Annex IX-1

Integrated Report of Working Group 4 (2003)

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Chapter 1 Situation of remote sensing monitoring in NOWPAP region

The present situation of remote sensing monitoring in the region was reviewed based mainly on National Reports submitted to the first FPM in February 2003.

1.1 Sensors used for Marine Environmental Monitoring

Sensors currently used for marine environmental monitoring in NOWPAP Members are shown in Table 1. Japan, China, Korea, and Russia use 4, 2, 5, and 9 types of sensors, respectively, mainly for marine environmental monitoring.

Table 1 Sensors used for Marine Environmental Monitoring in NOWPAP Members

Sensor	Satellites	NOWPAP Members			
		Japan	China	Korea	Russia
AVHRR (Advanced Very High Resolution Radiometer)	NOAA	○	○	○	○
SeaWiFS (Sea-Viewing Wide Field-of-View Sensor)	OrbView-2	○		○	
MODIS (Moderate Resolution Imaging Spectroradiometer)	Terra Aqua	○		○	○
GLI (Global Imager)	ADEOS-II	○			○
MVISR (Multi-Channel Visible and IR Scan Radiometer)	FY-1	○	○		
S-VISSR (Stretched-Visible and Infrared Spin Scan Radiometer)	GMS-5			○	
OCM (Ocean Color Monitor)	IRS-P4			○	
VISSR (Visible and infrared spin Scan Radiometer)	METEOSAT				○
HRVIR (High-Resolution Visible Infrared)	SPOT				○
RLS-BO (Side-looking radar)	Okean-01 Okean-O				○
MSU-SK, MSU-E (multispectral scanner)	Resurs–01				○
SAR (Synthetic Aperture Radar)	ERS-1				○
AMI-SAR (Active Microwave Instrument - Synthetic Aperture Radar)	ERS-2				○
ASAR (Advanced Synthetic Aperture Radar) MERIS (Medium Resolution Imaging Spectrometer Instrument)	ENVISAT				○
TMI (TRMM Microwave Imager)	TRMM				○

1.2 Utilization of Remote Sensing in NOWPAP region

1.2.1 Japan

1.2.1.1 Sea surface temperature

AVHRR (Advanced Very High Resolution Radiometer) on POES (Polar orbital Environmental satellites) NOAA has been observing sea surface temperature for a long time. Receiving systems for AVHRR are widely distributed in Japan, among which about 30 receiving stations from Hokkaido to Ishigaki Island are in operation.

NASA (National Aeronautics and Space Administration) and NOAA (National Oceanic and Atmospheric Administration) provide sea surface temperature data (MCSST: Multi-Channel Sea Surface Temperature) observed by AVHRR on the POES NOAA satellite as the products of the AVHRR Pathfinder Project. In Japan, national research institutes, educational institutions, and fishery related institutes such as fisheries experiment stations provide SST data observed by AVHRR on the POES NOAA satellite.

1.2.1.2 *Chlorophyll-a* and ocean color related data

SeaWiFS (Sea-Viewing Wide Field-of-View Sensor) contributed to observation of *chlorophyll-a* concentration and research of ocean color science.

NASDA (National Space Development Agency of Japan) receives SeaWiFS data at Tokai University, produces *chlorophyll-a* distribution maps in waters around Japan, and provides them for SeaWiFS authorized users.

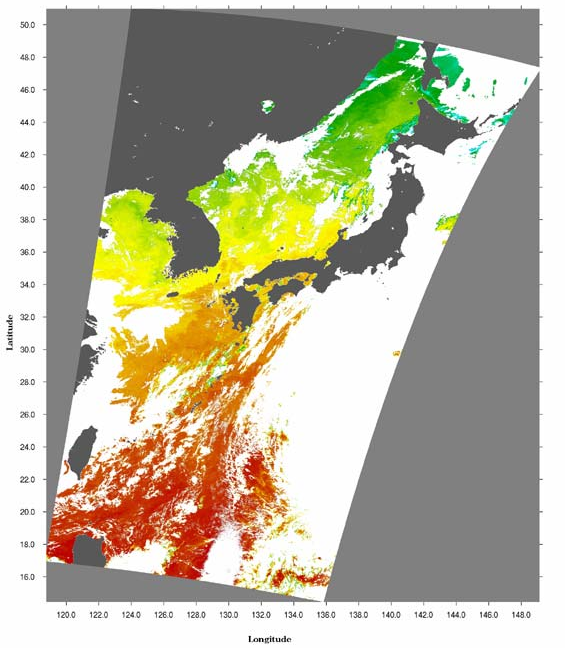
There is no restrictions on the use of the MODIS (Moderate Resolution Imaging Spectroradiometer) data has no restrictions on use. Therefore, a variety of institutes, mainly educational institutions such as universities, receive and process the data. Tokai University receives MODIS data in Kumamoto, Japan, and NASDA processes and provides *chlorophyll-a* distribution map, and sea surface temperature map. Program for GLI (Global Imager) is modified and applied to produce high-level processed datasets for the MODIS data as NASA does not open the programs for MODIS because of copyright issues. Figure 1 shows *chlorophyll-a* distribution and SST observed by MODIS and provided by NASDA.

1.2.2 China

Currently, the main satellites now operated in China for marine monitoring are NOAA and FY-1. NOAA is mainly used in weather monitoring, such information as cloud, heat and coastal water temperature can be acquired from it. The FY-1 with resolution of 1.1km is mainly used in weather and marine monitoring. In part of Chinese coastal area (Bohai Sea and East Sea), the information of HAB and *chlorophyll-a* is provided by FY-1.

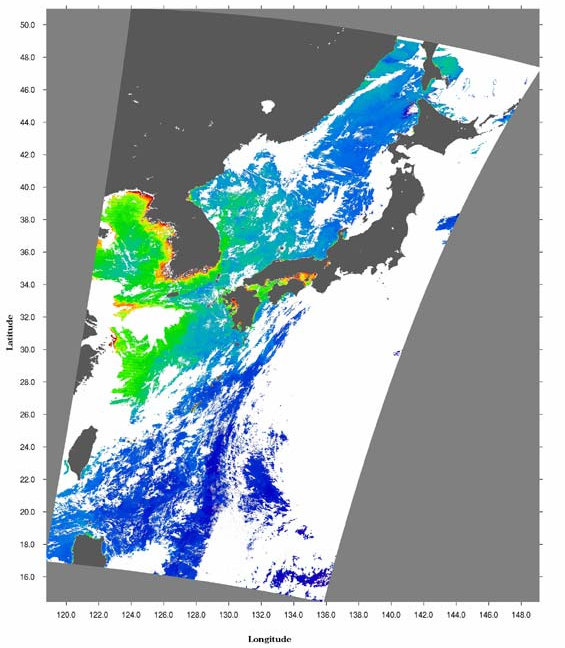
But the effectiveness of the both satellites is not very good in marine monitoring. In the near future China plans to develop a Chinese MODIS with resolution of 250m in marine monitoring.

At present, China use satellite data to measure coastal water quality, to forecast the influence of social economic factors such as land-use, urbanization etc. on the coastal line, to monitor the dynamic change of the coastal line wet-land. China uses hyperspectral remote sensing to monitor some items such as turbidity, *chlorophyll-a* and CDOM (colored dissolved organic matter). China also uses the satellite data in HAB fast spot monitoring.



SST

http://kuroshio.eorc.nasda.go.jp/ADEOS/mod_nrt/data/nrt/day/200209/3002/A2GL10209300201OD1_OSTFR_03036_03654_sst.jpg



Chlorophyll-a

http://kuroshio.eorc.nasda.go.jp/ADEOS/mod_nrt/data/nrt/day/200209/3002/A2GL10209300201OD1_OCSFR_03036_03654_chla.jpg

Figure 1 SST and *chlorophyll-a* by MODIS (September 30, 2002)

1.2.3 Korea

Korea is operating five kinds of earth observing satellites with a marine remote sensing system in NFRDI, Korea, is shown in Figure 2). The real-time information on sea surface temperature around the Korean waters was acquired from NOAA seriesand that around the entire western Pacific Ocean from the GMS-5. The ocean color such as phytoplankton distributions around the Korean waters is provided from the SeaWiFS, MODIS and OCM satellites.

NOAA satellites with AVHRR provide real-time information for water temperature in the Korean waters 6 times per day, while GMS-5 with S-VISSR provides that in the Northwestern Pacific 8 times per day. The spatial solutions are 1km with accuracy of 0.5℃ for NOAA and 5km with accuracy of 1℃ for GMS-5. NOAA data is very useful to understand the thermal front and optimal temperature for sustainable fishing in Korean waters and GMS-5 data can be used for negotiation of the issue on the fishing ground of saury between neighboring countries such as Russia and Japan.

The satellite data on water temperature and ocean color can be available in web site (http://www.nfrdi.re.kr/kodc) for free. These data are updated and provided to fisherman very promptly every day.

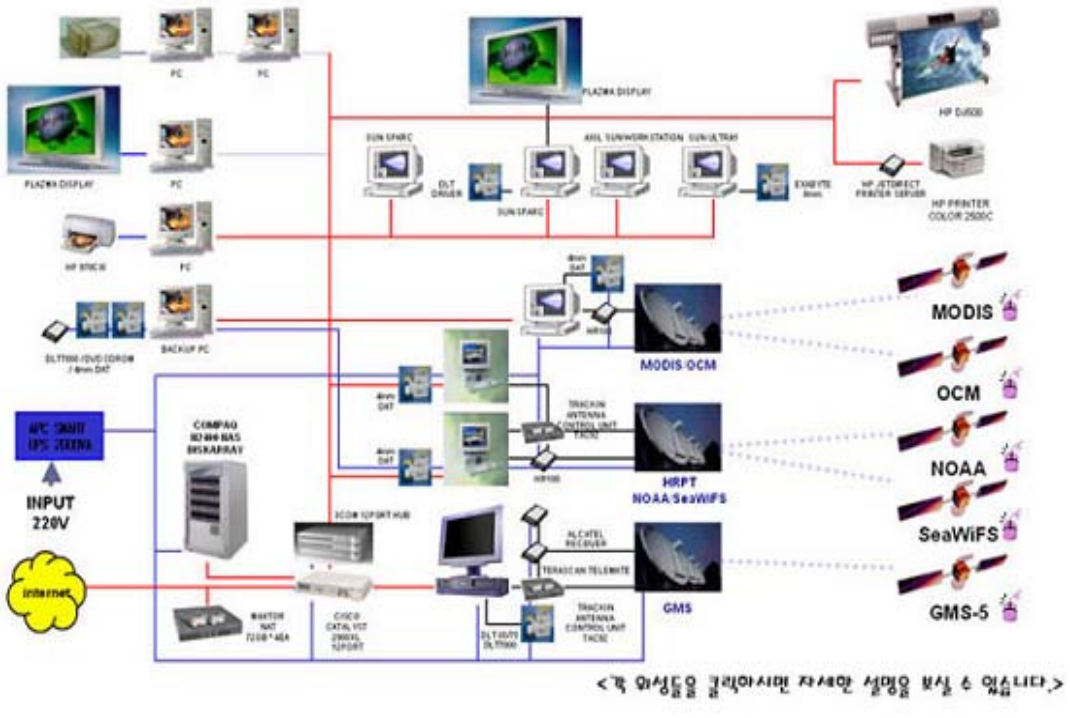


Figure 2 Marine remote sensing system in NFRDI, Korea

1.2.4 Russia

1.2.4.1 Apkon 2 system

Apkon 2 system can be used for land, sea ice and ocean monitoring and surveillance.

1.2.4.2 NOAA

The NOAA Coastal Services Center serves as the nation's coastal resource manager.

1.2.4.3 Passive microwave Aqua AMSR-E, ADEOS-II AMSR

The important feature of microwave data is that SST and near surface wind can be measured through clouds. This is a distinct advantage over the traditional infrared SST observations that require a cloud-free field of view. Ocean areas with persistent cloud coverage can now be viewed on a daily basis. Furthermore, microwave SST and wind speed data are not affected by aerosols and are almost insensitive to atmospheric water vapor. Additionally, the fields of the total atmospheric water vapor, cloud liquid water content, precipitation, sea ice compactness, etc. can also be retrieved.

1.2.4.4 Active microwave ERS-2 SAR, ENVISAT ASAR, QuikSCAT9

A high spatial resolution of SAR data makes it possible to study sea surface water circulation in a range from hundreds meters to several tens kilometers. The eddies, fronts, currents, upwellings, internal wave, island wakes, sea ice, oil pollution, ship wakes as well as the imprints of the various atmospheric phenomena are revealed on SAR images due to their brightness contrasts and distinctive spatial characteristics.

1.2.5 Summary of Utilization of Remote Sensing in NOWPAP Region

Most countries in NOWPAP region use NOAA for SST observation due to its established methodology and observation frequency. The remote sensing data are utilized for fisheries. NOAA will be used for SST observation continuously in the future.

Regarding *chlorophyll-a* and ocean color data, sensors used in NOWPAP Members vary from each other. Japan uses SeaWiFS, MODIS, GLI, and FY-1 (MVISR); China uses FY-1 (MVISR); Korea uses SeaWiFS, MODIS, and OCM; Russia uses MODIS, GLI etc., even though ocean color observation is not clearly stated. Methods of remote sensing data

utilization should be integrated to make the best use of ocean color sensors in NOWPAP region.

For oil spill application, Synthetic Aperture Radar (SAR) could be used and its utilization needs to be considered in the future.

1.3 Major Research Activities

1.3.1 Japan

1.3.1.1 Sea Surface Temperature

SST observed by AVHRR helps to understand time and spatial fluctuations of water mass, ocean front, and eddy. These data are utilized for researches of physical processes. Moreover, recent provisions of sea surface temperature for fishery and the research of the formation mechanism of fishing ground are considered as examples.

1.3.1.2 Ocean color sensor

Observation of *chlorophyll-a* concentration by ocean color sensor such as SeaWiFS helps to catch and predict fluctuation of time and spatial distribution of primary productivity. The examples of application to fishery are the tentative provision of data to fishermen, and the research of the formation mechanism of fishing ground with SST data. Also, there is a possibility of ocean color application to the research of algae blooms.

NASA and NASDA jointly worked on algorithms between OCTS (Ocean Color and Temperature Scanner, ADEOS-I) and SeaWiFS so that both sensors keep a consistency in measuring *chlorophyll-a* distribution. At present, OCTS is processed with the adjusted algorithm, and the datasets are open to the public. NASDA also statistically adjust the parameters between SeaWiFS and MODIS to keep a consistency in *chlorophyll-a* distribution. The consistent *chlorophyll-a* distribution data from November 1996 derived from different sensor is available. As for *chlorophyll-a* distribution data derived from GLI, adjustments between different sensors are planned to keep the consistency.

1.3.1.3 Marine Environmental Watch System for Northwest Pacific Region

In order to promote sea observation by satellite remote sensing, the Ministry of the Environment of Japan started the project called “Marine Environmental Watch System for Northwest Pacific Region” to NPEC (Northwest Pacific Region Environmental Cooperation Center) in March 2002 (http://www.nowpap3.go.jp/jsw/). This project has two objectives:

one is to study the possibility of ocean observation by polar orbital meteorological satellite; another is to study a suitable system for ocean pollution monitoring by meteorological satellite. With regard to the former, ocean observation by AVHRR on the NOAA satellite and MVISR (Multi-channel Visible and IR Scan Radiometer) on the FY-1 satellite is selected. These satellites observe with relatively high frequency in time, and it is meaningful to increase an observation opportunities, while clouds frequently cover the ocean. MVISR has similar abilities such as resolution and bands to AVHRR, and is able to observe in blue and green bands. With regard to the latter, meteorological satellite has a limitation in their abilities to observe ocean environment, especially in a sense of pollution, because these satellites are not originally designed to observe ocean environment.

In this project all received data is archived so as to be used in the future researches. Catalog/database system manages the observation data in the archives. The data is accessible on the web, and distribution maps such as cloud and SST and 10-day composite image of SST of day and night are available. In order to promote the data use, data is processed corresponding to the requirements of users.

1.3.2 China

1.3.2.1 Application for HAB monitoring

The main research activities on remote sensing for marine monitoring are focusing on the remote sensing multi-sensor integrated system research, HAB feature spectrum measurement and satellite remote sensing monitoring feasibility study, the quick transmission of the remote sensing image data through internet for real-time monitoring, remote sensing application technology and method research, By all efforts, China finds three methods of satellite remote sensing monitoring for HAB disaster as follows:

- The first one is image synthesization. The direct character of most HAB phenomena is the abnormity of the coastal water color. Using this characteristic, and choosing three bands image to synthesize false-color image, China will find the exceptional coastal water area, which is the HAB area.
- The second one is to use the difference of the temperature of the coastal water. The change mechanism of the temperature of the coastal water is distinctively different before and after HAB happens.
- The third one is the information extraction of the coastal water surface cell biology quantity, which calculates using the satellite image band, builds relationship of

image radiation brightness and HAB phytoplankton cell quantity, then inverses coastal water surface phytoplankton cell quantity, according to the threshold of the HAB biology cell quantity. Therefore the HAB areas are confirmed and measured.

1.3.2.2 Needs of *in situ* data

Despite that remote sensing is a better tool of marine monitoring, China still cannot abandon the manual sampling and lab analysis. When red tides occurs, the RS image can only tell us the move direction and developing trend. The algae species that cause red tides should rely on manual sampling and lab analysis.

1.3.3 Korea

The calibration and validation of satellite data is done through the comparison with the *in situ* data. To actively use the IR band data of MODIS satellite, Korea is trying to find the relationship of SST between NOAA IR band data and MODIS radiance data at the same time and space.

The information of ocean color is obtained from SeaWiFS with resolution of 1km. *chlorophyll-a* information is estimated using 2 ocean color algorithms with the band ratio between 490nm and 550nm. Korea receives Indian ocean color satellite (OCM) data once every other day. The resolution of OCM (360 m) is three times higher than that of SeaWiFS. Therefore it is possible to monitor ocean color in the bay and coastal water. For calibration and validation, OCM data is compared with SeaWiFS data. After calibration and validation of OCM data, *Chlorophyll-a* concentration in the coastal water of the Korean peninsular is measured.

Korea is also monitoring the turbid water using the band of red, green and blue on MODIS. The quantification of turbid water with digital data from MODIS is in progress.

1.3.4 Russia

1.3.4.1 The Inter-Institute Center for the Satellite Monitoring of Environment

The main mission of the Center is to conduct the regional satellite monitoring of various natural objects and processes in the frames of scientific programs and applications conducted in institutes.

- Monitoring objects-at present:

  SST, frontal zones, eddies, currents, sea ice, typhoons etc.

- Monitoring objects-in sight:

  forest fires, floods, oil pollutions at sea

- Monitoring applications-at present:

  – scientific investigations (physical oceanography and meteorology);

  – information support of maritime cruises;

  – fishing areas productivity evaluation and forecast

1.3.4.2 Marine monitoring projects using satellite data

The main goal is to investigate dynamic phenomena and processes in Far Eastern seas and in the Northwestern Pacific on the basis of development and application of remote acoustic, optical, and passive and active microwave techniques.

- Comprehensive investigation of oceanic processes, characteristics and resources of Far Eastern Russian seas.

- Investigation of the state and operation of marine ecosystems of the Far Eastern seas and their productive possibilities.

- Comprehensive study of the state and variability of the coastal zone of the Far Eastern seas.

1.3.4.3 Research activities on remote sensing for marine applications

-Passive and active microwave remote sensing-

- Coastal zone oceanography

- Coastal zone metrology

- Air-sea interaction in the coastal zone

- Relation of the coastal zone and the open sea

1.3.5 Summary of Major Research Activities in NOWPAP region

Japan, China, and Korea have been researching ocean color. Especially in China and Korea, researches on ocean color (related to HAB in China) comparing *in situ* data with remote sensing data have been conducted due to serious damage to fishery caused by red tide. In Japan, chemical and biological processes in the ocean have been studied such as estimation of primary productivity including its variation in time and space through the observation of *chlorophyll-a* concentration by ocean color sensor. Also in Japan, variation of water body, ocean front, eddies in time, space, and mechanism has been studied by the observation of SST as well as studies of ocean color.

In Russia, regional satellite monitoring has been conducted/studied targeting SST, frontal zones, eddies, currents, sea ice, typhoons etc presently; and forest fires, floods, oil pollutions at sea in sight. Also, investigation of physical processes in Far Eastern seas is conducted based on the development and application of remote acoustic, optical and passive and active microwave techniques.

Chapter 2 Challenges and Future Prospects in NOWPAP region

2.1 Japan

2.1.1 Ocean color

GLI/ADEOS-II was launched in December 2002 to improve observation program of OCTS/ADEOS-I from the view of observation range and precision. It has 23 bands in visible and near infrared, 6 bands in infrared, and 7 bands in intermediate and thermal infrared wavelength. It succeeded in transmitting the first image in January 2003, and NASDA planed to open its data to the public from December 2003.

2.1.2 Proposed plan of work for remote sensing on ocean environment

It is important to monitor fluctuation of ocean environment for the process studies in physical, biological and chemical oceanography, and fisheries. In the NOWPAP region, ocean environmental study will be expanded to a basin scale phenomena like the Tsushima current and to a regional scale phenomena like algae blooms in the coastal waters. Compared with current ocean observation methods using research vessels or observation buoys, remote sensing will provide opportunities to monitor a basin scale

phenomena instantly. The objectives for the studies are to establish a capability to analyze and predict basin and regional scale phenomena.

2.1.3 Analysis and examination for prediction methods of basin scale fluctuation

The objective of the work plan is to analyze basin scale variation of ocean phenomena and to predict basin scale phenomena of the Northwest Pacific. SST and *chlorophyll-a* since 1980s are major targets to be analyzed in time and spatial domain related to a climate change. Based on the response functions of these parameters to the climate change, related environmental parameters will be studied so as to develop methods to predict a change of the ocean.

- Analysis of temporal change of basic parameters

  Satellite estimates SST, *chlorophyll-a* concentration and attenuation coefficient in 4km grid. A basin scale phenomena could be classified into multiple regions based on the response functions to the climate change, and its details in time and space will be given to represent each region. Also, sea surface wind and sea surface height observed by microwave sensors will be studied to analyze and predict a volume transport from the Kuroshio and to predict its temporal change.

- Validation of temporal change of basic parameters

  Sea surface temperature data set in coarse resolution and in time series will be validated with the high resolution sea surface temperature data.

- Examination of Related Parameters

  Time series data set of SST and *chlorophyll-a* will be examined with highly correlated parameters. Precipitation, snowfall, sea level height, fluctuation and regime shift of fishery resources, and Southern Oscillation Index (SOI) are chosen as correlated parameters.

- Prediction of ocean fluctuation

  Based on analysis in time series, prediction methods of related parameters' fluctuations in the Northwest Pacific will be developed.

2.2 China

Four priorities in State 863 Program of China are established in the field of marine resource and environmental technology, one of which is concerned with the marine

monitoring. The main purpose of this priority is to develop advanced technologies in ocean dynamic environment monitoring, marine remote sensing and oceanic fishery information gathering, protecting marine environment and forecasting marine disasters. The priority also aims to build up the capability of fast spot monitoring of the marine environment, real-time and multi-dimensional monitoring of the ocean dynamic environment.

2.3 Korea

Korea is study the oceanographic features of the upwelling cold water, recurring eddy, red tide, optical properties, quantification of transparency and the like around the Korean peninsular by multi-spectral satellite remote sensing.

2.4 Russia

2.4.1 Current and future national satellite programs applied for marine monitoring

The main task of “SPUTNIK” Server (this server is joint project of SRC “Planeta” Russian Committee for Hydrometeorology (Rosgidromet) and Space Research Institute (IKI RAS)) is to provide information about Russian weather satellites.

2.4.2 Marine monitoring projects using satellite data

The project will study the structure, composition and spatial distribution of meso- and submesoscale inhomogeneities, their temporal variability using remote techniques in the Japan and Okhotsk seas including a shelf zone and transition zone between shallow and deep sea. Systems of operational detection and forecast of transfer and degradation of oil pollution adapted to Primorye and Sakhalin shelf will be created.

These investigations are currently central and have an additional support in connection of development of international projects in the Northwestern Pacific such as NEAR-GOOS, COOP, NOWPAP/UNEP and ICZM.

2.4.3 Projects with the European and Japan space agencies

- Investigation of mesoscale phenomena in the coastal zone of the Japan and Okhotsk seas with ERS-1 and ERS-2 SAR data. (Project AO-401 with ESA (1998-2003))
- Study of interaction of oceanic and atmospheric processes in the Japan Sea and the Southern Okhotsk Sea using ENVISAT ASAR and MERIS measurements. (Project AO-ID-391 with ESA (2002-2004))

- Agreement on Research Algorithm for the Advanced Earth Observing Satellite II between NASDA and the Pacific Oceanological Institute, Far Eastern Branch, Russian Academy of Sciences (POI FEB RAS)(2001-2004))

2.4.4 National priorities for the future activities in remote sensing of environment

- Rosaviakosmos-Federal Space Program (2001-2005)

  Manufacturing and launching of space apparatus:

  "Arkon", "Sich-1M", "Resurs-DK", "Resurs-01", "Meteor-3M"N2, "Electro", "Vulkan" and "Arkon-2"

- Khrunichev State Space Center

  Manufacturing and launching of space apparatus:

  "Monitor-E, -N, -C, -O, -P3, -P23

- NPO Mashinostroenia

  - Satellite with S-band SAR, VV and HH polarizations
  - Spatial resolution from several meters to 100-150 m (scan SAR)
  - Launching in the end of 2004 or in 2005

2.4.5 Suggested activities on the regional level

- Joint Monitoring programs based on remote sensing data

  Analysis of the ERS-1/2 and ENVISAT Synthetic Aperture Radar, ENVISAT MERIS, NOAA AVHRR and scatterometer data collected over the Northwest Pacific to study the surface manifestations of oceanic phenomena (currents, eddies, fronts, internal waves, upwellings), river/sea mixing zones, oil pollution, sea ice, and mesoscale regulated structures in the surface wind field which are important for coastal zone management and monitoring.

- Training and education courses

2.5 Summary of Challenges and Future Prospects in NOWPAP region

Challenges and future prospects in NOWPAP region are summarized as below.

2.5.1 Analysis and examination for prediction methods of basin scale fluctuation

- Analysis of temporal change of basic parameters
- Validation of temporal change of basic parameters
- Examination of related parameters
- Prediction of ocean fluctuation

2.5.2 Suggested activities on the regional level

- Joint Monitoring programs based on remote sensing data
- Training and education courses

Chapter 3 Plan of Work for Remote Sensing Monitoring in NOWPAP Region

1. Objective and Long-term Strategy

The role of CEARAC is to coordinate with NOWPAP Members for establishing a collaborative, regional monitoring programme using remote sensing (Figure 3). 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 RS under a cooperative plan and to provide analyzed results.

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

Then CEARAC held the First NOWPAP Working Group 4 Meeting, in the Pacific Oceanological Institute (POI) of Russian Academy from December 1st to 3rd, 2003, in Vladivostok, Russia. At this meeting, CEARAC proposed that ‘Eutrophication’ and ‘Oil spill’ should be the targets of marine environmental monitoring by RS for the time being.

The First NOWPAP Working Group 4 Meeting agreed that WG4 would focus on eutrophication and oil spill.

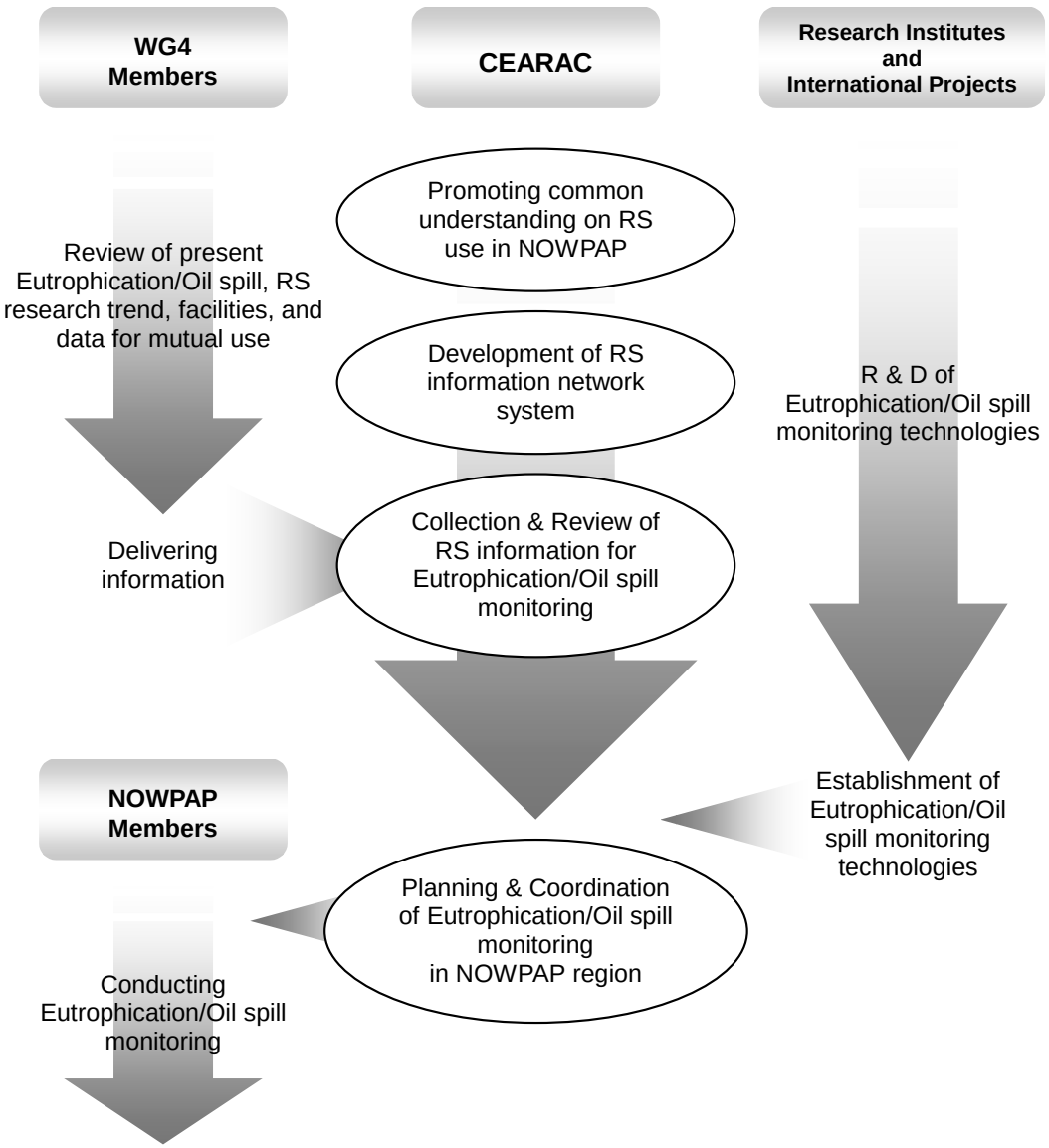


Figure 3 Diagram of long-term strategy

2. Detailed Workplan for WG4

2.1 Applications Supported by Remote Sensing

Regarding the application of RS to eutrophication monitoring, NOWPAP Members shared the common understanding that RS can provide data and information on *chlorophyll-a* concentration, suspended solids (SS), colored dissolved organic matter (CDOM), primary productivity of plankton, red tide, sea surface temperature (SST) fields, and can help to analyze mechanisms of eutrophication and red tide, to predict red tide, and to provide information for adaptation and mitigation for eutrophication.

Regarding the application of RS to oil spill monitoring, NOWPAP Members also shared the common understanding that RS can provide data and information on early detection of slicks, size estimates, damage assessment, location of oceanic dynamic features (current and river outflow fronts, eddies, etc.), fields of physical oceanic and atmospheric parameters (wind, waves, SST, etc.), and can help to identify the polluters including accidents and illegal discharge of waste waters from ships, to predict the movement and weathering of the slick, and possibly the nature and thickness of the oil.

2.2 Definition of User's Needs and Gaps

It would be necessary to clarify the gap between user's requirements on remote sensing requirements and present capacity of RS on eutrophication monitoring and oil spill detection. Users of RS on eutrophication and oil spill are administrative organizations (environment, infrastructure development, fishery etc.), fishery/maritime organizations, research institutes, and so on.

The user's needs and gaps should be further clarified on a basis of the each country's situation. NOWPAP requests each member to assess its needs and effectiveness of cooperative marine environmental monitoring for proper conservation and use of Northwest Pacific, and to make and conduct a cooperative monitoring plan, once its needs and effectiveness are clarified.

2.3 Towards the Operational Monitoring

2.3.1 Eutrophication

(1) Appropriate parameters for the monitoring of eutrophication

Concerning eutrophication monitoring, for the time being, monitoring parameters should be 1) *chlorophyll-a* concentration that is already in practical use and is a good indicator of eutrophication; and 2) primary productivity that is estimated by observed *chlorophyll-a* concentration, sea surface temperature (SST), and photosynthetically available radiation (PAR).

(2) Monitoring method

Generally, *chlorophyll-a* concentration is estimated from two steps as shown below:

1) Atmospheric correction algorithm retrieves water-leaving radiance (L_W), and
2) In-water bio-optical algorithm estimates *chlorophyll-a* concentration from L_W

Presently in the open ocean water (Case I water), this method has been almost established for *chlorophyll-a* concentration. In contrast, in the coastal water (Case II water), the bio-optical algorithm is still under research and development, because of complexities due to the existence of SS and CDOM as well as *chlorophyll-a.* Recently, a neural network method and an iterative method have been introduced to estimate *chlorophyll-a,* SS, and CDOM.

(3) Modeling and prediction of eutrophication

Remote sensing can provide daily and global *chlorophyll-a* concentration data and SST data. Together with in situ data, remotely sensed data can be used for analyzing and studying the physical, chemical, and biological processes of eutrophication.

To predict eutrophication and red tide, ecosystem model capable of predicting plankton activity as well as hydrodynamic model capable of predicting currents and waves can be used.

2.3.2 Oil spill

(1) Appropriate parameter for the monitoring of oil spill

Concerning oil spill monitoring, monitoring parameters should be 1) radar backscatter, 2) induced fluorescence, 3) *chlorophyll-a* concentration, 4) SST, 5) Sea surface wind and 6) Sea ice.

(2) Modeling and prediction for oil spill

A large number of oil spill models are being used for predicting the behavior and fate of oil spills in marine environment. These range in capability from simple trajectory, or particle-tracking models, to three-dimensional trajectory and fate models that include simulation of response actions and estimation of biological effects. All present models describe the key physical and chemical processes, which transport and weather the oil on and in the sea. These physical and chemical processes are: 1) advection, 2) spreading, 3) evaporation, 4) natural dispersion, 5) emulsification, 6) oil-shoreline interactions, and 7) oil properties.

2.4 Development of Remote Sensing Information Network System

One of the final goals of WG4 is to establish marine environmental monitoring systems by remote sensing in the NOWPAP region. For establishing the monitoring systems, it is important to collect data and information, to forecast the development and behavior of eutrophication and oil spill, and then to disseminate data and information on the present conditions of eutrophication and oil spill and the forecasting results speedily. Based on the precise data and information provided, the policy-makers, monitoring and/or mitigation executing agencies, scientists and researchers, and ocean users in the region can make suitable measurements when eutrophication and oil spill might cause pollution problems.

However, data and information about the marine environment by remote sensing are actually scattered in different organizations in the NOWPAP region. In order to share their usability, to share existing research and development resources and to understand the future trends in marine environmental monitoring, developing remote sensing information network system, which integrates the scattered information, is the basic work. The information network system can be used for integrating scattered data and information, for promoting common recognition on environmental monitoring by RS, for capacity building, and for public outreach.

2.4.1 Establishment of Portal Site

(1) Objective of the portal site

Development of the information network system related to the marine environmental monitoring by RS should be carried out step by step because of the cost and technical difficulties. The First WG4 Meeting agreed on the development of the portal site on remote sensing in the NOWPAP region as the first step for the remote sensing information network system. A portal site is proposed as an option to share the common understanding on the status, challenges, and opportunities of marine environmental monitoring by RS in the NOWPAP region and to share the information for the future monitoring system establishment (Figure 4).

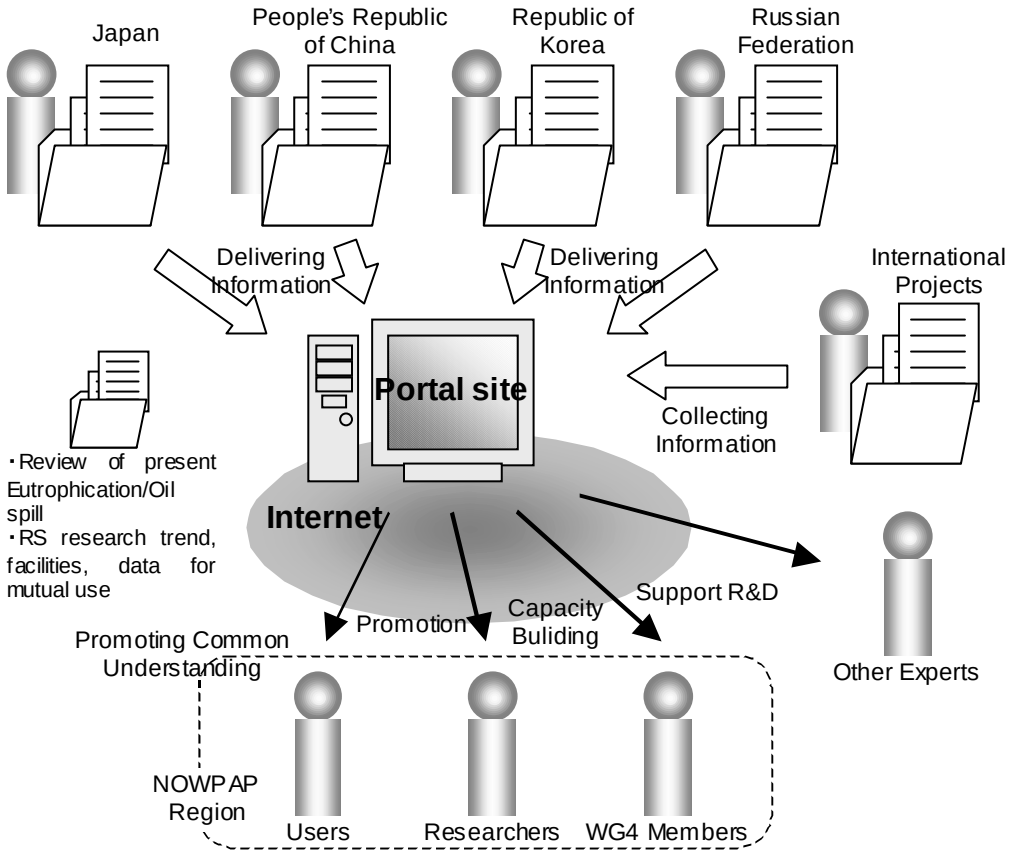


Figure 4 Diagram of portal site

The portal site consists of many website addresses which provides information on marine remote sensing. The main information sources of the portal site are NOWPAP Members. Each NOWPAP Member will be requested providing website addresses of related information to CEARAC. The information will also be referred from national reports as well as from other regions and projects if necessary. Information is organized and can be searched by items such as sensor, utilization field, or country. Users in the NOWPAP region can access the portal site and obtain information from it.

(2) Contents in the portal site

The portal site provides the following information:

- Specification of available sensors
- Information on data and products
- Reference list on monitoring of eutrophication and oil spill
- Utilization examples of monitoring eutrophication and oil spill
- Research trend
- List of related organizations
- News
- Education materials and publicity materials useful for capacity building

This information will be accessed freely and searched by three items: sensor, utilization field, and Member. The website is in English.

It takes several steps to establish the portal site. They are: 1) Preliminary design, 2) Collection of information, 3) Confirmation of information, 4) Organization of information, 5) Detailed design, 6) Development, and 7) Delivery of information.

2.4.2 Establishment of Website on Oil Spill Monitoring

The first WG4 meeting also agreed that CEARAC would support the development of the website on oil spill remote sensing at the Pacific Oceanological Institute (POI) of Russian Academy.

(1) Objective of the CEARAC website on oil spill monitoring

The purposes of developing the CEARAC website are as follows:

(a) Providing statistical data on oil pollution of the Northwest Pacific with a special attention to the coastal areas and to the areas where there are potential sources of oil pollution.

(b) Providing description of state of art of space-borne and airborne remote sensing techniques of oil pollution detection and monitoring.

(c) Providing short description of oil behaviour in the marine conditions.

(d) Providing program for visualization of the trajectory of a pollution spreading using the pollution spreading forecast system.

(e) Providing information on similar projects in Europe and the United States.

(2) Contributions of the CEARAC website on oil spill monitoring to CEARAC activities

The Website on oil spill monitoring is expected to make the following contributions to the CEARAC activities:

(a) Providing information on availability of airborne and satellite-borne remote sensing instruments for oil pollution monitoring in China, Japan, Korea and Russia.

(b) Providing information where and how to obtain the satellite SAR measurements over the particular area in a case of detection of oil pollution due to ship transport operation, fishery activity, river outflow as well as accidents.

(c) Disseminating CEARAC activities and results in the community of potential users of remote sensing techniques for marine pollution and in the public organizations.

(d) Providing links to the environmental information important for oil pollution monitoring.

(3) Contents of the CEARAC website on oil spill monitoring

It is designed to develop the following sections (pages) in the website:

- Remote sensing techniques of oil pollution detection; comparison of their efficiency; algorithms of interactive and automatic detection of oil spills (Links).
- Updated database of the georeferenced satellite SAR images of the Northwest Pacific.
- Updated database of the annotated georeferenced satellite SAR images of the Northwest Pacific with revealed oil pollution.

- Oil pollution of the Northwest Pacific; main sources of oil pollution; current situation and tendency (search via Internet).
- News – mainly via Links.
- Oil pollution spreading models (Links).
- Environmental information important for oil pollution monitoring – Links to the Japan, Korea, China and Russia sources of data.
- Influence of oil pollution on marine ecosystems (Links).
- International regulations on marine oil pollution – Links (UNEP)

2.5 Public Outreach

For public outreach, CEARAC website (http://cearac.nowpap.org/) and Newsletter are designed to introduce WG activities, to stress the usefulness of marine environmental monitoring by RS, and to broadcast the importance of putting the monitoring into effect. Together with the RS portal site and the website on oil spill monitoring to be developed, CEARAC website is expected to promote active research and development work, and RS applications.

2.6 Capacity Building of NOWPAP Members

The final goal of WG4 is to establish RS monitoring system of eutrophication and oil spill. For that purpose, NOWPAP Members are expected to share the common understanding on marine environmental monitoring by RS and to establish cooperative relationship so that NOWPAP Members can help each other in technical aspects.

With regards to training courses, in order to avoid duplicated work, NOWPAP Members should make the best use of existing training courses provided by other regions or organizations that are conducting similar activities. The First WG4 Meeting suggested posting the information about existing training courses and projects provided by other international organizations on the proposed portal site.

2.7 Cooperation with Other Regions and Organizations

In other regions and projects, there are various on-going activities related to marine environmental monitoring using RS. To implement NOWPAP activities effectively, it is vital

for CEARAC to understand these on-going activities in order to strengthen collaborative approach. The projects are listed below.

(1) NEAR-GOOS (North-East Asian Regional Global Ocean Observing System).

(2) COOP (Coastal Ocean Observations Panel).

(3) IOCCG (International Ocean Colour Coordinating Group).

(4) PICES (North Pacific Marine Science Organization).

(5) Red Tide Watcher in Asian Waters.

2.8 Capability of CEARAC

In order to support CEARAC, in 2002, the Ministry of the Environment of Japan established the Marine Environmental Watch System for Northwest Pacific Region. This Watch System is receiving and processing NOAA and FY-1 data and disseminating the data and products such as SST and *chlorophyll-a* on the Internet. NPEC is managing and operating the system. The system consists of five subsystems. They are acquiring and processing SS, Analyzing SS, Recording SS, Information Disseminating and Search SS, and File Transfer Protocol SS.

Also, to support CEARAC activities, NPEC is conducting the Toyama Bay Project. This Project started in April 2003 and will continue until March 2006. The objective of the Project is to develop the algorithm for measuring the concentrations of chlorophyll-a, suspended solid and colored dissolved organic matters in Toyama Bay by means of remote sensing technology. The following organizations are participating in this project: NEPC, Toyama Prefectural Environmental Science and Research Center, Toyama Prefectural Fishery Institute, Nagasaki University, and Toyama University.

2.9 Standardization of National Reports and Integrated Report

CEARAC proposed the Guidelines for National Report. The First WG4 Meeting agreed that each Working Group member would feedback comments and suggestions on the guideline, and CEARAC would revise the guideline by referring to the comments and suggestions. Each NOWPAP Member will prepare a draft national report based on the revised guideline by the Second Working Group 4 Meeting. The suitability of the guideline will be discussed and assessed at the Second Working Group 4 Meeting.

WG4 Members would submit the national report to the Working Group 4 every two years, and also agreed that CEARAC would prepare the integrated report every two years based on the national reports. The Director of CEARAC will submit the integrated report to CEARAC Focal Points Meetings.

2.10 Long-term Plan

CEARAC will continue to update and maintain the portal site and website on oil spill monitoring, and CEARAC will put its continuous efforts on planning and coordinating the eutrophication monitoring and oil spill detection work in the NOWPAP region (Table 2).

Table 2 Long-term plan

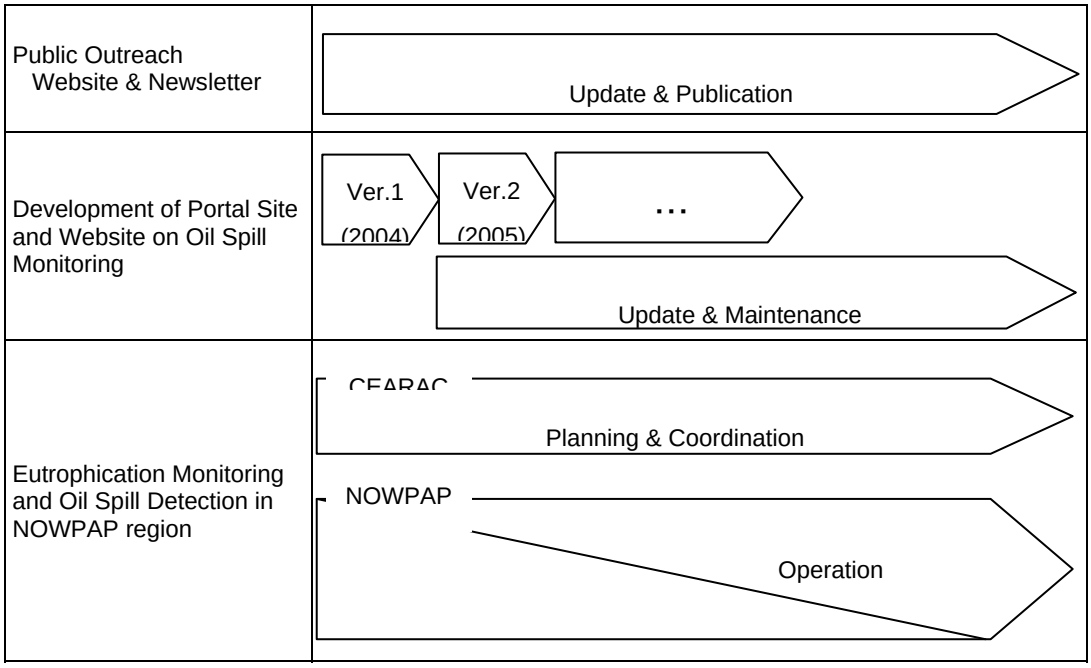
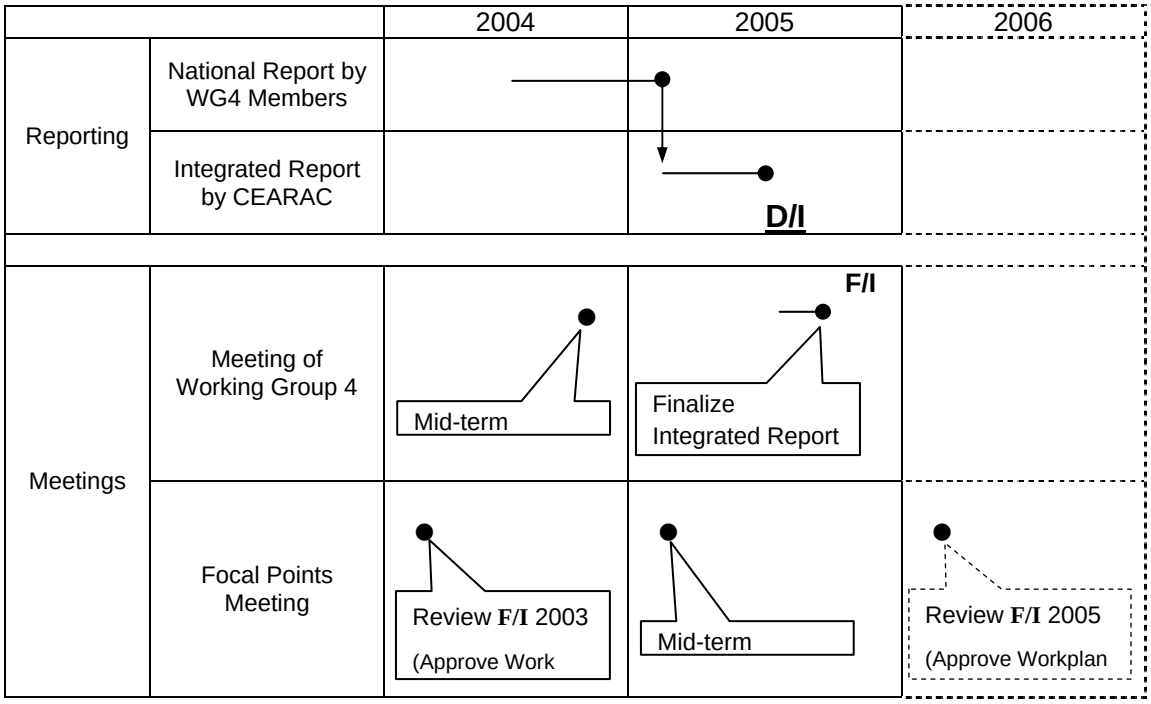


Table 3 Workplan for 2004/2005 (Reporting & Meetings)



D/I: Draft Integrated Report, **F/I:** Final Integrated Report

2.11 Proposed Work Plan for 2004/5

The proposed Work Plan for 2004/5 includes compiling integrated report, convening FPM and WG4 meetings, setting up a portal site and website on oil spill monitoring, disseminating information, and convening workshops (Table 3).

At the first WG4 meeting, CEARAC proposed holding the Second WG4 Meeting in Beijing in Autumn 2004.

Chapter 4 Activities of NOWPAP WG 4 in 2003

NOWPAP WG 4 conducted the activities related to making up the workplan for WG4 in 2003.

In the First FPM of CEARAC in February 2003, the remote sensing (RS) subgroup agreed that 8 main issues needed to be focused on by Working Group 4. After the first FPM, CEARAC planned to hold the First Working Group 4 Meeting to further discuss these 8 main issues.

Before holding the meeting, CEARAC organized a series of Internet meetings to define the provisional agenda items of the First NOWPAP Working Group 4 Meeting and to have preliminary discussion on each items.

Then CEARAC held the First NOWPAP Working Group 4 Meeting, in the Pacific Oceanological Institute (POI) of Russian Academy from December 1st to 3rd, 2003, in Vladivostok, Russia. This meeting agreed that 'Eutrophication' and 'Oil spill' should be the targets of marine environmental monitoring by RS for the time being.

In the first WG4 meeting, CEARAC proposed a 'Plan of Work for the NOWPAP Working Group 4'. After a productive discussion, the First WG4 Meeting agreed on the 'Plan of Work'.