Annex XI
Workplan and Budget for the NOWPAP WG4 (RS)

1 Objective and background

The role of CEARAC is to coordinate with NOWPAP Members for establishing a collaborative, regional monitoring programme using remote sensing. In order to do that, CEARAC will continue to cooperate with NOWPAP members, and research institutions and international projects, even though it is not the responsibility of CEARAC itself but that of NOWPAP members to conduct monitoring by remote sensing under a cooperative plan and to provide analyzed results.

The objectives of CEARAC WG4 are to develop capability to provide scientists, policy makers, and ocean users with necessary data and information on remote sensing, to enhance remote sensing application to the monitoring of coastal and marine environment in the NOWPAP Region, and to propose activities to establish remote sensing monitoring system and to collect data and information to realize the proposed activities.

As the highest priority of WG4 activity, National Reports were prepared and submitted to CEARAC from each country by July 2005. Preparation of Integrated Report is now in progress by CEARAC based on the National Reports contents. Its interim progress was submitted to all WG4 members in July, and then comments and opinions to the interim progress were discussed among the WG4 member on the Internet. As a result of the discussion among the WG4 members and consideration by the secretariat, it was agreed to add one page of summary and recommendation chapter to the Integrated Report. The work plan of WG4 for 2006-2007 was prepared following the recommendation of activity for WG4 for the next two years, which was suggested in this chapter.

2 Work plan for 2006-2007

The work plan for 2006- 2007 is summarized in Table 1.1 below.

Table 1.1 Work plan for 2006-2007.

		2006 (FPM^{4th}, WG4^{3rd})	2007 (FPM^{5th})
Planning & Coordination of Eutrophication /Oil spill monitoring in the NOWPAP Region	Refinement of guideline being prepared by NPEC for local governments of each country	Review; Publication	
	Training of officers of young researcher, students, and officers of local governments	Planning/Coordination	Implementation
Development of remote sensing information network system	Integration of new function to search related publication	....	
	Establishment of Digital Library	Design	Establishment
Joint activities with IOC/WESTPAC ocean color project			

Search of other possible usage of the satellite remote sensing to environmental monitoring in the NOWPAP Region	Feasibility study	

2.1 Refinement of guideline being prepared by NPEC for local governments of each country

NPEC has been working on a project called the “Toyama Bay Project” since 2002, in order to evaluates usefulness of coastal zone eutrophication monitoring using ocean color satellite data, recognizing that distribution of chlorophyll a is a good indicator for eutrophication.
It is of great importance to share the result and lessens learned in this project towards the establishment of cooperation monitoring, as it is the final goal of NOWPAP WG4.
A draft guideline for monitoring of eutrophication in coastal area using satellite data is under development by NPEC, which intends to be a basis for establishing common methods for evaluating and using satellite data for cooperative environmental monitoring in the NOWPAP Region, taking into account the results and issues raised in the “Toyama Bay Project”.
It, however, may be difficult to utilize this guideline as it is, because of large difference of surrounding in each county. Therefore, it is necessary to have experts from the NOWPAP Region to review and refine the guideline prepared by NPEC so that it would match the situation in each region. CEARAC will ask WG4 members to cooperate with further developing the guideline for eutrophication monitoring to fit in the situation of each county in the NOWPAP Region. Practical activities such as localizing guideline including translation and adding case studies are expected. These works will be implemented under the MOU with experts in NOWPAP Members. The draft outline of the guideline prepared by NPEC is explained in annex 10-1 for review and work plan and schedule is summarized as follows in table 2.1.

Table 2.1 Work plan and budget of refinement of guideline of NPEC.

Work plan	Schedule	
- Reviewing of the draft guideline - Localizing guideline including translation to Chinese, Korean and Russian - Adding case study of each country - Distribution of the guideline	Aug 2005	Submission of the draft outline of guideline of NPEC to WG4 members
	Sep 2005 3rd FPM	Reporting the draft outline of guideline of NPEC to the 3rd FPM
	March 2006 4th FPM	Completion of the guideline of NPEC
	Summer 2006 3rd WG4	Discussion on preparing the guideline of WG4
	Dec 2006	Publication of the guideline

2.2 Training of young researcher, students and officers of local governments

In order for NOWPAP Members to help each other in technical aspects of remote sensing in an effective way, it is necessary to establish collaborative framework. As capacity building of NOWPAP Members, CEARAC is planning to offer a training program on remote sensing data processing and analysis and its application to study marine and coastal environment monitoring. The duration of the training program will be one week and designed for young researcher, students, and local government officers involved in any aspect of marine and coastal environment monitoring. CEARAC will provide trainers under the MOU with NOWPAP WG4 Members, manuals for each participant, and the training venue. The draft proposal of remote sensing of young researcher, students and officers of local governments is attached in annex 10-2 for review.

Table 2.2 Work plan and schedule of remote sensing training.

Work plan	Schedule	
- Consideration of training program - MOU with WG4 members - Management of training	Sep 2005 FPM 3rd	Reporting the draft proposal of the training program
	Mar 2006 4th FPM	Finalizing the training program
	Summer 2006 3rd WG4	Reviewing the implementation plan of the training
	Dec 2006	Finalizing the implementation plan and coordination of related agencies
	2007	Implementation of training

2.3 Further development of RS portal site, web site on oil spill monitoring by remote sensing and environment watch system, including publication database and digital library

Establishment of Publication Database

Existing RS portal site is still in development phase and providing only link information of the other websites related to the marine and coastal environmental monitoring by remote sensing. A new function of searching publication on marine and coastal environment monitoring by remote sensing should be integrated into existing RS portal site (Fig. 1). Keep tracking of new publications is essential in order to understand the latest trend and findings. Publication shall be limited to eutrophication and oil spill by remote sensing. Publications referred in National Report and Integrated Report also shall be added to the database.

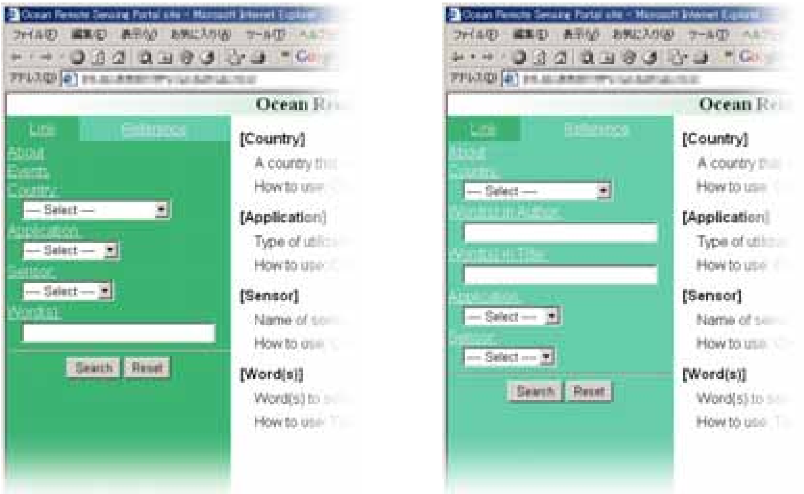

Fig. 1 Screenshots of publication search function under consideration.

Establishment of D

During discussions at the first meeting of NOWPAP WG4 and the second CEARAC FPM it was pointed out that common understanding and information sharing should be promoted on application and interpretation, the status and future prospects of research and development, and the real use of remote sensing in marine environmental monitoring. Based on such observations, NOWPAP WG4 considered the development of a remote sensing information network and started a portal site on the Internet. However, the portal site's role of navigating locations of scattered information and data is limited in its quality and quantity, and remote sensing information network requires constant update of its information for its usefulness. Thus, it is necessary to consider step-by-step procedures to develop a remote sensing information network, taking account of realistic limitations, such as development cost, content provision, and so on. The first step is the development of an ongoing portal site that reviews and provides locations of scattered information and data. The second step is the development of a digital library that also provides consistent time series of information and data. The Marine Environmental Watch Project, which is currently expanding its functions, is worth considering as a base for the digital library. The schedule of implementing the digital library is summarized in table 2.3.

Table 2.3 Work plan of further development of remote sensing information network.

<table>
<tr><th>Work plan</th><th colspan="2">Schedule</th></tr>
<tr><td rowspan="4">- Collection and categorization of publications
- Designing of structure of publication database
- Implementation to the existing RS portal site
- Test operation
- Feasibility study of establishing digital library
- Establishment of digital library</td><td>Sep 2005
3rd FPM</td><td>Reporting draft structure of publication search function</td></tr>
<tr><td>Mar 2006
4th FPM</td><td>Starting of test operation of publication search function</td></tr>
<tr><td>Summer 2006
WG4 3rd</td><td>Discussion on draft implementation plan of digital library</td></tr>
<tr><td>2007</td><td>Implementation of digital library</td></tr>
</table>

2.4 Joint activities with IOC/WESTPAC ocean color project

WG4 has been implementing activities related to marine and coastal environment monitoring with remote sensing from the perspective of its utilization in intergovernmental framework, while IOC/WESTPAC makes efforts on Ocean Color Remote Sensing as a scientific activity. Because both groups partly cover the same geographic areas and subject, it is considered to work together through co-organizing workshop and training activity to achieve their own goals respectively

NPEC has been organizing International Workshops on Remote Sensing of the Marine Environment in the Northwest Pacific Region since 1999. The aim is to contribute to the development of marine environmental monitoring technologies derived from remote sensing. In the workshop, relevant countries (Japan, China, Korea and Russia), including NOWPAP WG4 members, attended to make presentations on remote sensing application, examples of marine environmental monitoring, research and development trends, and so on, and to exchange information. NPEC may consider the possibility of joint hosting of workshops with other organization such as IOC/WESTPAC and PICES.

2.5 Search of other possible usage of the satellite remote sensing to environmental monitoring in the NOWPAP Region

Activities of WG4 have been implemented to the present based on the agreement at the 2nd CEARAC FPM. They are eutrophication and oil spill to be the main targets of marine and coastal environmental monitoring by remote sensing. National Reports, on the other hand, indicated other serious coastal environmental issues in the NOWPAP Region, such as coastal erosion and discharge of murky waters from rivers.

In accordance with such background, NPEC may consider possibility of monitoring other phenomena by remote sensing, which might be useful to decide the future activities of WG4.

3 Budget

The budgets for 2006-2007 are summarized in Table 3.1. NPEC is considering supporting the activities of 2.3, 2.4 and 2.5, taking into account of CEARAC budget allowance.

Table 3.1 Budgets for 2006-2007.

Activity	Source of budget	Budget US$
2.1 Refinement of guideline being prepared by NPEC for local governments of each country	CEARAC	15,000
2.2 Training of young researchers, students, and officers of local government	CEARAC	15,000
2.3 Further development of portal site, web site on oil spill monitoring by remote sensing and environment watch system, including publication database and digital library	NPEC	T.B.D.
2.4 Joint activities with IOC/WESTPAC ocean color project	NPEC	T.B.D.
2.5 Search of other possible usage of the satellite remote sensing to environmental monitoring in the NOWPAP Region	NPEC	T.B.D.
TOTAL		30,000+ α

T.B.D.: To be determined.

Annex 11-1

A draft outline of guideline for monitoring of eutrophication in coastal area using satellite data

Table of Contents

I. Purpose and background of the project

Northwest Pacific Region Environmental Cooperation Center (NPEC) is designated as Special Monitoring and Coastal Environmental Assessment Regional Activity Center (CEARAC) and is working on development of evaluation method for marine and coastal environment using satellite remote sensing.

In the NOWPAP Region, red tide and eutrophication are becoming major problems, calling for joint monitoring as preventive measure. NPEC, recognizing that distribution of Chl-a is a good indicator for eutrophication, has commenced a project called the "Toyama Bay Project", which evaluates usefulness of monitoring of eutrophication in coastal area using satellite data.

A draft guideline for monitoring of eutrophication in coastal area using satellite data is under development by NPEC, which intends to be a basis for establishing common methods for evaluation and using satellite data for cooperative environmental monitoring in the NOWPAP Region, taking into account of the results and issues raised in the "Toyama Bay Project".

It, however, may be difficult to utilize this guideline as it is, because of large differences of surroundings in each county. Therefore, it is necessary to have experts from the NOWPAP Region to review and refine the guideline prepared by NPEC so that it would match the situation in each region, and to have individual guidelines developed for the NOWPAP Region. As a result, it is desirable that the use of satellite data for eutrophication monitoring in the NOWPAP countries and regions will be actively promoted in the future.

II. Eutrophication and satellite remote sensing

1. Introduction

- Understanding marine environment with focus on eutrophication, and corresponding research

Environmental indicators to confirm the level of eutrophication are; Nitrogen (NO3-N, NH4-N, etc) and Phosphate (PO4-PM, etc) (nutrients for phytoplankton), Chl-a (indicator for red tide and eutrophication), Suspended Solid and Transparency (indicator for Turbidity), and COD (indicator for organic pollution).

- Advantage of eutrophication monitoring using satellite remote sensing

Satellite data can be obtained and utilized by any person and any place. Compared to the in situ monitoring data, it is often superior in terms of ranges covered, continuity, and irrelevance to national boundaries. Combined with the in situ data, satellite data can be utilized beneficially as monitoring information. The level of Chl-a, which strongly correlate to eutrophication level, can be estimated from the Ocean Color Satellite data.

- Disadvantage of eutrophication monitoring using satellite remote sensing

Accuracy of satellite data needs to be validated for each sea area, as there could be substantial margin of errors in data taken from coastal areas where there are high concentration of colored dissolved organic materials and suspended inorganic materials. This disadvantage can be supplemented by in situ data.

- Usefulness of eutrophication monitoring by satellite remote sensing

Satellite remote sensing makes it possible to estimate spatio-temporal Chl-a concentrations. Also, the usefulness of satellite monitoring can be further improved when correlation between Chl-a concentration and organic pollution indicator such as COD is found. There is an algorithm reported, although data are taken from the outer ocean (northern North Pacific Ocean), that enables estimation of the concentration of nitrate in sea surface currents. Nitrate is one of the major constituents of nutrient, it can be estimated from water temperature and Chl-a concentration obtained from satellite monitoring (Goes, J.I. et al.1999).

This guideline gives methodology on how to obtain and analyze satellite data, analysis of in situ data for validating the accuracy of satellite data and integrated evaluation of satellite data with other environmental data.

2. Satellite Data

1) Monitoring variables

a. Chl-a

Chl-a is contained in all species of phytoplankton, and it can be regarded as total amount of phytoplankton that is the base element of biological production of the ocean. In other words, measuring the level of Chl-a enables monitoring of mass generation by phytoplankton. If eutrophication proceeds, Chl-a concentrations become abnormally high and it often result increase of red tide.

Satellite remote sensing allows the estimation of the oceanic Chl-a by measuring water-leaving visible radiation of each wavelength of sea surface. Chl-a concentration can be determined by the color of the water leaving light; greener is higher, hence Chl-a present in water absorbs blue light.

b. Sea Surface Temperature

Satellite remote sensing allows the measurement of sea surface temperature using infrared and/or microwave ranges of electromagnetic waves. Seasonal change in meteorology and basic information such as current rip can be obtained from data on water temperature of ocean current.

2) Sensors

a. Chl-a

Satellite observation of ocean color began in 1978 with the launch of the Coastal Zone Color Scanner (CZCS) instrument on the NIMBUS-7 satellite (Mitchell, 1994). CZCS was a demonstration mission to establish the technological and scientific feasibility of mapping ocean phytoplankton pigment concentrations from satellite and its observation continued through about June 1986, although with problems caused by sensor degradation in its later years (Evans and Gordon, 1994.) After about 10 years of blank period, NASDA (predecessor of JAXA (Japan Aerospace Exploration Agency)) launched the Japanese Ocean Color and Temperature Sensor (OCTS) on the ADEOS satellite that operated from August 1996 to June 1997. NASA subsequently launched the Sea-Viewing Wide Field-of–view Sensor (SeaWiFS) in August 1997, which has a five-year design life and continues to operate in 2005, and the Moderate Resolution Imaging Spectroradiometer (MODIS) launched on TERRA in December 1999 and on AQUA in May 2002. JAXA then launched Global Imager (GLI) on the ADEOS-II satellite. It enabled frequent, accurate and global observations of various geo-physical parameters in the ocean (Ishizaka *et al*., 2004). However, operation ceased due to mechanical trouble in October 2003, 10 months after its launch. NASA have been maintaining time series of the aforementioned data, it is necessary, however, to ensure the compatibly of each data for time series analysis.

SeaWiFS (Sea-viewing Wide Field-of-view Sensor) and MODIS (The Moderate Resolution Imaging Spectro-radiometer) are the ocean color sensors currently in operation that monitors Chl-a, concentrations and also the monitored data is open to the public via the Internet.

SeaWiFS Chl-a concentration data from September 1997 (right after its launch) to December 2004, can be obtained for free of charge by submitting user application to NASA, Methods for acquiring SeaWiFS data depends on the purpose (research or commercial). MODIS data is received at many organizations, and is open to the public via the Internet.

b. Sea Surface Temperature

Sea Surface Temperature is estimated by processing of NASA AVHRR (Advance Very High Resolution Radiometer) and NASA MODIS data. The data are received by many organizations and transmitted to the public via the Internet.

3) Obtaining data

a. Chl-a

<SeaWiFS>

If SeaWiFS Chl-a data are used for research, they can be obtained free of charge, under conditions that NASA authorizes the purpose of data use. Process for user registration is described in details on 'SeaWiFS Project Information' site in SeaWiFS Project Homepage (http://oceancolor.gsfc.nasa.gov/SeaWiFS/).

SeaWiFS Chl-a data can be obtained via the Internet from NASA Goddard Distributed Active Archive Center. NASA provides SeaWiFS data products in different spatial resolution, either in GAC (Global Area Coverage) or in LAC (Local Area Coverage). Both GAC and LAC data can be utilized for monitoring of coastal areas.

<MODIS>

MODIS data that had been received by ground station of JAXA and processed by JAXA GLI algorithm can be downloaded from the Northwest Pacific Region Marine Environment Watch Homepage (the Marine Environment Watch Homepage). To download, user registration is necessary, which can be done on the website below.

URL for user registration: http://www.nowpap3.go.jp/jsw/eng/search/regist.html

Method to download MODIS Chl-a concentration data is described in the website below:

http://www.nowpap3.go.jp/jsw/eng/software/

b. Sea Surface Temperature

AVHRR data can also be downloaded from the Marine Environment Watch Homepage. The method for user application is the same as for MODIS data.

4) Processing Method

a. Setting up of Processing Systems

SeaDAS (SeaWiFS Data Analysis System), a free software developed by NASA, is the most suitable choice for processing and analyzing Chl-a data from SeaWiFS SeaDAS may be run on PC-Linux, which enables the construction of processing environment at low cost.

For processing and analyzing Chl-a data from MODIS and Sea Surface Temperature data from AVHRR, Excel program from Microsoft may be used.

b. Extraction of Data

i. Chl-a

<SeaWiFS>

To extract Chl-a data, L1A level data need to be obtained from NASA DAAC, and atmospheric correction and geometric correction need to be conducted.

<MODIS>

MODIS Chl-a data retrieved by application of JAXA GLI algorithm can be obtained from the Marine Environment Watch Homepage.

ii. Sea Surface Temperature

AVHRR-derived SST data can be processed data by the Marine Environment Watch Homepage.

3. In Situ Data

To maximize the usefulness of satellite monitoring, it is essential to obtain in situ data coinciding in time and space with satellite data. Match up data set is used for calibration and validation.

1) Monitoring Items and Measuring Method

a. Chl-a concentration

In situ measurements of Chl-a concentration are used for calibration and validation of satellite data. They are also a good indicator of eutrophication and correlate with organic pollution level, such as COD, etc.

b. Suspended Solid (SS) and Chromatic Dissolved Organic Material (CDOM)

SS and CDOM are measured as they influence on errors of satellite-derived Chl-a concentration. It is recommended to compare the measured SS and CDOM values with satellite data and with Water-Leaving Radiance,

c. Water-Leaving Radiance

In situ Water-Leaving Radiance of sea surface can be monitored by measuring profile of reflectance in water. The data are used to calibrate and validate in-water algorithms.

d. COD and Nutrient

COD is an indicators of organic pollution. If they are measured simultaneously, it may be useful to develop further understanding of the behavior of eutrophication and organic pollution process. This will make it possible satellite remote sensing function as a monitoring tool of organic pollution that is leading to eutrophication for local use.

e. Sea Surface Temperature and Salinity

In situ SST measurements are used to evaluate the errors of satellite-derived SST fields. They are also used to calculate growth rate of phytoplankton. Measurements of surface salinity make it possible to estimate how much fresh water due to river outflow and precipitation is flowing into the target area.

f. Transparency

Transparency can be used to grasp a rough figure on average turbidity in the surface seawater. Measurement method is simple. There are plenty of data in the past, which can be used for comparison with the present data in particular in the NOWPAP Region.

g. Other items

Other items that can be measured are vertical distribution of water temperature and salinity. It is also advisable to keep records of the weather conditions including atmospheric temperature, cloudiness, wind speed and direction, waves and wave undulation, etc. during satellite sensing.

h. Measurement method

Please refer to Manual for oceanographic observation (Japan Meteorological Agency) and Marine Monitoring Guideline for the Correction and Validation of Satellite Sea Color Data (Earth Science and Technology Forum/Earth Monitoring Committee, Marine Environment Science Team 2001) for the detailed measurement methods and notes to be taken care of the measurements of Chl-a, Suspended Solid, Chromatic Dissolved Organic Material, and Water-Leaving Radiance.

2) Determining Sampling Points

a. Number of Sampling Points and Spatial Scales

About 10 in situ sampling points (the more the better) are desirable per 1 measurement from satellite. It is necessary to set the sampling points in coastal area, outer sea and also at the border, to obtain wider range of in situ data. Due to limited spatial resolution of satellite data, sampling points need to be set at least 1 km apart from each other.

b. Distribution of Sampling Points

It is desirable to set fixed points if continuous in situ monitoring is possible; however arbitrary points are acceptable for a single-shot measurement. Coastal topography and sea bathymetry as well as the location of river outflow need to be considered when determining the sampling points.

3) Monitoring Frequency and Timing

When determining monitoring frequency and timing, climatic (less cloud coverage is preferable) and oceanographic conditions (times when river waters flow in and growth of phytoplankton is active should not be missed) need to be considered. Regular monitoring (once a month, for example) is necessary if temporal variations of water quality need to be captured by in situ monitoring. However, if more match up data set are needed, the monitoring shall be specialized in obtaining more sea truth data, and the monitoring timing could be focused om short terms under good conditions.

4) Requisites for Monitoring and Analysis

Vessels used for monitoring need to have enough seaworthiness and speed to implement what is laid out in the monitoring plan. Positioning system (e.g. GPS) and navigation system is also required.

Participation of organization that holds necessary capability and equipments for analyzing Chl-a, COD, SS, CDOM and other nutrient salts is essential.

It is desirable to obtain Water-Leaving Radiance data to verify in-water Algorithm.

4. Overall Evaluation

1) Accuracy Evaluation

a. Evaluation of Underwater Algorithm (Analysis of Profiling Reflectance)

Correlation shall be analyzed between in situ Chl-a concentration and satellite-derived Chl-a concentration (satellite Chl-a concentrations), calculated from Water-Leaving Radiance using the underwater algorithm. This analysis can clarify if there are any discrepancies, wether in atmosphere or underwater part in the estimation algorithm of Chl-a concentrations by satellite. It is essential to improve the accuracy of satellite monitoring

b. Analysis of correlation between in situ and satellite Chl-a concentration

Correlation between in situ and satellite Chl-a concentration shall be analyzed. It is more preferable to look into differences between in situ and satellite chlorophyll a concentration depending on levels of CDOM and SS. If there are many sets of satellite and in situ data and certain correlation is observed between these data, the correlation can be applied to bring satellite data close to in situ data through calibration and validation. It is also useful to confirm if satellite data can be used as relative data.

In general, the data from satellite is often overestimated compare to in situ data when the concentration of SS and CDOM become higher. Thus, its comparison to in situ data is required when satellite Chl-a data is to be used as absolute value. When SS and CDOM are considered to be high, e.g. after heavy rain and inflow of turbid water, it is recommended not to use satellite Chl-a concentration data, as it is likely to be strongly affected by high SS and CDOM.

2) Integration with the Existing Monitoring System

a. Understanding spatio-temporal variations of eutrophication by Ocean Color Satellite

If no substantial temporal differences are observed in differences between satellite data and in situ data, satellite data can be used for analyzing time-series behavior. As many data can be obtained from one measurement in satellite monitoring, averaging these data will balance out errors from each value. Also, satellite monitoring can help understand spatial characteristics of eutrophication, as data can be obtained to cover wide range of area. The usefulness of satellite monitoring is expected to increase when accuracy of satellite Chl-a concentration data is improved.

b. Evaluation of Eutrophication

If COD or concentration of various nutrient salt (e.g. Phosphorus, Nitrogen, etc.) is measured at the same time, understanding on the relationship with Chl-a and causes of eutrophication may be further developed.

c. Comparison of existing data (Chl-a, COD) to satellite data and Data Complementation

By comparing of spatio-temporal variation of satellite Chl-a concentration data to the existing water quality data for the target sea area, variation patterns and reproducibility of satellite data may be evaluated.

Appendix 1

A case study in Toyama Bay

1. Objective and Background

In order to evaluate the effectiveness of remote sensing techniques as a monitoring tool for the marine and coastal environment, a case study was conducted in Toyama Bay. In this study, MODIS Chl-a was analyzed with sea-truth data for validating in-water algorithms for estimating Chl-a concentration.

In addition, SeaWiFS Chl-a concentration data were analyzed to understand spatio-temporal variation of water quality in Toyama Bay. The correlation between phytoplankton and seawater pollution (COD; Chemical Oxygen Demand, classified phosphate) were studied to understand the process of pollution.

2. Method

1) Monitoring survey of Toyama Bay

a.Observed variables with vessel

pH, temperature, salinity, water color, transparency, underwater radiances (measured by Profiling Reflectance Radiometer (PRR) 600)

Temperature and salinity (measured by CTD)

b.Analyzed variables in lab

DO(Dissolved Oxygen), Chl-a, SS(Suspended Solid), CDOM(Colored dissolved organic matter), classified phosphate, silicate, total nitrogen, COD etc.

2) Obtaining ocean color satellite data

MODIS Chl-a data was obtained through Marine Environmental Watch System. The data was processed based on the algorithm, which was developed by JAXA for GLI, a sensor on board on ADEOS-II satellite.

SeaWiFS Chl-a data of Toyama Bay from 1998 to 2003 was also obtained and processed for the coverage from longitude 136.5 to 138.5 degrees east and latitude 36.5 to 38.0 degree north. (Fig. 1)

Fig.1 Location of study area.

3. Analysis and discussion

1) Analysis of time series satellite Chl-a concentration

a. Analysis of daily Chl-a concentration image

Chl-a concentration patterns of Toyama Bay in May 2003 were observed (Fig.1). As described later, satellite Chl-a concentration tended to be over estimated than in-situ Chl-a concentration data, when high concentration of SS and CDOM caused by discharge of murky waters was detected. Few rainfall and river discharge, however, was measured in studied period shown in Fig.2, and it was considered that high Chl-a concentration was moved with the anti-clockwise flowage pattern, which was previously suggested in Toyama Bay (Uchiyama 1993).

By this means, remotely sensed Chl-a images are useful but not limited to detect its concentration and its transition pattern with the flowage pattern.

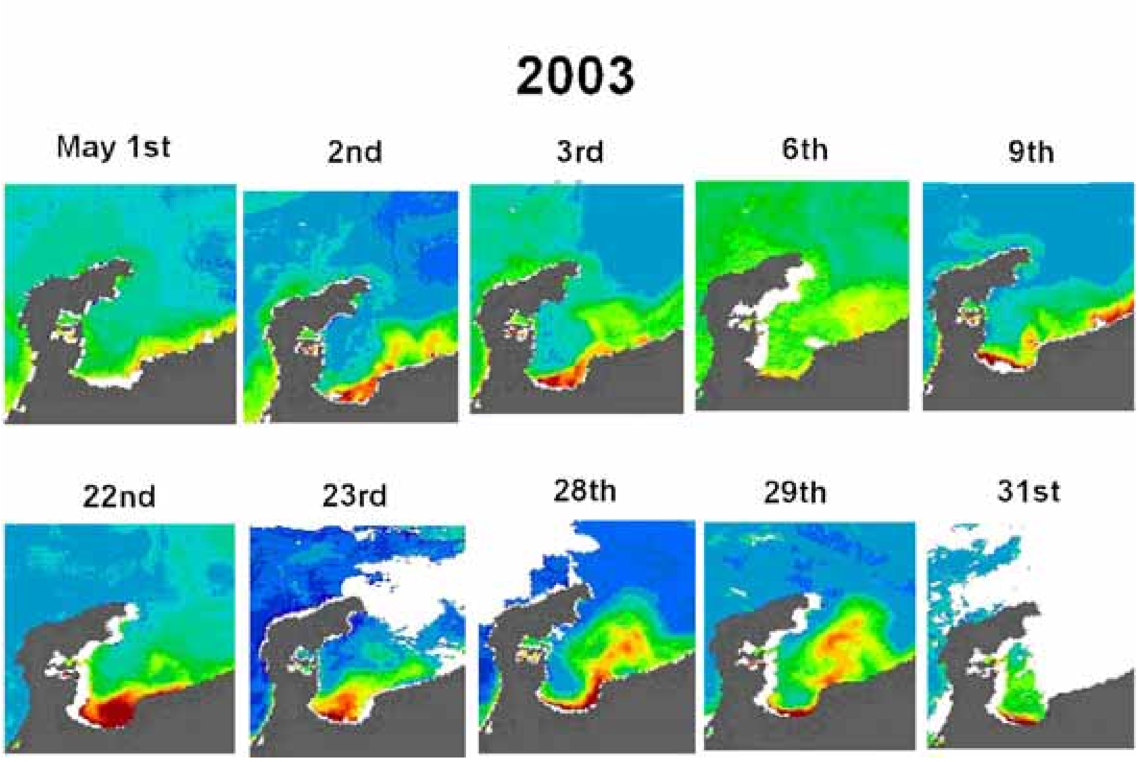

Fig. 2 Chl-a concentrations pattern of May 2003 observed by MODIS in Toyama Bay

b. Analysis of monthly Chl-a concentration image

The monthly average SeaWiFS Chl-a concentration image below indicates two peaks of Chl-a concentration every year, one in early spring (March and April) and the other in fall (October and November). It also shows that the Chl-a concentration of the inner area of the bay is higher every summer (June, July and August) and fall (September and October) than in the other seasons (Fig. 3).

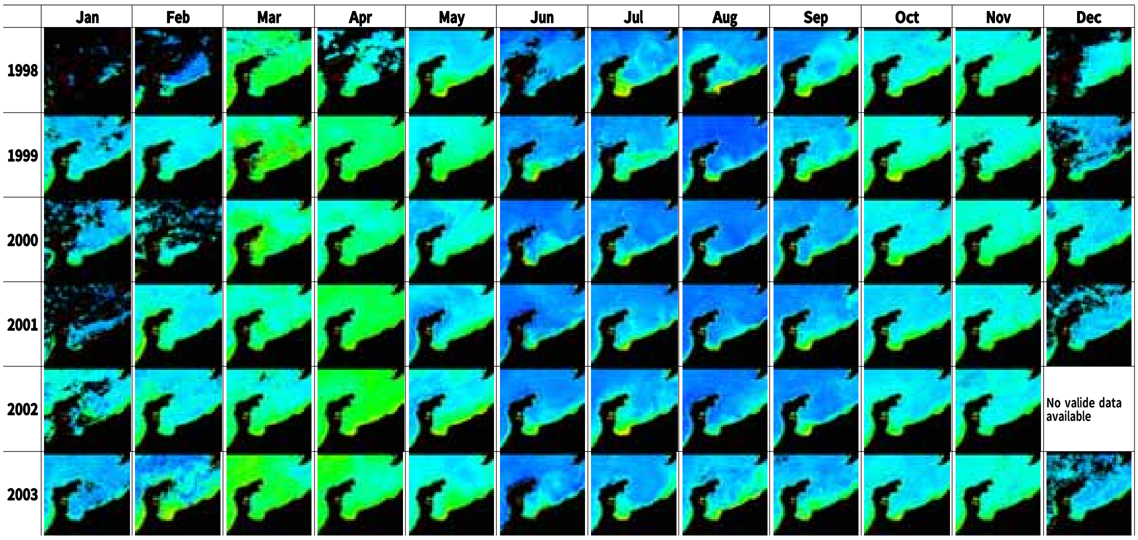

Fig. 3 Monthly average SeaWiFS Chl-a image of Toyama Bay.

c. Seasonal variability of Chl-a concentration in three different areas

Time series of daily SeaWiFS Chl-a concentration in three different areas showed different characteristic of seasonal variation (Fig. 4). There were two apparent peaks of Chl-a concentration in spring and fall every year in outer area. This corresponds to the timing of seasonal phytoplankton bloom offshore or in the NOWPAP Region (excluding Yellow Sea) (Yamada 2004), and it is expected that the land source nutrient input is minimum. On the other hand, Chl-a concentration in inner area was higher in summer and fall and radically changed in short period of time. This may be caused by nutrient input from river, and possible eutrophication by human activity is suspected. It is clear that the middle part of the bay is also influenced by river discharge but the influence is relatively smaller than the inner part.

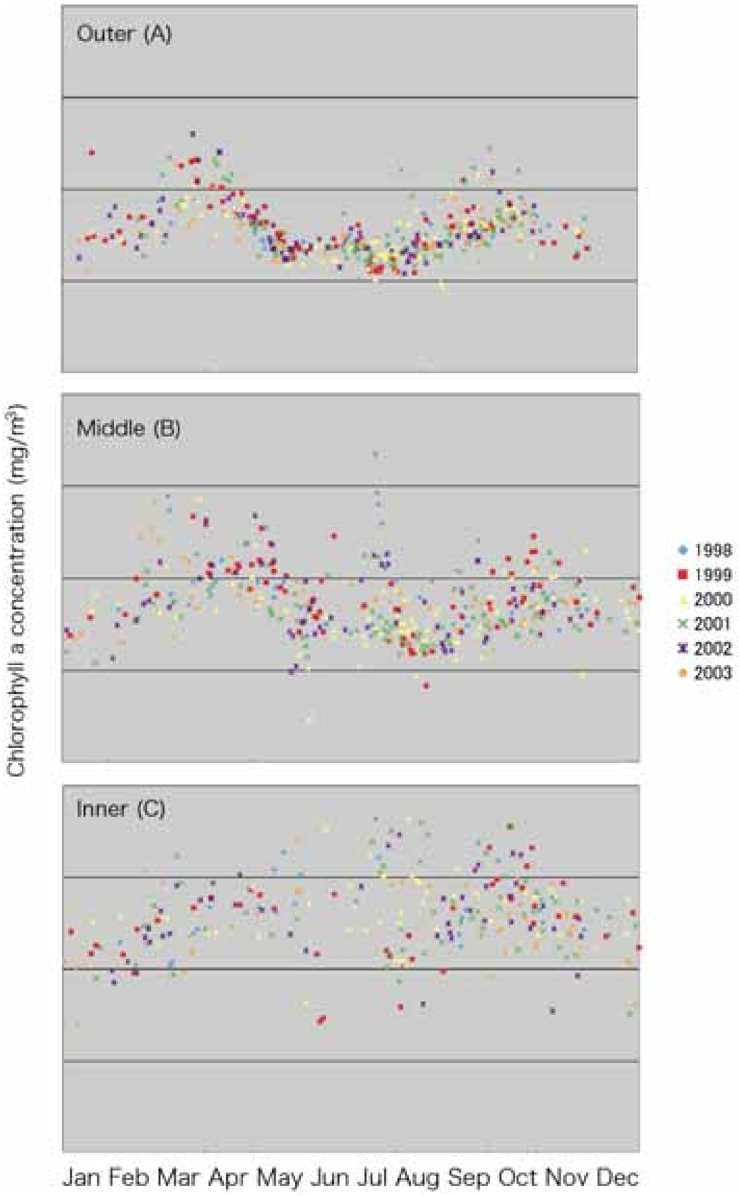

Fig. 4 Seasonal variability of Chl-a concentration in three different areas. Each area, outer (A), middle (B) and inner (C), is corresponding to the location in Fig. 1.

2) Validation of satellite Chl-a concentration

a. Validation of in-water algorithms

The correlation between in situ Chl-a concentrations and one derived from three existing in-water algorithms of SeaWiFS, MODIS and GLI were investigated, using data observed in Isahaya, Ariake (Kyushu Region), East China Sea (ECS), Wakasa Bay (Japan sea) and Toyama Bay (Fig.5). The results showed strong relationship in ratio 1:1, varying coefficient of correlation 0.85 to 0.88 and square error of 0.015 to 0.016 in all data. When investigating data of Toyama Bay solely, the coefficient of correction, the coefficient of correlation varied 0.55 to 0.58, however square error was 0.052 to 0.057. The above results indicate that there is no unique characteristic in Toyama Bay, thus, existing in-water algorithms can be applied to estimate Chl-a concentration in Toyama Bay. It also suggested that there might be a problem in atmospheric correction.

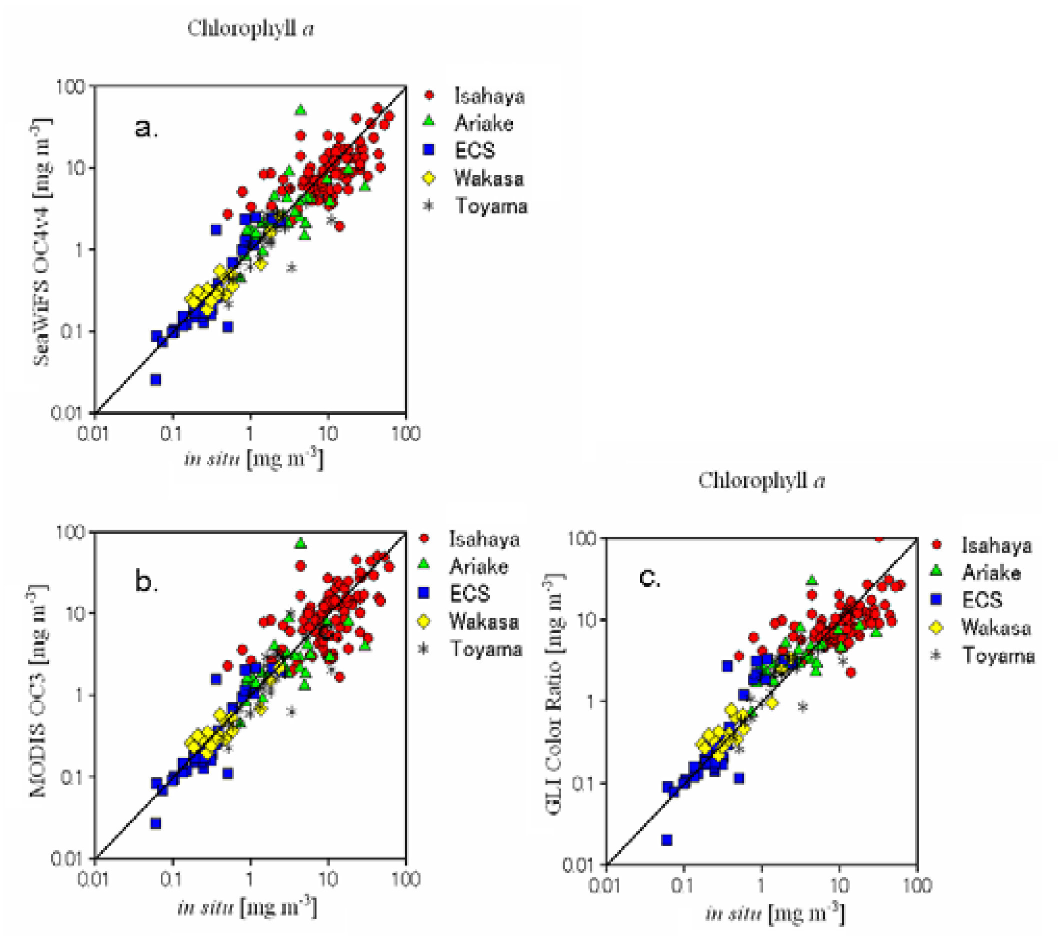

Fig.5 Relationships in situ Chl-a and one derived from three existing in-water algorithms SeaWiFS, MODIS and GLI

b. Correlation of Chl-a concentration between in situ and MODIS

The correlation between in situ and MODIS Chl-a concentration processed by JAXA GLI algorithm was investigated using match up data of 4 cruises (Fig. 6). Liner regression was found in all cases. MODIS Chl-a concentration was slightly underestimated in one case (July 23, 2004), while strong positive correlation (R = 0.88 **, N=9) was found. In contrast, MODIS Chl-a concentrations for other three cases tended to be overestimated. It was suggested that the underestimation of MODIS Chl-a concentration of July 23, 2004 may be affected by anomaly of mirror on MODIS instrument, which was reported by NASA.

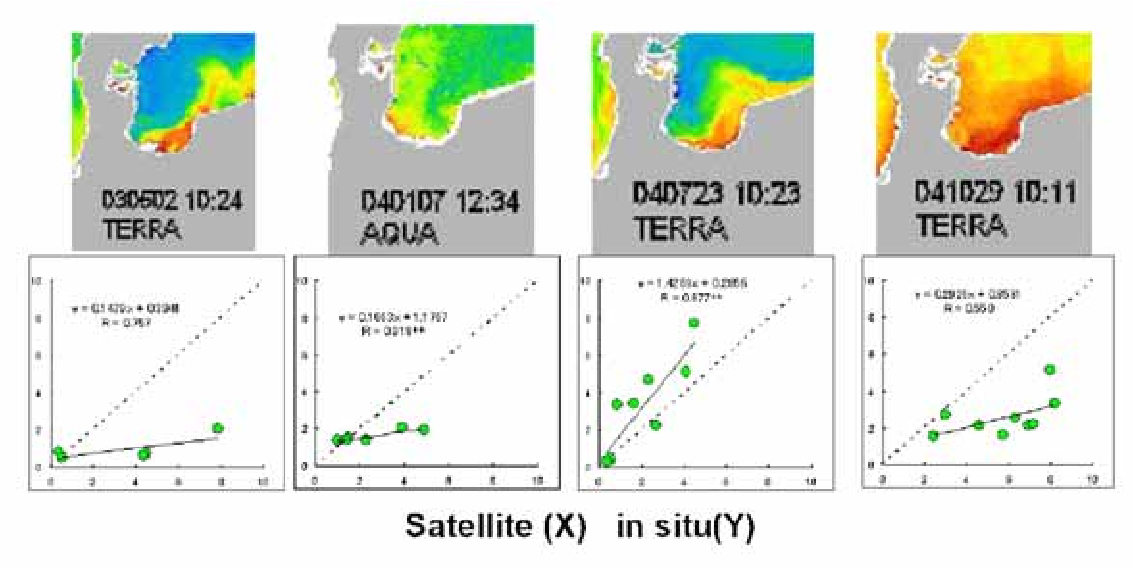

Fig.6 Relationship between satellite and in situ Chl-a.

c. Analysis of MODIS Chl-a concentration with SS and CDOM

The difference between in situ and MODIS Chl-a concentration and its relationship with SS and CDOM were studied. It was found that MODIS Chl-a concentration tends to be overestimated when the concentration of SS and CDOM become higher (Fig. 7).

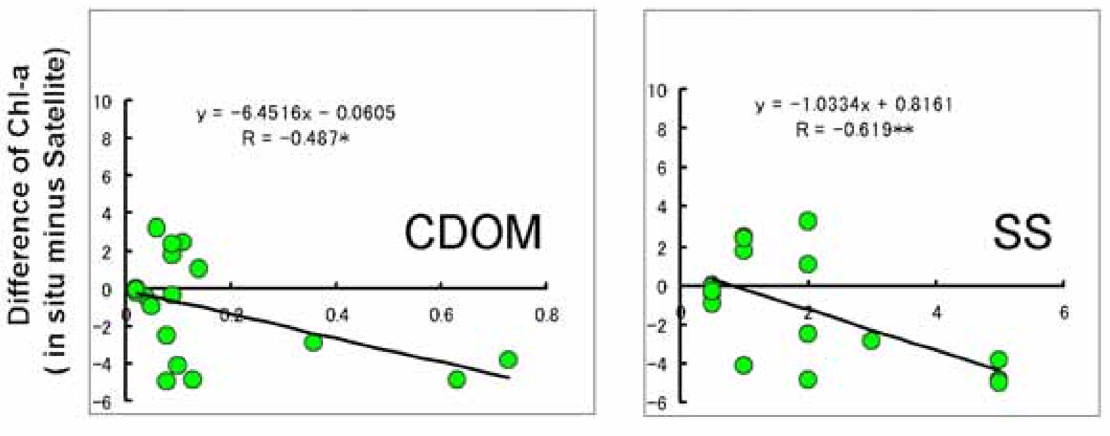

Fig.7 Analysis of MODIS Chl-a concentration with SS and CDOM.

3) Correlation between in situ Chl-a concentration and COD

Strong positive correlation (R = 0.87, N = 86) was found between in situ Chl-a and COD (Fig. 8). Less variability was found especially in spring and summer, when seasonal stabilization of upper water layer is promoted. This result suggested that the satellite monitoring of Chl-a is possible for monitoring of organic pollution indicated COD.

It was considered that the section of regression formula is indicating whole organic matter other than phytoplankton, such as detritus, dissolved organic matter and zooplankton. Further analysis of the constituent of the section is necessary to understand the process of organic pollution.

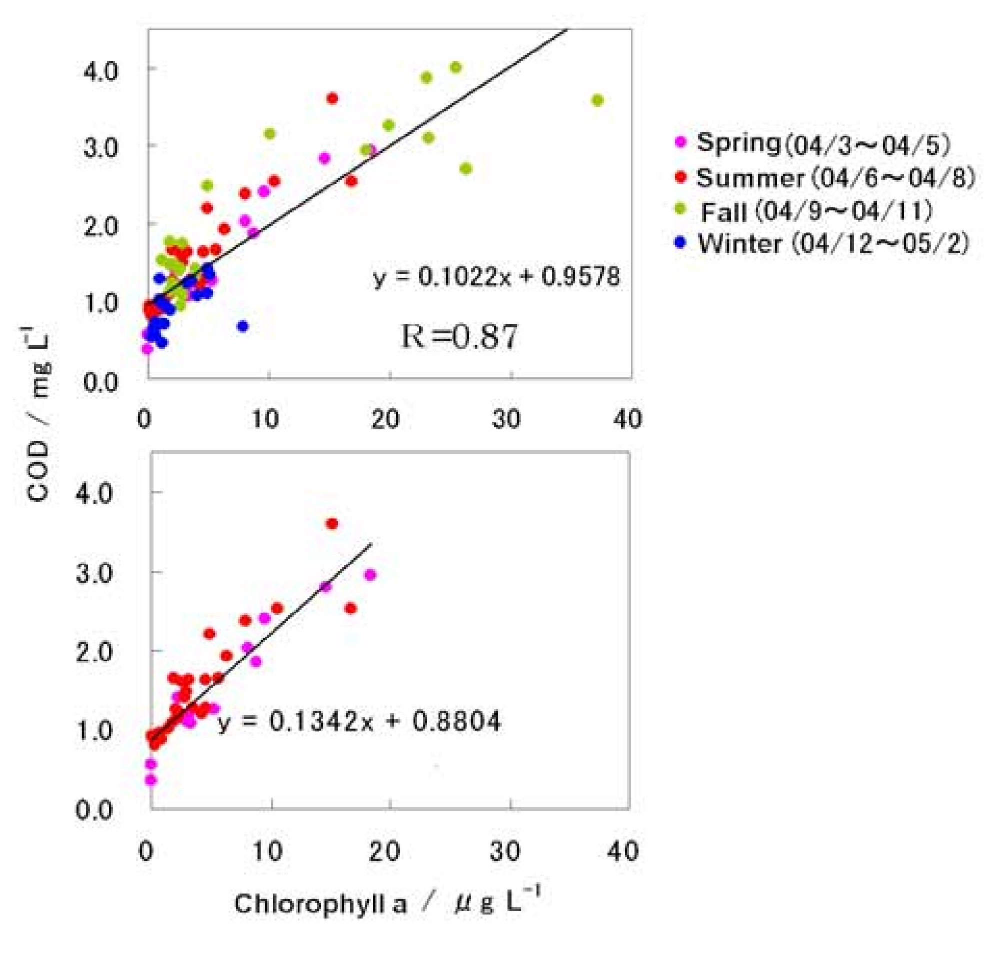

Fig.8 Correlation between Chl-a concentration and COD in Toyama Bay

4. Overall evaluation of remote sensing as monitoring tool

1) Detecting spatio-temporal variation of eutrophication by ocean color satellite

Liner regression was found in relationship between in situ and MODIS Chl-a concentration data (Fig.5). The characteristics of variation pattern were represented well, as Chl-a concentration in inner area of the bay is higher every summer and fall, through analyzing of time series of satellite Chl-a concentration data (Fig.2). Thus, it is possible to detect eutrophication by using ocean color satellite data as relative value in Toyama Bay.

2) Evaluation of eutrophication from in situ investigation

Since strong positive correlation (R = 0.87, N = 86) was found between in situ Chl-a concentration and COD, as an indicator of eutrophication, monitoring of Chl-a concentration by satellite may be useful to find the characteristics of eutrophication and organic pollution in coastal area.

3) Others

Monitoring by satellite is more economical than vessel survey, and it also can estimate the conditions regularly even when there is no vessel survey. In addition, we can discuss the characteristics of eutrophication further through analyzing satellite Chl-a concentration data with other environmental elements such as river discharge or sea temperature and salinity.

Annex 11-2

Draft proposal for remote sensing training of young researcher, students, and officers of local government

1. Background

Capacity building of NOWPAP Members, including trainings, was agreed as one of the five main issues to be focused on by Working Group 4(WG4) at the first FPM of CEARAC in February 2003. National report on Ocean Remote Sensing in China and Russia, prepared in 2005, suggested the enhancement of technical training program of remote sensing in the NOWPAP region.

2. Objective

In order for NOWPAP Members to help one another in technical aspects of remote sensing in an effective way, it is necessary to establish collaborative framework. This draft proposal of remote sensing training aims at a capacity building of NOWPAP Members. CEARAC will offer a training course on satellite remote sensing of the ocean color and its application to marine and coastal environment monitoring.

3. Description of Training Course

The duration of the training course will be one week (i.e. 5 working days) and intended for 12 persons at the maximum including young researchers, students, and officers of local government, involved in any aspect of marine and coastal environment monitoring.
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The training course will include:

- Lecture session covering selected topics in the field of satellite oceanography, as well as visible, infrared, passive and active microwave sensors.
- Practical sessions including hands-on training on various image processing software, and case studies of marine and coastal environment monitoring.

By the end of the course, participants should be able to

- Understand how remotely sensed data can be used in marine and coastal environment monitoring.
- Be aware of the benefits and limitations of remote sensing in marine and coastal environment monitoring.
- User remote sensing data in a geographic information system (GIS) environment.

4. What CEARAC will provide

a Trainers. CEARAC will provide trainers under the MOU with experts in NOWPAP Members.

b Materials and training venue.

1. CEARAC will provide manuals for each participant.
2. CEARAC will provide the venue for training with 12 computers for participants and 1 computer for an instructor.

5. Participation Fees and Requirement.

There will be no registration fees for the course. Travel, hotel accommodation and other expenses are in charge of each participant. Interested participants shall complete the application form and submit it to CEARAC. Participants will be selected based on their application materials. The candidates should be fluent in English.

6. Obligation of the participants

At the end of the training course, participants are obligated to submit a report to CEARAC. This report should include the result of data processing and analysis during the training period. CEARAC shall have a right to use those reports for its own purposes.

7. Schedule

The training is planed to be held in 2007.

8. Items to be considered

- Venue of the training course
- Possibility of joint organizing of the training with other remote sensing workshops and conferences.
- How and where to announce the training course to potential participants.