



REGIONAL CO-OPERATIVE AGREEMENT FOR ASIA
AND THE PACIFIC REGION

INTERNATIONAL ATOMIC ENERGY AGENCY



***IAEA/RCA RAS/7/011
Final Project Meeting
On
"Enhancing the Sustainability of the Marine
Coastal Environment"; Component 3
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REPORT

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TABLE OF CONTENTS

1.	Introduction.....	3
1.1	Background.....	3
1.2	Objectives of the Meeting.....	4
2.	Country reports - Abstracts.....	4
3.	Accomplishments.....	7
4.	Project Outcomes - End Users, applications and achievements.....	13
4.1	Receptor binding assay.....	13
4.2	Radiometric dating & cysts analysis of sediment cores.....	15
5.	Conclusions.....	17
5.1	Preliminary assessment of project impact.....	17
5.2	Project effectiveness.....	17
5.3	Project efficiency.....	18
5.4	Assessment of sustainability.....	18
5.5	Major strengths and weaknesses.....	19
5.6	Lessons learned.....	22
6.	Recommendations.....	23
6.1	Recommendations to the IAEA and national RCA Coordinators.....	23
6.2	Recommendations to government authorities and National RCA Coordinators:.....	24

1 Introduction

1.1 Background

This project extension was designed to build on the achievements of the subproject “Management of the Marine Coastal Environment and Its Pollution” under the joint UNDP/RCA/IAEA project “Better Management of the Environment, Natural Resources and Industrial growth through Isotope and Radiation Technology” RAS 97/030. Activities under the subproject were implemented under RAS 8083 “Management of marine coastal environment pollution” funded by Australia, RAS8080 “Better Management of the Environment and Industry through Isotope and Radiation Techniques, component 1 on Marine pollution” and partly under RAS 8076 “Better Management of Environment & Industrial Management”.

The project extension consisted of three components:

1. Extension and application of the marine database (ASPAMARD)
2. Fate and behaviour of pollutants
3. Harmful algal bloom concerns

This document reports the activities and achievements related to Component 3 on “Nuclear Techniques to Address Specific Harmful Algal Bloom Concerns” that were carried out under RAS7011. The achievements reported herein comprised those attained at the regional as well as the national levels.

Increasing frequency and intensity of harmful algal blooms (HABs) in South East Asia and their associated adverse public health and socio-economic impacts pose a major concern for countries in the region. Two approaches to the problem were used which addressed:

(1) Toxin quantification: the need for a rapid and sensitive assay to complement and eventually replace the current live mouse bioassay is recognized as essential to the enhancement of shellfish toxicity monitoring and management of HABs. The receptor binding assay that has been developed recently at the NOAA laboratory (Charleston, USA) is recognised as the most viable alternative to the mouse assay. Most Member States (MS's) already have the basic hardware requirements to implement the technology.

(2) HAB occurrences: at present, very little is known on the history of HAB events within the region. Therefore, there is also a need to understand further the influence of natural and anthropogenic causes of harmful algal blooms through the study of sediment cores using radiometric dating techniques and, the identification and quantification of modern and fossil cysts in the sediment.

There are 7 countries participating in this project: China, Indonesia, Malaysia, Pakistan, Philippines, Thailand and Vietnam. The participation of end users was one of the requirements for this project. Targeted end users are from the regulatory authorities responsible for certification of seafood safety, health departments and the fisheries industry. A list of end users is given in annex 3.

1.2 Objectives of the Meeting

This regional meeting is designed to;

- Receive final country reports for each component
- Assess national progress made under each activity
- Draft a Terminal Project Report
- Make recommendations to the IAEA and to MSs based on project outcomes

2 Country reports - Abstracts

For the efficient and effective conduct of the Meeting, the participating countries were requested, in advance, to prepare Country Reports covering the present status of the topics in their countries. The Country Reports are attached as Annex 5 to this report.

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China

China is one of the countries facing increasing HAB problems. Paralytic shellfish toxins and diarrhetic shellfish toxins are the two main HAB toxins in China. Mouse bio-assay is the most commonly used method currently in toxic HAB monitoring. With the help of equipment supplied from IAEA as well as technique training from the expert laboratory (NOAA), China has set up the traditional receptor binding assay for PSP and NSP toxins. The team made comparison with mouse bioassay, ELISA and HPLC and also applied the assay in shellfish toxin monitoring. It is found out that the receptor binding assay is a fast, sensitive, effective and relatively simple assay for the toxin analysis. Once the availability of the tritium labeled toxin standard has been solved, it certainly could be an alternative method for routine monitoring of HAB toxins.

More than 200 sediment samples from five areas in coastal water of Southeastern China Sea were collected. 29 species of dinoflagellate cyst were identified. Two sediment core samples in Xiamen Harbor were collected and analyzed. The results showed that the sedimentation rate here was very high. Based on cyst studies, an *Alexandrium tamarense* bloom appeared to have happened in Autumn of 2002, though there is no report. It is concluded that through this project, cysts monitoring and identification has improved greatly in China. The sediment studies, including cyst analysis and isotope dating, are of critical importance to HAB monitoring.

Indonesia

Harmful algal identification and sedimentation rate studies have been carried out by CRDAT National Nuclear Energy Agency Yogyakarta, Indonesia. Sodium polytungstate was used for separating cysts from sediments. Pb-210 dating was performed by gamma spectrometry at 46.5 keV for sedimentation rate studies. Sampling location selected were Semarang, Muria and Surabaya coasts for cyst identifications and Cirebon, Semarang, Muria and Surabaya coasts for sedimentation rate studies. More species were identified at Tanjung Mas Port Semarang and near

Tanjung Perak Surabaya may come from ports activities. Fast sedimentation rates of 10 cm/y at Cirebon may be caused by human activities and river contribution. Fluctuating sedimentation rates at Semarang may be caused by sandy sediment core or sediment layer mixing.

Malaysia

During the period 2003 – 2005, Malaysia participated in two activities, namely the receptor binding assay and sedimentation rate studies. Facilities for the RBA were established at Universiti Kebangsaan Malaysia (UKM) and the Malaysia Department of Fisheries. Personnel competent to perform the RBA were trained through a national training workshop. UKM also provided training in the RBA to trainees from Pakistan and Indonesia. Malaysia successfully participated in the RBA interlaboratory exercise. Sediment cores for chronology studies were collected from the Straits of Malacca and west coast of Sabah. Facilities for sediment dating were established in Universiti Kebangsaan Malaysia and Malaysian Institute for Nuclear Technology (MINT). Chronology of *Pyrodinium bahamense* blooms could not be established due to absence of cysts in the sediment cores.

Pakistan

HAB events have been found to occur along the entire 960 km long coast of Pakistan at selected locations mainly at Karachi coast (locations: Manora, Sandspit, Rehri and Korangi), Gwadar, Pasni, and Miani Hor. It appears that the coasts of Gwadar and Karachi are more susceptible to occurrence of HAB events. The bloom forming toxic phytoplankton species like *Noctiluca scintillans*, *Ceratium furca*, *Phaeocystis sp*, *Dictyocha*, *Rhizosolenia*, *Protoperdinium*, *Alexandrium*, *Gymnodinium*, *Prorocentrum minimum*, *Pyrodinium bahamense* were identified in the water samples. The blooms are mostly of green, brown, dark brown and orange red in colour. The presence of green bloom and orange red colour bloom by *Noctiluca* species seems interesting and needs to be studied. HAB events have resulted in issues like migratory fish irritation, fish kill events, and shrimp kill events. HAB Cyst species as identified so far in bottom 2 cm slice of 28 inter-tidal sediment cores (dia 6 cm) collected from eight (8) selected locations along Pakistan coast include those of *Prorocentrum*, *Gymnodinium*, *Alexandrium*, *Protoperdinium*. Live Cyst Cell densities ranged from 2 – 53 Cysts/gram of sediments. The sediment core (No. GW1) collected off Gwadar Coast has indicated presence of Toxic/Harmful Algal Species namely: *Pyrodinium bahamense* at a depth of 2 cm. Mass mortality of fish has been reported previously along Gwadar coast. PINSTECH received essential supplies and expert assistance from IAEA/RCA for establishment of Receptor Binding Assay Laboratory for PSP analysis; radiometric dating of sediment cores and conduct of a National Training Course on HAB Concerns in Islamabad/Karachi during June, 2005. ²¹⁰Pb dating was performed on 2 cm slices of two complete cores collected from Jiwani and Port Qasim Karachi. ²¹⁰Pb based sedimentation rates of about 0.5 cm/yr were calculated using “Constant Rate of Supply” (CRS) Model. IAEA/RCA awarded two training fellowships and one scientific visit to researchers from PINSTECH. The end-user institutions in collaboration with PINSTECH are willing to continue the HAB related activities in collaboration with national nuclear institute. For future studies, the national institute plans to focus on determination of the source, fate, and consequences of algal toxins, development of forecasting capabilities for the occurrence and impacts of HABs as well as management and mitigation strategies to minimize impacts of biotoxins and harmful algae in terrestrial/marine environment in

terrestrial environment (lakes, dams etc.) and marine coastal environment (marine foodwebs) and fisheries.

Philippines

Receptor binding assay for PSP toxins was fully established in terms of available expertise, results inter-comparability, and equipment availability. One of the staff, Ms. Azucena de Vera, has served as expert in two countries in the region to assist in the establishment of RBA. The Philippines also hosted visitors from the other countries in the region in relation to RBA.

Intercomparison studies between mouse bioassay, RBA and HPLC method have been conducted and gave good agreement among methods. RBA is now being used as an assay method for uptake studies of the saxitoxins in shellfish in field conditions. Its application in monitoring work will be taken up once 3HSTX is commercially available.

The research work on the tritium labelling of saxitoxin has provided the method of labelling saxitoxin with aqueous tritium by exchange reaction. Making small quantities of low specific activity ³HSTX in the laboratory can be done quite easily but producing large amounts of high specific activity 3HSTX is much more difficult because of limited availability of high specific activity tritium and also of saxitoxin. The feasibility of iodinating μ -conotoxin is being explored for producing an alternative radioligand for RBA.

Sampling for sediment dating and cyst analyses have been completed in five study areas/bays (Manila bay, Malampaya Sound, Bolinao area, Masinloc area, and Honda Bay). About 40 cores have been collected in these areas. Results of the work in Manila Bay and Malampaya Sound have been published in ISI covered journals. A dinoflagellate cyst analysis facility has been established at the Marine Science Institute, University of the Philippines which serves as Regional Resource Unit (RRU) of IAEA. Fellows from Pakistan and Indonesia have undergone short term training in this RRU. The facility has also been serving for the analysis of samples from other areas of the country.

For the first time a cyst based model has been developed for a tropical dinoflagellate as a result of the interdisciplinary collaboration at the University of the Philippines. The Pyrodinium model for Manila Bay was presented as an oral paper during the International Conference on Harmful Algal Blooms in South Africa in 2004. A manuscript on this model together with two others on the circulation of the Bay have been accepted for publication and is now in press (Harmful Algae, Elsevier).

Thailand

The work have been done during the last three years (2003-2005) are listed as the followings: 9 sediment cores from one area along the east coast of the Gulf of Thailand were dated by radiometric (²¹⁰Pb) dating technique. The sedimentation rate was varied from 0.221-2.294 gm/cm².yr. Grain size distribution was done by laser diffraction technique. The data of cyst identification in surface sediment from 14 stations of the same area done by Marine Science Department, Chulalongkorn University was included in the country report. Nuclear based (RBA) technique was established at OAP since June 2005 by assistances of IAEA expert. Several local mollusks were analyzed for PSP using this technique. To verify the technique, collaboration with the Fishery Inspection and Quality Control Division (FIQCD) for RBA vs. mouse bioassay inter-laboratory comparison was established.

The labelled saxitoxin (^3H -STX) has also locally been produced at Radioisotope Production Program, OAP, but with insufficient high specific activity for RBA at the moment (maximum of 4 Ci/mmol). Therefore, validation of the end-product has not yet been performed.

Vietnam

During the period 2003 – 2005, sediment cores for chronology studies were collected from Cam Ranh Bay (3 cores), Ha Long Bay (3 cores), and Tuy Phong Bay (3 cores). Facilities for the RBA were established mid 2005 at the Nuclear Research Institute in DaLat. One staff went to PNRI (Philippines) for a scientific visit on how to perform the RBA. Then, one week expert mission was undertaken by Dr. Azucene De Vera from PNRI to establish the RBA method in DaLat NRI. Twenty samples of pernavipidis have been taken from Cam Ranh Bay for saxitoxin analysis by RBA method.

3 Accomplishments

A summary of the accomplishments for Component 3 showing how the objectives of the Project were successfully met are presented in succeeding paragraphs. These objectives are from the Project Framework Matrix and agreed upon by participating Member States at the PFM in Kuala Lumpur in March 2003 (Annex 4).

Specific objective 1: To enhance regional capability to produce PSP toxin standards, in particular radiolabeled toxins.

Verifiable indicator: availability of labelled toxin standards for use in PSP toxins RBA

Actual accomplishments: the activity was undertaken by two Member states (PHI, THA).

Philippines – Tritiated STX was prepared by exchange reaction. However, product of sufficient specific activity suitable for high throughput and sensitive RBA could not be produced due to unavailability of high specific activity tritium locally. Current labelling efforts focus on production of I125-labelled Conotoxin.

Protocols suitable for ^3H -labelling of STX were made available to the IAEA.

Means of verification: Final Technical Project Report submitted to the Philippine Department of Science and Technology and PHI7006 Project Report.

Thailand – ^3H -STX has been produced by isotopic exchange reaction. However, the specific activity obtained was not sufficiently high for RBA application. The limiting factor was unavailability of high specific activity tritiated water.

The product has yet to be validated by end-users.

Means of Verification: Country Report presented in this meeting.

Specific objective 2: To further transfer of the receptor binding assay technology to interested Member States

Verifiable indicator: Equipped laboratory facilities and trained personnel are in place in all participating Member States

Actual accomplishments: The RBA method was transferred to all the participating MSs with exception of Indonesia.

China – Laboratory facilities required to perform the RBA are available in First Institute of Oceanography, State Oceanic Administration of China. Trained personnel (2) are available in FIO, SOA of China. An expert mission was provided to FIO to implement the RBA in China in Dec.2004.

Means of Verification: Project report “Establishment on receptor binding assay for PSP toxins and comparative studies on RBA with mouse bioassay and immunoassay for PSP toxins” was presented to national CEOHAB project in Sept.2004.

Malaysia – Laboratory facilities required to perform the RBA are available in Universiti Kebangsaan Malaysia and The Malaysia Department of Fisheries (shellfish toxicity monitoring agency). Trained personnel are available in UKM (4) and the Malaysia Department of Fisheries (3). A fellowship trainee and scientific visit from Pakistan were hosted in 2004.

Means of Verification: Studies using the RBA were reported at the JSPS seminar in 2003 and published in *Toxicon*. Data from the interlaboratory calibration exercise were presented at this meeting.

Pakistan – Laboratory facilities required to perform the RBA are available in the Pakistan Institute of Nuclear Science and Technology (PINSTECH). Trained personnel are available in PINSTECH, Islamabad and NIO Karachi. One fellowship, one scientific visit and an expert mission from Malaysia were provided to PINSTECH to implement RBA in Pakistan.

Means of Verification: Country Report presented in this meeting.

Philippines – The RBA method has been established through intercomparison studies using HPLC, MBA and RBA. The facilities include a well-type counter as well as a conventional LSC.

As an RRU, it has accepted scientific visitors from Pakistan and Vietnam. It has also sent expert missions to Thailand and Vietnam to assist in establishing the RBA in these countries.

Means of Verification: A poster and a paper presentation were made in the local Chemistry Congress.

Thailand- Laboratory facilities required to perform the RBA are mostly available at Radioactive Waste Management Program, OAP, and some at Marine Sciences Institute, Burapha University. One expert mission from Philippines was provided to OAP in order to establish national capacity of RBA technique for PSP toxin detection in May 23-June 3, 2005. There are 8 personnel trained at OAP, and two from Marine Sciences Institute, Burapha University.

Means of Verification: The results of PSP toxin inspection of samples from local market and provided from FIQCD by RBA technique were presented in this meeting.

Vietnam – Laboratory facilities required to perform the RBA are mostly available at the Atomic Energy Institute and at the Institute of Oceanography. One scientific visit to Philippines and an expert mission from Philippines were provided to establish RBA

in Vietnam. Samples of *pernaviridis* taken from Cam Ranh Bay and market samples were analysed by RBA method for saxitoxin content.

Means of Verification: The result of PSP toxins analysis by RBA in shellfish collected from domestic market was presented during this meeting.

Specific objective 3: To establish the receptor assay method in some Member State laboratories.

Verifiable indicator: Demonstrated performance in intercalibration QA/QC exercise with expert laboratory

Actual accomplishments: An interlaboratory calibration exercise coordinated and funded by NOAA Charleston Laboratory (US) was undertaken with 6 participants of 5 countries, namely, CPR, MAL, PAK, PHI (PNRI, MSI) and THA.

1. All the six participating institutions in the member countries performed the assays. Specific problems encountered by some participating countries were:

- i. **China** – ³H-STX and membrane preparation could not be shipped by NOAA due to Customs restrictions. The assay was performed using material already available in the country (previous IAEA shipment).
- ii. **Pakistan** – membrane preparation could not be provided due to Customs restrictions. ³H-STX was shipped but arrived in unusable state due to long storage at high temperature in transit in Dubai.
- iii. **Philippines** – First shipment of ³H-STX was delayed, resulting in degradation. A second shipment was made and the assays were carried out successfully.
- iv. **Thailand** – Second shipment of ³H-STX was not stored at the proper temperature for a week while awaiting collection in Bangkok.

2. Four participating laboratories (CPR, MAL, PHI-PNRI, THA) reported data in time for analysis by the NOAA laboratory and discussed during the final project meeting. Results from PHI-MSI were not yet available for the final project meeting.

3. Two counting formats were used:

Malaysia – PE/Wallac Microbeta counter

Philippines - (PNRI, MSI) – Packard microplate counter

China, Pakistan, Thailand – conventional LSC

4. Results of analysis on data reported by the participating institutions are shown in the table 1.

- QC checks for all laboratories were well within acceptable limits
- This is the first measurement of RSDR (between laboratory variability) for this assay and is well within the specifications for within laboratory variability

The data from the round robin exercise will assist greatly in obtaining approval of a protocol by the AOAC that will be used for the AOAC collaborative trial which will be implemented under the INT7016.

Table 1. Summary of PSP toxin content obtained by the participating institutions. Values for the unknown samples RR1-RR7 are in µg STXequiv/100g shellfish meat.

	MAL	THA	CPR	PHI	AV	SD	RSD	Expected Value*
QC (in assay conc., nM)	2.8	3.5	2.8	2.5	2.9	0.4	14.3	3.0
RR1	54.2	38.1	38.8	44.2	43.8	7.4	17.0	46.0
RR2	513.0	457.0	466.0	550.6	496.7	43.5	8.8	480.0
RR3	768.0	574.0	551.0	502.3	598.8	116.7	19.5	715.0
RR4	628.0	581.0	833.0	536.1	644.5	131.1	20.3	518.0
RR5	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL
RR6	478.0	344.0	450.0	301.9	393.5	84.0	21.4	438.0
RR7	124.0	114.0	79.0	70.3	96.8	26.2	27.0	104.0

*average of 5 independent assays at NOAA

Specific objective 4: To refine strategies for sediment sampling and cyst analysis for the past and present distribution of HAB species in the region.

Verifiable indicator: More focussed and refined sedimentation and related studies in correlation with harmful algal blooms.

Actual accomplishments: A large number of sediment cores were collected in 29 areas (Mal – 6, Phil – 5, Pak – 8, Thai – 1, Indo – 4, Chi – 5) throughout the region. A total of 47 cores were analysed for sedimentation studies and 132 sediment cores for cyst analysis. Pb-210 dating laboratories were established / improved in all participating countries through training, visits, expert missions and provision of consumables/equipment by the national governments and the IAEA. These facilities and capabilities can now be used for other environmental studies and management/monitoring of aquatic environments.

Members States agreed that the unit Bq/Kg will be used to report radioactivity data in order to make intercomparison of results and reporting easier. For Cyst numbers it was agreed that number of cysts per gram should be used. The sedimentation rate and cyst studies were complimented by physio/chemical analysis to gain a better understanding of the dynamics of HAB's.

Publication of the results in ISI covered journals have been done for the works in Manila Bay and Malampaya Sound, Palawan, Philippines.

China - Cyst sampling and analysis becomes one of the important components in Chinese national HAB project. The collection of sediment samples are carefully designed before each cruise. More multi tube core sampler is used instead of crab sampler.

Indonesia – Four universities interested in program of sedimentation rate study, and this facility has been used for research and environmental monitoring for 4 areas in north Java coast. It will be continued for other selected area. Collaboration with Yogyakarta Environmental Management Institute is in prcess for location of south coast Java (Indian Ocean Coast) located in Yogyakarta Province. Collecting data of

harmful algal will be continued in collaboration with universities to study the vertical and horizontal distribution.

Pakistan - The National Nuclear Institute (PINSTECH, Islamabad) and various end-user institutions (CEMB, NIO, WWF, PN, CEMB etc.) have strongly collaborated and refined strategies for sediment sampling (horizontal distribution & vertical profile) for cyst analysis to establish past and present distribution of HAB species along Pakistan coast.

Malaysia - Universiti Kebangsaan Malaysia and the Malaysia Institute for Nuclear Technology intend to collect more sediment cores from areas not previously sampled. During the project period 18 sediment cores were obtained from selected locations in the Straits of Malacca and the west coast of Sabah. None of those samples contained *Pyrodinium* cysts so estimation of the year in which the species first appeared in Malaysian waters could not be made.

Philippines - Standard techniques for sediment collection, sampling, and analysis for dating and cyst abundance have been used and will be used in other areas affected/potentially affected by HABs. RRU for cyst sampling and analysis has been established and used for transfer of technology to three fellows from the region (Pakistan, Indonesia and Vietnam)

Thailand - The strategies for sediment sampling and sediment dating was refined by sampling and dating of 9 sediment cores of Angsila, Sichang Island, Sri Racha, Laem Tan and Laem Chaban in Chonburi Province of the east coast of the Gulf of Thailand. The dating result was then applied by master student of Chulalongkorn University on his study of *Species and abundance of Dinoflagellate cysts in the surface sediment of Ang Sila, Si Racha, and Laem Chabang areas*. From his study 30 species of phytoplankton were found, 28 species were identified and 2 species were unable to identify. Although it is a horizontal distribution study, it gives a clear picture of distribution of cysts of the study area.

Specific objective 5: To obtain data and complete a database to help in determining the anthropogenic and natural influences on HAB occurrence in the region.

Verifiable indicator: An expanded data-base available in electronic or hard-copy.

Actual accomplishments: The national databases of the participating countries are now available for merging into the regional database. The database will be published by the group and collated by the RRU (UP/MSI) with assistance of the lead-country (AUL). Highlights of the results will be uploaded at the IOC-Ocean Portal (HABSEA-Portal). This will make data available to participants and other interested parties (like end-users and stakeholders) for further analysis/study and or management purposes. The new regional database will facilitate a better understanding of the effects of regional climate variability, human activities and other environmental factors on the dynamics of HAB's. The database will also indicate gaps in knowledge and geographical areas. This will identify further areas of study and management concern.

China - China will provide all opened HAB monitoring data.

Indonesia – Cirebon, Muria, Semarang and Surabaya coast have been selected for sedimentation rate study and 12 sediment cores have been analyzed. Fast

sedimentation rate occurred at Cirebon coast up to 10 cm/y might be caused by human activities or river contribution as the sediment sources. Fluctuated sedimentation rate at Semarang core might be caused by sandy sediment or layer mixing.

Muria, Semarang and Surabaya coast were selected for harmful algal concern, 17 species have been detected. More species at Semarang and Surabaya come from port transportation activities.

Pakistan - 28 inter-tidal sediment cores/seawater samples were collected from 8 selected locations along 960 km long coastal strip of Pakistan. The coasts of Gwadar and Karachi are found more susceptible to occurrence of HAB events. HABs are mostly of green, brown, dark brown and orange red in colour. Maps have been prepared w.r.t. occurrences of HAB events, fish/shrimp kill events and presence of HAB Cyst in sediment profiles along Pakistan coast. Live cells of *Gymnodinium*, *Alexandrium*, *Protoperdinium* and *Pyrodinium bahamense* are found in bottom 2 cm slice of selected cores. ^{210}Pb based sedimentation rates are found to be ~ 0.5 cm/yr. The measured ^{210}Pb activities in sediment profile are comparable with data reported for other coastal areas in the region.

Malaysia - Data will be published in the web site or scientific journal.

Philippines - Data base for Manila Bay has been completed and published. More data will be made available from the other 4 study areas already sampled. Studies in Manila Bay have shown that physico-chemical changes which are affected mostly by the tropical monsoons and also by some anthropogenic influences play major roles in the dynamics of toxic algal blooms in Manila Bay. This could be also true in other areas with similar conditions.

Thailand - Data of red tide occurrences in the Gulf of Thailand collected by the Aquatic Resources Research Institute, the Department of Marine Science of Chulalongkorn University; Pollution Control Department and the Department of Marine and Coastal Resources of the Ministry of Natural Resources and the Environment during 1957-2005 was provided to the new regional data-base on red tide occurrences.

Specific objective 6: To work towards developing a predictive model for the occurrence of HAB in the region.

Verifiable indicator: Availability of preliminary model for predicting algal blooms.

Actual accomplishments: The first model for tropical toxic blooms “Pyrodinium” has been completed for Manila Bay, by an interdisciplinary group at the University of the Philippines and presented during the International Conference on Harmful Algal Blooms in South Africa in 2004. The corresponding manuscript is now “in press” (Harmful Algae). Similar models can be developed for other HAB organisms in the area. The new regional database will be an important verification tool for testing these new models.

China - South China Sea Institute of Oceanology is working on the modeling of large scale HAB process in the coastal water of East China Sea. Other Chinese institute did some HAB modeling in some coastal estuary or bayment area.

Indonesia – Developing a predictive model for the occurrence of HAB could not be performed yet because there was not enough data. Collecting data should be continued.

Malaysia - Prediction model on HABs for Malaysia waters was not available because there was insufficient data, especially on cysts. Furthermore, an expert visit for this component could not be implemented due to unavailability of a suitable expert.

Pakistan - The data collected by PINSTECH in collaboration with end-user institutions will help development of predictive model by the national focal points (NIO, CEMB-Karachi University, Marine Fisheries Department etc.) and other regional focal points to validate developed model applications.

Philippines - Three models to help describe, understand and predict Pyrodinium and other phytoplankton blooms in Manila Bay were completed and now in press. These are: a 3D POM model, the SWAN model and a cyst based 3 D Langrarian particle dispersal model. The models were validated/will be validated using existing data and other HAB events in other areas.

Thailand - Predictive models of red tide occurrences in the Gulf of Thailand and the Andaman Sea are now being developed by Physical Oceanographic group of Marine Science Department, Chulalongkorn University and Phuket Marine Biology Center, Department of Marine and Coastal Resources, Ministry of Natural Resources and the Environment. The data-base developed under 2.5 will help in verification of the models developing mentioned above.

4 Project Outcomes - End Users, applications and achievements

4.1 Receptor binding assay

China – Comparative studies were carried out on receptor binding assay with AOAC mouse bioassay, Elisa immunoassay as well as HPLC method. RBA was applied in shellfish toxin monitoring in Zhoushan islands in East China Sea during the spring HAB in 2004. One shellfish sample was detected to contain PSP or TTX by both RBA and MBA. The technique is ready to be transferred to the end users.

Malaysia – Establishment of the RBA has enabled comparative studies on PSP toxins to be carried out. Participation in this project provided justification for the establishment of RBA facilities in Universiti Kebangsaan Malaysia using in-country funds. These facilities are available for use by other agencies in the country. In country training was provided to several end-user institutions.

While the Malaysia Department of Fisheries now has the capability to perform the RBA, its use in routine shellfish toxicity monitoring will most likely depend on recognition and adoption of the method at the international level.

Success story: Proven capability to implement various steps in the RBA makes Malaysia one of the countries in the region where training in the technique can be pursued. Malaysia is also able to provide experts for IAEA expert missions on the RBA if required.

Pakistan – Through assistance provided by IAEA/RCA, the National Nuclear Institute (PINSTECH, Islamabad) has established Receptor Binding Assay Laboratory at the Ecological Research Section of RIAD/PINSTECH for PSP analysis in 2005. Due to unavailability of labelled saxitoxin to Pakistan (restriction of import of toxic material to Pakistan) no further work was carried out. However a national training course was conducted to demonstrate RBA. Eight end user institutes took part in this training course.

Philippines – Collaboration with the regulatory agency for seafood safety entered into the second phase with the implementation of the national program aiming for the transfer of RBA to the regulatory agency. The RBA method may be used by the regulatory agency in the screening of samples for PSP contents as soon as the labelled compound becomes commercially available. The use of RBA will translate into shorter shellfish ban and better management of PSP cases in the country.

The receptor binding assay technique is fully established in the Philippines and is now going to be transferred to the regulatory authority on seafood safety as soon as ³HSTX becomes available commercially. As an RRU, it has trained people on the use of RBA.

Success stories: A high throughput method is now available for routine monitoring for PSP toxins in seafood thus helping in the seafood safety efforts in the country. The RBA method is also being used in saxitoxin uptake studies as a complementary tool for the assessment of PSP toxicity in various species of shellfish.

Thailand – Even though labelled ³H-STX could be produced at OAP, the specific activity is not sufficiently high for RBA. Therefore, the end-product has not yet been distributed to our end users in research institutes, universities, and Fisheries Department for validation. However, OAP established inter-collaborations with local organization, Fisheries Inspection and Quality Control Division (FIQCD), Fisheries Department, Ministry of Agriculture and Cooperation for such an activity. Subsequently, the validation of RBA technique with AOAC mouse bioassay will be performed at OAP, and at FIQCD, respectively, in the future. In addition, RBA was used to inspect shellfish samples collected from domestic markets and obtained from FIQCD. PSP toxin was detected from 6 of 16 samples but with very low concentrations ranging from 4 to 10 µg STX eq/100 g. The results will be reported to the FIQCD for recording. Importantly, the RBA technique will be available for determination of PSP by OAP trained personnel whenever the PSP contamination becomes national hot issues and the technique has been recognized and adopted internationally.

Vietnam – In September, 2005, the 1st trial on RBA was carried out in the Atomic Energy Institute. However, RBA should now be applied by the Institute of Oceanography, who has responsibility in algal toxins studies. There would have to be more personnel trained and facility support to establish a RBA laboratory in Vietnam. It would be considered as potential method for national monitoring of PSP toxins and others neurotoxins (TTX, NSP).

4.2 Radiometric dating & cysts analysis of sediment cores

China - This is the first time to link cyst density and distribution to the HAB bloom in China. The techniques and results are transferred to HAB monitoring and marine environment management agencies of the State Oceanic Administration. It is suggested that cyst collection and identification should be included in HAB monitoring activities in the area, where cyst forming dinoflagellates are the main causative HAB organisms. To understand the history of HAB in an area that currently has frequent HAB, it is necessary to conduct isotope dating together with cyst analysis.

Success story: After analysing cyst data from core sample at Xiamen Harbor, it was concluded that two blooms of *Alexandrium tamarense* appeared in spring and autumn, 2002. However, the bloom in spring was the only one reported. The autumn bloom was missed possibly because it only lasted for a short period. Therefore this type of cyst survey could help to discover future blooms.

Indonesia – Data generated have been used by four universities (Diponegoro University (Semarang), Universitas Islam Indonesia (Yogyakarta), Brawijaya University (Malang) and Sekolah Tinggi Teknik Nuklir (Yogyakarta) for student's research on sedimentation rate studies and will be used for port authority and environmental and marine departments. At present, we have the capability in cyst determination. More data will be collected to include vertical and horizontal cyst distribution.

Success stories: Sedimentation rates were performed by CRDAT (National Nuclear Energy Agency Yogyakarta) and Universities for 4 areas. Twelve sediment cores were analysed and more will be determined at other selected areas. Fast sedimentation rate up to 10 cm/y occurred at Cirebon coast might be caused by human activities and river water contribution. Three areas were studied for algal identification of 8 samples. Seventeen harmful algal species were identified. More algal species identified in Semarang and Surabaya might come from ports activities.

Malaysia – Sediment cores for sedimentation studies were collected from the southern part of the Straits of Malacca and west coast of Sabah. Sedimentation rate was determined by ^{210}Pb dating. The cores were also analyzed for the presence of *Pyrodinium* cysts.

Success story: Sedimentation rates were successfully determined. Mean sedimentation rates obtained were less than 1.0 cm/yr for both locations. No *Pyrodinium* cyst was found in the cores.

Pakistan – IAEA/RCA significantly supported Pakistan to establish/enhance HAB/Red Tide research related technical facilities and human resource development programme. Through assistance provided by IAEA/RCA, the National Nuclear Institute (PINSTECH, Islamabad) has established ^{210}Pb dating facilities to establish the chronology of HAB Cyst occurrences in sediment cores along Pakistan coast. As such a team of researchers from End-user institutions (CEMB & NIO, Karachi); and National Nuclear Institute (PINSTECH, Islamabad) specially got trained at the Philippine Nuclear Research Institute (PNRI)/Univ. of Philippines in Cyst identification, and ^{210}Pb dating of HAB Cyst sediment cores is now engaged in sampling along Pakistan coast and analysis of seawater/sediment cores to produce and

refine database on past and present distribution of HAB species, HAB Cyst sediment chronologies and their comparison with the regional events on record.

Success stories: To promote HAB related national activities in Pakistan under the charter of IAEA/RCA Marine Project RAS/7011, the National Nuclear Institute (PINSTECH) successfully conducted a National Training Course on HAB Concerns in Pakistan at Islamabad/Karachi during June, 2005. IAEA/RCA provided two expert lecturers for the NTC event in Islamabad/Karachi. The end-users are quite willing to participate in the future activities of the HAB related R&D Programme both at national and regional level in collaboration with the national nuclear institute. The national nuclear institute is now fully capable of making use of the developed expertise in collaboration with end-user institutions to evaluate HAB Cyst sediment chronologies/records in marine coastal environment / terrestrial environment (lakes, dams etc.), coastal sediment erosion monitoring, management and mitigation strategies and water resources management (siltation in dams/dam safety issues etc.) in Pakistan.

Philippines – The Philippine Government also benefited through the project work in the Manila Bay area. Collaborations were initiated with local organisations (Dept. of Environment and Natural Resources, Bureau of Fisheries, Philippine Council for Aquatic and Marine Resources, Dept of Health, and University of Philippines) on risk assessment for Manila Bay. The models developed for a tropical toxic algal bloom and the current systems in Manila Bay can now be used for management purposes and being validated in other HAB affected areas in the country specially those utilized for mariculture purposes.

Success stories: By having the RRUs in sediment dating and dinoflagellate cyst analysis, transfer of knowledge and technology has been facilitated in the country and the region even for use in other environmental concerns like dam/water resources management and soil erosion. The first cyst based model of the bloom of a tropical toxic dinoflagellate species in Manila Bay will serve as basis for the development of other HAB models in the country and the region

Thailand – The end users such as the marine like: the Marine Science Department of Chulalongkorn University, Kasetsart University, and Burapha University; regulatory bodies like the Pollution Control Department, Ministry of Natural Resources and the Environment; regularly use data and ^{210}Pb dating techniques for their further research, regulating and managing of HAB occurrences and its impacts to health and economic of the Thai people and the country.

Success Stories: Age and sedimentation rate determination by nuclear based radiometric (^{210}Pb) technique is now well established at OAP. Furthermore application of nuclear based radiometrics (^{210}Pb) techniques to determine age and sedimentation rate was applied by the Department of Environmental Quality Promotion Department (DEQP) in cooperate with OAP in their three research projects: *Study of impacts to environmental quality from intensive shrimp farming areas in Chantaburi and Trad Province; Study of biological markers in sediment of the upper Gulf of Thailand; and Improving of environmental quality at Tale Noi in Songkhla lake at Songkhla and Satun Province.* Beside than the marine coastal environment, radiometric (^{210}Pb) dating techniques was used in determining anthropogenic and natural (climate changes) impacts on sedimentation in dam and water reservoirs through cooperated project between the Royal Irrigation Department

and OAP: *Sedimentation study of Lum Phra Phloeng Dam, Nakorn Ratchasima Province.*

Vietnam – A ^{210}Pb dating facilities established at the Dalat Nuclear Institute is now available to determine age and sedimentation rates for environmental problems in addition to HABs concerns. The nine sediment cores collected in Cam Ranh Bay, Ha Long Bay and Tuy Phong Bay during the period 2003 – 2005 will help in analysing cysts and in assessing HABs occurrence.

Success stories: Through fellowship training and scientific visits in sediment dating and dinoflagellate cyst analysis at the RRUs (Philippines), transfer of knowledge and technology has been facilitated in the country and collaboration was developed.

5 Conclusions

5.1 Preliminary assessment of project impact

This project component has significant impact in all the Member States as identified in the project outcomes section above.

The project established and/or enhanced the capability to monitor PSP toxins in China, Malaysia, Pakistan, Philippines, Thailand and Vietnam. Expertise in RBA applications and marine environmental studies has been expanded significantly in the region. Strong collaborations have been developed with government agencies and the fisheries industry through project activities, with recognisable socio-economic outcomes benefiting the public. Beneficial networks have been strengthened among the Member States in the region. Based on the experience gained under this component, new national and regional TC projects could be implemented.

The project also established and/or enhanced the capability in Pb-210 dating and reconstruction of HAB histories in the region.

The first cyst based model of the bloom of a tropical toxic dinoflagellate species in Manila Bay will assist in coastal management. It will help in predicting the origin and dispersion of HABs and thus mitigate their negative impacts.

5.2 Project effectiveness

This project component has been effective in enhancing regional cooperation as evidenced by exchange of experts/trainees amongst countries in the region. It has produced significant outcomes in the area of RBA/PSP detection in sea-food.

Future applications of Pb-210 sediment dating have been explored and have contributed to new project proposals at the national level that will use and further develop reconstruction of environmental histories in water storage dams, soil erosion and coastal zones. The collaborations established among nuclear institutes, governmental agencies and academic institutes/ universities effectively contributed to the achievement of the project objectives.

The successful functioning of RRU's in delivering expert missions and providing fellowship training also demonstrates that the capabilities being built within this project are contributing to sustainability of the RCA.

5.3 Project efficiency

This project component successfully accomplished the majority of its objectives as defined during the Project Formulation Meeting (see Framework Matrix in Annex 4). However, in some countries, efficiency was somewhat affected by changes in counterparts over the lifetime of the project, delayed delivery of the consumables due to trade restrictions and customs regulations.

It builds on the achievements of previous RCA projects including RAS/8/080 and RAS/8/076 and was efficiently undertaken largely due to consolidated regional networks established as a result of previous RCA projects which were further strengthened here and will be harnessed in the future.

A specific objective for the production of tritium labelled saxitoxin was not met due to difficulties in obtaining high specific activity tritiated water.

5.4 Assessment of sustainability

Sustainability has been demonstrated through the application of these techniques to commercial problems in a number of countries and through the recognition by end users and beneficiaries of the usefulness of these techniques to solve economically important problems. This can be seen in the following examples.

China – Both RBA and cyst analysis are included in the national HAB project to explore fast and sensitive methods for HAB toxin detection, as well as to dertermine the role of cyst in the initiation of HABs. First & Third Institute of Oceanography recommended to State Oceanic Administration to continue applying these two techniques in the routine HAB monitoring in some areas.

Indonesia – A joint study on sedimentation in the south coast of Java in Yogyakarta province and other selected areas, involving collaboration between local universities in Yogyakarta and the Yogyakarta Environmental Department has been planned. Collection of data will continue in collaboration with universities to study vertical and horizontal distribution of harmful algal species as part of HAB monitoring.

Malaysia – The RBA, cyst mapping and sediment dating are being applied in various government-funded projects. The Department of Fisheries (shellfish toxicity monitoring agency) has shown strong commitment for the RBA by having personnel trained and also investing in the necessary facility to implement the technology. Sustainability of the RBA could also be increased by exploring its use for the monitoring of other seafood toxins.

Pakistan – Nuclear Institute (PINSTECH) and end-user institutions (Center of Excellence in Marine Biology-Karachi Univ., WWF-Pakistan, NIO, Pakistan Museum of Natural History/Pakistan Science Foundation, and Hydrographic Department of Pakistan Navy) will continue to collaborate for routine monitoring of HAB events, toxic phytoplankton identification and reconstruction of HAB cyst sediment records using Pb-210 techniques. Pakistan Science Foundation will be requested to provide funds to make the project on sustainable pathways.

Philippines – All the aspects of the project are being continued with local funding support from the Department of Science and Technology and local implementing Institutes. Collaborations and transfer of technology are continuing particularly with the Bureau of Fisheries of the Department of Agriculture, national water authority, Department of Environment and Natural Resources. Knowledge and technologies gained are being applied in other environmental concerns such as dam siltations, toxin kinetics in marine environment, sedimentation and soil erosion. Models derived from this project are now being validated in other areas especially those which are used for mariculture purposes.

Thailand – There is continuing collaboration in the area of ^{210}Pb dating with end users such as the Marine Science Department of Chulalongkorn University, Kasetsart University, and Burapha University; regulatory bodies like the Pollution Control Department, Ministry of Natural Resources and the Environment. FIQCD also expressed interest to apply the RBA technique for determination of PSP in shellfish, seawater and plankton extracts from harvesting areas. An inter-laboratory comparison of the RBA and the mouse bioassay, the method currently used by FIQCD, was carried out. Sustainability could also be implemented by National Project titled “ The Production of 3H-STX for PSP Detection by Receptor Binding Assay” funded by Ministry of Sciences and Technology.

Vietnam – Cyst and algal toxins studies are the major part of the HABViet project supported by DANIDA, JSPS multilateral collaborative research, and government projects. The laboratory facility is also funded by local government, JICA (Japan) as well as other international programmes. There is good collaboration between the Institute of Oceanography, Ministry of Fisheries and Ministry of Medicine in the study on HABs and their effects on the economy and society. With efforts made to prevent economic loss and protect human health from its harm. A bilingual guide book on identification of harmful algae in Vietnamese water (HABViet phase 1) was published in 2004. Local training on HABs and their effects was also organized by Institute of Oceanography. Furthermore, information for public awareness was disseminated by TV, radio and newspapers.

The RRUs play an important role in the sustainability of this project by providing readily available technical expertise to RCA Member States.

5.5 Major strengths and weaknesses

China:

Strengths - This work got the support both from the IAEA and the national project. End users such as fishery agencies and marine environmental monitoring agencies are very interested in these two techniques.

Weaknesses - For the technique transfer of RBA, the main problem is that the tritium labeled saxitoxin standard is not commercially available. There are still some technical difficulties in application of these two techniques for the end users, such as equipment and resources availability.

Indonesia:

Strengths: Sedimentation study program have been supported by CRDAT National Nuclear Energy Agency, Universities and Yogyakarta Environmental Management Institute and have facilities for this work.

Weakness: There are no working alpha spectrometric facilities in CRDAT Yogyakarta, (the unit is it still under repair). Therefore, Pb-210 was analyzed by gamma spectrometry and the laboratory throughput was greatly reduced.

Malaysia:

Strengths

1. Strong government support for innovative R&D activities
2. Strong government support for multilateral and international projects
3. Good collaboration between academia and government agencies
4. Strong interest from the Department of Fisheries (monitoring and regulatory agency)
5. Pre-existence of R&D facilities and personnel ready to receive the technology

Weaknesses:

1. Expensive consumables i.e., tracers and silver disc.
2. Lower funding priority for basic research

Pakistan:

Strengths: This Project has provided a forum among regional countries and national end-user institutions/nuclear institutes to learn from each others experiences. Provision of consumables/scientific supplies and experts by the IAEA/RCA to Pakistan have proved to be a great strength in developing basic infrastructure and human resources to initiate HAB related R&D activities in Pakistan such as toxic phytoplankton identification, HAB Cyst identification, toxin quantification using RBA technique and reconstruction of HAB Cyst sediment record using ^{210}Pb dating technique.

Weaknesses: There have been problems in the execution of project laboratory activities due to delay in receipt of scientific consumables and supplies (such as tritiated saxitoxin/ ^3H labeled saxitoxin) to be used for HAB toxin quantification due to import/export restrictions imposed on Pakistan. This has retarded the project progress w.r.t. RBA studies. Further, there have been problems in the stability of labelled STX standard due to the delay in transportation. This has affected the reproducibility of toxin quantification data for intercomparison exercise related studies at the national RBA Lab. established at the nuclear institute (PINSTECH). Lack of equipment support by the Government to end-user institutions contributed to a major weakness to the outputs of this project as it slows down the pace of R&D work.

Philippines:

Strengths: The Philippine Nuclear Research Institute and the University of the Philippines Marine Science Institute (UP-MSI) and the National Institute of Geological Sciences (UPNIGS) complemented each other in terms of facilities and expertise resulting in the successful implementation of the project.

IAEA support in terms of experts, training and equipment and local funding support from the Department of Science and Technology and local implementing institutions made possible the availability of personnel and operating budget for the project.

Technical backstopping has been efficiently provided by IAEA. The involvement of the end-user in the project activities ensured the utilization of the technologies. The sensitivity of the RBA method is especially useful because the current regulatory limit for STX toxicity in shellfish in the country is already at the detection limit of the mouse bioassay.

Weaknesses:

1. Tritium-labelled saxitoxin became commercially unavailable after the September 11 incident.
2. Most of the items that are needed by the project had to be imported.
3. Project resources were not always available at the time they were needed due to differences in project implementation schedule and strategies.

Thailand:

Strengths: Good communication between member states and the IAEA technical officer, good collaboration among member states and national research institutes and timely supply of reagents and equipment.

²¹⁰Pb radiometric dating technique is well equipped at OAP and this technique is now well-known among Thai scientists. Through good communication and collaborated with research institutes, the cysts identification technique is well established at the Aquatic Resources Research Center and Marine Science Department, Chulalongkorn University etc.

With some more training on RBA technology, OAP can take a lead in coordinating the national laboratory and transference of this technology to regulatory and monitoring agencies.

For labeling of STX, the major strengths are the experienced team of radioisotope production and labeled compound, a well-facilitated hot laboratory, and the strong support from senior supervisors at Radioisotope Production Program (RPP).

Weaknesses: Lack of experience on tritium labelling.

In this case, technical assistance on tritium labeling is absolutely needed to facilitate the project. Specific training, scientific visit, and expert advice will also expedite the success of the project. One scientific visit has been applied but has not been awarded yet since late 2003. It is extremely urgent to get whether a specific training in a qualified laboratory on labeling technique or technical assistance by an expert on the subject.

Unavailability of high specific activity of tritiated water

It is impossible to obtain high specific activity of the labeled STX without using high specific activity tritiated water. None is locally available.

Unavailability of equipment for RBA at Radioisotope Production Program

Bioactivity of the end-product could not be tested in lab because there is no equipment required for performing RBA available. Therefore, the validation of the labeled STX produced could not be performed in-house.

Lack of appropriate detector for HPLC detection and identification

Concentration and identification of starting cold STX could not be done without an appropriate detector, in this case, fluorescence detector. It is necessary to have an HPLC set equipped with fluorescence detector for determination of the specific activity of the labeled compound as well. At present, none is available at RPP.

The weakness point is that it is a nuclear based technique causing difficulties for end users to perform assay by their own i.e. training and certified for radiation safety of personnel is required by regulatory body. ³H STX is difficult to access commercially.

Vietnam:

Strengths:

- Strong support from Vietnamese government for HABs study.
- Good collaboration with other international agencies such as IOC, DANIDA, JSPS, JICA.
- Availability of good laboratory facilities with the assistance of governmental and international support.
- Availability of trained personnel in the field of HAB studies.

Weaknesses: The lack of experienced personnel available to establish RBA for algal toxins study. No ready access to tritiated STX toxin for RBA.

5.6 Lessons learned

China - Although the receptor assay is sensitive and reliable for detection of total toxicity of the many derivatives of PSP toxins, it could not differentiate tetrodotoxin from saxitoxins. HPLC or LC-MS is still needed to confirm the toxin identity.

Resting cysts of dinoflagellates were difficult to identify, and some cysts can only be identified until after germination.

Indonesia – More information sharing and discussions are needed to obtain better funding and improve collaboration with biological departments.

Malaysia - One of the important lessons learned from this project was that implementation of technology transfer necessitates the pre-existence of suitable facilities and interested personnel, coupled with government support. Interest in the technology could rapidly wane with continued lack of material support. With regard to the RBA, it became obvious early on that a major limiting factor would be the high cost of consumables, especially imported plasticware. It was also noted that restrictions on movement of STX would be detrimental to the implementation of the technology. Resting cysts of dinoflagellates were difficult to indentify.

Pakistan - In order to achieve sustainability for HAB toxin quantification, alternate radiolabelled STX (such as ¹³¹I or ³⁶S labelled snail peptide- conotoxin) are to be developed locally by the nuclear institute for distribution to the end-users.

Philippines - This regional project has shown the expanded applications of nuclear techniques for problems of socio-economic and environmental significance. The potential uses of RBA and Pb-210 for research and monitoring activities have been highlighted through this project.

Future national and inter-regional collaborations could be facilitated through the use of standard techniques such as those developed in this project.

In future regional projects, the availability of reagents and materials should be ensured. Concerns in shipping of materials should be made part of the planning process to avoid delays in project implementation.

Strong collaboration between the nuclear institute and the end-user institutes from the onset was a major factor in the successful implementation of the project.

The strong support from the government contributed to the successful implementation of the regional project.

Thailand - some objectives were not fully achieved on schedule due to many factors. To fully achieve all objectives good communication and good administration are the most important factors. The counterparts should inform key-personnel involved as soon as possible about the problem faced in order to be able to solve the problem timely.

The experience gained will lead to improved project management in the future.

Vietnam - The RBA can potentially be applied to algal toxin monitoring in Vietnam.

6 Recommendations

Most of Member States could benefit from additional support and resources under the framework of their national TC projects under the IAEA and/or own nationally funded projects.

6.1 Recommendations to the IAEA and national RCA Coordinators

1. Request IAEA and RCA coordinators to fully support the concept proposal entitled *Applications of Nuclear Techniques to Management of Hazardous Algal Blooms (HABs) in the Asia-Pacific Region* which was submitted through the RCA for the 2007/8 TC cycle.
2. Request IAEA and RCA Member States to develop and maintain a framework on the RCA website for project documentation (e.g. reports, training records) and success stories.
3. Request IAEA to make available tritiated saxitoxin to all interested member states including former counterparts of closed TC projects.
4. Request IAEA to continue to fund activities related towards the complete establishment of the receptor binding assay method through:
 - a. Assistance in the effort towards the commercial production of ³HSTX or other suitable radiolabelled toxin. It is therefore recommended that the technical sub-contract fund towards the production of iodinated conotoxin offered to the University of the Philippines (Dr. Lourdes Cruz) should be retained under this project.
 - b. Training of the end-user institutes in the use of the RBA technique.
 - c. Provision of major equipment to end-user institutes.
5. Request IAEA to provide assistance in the collation, analysis and publication of the regional cyst and sediment dating data bases.
6. The IAEA should support the production of a stably-labeled STX for the RBA. This would enable performing of the RBA using a filtermat format as opposed to the current microplate format. This would significantly cut down the cost of performing the assay.
7. The IAEA should support the application of the RBA for the detection and monitoring of other suitable seafood toxins. The assay is already proven useful for the detection of domoic acid that causes ASP. One of the seafood toxin detection that would greatly benefit from the application of the RBA is ciguatera fish poisoning. This is a very important problem in many tropical and subtropical countries. Unfortunately it is also one of the most problematic toxins to monitor using the mouse bioassay.

8. The IAEA should increase sponsorship of participants from the region to attend relevant scientific conferences with the provision that the participants give presentations pertaining directly to the application of the RBA in studies on HABs.

6.2 Recommendations to government authorities and National RCA Coordinators:

China - It is recommended that nuclear science and oceanography institutions should work together to reach the final goal of this concern.

Indonesia – More funds supporting for HAB program are requested.

Malaysia – Continue support for seafood toxicity monitoring programme and studies related to HABs

Pakistan – The National Environmental Protection Agencies (GoP) and Environmental NGOs should be approached through proper channel to formulate and enforce regulations for routine monitoring of HAB toxin levels in commercial sea-food in Pakistan using procedures such as RBA technique in order to ensure export of quality level certified fisheries products/sea-food. The RCA National Coordinator can help streamline action procedures in this direction.

Philippines

1. The capability for extracting and purifying saxitoxin from raw materials needs to be further supported and enhanced.
2. Self-sufficiency in producing saxitoxin standards including the radiolabelled standard should be attained to ensure viability of RBA in routine monitoring.
3. Intercomparison of results especially at the lower toxicity levels needs to be done and efforts should be made to have the RBA integrated in the monitoring of PSP toxins by the national regulatory agencies.
4. Other HAB affected and potentially affected (*i.e.* aquaculture sites) need to be studied for occurrences of dinoflagellate cysts in the sediments. Those areas should also be monitored for changes/succession in phytoplankton species to enable management strategies to be formulated for yet to be identified HABs.
5. The models generated from this program need to be validated in order to make them fully useful for the management of toxic algal blooms in the region.

Thailand - It will be more beneficial if the project outcome is widely used and known. The government authorities and National RCA Coordinators should make people recognize about the outcome of this project, and bring the laboratory outcome to national and international level. Training and technical assistance to related regulatory bodies will certainly assure the reproductively and sustainability of the outcome of this project.

Vietnam - Need to have strong attention from government to keep the long term monitoring system as well as facility support to establish RBA in Institute of Oceanography.

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