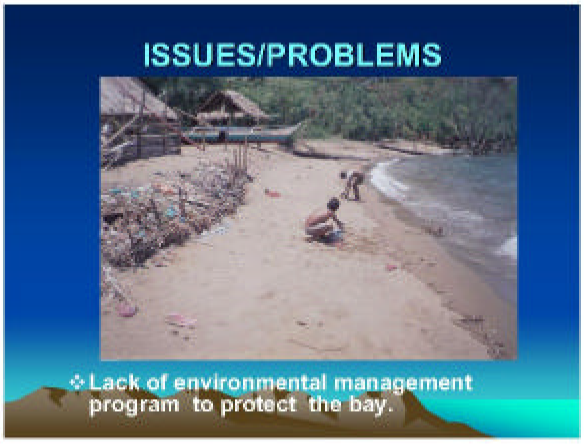

ISSUES/PROBLEMS
❖Indiscriminate gathering of marine resources (sea shells, mollusk and crustaceans).


ISSUES/PROBLEMS
❖Illegal cutting of mangrove trees resulting to heavy siltation and flood.


ISSUES/PROBLEMS
❖Illegal fishing structures in rivers.

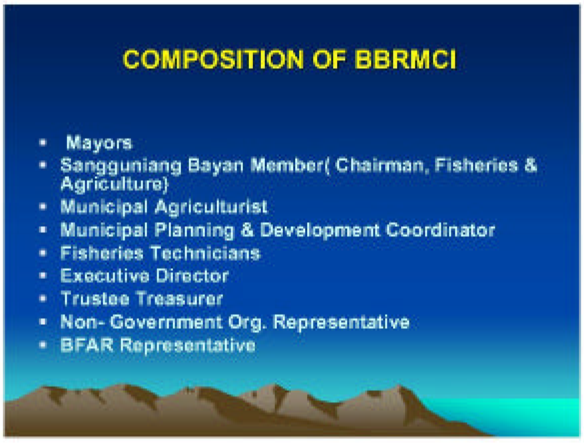

ISSUES/PROBLEMS
❑Conversion of Mangroves into Fishpond


ISSUES/PROBLEMS
❖Weak enforcement of fishery laws and ordinances.


ISSUES/PROBLEMS
❖Lack of environmental management program to protect the bay.


WHAT HAS BEEN DONE?
I. Signing of the MOA, 1996.
(Partnership Agreement among the municipalities of Anilao, Barotac Nuevo & Banate)
Legal Basis
- RA 7160
Amended, 1999.
Code of Partnership, 2002.


WHAT HAS BEEN DONE?
II. Creation of the Banate Bay resource Management Council, Inc.
(BBRMCI)


COMPOSITION OF BBRMCI
▪ Mayors
▪ Sangguniang Bayan Member(Chairman, Fisheries & Agriculture)
▪ Municipal Agriculturist
▪ Municipal Planning & Development Coordinator
▪ Fisheries Technicians
▪ Executive Director
▪ Trustee Treasurer
▪ Non- Government Org. Representative
▪ BFAR Representative


POWERS & FUNCTIONS OF BBRMCI
▪ Prepare comprehensive & integrated bay resource management plan


POWERS & FUNCTIONS OF BBRMCI
▪ Manage fishing activities
▪ Supervise implementation of all approve programs & projects
▪ Coordinate with concerned agencies
▪ Create committees

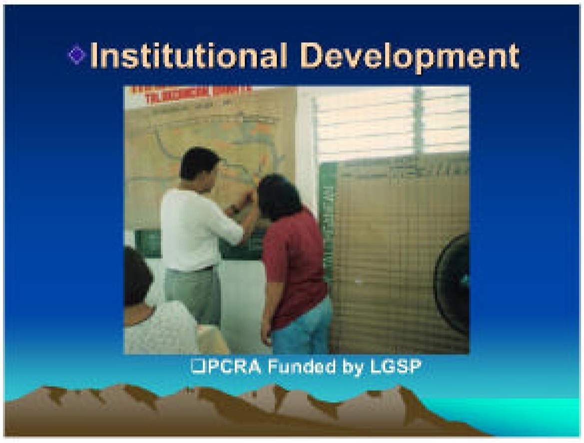

Preparation of the Comprehensive CRM Plan

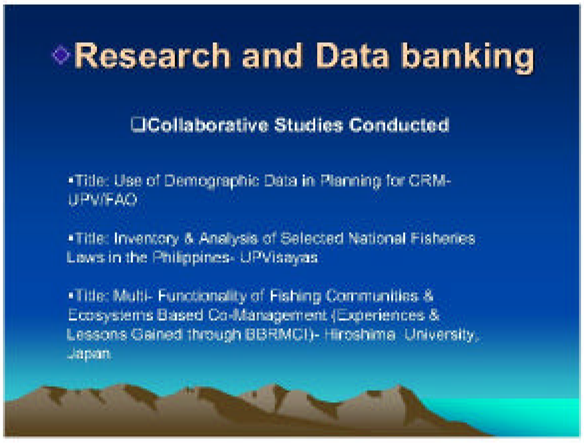

Vision of the Plan
" An ecologically balanced environment
With a self-reliant and empowered fisherfolk
Working together for the improvement of their Quality of life."

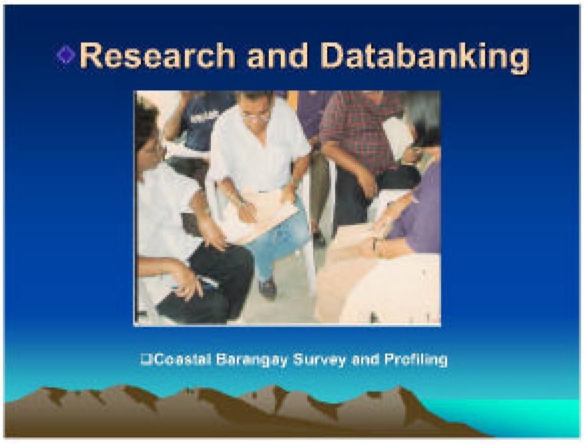

WHAT HAS BEEN DONE?
Components of the Coastal Resource Management Plan
➢ Institutional Development
➢ Research and Data banking Development
➢ Mangrove and Land Use Development
➢ Law Enforcement
➢ Livelihood Development

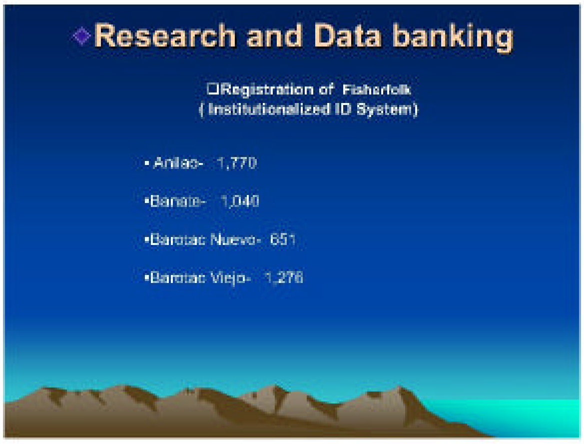

Institutional Development
Organized and strengthened People's Organization


Institutional Development
PCRA Training


Institutional Development
PCRA Funded by LGSP

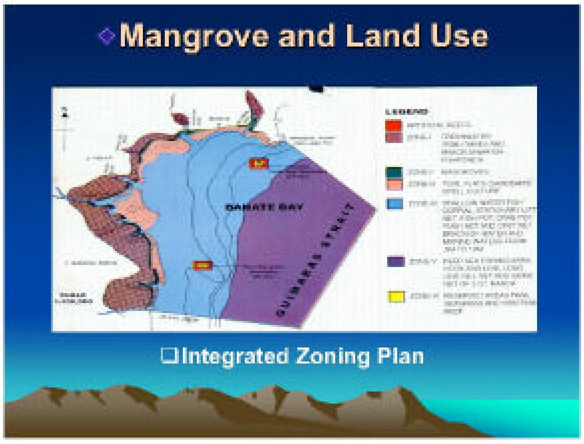

Research and Data banking
Collaborative Studies Conducted
•Title: Use of Demographic Data in Planning for CRM-UPV/FAO
•Title: Inventory & Analysis of Selected National Fisheries Laws in the Philippines- UPVisayas
•Title: Multi- Functionality of Fishing Communities & Ecosystems Based Co-Management (Experiences & Lessons Gained through BBRMCI)- Hiroshima University, Japan


Research and Databanking
Coastal Barangay Survey and Profiling


Research and Data banking
Registration of Fisherfolk
(Institutionalized ID System)
•Anilao- 1,770
•Banate- 1,040
•Barotac Nuevo- 651
•Barotac Viejo- 1,276


Research and Databanking
Project Monitoring


Research and Data banking
Water Quality Monitoring and Classification-2001 (Class B) by DENR
Red tide Monitoring - yearly


Mangrove and Land Use
LEGEND
BANATE BAY
GUIMARAS STRAIT
❑Integrated Zoning Plan

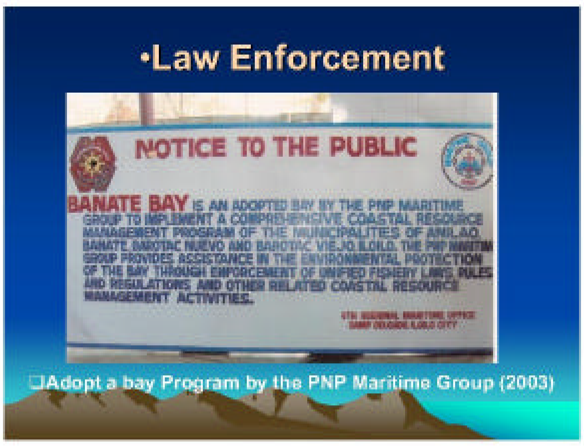

Mangrove and Land Use
BANATE BAY
ZONING PLAN
❑Coastal Mapping
❑Banate Bay Zoning Plan

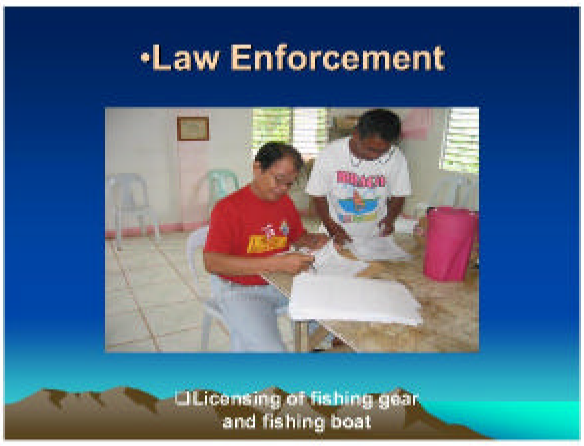

Mangrove and Land Use
❑Mangrove Planting
❑Coastal Clean-up

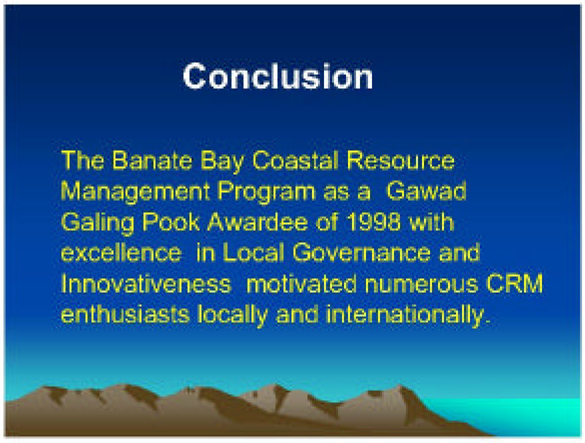

Mangrove and Land Use
❑Mangrove Nursery Development


LAW ENFORCEMENT
❑Patrol and Surveillance

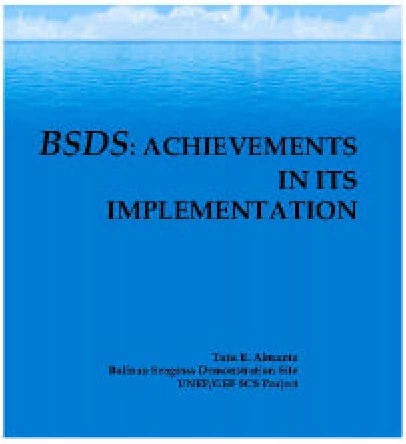

LAW ENFORCEMENT
❑ Harmonized Municipal Ordinance – Legal Basis RA 8550
❑Formulate Policies for the Protection of Marine Resources


•Law Enforcement
NOTICE TO THE PUBLIC
BANATE BAY IS AN ADOPTED BAY BY THE PNP MARITIME GROUP TO IMPLEMENT A COMPREHENSIVE COASTAL RESOURCE MANAGEMENT PROGRAM OF THE MUNICIPALITIES OF ANILAO, BANATE, BAROTAC NUEVO AND BAROTAC VIEJO, ILOILO. THE PNP MARITIME GROUP PROVIDES ASSISTANCE IN THE ENVIRONMENTAL PROTECTION OF THE BAY THROUGH ENFORCEMENT OF UNIFIED FISHERY LAWS, RULES AND REGULATIONS AND OTHER RELATED COASTAL RESOURCE MANAGEMENT ACTIVITIES.
❑Adopt a bay Program by the PNP Maritime Group (2003)


•Law Enforcement
❑Licensing of fishing gear and fishing boat



(14) Best Practices in MPA Management: Case study of the BSDS in Bolinao, Pangasinan

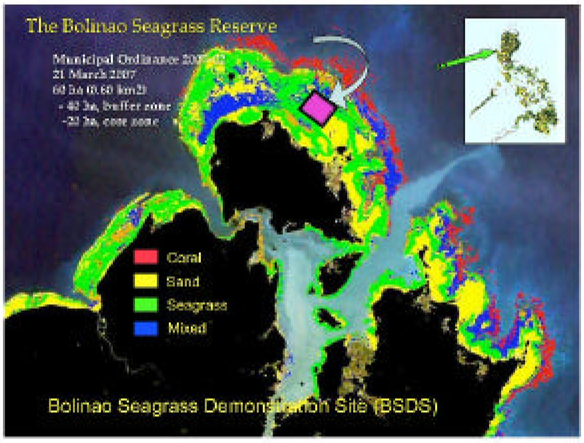


2. Objectives & Activities

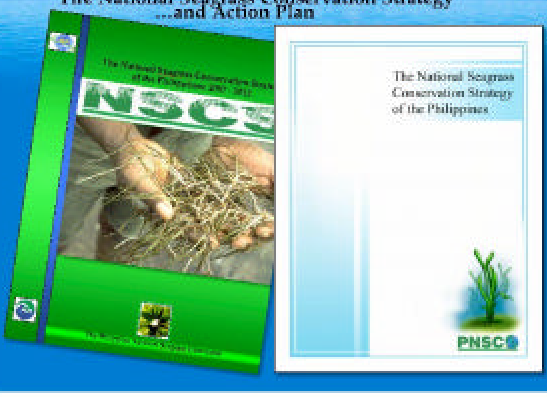
Objective 1: Development & Implementation of Management Plan Based on Comprehensive Data & Information

Activities:

1. Survey, assess, map seagrass resources; presented to MB, stakeholders;
2. Series of consultations to draft, review, endorse ordinance to
3. Establish the Bolinao Seagrass Reserve (approved 21 Mar 2007); PNSC approved (27 Apr 2007) developed Management Plan for the reserve by December 2007;
4. The Philippine National Seagrass Conservation Strategy & Action Plan published
5. Completion and adoption on actual use of Database design
6. Management Plan of Bolinao approved.



The National Seagrass Conservation Strategy ...and Action Plan



Objectives & Activities (*con't*)

Objective 2: Information and Education Campaign (IEC)

Activities:

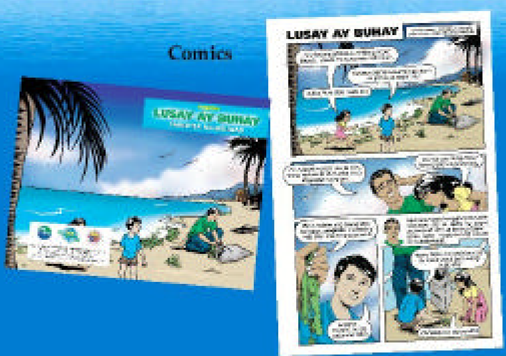
1. Project Orientation conducted among all stakeholders;
2. Validated current local seagrass knowledge = IEC program;
3. BSDS billboard installed at entrance of the municipality;
4. Brochure, posters, comics, t-shirts, pins, bags, distributed;
5. "*Tarektek*" Seagrass Festival launched at Bolinao Town Fiesta 18 Apr 07);
6. 30-sec video plug on seagrass for TV & radio being finalized;
7. BSDS incorportated in local (Marine Science) courses, presented in int'l fora (Zanzibar, Sept 2006; Kobe, Oct 2006; China 2006);
8. CD with 2,160 seagrass data & literature entries in the Phil (categorized, some with abstracts) ready for distribution;
9. 'Star-gazing' event took place (evening of 20 Apr 07) with BSDS support to highlight seagrass (*"From the grasses of the sea…to the stars in the sky"*)

Information, Education Communication (IEC)

Information, Education Communication (IEC)

Information, Education Communication (IEC)

Comics



IEC materials

T-Shirts

…& bags, pins, etc.

Information, Education Communication (IEC)

Billboard (10m x 4 m)

'Tarektek' Seagrass Festival

18 Apr 2007 Bolinao

Objectives & Activities (*con't*)

Objective 3: Capacity Building

Activities:

1. Training on seagrass taxonomy & associated marine flora & fauna conducted, including measurement of biological parameters;
2. Solid waste management training implemented;
3. A study tour of BSDS Management Board members conducted in Puerto Princesa City, Palawan;
4. *Seagrass Watch* training conducted (9-11 Apr 2007) as a seagrass assessment & monitoring methodology
5. Training on Database;
6. Training on Enforcement (Legal & Paralegal);
7. Implementation of the Bolinao Seagrass Reserve;
8. Training on proper implementation of Municipal Ordinance

Training/Workshops in...

seagrass taxonomy

solid waste management

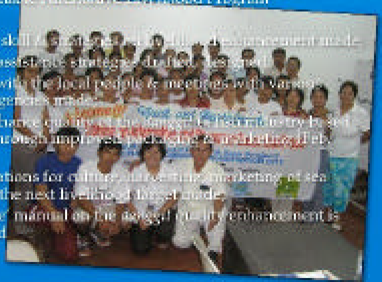
SeagrassWatch

plastic '*danggit*' wrapper

Objective 4: Sustainable Alternative Livelihood Program

Activities:

- Survey on the skill [illegible] made
- From results, assistance strategies [illegible] designed
- Consultation with the local people & meetings with various government agencies made
- Training to enhance quality of the [illegible] (based on seagrass) through improved packaging & marketing (Feb 2007);
- Initial consultations for culture, [illegible] marketing of sea cucumbers as the next livelihood target made
- A 'comics-type' manual on the danggit quality enhancement is being prepared



Stakeholder involvement

Name of stakeholder group	Roles (as in the operational plan)	Level of involvement (indicators)
1. Local Government of Bolinao	1a. Ensure the maintenance of the socio-economic and ecological values of seagrass and the equitable distribution of benefits derivable from them; 1b. Enforce all laws and ordinances relative to the governance of the municipality; 1c. Implement all approved policies, programs, project services and activities of the municipality; 1d. Protect the environment and impose appropriate penalties for acts that endanger the environment; 1e. Support the implementation of the Bolinao Seagrass Demonstration Site during the project period; 1f. Enact ordinances, approve resolutions and appropriate funds for the sustainability of the project after its completion in 2008;	1a. Very High (ordinance on seagrass reserve, MoA to support; high rate of compliance; low rate of complaints; high rate of participation in project activities) 1b. Very High (high level of understanding of the laws on the part of the populace; high rate of compliance; low rate of complaints) 1c. High (high level of understanding of the policies, services and activities on the part of the populace; high level of their visibility) 1d. Very high (high rate of compliance to relevant laws and of the rate of confiscations and reprimands) 1e. Very high (ordinance on seagrass reserve, MoA to support; high rate of participation in project activities; voluntary financial and in-

4. Stakeholder involvement (*con't*)

2. Community Environment and Natural Resources Office	2a. Initiate and formulate plans by guiding and supervising the community in the activities set forth for the management and protection of the resources; 2b. Collect information and analyze reports pertaining to the environment and resources and recommend measures to address environmental issues and concerns; 2c. Design and recommend protective measures to assure sustainability of natural resources, to promote equitable access to natural resources and conserve the environment for the future generations.	2a. High (high visibility of the plans); Low (limited community supervision on environmental protection); high (high rate of attendance in workshops) 2b. Low (low visibility of info collection and analysis and their results); High (high visibility of printed recommendations) 2c. Medium (medium visibility of the designs and recommendations)
3. Municipal Agriculture Office	3a. Develop plans and strategies on agricultural and fishery programs and implement them upon approval thereof by the Municipal Mayor; 3b. Enforce rules and regulations relating to agriculture and fisheries and exercise such powers and perform other duties and function as may be prescribed by law or ordinance.	3a. Medium (limited visibility of the plans and strategies); Low (Low visibility of implementation actions and outcomes) 3b. Medium (limited visibility of enforcement actions; High (frequent attendance in BSDS activities e.g. meetings)

Stakeholder involvement (*con't*)

4. Bureau of Fisheries and Aquatic Resources	4a. Contribute to the development and management of the fishery resources and in providing fisheries livelihood projects; 4b. Expand and strengthen existing efforts to promote various farming technologies in fisheries that are highly productive, cost effective and within the ecological limits of Bolinao; 4c. Disseminate information through intensified IEC to create public awareness and help empower the private sector to assume primary responsibility for food security and management of its own resources.	4a. High (high number of attendance in Mgmt Board meetings, other BSDS activities); medium (limited capacity to provide livelihood projects) 4b. Medium (limited visibility of actions to promote farming technologies specific for Bolinao) 4c. Medium (limited visibility of actions and tangible materials on IEC
5. Fisheries and Aquatic Resources Management Council	5a. Assist in the preparation and recommendation of management plan to be submitted to the Municipal Council for enactment; 5b. Assist in the enforcement of fishery laws, rules and regulations in the municipal waters; 5c. Perform other functions necessary for the success of the project	5a. Medium (limited participation in the plan preparation); High (substantial participation in recommending the plan) 5b. Low (low visibility of actions and tangible materials on law enforcement) 5c. Medium (limited actions and in-kind contributions, but with expressed commitment of support)

Stakeholder involvement (*con't*)

6. Bantay Dagat (Baywatch)	6a. Monitor and control illegal fishing activities to reduce damage to fish stocks, habitats and protected areas such as coral reefs and seagrass beds; 6b. Manage effective monitoring and evaluation system using patrol boats and communication; 6c. Enforce laws and municipal fisheries ordinance	6a. Medium (limited assistance except in validation of the Seagrass Reserve, attendance in taxonomy workshop) 6b. Low (Low visibility of monitoring and evaluation actions and materials) 6c. Medium (limited visibility of enforcement actions and materials)
7. Bolinao Private Organization Federation (Represented by the Bolinao Marine Environment Ecological Fund Foundation, Inc)	7a. Maintain the management of a marine protected area and mangrove reforestation project	7a. Very high (very high visibility in BSDS activities, e.g. member of mgmt board, with high attendance number in major policy-making activities)
8. Local Fishers	8a. Beneficiary of the products of researches and surveys and learning through collaborative management, management approaches, trainings and information dissemination	8a. Very high (very high visibility in practically all major BSDS activities, with actual contributions in the form of time and effort and first-hand experiences shared)

Stakeholder involvement (*con't*)

9. Marine Science Institute, University of the Philippines	9a. Shall conduct research on the flora, fauna, and coastal oceanography in the area; 9b. Shall provide laboratory and office space and expertise to the demo site project; and 9c. Shall act as the environmental watchdog especially in the northern part of the Philippines using the scientific results.	9a. Very high (very high visibility of actions and materials on the seagrass ecology and oceanography of Bolinao); High (high rate of utilization of these materials in academic instructions and research and policy formulations); 9b. Very high (very high visibility of the space, materials and expertise provided, complemented with small funds for their maintenance) 9c. High (high visibility of the actions (e.g. actual research, traineeships), and materials (e.g. publications in both English and the vernacular) indicating high degree of the expertise required)

5. Achievements

5.1. Major Outputs

1. Project orientation workshop;
2. 2 MB meetings;
3. BSDS assist in new zoning plan;
4. Ordinance for Seagrass Reserve (approved 21 March 2007);
5. MoA for partnership;
6. Field assessment of sg info;
7. Database on seagrass resources;
8. Collated info on local seagrass knowledge;
9. Management plans
10. Strategies & Action Plan
11. Publications & printing in fora
12. IEC plan & materials (30-sec video plug, 10mx4m billboard, posters, brochures);
13. 50 trainees, taxonomy;
14. 64 trainees, waste management;
15. 29 trainees in SeagrassWatch; Livelihood assistance strategy; Launching of '*Tarektek*' (Seagrass Festival) with town fiesta celebration

Achievements (*con't*)

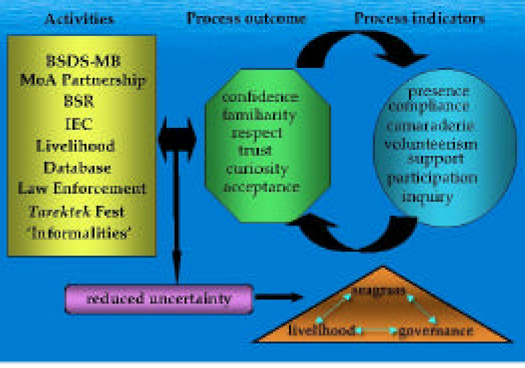
5.1:

16. Production of Livelihood Manual
17. Manual of Seagrass Monitoring adopting seagrass watch concept
18. Bolinao Seagrass Reserve Mngt Plan
19. Assessment of 13 permanent seagrass sampling by local people
20. Delineation and installation of buoys 60 hectares Bolinao seagrass Reserve

All of these activities are well documented

Achievements (*con't*)

5.2. Outcomes & impacts



Achievements (*con't*)

Although largely unquantifiable, perhaps, the greatest & most significant accomplishment of BSDS after 27 months of operation & upon which the above outcomes are founded is:

…in less than 3 years, trust & confidence, anchored on acceptance & mutual respect, was built by & among BSDS partners.

6. Good practices & lessons learned

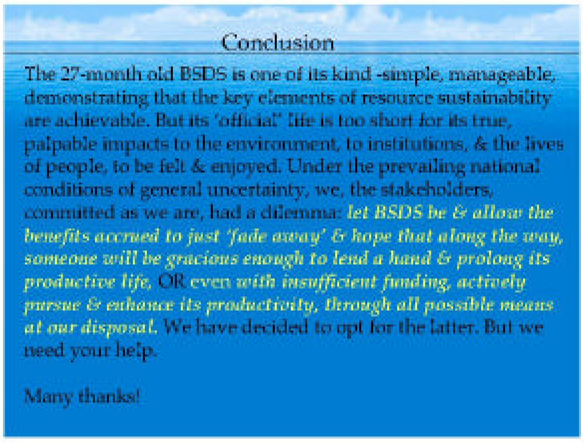
Primary considerations

1. *'Duty-of-care' as the mechanism to attain sustainability*
2. *The benefits from all these issues have to be sustained*
3. *The trust & confidence, anchored on acceptance & mutual respect, built by & among BSDS partners predicate all these practices*

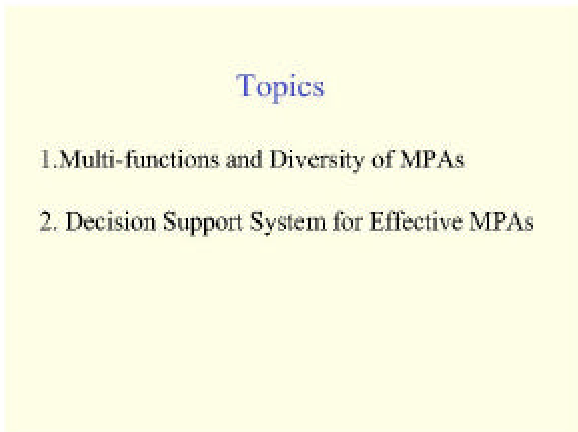
Good practices & lessons learned (*con't*)

13 Issues re Good Practices towards sustainability

1. *Capacity building & institutional strengthening*
2. *Participatory process*
3. *Consensus building*
4. *Strengthening local identities*
5. *Interdisciplinarity & intersectorality*
6. *Effective & efficient communication*
7. *Long-term benefit*
8. *Transferability*
9. *Culturally respectful*
10. *Gender &/or sensitivity issues*
11. *National legal policy*
12. *Documentation*
13. *Evaluation*

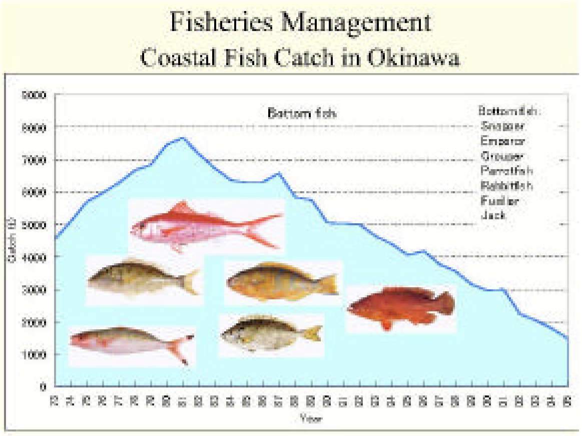


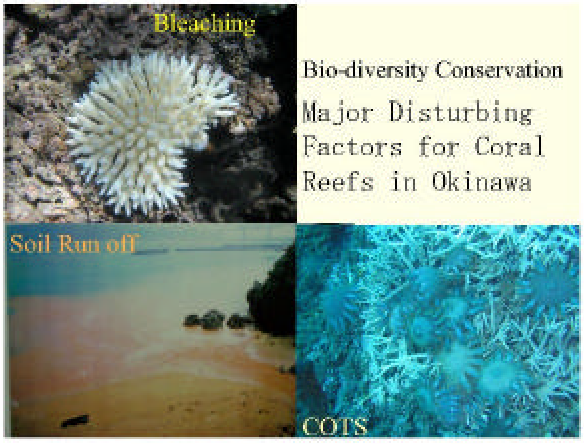
(15) Coral Reef MPAs in Okinawa and Asia-Pacific: Considerations for Designing Effective Co-managed MPAs



Multi-functions of MPAs

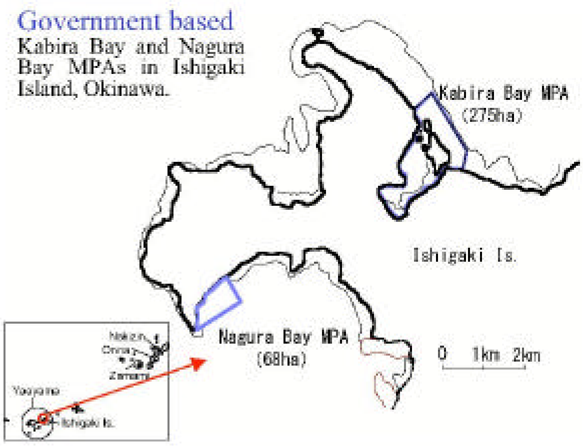
1. Fisheries Management
2. Bio-diversity Conservation
3. Tourism Promotion

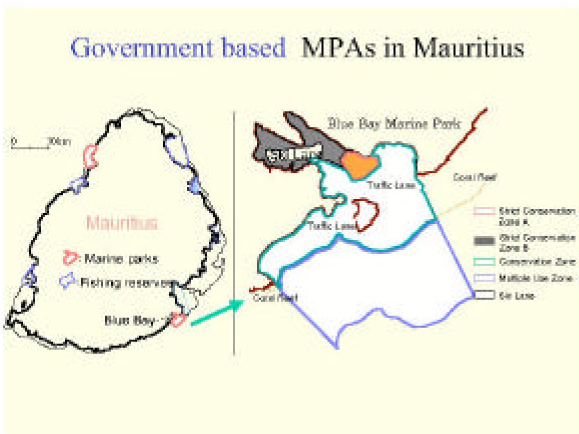


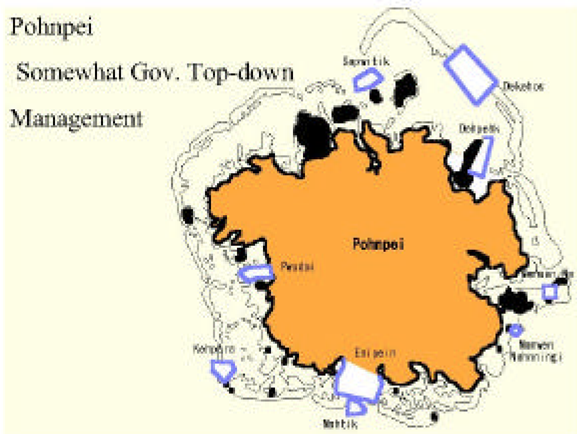


Diversity of MPAs

1. Government or Community-based
2. No-take or Buffer (Multi-use)
3. Permanent or Limited Period
4. All species or Target Species



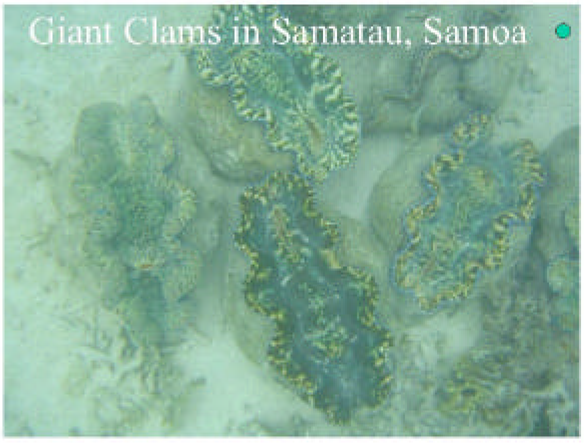


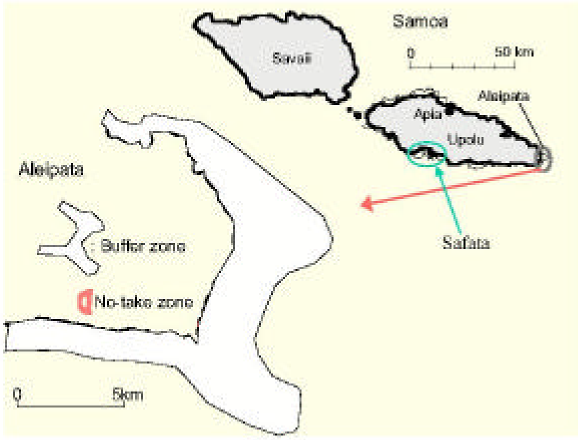


No-take or Multi-purpose use MPAs

1. Samatau: community-based MPA in Samoa.
2. Aleipata: combination of no-take and multi-use MPAs in Samoa.

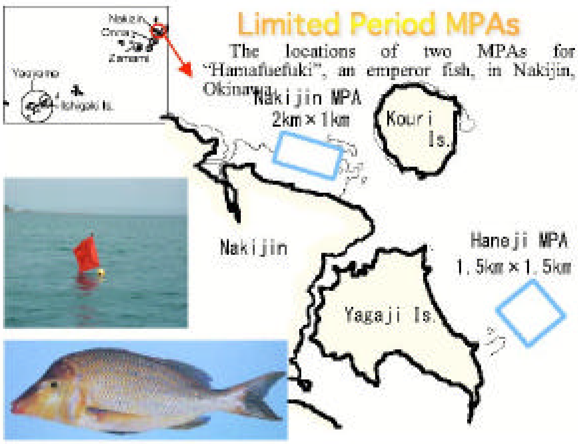
There were 60 community-based MPAs in 2005 in Samoa.

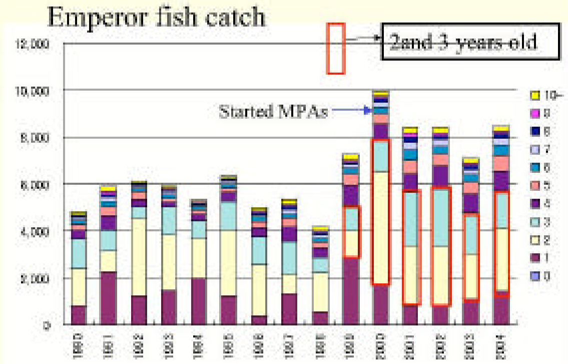




Limited Period MPAs

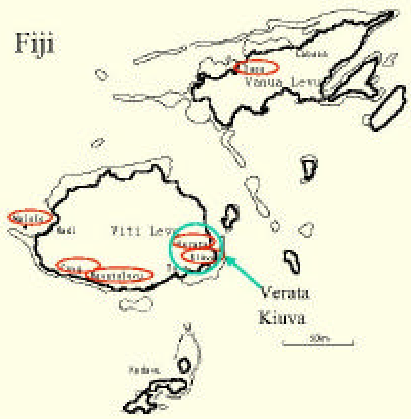
1. Yaeyama: emperor fish MPAs in Okinawa (closure of spawning season).
2. Nakijin: emperor fish MPAs in Okinawa (closure of young fish aggregation).





Limited Species MPAs

1. Verata: a bivalve MPA in Fiji.
2. Kiuva: a bech-de-mer MPA in Fiji.



Towards Effective MPA System

1. Need more co-managed MPAs

   Local government follow-up is important for sustainable MPAs
2. Asia-Pacific style (tropical vs. temperate)
3. Quantitative research on spillover effect
4. Effective boundary marks, enforcement and alternative income sources for sustainable MPAs
5. Integrated Coastal Management for land-based discharges

Decision Support System for MPA Designing

1. Who makes the decisions?
2. What needs to be decided?
3. What kinds of information are needed?
4. Who, how and what supports?

Who makes the decisions?

1. Communities
2. Local governments

What needs to be decided on MPA design?

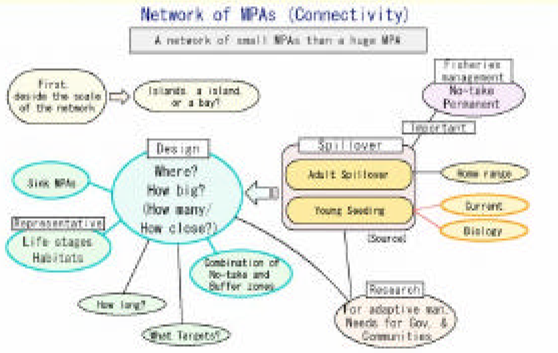
1. Where?
2. How big?

(3. How many? How close?)

4. Rules

(How long? What targets?)

Where? Needs science & community knowledge



How large the size of a MPA should be?

- The larger, the better for bio-diversity.
- Too large MPAs narrow the fishing grounds.

Area size of MPAs

1. FRMP in Philippines: 2-200ha, avg. 35ha
2. Kirivati: 18,470,000ha
3. Great Barrier Reef: 32,000,000ha
4. Northwest Hawaii Monument: 36,000,000ha

MPA: Size, Term, Aim, Base, Type no. 1

Nations	Districts, Projects	No.	Area (ha)	Term	Aim[1]	Base[2]	Types	Data source
Philippines	Fisheries Resource Managerrent Project	69	2-200 (avg. 35)		F.M.	CO	No-take	FRMP 2000
	Banate Fish Reserve	1	25	No limit	F.M.	CO	Fish	Interview etc.[3]
	Banate Shellfish Reserve	1	25	No limit	F.M.	CO	Shellfish	Interview etc.
	Surigao (Mangrove areas)	3	13.7-55.3				No-take	Interview etc.
	Surigao (Coral reefs)	3	10-15.4				No-take	Interview etc.
	Cadiz	1	4,822	No limit	F.M.	GB	Buffer[4]	Interview etc.
	Sagay Protected Seascape	1	32,000	No limit	B.D.	GB	Buffer	Sagay City nd
	Sagay Marine Reserves	3	2,000	No limit		GB	No-take	Interview etc.
Indonesia	Spermonde Islands	6	4-6	No limit	F.M.		No-take	Interview etc.
Fiji	Barata	1	24	No limit	F.M.	CO	A bivalve	Tawake et al. 2001
	Navutulevu	1	About 100	5 years	E.T.	CB	No-take	Interview etc.
	Cuvu	1	About 170	No limit	E.T.	CB	No-take	Interview etc.
	Malolo Island	1	>1,000	3 years	F.M.	CB	No-take	Interview etc.
	FLMMA	75	10-20% of coastal area					Interview etc.
Samoa	Aleipata	1	6,668	No limit	B.D.	GB	Buffer	Interview etc.
	Safata	1	6,438	No limit	B.D.	GB	Buffer	Interview etc.
	Near-shore Villages	38	0.5-17.5		F.M.	CB	No-take	King & Faasili 1999

MPA: Size, Term, Aim, Base, Type no. 2

Nations	Districts, Projects	No.	Area (ha)	Term	Aim[1]	Base[2]	Types	Data source
FSM	Pohnpei	5	39-795 (avg. 259)	No limit		GB	No-take	Interview etc.
Mauritius	Blue Bay Marine Park	1	353	No limit	B.D.	GB	Buffer	Interview etc.
	Balaclava Marine Park	1	485	No limit	B.D.	GB	Buffer	Interview etc.
	Fishing Reserves	8	282-2942	No limit	F.M.	GB	Buffer	Interview etc.
Okinawa	Yaeyama	4	1600[5]	APR-MAY	F.M.	CO	No-take	Interview etc.
	Hanaji, Nakijin	2	425	AUG-NOV	F.M.	CO	No-take	Interview etc.
	Kabira Higashiuinan	1	275	No limit	F.M.	GB	Shellfish &	OPG[6] 804
	Nagura Higashiuinan	1	68	No limit	F.M.	GB	No-take	OPG 804
Kiribati	Surrounding Areas	1	18,470,000	No limit	B.D.	GB	Buffer	Interview etc.
Australia	Great Barrier Reef	1	34,440,000	No limit	B.D.	GB	Buffer	Davis 2006
Hawaii	Northwestern Monument	1	36,000,000	No limit	B.D.	GB	Buffer	Davis 2006

1: Main aim: F.M.: Fisheries Management, B.D.: Bio-Diversity, E.T.: Eco-Tourism

2: Main management body: CO: Co-management, GB: Government-Based, CB: Community-Based

3: Interview etc. include unpublished documents obtained in the study sites.

4: Buffer includes multipul use zones etc.

5: This is a planed area. Actual area was smaller than this figure.

6: Okinawa Prefectural Government

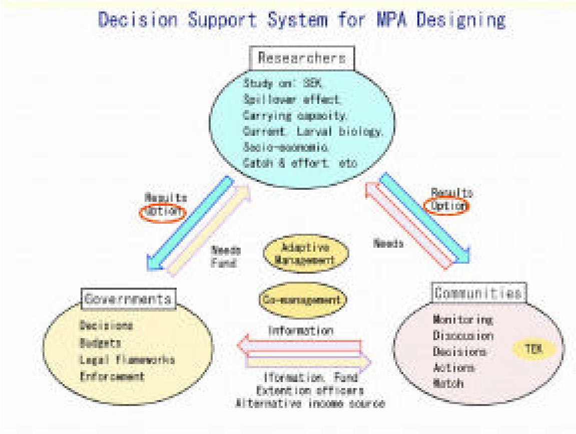
Blank spaces mean that data were not obtained or difficult to classify.

What kinds of information are needed?

1. Scientific Ecological Knowledge (SEK) + Traditional Ecological Knowledge (TEK)
2. Existing information
3. Information for networking (current & larval biology)
4. Socio-economic information
5. Fisheries data (catch, effort, methods, number of fishermen)
6. Carrying capacity for eco-tourism

Who, how and what supports?

1. Extension officers
2. Co-management among communities, local government and researchers
3. Adaptive management
4. Networks of people & information
5. Learning system


Decision Support System for MPA Designing
Researchers
Study on: SEK,
Spillover effect,
Carrying capacity,
Current, Larval biology,
Socio-economic,
Catch & effort, etc
Results
Option
Needs
Fund
Adaptive
Management
Results
Option
Needs
Co-management
Governments
Decisions
Budgets
Legal flameworks
Enforcement
Information
Iformation, Fund
Extention officers
Alternative income source
Communities
Monitoring
Discussion
Decisions
Actions
Watch
TEK

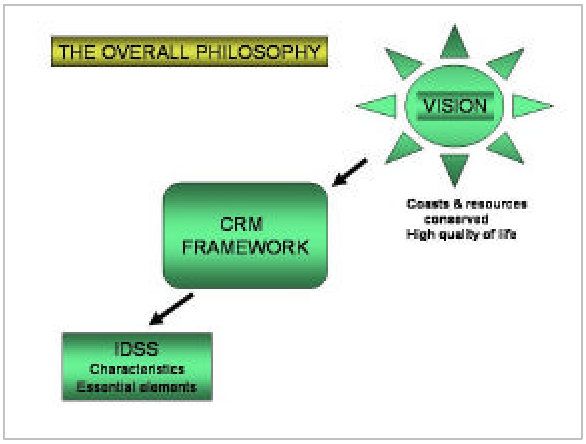

Thank you

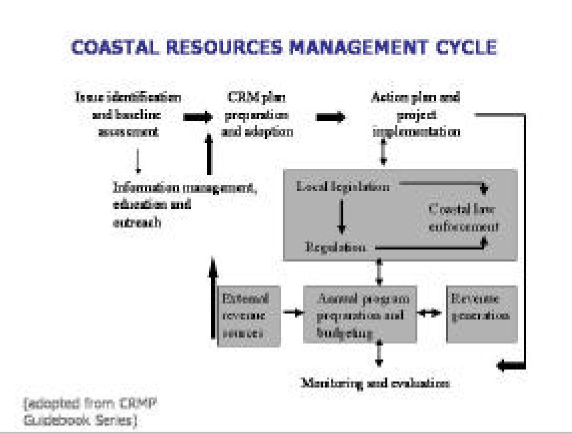
A.4 Group Discussion and Presentation

Presentation of the Managers Group

FROM A

MANAGER'S PERSPECTIVE



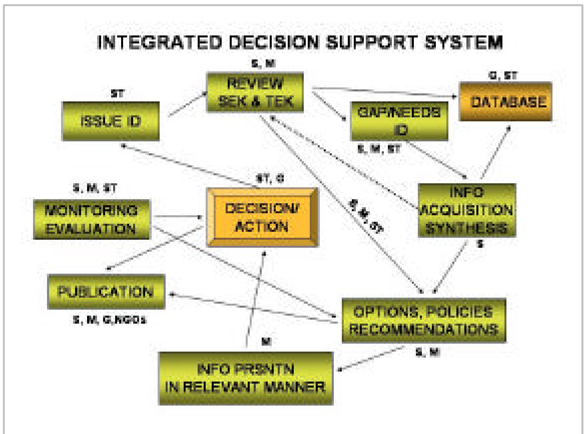


INTEGRATED DECISION SUPPORT SYSTEM

1.2 Characteristic of DSS
1. Cost effective
2. Top/bottom questions can be accommodated
3. Issue based-user driven
4. Sustainable/realistic
5. Consistency driven
6. Dynamic/adaptive
7. Holistic/Integrated
8. Collaborative effort
9. Knowledge based (TEK,SEK)
10. Accessible
11. Gender sensitive/culture
12. Participatory approach
13. Proactive
14. Long term, programmatic

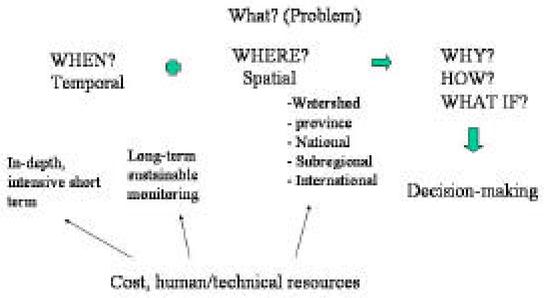
1.1 Essential Components
1. Transfer of outputs to decision makers + stakeholder
2. Stakeholder involvement + empowerment
3. Resource mapping/profiling (exist data, new data need) Database development, SEK/TEK
4. Human capacity
5. Trust-SC, Social acceptability
6. Capital (external/sources funding)
7. Equipment, infrastructure, institutions
8. Documenting process
9. Monitoring, evaluation
10. Assessment
11. Communication platform/network
12. Capacity building
13. Feed back

1. Ecology of target species Scientist
2. Identification of priority areas Scientist
3. Identification of threats to resources Scientist
4. State of resources/environmental conditions/ Scientist
5. Socio-economic condition, site Scientist
6. Existing legal framework Manager
7. Interests&needs of stakeholder/resource owners Manager
8. Tools capacity/process available for decision making Scientist
9. Stakeholder level involvement Manager
10. Environmental standard Scientist
11. Risk and assessment to process Scientist
12. Option and scenario outcome/.trade offs Scientist
13. Mitigation measures Scientist
14. Relevant background information/lesson learned from previous/similar situations Scientist
15. Cost/benefits/sustainability of benefit/ Scientist



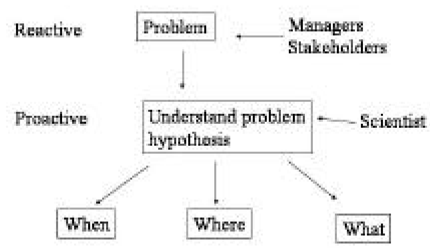
Presentation of the Scientists Group

Essential elements in developing the DSS



Role of Scientist:
Educating managers/stakeholders?
-May result to sustained funding through understanding value by managers
Pro-active (forecast) or reactive (response based on the level of knowledge)?
-Depends on country, manager, presence of stakeholder organizations
-Depends on problem (scale, seriousness, economics)

Outputs
- Document on what experiments are needed (when monitoring needed)
- Understand minimum data needs for managers



Cases

- Network of MPA's
- Nutrification (Cause & effect)
- Sedimentation (Cause and effect)
- Non-sustainable resource use
  - Tourism Over-development

Network of MPAs

- Background case in Fiji – 1 island chain, 50 MPAs
- DSS: where MPAs should be placed based on suitability, sustainability, replicability, etc.
- Management needs to decide on the location of these MPAs:
  - What information needed?
  - How does their reef interact with others?
    - Current patterns (reef, offshore) and meteorological
    - Bathymetry
    - How do larvae disperse? Life history?
    - Ecological condition

- Information on larval life history (e.g. corals, COTS) as related to reef connectivity is scarce/limited.
- Adaptive management in Fijian case was brought up.

Physical Aspect/Characteristic/Factors	Currents	Backreef Tidal & ocean currents Wind-induced currents Density currents
	Bathymetry Waves/wind River discharge Solar radiation Lunar phase	
	Temperature Salinity	
Biological Factors	Spawning period Mechanism (spawner or brooder) Swimming capability Retention time Grazing pressure Habitat condition (both for sink and source areas)	

■ Managers request info from scientists. Scientists evaluate given resources and time, what data can be covered.
■ Suspicion and doubt exist between managers exist (especially in South Pacific Islands)
■ Bolinao case: decision based on a lot of factors, science just a small part.
■ In Fiji, collaboration can be through locally trusted scientist.
■ Communication of scientific findings must be made at the level "understandable" for the managers and stakeholders.
■ Culture and language are important. Interpreter may be preferred to present scientific results.

Modes of cooperation

- Involvement
- Collaboration
- Presentation/communication

Case 2: Sedimentation and Nutrification

Manager needs
- Causes?
- Effects?
- Level of problem
- Mitigation steps?
- Prevention/regulation

Scientists provide
- Level of sediment/nutrient discharge
  - "natural level"
  - Short-term (high discharge events)
  - Long-term trend
- Anthropogenic (socio-cultural)
- Identification of source areas
- Cause and effect relationship (multiple processes and levels)
  - → Predictive models
  - → Recommendation based on scenarios
- Natural response patterns (reef ecology response → carrying capacity)
- Options/solution alternatives/management measures

Case 2: Sedimentation and Nutrification

Mitigation approaches…

→ Control on sources (e.g. mulching, improved waste management)

→ Control on process (e.g. retention ponds)

Case 3: Tourism over-development

What do managers know?

Natural/Environmental
- Direct impacts
- Pollution
- Water quality
- Degraded environment
  - Sedimentation, disruption of natural cycles
- Over use of natural resources
- Natural hazard vulnerability

Socio-economic
- Cultural
- Concept of carrying capacity
- Money matters
- Infrastructure development (hard engineering)
- Curio trade

Governance
- Awareness campaigns
- Planning development
- Enforcement of laws
- Government regulations

Another way to look at these…

Causes
- Direct impact
- Over use/inappropriate of resources
- Infrastructure development
- Money matters/Business

Effects
- Trade
- Pollution
- Water quality
- Degraded environment

Mitigations
- Concept of carrying capacity
- Government regulation and enforcement

What scientist can provide

- Past and present
  - Land use
  - Water quality
- Cause and effect
- Predict future 'scenario' ⇨ Integration of:
  - Data
  - Model
- Mitigation + recommendations
- Predicted trends

Keywords & Themes

- DSS Scheme
  - Past and present
  - Cause & effect
  - Predict scenarios
  - Mitigation measures, evaluation of measures
  - Recommendations
- Problem-based
- User-driven (Appropriate users and resources)
- Inclusive of users in development phase
- Identify users (output; process)
- Training/Awareness/Capacity building
  - What can DSS do for you? (Case studies and demonstrations)
- Support for DSS use
- Commitment by scientists (financial, human resources)
- Resource appropriate
- Adaptive development
- Transferability (Spatially, temporally)
- Socializing
  - Provision of appropriate mechanisms (Scientist ←→ Users)

Short Transcript of Group Discussion

I. Discussion

Managers

- (Ms. Tutu Almonte) Scientists shouldn't really EDUCATE managers but coach us instead. Sometimes we are unfamiliar with technical terms. That is why we need you to coach us.
- (Ms. Mary Larroza) Scientists should be humble enough and open-minded.
- (Ms. Tutu Almonte) You should lower down your rates in terms of consultancy.
- (Dr. Victor Bonito) It is important to have a common goal in the end, something more general like improving the quality of life so that trust can be built among partners.

Scientists

- (Doc fortes) Partnerships between both groups (managers and scientists) are really needed.
- (Dr. James Comley) to have a vision (for the site) is the responsibility of the manager. Managers and scientists don't necessarily have to have the SAME vision. Scientists can have their own vision which by pursuing that vision they in turn help managers realize their vision for their community.
- (Dr. Rubio) Sometimes we tap scientists (outside the community) so their objectives may not be in sync with the community and they may not be involved in the actual decision-making of the community.
- (Dr. James Comley) Most of the DSS that we are talking about is reactive. If we do a DSS that is aimed at helping the community then that one is a PROACTIVE. Both are completely different from each other in not exactly the way they are structured but more of how they are communicated to the community.
- (Dr. Comley) Reactive DSS is problem-based.
- (Prof. Nadaoka) At first, we may be motivated by reactive DSS but later on we should engage in a PROACTIVE DSS.
- (Dr. Comley) Proactive DSS means problem prevention while reactive DSS is more of a panic mode for a certain problem, for example fish kills. It is critically important that managers know what a DSS is and how they can utilize it.
- (Dr. Paringit) In the end, DSS might turn out to be just a fortune teller. That is the worst case scenario.
- (Prof. Fortes) Next step is for someone to integrate what we have talked about and package it so that it can be useful for the next workshop.
- (Dr. Dan Ling Tang) I think we need a simple chart of simple input and output.
- (Prof. Fortes) there should be a core group of participants who would draft a document that can help the participants of the next workshop.

II. Closing Remarks (Prof. Nadaoka)

- Managers can educate us scientists. You have to educate us on what is actually happening in your site. I think it is important on how to come up collectively with such a system.

A.5 Photos of the 1st Regional Workshop

The Workshop Participants

The workshop was attended by a total of 24 participants from Japan, China, Fiji Islands, Indonesia, Malaysia, Thailand, Vietnam and the Philippines.

Prof. Nadaoka, APN Project Leader, welcomes the participants and delivers the keynote address

Prof. Fortes, APN Project Collaborator and workshop organizer, briefs the participants about the workshop

Participants share their experience…


Participants brainstorm during the workshop proper
The Management Group
The Science Group

APPENDIX B

A Regional Training Course/Workshop

Asia-Pacific Regional Training Course / Workshop on the Utilization of an Integrated Decision Support System in Managing Tropical Coasts

Puerto Galera Biosphere Reserve, Philippines, 26-30 May 2008

Appendix B.1 Programme and List of Participants

A Regional Training Course / Workshop

Asia-Pacific Regional Training Course / Workshop on the Utilization of an Integrated Decision Support System in Managing Tropical Coasts
Puerto Galera Biosphere Reserve, Philippines, 26-30 May 2008

Background

On 24-25 January 2008, a group of experts in Asia-Pacific met in a workshop in Manila (Philippines) to develop an integrated decision support system to manage changes in tropical coastal ecosystems. The workshop aimed: (1) to synthesize the results of various research work conducted in Asia-Pacific countries and come up with an integrated model of tropical coastal environments; (2) to formulate a decision support system, within the framework of research collaboration and community participation, for studying such environments and for proposing solution alternatives to address coastal environmental problems; and (3) to solicit the participation of a group of coastal scientists in the region to exchange data and experiences in developing local DSS in order to improve their proficiency in evaluating coastal environmental changes. The outcome of the workshop was an initial DSS integrating numerical modeling, remote sensing and geographic information systems, while considering socio-economic drivers of change. The system is an integral part of a framework for Integrated Coastal Resources Management. Derived from case studies, the highlights include an elucidation of:

1. The essential elements in developing a DSS (e.g. transfer of outputs to decision makers + stakeholders, stakeholder involvement and empowerment, resource mapping/profiling, database development, SEK/TEK, human capacity, social acceptability, capital, infrastructure, institutions, documentation, assessment, monitoring and evaluation, communication platform/network, capacity building, feed back)
2. The characteristics of a DSS (e.g. cost effective, top and bottom questions can be accommodated, issue based, user driven, sustainable, realistic, dynamic, adaptive, holistic/integrated, knowledge-based (TEK and SEK), accessible, gender/culture sensitive, participatory, proactive, long term, programmatic)
3. Inputs from scientists and coastal managers
4. Outputs (e.g. document on what experiments are needed, understanding of the minimum data needs for scientists and managers)

Objectives

An advancement and essential follow up of the workshop in January 2008, the present workshop aims:

1. To demonstrate the kinds of data and information required in developing a DSS;

2. To test the utility and reliability of the 'developed' DSS;

3. To train coastal area management practitioners in the development and use of the DSS;

4. To facilitate exchanges of useful and relevant experiences among the participants aimed towards a sustained scheme of regional collaboration

Focus
The workshop will focus on an actual case of a developmental problem in Puerto Galera Biosphere Reserve –***coastal tourism***. Thus, the participants will be exposed and be given on-site guidance on different aspects (e.g. physical, biogeochemical, socio-economic) of the coastal environment and in putting these pieces together within the framework of the DSS and ICRM. This is to improve their understanding of the complexities brought about by tourism in a coastal environment and how the issues can be resolved or at least mitigated using a locally based integrated decision support system.

Participants and Resource Persons

Participants are mid-level decision makers from countries in East and Southeast Asia and the South Pacific regions. They are expected to have working knowledge in either the physical or natural sciences or on policy, planning and community resource management. The Resource Persons will be mostly the collaborators of the Asia-Pacific Network for Climate Change Research Project spearheaded by the Tokyo Institute of Technology in Tokyo, Japan. They include the following:

FIJI (1)

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ngaind@yahoo.com <mailto:ngaind@yahoo.com>

PROGRAM OF ACTIVITIES

[All sessions will be in plenary, to take place at the Conference Hall of the Apartelle; Coffee/Tea/Juice and light snacks will be available at the back of hall while in session]

Day 1 (May 25, Sun): Arrivals at Manila Airport; stay at Quezon City (Fersal Inn Kalayaan)

Day 2 (May 26 (Mon):

0530: Leave Fersal Inn for Puerto Galera (three minivans)
0800: Arrival in Batangas City Pier; coffee
0830: Leave Batangas City Pier (on board the Ferry, "Commandos")
1000: Arrival in White Beach, Puerto Galera
1030: 'Brunch' (breakfast-lunch) for non-Puerto Galerans only
1130: Organizational activities
1330-1400: Registration (Conference Hall, 4th Fl. of Apartelle)
1400-1500: Opening Ceremony
1400-1405: Introductions (Ms. Genevieve Regino, EMCEE)
1405-1415: Welcome Remarks by the Honorable Mayor Dr. Hubbert Christopher A. Dolor
1415-1425: Welcome Remarks by Professor K. Nadaoka
1425-1435: Training Course Overview (Dr. Miguel D. Fortes)
1435-1500: Pictorials

1500-1800: Short trips to Sabang Cove, Small and Big Lalaguna Muelle Bay & Puerto Galera Bay, Bayanan, White Beach
1800-1845: Organizational activities
1900-2030: Dinner at Apartelle Francesca (for non-Pto. Galerans only)

2030-2130: Short exposure to the nightlife in White Beach

Day 3 (May 27, Tue)

Plenary Presentations

0900-0925: *"Coastal Research Initiatives of the Tokyo Institute of Technology in Asia-Pacific: Providing A Sound Basis for Ecosystem Conservation and Tourism Development"* (Professor Kazuo Nadaoka, Coordinator/Project Leader, APN Project)
0925-0950: *"Priority Coastal Environmental Tourism Issues in Puerto Galera: Where and How Science Can Help"* (Mr. Carmelo Garcia, President, TOSCA)
0950-1015: *"Coastal Tourism in Puerto Galera Biosphere Reserve: Cutting the Hands That Feed"* (Dr. Miguel D. Fortes, UNESCO-MAB-Philippines Focal Point)
1015-1040: *"Designing Effective MPAs: A Tool in Sound Coastal Fisheries and Tourism Development"* (Dr. Shinichiro Kakuma, Agriculture and Fisheries Development, Yaeyama Office Okinawa Prefectural Government)
1040-1105: *"Coastal Tourism in Fiji: How Applied Science Helps"* (Dr. James Comley, Institute for Applied Science, USP, Fiji)

Focused Discussion and Sharing 1

1105-1200: Open focused discussion on priority coastal tourism issues in Puerto Galera and elsewhere where marine science is needed for their resolution **(All participants are encouraged to share their related experiences)** (Dr. James Comley, Moderator)

1200-1330: LUNCH TO BE PROVIDED TO EVERYBODY

Demonstrations on Coastal Ecosystem Monitoring and Computer Simulations

1330-1350: *"Modeling Sediment and Nutrient Discharge from Todoroki Watershed (Ishigaki Island, Okinawa)"* (Mr. Ariel C. Blanco, TiTECH)
1350-1410: *"Field Observations and Numerical Simulation for Understanding Milkfish Culture Impacts on the Coastal Environment of Bolinao, Philippines"* (Mr. Kota Ashikawa, TiTECH)
1410-1430: *"Numerical Modeling as a Decision-Support Tool for Conservation and Management: Simulation Scenarios for Laguna de Bay, Philippines"* (Mr. Eugene C. Herrera, TiTECH)
1430-1450: *"Puerto Galera Water Modeling: Towards the Development of Decision Support System for Water Resources Management"* (Mr. Tanuspong Pokavanich, TiTECH)
1450-1510: *"SeagrassNet as a Decision Support System in Conserving the Coasts for Tourism in Puerto Galera"* (Dr. Miguel D. Fortes, Professor, UPMSI)
1510-1530: **Invited or voluntary contributions from the other participants**

Focused Discussion and Sharing 2

1530-1700: Open focused discussion on priority coastal tourism issues in Puerto Galera and elsewhere where marine science is

needed for their resolution **(All participants are encouraged to share their related experiences)** (Dr. K. Nadaoka, Moderator)
1700-1830: Open Schedule
1830-2030: Dinner at the Apartelle (for non-Puerto Galerans only)

Day 4 (May 28, Wed)

0900-1100: Focused Field Exposure (participants will formed in teams of 3 and encouraged to visit White Beach to assess and document the good and not-so-good practices and discuss these with the group in the afternoon. Focus will be on how marine science and oceanography could be useful in enhancing or improving the situation. Prepared guide questions will be provided)

1200-1330: LUNCH WILL BE PROVIDED

Demonstration and Training on Remote Sensing/GIS and Socio-Environmental Scan of Puerto Galera

1330-1600: *"Training/Demonstration on the Use of Remote Sensing/GIS for Tourism"* (Dr. Enrico Paringit, UPCE)
1600-1630: *"A Socio-Environmental Scan of Puerto Galera As A Decision Support System for Tourism"* (Dr. Ma. Cecilia Rubio-Paringit, De La Salle University)
1630-1700: Open Forum
1700-1800: Informal oral presentation by participants on the morning's field exposure in White Beach (10-min each team)
1830-2030: Dinner at the apartelle (for non-Puerto Galerans only)

Day 5 (May 29, Thu)
0830-1130: Field validation of data and information at selected sites (visits to study stations and giant clam nursery)
1400-1730: Discussion on refinement and applications of DSS
1730-1830: Open Schedule
1830-2030: Dinner at the apartelle (for non-Puerto Galerans only)

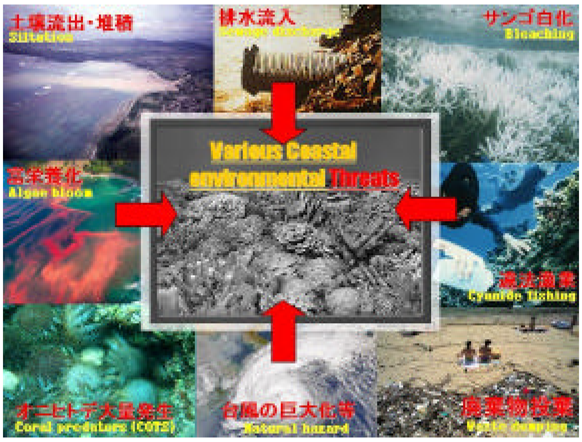
Day 6 (May 30, Fri)
0830-1000: Discussion on continuous scheme of collaboration; Closing Ceremonies, Awarding of Certificates
1000-1030: Check out of apartelle
1030-1200: In-transit to Batangas City Pier (on board "Commandos")
1230-1530: In transit to Quezon City and Fersal Inn Kalayaan (minivans))

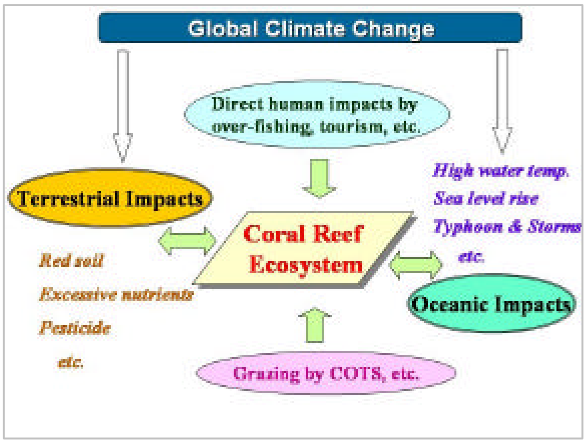
Day 7 (May 31, Sat): Departures for the airport, etc.

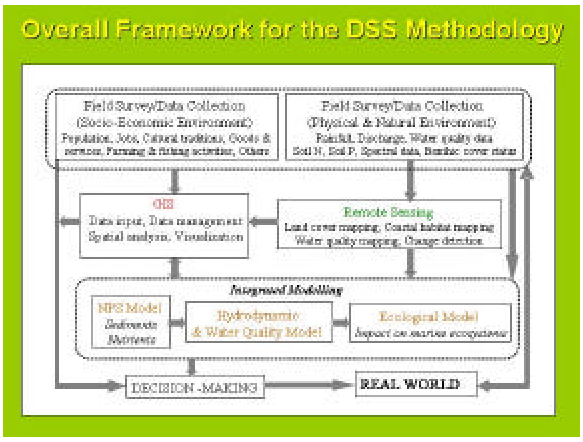
END OF TRAINING COURSE

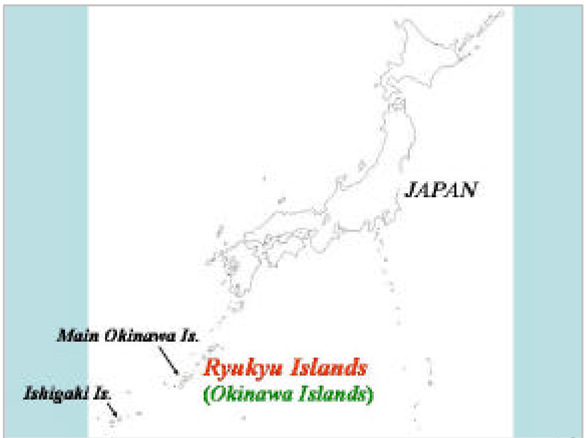
B.2 Workshop Presentation Slides

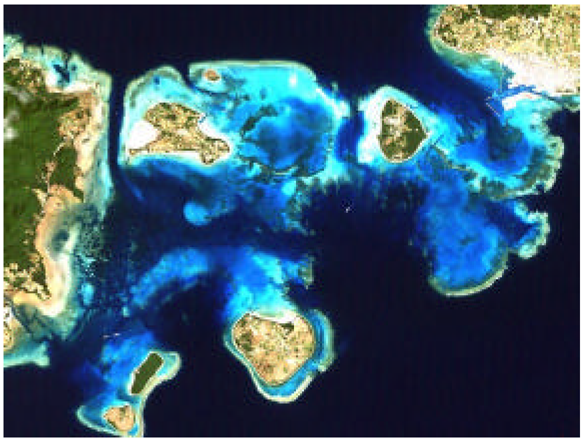
(1) Coastal Research initiatives of the Tokyo Institute of Technology in Asia-Pacific: Providing a Sound Basis for Ecosystem Conservation and Tourism Development

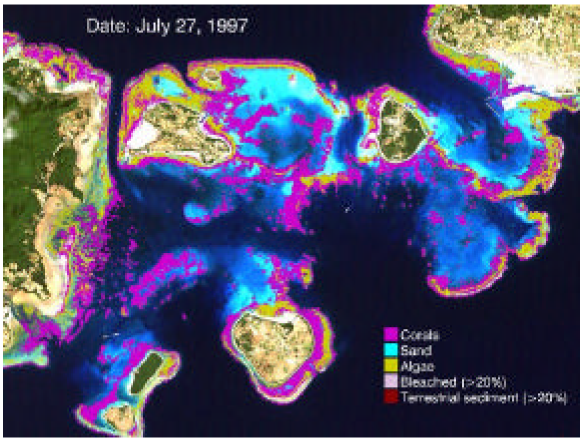


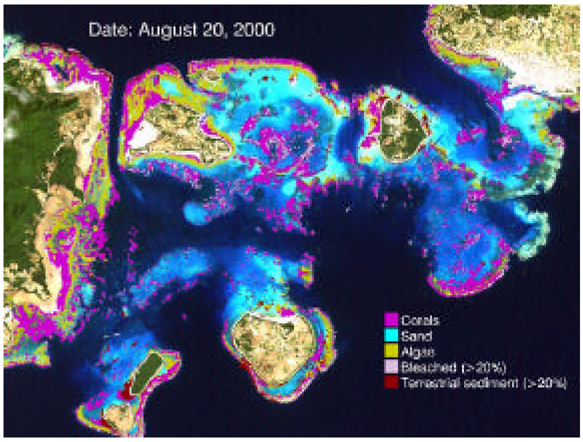


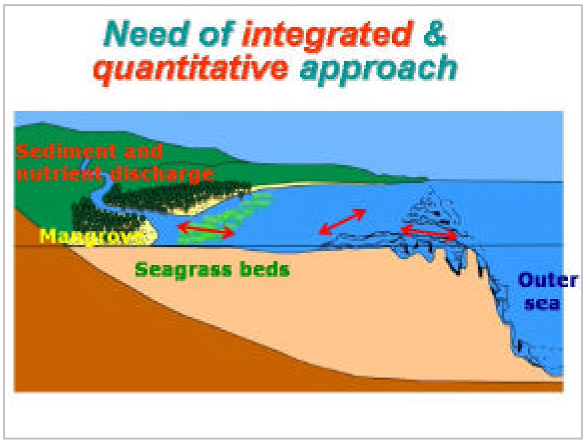


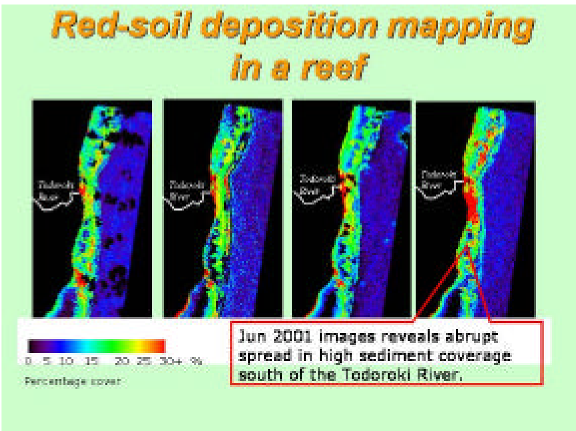


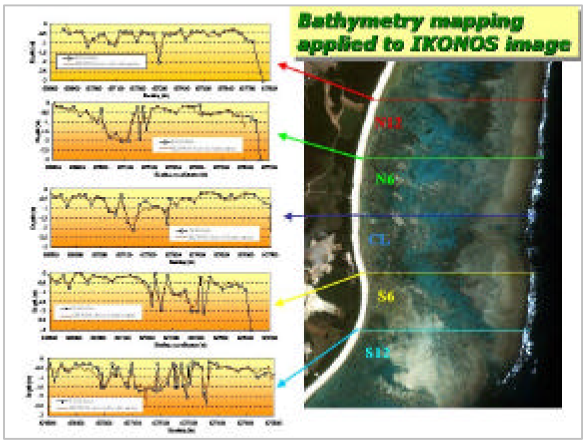


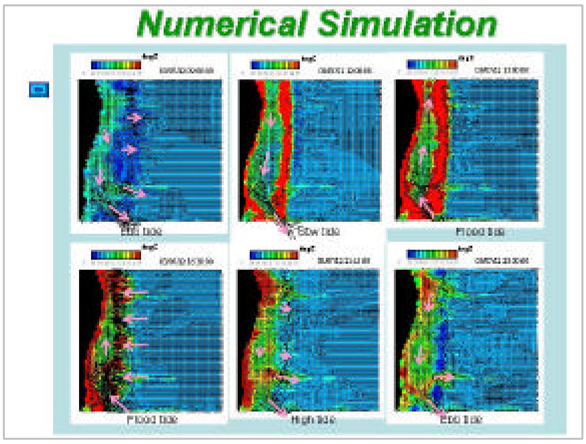

Date: July 27, 1997
Corals
Sand
Algae
Bleached (>20%)
Terrestrial sediment (>20%)


Date: August 20, 2000
Corals
Sand
Algae
Bleached (>20%)
Terrestrial sediment (>20%)

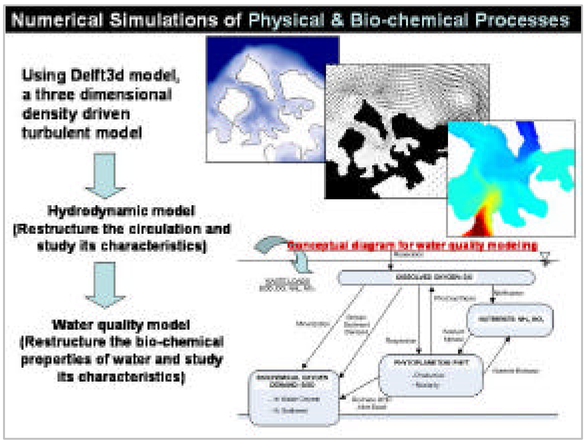

Need of integrated & quantitative approach
Sediment and nutrient discharge
Mangrove
Seagrass beds
Outer sea


Red-soil deposition mapping in a reef
Todoroki River
0 5 10 15 20 25 30+ %
Percentage cover
Jun 2001 images reveals abrupt spread in high sediment coverage south of the Todoroki River.

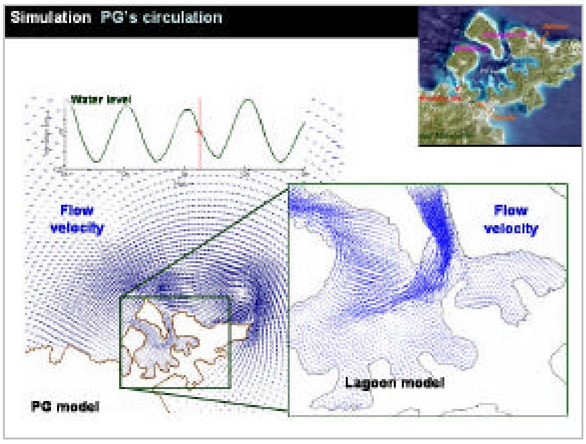

Bathymetry mapping applied to IKONOS image
N12
N6
CL
S6
S12



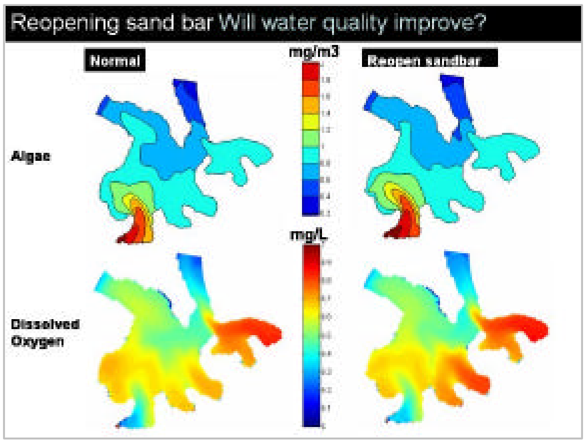
Numerical Simulation
Ebb tide
Slow tide
Flood tide
Flood tide
High tide
Ebb tide



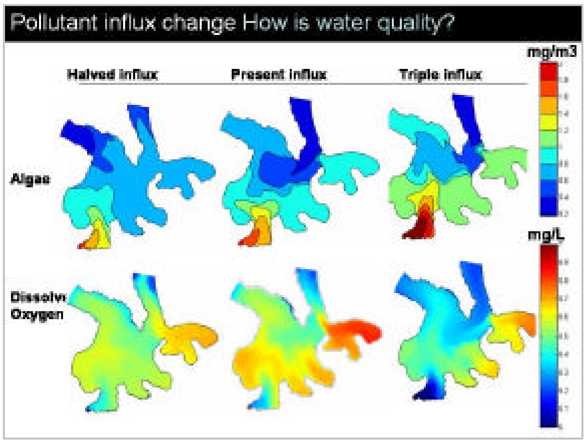
Numerical Simulations of Physical & Bio-chemical Processes
Using Delft3d model, a three dimensional density driven turbulent model
Hydrodynamic model
(Restructure the circulation and study its characteristics)
Water quality model
(Restructure the bio-chemical properties of water and study its characteristics)
Conceptual diagram for water quality modeling



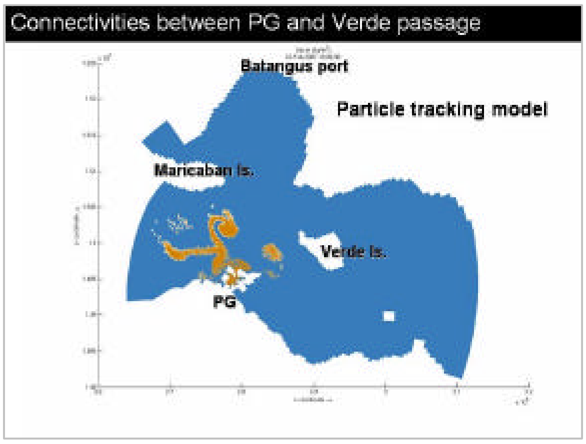
Simulation PG's circulation
Water level
Flow velocity
Flow velocity
Lagoon model
PG model



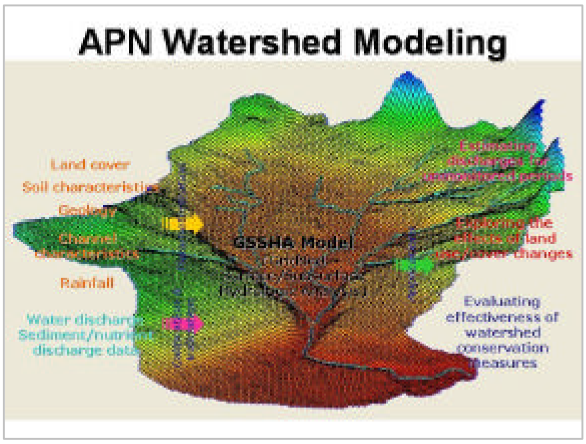
Reopening sand bar Will water quality improve?
Normal
mg/m3
Reopen sandbar
Algae
mg/L
Dissolved Oxygen



Pollutant influx change How is water quality?
mg/m3
Halved influx
Present influx
Triple influx
Algae
mg/L
Dissolve Oxygen

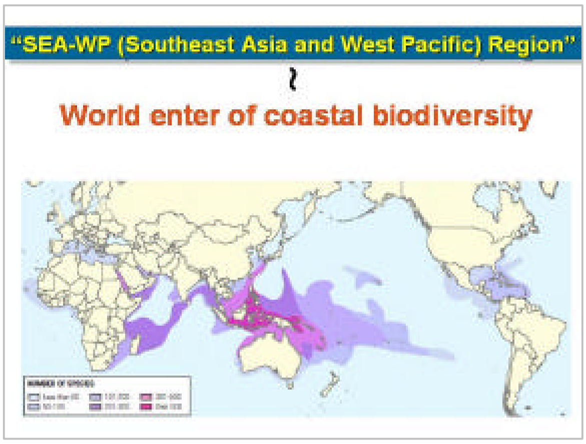


Connectivities between PG and Verde passage
Batangus port
Particle tracking model
Maricaban is.
Verde is.
PG

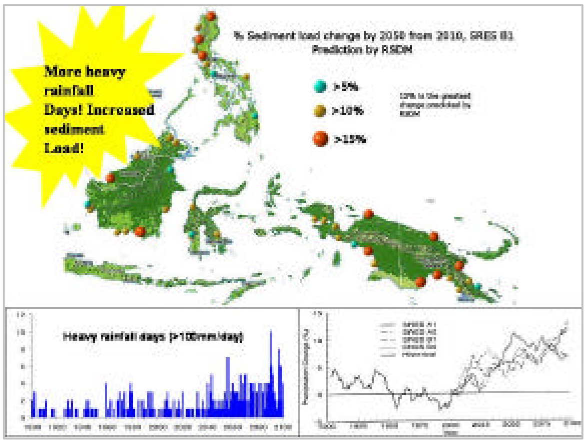


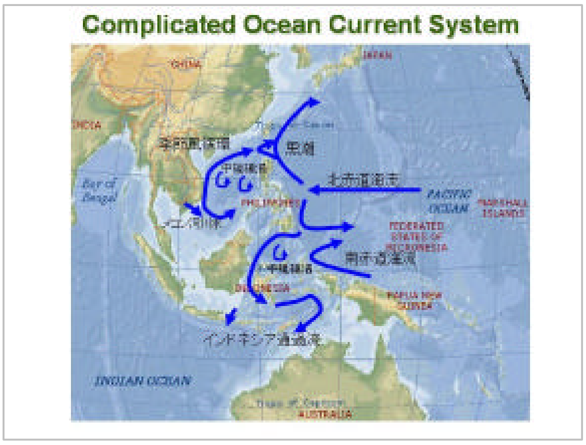
APN Watershed Modeling
Land cover
Soil characteristics
Geology
Channel characteristics
Rainfall
Water discharge
Sediment/nutrient discharge data
GSSHA Model
Estimating discharges for unmonitored periods
Exploring the effects of land use/cover changes
Evaluating effectiveness of watershed conservation measures

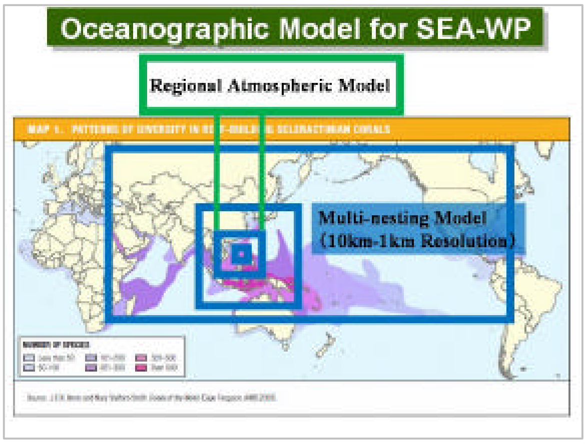
Torodoki Watershed and Shiraho Reef

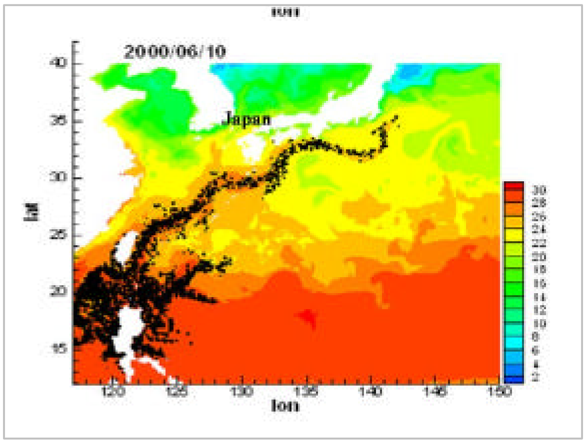

"SEA-WP (Southeast Asia and West Pacific) Region"
≀
World enter of coastal biodiversity

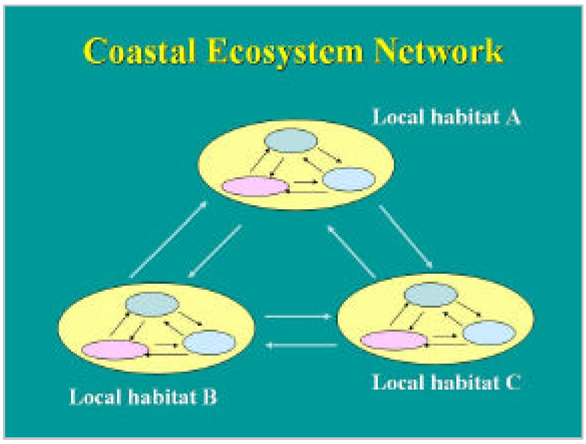

SEA-WP Area at Big Danger
INDIAN OCEAN

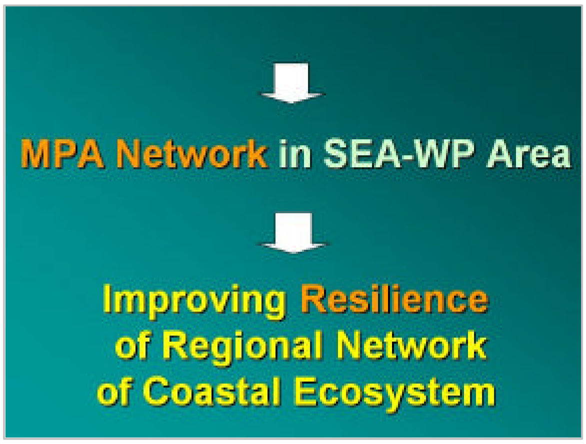

More heavy rainfall Days! Increased sediment Load!
% Sediment load change by 2050 from 2010, SRES B1
Prediction by RSDM
>5%
>10%
>15%
Heavy rainfall days (>100mm/day)

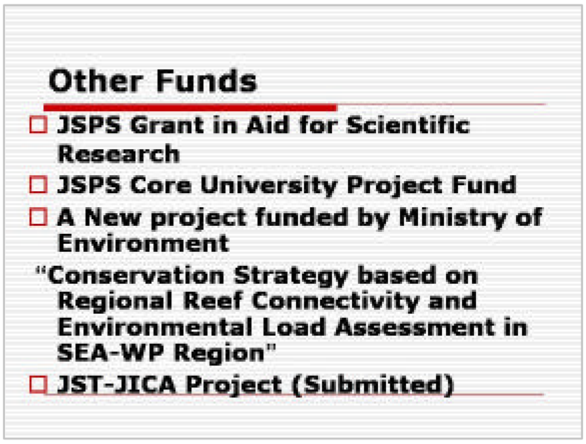

Complicated Ocean Current System
黒潮
北赤道海流
インドネシア通過流
PACIFIC OCEAN
Bay of Bengal
INDIAN OCEAN
AUSTRALIA


Oceanographic Model for SEA-WP
Regional Atmospheric Model
Multi-nesting Model
(10km-1km Resolution)

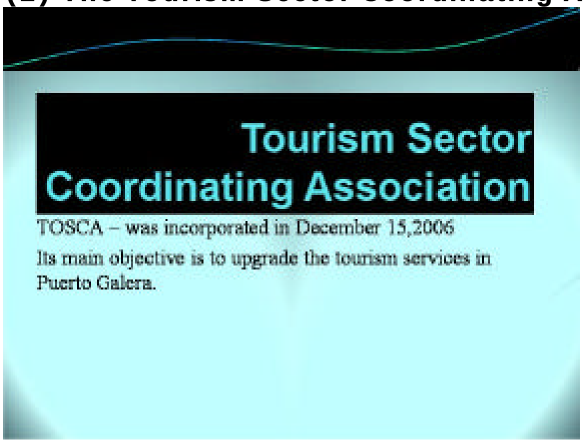

2000/06/10
Japan
lat
lon

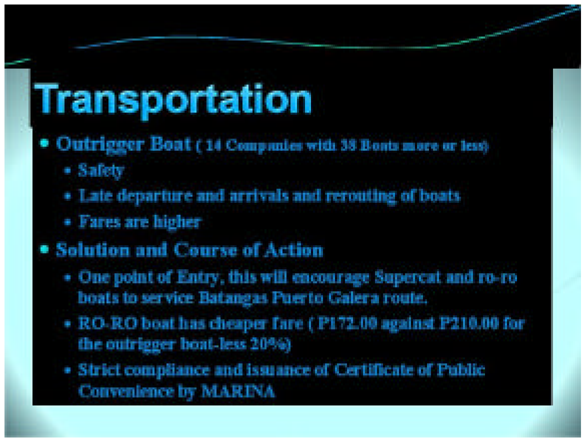

Coastal Ecosystem Network
Local habitat A
Local habitat B
Local habitat C

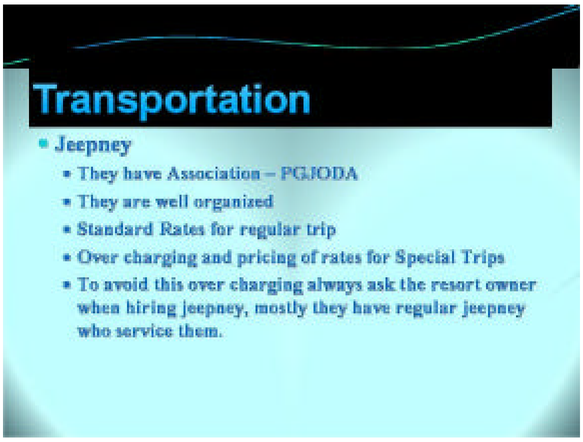

MPA Network in SEA-WP Area
Improving Resilience
of Regional Network
of Coastal Ecosystem

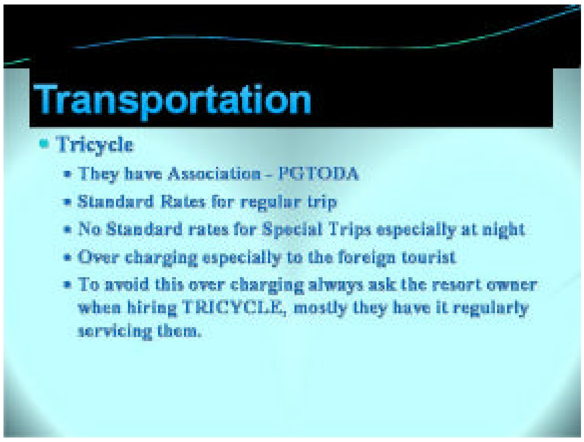


(2) The Tourism Sector Coordinating Association of Puerto Galera









Accommodations

- Lack of Standards
- Over crowding of Rooms (6-10 persons per room)
- Improper Marketing Segmentation
- Inadequate Amenities
- In order to avoid misleading information, always check and validate it to the Tourist Information Office
- Beware of some illegal recruiter, the Municipality issued IDs to legitimate tour guide

Power and Water

- Frequent Brown-outs
- Resorts do not report to the Electric Company when they add and upgrade electric appliances
- Over crowding of tourist consumed much water
- Illegal loggings in the mountains of Puerto Galera
- Solution:
  - Tapping of electricity at Malapaya in Batangas for cheaper rates and continuous supply of power
  - Develop cheaper renewable source of Energy
  - Reforestation of the denuded mountains of Puerto Galera

Peace and Order

- Unsolved crimes such as robberies and hold-ups
- Shooting of some drunk policemen
- Lack of good policemen
- Too many points of entry
- Solution:
  - Proper training of policemen
  - Reprimand, suspend or dismiss erring policemen
  - Police visibility
  - Private resort must hire security guards

Garbage and Destruction of the Environment

- Non-Segration of Garbage
- Lack of Planning
- Lack of Monitoring and Control
- The community is not cooperative in addressing the garbage problem
- Illegal and destructive fishing,
- Too many ordinance which were not implemented
- Illegal logging
- People of Puerto Galera have been using illegal logs but until now no one was apprehended
- Lack of information and education campaign

Drugs and Prostitutions

- Sabang in particular is the center of prostitution
- Drugs Pushers were apprehended by PEDEA Agent
- Many points of entry made it hard to check human and drug trafficking
- Human trafficking especially minors
- Issuance of Pink Card by the LGU for the GRO in Sabang
- Regular check-up of the GRO makes the prostitution looks legal by the LGU

Food Supply

- Expensive foods compared to adjacent town
- Overpricing of Basic Commodities
- Lack of supplies
- Taking advantage by some businessmen
- Course of Action
  - Agro-forestry
  - Farming
  - Regulations

Graft and Corruption in Government and Private Sector

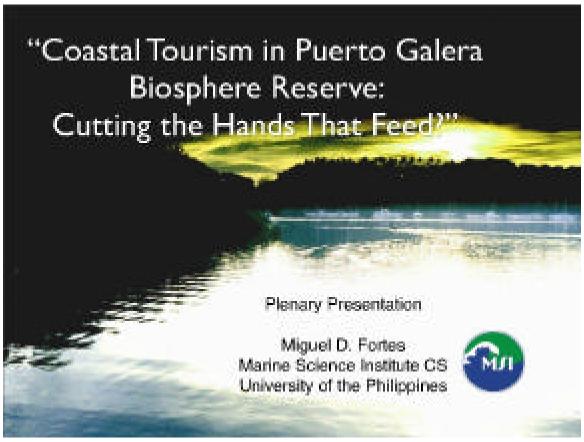
- The National Government Agencies such as the BIR. DENR, LGU. DPWH, MARINA, COAST GUARD ETC.
- Approval of ECC by the DENR even to the critical areas
- Approval of boat permits and fare of boats by MARINA
- Some passenger boats travel without being check by the Coast Guard
- Establishment do not issued Official Receipts
- Resort owners cheat in paying taxes by not declaring the correct income
- Indiscriminate construction of Resort owners
- Sub-standard roads
- Until now the LGU has no approved CLUP

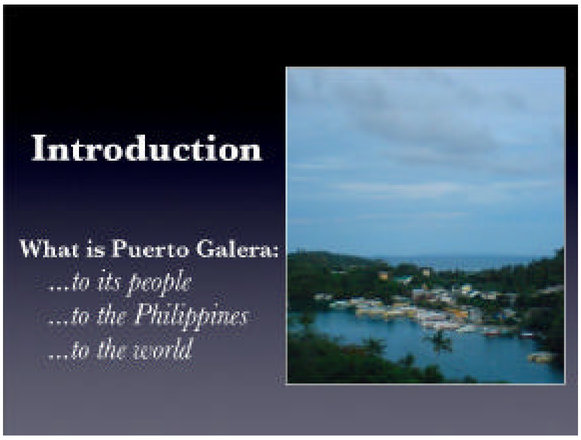
- THE BASIC SOLUTION TO THESE PERENNIAL PROBLEMS IS COMMON SENSE, BUT SOMETIMES OR MOST OF THE TIMES DUE TO GREEDINESS…
- COMMON SENSE IS NOT COMMON.

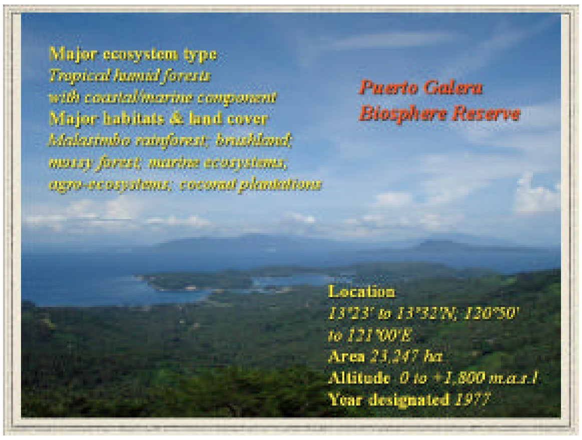
Thank you

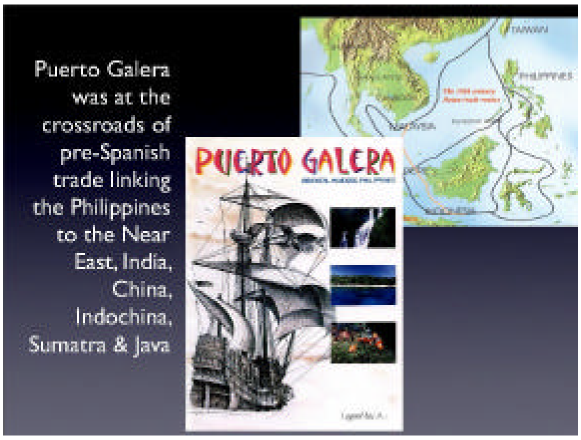
and have a nice day!

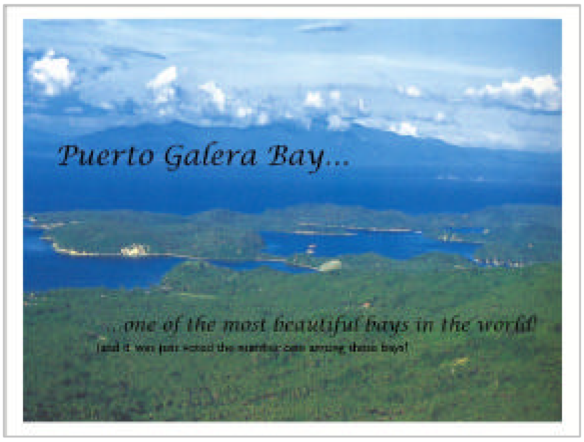
(3) Coastal Tourism in Puerto Galera Biosphere Reserve: Cutting the Hands that Feed?











TOURISM DEVELOPMENT CONCERNS AND ISSUES IN PGBR

SWOT ANALYSIS

STRENGTHS:

1. Abundant coastal & terrestrial resources
2. Natural, Cultural & Historical potentials
3. Potentials for ecotourism destinations
4. Proximity to Manila
5. High literacy rate
6. Available academic & technical support
7. Environmental Users Fee

STRENGTHS (con't)

8. Hospitable & trainable people
9. Good peace & order situation
10. LGU support (receptive developmental leadership in the municipality)
11. On going upgrading of seaports, roads & communication facilities
12. Availability of power supply & water resources
13. Existing resorts & other destinations
14. Private sector & community support

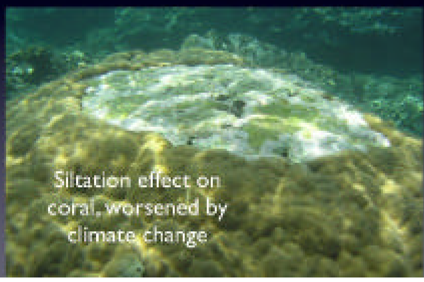
WEAKNESSES

Inadequate community appreciation of the fact that *tourism that is anchored on clean & well-managed environment is the most sustainable form of tourism for PGBR*

PG has not been successful in sustaining its beauty, enhancing its natural diversity, enriching its cultural history, & mobilizing its people in protecting this legacy. In other words, it has been 'cutting that hands that feed'.

What are the signs?

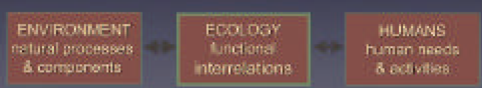
Is this the kind of tourism PG wants?

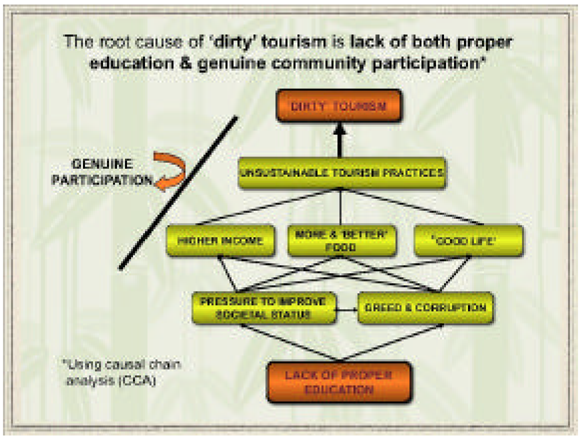


What are the roots of the problems?

Ecological theory seldom applied in ICAM

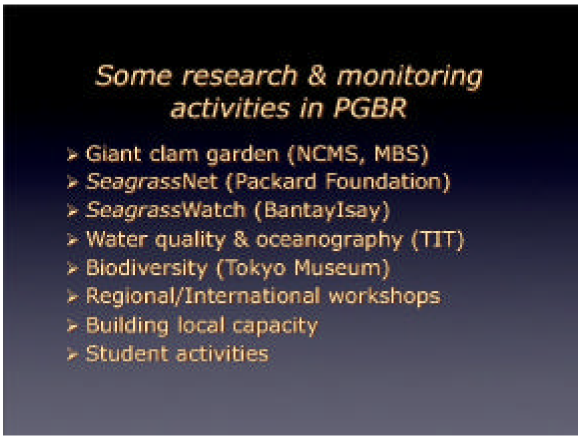
- But ecological knowledge -including not only theory, but also facts, observations, research results, observations, syntheses, models, & methods of investigation -has been extremely important in developing approaches to a wide range of environmental problems.
- This stems from the 'man-environment' model, given below, which identifies the essential & crucial role of ecology:





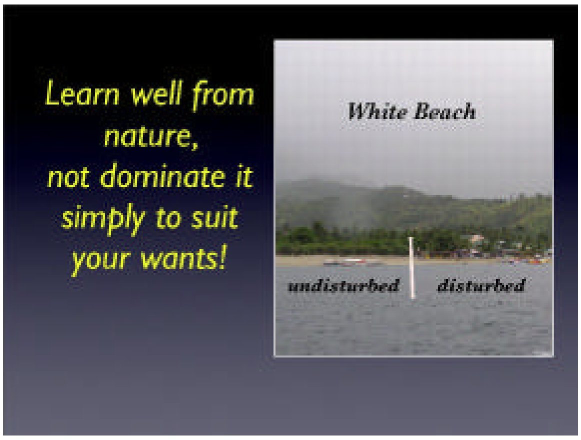
The root cause of 'dirty' tourism is lack of both proper education & genuine community participation*
DIRTY TOURISM
GENUINE PARTICIPATION
UNSUSTAINABLE TOURISM PRACTICES
HIGHER INCOME
MORE & 'BETTER' FOOD
'GOOD LIFE'
PRESSURE TO IMPROVE SOCIETAL STATUS
GREED & CORRUPTION
*Using causal chain analysis (CCA)
LACK OF PROPER EDUCATION

What are we doing about them?



Some research & monitoring activities in PGBR
➢ Giant clam garden (NCMS, MBS)
➢ SeagrassNet (Packard Foundation)
➢ SeagrassWatch (BantayIsay)
➢ Water quality & oceanography (TIT)
➢ Biodiversity (Tokyo Museum)
➢ Regional/International workshops
➢ Building local capacity
➢ Student activities

...a simple, 'best practice' that works!



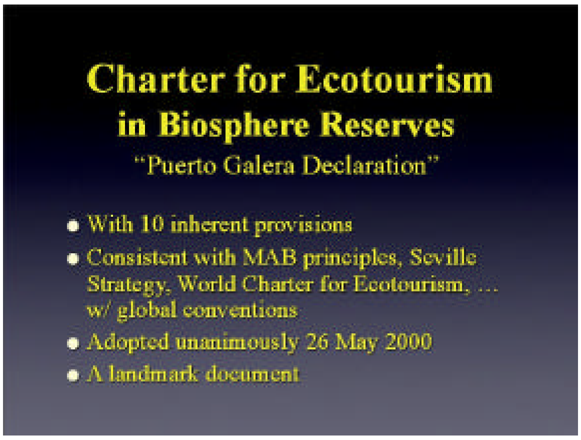
Learn well from nature, not dominate it simply to suit your wants!
White Beach
undisturbed
disturbed

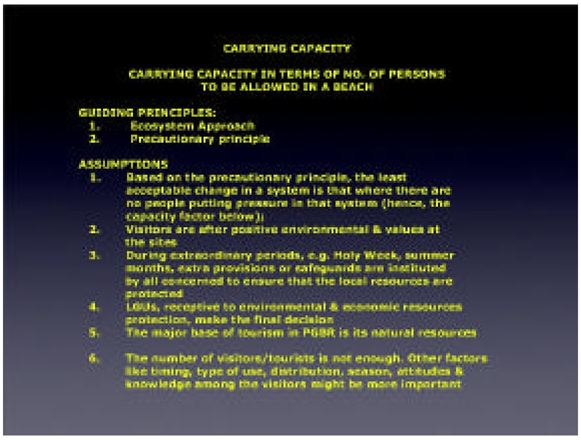
Joint Regional Training Course/Workshop
"Practical Methods in the Study of Marine Plant Biodiversity & Management in Asia-Pacific"
Pto. Galera Biosphere Reserve, Philippines, May 23-29, 2004
38 participants, 11 countries

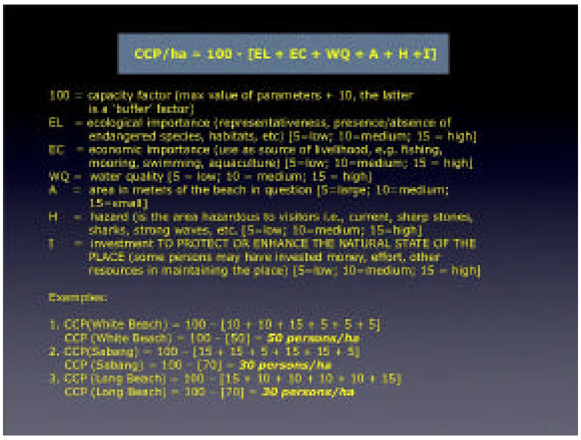
How "BantayIsay" was born
Volunteers
Demonstration
Community consultation
Support & political will
Regional workshop
BantayIsay
Exec. Order 02-01


The spirit of environmentalism


Political will, or uninformed obstinacy?

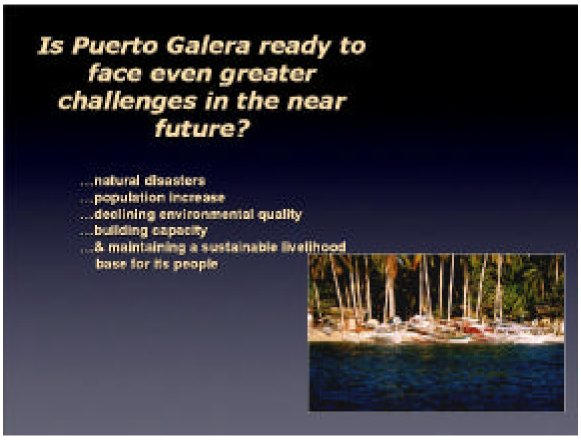

Charter for Ecotourism
in Biosphere Reserves
"Puerto Galera Declaration"
With 10 inherent provisions
Consistent with MAB principles, Seville Strategy, World Charter for Ecotourism, … w/ global conventions
Adopted unanimously 26 May 2000
A landmark document

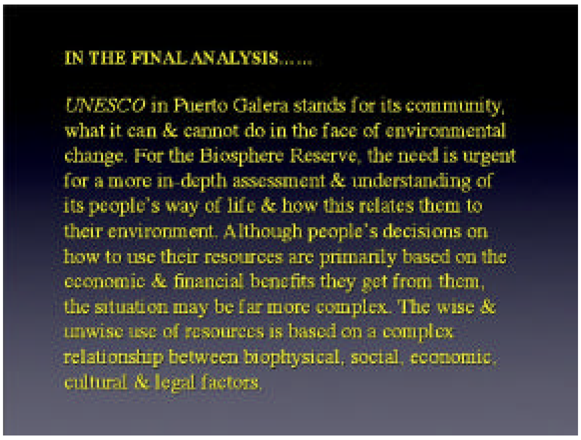

CARRYING CAPACITY
CARRYING CAPACITY IN TERMS OF NO. OF PERSONS TO BE ALLOWED IN A BEACH
GUIDING PRINCIPLES:
1. Ecosystem Approach
2. Precautionary principle
ASSUMPTIONS
1. Based on the precautionary principle, the least acceptable change in a system is that where there are no people putting pressure in that system (hence, the capacity factor below);
2. Visitors are after positive environmental & values at the sites
3. During extraordinary periods, e.g. Holy Week, summer months, extra provisions or safeguards are instituted by all concerned to ensure that the local resources are protected
4. LGUs, receptive to environmental & economic resources protection, make the final decision
5. The major base of tourism in PGBR is its natural resources
6. The number of visitors/tourists is not enough. Other factors like timing, type of use, distribution, season, attitudes & knowledge among the visitors might be more important


CCP/ha = 100 - [EL + EC + WQ + A + H + I]
100 = capacity factor (max value of parameters + 10, the latter is a 'buffer' factor)
EL = ecological importance (representativeness, presence/absence of endangered species, habitats, etc) [5=low; 10=medium; 15 = high]
EC = economic importance (use as source of livelihood, e.g. fishing, mooring, swimming, aquaculture) [5=low; 10=medium; 15 = high]
WQ = water quality [5 = low; 10 = medium; 15 = high]
A = area in meters of the beach in question [5=large; 10=medium; 15=small]
H = hazard (is the area hazardous to visitors i.e., current, sharp stones, sharks, strong waves, etc. [5=low; 10=medium; 15=high]
I = investment TO PROTECT OR ENHANCE THE NATURAL STATE OF THE PLACE (some persons may have invested money, effort, other resources in maintaining the place) [5=low; 10=medium; 15 = high]
Examples:
1. CCP(White Beach) = 100 - [10 + 10 + 15 + 5 + 5 + 5]
CCP (White Beach) = 100 - [50] = 50 persons/ha
2. CCP(Sabang) = 100 - [15 + 15 + 5 + 15 + 15 + 5]
CCP (Sabang) = 100 - [70] = 30 persons/ha
3. CCP (Long Beach) = 100 - [15 + 10 + 10 + 10 + 10 + 15]
CCP (Long Beach) = 100 - [70] = 30 persons/ha


Decongest the coast!


THE PHILOSOPHY & BASIC FRAMEWORK OF RESEARCH & CONSERVATION ACTIONS IN PGBR
SCIENCE
EDUCATION
UNESCO MAB, TIT, UP, ETC.
CULTURE
COMMUNICATION
WISE PRACTICE AGREEMENTS
WISE PRACTICES


Is Puerto Galera ready to face even greater challenges in the near future?
...natural disasters
...population increase
...declining environmental quality
...building capacity
...& maintaining a sustainable livelihood base for its people



(4) Designing Effective MPAs: A Tool for Sound Coastal Fisheries and Tourism Development

Topics

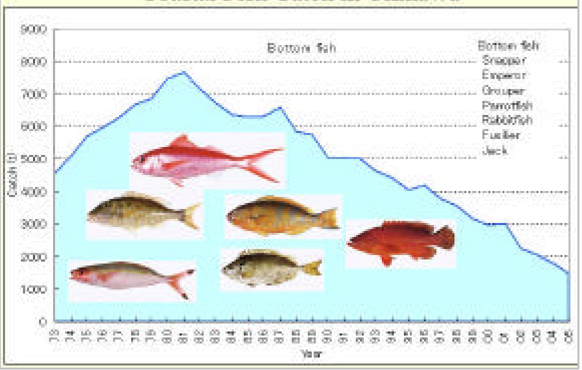
1. Multi-functions and Diversity of MPAs
2. MPAs for Eco-tourism
3. Decision Support System for Effective MPAs
4. MPA Cases in Yaeyama, Okinawa

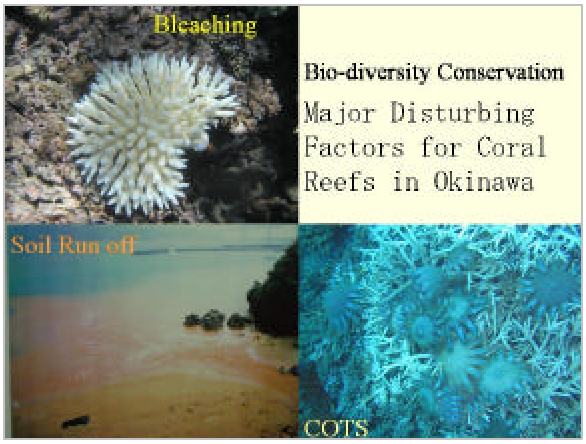
Multi-functions of MPAs

1. Fisheries Management
2. Bio-diversity Conservation
3. Tourism Promotion

Fisheries Management

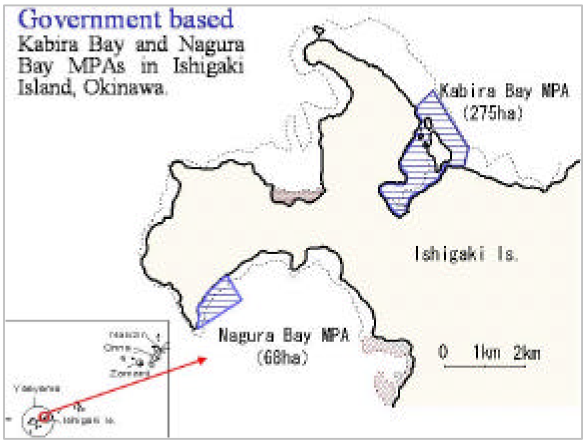
Coastal Fish Catch in Okinawa





Diversity of MPAs

1. Government or Community-based
2. No-take or Buffer (Multi-use)
3. Permanent or Limited Period
4. All species or Target Species



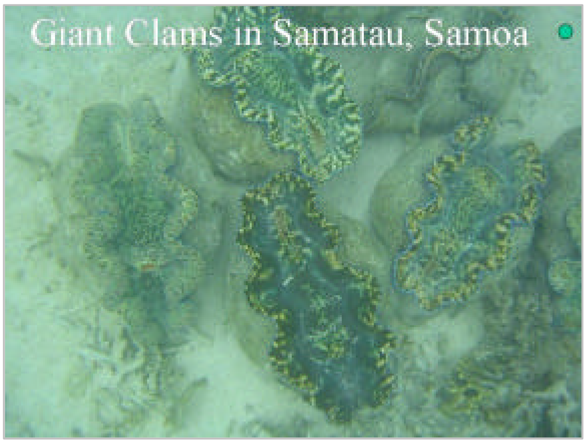
Pohnpei

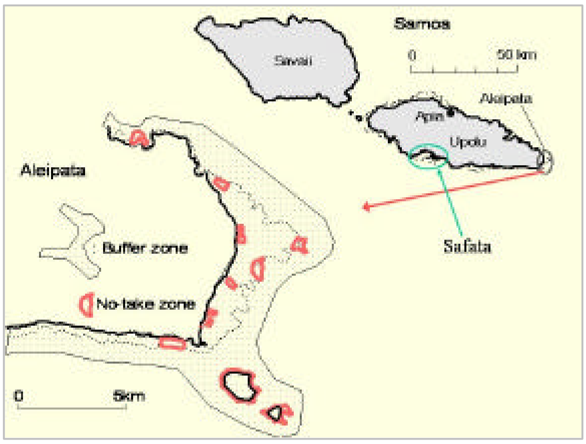
Somewhat Gov. Top-down Management

No-take or Multi-purpose use MPAs

1. Samatau: community-based MPA in Samoa.
2. Aleipata: combination of no-take and multi-use MPAs in Samoa.

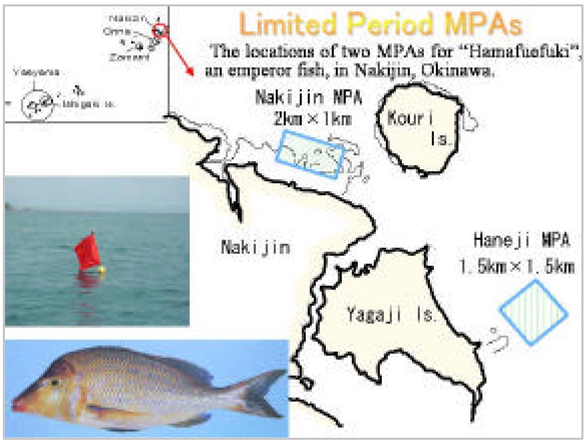
There were 60 community-based MPAs in 2005 in Samoa.

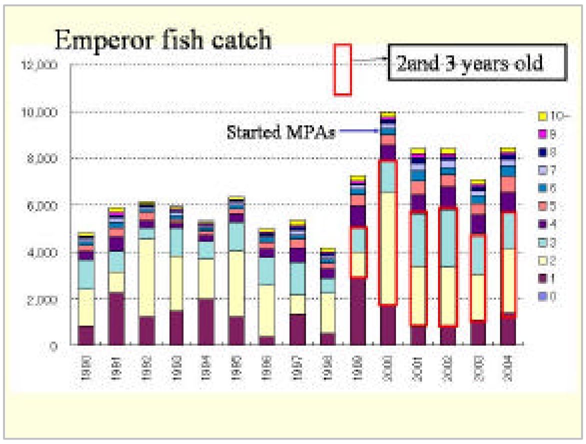




Limited Period MPAs

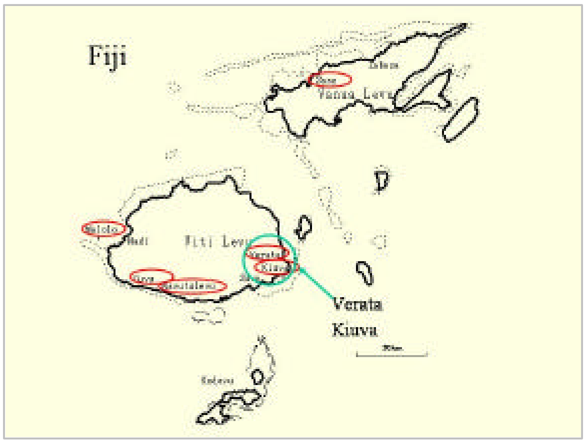
1. Yaeyama: emperor fish MPAs in Okinawa (closure of spawning season).
2. Nakijin: emperor fish MPAs in Okinawa (closure of young fish aggregation).





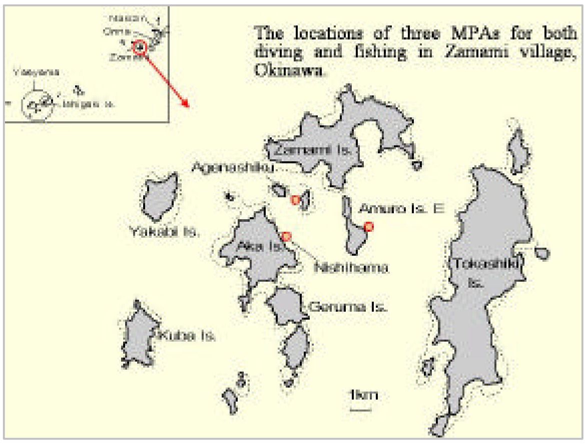
Limited Species MPAs

1. Verata: a bivalve MPA in Fiji.
2. Kiuva: a bech-de-mer MPA in Fiji.

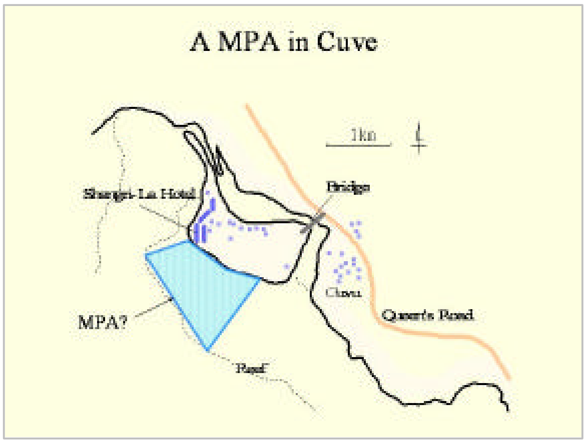


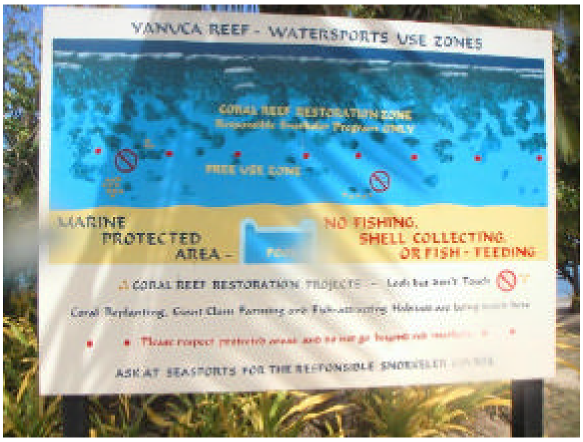
MPAs & Eco-tourism

1. Zamami: both diving and fishing MPAs in Okinawa.
2. Cuvu: a collaborative MPA of hotel and community in Fiji.
3. Malolo in Fiji & Blue Bay in Mauritius.

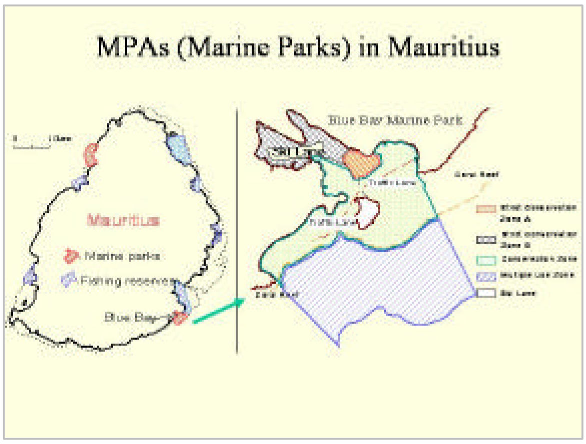

The locations of three MPAs for both diving and fishing in Zamami village, Okinawa.
Zamami Is.
Agenashiku
Amuro Is. E
Yakabi Is.
Aka Is.
Nishihama
Tokashiki Is.
Geruma Is.
Kuba Is.
1km


Fiji
Viti Levu
Malolo
Nadi
Cuvu


A MPA in Cuve
1km
Shangri-La Hotel
Bridge
Chuvu
Queen's Road
MPA?
Reef


YANUCA REEF - WATERSPORTS USE ZONES
CORAL REEF RESTORATION ZONE
FREE USE ZONE
MARINE PROTECTED AREA -
NO FISHING, SHELL COLLECTING OR FISH - FEEDING
CORAL REEF RESTORATION PROJECTS


Malolo


MPAs (Marine Parks) in Mauritius
Mauritius
Marine parks
Fishing reserves
Blue Bay
Blue Bay Marine Park
Ski Lane
Coral Reef


Tourism Promotion
Mauritius, Blue Bay MPA

Towards Effective MPA System

1. Need more co-managed MPAs

   Local government follow-up is important for sustainable MPAs
2. Asia-Pacific style (tropical vs. temperate)
3. Quantitative research on spillover effect
4. Effective boundary marks, enforcement and alternative income sources for sustainable MPAs
5. Integrated Coastal Management for land-based discharges

Decision Support System for MPA Designing

1. Who makes the decisions?
2. What needs to be decided?
3. What kinds of information are needed?
4. Who, how and what supports?

Who makes the decisions?

1. Communities
2. Local governments

What needs to be decided on MPA design?

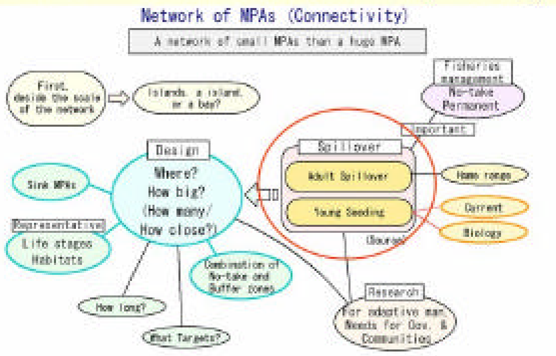
1. Where?
2. How big?

(3. How many? How close?)

4. Rules

(How long? What targets?)

Where? Needs science & community knowledge



How large the size of a MPA should be?

- The larger, the better for bio-diversity.
- Too large MPAs narrow the fishing grounds.

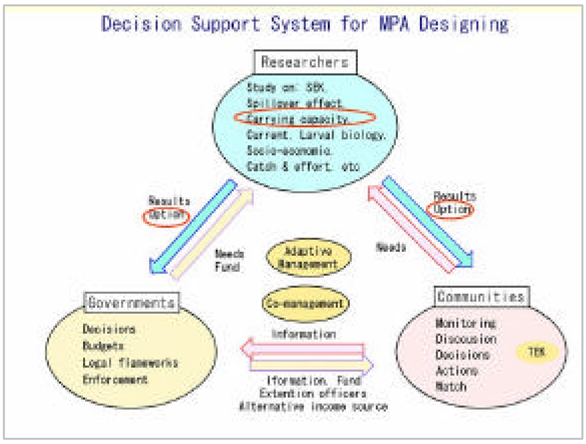
What kinds of information are needed?

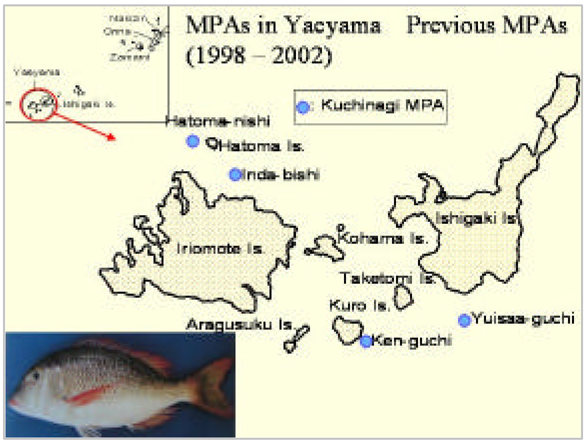
1. Scientific Ecological Knowledge (SEK) +

   Traditional Ecological Knowledge (TEK)
2. Existing information
3. Information for networking (current & larval biology)
4. Socio-economic information
5. Fisheries data (catch, effort, methods, number of fishermen)
6. Carrying capacity for eco-tourism

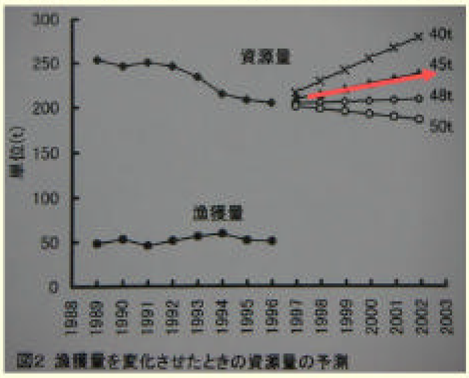
Who, how and what supports?

1. Extension officers
2. Co-management among communities, local government and researchers
3. Adaptive management
4. Networks of people & information
5. Learning system

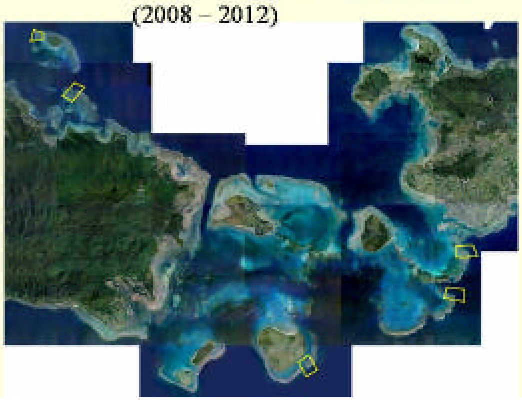




If cut the catch by 10 % → The stock would increase 23 %



MPAs in Yaeyama New MPAs
(2008 – 2012)



Changing batteries of MPA boundary buoys

Differences between Previous and New MPAs

	Previous MPAs	New MPAs
Targets	All (no-take)	All (no-take)
Term	April – May	April – June
Number of MPAs	4	5
Size of MPAs	20 ha	100 ha

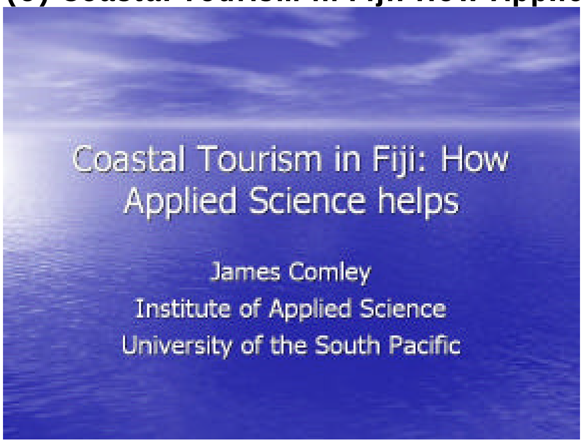
Decision Support System in Yaeyama MPA Designing

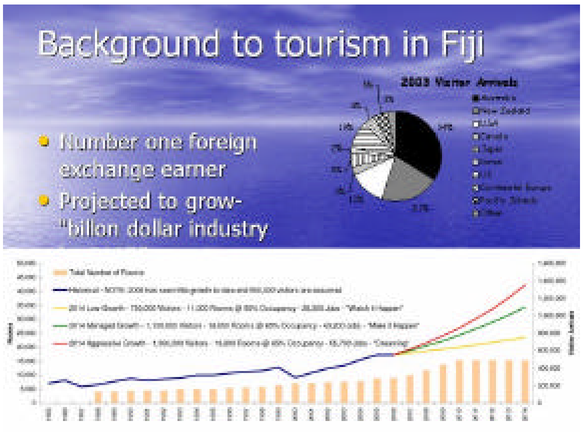
/TEK on spawning grounds & period

/Scientific research on age (otolith), length, gonads, catch & effort, etc.

/Many meetings among fishermen, divers, scientists, local government (extension officers)

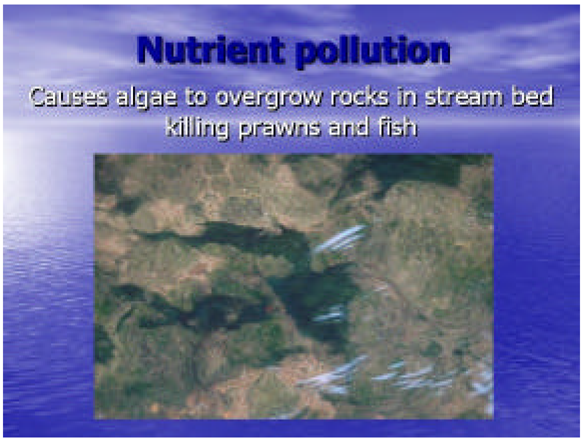
(5) Coastal Tourism in Fiji: How Applied Science Helps





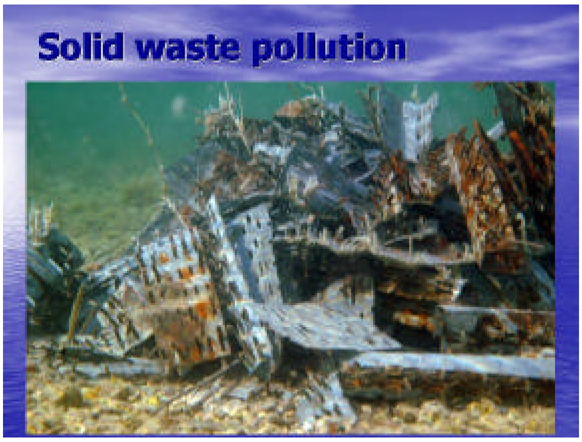

Nutrient pollution
Improper wastewater disposal (hotels, housing, & villages)
Piggeries
Agriculture and tourism development

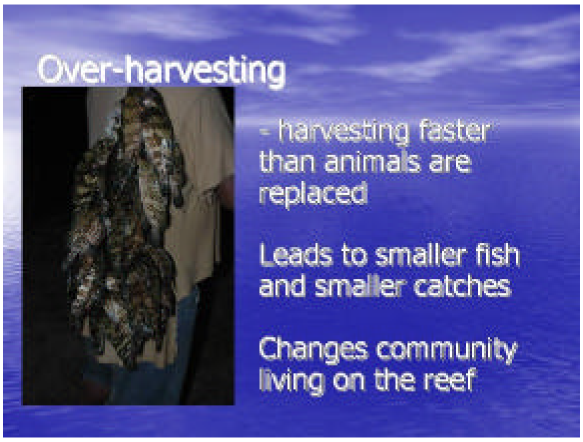

Nutrient pollution
Causes algae to overgrow and kill coral and other organism

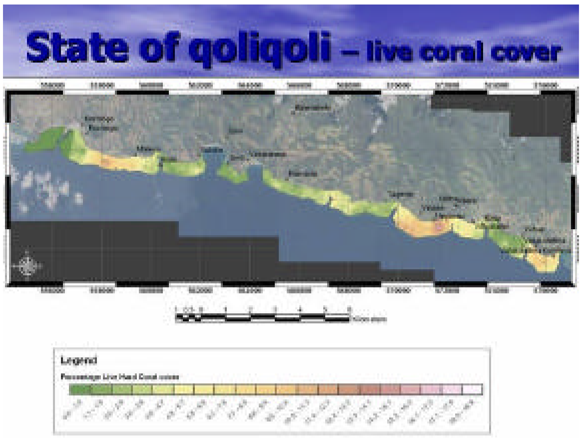

Nutrient pollution
Causes algae to overgrow rocks in stream bed killing prawns and fish


Sedimentation
from poor land use practices
Smoothers corals
Brings nutrients
Covers beach and reef with rocks and gravel

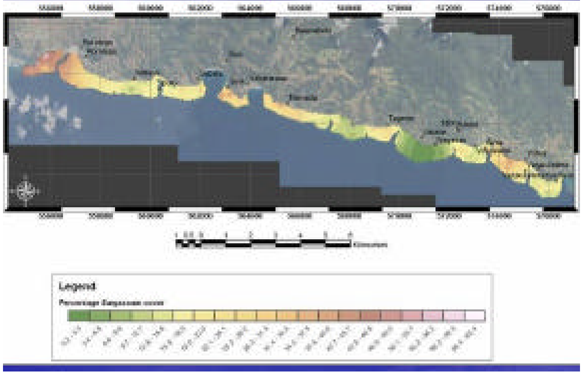

Sedimentation


Solid waste pollution


Over-harvesting
- harvesting faster than animals are replaced
Leads to smaller fish and smaller catches
Changes community living on the reef


State of qoliqoli – live coral cover
Legend

State of qoliqoli – Sargassum cover

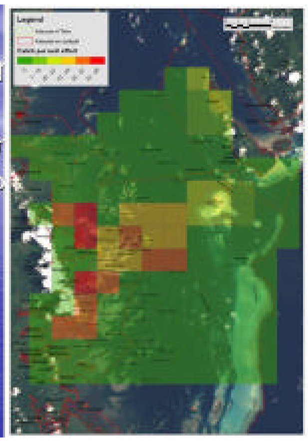


Nutrient levels

- Extensive (6yrs) monitoring
  - Established piggeries/communities as key nutrient sources
  - Piggeries- composting cooperative
  - Waste water treatment project- wetlands
- Collaborative project with APN programme- examining the fate of nutrients/sediments

Fisher

- Natior … rveys
- Grid o … odel



Land-use practices

- Collaborative project with IUCN (WANI)
  - Community-appropriate landuse practices
  - Watershed modelling
  - Planting regimes

MPA designation

- Already 220 community-based MPAs
- Key question- do these contribute to conservation as networks
- Aggregation of MPAs at Governance level
- New project using reserve design planning process to asses their spatial attributes as a network

Governance- Korolevu-I-Wai / Koroinasau Qoliqoli Trust Objectives

1. Improve "health" of qoliqoli and harvests of subsistence marine products
2. Strengthen traditional governance & cultural connection to qoliqoli
3. Ensure development in Tikina has proper authorization and is done in a manner to minimize damage to qoliqoli
4. Ensure sustainable use of qoliqoli
5. Improve economic benefits derived from use of qoliqoli
6. Distribute economic benefits from qoliqoli fairly

Governance- Korolevu-I-Wai / Koroinasau Qoliqoli Trust Objectives

How to achieve objectives?

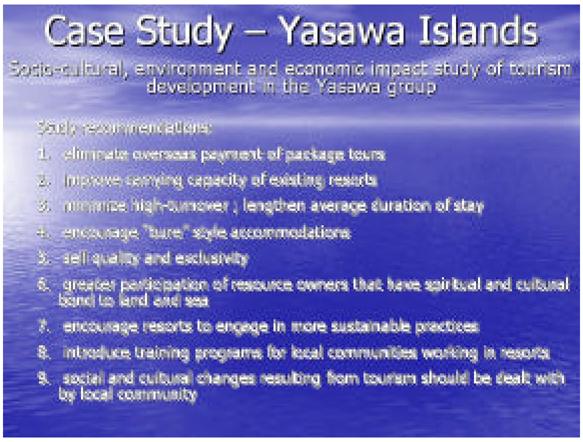
1. Marine management plan : Zoning, Tabu areas, monitoring state of qoliqoli, regulating use, enforcement of rules
2. Improving land-use practices
3. Working with tourism industry / gov't offices to resolve qoliqoli-related issues
4. Education - qoliqoli issues and current affairs
5. Strengthen traditional channels of communication and discussion

Case Study – Yasawa Islands

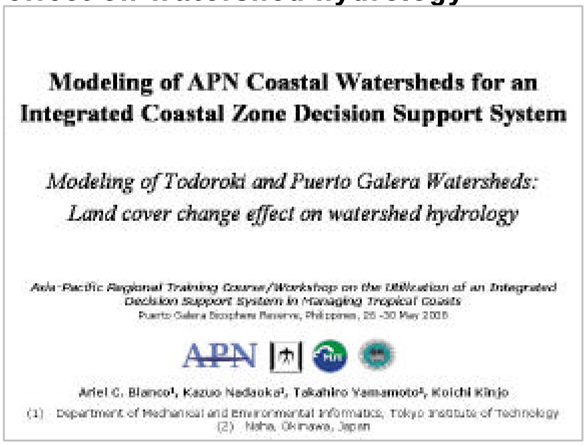
Socio-cultural, environment and economic impact study of tourism development in the Yasawa group

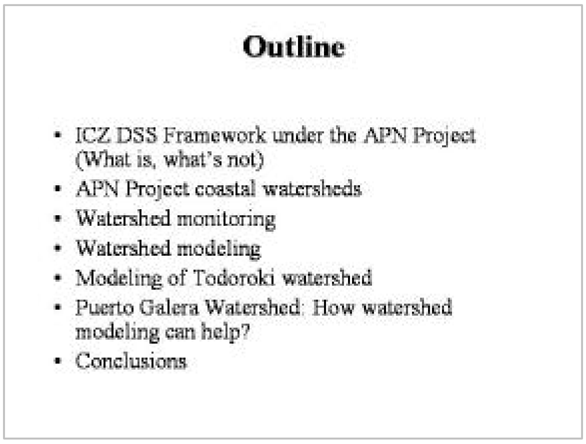
Major study findings:

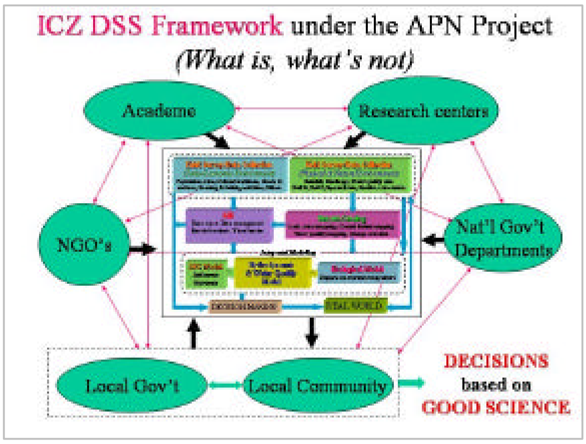
1. only small % of population directly engaged with tourism
2. loss of quality time for communal work – tourist interactions
3. sewerage issues on reefs from development and boats
4. land and sea stressed from human activities
5. rapid increase in trash (plastics, glass, other litter)
6. increase in alcohol and kava consumption & increase in socio-cultural problems such as teenage pregnancy
7. tension between locals and investors because of improper stakeholder consultation
8. widespread impact on marine ecosystem
9. strengthening of community bond by observing traditional protocols

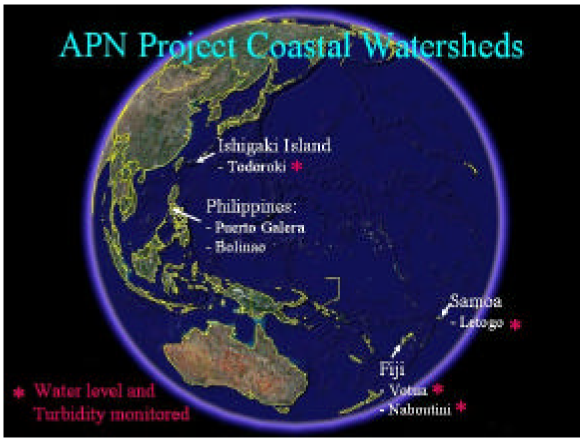


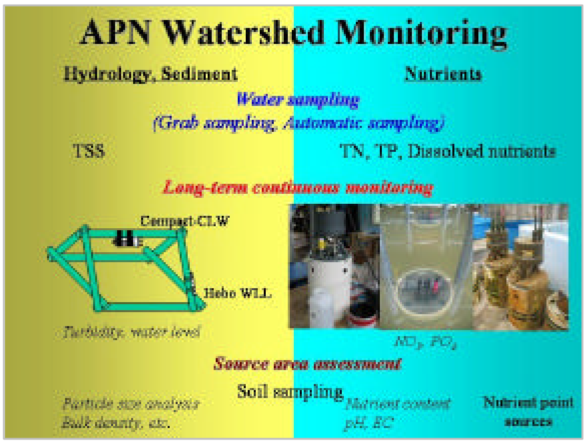
(6) Modeling of Tororoki and Puerto Galera Watersheds: Land cover change effect on watershed hydrology

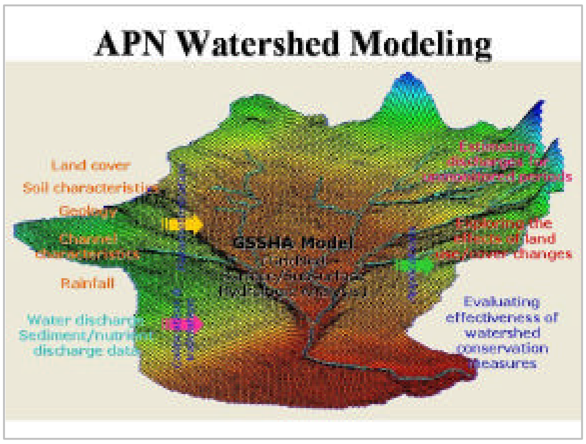


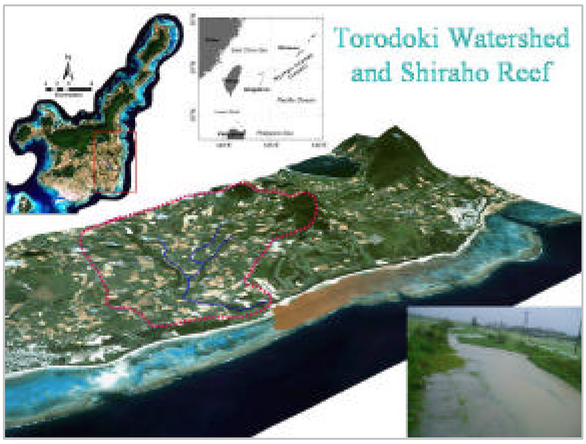


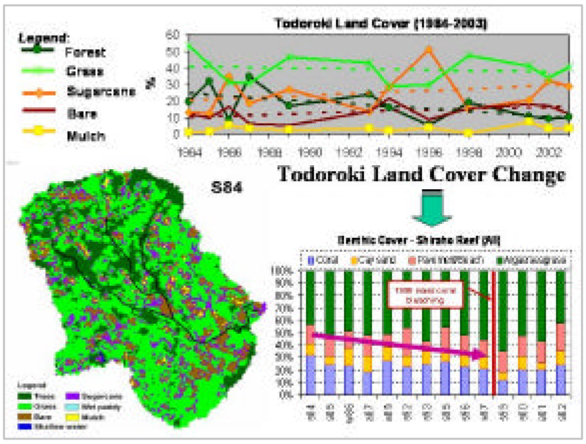


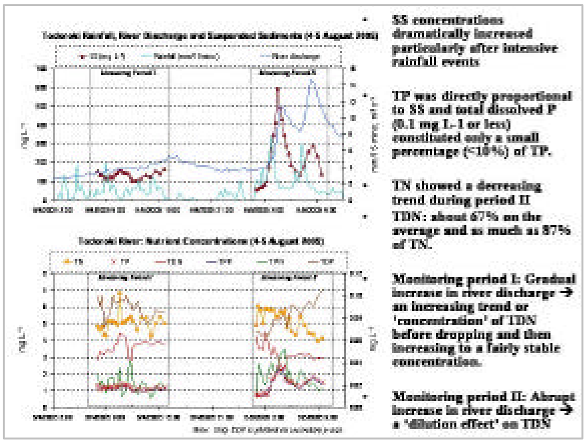


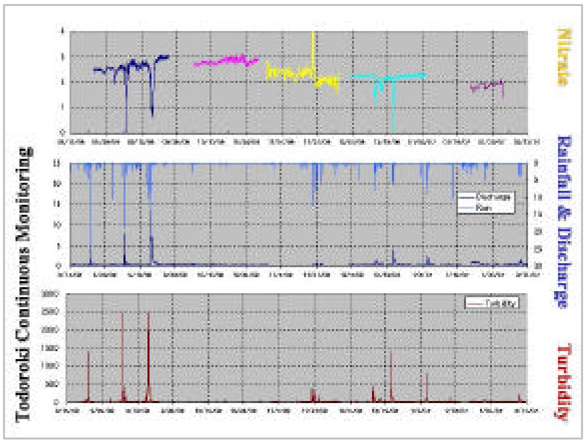


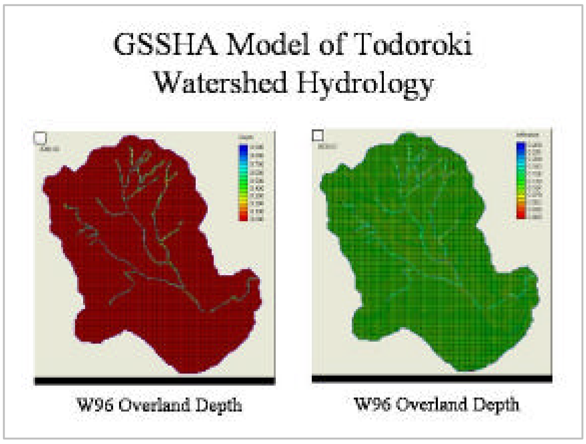


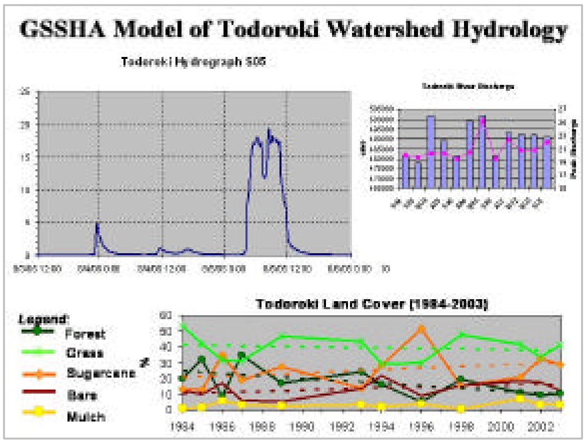

Torodoki Watershed
and Shiraho Reef

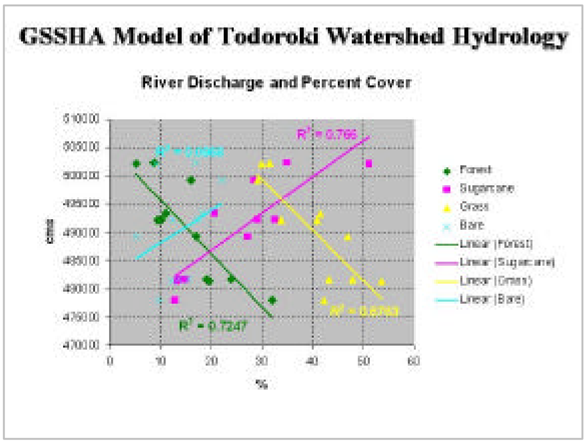

Todoroki Land Cover (1984-2003)
Legend:
Forest
Grass
Sugarcane
Bare
Mulch
S84
Todoroki Land Cover Change
Benthic Cover - Shiraho Reef (All)

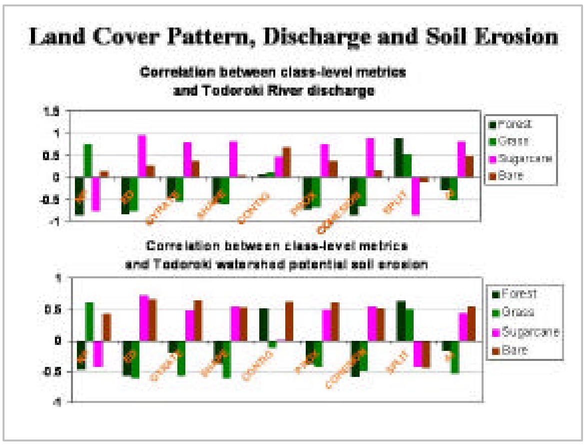

Todoroki River: Nutrient Concentrations (4-5 August 2005)
SS concentrations dramatically increased particularly after intensive rainfall events
TP was directly proportional to SS and total dissolved P (0.1 mg L-1 or less) constituted only a small percentage (<10%) of TP.
TN showed a decreasing trend during period II
TDN: about 67% on the average and as much as 87% of TN.
Monitoring period I: Gradual increase in river discharge → an increasing trend or 'concentration' of TDN before dropping and then increasing to a fairly stable concentration.
Monitoring period II: Abrupt increase in river discharge → a 'dilution effect' on TDN

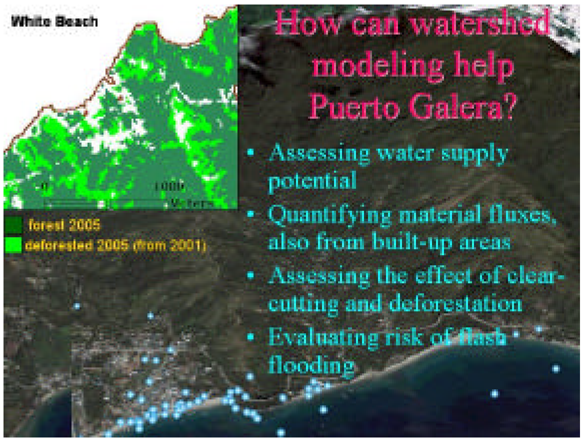

Todoroki Continuous Monitoring
Nitrate
Rainfall & Discharge
Turbidity

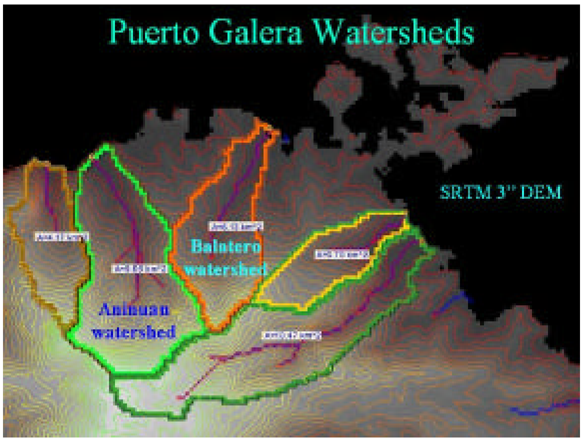

GSSHA Model of Todoroki
Watershed Hydrology
W96 Overland Depth
W96 Overland Depth

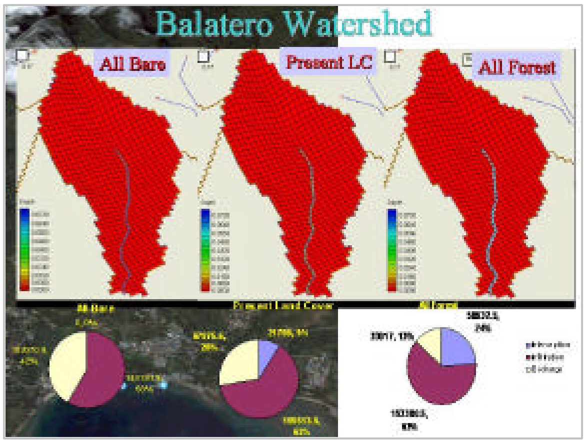

GSSHA Model of Todoroki Watershed Hydrology
Todoroki Hydrograph S05
Todoroki Land Cover (1984-2003)
Legend:
Forest
Grass
Sugarcane
Bare
Mulch

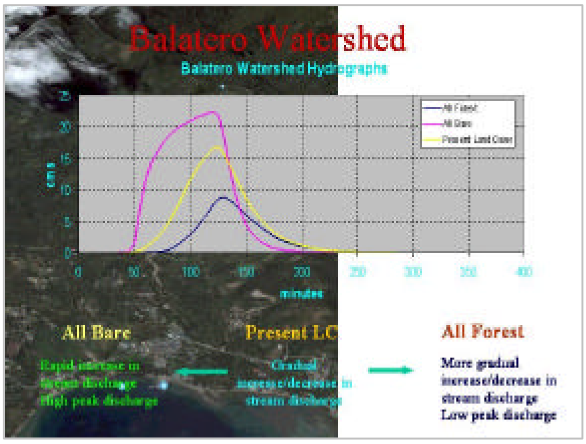

GSSHA Model of Todoroki Watershed Hydrology
River Discharge and Percent Cover
Forest
Sugarcane
Grass
Bare
Linear (Forest)
Linear (Sugarcane)
Linear (Grass)
Linear (Bare)
R² = 0.766
R² = 0.7247
cms
%

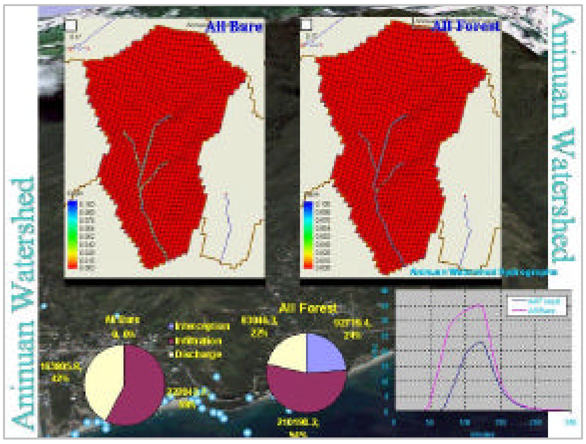

Land Cover Pattern, Discharge and Soil Erosion
Correlation between class-level metrics
and Todoroki River discharge
Correlation between class-level metrics
and Todoroki watershed potential soil erosion
Forest
Grass
Sugarcane
Bare











Conclusions

- Long-term continuous monitoring reveals discharge dynamics not adequately captured by intermittent grab sampling
- Land cover composition and landscape patterns have significant influence on river/stream discharge
- Watershed modeling is a useful tool for understanding effects of land cover change, among other factors, and hence for supporting decision-making in a coastal environment.

(7) Field Observations and Numerical Simulation for Understanding Milkfish Culture Impacts on the Coastal Environment of Bolinao, Philippines

Field Observations and Numerical Simulation for Understanding Milkfish Culture Impacts on the Coastal Environment of Bolinao, Philippines

a regional training workshop

Asia-Pacific Regional Training Course/Workshop on the Utilization of an Integrated Decision Support System in Managing Tropical Coasts

Puerto Galera Biosphere Reserve, Philippines, 26 -30 May 2008

Kota ASHIKAWA[1], Kazuo NADAOKA[1], Eugene C. HERRERA[1], Takahiro YAMAMOTO[1], Cesar L. VILLANOY[2] and Erlinda E. SALAMANTE[2]

[1]Tokyo Institute of Technology, Tokyo, Japan
[2]National Institute of Geological Sciences
University of the Philippines, Diliman

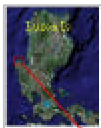
Presentation Outline

In this presentation…

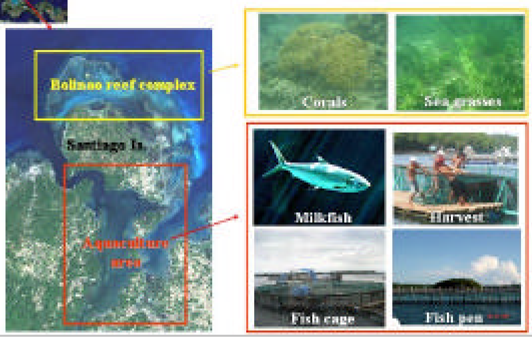
- introduce monitoring and modeling of water flow and water quality
- explain how monitoring and modeling help us to understand and address coastal environmental problems

1. Study site and its Environmental problem
2. Monitoring and Modeling
3. Summary

Study Site: Bolinao, Pangasinan, Philippines



One of the top producers of **Milkfish (Bangus)** in the Philippines.



Environmental Problem

- Too many fish structures & Too much fish feeds
- Phytoplankton blooms & Sediment enriched in organic matters
- Lack of dissolved oxygen

→ **Massive milkfish kills occurred in 2002 and 2007**

Study Objectives

Government of Bolinao (management side):
- ordered the gradual demolition of fish structures
- adopted a policy that fish pens will no longer be allowed

Residents of Bolinao :
- Milkfish is a main resource of food and income for people

Needed is the solution considering conservation of water resource and people's benefit and life

Study Objectives:
- To understand water flow & water quality in order to evaluate impacts of the aquaculture on the coastal environment.
- To transfer the research results to management alternatives

How to Approach This Problem?

1. Field Observations: collect field data
- ➢ Water flow - flow velocity & direction, wave
- ➢ Water quality - nutrients, phytoplankton, turbidity, dissolved oxygen
- ➢ Sediment condition- organic matter, oxygen demand
- ➢ Aquaculture activities - the number and location of fish structures
  - the volume of fish feeds

2. Numerical Simulation: understand the environment system better
- ➢ Water flow modeling
- ➢ Water quality modeling

3. Decision-Making: utilize the study results for proposing alternatives
- ➢ Stocking density
- ➢ Volume and frequency of feeding and harvest
- ➢ Location of fish pens and cages
- ➢ Others

Field Observations (14Nov – 2Dec 2007)

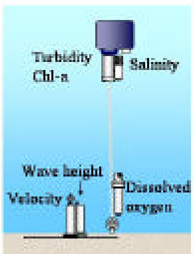
- Collecting data of water flow and water quality
- 12 stations around Santiago Island, Bolinao
- Collaboration with Marine Science Institute University of the Philippines

Bolinao Marine Laboratory (UP MSI)

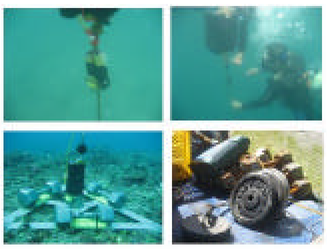
Monitoring locations

Monitoring Using Sensors

Data-logging sensors -19 days continuous measurement
(attached to moored buoys and fixed on the bottom)



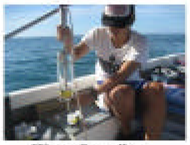
Example of sensor deployment



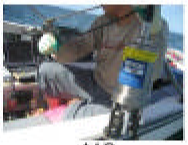
Water Quality Monitoring

Water sampling:
- Analysis of nutrients (NH_4^+, NO_2^-, NO_3^-, PO_4^{3-}, SiO_2)
- Analysis of chlorophyll-a

Multi-quality meter, AAQ:
-Vertical profiling of water quality
(Temperature, Salinity, Chl-a, Turbidity, pH, Dissolved oxygen)



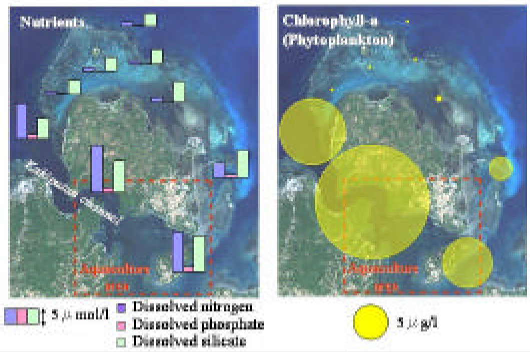
Water Sampling



AAQ

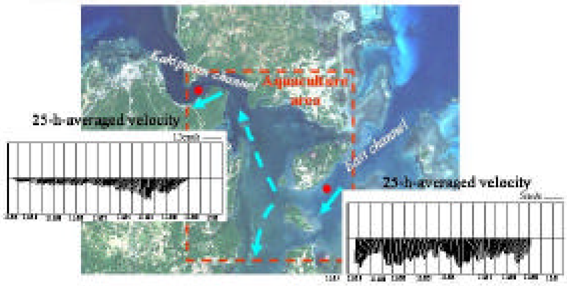
Excessive Fish Feeds Impacts

- Nutrient enrichment & phytoplankton blooms in aquaculture area
- Polluted water disperse towards close to the reef



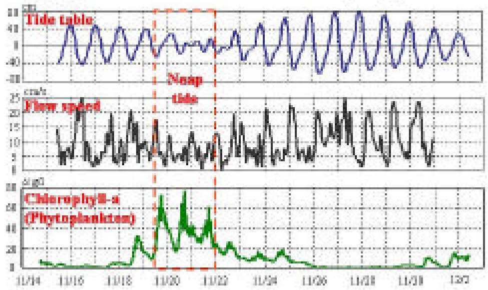
Why is the Kakiputan Channel so Polluted?

- Water cannot flow freely due to the narrow and curvy topography
- In a tidal cycle, polluted water tends to gather in the channel
- Demolishing some fish structures in the channel would prevent fish kills



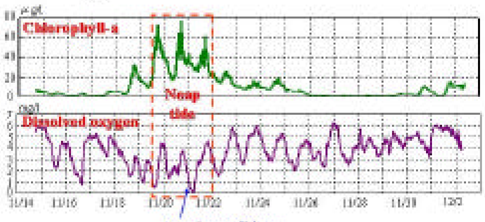
Phytoplankton Blooms

- Flow speed become slow during neap tide
→ Low tidal exchange and weak vertical mixing
→ Phytoplankton blooms tend to occur during neap tide



What Can Happen by Phytoplankton Blooms

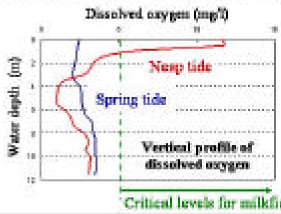
During Neap tide:
- Massive dead phytoplankton accumulate on the bottom
→ Oxygen is consumed to decompose dead phytoplankton
→ Low oxygen level near the bottom



Milkfish Kills due to Oxygen Depletion

During spring tide:
- Decrease of phytoplankton
  - **Depletion of oxygen production near the surface water**
- Strong flow speed and strong vertical mixing
  - **Upwelling of anoxic water from the bottom to the surface**

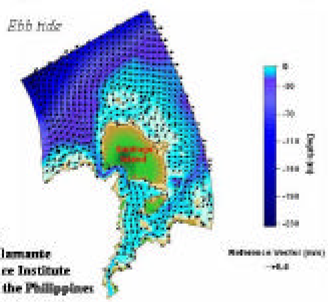
Low oxygen condition from the surface to the bottom water
High possibility of milkfish kills especially during spring tide



Numerical Simulation

- Water flow modeling: Delft-3D FLOW

Objectives: describe the water flow processes and incorporate the simulation result to water quality model



simulated by
Erlinda E. Salamante
Marine Science Institute
University of the Philippines

- Water quality modeling: Delft-3D WAQ

Field observations
- Collect additional field data (8Jun – 19Jun 2008)

Improve water flow modeling
- Considering wave effect

Water quality simulation

Various management scenario assessment
- Change the location of fish structures
- Decrease the number of fish structures
- Change the stock of fish structures and the amount of fish feeds
- Others

Find a better scenario considering conservation of water resources and benefit from aquaculture

Summary

- High feeding input from fish structures have contributed significantly to nutrient enrichment and phytoplankton blooms not only in the aquaculture area but also right close to the Bolinao reef complex
- Water in the Kakiputan channel relatively tend to be polluted. Lessening the number of fish structures in the channel, fish kills would be avoided
- Dissolved oxygen in the aquaculture area was less than the critical level from surface to bottom water especially during spring tide
- Numerical simulation will contribute to evaluate various management scenarios and propose solution alternatives for milkfish culture

Acknowledgements

University of the Philippines - Marine Science Institute
Bolinao Marine Labolatory

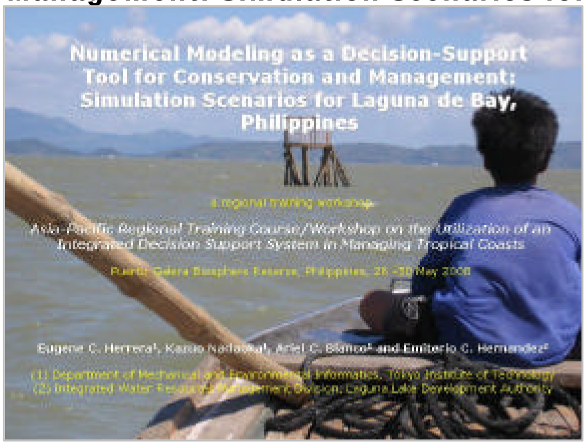
Tokyo University of Marine Science and Technology

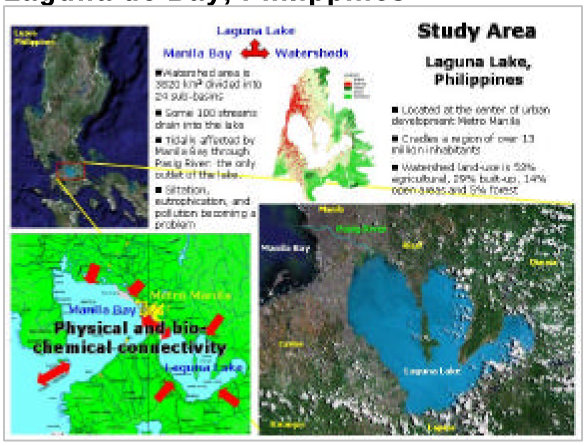
APN Asia-Pacific Network for Global Change Research (APN)

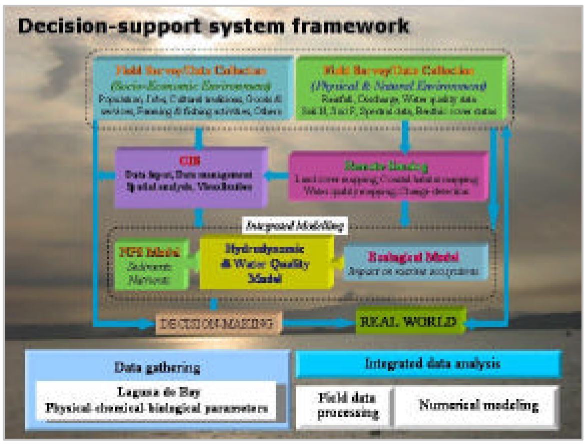
Japan Society of the Promotion of Science (JSPS)
Grants-in-Aid for Scientific Research
The JSPS Core University Program

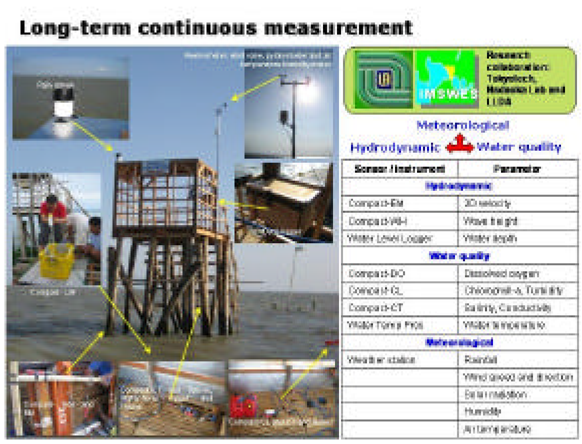
Bolinao Mayor Alfonso Celeste & Residents of Bolinao

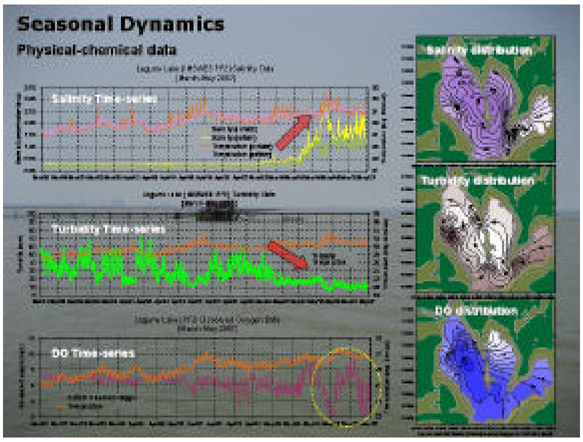
(8) Numerical Modelling as a Decision Support tool for Conservation and Management: Simulation Scenarios for Laguna de Bay, Philippines

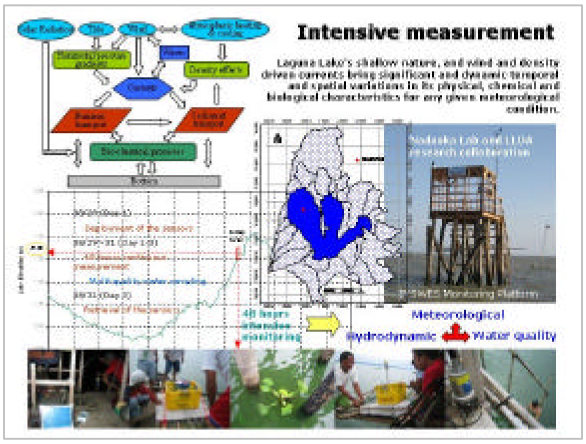


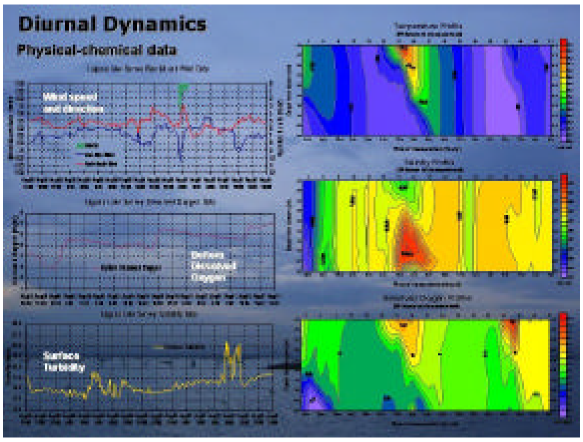


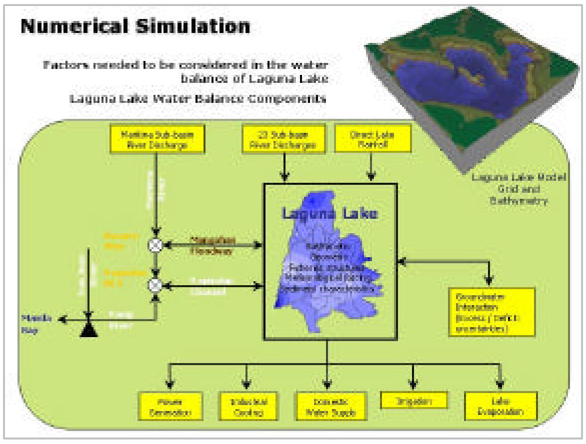


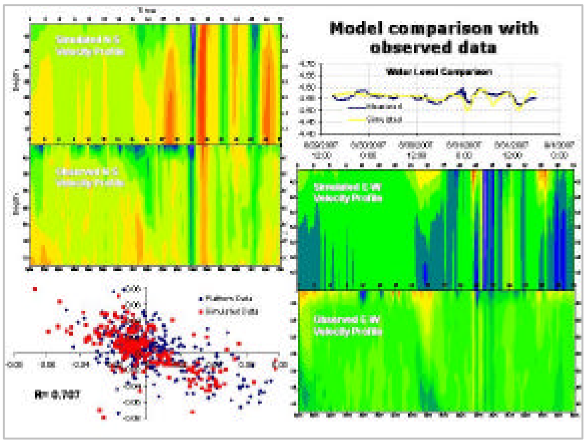


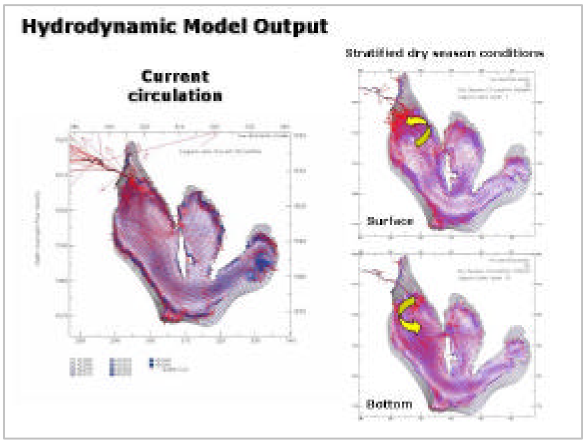

Seasonal Dynamics
Physical-chemical data
Salinity Time-series
Turbidity Time-series
DO Time-series
Salinity distribution
Turbidity distribution
DO distribution

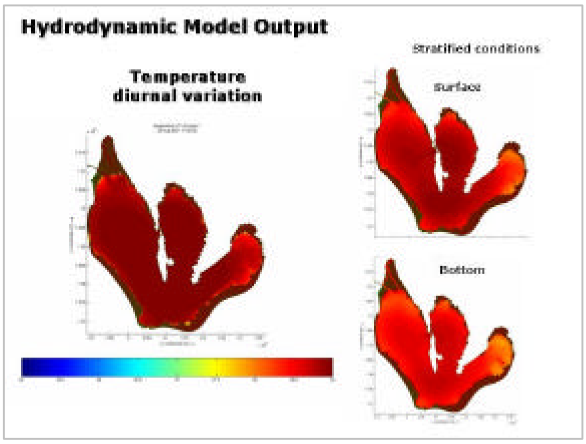

Intensive measurement
Laguna Lake's shallow nature, and wind and density driven currents bring significant and dynamic temporal and spatial variations in its physical, chemical and biological characteristics for any given meteorological condition.
Nadaoka Lab and LLDA research collaboration
48 hours intensive monitoring
Meteorological
Hydrodynamic
Water quality

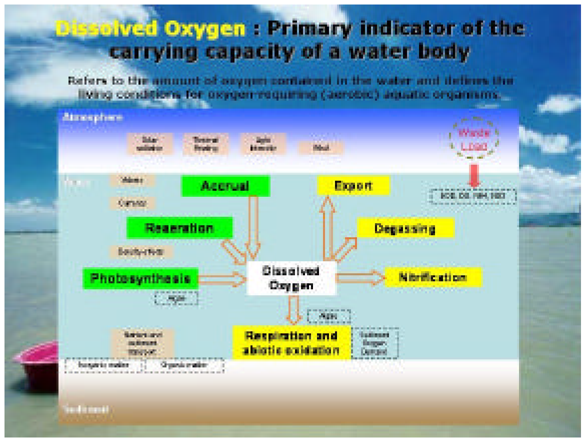

Diurnal Dynamics
Physical-chemical data
Wind speed and direction
Surface Turbidity

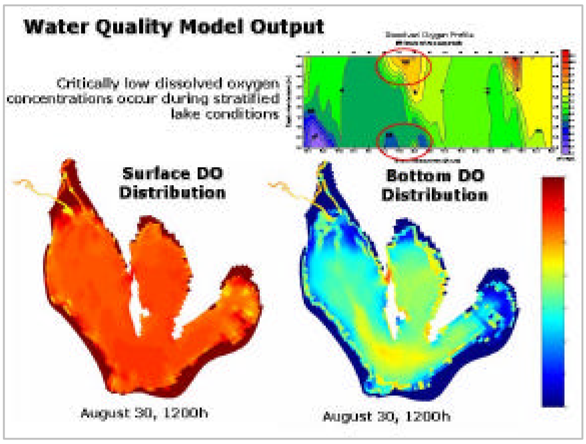

Numerical Simulation
Factors needed to be considered in the water balance of Laguna Lake
Laguna Lake Water Balance Components
Laguna Lake
Laguna Lake Model Grid and Bathymetry
Manila Bay

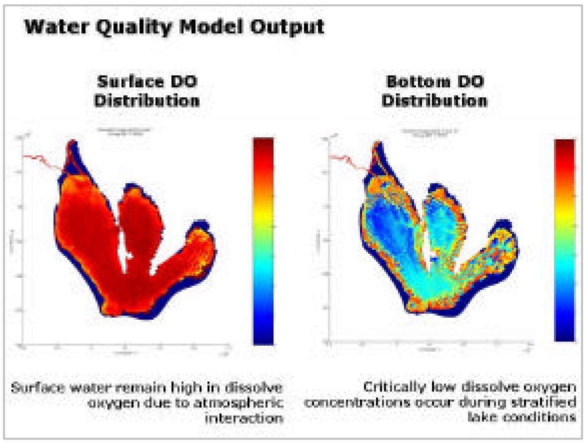

Model comparison with observed data
Water Level Comparison
R= 0.707


Hydrodynamic Model Output
Current circulation
Stratified dry season conditions
Surface
Bottom

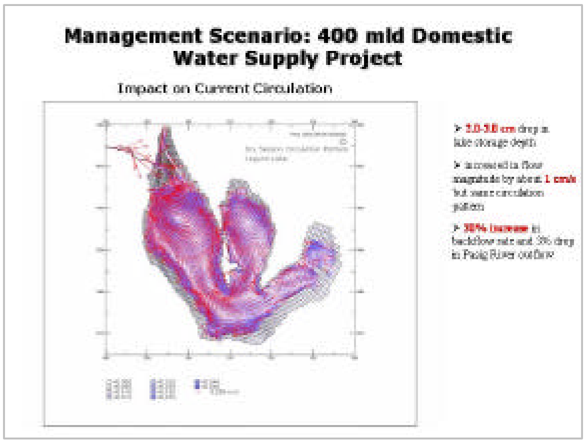

Hydrodynamic Model Output
Stratified conditions
Temperature diurnal variation
Surface
Bottom

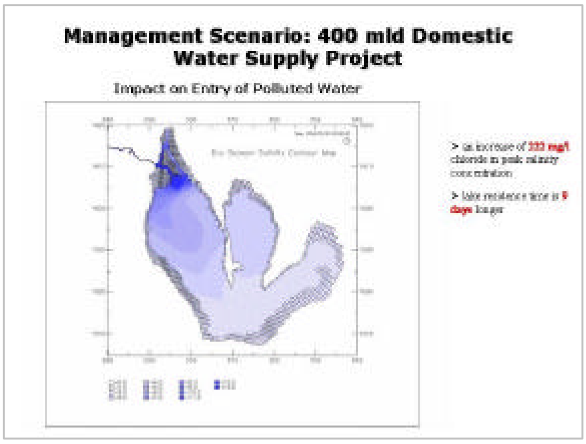

Dissolved Oxygen : Primary indicator of the carrying capacity of a water body
Refers to the amount of oxygen contained in the water and defines the living conditions for oxygen-requiring (aerobic) aquatic organisms.
Atmosphere
Waste Load
Accrual
Export
Reaeration
Degassing
Photosynthesis
Dissolved Oxygen
Nitrification
Respiration and abiotic oxidation
Sediment

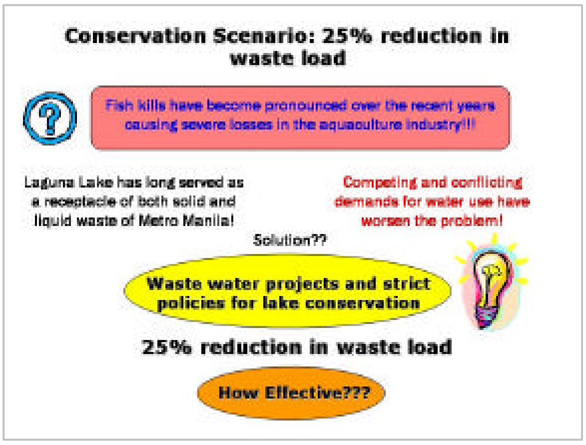

Water Quality Model Output
Critically low dissolved oxygen concentrations occur during stratified lake conditions
Surface DO Distribution
Bottom DO Distribution
August 30, 1200h
August 30, 1200h

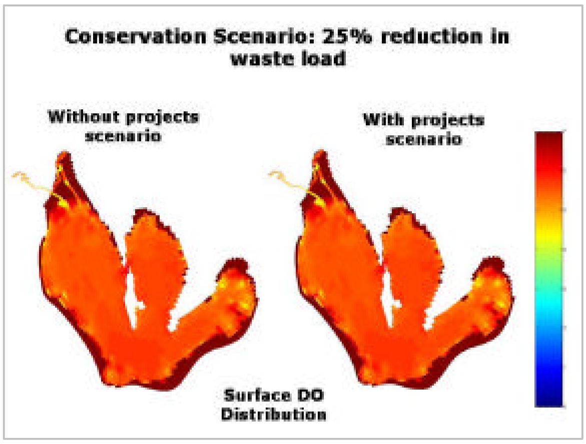

Water Quality Model Output
Surface DO Distribution
Bottom DO Distribution
Surface water remain high in dissolve oxygen due to atmospheric interaction
Critically low dissolve oxygen concentrations occur during stratified lake conditions

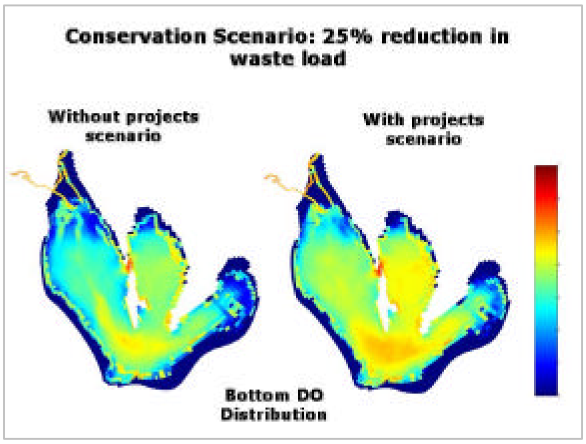

Management Scenario: 400 mld Domestic Water Supply Project
Metro Manila is bound to experience water crisis unless the government finds more sources of raw water soon!!! (Manila Times)
Metro Manila water demand already exceeded current capacity for supply!
Other dam water sources will be available only in year 2016!
Solution??
LAGUNA LAKE
400 mld Domestic Water Supply Project
How FEASIBLE???

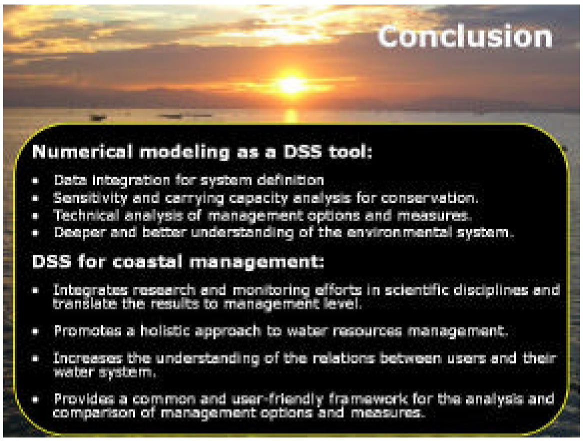

Management Scenario: 400 mld Domestic Water Supply Project
Impact on Current Circulation


Management Scenario: 400 mld Domestic Water Supply Project
Impact on Entry of Polluted Water

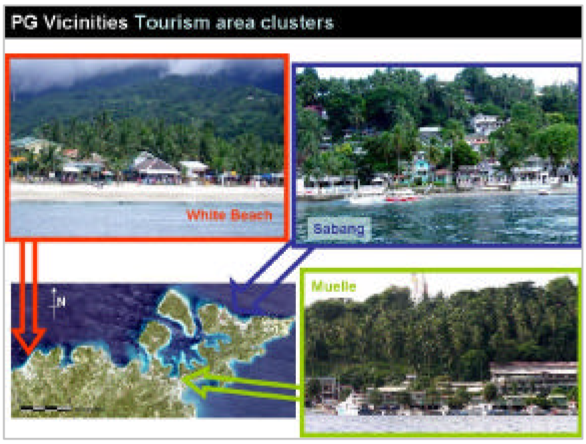

Conservation Scenario: 25% reduction in waste load
Fish kills have become pronounced over the recent years causing severe losses in the aquaculture industry!!!
Laguna Lake has long served as a receptacle of both solid and liquid waste of Metro Manila!
Competing and conflicting demands for water use have worsen the problem!
Solution??
Waste water projects and strict policies for lake conservation
25% reduction in waste load
How Effective???

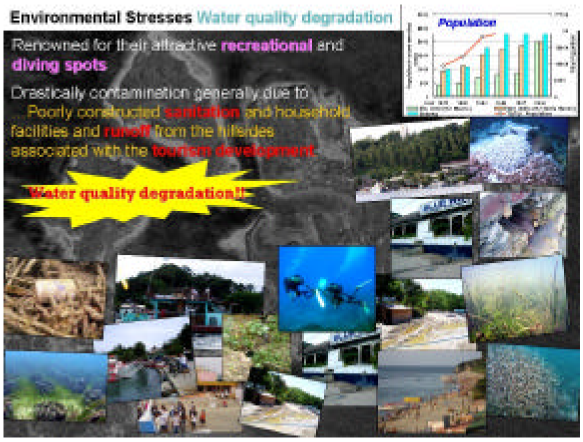

Conservation Scenario: 25% reduction in waste load
Without projects scenario
With projects scenario
Surface DO Distribution

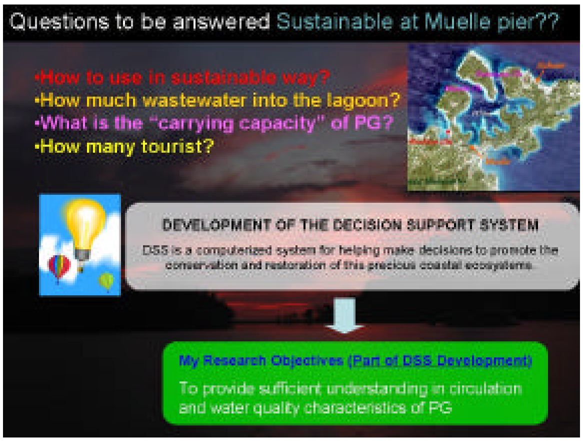

Conservation Scenario: 25% reduction in waste load
Without projects scenario
With projects scenario
Bottom DO Distribution

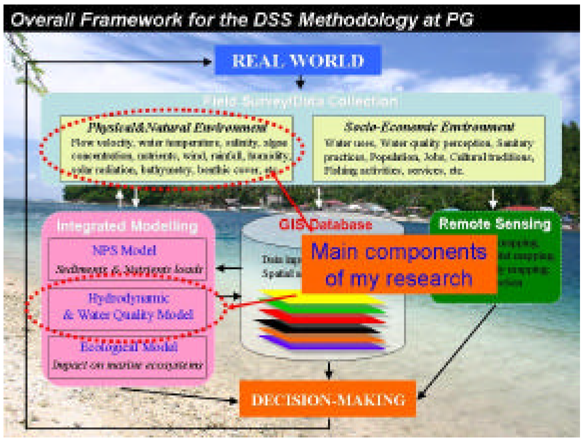


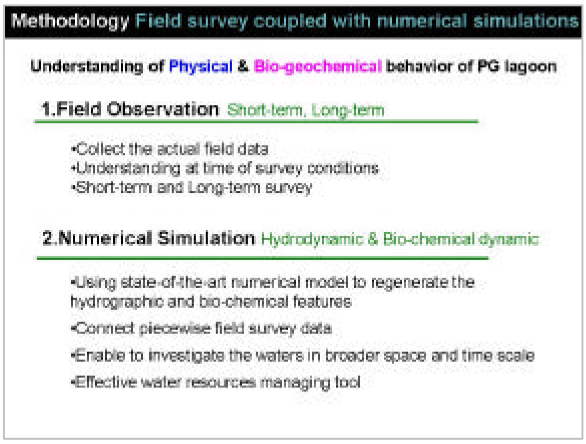
(9) Puerto Galera Water Modeling: Towards the Development of a Decision Support System for Water Resources Management

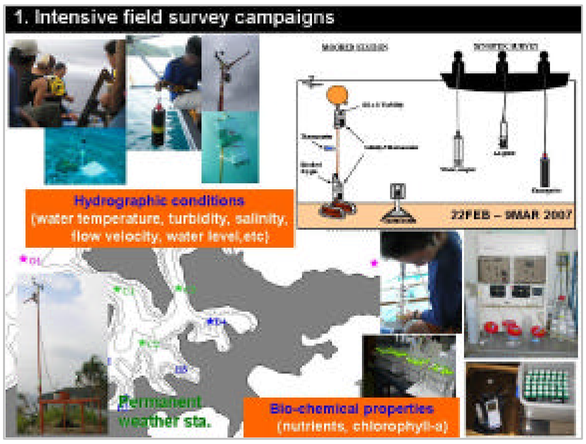


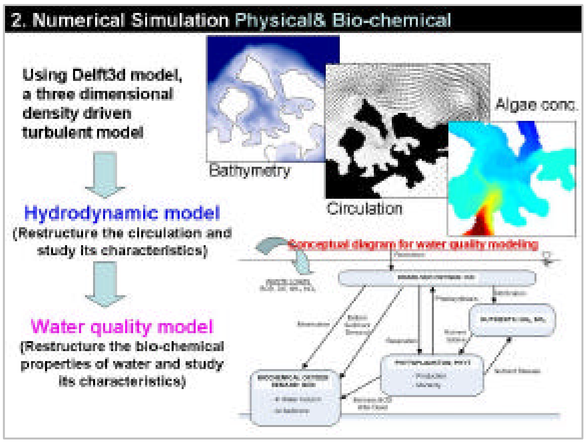


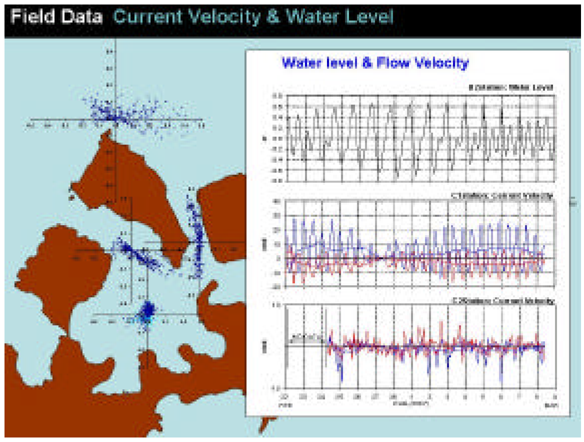


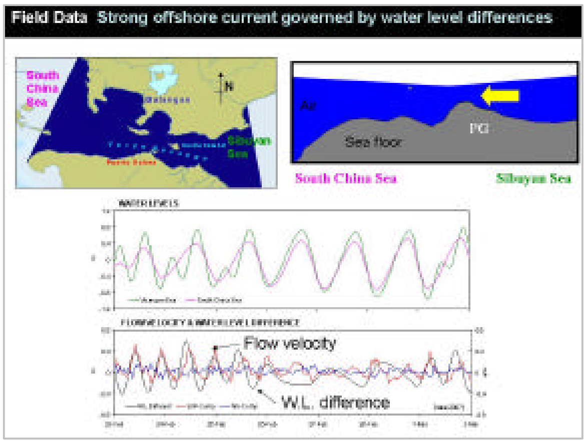


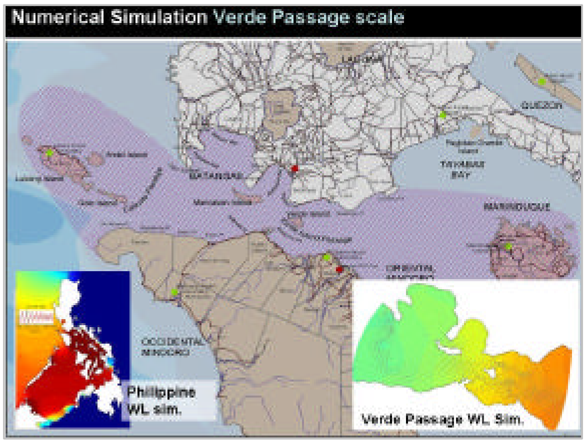

Methodology Field survey coupled with numerical simulations
Understanding of Physical & Bio-geochemical behavior of PG lagoon
1.Field Observation Short-term, Long-term
•Collect the actual field data
•Understanding at time of survey conditions
•Short-term and Long-term survey
2.Numerical Simulation Hydrodynamic & Bio-chemical dynamic
•Using state-of-the-art numerical model to regenerate the hydrographic and bio-chemical features
•Connect piecewise field survey data
•Enable to investigate the waters in broader space and time scale
•Effective water resources managing tool

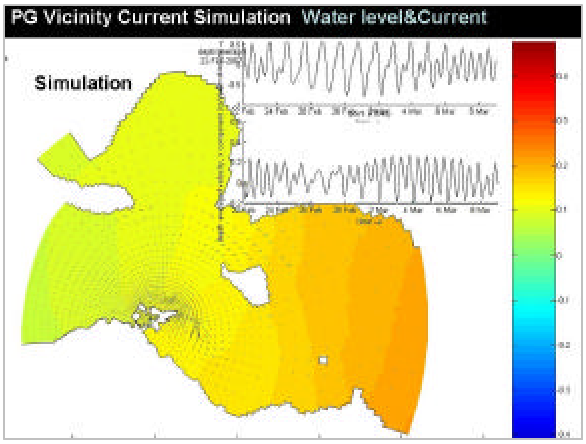

1. Intensive field survey campaigns
Hydrographic conditions
(water temperature, turbidity, salinity, flow velocity, water level,etc)
22FEB – 9MAR 2007
Permanent weather sta.
Bio-chemical properties
(nutrients, chlorophyll-a)

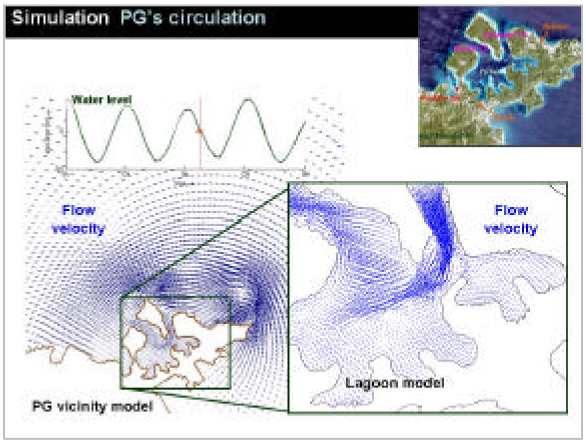

2. Numerical Simulation Physical& Bio-chemical
Using Delft3d model, a three dimensional density driven turbulent model
Bathymetry
Circulation
Algae conc.
Hydrodynamic model
(Restructure the circulation and study its characteristics)
Water quality model
(Restructure the bio-chemical properties of water and study its characteristics)
Conceptual diagram for water quality modeling

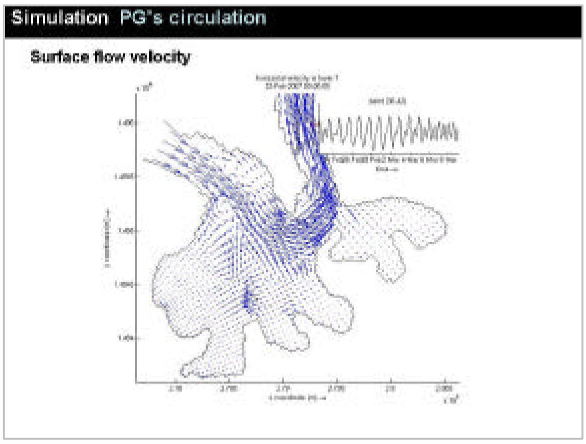

Field Data Current Velocity & Water Level
Water level & Flow Velocity

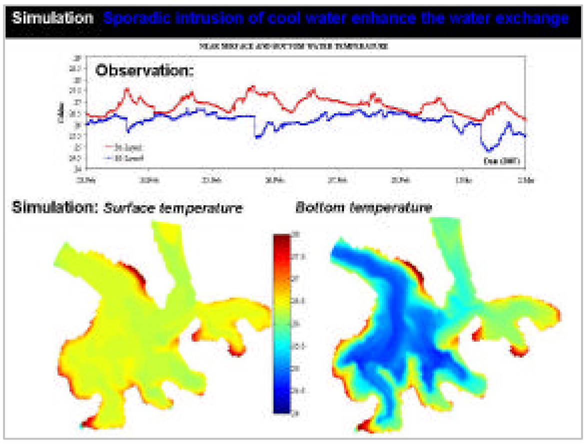

Field Data Strong offshore current governed by water level differences
South China Sea
Sibuyan Sea
Sea floor
PG
South China Sea
Sibuyan Sea
WATER LEVELS
Flow velocity
W.L. difference

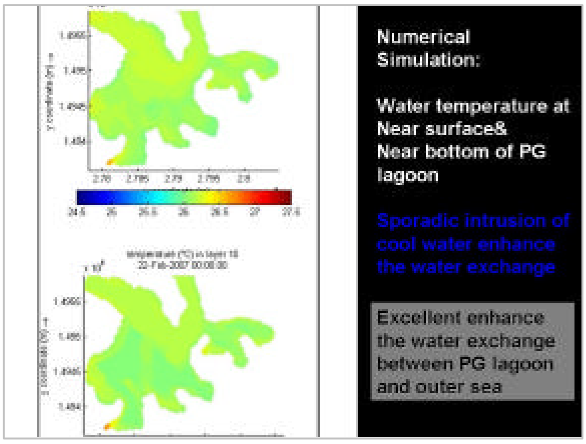

Numerical Simulation Verde Passage scale
QUEZON
BATANGAS
MARINDUQUE
OCCIDENTAL MINDORO
Philippine WL sim.
Verde Passage WL Sim.

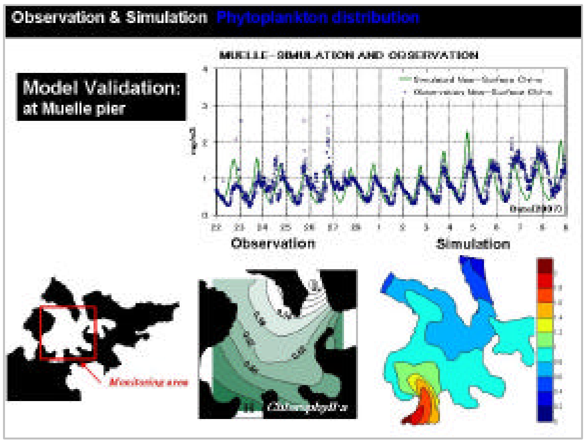

PG Vicinity Current Simulation Water level&Current
Simulation

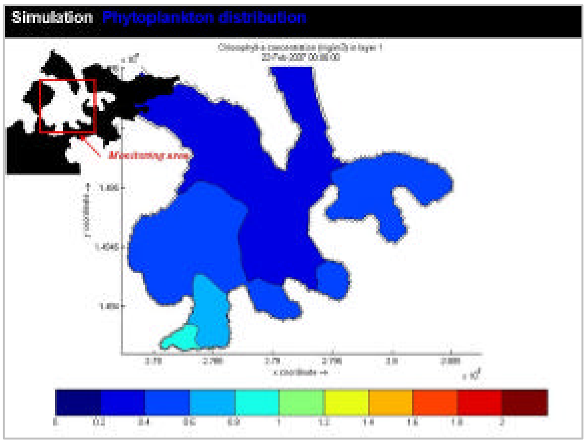

Simulation PG's circulation
Water level
Flow velocity
Flow velocity
Lagoon model
PG vicinity model

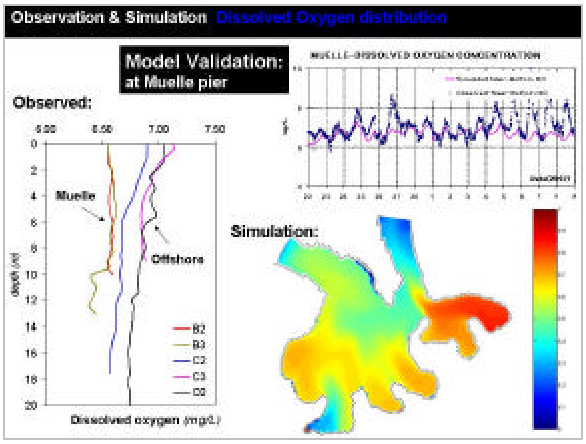

Simulation PG's circulation
Surface flow velocity

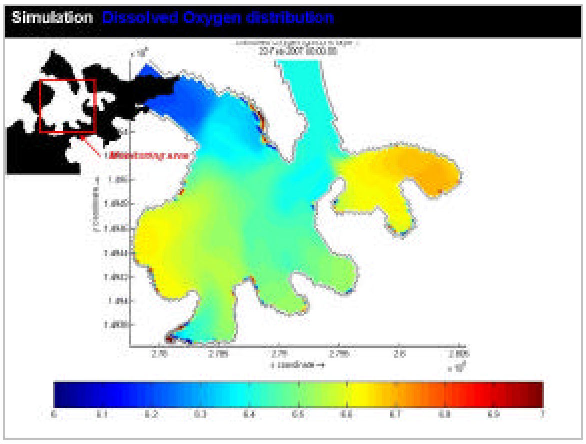

Simulation Sporadic intrusion of cool water enhance the water exchange
Observation:
Simulation: Surface temperature
Bottom temperature

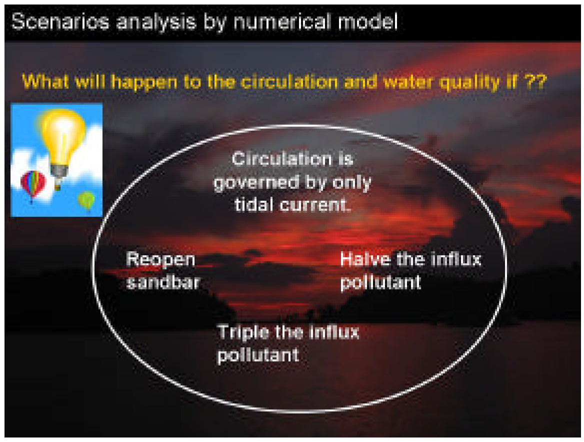

Numerical Simulation:
Water temperature at Near surface& Near bottom of PG lagoon
Sporadic intrusion of cool water enhance the water exchange
Excellent enhance the water exchange between PG lagoon and outer sea

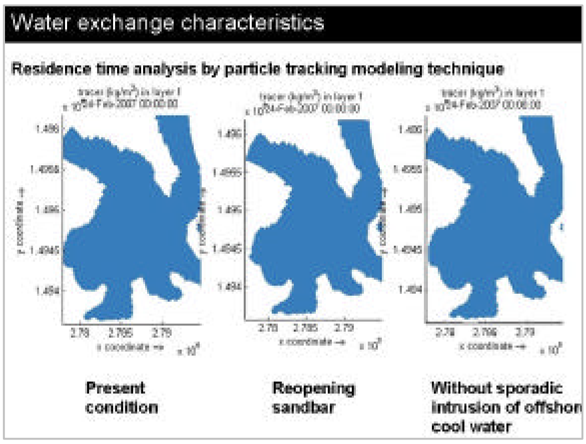

Observation & Simulation Phytoplankton distribution
Model Validation: at Muelle pier
MUELLE - SIMULATION AND OBSERVATION
Observation
Simulation
Monitoring area
Chlorophyll-a

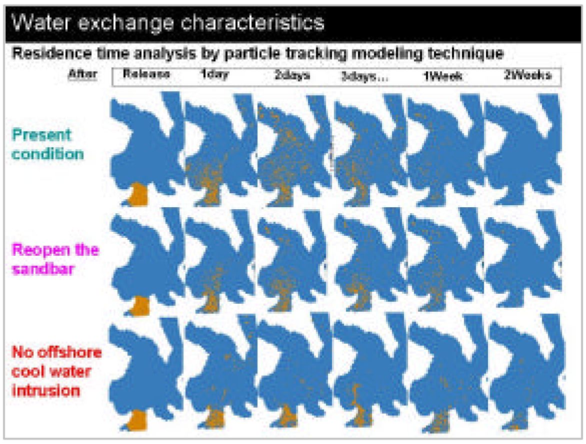

Simulation Phytoplankton distribution
Monitoring area

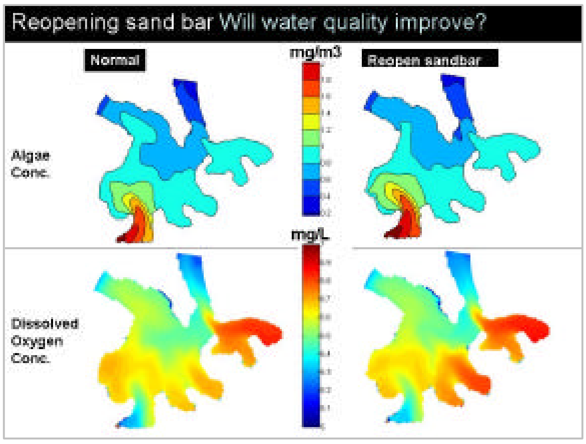

Observation & Simulation Dissolved Oxygen distribution
Model Validation: at Muelle pier
MUELLE-DISSOLVED OXYGEN CONCENTRATION
Observed:
Muelle
Offshore
Dissolved oxygen (mg/L)
Simulation:

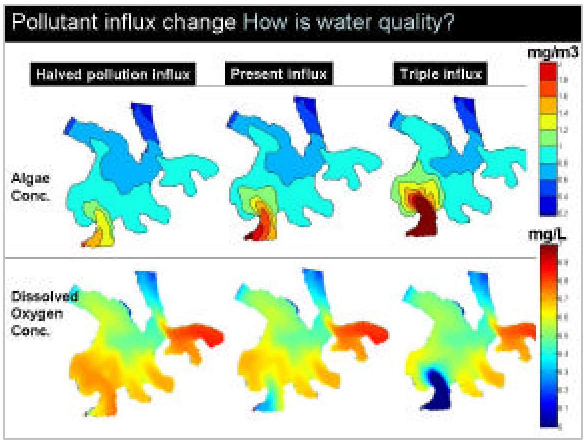

Simulation Dissolved Oxygen distribution
Monitoring area

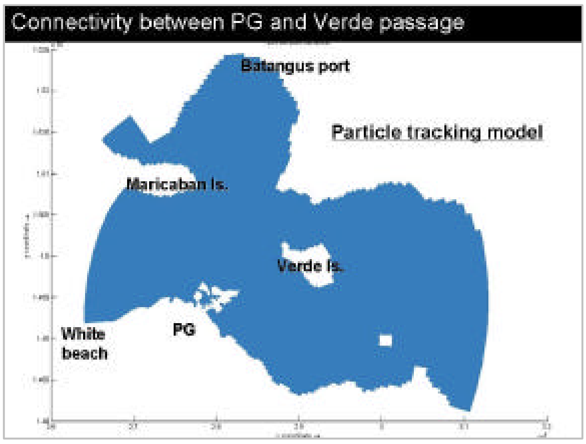

Scenarios analysis by numerical model
What will happen to the circulation and water quality if ??
Circulation is governed by only tidal current.
Reopen sandbar
Halve the influx pollutant
Triple the influx pollutant











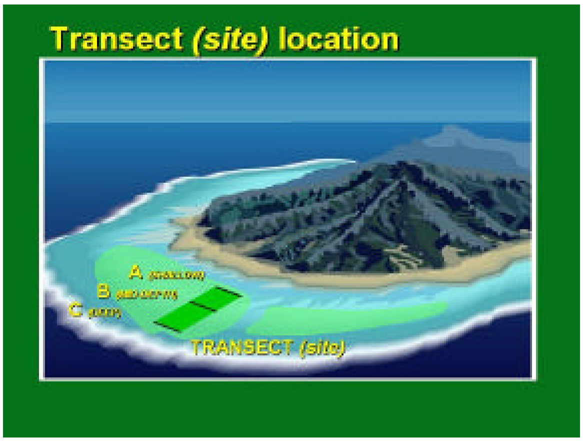
SUMMARY

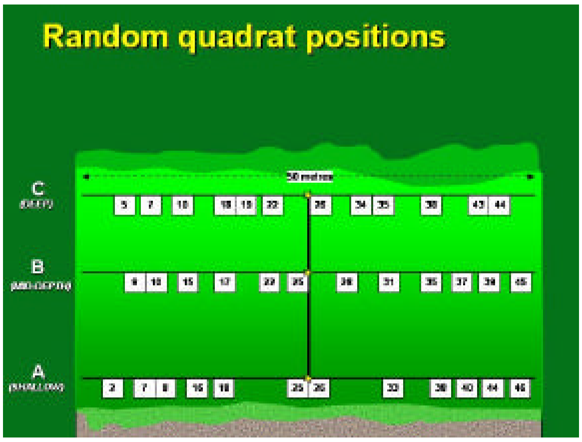
- Field observation coupled with numerical model can deliver the basic understanding of PG circulation and are important elements of DSS.
- Numerical simulation can be used to extend limitation of field data and to predict and answer what if scenarios.
- PG water circulation is governed by the differences of water level between two sides of Verde Passage.

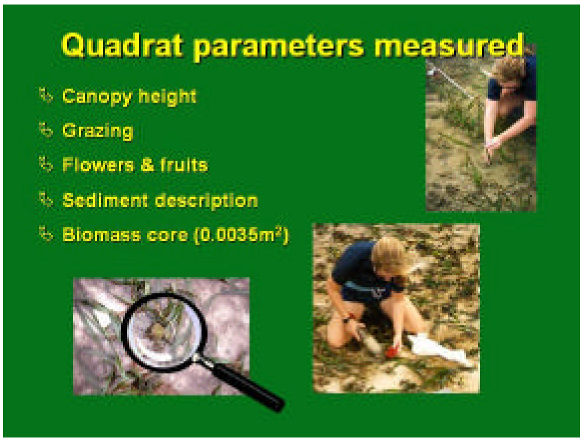
SUMMARY

- Immediate intermittent intrusion of cool water is very important to maintain the water exchange and water quality of PG lagoon especially around Muelle pier.
- Open sand bar can deliver positive improvement of water quality at area very close to sandbar. The improvement of water quality at Muelle cove is limited.
- The most effective way to mitigate the water quality problem at Muelle cove is to reduce the amount of input pollution.

(10) SeagrassNet as a Decision Support System in Conserving the Coasts for Tourism in Puerto Galera

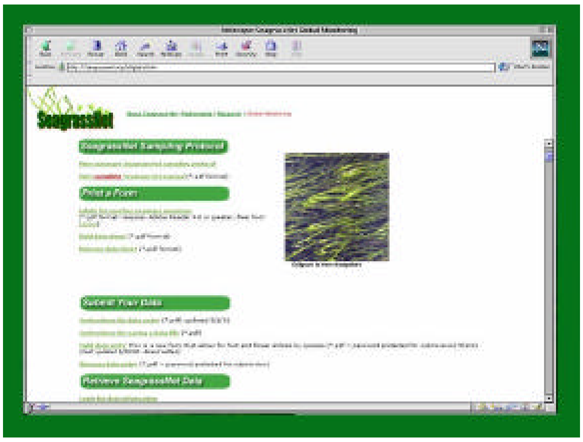


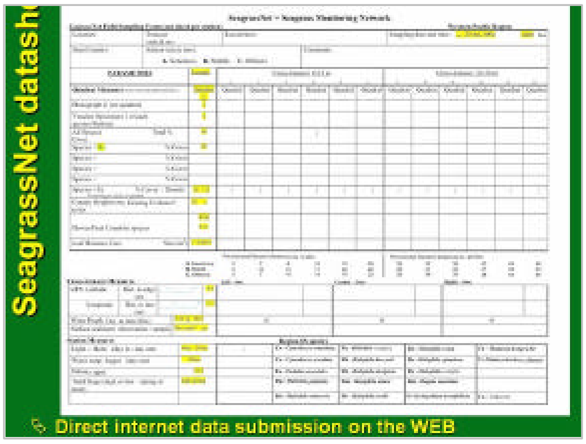


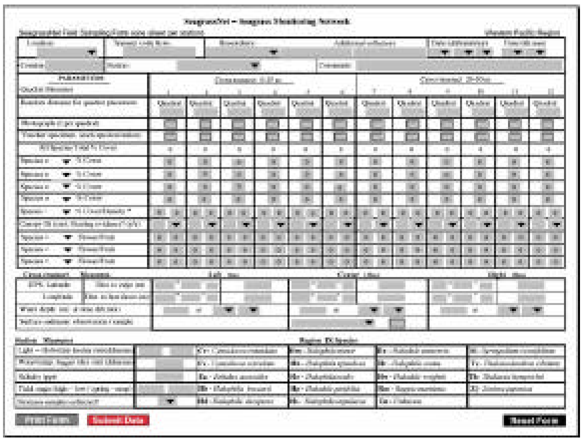


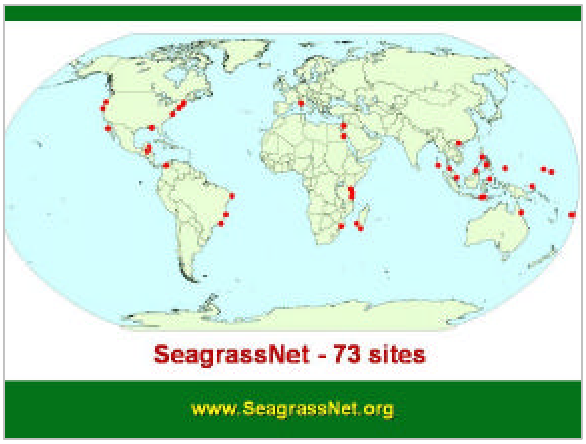

Manado, Indonesia
Placencia, Belize
Cabo Frio, Brazil
New Hampshire, USA

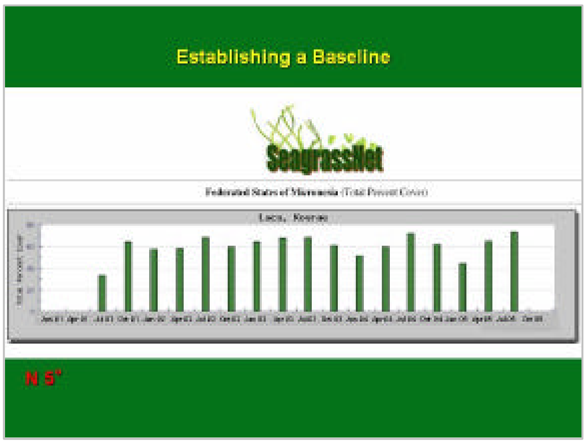

Pohnpei, Micronesia
Inhaca Island, Mozambique
2007
Wadi Gemal, Egypt
Eilat, Israel

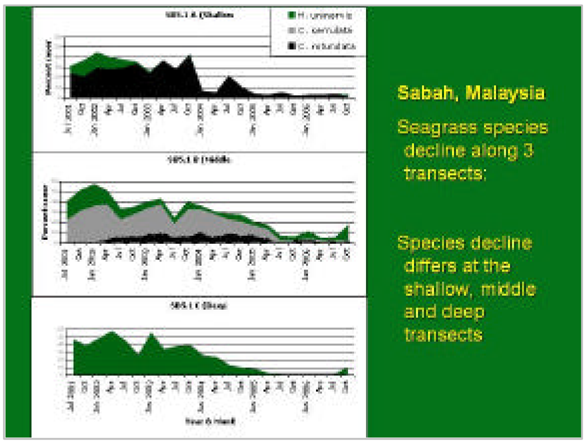

SeagrassNet
SeagrassNet Sampling Protocol
Print a Form
Submit Your Data
Retrieve SeagrassNet Data

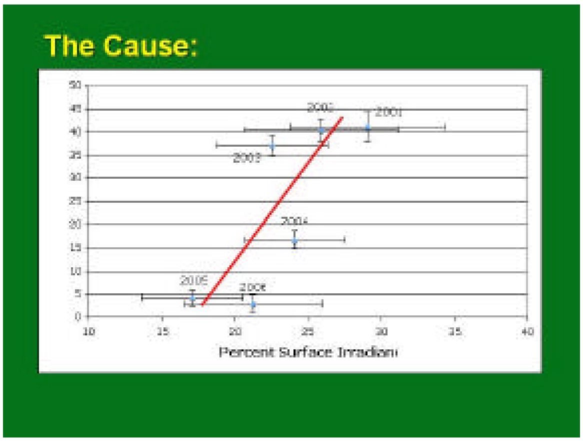

SeagrassNet datash
Direct internet data submission on the WEB

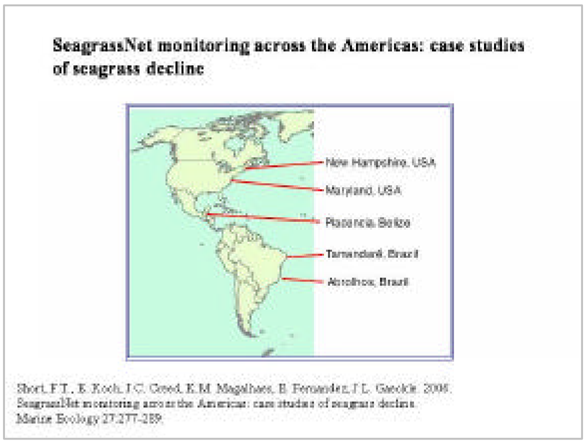

SeagrassNet – Seagrass Monitoring Network

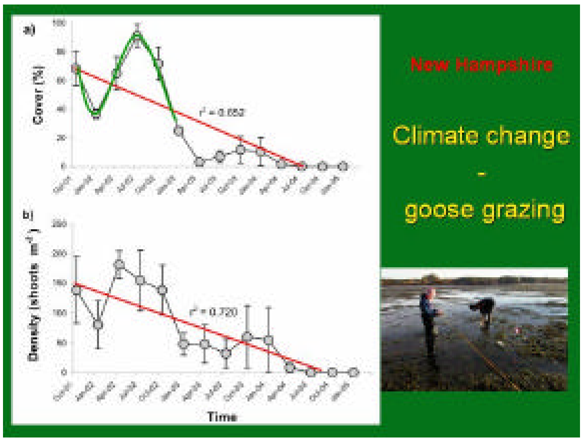

SeagrassNet - 73 sites
www.SeagrassNet.org

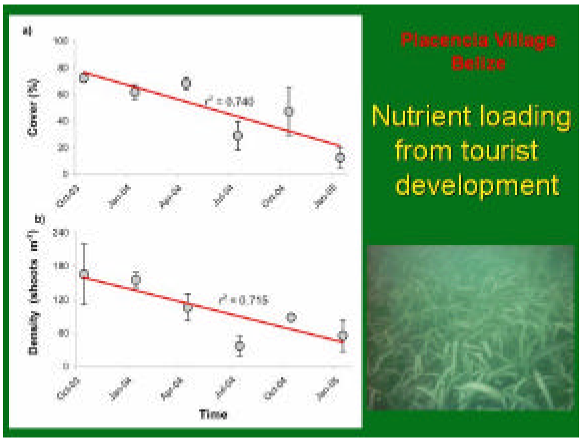

Establishing a Baseline
SeagrassNet
Federated States of Micronesia (Total Percent Cover)
N 5°

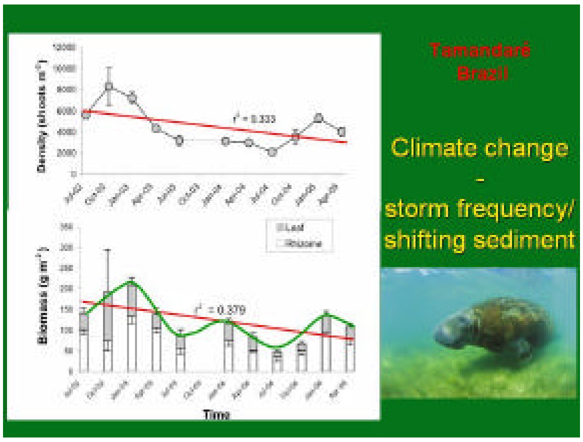

Sabah, Malaysia
Seagrass species decline along 3 transects:
Species decline differs at the shallow, middle and deep transects


The Cause:
2002
2001
2003
2004
2005
2006
Percent Surface Irradiance


SeagrassNet monitoring across the Americas: case studies of seagrass decline
New Hampshire, USA
Maryland, USA
Placencia, Belize
Tamandaré, Brazil
Abrolhos, Brazil
Short, F.T., E. Koch, J.C. Creed, K.M. Magalhaes, E. Fernandez, J.L. Gaeckle. 2006. SeagrassNet monitoring across the Americas: case studies of seagrass decline. Marine Ecology 27:277-289.


New Hampshire
Climate change
-
goose grazing
a)
Cover (%)
b)
Density (shoots m⁻²)
Time

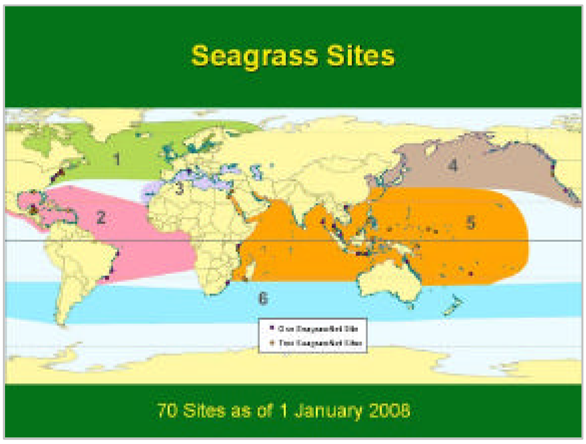

Placencia Village
Belize
Nutrient loading from tourist development
a)
Cover (%)
b)
Density (shoots m⁻²)
Time

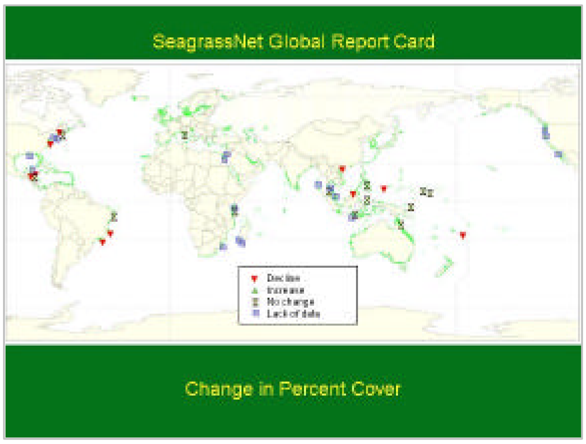

Tamandaré
Brazil
Climate change
-
storm frequency/ shifting sediment
Density (shoots m⁻²)
Biomass (g m⁻²)
Time

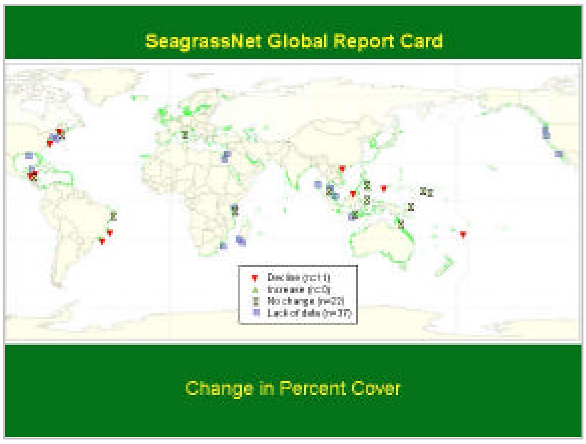

Suspended Sediments
--
Massive land clearing and deforestation in Malaysia

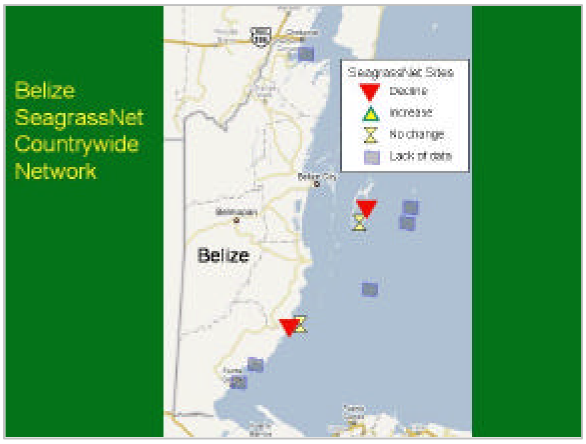

Nutrient Enrichment > Algae

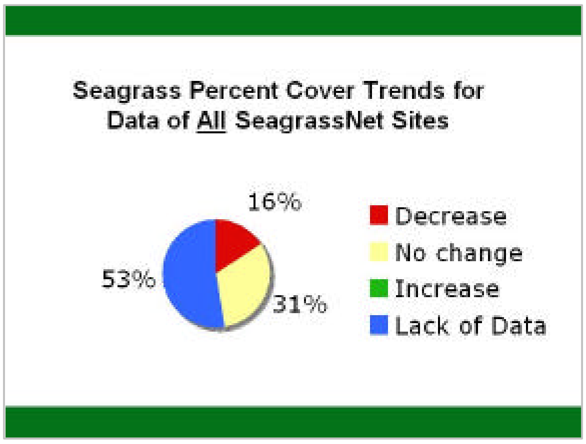

Causes of decline globally:
Sediment loading
Nutrient loading
Climate change
Direct physical damage
© Galice Hoarau

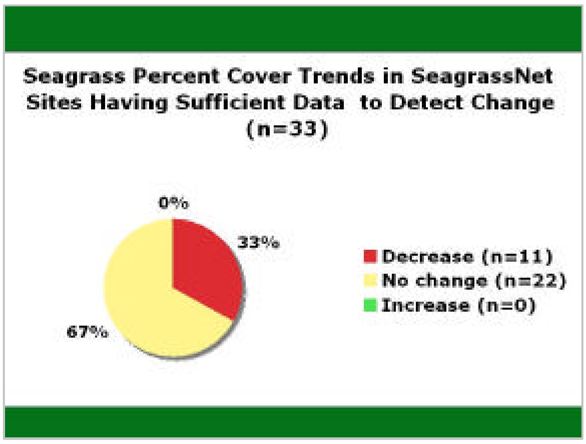






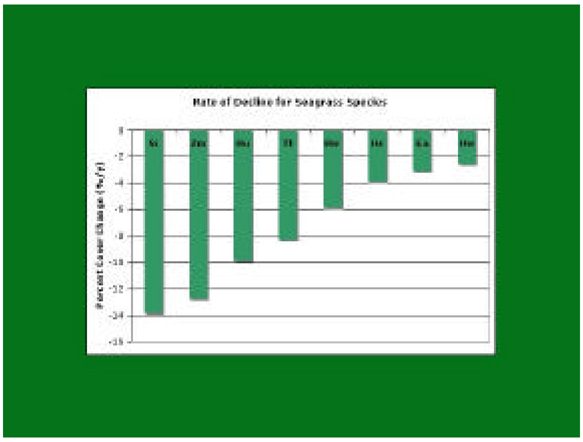


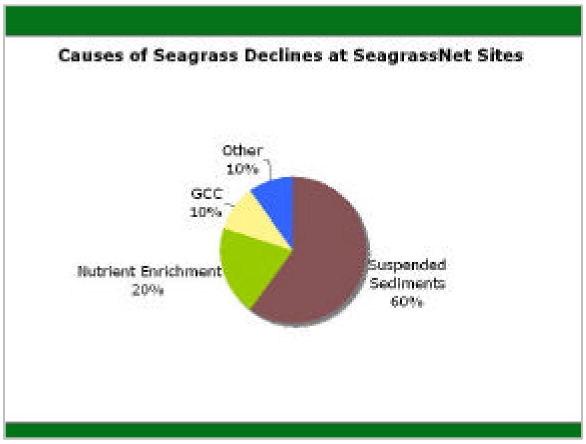


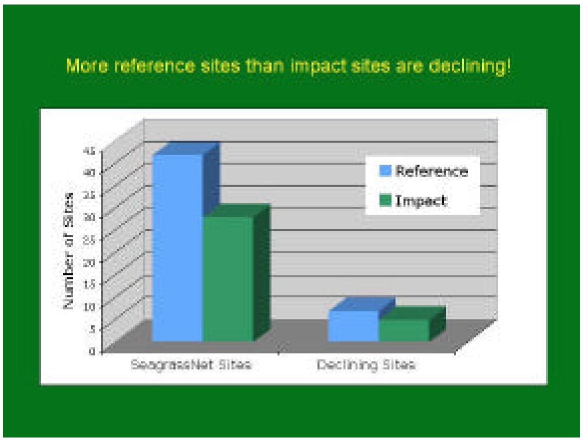


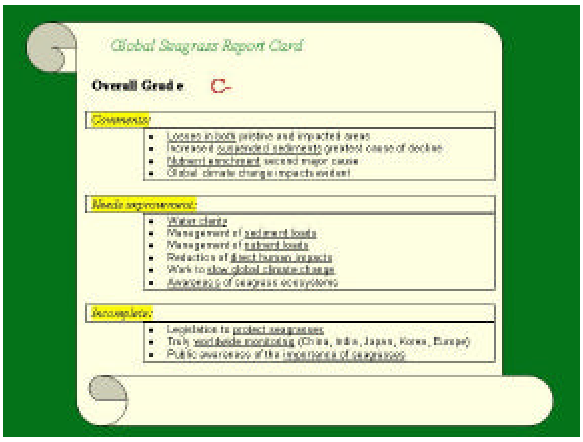
Seagrass species showing decline
at SeagrassNet sites

Dominant Seagrass Species	Sites (or Sub-transects) Showing Declines
Halodule wrightii	3
Zostera marina	3
Thalassia testudinum	1
Enhalus acoroides	1
Zostera japonica	1
Halophila spinulosa	1(2T)
Halodule uninervis	1(2T)
Syringodium isoetifolium	1(2T)
Cymodocea rotundata	1(1T)
Cymodocea serrulata	1(1T)
Ruppia maritima	1(1T)
Thalassia hemprichii	1(1T)

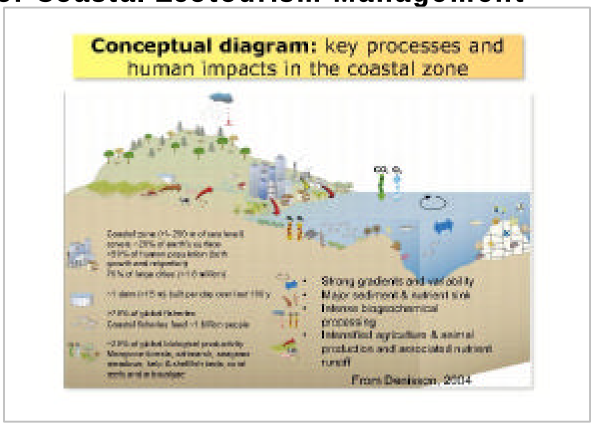




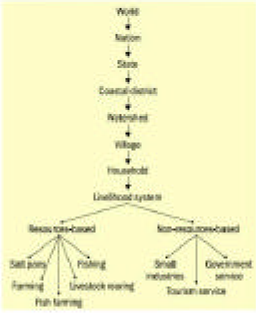




(11) Spatial Decision Support System for Coastal Ecotourism Management



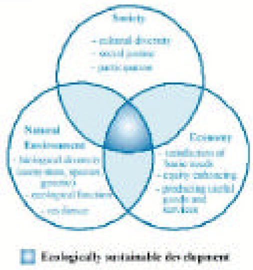
Hierarchy of Coastal Ecosystems



Towards a sustainable coastal tourism

Ecologically sustainable development:

- acknowledges the interdependence of society, natural environment and economy
- Recognizes that the present environment presents opportunities and sets constraints
- is also about bringing together the various interest groups



Ecologically-sustainable tourism

- Does not use non-renewable resources faster than renewable substitutes can be found for them
- Does not use **renewable resources faster** than they can be replenished
- **Minimizes** operational **energy** consumption
- Does not release pollutants faster than the biosphere can process them to a harmless state
- Has **no impact** on biodiversity and ecological systems and processes
- Maintains a full range of recreational, educational and cultural **opportunities** for the **present** generation and **future** generations
- **Benefits local communities** and the region socially and economically
- Does not affect the capacity of **other sectors** of the economy to achieve ecological sustainability.

Guiding Principles for Sustainable Coastal Dev't

- Interdependence
- Balance
- Cumulative impacts
- Value for conservation
- Cultural heritage
- Flexibility
- Integrated planning
- Consultation with the community
- Siting
- Design
- Monitoring

Coastal Tourism:Stages of development process

Stage 1: Feasibility

Stage 2: Planning & design

Stage 3: Assessment & approval

Stage 4: Construction

Stage 5: Operation & management

Terms of environmental acceptability (1)

- avoid changing or damaging, either directly or indirectly, coastal sites of ecological, heritage, cultural, scientific or educational significance such as:
  - Mangroves
  - Wetlands
  - Dunes
  - Estuaries
  - Historical or archaeological sites
  - Sacred or culturally significant sites - sites containing any threatened or endangered species
  - nesting sites for marine reptiles, mammals and sea birds

Terms of environmental acceptability (2)

- investigate and plan according to:
  - soil type (erosion potential, structural capacity, suitability for building and the presence of acid sulfate soils)
  - presence of threatened or **endangered** plants or animals
  - **resilience or fragility** of existing vegetation
  - **other uses** of catchment areas that you may affect or that may affect you
  - **cumulative pressure and impact** of other activities in the area
-

Terms of environmental acceptability (3)

- incorporate buffer areas
- avoid interfering with others' use of land or water in the surrounding area
- minimise or eliminate vegetation clearance and maintain tree cover and dunal vegetation - you can also collect seeds and save seedlings to transplant for revegetation
- incorporate measures to prevent erosion, subsidence, landslip and inundation
- incorporate waste management measures which prevent unacceptable pollution of the land and water
- comply with the planning requirements for your type of development.

Terms of social acceptability (1)

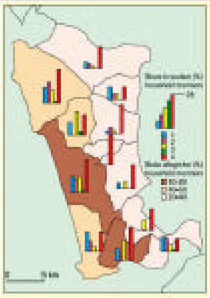
- recognise that **current land use - is valid**, and some people will not want it to change
- ensure that the development will place no undue financial burden on local communities
- investigate surrounding land uses which may affect your development or with which your development may be incompatible

Terms of social acceptability (2)

- consider the development's potential to disturb local residents due to:
  - loss of outlook or views
  - sunlight restriction
  - decrease in privacy
  - pollution (air, noise, water, light)
  - traffic and parking problems
  - loss of open space or parkland
  - loss of heritage or cultural sites

Terms of social acceptability (3)

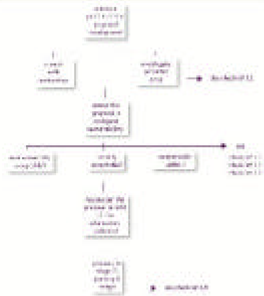
- consult further with local communities about the likely impact of the proposed development
- use the consultation process to obtain ideas and to gain support
- identify local concerns
- formulate a community contract or agreement



Terms of economic viability (1)

- identify your **proposed market**, now and in the future
- identify **existing facilities and/or activities** that cater for this market, whether there are too few or whether they lack characteristics for which there is a demand
- assess the **compatibility** of proposed activities with others currently available in the area
- consider and compare the **cost** of acquisition, consolidation or long-term lease of the land
- identify **funding sources**, and any government **incentives** such as tax concessions or rate reductions

Checklist for tourism development



Terms of economic viability (2)

- Prepare cash flow projections for both the development and operational phases of the project, including:
  - cost of environmental rehabilitation and regeneration
  - anticipated costs and contingency budgets
  - likely level of use and expenditure
  - realistic estimates of projected revenues, in both the short and long terms
  - projected profit and loss for short- and long-term intervals
  - expected yield on the investment, profit margin and rate of return
  - projected discounted cash flow analysis over the life of the project
  - financing of the project and any annual debt servicing implications
  - sensitivities to factors such as cost and timing over-runs, higher inflation and interest rates and decreased usage rates
  - appraisal of project options - for example, development in stages, possible modifications, scaling down, increased equity versus finance

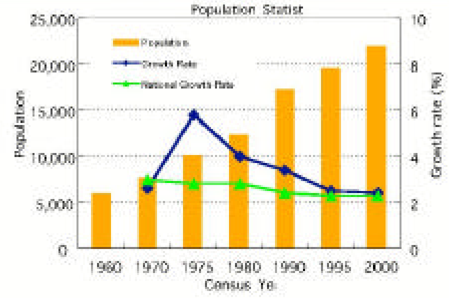
Terms of economic viability (3)

- **costs**
- Viability of development
- **marketing strategy**
- Compensation for affected communities

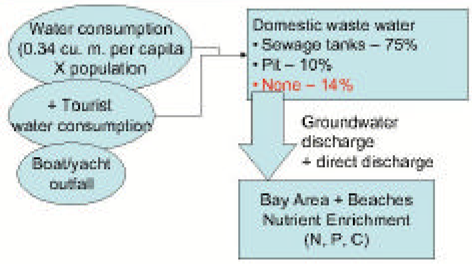
Information for Better Coastal Tourism Management

- Clearly, we need information to make better decisions on sustainable coastal tourism
- What are the sources of these information?
  1. Census Data
     - Population and housing
     - Construction and Infrastructure
     - Agriculture and Fisheries
  2. Field surveys by scientists, monitoring by people
  3. Maps
     - Remote sensing: Satellite images, aerial photography
     - Thematic maps by government agencies
  4. Local government transactions
  5. Tourism facility operations

Puerto Galera: Population Growth



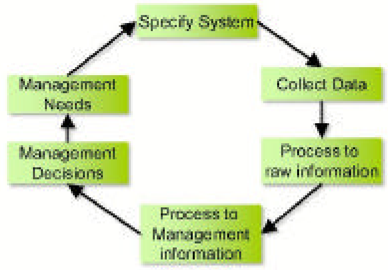
Puerto Galera Environmental Loads – Sewage Outfall



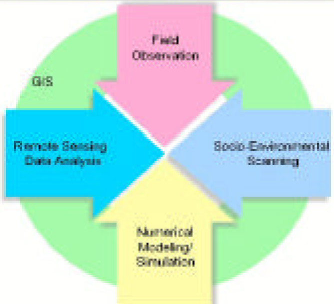
RMIS Implementation Requires

- Precise definition of information needs
  - Type
  - Resolution
  - Accuracy and reliability when required
- Detailed information on physical environment in which the system will operate
  - Physical characteristics
  - Detailed description of resources to be monitored
- How the resources are to be managed
  - How is the information going to be used
  - Who will use the information
  - Who will collect and prepare the information
- Other relevant considerations
  - Financial, logistics, political, and other constraints

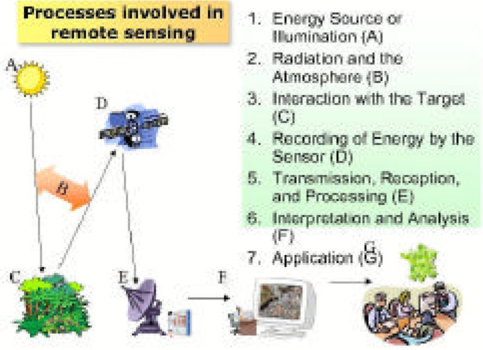
Information Flow in RMIS



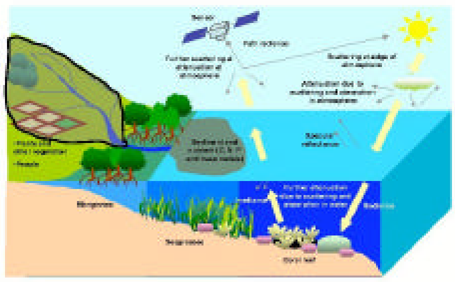
Science-based tools for assessment



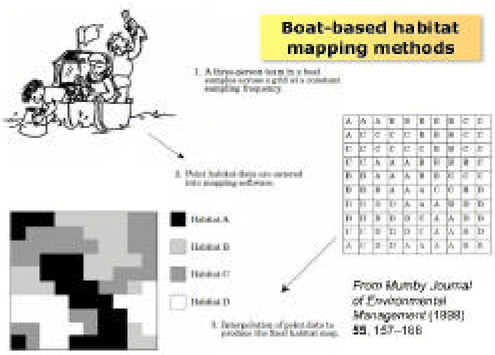
Processes involved in remote sensing



Features of the coastal zone and the remote sensing process

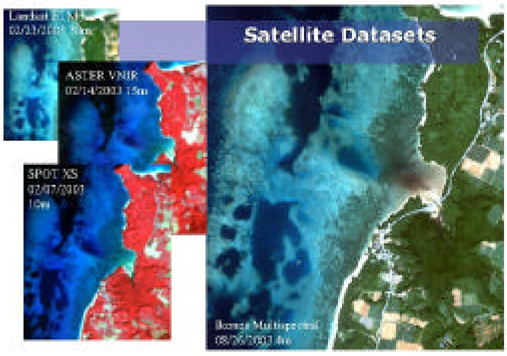


Boat-based habitat mapping methods



Uses of Remote Sensing

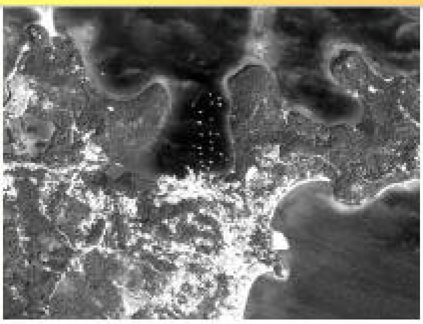
- Production of base maps/charts
- Resource inventory and baseline mapping
- Monitoring land-cover patterns and disasters
- Monitoring population structure
- Monitoring other environmental features and processes
  - Environmental sensitivity
  - Water circulation
  - Shoreline changes
  - Aquaculture management
  - Biological productivity
- Field survey planning



Example: Single Band (Blue) Image

Example: Single Band (Green) Image

Example: Single Band (Green) Image



Example: Single Band (NIR) Image

Example: True Color Image

Example: Near Infrared (NIR) Image

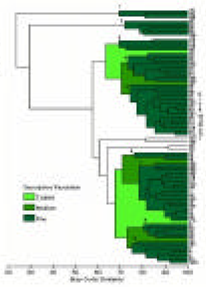
Applications of Remote Sensing For Coastal Habitat Assessment and Monitoring

Mapping Corals and Macroalgae

- Satellite images reveal a lot of information through tone, color, texture, and pattern of different habitat
- CONTEXTUAL EDITING - "the application of common sense to habitat mapping"

Field data multivariate classification

Right: Dendrogram for seagrass habitats showing three levels of descriptive resolution. Clusters 1 and 2 exist at all three levels of the hierarchy and small clusters such as those between 5 and 6 (uncoloured), are removed because they are too rare



From Edwards et. al (2000)

Preliminary marine classification

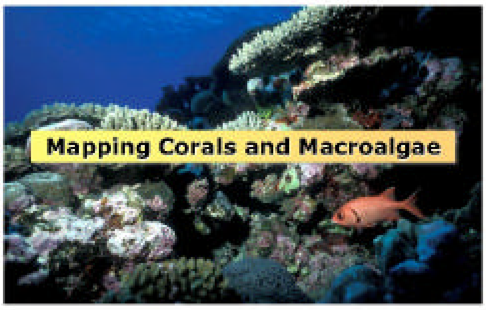
General habitat type	Specific habitat classes
Reef	Forereef Spur and groove Gorgonian plain Montastraea reef *Acropora palmata* zone (i.e. branching corals) Reef crest Back reef Mixed back reef community (seagrass / corals) Algal rubble, *Porites* spp. zone Carbonate pavement Patch reef
Bare Substratum	Sand Mud Hard substratum
Seagrass	*Thalassia* dominated (high density) *Thalassia* dominated (low density) *Syringodium* dominated (high density) *Syringodium* dominated (low density) Mixed seagrasses (high density) Mixed seagrasses (low density)

From Edwards et. al (2000)

Seagrass habitat classification

Descriptive Resolution

Coarse	Medium	Fine
Rare habitat classes (removed)		*Halodule wrightii* of low standing crop (5 g m-2)
		Syringodium filiforme of low standing crop (5 g m-2)
		Thalassia testudinum, *Syringodium filiforme*, and *Halodule wrightii* of low to medium standing crop (< 10 g m-2)
Seagrass habitats 4, 1	*Thalassia* and *Syringodium* of medium to high standing crop	*Thalassia testudinum* and *Syringodium filiforme* of standing crop (5-80 g m-2)
		Thalassia testudinum and *Syringodium filiforme* of standing crop (80-280 g m-2)
Sand habitats 6, 7, 8	low standing crop *Thalassia* and sparse algae	*Thalassia testudinum* of low standing crop (5 g m-2) and *Batophora* sp. (33%)
		Thalassia testudinum of low standing crop (5 g m-2) and sand
	low to medium standing crop	medium dense colonies of calcareous algae – principally *Halimeda* spp. (25 m-2) *Thalassia testudinum* of low standing crop (< 10 g m-2)
Algal habitats 9	*Thalassia* and dense calcareous algae	dense colonies of calcareous algae – principally *Penicillus* spp. (35 m-2) and *Halimeda* spp. (133 m-2) *Thalassia testudinum* of medium standing crop (~80 g m-2)



Macroalgae

Describes algae that are large enough to see by the eye

1. Fleshy algae
2. Calcareous algae
3. Turf algae
4. Crustose algae

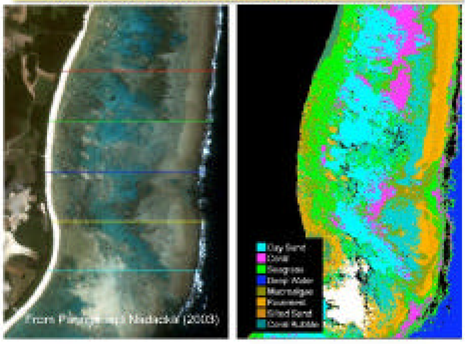
Three species -

- Red - important reef-building organisms
- Green algae (Chlorophyta) ex. Enteromorpha, Halimeda
- Brown algae (Phaeophyta) - contain brown pigment fucoxanthin

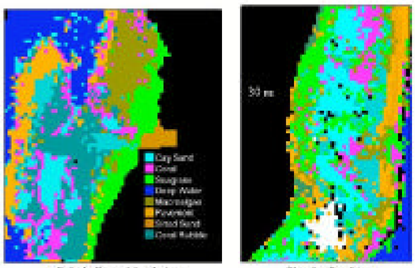
General Classes

- Sand
- Seagrass
- Corals
- Algae

Sample of Image Classification

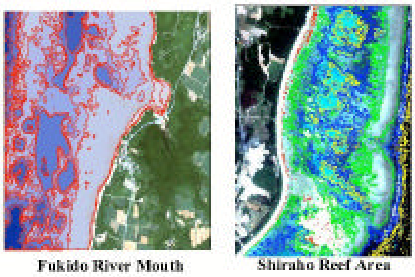


Benthic Cover from Image Classification



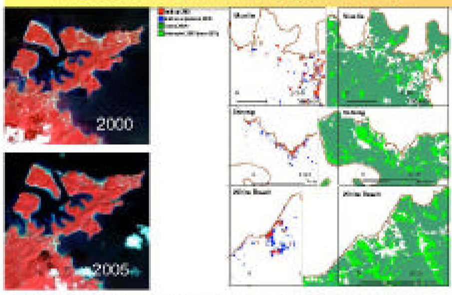
Fukido River Mouth Area — Shiraho Reef Area

Bathymetry Mapping



Fukido River Mouth — Shiraho Reef Area

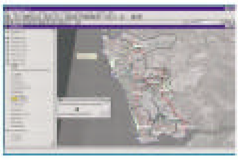
Puerto Galera: Land Cover Study



Images taken from Advanced Spectral and Thermal Radiometer (ASTER)

The DSS Toolkit

1. Visualization tools
2. Spatial analysis techniques
3. Advanced analysis modelling tools
4. Decision alternatives evaluation



Decision support systems (DSS)

- ***Definition***: Systems that provide help in making decisions in complex situations by using data and models to evaluate one or alternative models of solution of a management issue
- Basically a reduction of decision alternatives so managers can evaluate

DSS: Key features

- They do not make decisions!!!
- It must use data and models to mimic aspects of the environment that are of interest
- It is interactive
- Used to confront complex issues

Some definitions (1)

- *Decision:* choice between alternatives
- *Decision frame:* set of alternatives
- *Candidate set:* individuals to whom decisions will apply
- *Decision set:* set of all individuals that are assigned a specific alternative
- *Criterion:* basis to which a decision is measured and evaluated
- *Factor:* criterion that enhances or detracts from suitability
- *Constraint:* serves to limit alternatives under consideration

Some definitions (1)

- *Decision rule:* procedure by which criteria are selected and combined
- *Choice function:* mathematical means of comparing alternatives
  - Choice heuristic: procedure than function
- *Evaluation:* process of applying a decision

Types of decisions

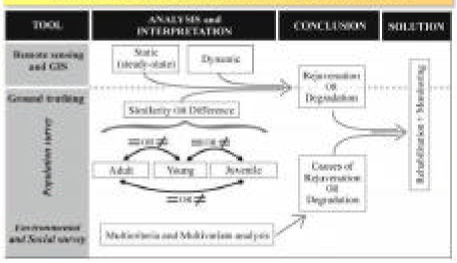
	Single criteria	Multicriteria
Single objective		
Multicriteria objective		

Multicriteria Evaluation (MCE)

Steps:

- Identify the factors and describe the model
- Create the numerical relationship between factors and suitability
- Scale the suitability
- Determine the weights to be applied

DSS as early warning system



From F. DAHDOUH-GUEBAS, 2007

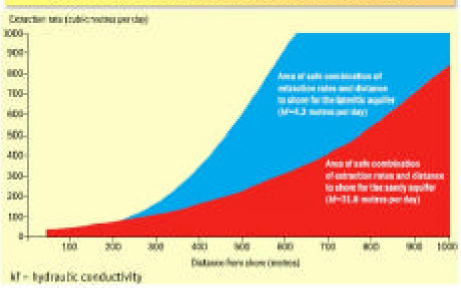
Problems associated with coastal tourism

- Lack/absence of wastewater disposal facility
- Lack/absence of solid waste disposal facility
- Shortage in (good) water supply
- Unplanned development – crowding
- Pollution
- Degradation of habitats
- Degradation of sea water quality
- Conversion of important land uses
- Loss of cultural identity (social)

Some key management actions

- Pollution abatement plans
- MONITORING and EVALUATION of environmental conditions
- Policies, laws, permits and enforcement
- Financing
- IEC (Information, Education and Communication)
  - Through scenario-building (e.g. modeling)

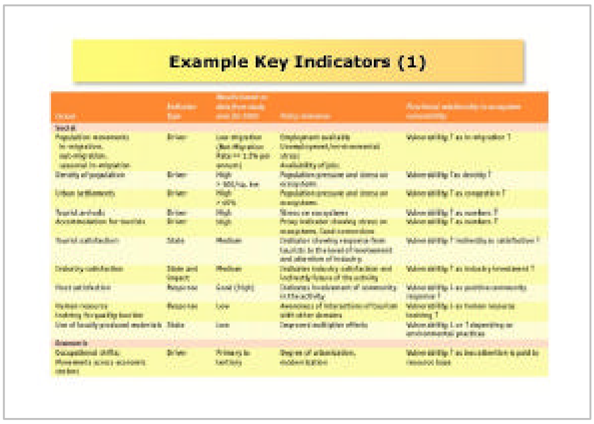
Example of indicative models

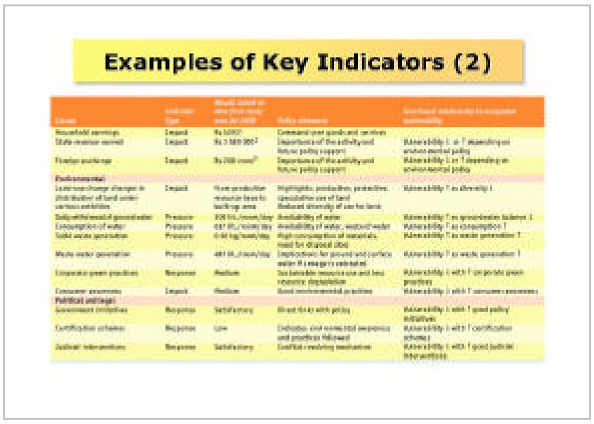


Monitoring and Evaluation of Key Indicators

Recommend use of D-P-S-I-R approach

D - Drivers
P - Pressures
S - State
I - Impact
R - Response





Workshop Proper (1)

- What **tourist attractions** do we have?
- What **tourism facilities** do we operate?
- What **problems and or issues (hot spots)** in our areas that affect tourism? Classify them as D-P-S-I-R
- Where are they (3 above) located?
  - Find them in the image map and label accordingly

Workshop Proper (2)

- What kind of **information** do we need in order to **better manage** coastal tourism activities?
- What **management approaches** can we take given the availability of information mentioned above?

(12) Environmental Monitoring and Management through Socio-Economic Profiling

Environmental monitoring and management through socio-economic profiling

Maria Cecilia D. Rubio-Paringit

DLSU–Manila

Marine Pollution

- Marine debris - any manufactured or processed solid waste material that enters the marine environment from any source
  - Recreational and tourism–related
  - Fishing debris
  - Sewage–related debris
  - Shipping waste
- Waste water – any untreated water used for household, industrial and commercial purpose
  - Domestic waste water
  - Industrial waste water

Some Environmental impacts on tourist beaches

- Lethal or sub-lethal effects on marine fauna and flora
- Decreases scenic potential of tourists
- Brings risks to tourist and local people's health
- Damage ships

Coastal Zone Management

- Comprehension of the complexity of coastal zone problems by human activities
- Integration between socio–economic and environmental studies
- Participation of the community in the production and use of scientific studies
- Evaluation of community perception is the 1st step

Aims

- Impact of **human activities** in some tourism areas

↕

seawater quality

- integrated **socio-environmental approach**

↓

emphasize the **community's role** in water quality improvement efforts.

Case 1: Cassino Beach, Rio Grande City

- Beach litter
- 2 study sites
- Litter quantification –
  - litter sampling
  - More waste in area1

Socio-economic characteristics

	Area 1	Area 2 ●
Origin	Local (63%)	Non-local (57.7%)
Educational level	Fundamental school (40.6%)	Under graduation (46.6%)
Sex Annual income	Female (58.3%) < US$3200 (50%)	Female (67.1%) > US$3200 (80.8%)
Duration of stay	< 2days (61.5%)	> 2 days (68.5%)

● **Richer,**
More educated,
Non-local,
Stays longer

Problems of Cassino Beach

PROBLEM	Area 1 (%)	Area 2 (%) ●
Litter	24	27.4
No Problem	27.1	19.2
Dogs	11.5	13.7
Wastewater	6.3	6.8
Lack of shadow	6.3	5.5
Over occupation	3.1	2.7
Lack of infrastructure	2.1	2.7
Toilet facilities	1.0	4.1
Other	14.6	15.1
No answer	4.2	2.7
	100	100

● **Richer,**
More educated,
Non-local,
Stays longer
Identifies more problems

Behavior related to litter

Questions	Answers	Area 1 (%)	Area 2 (%) ●
Do you usually consume food and beverage in the beach?	Yes	86	65.8
	No	14.6	34.2
What do you usually do with your residues generated in the beach?	Leave directly on the beach	2.1	0
	Carry it to home	26	57
	Put it waste bins	64.6	43.8
Do you have at least once leaved litter on the beach? If yes, are you guilty?	No	74	76.3
	Yes.I am guilty	6.3	16.1
	Yes, I am not guilty	14.6	8.2
Do you smoke? If yes, do you normally leave cigarette butts on the beach?	No	67.7	80.8
	Yes, I normally have	19.8	8.2
	Yes, I normally do not leave	9.4	9.6

● **Richer,**
More educated,
Non-local,
Stays longer
Better behavior

Litter Perception

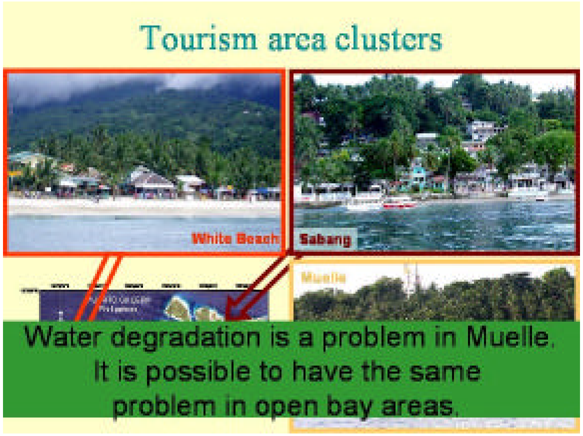
Questions	Answers	Area 1 (%)	Area 2 (%)
What is the main source of litter on the beach?	Beach users	91.7	95.9
	Boats	2.1	0
What is the main problem that marine debris can cause?	Impact to people's health and safety	56.3	32.9
	Impact to marine biota	26.0	28.8
	Beach become unattractive	10.4	38.3
Did you suffer any kind of problem with the litter on the beach? If yes, what happened?	No	68.8	47.1
	Yes, wounds	10.4	15.1
	Yes, diseases	12.5	5.5
	Yes, discomfort	8.3	32.7
Do you think that Cassino beach have been unclean?	Yes	28.1	27.4
	No	58.3	54.8
	More or less	13.5	35.1
Do you believe this dirtiness is causing any trouble to you?	Yes	31.3	23.3
	No	61.5	69.9
	More or less	4.2	4.1
What is your suggestion to reduce the litter quantity on the beach?	Improvement of peoples education	39.6	46.6
	More trash bins	35.4	38.4
	Distribution of plastic bags	11.5	8.2
	Application of penalty	12.5	1.4
	Advertisement sheet	9.4	2.7
	More cleaning	8.1	5.5

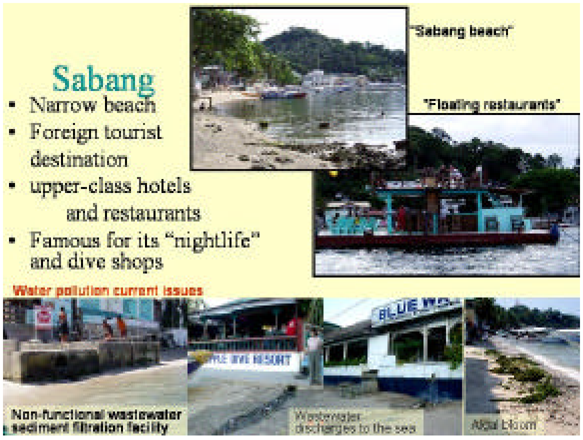
Findings

- Litter generation is related to socio-economic characteristics
- Public perception — important for establishing administrative priorities

Case 2: Puerto Galera

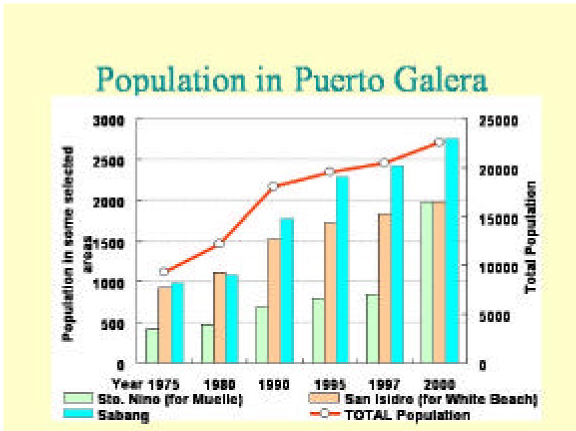
- Waste water

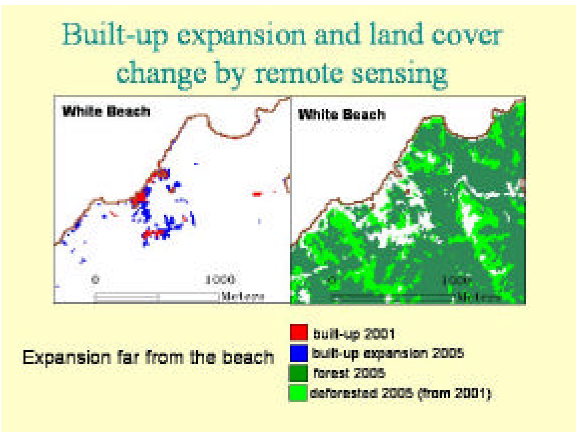


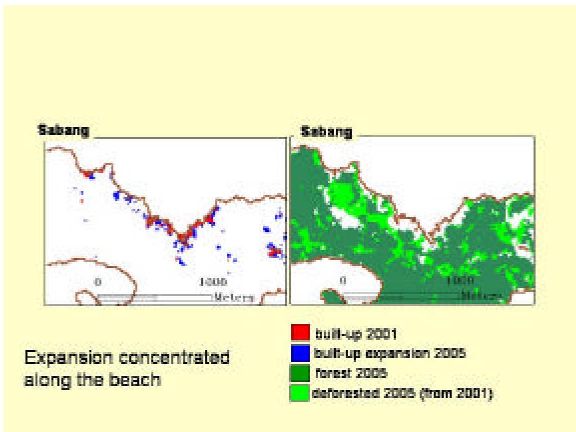


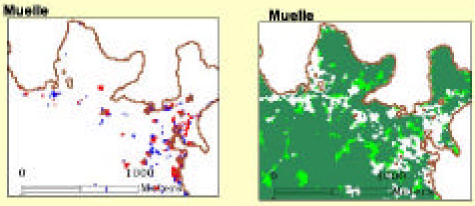
Materials used

- Social – social profiling by questionnaire& interview surveys
- Environmental – remote sensing (using ASTER imageries), GIS and GPS survey
  - Bio-physical – water quality measurement by STD-type sensor



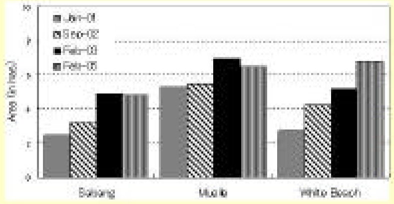






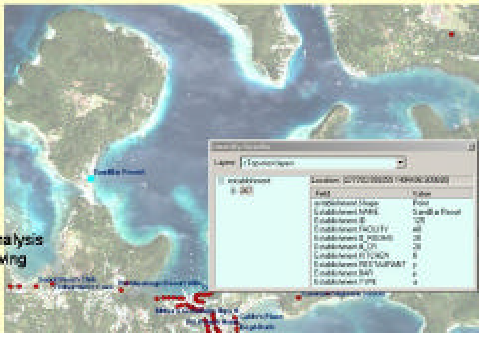
Expansion far from the beach

Built-up area growth



Population growth may not be the main factor of water pollution problem.

GIS set-up for organizing all data



For further analysis
For easy viewing

Outline of social survey

- Actual situation
  - Existing sanitation facilities
  - Activities and sanitation practices
- Perception on water quality
  - Indicators
  - Duration
  - Negative effects
- Opinion on pollution problem

Check on environmental awareness and commitment.

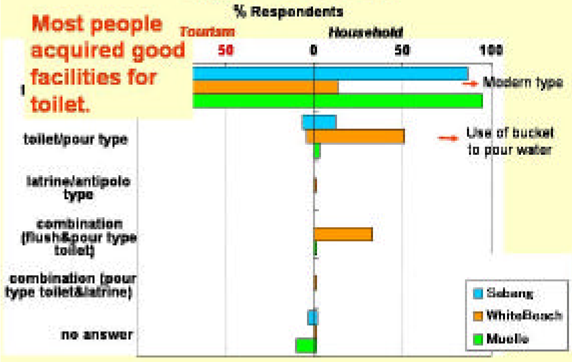
Knowing People's Perception on Water Pollution

	tourism	*household*
Sabang	32	74
White beach	24	91
Muelle	10	96
Batangas Channel*		40*

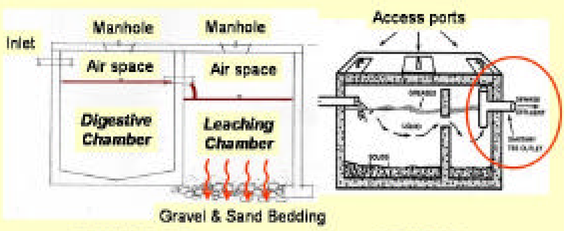
No. of respondents

Tourism sector – as represented by hotel/restaurant owners or managers
Household sector– as represented by the head of the family

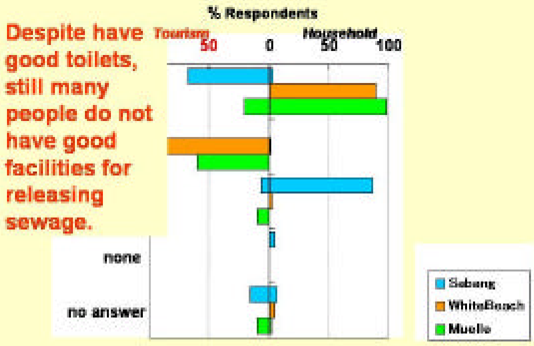
Type of Toilet

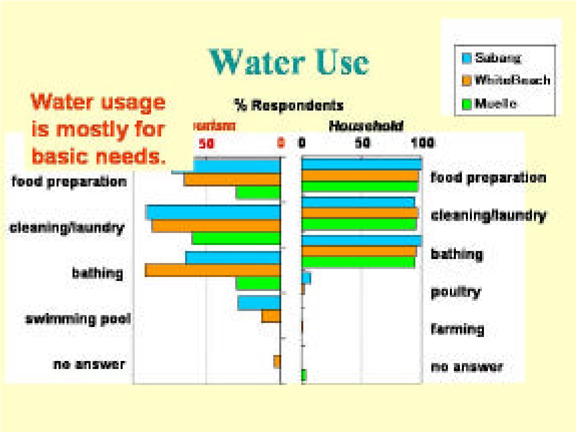


Sealed vs. Open Septic Tank

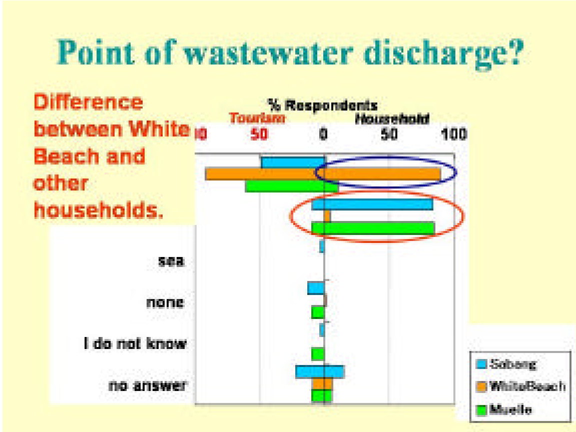


Septic Tank Systems

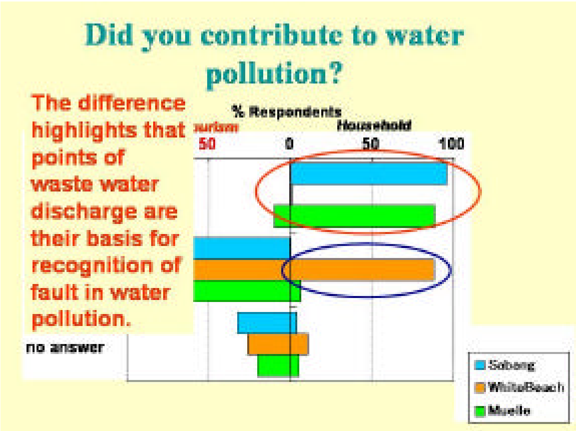




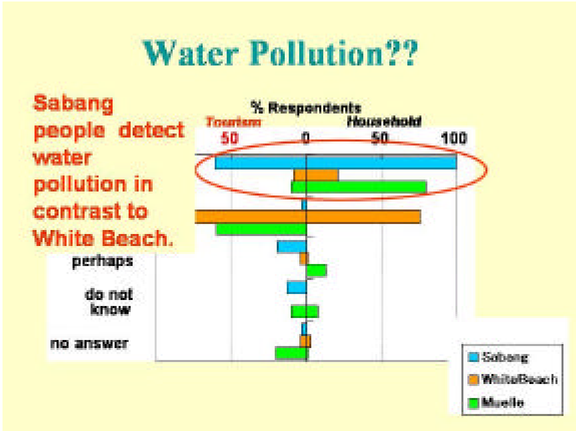
Water Use
Water usage is mostly for basic needs.
% Respondents
Tourism
Household
50
0
0
50
100
food preparation
cleaning/laundry
bathing
swimming pool
no answer
poultry
farming
Sabang
WhiteBeach
Muelle



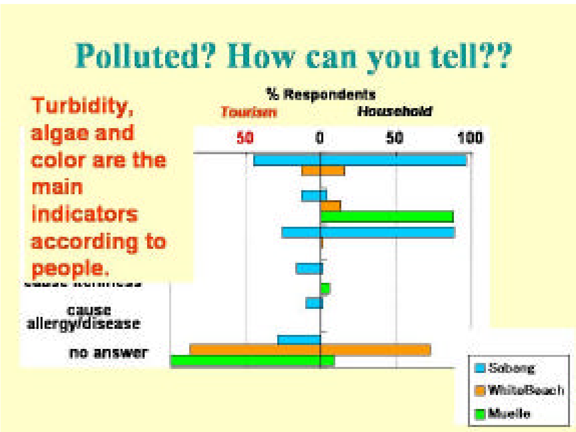
Point of wastewater discharge?
Difference between White Beach and other households.
% Respondents
Tourism
Household
50
0
50
100
sea
none
I do not know
no answer
Sabang
WhiteBeach
Muelle



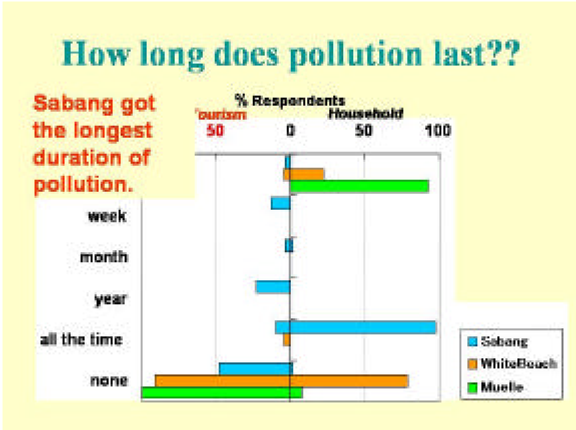
Did you contribute to water pollution?
The difference highlights that points of waste water discharge are their basis for recognition of fault in water pollution.
% Respondents
Household
50
0
50
100
no answer
Sabang
WhiteBeach
Muelle



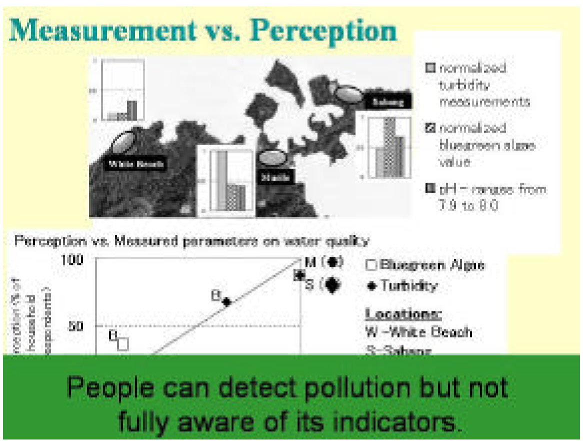
Water Pollution??
Sabang people detect water pollution in contrast to White Beach.
% Respondents
Tourism
Household
50
0
50
100
perhaps
do not know
no answer
Sabang
WhiteBeach
Muelle



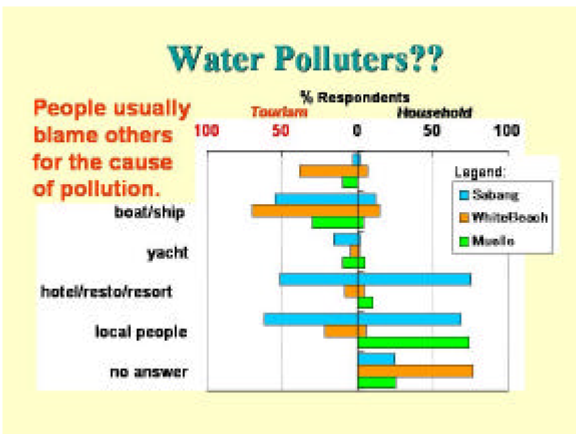
Polluted? How can you tell??
Turbidity, algae and color are the main indicators according to people.
% Respondents
Tourism
Household
50
0
50
100
cause allergy/disease
no answer
Sabang
WhiteBeach
Muelle



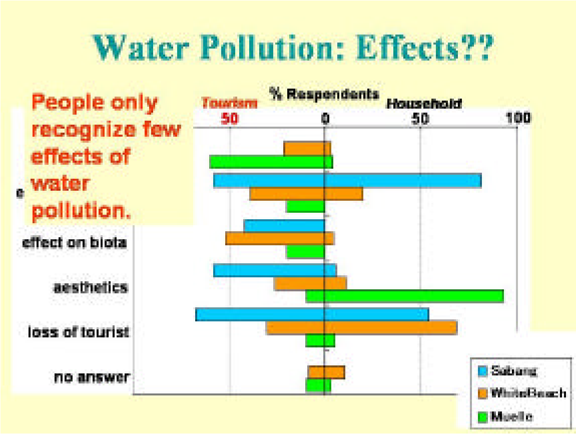
How long does pollution last??
Sabang got the longest duration of pollution.
% Respondents
Household
50
0
50
100
week
month
year
all the time
none
Sabang
WhiteBeach
Muelle

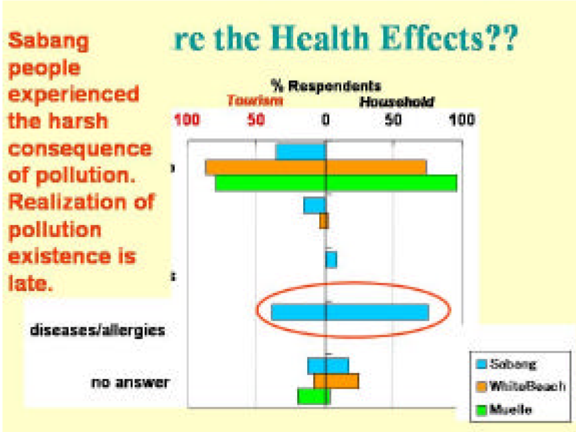


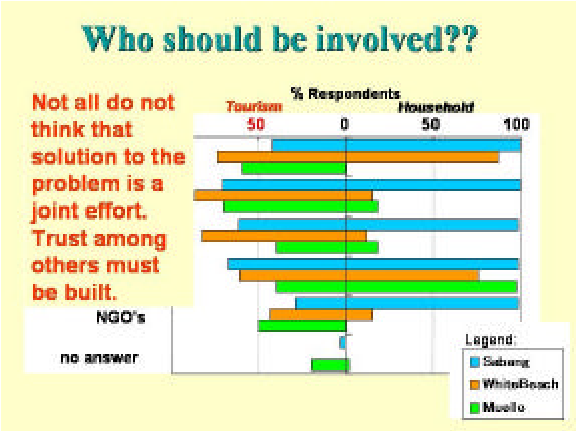
Measurement vs. Perception
normalized turbidity measurements
normalized bluegreen algae value
pH – ranges from 7.9 to 8.0
White Beach
Sabang
Muelle
Perception vs. Measured parameters on water quality
100
50
M
S
Bluegreen Algae
Turbidity
Locations:
W –White Beach
People can detect pollution but not fully aware of its indicators.

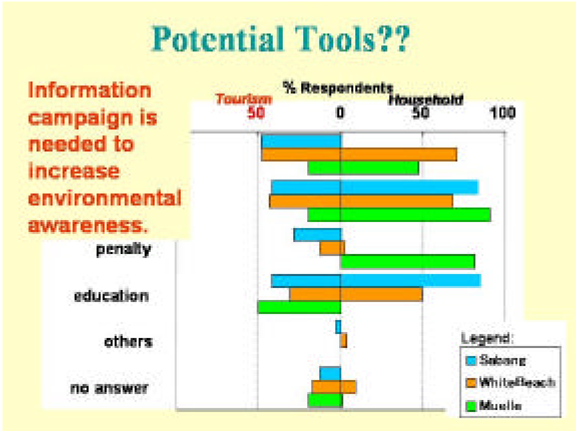


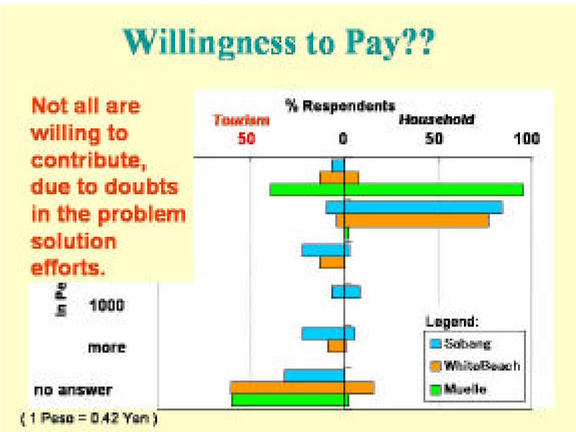
Water Polluters??
People usually blame others for the cause of pollution.
% Respondents
Tourism
Household
100
50
0
50
100
boat/ship
yacht
hotel/resto/resort
local people
no answer
Legend:
Sabang
WhiteBeach
Muelle









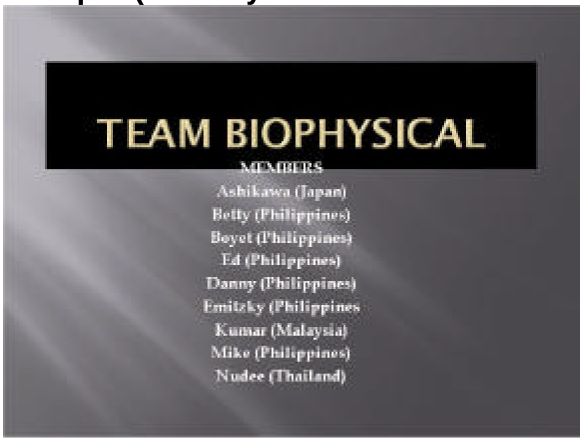


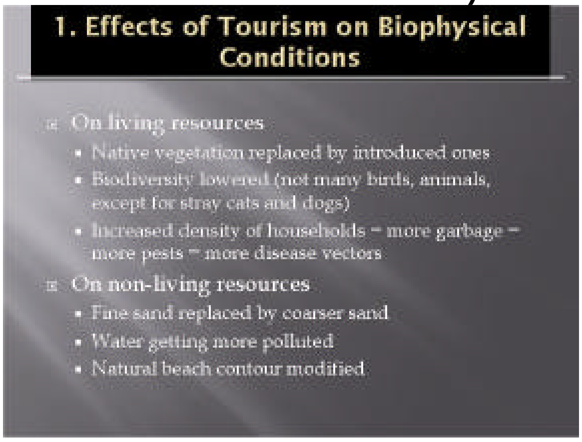
Summary of Findings

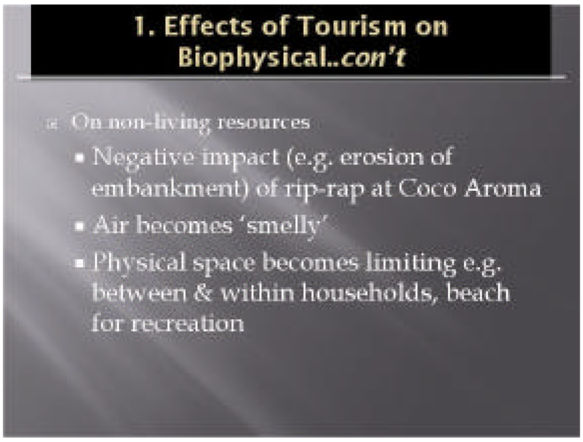
- **Social Profiling & feedback system**
  - Reveal people's activities, practices and perception
  - Perception and measurements: complementary tools for monitoring
  - Best solution to water quality is reduction of waste load and improve sanitation practices
- **Integration approach**
  - Social, physical and biological aspects of ecosystems provides clear picture of environmental problems for effective management
  - People's involvement necessary in monitoring and planning

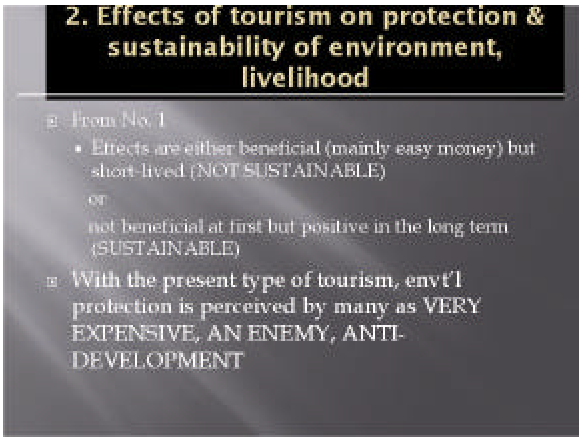
B.3 Group Presentations

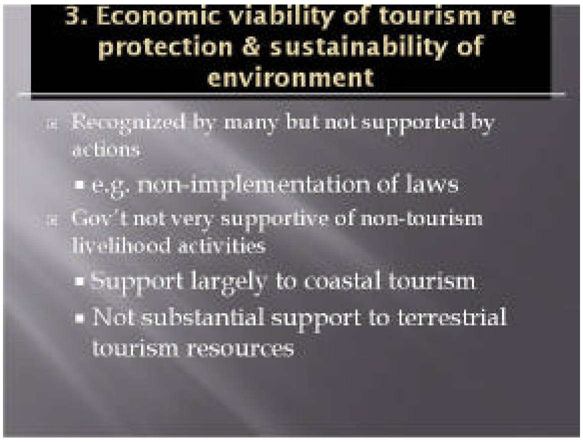
Group 1 (Bio-Physical Indicators of the Environment vis-à-vis Tourism)

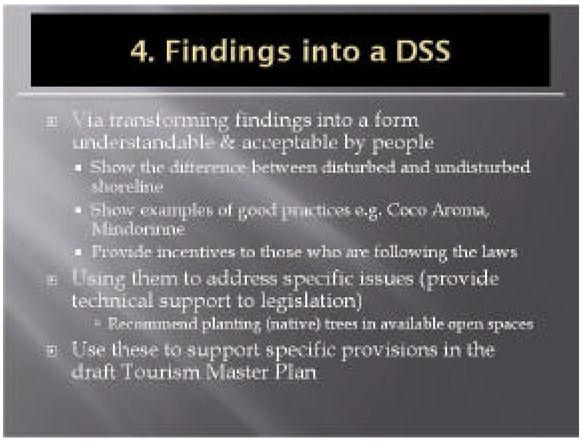




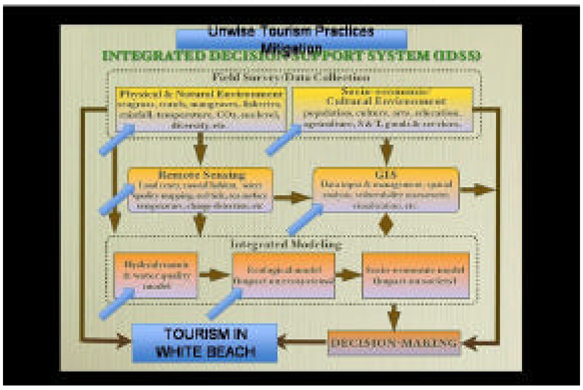








5. Integration of findings into an IDSS



Group 2 (Social Indicators of the Environment vis-à-vis Tourism)

The Social Group

Members:

Professor Kazuo Nadaoka

Ms. Eiko Tsukamoto

Rose Arnela

Genevieve Regina

Eugene C. Herrera

Nguyen Dang Ngai

Ichwan Makmur Nasution

Observations:

❑Source of living of Mangyans is farming/kaingin

❑ Foreigners / Villagers give donations to Manyans

❑There are government outreach programs for education / livelihood to Mangyans

❑The price of local commodities increased

❑Low education to local people for environmental management

❑Hotel owners: good management practices applied in White beach

❑Beach resort frontline has extended shoreward over the years

❑ Prostitution

Observations:

❑Discharge is through septic tanks (infiltration)

❑Domestic water is from groundwater

❑Direct infiltration of contaminated liquid waste to groundwater and flows directly to seawater

❑No master plan for infra development

❑Sabang and white beach tourists are different

❑White beach tourists are domestic

❑Around 95% of Sabang tourists are foreigners because of dive spots (diving and night life)

1. Indicators of tourism effects to social conditions in White Beach

❑ *Livelihood Shifts and larger opportunities (shop & resort staff, boat operation, construction, masseures)*

❑ *Migration and relatively more foreign investors*

❑ *People in White beach have good vision on tourism (foreigners & local)*

❑ *Tourists extends help to native people*

❑ *Tourism in place of fisheries and farming especially during peak season*

❑ *Income from tourism is somewhat enough for locals*

❑ *Prostitution acceptance*

2. Indicators of tourism impacts to environment and livelihood

❑*Unmanaged sewerage (health concern)*

❑*Potable water source problem (health concern)*

❑*Increase in income opportunities*

❑*Current benefits are important to the people but have limited awareness and interest to environmental management*

3. Indicators of economic viability of tourism in rel. to environment protection

❑*Still viable but necessary measures should be aggressively done:*

-more education campaigns on environmental protection to foster better cooperation

-implementation and enforcement of laws

4-5. Transformation of findings to DSS

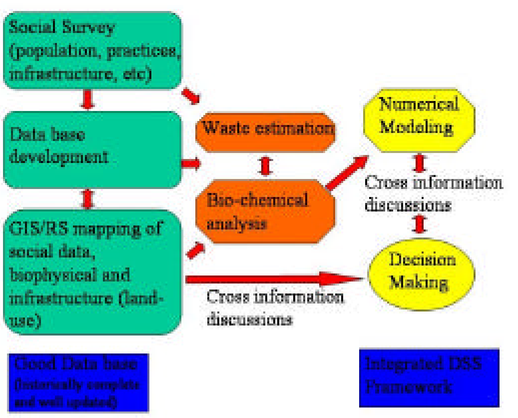
❑*Social data to integrate to DSS as input for waste quantification.* ***Database development is necessary.***

❑***Social survey importance should recognized.*** *Coordination with local government is important for sustainable social data.*

❑***Tourist/local population inventory is necessary to estimate the amount of waste loading***

❑*Social data is a proper link to connecting to DSS*

❑*Historical change in social data is important in trend analysis for DSS*



Some images from the team field survey trip..

Some images from the team field survey trip..

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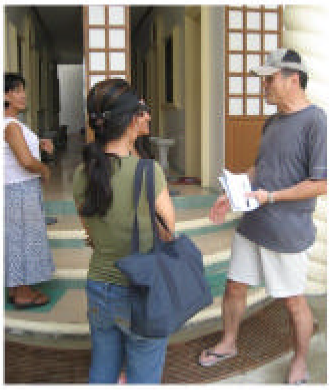


Group 3 (Infrastructure Indicators of the Environment vis-à-vis Tourism)

"Infrastructure" Indicators

The Infrastructure Group (Group3)

James (Fiji)
Daisy (Pilipinas)
Shin (Nihon)
Ariel (Pilipinas)
Sama (Thailand)

"Infrastructure" Indicator Groups of Environmental Conditions

- Land use
- Wastewater
- Solid waste
- Electricity
- Water supply
- Roads/access
- Building type/quality/location
- Communications
- Catchment/watershed
- Other Infrastructure

"Infrastructure" Indicators of Environmental Conditions

- **Land use**
  - Residential
  - Commercial (e.g. hotels, bars, restaurants, dive shops, souvenir shops)
  - Agricultural
  - Forest
- **Wastewater**
  - Estimated volume of waste water generated
  - % Direct to sea
  - % Direct to ground
  - % To septic tanks (% open, % sealed)
- **Solid waste**
  - Quantity of waste generated
  - % business, % houses doing segregating
  - Garbage collection frequency
  - Existence and capacity of dumpsite

"Infrastructure" Indicators of Environmental Conditions

- **Electricity**
  - Power demand/consumption (household, commercial)
  - No. of days with no power
  - No. of business establishments and houses with generators
- **Water supply**
  - Water consumption (household, commercial)
  - Water supply source (e.g. wells, springs)
  - Days of water shortage
  - Water quality testing
  - Purification (% direct tap, % filter, % boil)

"Infrastructure" Indicators of Environmental Conditions

- **Roads/access**
- **Building type/quality/location**
  - % hotels, % houses, % restaurants, etc.
  - Distance from each one building to another, Distance from shore
  - Building materials (e.g., concrete, wooded, mixed)
  - Building heights

"Infrastructure" Indicators of Environmental Conditions

- **Communications**
  - No. of people aware of environmental issues and programs
  - Involvement/participation of local community
- **Other Infrastructure**
  - Pier
  - Settlement ponds
  - Rip-rap
  - Wooden paths/walkway

Gray water flowing and dripping…

A septic tank under construction – one chamber only?

Water supply system…

Garbage anywhere?
← Even between buildings?


Proper disposal of garbage?

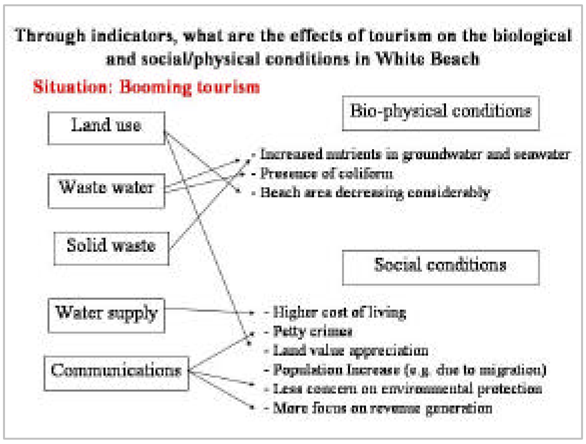

Narrow passageways!

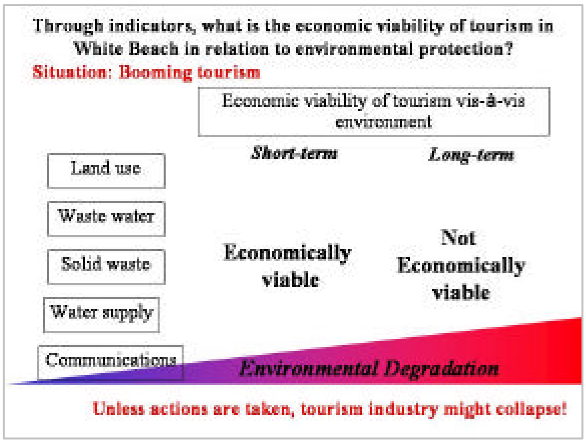

Building types in White Beach…

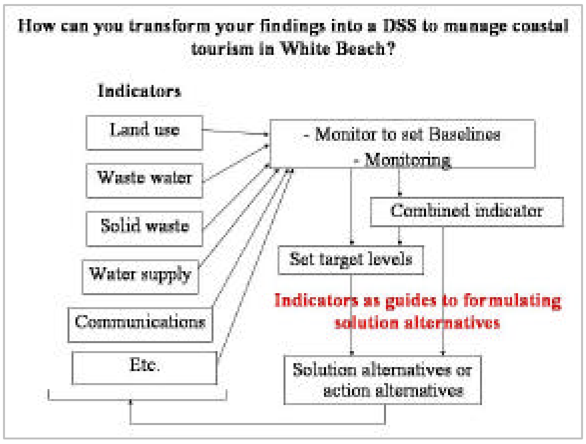

Wooden path and riprap…


A healthy discussion with a local (bar owner)…

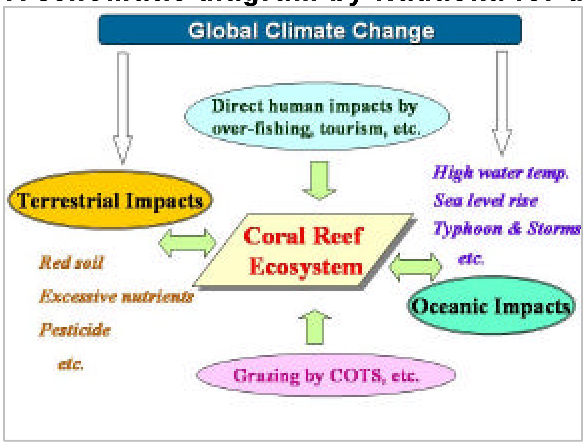

A fruitful discussion…

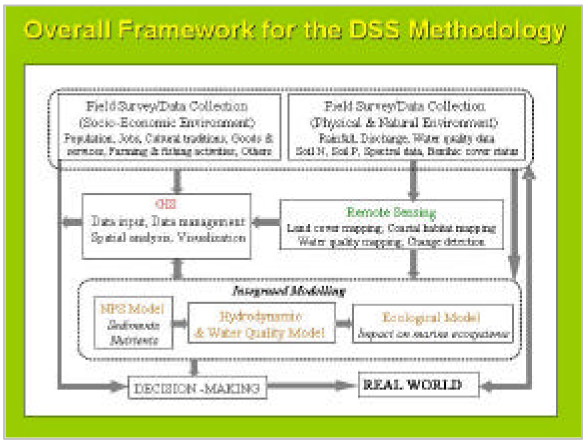

Through indicators, what are the effects of tourism on the biological and social/physical conditions in White Beach
Situation: Booming tourism
Land use
Waste water
Solid waste
Water supply
Communications
Bio-physical conditions
- Increased nutrients in groundwater and seawater
- Presence of coliform
- Beach area decreasing considerably
Social conditions
- Higher cost of living
- Petty crimes
- Land value appreciation
- Population Increase (e.g. due to migration)
- Less concern on environmental protection
- More focus on revenue generation

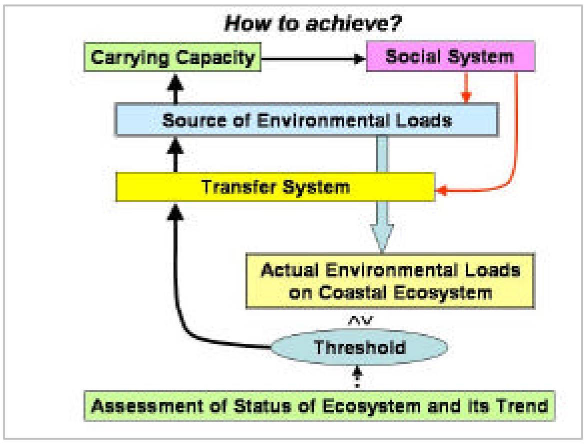




A schematic diagram by Nadaoka for discussion on DSS







B.4 Photos of the 2nd Regional Workshop


Field Visit to Sabang, Puerto Galera


Sabang Environment


Sabang Environment
A common site…
…improper wastewater management!
Drainage pipe discharges wastewater to the sea!


Sabang Environment
Establishments directly discharges waste to the sea!


Workshop Presentations
To its people:
...it is life
...a home
...a future
A Regional Training
Course/Workshop
Asia-Pacific Regional Training
Course/Workshop on the
Utilization of an Integrated
Decision Support System in
Managing Tropical Coasts


Workshop Presentations


Focused Discussion and Sharing


Group Discussion before heading to White Beach


Focused Field Exposure (White Beach)


Closing Ceremony

Appendix C: Funding sources outside the APN

Japan Society for the Promotion of Science (JSPS)
Co-funding for workshop 1 (UP MSI, Philippines)
Co-funding for workshop 2 (Puerto Galera, Philippines)

Marine Science Institute, University of the Philippines, Diliman, Quezon City, Philippines (in-kind)

Institute of Applied Science, University of the South Pacific, Suva, Fiji Islands (in-kind)

Marine Studies Programme, University of the South Pacific, Suva, Fiji Islands (in-kind)

Reef Explorer Fiji Limited, Korolevu, Fiji Islands (in-kind)

Forestry Division, Ministry of Natural Resources, Environment and Meteorology (MNREM), Samoa (in-kind)

Water Resources Division, Ministry of Natural Resources, Environment and Meteorology (MNREM), Samoa (in-kind)

Appendix D: Glossary of Terms

IAS: Institute of Applied Science, University of the South Pacific

UPMSI: University of the Philippines Marine Science Institute

USP: University of the South Pacific

RSDM: Regional Sediment Discharge Model