２.国際交流・国際協力

国際交流委員会の活動（農学部各種委員会の活動の項参照）

外国人客員教官との共同研究

2008年度の外国人客員教員との共同研究は表１の通りである。また、この項の末尾に客員教員による共同研究報告書を添付する。

国際共同研究・海外学術調査

農学研究科における、国際共同研究・海外学術調査は、近年極めて活発に行われており、多数の教員・院生が海外で研究・調査活動を行うと同時に、海外からの研究者の受入も多数に上る。具体的な活動内容については、「Ⅲ. 研究教育活動」の各分野の「Ａ－4. 国際交流・海外活動」を参照のこと。

学生交流プログラム

国際交流科目の一つ、「変容する東南アジアー環境・生業・社会」を開講した。国際交流科目は、全学共通科目であり、各学部1・2回生を海外に2週間程度派遣して、学生の国際交流促進をはかる目的で実施する。本年度は、8月25日～9月6日、学生14名をタイ・カセサート大学に派遣した。一方、10月14～24日、同大学から8名の学生を受け入れた。

国際交流室の活動

１）新入留学生のためのオリエンテーション

2008年度の国別留学生数は表2のとおりである。

新入生に対する大学での勉学および日常生活に関するオリエンテーションを、4月8日（火）に国際交流室で行った。その後、カンフォーラにおいて歓迎会を開催した。遠藤研究科長、縄田農学部国際交流委員長、農学部国際交流室長、農学部事務各掛、京都大学生協役員などの参加・協力を得て、29名の新入留学生をはじめ、客員教授、農学部に在籍する外国人研究者、留学生、教職員等、約60名が出席し、新入留学生は自己紹介を行った。

２）バス一日見学旅行

農学部のスクールバスを利用したバス見学旅行を、例年、年に1、2回開催している。今年度は参加者37名で、5月27日（火）に滋賀県立琵琶湖博物館、草津市立水生植物公園水の森、栗東あられ本舗工場を見学した。11月13日（木）には招徳酒造株式会社（伏見）、かんばやし春秋抹茶工場を見学、さらに世界文化遺産である平等院を拝観した。

３）夏の見学旅行

7月24日～7月26日にかけて、総勢26名で京都大学瀬戸臨海実験所（白浜）、南方熊楠記念館、千畳敷を見学して民宿に宿泊、翌日は熊野古道を少し歩き、熊野速玉神社、熊野本宮に参拝

して世界文化遺産に触れ、さらに潮岬まで足を延ばした。

4）世界の料理講習会

2004年9月からほぼ月1回、世界各地からの留学生や研究生に、母国の料理を作ってもらい、試食する世界の料理講習会を行っている。今年度はロシア料理講習会(6月10日)、中国料理(7月1日)、ベトナム(11月18日)と3回行った。毎回20－30名の学生（留学生を含む)、教職員などが参加して、各国の珍しい料理を楽しむと同時に相互交流の機会となっている。

5）フットボールゲームとバーベキュー大会

2002年から年1回、留学生と日本人学生との交流をより深めるためにフットボールゲームとバーベキュー大会を開催している。2008年度は6月14日（土）に開催した。国単位での参加や研究室単位での参加もあり、年々参加者数が大幅に増えている。参加者全員が試合に参加できるよう、ゲームの時間を短縮して行った。今年度は応用生命科学専攻・醗酵生理及び醸造学チームが優勝した。その後、バーベキューを楽しみ、大いに交流を計った。

6）ほっこりカフェ

今年度、新しく始めた行事として、留学生に主に自国の農業について紹介してもらい、参加者はコーヒーを飲みながら質問するというフランクなミーティングを2回開催した。1回目は10月21日、ベトナムの農業（演者　応用生命科学専攻 Do Thi Di Thienさん 修士1年)、2回目は12月22日、ヒマラヤを耕す一ネパールの農業一（演者 農学専攻 Shanta Karkiさん 博士3年)。40名近くの参加者で活発な質疑応答が行われた。

7）日本語教室の開設

1996年4月から農学部留学生を対象に日本語教室（初級、中級、上級）が開設されている。今年度の参加学生は総計約30名であった。

8）プレカウンセリング室の開設

2002年10月から、留学生の抱える問題が深刻化する前に、孤独感、研究上の悩みなどを解放する場として、週１回プレカウンセリング室を開設している。本年度も、留学生の修学および日常生活における悩みごとの相談に応じた。

9）農学部国際交流ニュースレター

1988年1月に第1号を発刊して以来、年2回の発刊を続けてきた。本年は第42号（9月)、第43号（3月）を発行した。農学部内では外国人客員教授、外国人留学生・研究者・研究生をはじめ、教職員、院生、3、4回生に配布し、京都大学本部、他学部、研究所およびセンター、附属図書館などの関係部局にも送付して広報に努めた。学外へは農学研究科を退職された諸先生方、他大学における国際交流の諸機関、留学生を後援していただいている会社・団体、雑誌などの寄贈をいただいている団体・機関、学外の農学部国際交流推進後援会会員、本学部・研究科の外国人卒業生（研究生・研修員を含む）にも送付した（表3参照)。

10）図書および書籍の受け入れ

外国語新聞（3紙：英語、中国語、韓国語）と雑誌（外国語２誌、日本語9誌）を定期購読している。

11）留学希望等の照会

本学部・研究科の正規課程等への留学に対する問い合わせに対して回答した。

農学部国際交流推進後援会

農学部国際交流推進後援会は、農学部／農学研究科の教員・事務職員から構成されている。本年度は、平成20年度の会員加入に関する案内を7月に発送し、12月末現在、個人会員124名、団体会員１社の賛同を得た。上記国際交流室の活動の一部は、この後援会会費より支援している。

表１　外国人客員教員との共同研究

名　　　前	国　　　籍	所　　属	共 同 研 究　テーマ
Zaki Siddiqui Anwar	インド	アリガルフ　マスリム大学・助教授	ナラ・カシ類とマツ類の成長と萎凋病に及ぼす菌根菌と植物成長促進根圏細菌の影響
Pavel Barsukov	ロシア	ロシア科学アカデミー・主任研究員	ユーラシア寒冷地域における土壌有機物動態の解析
HakGyoon Kim	韓国	国立釜慶大学 教授	沿岸域における有害有毒赤潮の発生機構及び防除に関する研究
Sang Ha Noh	韓国	ソウル国立大学 教授	マシンビジョンによる果実の検出システムの開発
Darwin W. Anderson	カナダ	サスカチュワン大学 教授	土壌炭素動態のユニバーサル・モデルの構築

表２　国別留学生数（2008）

課　程 国　名	学　部	修　士	博　士	その他	計
アルゼンチン			2		2
バングラデシュ		1	2		3
ブータン			1		1
ブラジル		2	1	1	4
中国	7	10	14	7	38
エジプト			2		2
ガーナ			1		1
ホンジュラス			1		1
インド			1	1	2
インドネシア	1	3	5		9
イラン				1	1
イタリア				1	1
ケニア				1	1
韓国	4	1	3	1	9
マレーシア		1		1	2
マリ			1		1
モザンビーク				1	1
ミャンマー			1		1
ネパール			2		2
オランダ				1	1
ニュージーランド			1		1
ナイジェリア			1		1
パキスタン				1	1
フィリピン			2		2
スペイン				1	1
台湾		3	1		4
タイ	1	2	2	2	7
アメリカ				1	1
ベトナム		1			1
合　計	13	24	44	21	102

表３　ニュースレターの帰国研究者・留学生への送付状況（2008年）

配布号 国名	42号 (9月)	43号 (3月)	配布号 国名	42号 (9月)	43号 (3月)
アメリカ	13	13	日　　本	20	19
イ ラ ン	2	2	ニュージーランド	1	1
イ ン ド	4	4	ネパール	2	2
インドネシア	49	48	パキスタン	1	0
エジプト	4	4	パラグアイ	1	1
オランダ	2	2	バングラデシュ	6	6
カ ナ ダ	1	1	フィリピン	10	10
韓　　国	56	55	ブラジル	6	6
ガ ー ナ	1	1	フランス	2	2
ケ ニ ア	3	3	ブルガリア	3	3
コ ン ゴ	1	1	ベトナム	2	2
ス イ ス	1	1	ペ ル ー	1	1
スペイン	1	1	ベルギー	1	1
スリランカ	6	6	ポーランド	1	1
タ　　イ	50	50	マケドニア	1	1
台　　湾	18	18	マレーシア	2	2
タンザニア	4	4	南アフリカ	1	1
中　　国	35	35	ミャンマー	6	6
チ　　リ	2	3	メキシコ	5	5
ト ル コ	3	3	ラ オ ス	2	2
			合　計	330	327

REPORT

ZAKI SIDDIQUI ANWAR

My assignments as Guest Professor, Graduate School of Agriculture at Kyoto University include both teaching and research. I offered a course in "Microbial Ecology in Agriculture". Students showed great interests and they could discuss their view points. A special lecture was delivered by me on "Biocontrol of plant parasitic nematodes" before the faculty members. The discussion after lecture was fruitful for future research. We (I with host professor) presented a paper entitled "Biocontrol of *Meloidogyne incognita* using antagonistic fungi, plant growth promoting rhizobacteria and composted cow manure on tomato" in 5th international congress of Nematology at Brisbane, Australia July 13-18, 2008. A key note address on "Biocontrol of plant parasitic nematodes by bacteria and fungi" was delivered in 16th Annual meeting of Japanese Nematological Society at Tsukuba Japan, 17-19 September, 2008 in the session *IPM of Nematodes: Present Situation and Perspective*. We (Z.A. Siddiqui, M.S. Akhtar and K. Futai) also edited a book entitled "Mycorrhizae: Sustainable Agriculture and Forestry" during this period published by Springer. Three chapters in the book namely 1. Mycorrhizae: An Overview; 2. Arbuscular mycorrhizal fungi as potential bioprotectants against plant pathogens; 3. Ectomycorrhizae and their importance in forest ecosystems were written by us.

The research work was carried out on *Tricholoma matsutake* which is one of the favorite and most valuable food in Japan. It is associated primarily with Japanese red pine (*Pinus densiflora*) and show visible whitish mycelium-soil aggregated zone called 'shiro'. The annual harvest of matsutake has decline markedly because of pine wilt disease caused by the nematode *Bursaphelenchus xylophilus* in *P. densiflora* forests. Knowledge of the natural reproduction of this fungus and association with other microorganisms, especially bacteria, is therefore of paramount importance for successful management and to regenerate abundant matsutake sporocarps in pine forests.

It is well known that neither bacteria nor actinomycetes were isolated from just beneath fruiting body of *T. matsutake* which was proved by dilution plating method. Recent advances in the cultivation-independent approach are able to detect un-cultivable or rarely cultivable bacteria. Many species of bacteria have not been cultured due to lack of knowledge about their specific growth requirements. Till now the detection of bacteria around the Shiro of *T. matsutake* has been made only through cultivation methods. It was thought desirable to use molecular cultivation-independent methods for the detection of bacteria in the soil and to compare bacterial community structure using cultivation methods. The DGGE analysis was performed to examine the bacterial presence in the bacterial zero points revealed by dilution plate method. The results obtained are very useful and are under process for publication. It is hoped that at present, there is no method which is available for the cultivation of 'matsutake sporocarp'. The investigation of bacteria associated with *T. matsutake* is important, and may be useful for cultivation of matsutake mushroom.

We carried out frequent field survey of forest diseases mainly pine and oak wilts. We collected samples from different places. We worked on their control measures and discussed future plan of action.

Zaki A. Siddiqui
Guest Professor
Graduate School of Agriculture
Kyoto University,
Kyoto, Sakyo-ku 606-8502
JAPAN

SOIL TEACHING AT ANNUAL INTERNATIONAL SOIL-ECOLOGICAL EXCURSION IN SIBERIA AND ITS PROSPECTS

Pavel Barsukov[1,2] · Takashi Kosaki[3] ·Tetsuhiro Watanabe[2]

([1]Institute of Soil Science and Agrochemistry, Russia, [2]Kyoto University, [3]Tokyo Metropolitan University)

Beginning in 1995, annual international excursion in West Siberia has been organized for students, researchers, and lecturers from different universities throughout Europe. The focus of the excursion is on soil formation processes resulting from the interaction of climate, vegetation, soil parent substrata and ground water. Characteristics of soil formation and ecosystem succession under continental climatic conditions, as well as the impressive wealth of unaltered or virtually untouched landscapes of great beauty, are compared with those of agricultural and forest plantations. South part of West Siberia is ideal place for education in soil science because it includes (1) West Siberian Lowland with perfect latitudinal zonality; (2) Altai and Salair mountains with clear altitudinal zonality; (3) many intrazonal soils / ecosystems inside every zone, such as soils of raised peat bogs inside tundra and taiga zones, different salted soils inside forest steppe and steppe zones; (4) that allows to explore huge diversity of soils and soil forming factors. The regular excursion covers all latitude bioclimatic zones from the taiga to the steppe within West Siberian Lowland and all elevation belts from tundra to semi-desert in the Altai Mountains.

We consider future developments of the excursion the as follows: (1) to involve Japanese scientists and graduate students in our regular annual excursion; (2) to develop enhanced field courses in soil science in Siberia for undergraduate Japanese and European students; (3) to develop specialized excursions devoted to important environmental regional and global problems of the changing World (global climate change, sustainable land use, water management etc.).

A Korea-Japan Project to Mitigate Harmful Algal Blooms (HABs) with Clay and Algicidal Bacteria

HakGyoon Kim and Ichiro Imai, Kyoto University

Contents

I. Introduction

Marine and fisheries industries in Korea and Japan are very important for daily foods and marine activities such marine leisure, sports, and tour. They have been and will be in the pursuit of to strengthen the local marine industries and make it a viable industry in their local economy. In Korea, although the output of the fishery industry accounts for less than 1% of the country's GDP in 2000, it has a positive effect on the economic growth. It stimulates the development of services and infrastructure facilities in vessel construction and repair, fishing gear and marine electronics manufacturing, as well as in marketing (www.fao.org/fishery). Japan Fisheries Agency (www.jfa.maff.go.jp**)** explains that "The fishing industry has been prospering in coastal area and offshore area since old times in Japan and Japanese people have been so familiar with "Delicacies from sea" that they have been called as fish-eating race. At present, Japan is one of the world's most prominent fishery nations with about 7.4 million tons of fishing products a year in 1996, and fishery products take an important role indispensable for forming and maintaining healthy and rich dietary habits of Japanese style by furnishing animal protein necessary for the dietary habits of the Japanese stably."

However in recent, both countries are suffer from various abnormal phenomena such as coastal pollution, frequent outbreaks of harmful algal blooms (HABs), and mass appearance of jellyfish in some coastal areas. Of which, the red tides, a spectacular discoloration of seawater caused by the presence of large number of microscopic algae, can have a variety of adverse effects due either to the toxins produced by the algae or to the mass mortalities of culture fish by fish-killing dinoflagelates in both countries.

In Korea, HABs especially by dinoflagellate species cause mass mortalities of aquaculture fish in summer season, and resulted in shellfish poisoning syndromes in spring around Korean waters. Since 1995, the first widespread blooms caused by *Cochlodinium polykrikoides* blooms caused mass mortalities of culture fish. As it developed into widespread and persistent harmful red tides, Korea had established nation-wide regular monitoring network and begun to disperse clays in order to remove the *C. polykrikoides* cells from the water through flocculation since 1996 by the central and local governments. Based on the studies made so far, it can minimize the fisheries damages and proved not to induce significant negative impacts on water quality and benthic organisms so far. Besides clay dispersal, Korea is studying to find mitigation substances and techniques to minimize economic loss from the haunting HABs.

In Japan, the red tides became one of big constraints to the developments of coastal aquaculture industries especially since late 1960s. The number of red tides report in 1970s had jumped drastically to more than 200 cases per year along with the development of heavy industry in coastal terrestrial zone and fish aquaculture industry in marine embayments. Fish mass mortality cases with serious economic loss also increased (Fukuyo et al., 0000). With respect to the shellfish poisoning, the first recorded cases of PSP and DSP were occurred in 1948 and 1976, respectively. The Fisheries Agency together with the Ministry of Health and Welfare set guideline for monitoring and marketing regulation.

Therefore, the HABs are one of social and economic issues which must be treated with great care and cooperation with neighboring countries and internationally both in Korea and Japan.

II. Present Research and Management of HABs

1. Republic of Korea

1) HABs monitoring and prediction system

Korea has carried out national coastal and offshore water monitoring to understand the ocean dynamics, the status of coastal environment pollution, and annual changes of red tides. The oceanographic observation was initiated in 1921, and has compiled 88 years of oceanographic data up to 2009. It is therefore possible to keep track of the influences of climate changes on the coastal waters. The coastal environmental and HABs monitoring were carried out to assess the coastal pollution and outbreaks of red tides since 1972, and strengthened their frequency and intensity due to the rise of concern for coastal eutrophication and HABs especially since 1995.

(1) Oceanographic observations

Oceanographic observations in Korea waters have been carried out by National Fisheries Research and Development Institute(NFRDI) since 1921. It covers whole Korean waters including adjourning areas whose surface area is estimated as of 450,000 ㎢. Annually six times of regular oceanographic observations have been conducted at about 300 regular stations established parallel to the longitude. Sea surface temperature (SST) from NOAA and chlorophyll contents from SeaWiFS are on service for the public. Recent moderate satellite images from Moderate Resolution Imaging Spectro – radiometer (MODIS), Korean Arirang Satellite, and Indian Research Satellite (IRS) provide with valuable real time data and information essential for the conservation of coastal environment and marine living resources. Korea Ocean Data Center (KODC) disseminated all those data at real time on-line base using internet and automated telephone response system.

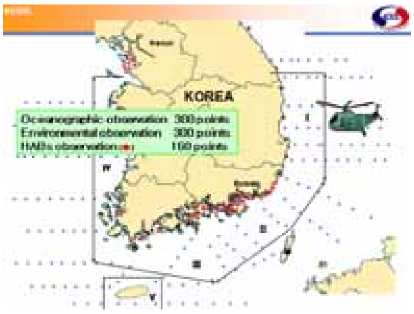


Fig.1. Locations of national oceanographic observations and environmental monitoring stations and one of research vessels,Tamgu-1 of NFRDI, in NFRDI.

(2) Coastal pollution monitoring

Since 1972, regular coastal monitoring and pollution watch have been conducted by the NFRDI to assess coastal water quality and its impact on marine flora and fauna. Under this project, a suite of biological and chemical parameters are being monitored. There are inorganic and organic nutrients, heavy metals, DOM, POM, COD, and persistent organic pollutants (POPs) such as PCB, TBTO, PAHs, Dioxin (Table 1). Physical parameters such as temperature, salinity, pH and biological parameters such as plankton abundance, bacterial population and chlorophyll contents were regularly investigated in the Korean waters.

Four times monitoring have been carried out from February to November to clarify the seasonal changes in the coastal and offshore water. This has provided metadata essential to build coastal environmental protection policy for the sustainable development, minimization of environmental impacts, and fisheries damage due to environmental constraints such as POPs, HABs, shellfish poisoning and summer anoxia. Now high quality assurances and quality controls for all data are being done for the regional and international cooperation.

Table 1. Water quality parameters measured for marine environmental monitoring

Body	Parameters	Parameters measured
Water	General	Temperature, Salinity, pH, DO, COD, Nitrite, Nitrate, Ammonium, Phosphate, Oily substances, SS, transparency, *E. coli.*
	Trace metals	Cu, Pb, Zn, Cd, Cr^{+6}, Hg, As, CN
	POPs	PCBs, TBT, Dioxin
Living animals	Productivity	Chlorophyll
	Trace metals	Cu, Pb, Zn, Cd, Cr^{+6}, Hg, As
	POPs	POPs, TBT
Sediments	General	Sieving, Ignition-loss, Total-sulphide, COD

Trace metals	Cu, Pb, Zn, Cd, Cr^{+6}, HG, As
POPs	PCBs, TBT, PAHs, Organic-chlorine

POPs : Persistent organic pollutant, TBT : Tributyl-tin

PCBs : Polychloro-biphenyls, PAHs : Poly aromatic hydrocarbons

(3) HABs monitoring

To take appropriate actions to protect the culture fish from fish-killing dinoflagellates blooms, Korea had started red tides monitoring as one of the coastal pollution monitoring program. Since the outbreaks of fish and shellfish kills for the first time in 1981, Korea established nation-wide regular HABs monitoring system independently. Now it has been strengthened to daily and/or weekly observations at regular stations from March to November by NFRDI and local authorities. When fish-killing HAB occur, it takes daily observation to find out the stretch of HABs distribution in the affected area to predict neighboring waters susceptible to be affected. The main target phytoplankton species are *C. polykrikoides, Karenia mikimotoi* and *Gyrodinium* sp.nov. This monitoring has been based on the mechanisms illustrated for the initiation and subsequent development of *C. polykrikoides* blooms (Kim et al., 1999).

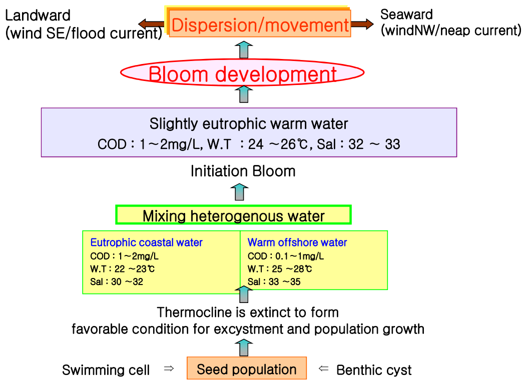


Fig. 2. Schematic diagram illustrated the initiation and subsequent development of harmful algal blooms in South Sea of Korea.

Most of the red tide information is distributed immediately to aquaculturists, fishermen and municipal administrative authorities by facsimile telegraph, internet web site (http:// www. nfrdi.re.kr) and automated telephone response system that begun to serve on 6 May, 1996.

In recent, real-time data from the state of art remote sensing and drifting and fixed buoy-watch are widely used for prediction. In this regards, it needs Korea to exchange their new findings on the bio-optic technology to estimate the areas affected by red tides with neighboring countries such as Japan and China.

2) Recent HABs and their impacts

(1) Recent changes in HABs

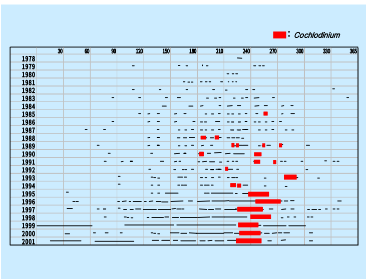
In Korea, the record of the first red tide might be the one that occurred in 639AD, which write “the seawater in the East Sea was discolored as red and a fish and turtle was dead in July, 639AD (秋七月 新羅 東海 水赤 且熱 魚鼈死).” The first scientific writing was reported in 1976 (Park and Kim, 1967). Since then, red tide has been one of important scientific topics in terms of environmental conservation.

The outbreaks of HABs were rare, and prevailed mostly by diatoms till 1980s, but became frequent and widespread during the 1990s (Kim et al., 1997) with dominant species of dinoflagellates. In those periods, dinoflagellates species other than *C. polykrikoides* blooms have been generally observed from early spring to late autumn, with the main season from June to September. In 1995, a fish killing dinoflagellate, *C. polykrikoides*, had formed dense blooms in almost all of the southern coastal waters, and persisted about two months. It resulted in the largest fish killing of an alleged as much as 1 million $US. Since then, *C. polykrikoides* have been one of the worst species owing to wide spread, long-persistency, and mass mortalities of culture fish.

Table 2. The phytoplankton Genus responsible for the HABs in Korean waters

Class (classis)	Order (ordo)	Red tide Organisms (Genus)
Cyanophyceae	*Chroococcales*	*Anabaina, Microcystis*
Cryptophyceae	*Cryptomonadales*	*Chroomonas*
Dinophyceae	*Prorocenrales*	*Prorocentrum, Cochlodinium, Karenia*
	Noctilucales	*Noctiluca*
	Peridiniales	*Alexandrium, Ceratium, Lingulodinium*
Bicillariophceae	*Centrales*	*Chaetoceros, Skeletonema,*
	Pennales	*Asterionella, Pseudonitzschia*
Raphidophyceae	*Raphidomonadales*	*Chattonella, Fibrocapsa, Heterosigma*
Chrysophyceae	*Dictyochales*	*Dictyocha*
Euglenophyceae	*Eutreptiales*	*Eutreptiella*
Protozoa	*Ciliophora*	*Mesodinium rubrum*

Based on four decadal observations of the phytoplankton community in Korean coastal waters, there were seasonal species changes representing typical temperate pattern of spring diatom and dinoflagellates in mid-summer. Up to 1980s, diatoms were the prevailing species except dinoflagellates in hot summer season of August. Since 1990s, the dinoflagellates become more important species in the context of harmful algal bloom. Especially since 1995, a fishkilling dinoflagellate *C. polykrikoides* have been a dominant species of HABs.



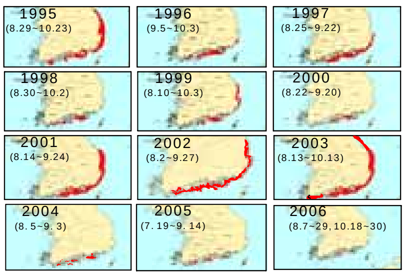


Fig. 3. Annual distribution in the periods of HABs since 1978, and the areas affected by fish-killing *C. polykrikoides* blooms in Korean coastal waters since 1995.

On the viewpoint of annual fluctuation of the HABs for the last two decades, it can be identified as 3 stages based on the spatial distribution, and their density and duration. The first initial stage is the term of 7 years from 1982 to 1988, the second from 1989 to 1994, and the third from 1995 to 2003. As shown in the table of the first stage, the area affected was localized in and around Jinhae Bay, South Sea with the highest cell density of 8,700cells/ml.

Table 3. Two decadal progress of *C. polykrikoides* blooms in Korean Coastal Waters

Terms	1982 1988	1989 1994	1995 2003
Area	Localized less than 8,700 & < 10days	South Sea/ East Sea	Widespread
Density(cells/ml)		< 25,000	< 43,000
Persistency		< 20days	up to 62 days

The 2nd stage could be defined as the development stage from localized ten days bloom to widespread-high density of twenty days blooms. After then, in the 3rd stage, they became widespread in whole South Sea. The highest density was sometimes reached 48,000cells/ml quite enough to kill aquatic animals. The duration of algal bloom was about one or two months long in general with annual fluctuation. In 2003, *C. polykrikoides* blooms recorded the highest density as of 48,000cells/ml, and the long persistent bloom as of 62 days.

(2) The impacts of HABs on sustainable fisheries

As seen in the global waters, the haunting HABs give a lot of impacts on the growth, recruitment and mortality of fish population in Korea. Especially, fish killing algal blooms became the direct and severe impacts on the coastal aquaculture industries. So far, it was proved that 3 fish killing species such as *C. polykrikoides* since 1989 , *Gyrodinium sp.*, in 1992 and *Karenia mikimotoi* since 1981 have been occurred in the Korean coastal waters (Kim et al., 1993, 1997). Among them, *C. polykrikoides* was the most harmful species. Next to it, *Gyrodinium* sp., a new species collected from Chungmu coast in 1992(Kim et al., 1995).

Based on the observations for the last two decades, the economic impact of HABs has been magnified partially by the widespread and fish-killing HABs and partially by the expansion of shellfish and fish culture farms. In August 1981, for example, Korea experienced the economic loss due to shellfish mortalities caused by *K. mikimotoi* red tides in Chinhae Bay (Cho, 1981; Park, 1982). The fisheries loss in 1981 was amount to US$ 2.6million (Kim, 2005). Another fish mortalities caused by *Gyrodinium* sp. resulted in severe fisheries loss of US$ 24.3 million in 1992.

In 1995, an alleged economic loss caused by *C. polykrikoides* bloom was US$ 95.5million, and it recorded as the biggest fisheries damages in Korea. In addition to the direct fish kill and impacts in coastal ecosystem, the halo effect from the HABs is unforeseen and difficult to quantify.

3) Management and mitigation

(1) Precautionary prevention

The ultimate goal of monitoring and mitigation on HABs is to protect public health, fisheries resources, industry of aquaculture, ecosystem structure and function, and coastal aesthetics. This requires a fundamental understanding of the many factors that regulate the dynamics of HABs, environmental impacts of the practical techniques and substances to be implemented to prevent the HABs damages, and their economic aspects pertaining to field application. In general, it is recommended to apply precautionary preventions owing to relatively low costs and environmentally friendly techniques than direct control methods.

In Korea, when the bloom threaten fish-kill, NFRDI issued HABs alert and ask aquaculturists to take precautionary actions, for examples, to reduce fish density in cages, lessen feed supply, transport fish to refuge sites, harvest fish or shellfish as early as possible, etc.. Of which, pumping bottom water to the surface is widely applied due to its efficiency, low costs, and easy operation. Korean central and local governments recommend aqculturists to install a red tide alarm system. This system, created by NFRDI research team in 2000, is to alert aquaculturist the approach of red tides enough to kill fish to take immediate actions such as stop red water supply into tanks and supply liquefied oxygen into fish tanks, automatically.

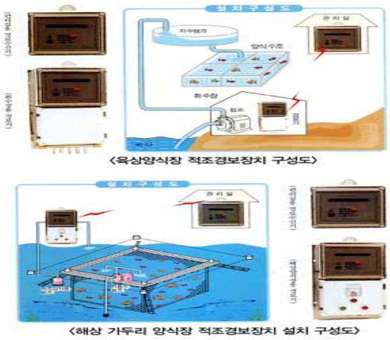


Fig. 4. Bottom water pumping in the cages, and red tide alarm system and schematic layout in the land-based fish tank (up) and fish cage(down) to alert aquaculture manager(NFRDI, 2002).

It consists of sensor and alarm apparatus. The sensor can detect the chlorophyll, temperature and turbidity. When it detect the HABs, it give alarm by sound in the daytime and by light in the night or simultaneously. It is possible to stop the seawater supply into the tank automatically and supply the liquid oxygen. It needs to take all reasonable implementation and countermeasures to combat the environmental challenges. The best way to minimize the damages is to find out the outbreaks of HABs at the initial stage and take emergent action. The present action plan consists of regular monitoring, quick announcement and alert fishermen. Recently, HAB alarm system and shield curtain for the fish cage are invented and can be commercially available.

(2) Control of HABs

☐ **Direct Control**

Korea has dispersed yellow clay on the coastal aquaculture farm to remove the fish killing dinoflagellates bloom, especially against *C. polykrikoides* blooms since 1996 (NFRDI, 2002, Kim, 2005). The clay can flocculate the dinoflagellates cells and sink to the bottom, which can dilute the cell density of dinoflagellates in the cages not to kill the accommodating fish.

Fig. 5. Clays scattering on the area affected by HABs in Korea(Kim, 2006).

Based on field and laboratory experiments, the yellow clay showed high removal rate of dinoflagellate from the water column and immediately sink to the bottom. It won't harm a fish and shellfish at the concentration dispersed on the fish cages to remove the fish killing dinoflagellates. Since then, clay scattering is regarded as one of promising controlling agents against fish-killing *C. polykrikoides* blooms in Korea. In recent, China, Japan, and USA have tried to use the clay to control the dinoflagellates blooms. This mitigation strategy looks promising, but considerable research is still needed to assess the impacts on the structure and function of marine ecosystem. Critical unknowns include the fate and effects of sunken cells and toxins on bottom-dwelling animals and the collateral mortality of co-occurring planktonic organisms. Decomposition of sedimented biomass and the resulting oxygen depletion are also serious concerns.

Predation and mortality of HAB species are obviously critical elements of bloom dynamics, but they also represent an avenue to explore with respect to **biological control** strategies. Research on predator-prey interaction is needed both to elucidate aspects of HAB dynamics and to identify opportunities for mitigation. The biological control of red tides by using grazers such as copepods, bivalves, and ciliates had been examined, but the results were minimal because of the huge scale of red tides. In Korea, it was found that some copepods and ciliates can graze the dinoflagellates such as *C. polykrikoides* and *Karenia mikimotoi.*

Viruses, parasites, and bacteria are also promising control agents, as they can be abundant in marine systems, replicate rapidly, and sometimes are host-specific. Up to now, no field trials of bloom control using viruses and bacteria have been attempted, in large part because of uncertainties about host specificity, pathogen stability, and environmental impacts. It is clear that "microbes" of this type can have profound impacts upon HAB population dynamics, but we have no practical knowledge of underlying mechanisms, or of their impacts on bloom dynamics and on the function of marine ecosystem. It needs to take comprehensive studies on their impacts on the biosphere especially.

□ **Indirect Control**

HAB species require major and minor nutrients that can be supplied either naturally or through human activities, such as pollution. Based on recent scientific findings, the increases in pollution are linked to increases in the frequency and abundance of HABs (GEOHAB, 2006). It follows that a reduction in pollution would lead to a decrease in bloom frequency. It is possible to reduce the outbreaks of coastal HABs by decreasing terrestrial nutrients or alter the nutrient ratios. Korea is studying on this issue to apply in the regulation of terrestrial discharges.

The other techniques undergoing for research in Korea is “**bio-manipulation”** which is to establish “**bio-remediation**” to control nutrients and population of HABs or grazers. It is one of poly-culture systems, which looks like the establishment of seaweed culture in front of fish culture to make macro-algae absorb organic matters transported both from fish cages and bottom sediments. Another technique, the **modification of water circulation**, might be artificial aeration to mix the water column, favoring species which thrive in well mixed waters over those requiring stratification. The design and evaluation of bio-manipulation strategies require a fundamental understanding of associated processes, such as the grazing losses, or the influence of water column mixing on species succession. These are important unknowns and thus represent promising research directions.

In enclosed or semi-enclosed areas, HABs linked to either local eutrophication or restricted circulation can be minimized by changing the circulation of water masses to optimize flushing of nutrient rich water and HAB species. For example, the tidal dam is one of promising applications. This also requires understanding of linkages between coastal hydrography, nutrient loadings, and bloom dynamics, of which little is known for most HAB species.

2. Japan

1) HABs monitoring and prediction system

(1) Water pollution monitoring

Based on the Global Environment Centre Foundation (GEC) in Japan, the Water Pollution Control Law defined river, lakes, reservoirs and coastal water areas as public water areas and obligated the governor of each prefecture to monitor the pollution of these areas. Water pollution monitoring system started in earnest, including the establishment of annual measurement plans and publication of measurement result. The Water Pollution Control Law designated effluent standards for wastewater discharged from factories and business establishments all over Japan. Furthermore, the law gave the privilege to the governor of each prefecture to designate even more severe effluent standards depending upon the water pollution condition of the governing area, and to supervise the factories and establishments for pollution prevention on behave of the national government. Thus completed system allows identification of pollution source by examining the water quality data of effluent from factories and establishments, which can be a pollution source, and water quality data of public water area which accepts pollutants(**nett21.gec.jp).**

The official monitoring program for the food poisoning syndromes such as PSP and DSP have been started in 1978 in northern Japan and some other areas where shellfish aquaculture operated.

(2) HABs monitoring

Some HABs are identified by red-tide monitoring. The Fisheries Research Agency (FRA) and Coast Guard take a charge of red tide monitoring in Japan. The FRA focuses on coastal sea areas with fishery and aquaculture activities, while the Coast Guard mainly covers offshore areas. Practically, FRA is the most important organization responsible for red-tide monitoring to protect the fishery and aquaculture industries. The FRA sometimes commissions the fisheries laboratories within prefectural governments as research organizations to monitor red tides. Thus, the FRA plays a substantial role in implementing red-tide monitoring in Japan.

The monitoring area of each fishery laboratory is small and limited to enclosed bays. The monitoring frequency differs among laboratories. For example, Kyushu Fisheries Coordination Office conducts aerial monitoring surveys using an aircraft. It has four flight routes that cover the entire Kyushu coastal area, for which a total of 6-8 flights have been made during June-October of each year. Water color and water temperature are monitored in the aerial surveys through visual observation and infrared monitoring, respectively. Aerial surveys are also carried out in the Seto Inland Sea by the Seto Inland Sea Fisheries Coordination Office. However, remotely sensed red-tide monitoring data using satellite can provide referential information, thus it needs to make good scientific development to make use of that information in real-time basis. In addition to regular HABs monitoring, local people, usually fishermen, inform fishery laboratory of the observation of red tides.

2) Recent HABs and their impacts

(1) Recent changes in HABs

In Japan, the record of the oldest red tide and the first impacts on fish and human illness were in 731AD and 1234AD, respectfully (Fukuyo et al., 2002). Of which, the first impacts of the red tide was written as "The estuarine water was discolored as red and grey dark, and resulted in mass mortality and human death in September, 1234 (文暦 元年, 九月二日戊戌 海水入淀河 殷黒如血 魚皆死 食魚者亦死)" in "The History of Great Japan." A Scientific works had been initiated in 1900 by Nishikawa on the *Noctiluca scintillans*. Since then till 1950, the report of red tides in Japan coastal waters were rare as of 10 – 25 reports per decade. After then, it gradually increased in its intensity and frequency. In general, there are two types of HABs in the Japanese coastal waters. The first is the red tides that cause mass mortality of fish and shellfish. The other is the blooms of toxin-producing plankton. Here the red tides of fish killing are mainly discussed.

Based on the national report submitted to CEARAC/NOWPAP (www.cerac-project.org), a total of 32 species caused red tides in the Kyushu coastal area during 1998-2002. The principal taxonomic groups were dinoflagellates and diatoms, of which five species that frequently caused harmful red tide events are *K. mikimotoi*, *N. scintillans* and *Heterosigma akashiwo*, and *Mesodinium rubrum* and *Skeletonema costatum* for harmless red tides. The harmful species of *Chattonella antiqua*, *Alexandrium catenella*, and *Ceratium furca* had caused red-tide events only once during 1998-2002 in the Kyushu coastal area. The harmful flagellated species that have recently caused red tides along the Honshu or Hokkaido coasts include *Heterocapsa circularisquama*, *K. mikimotoi*, *Cha. antiqua* and *C. polykrikoides*.

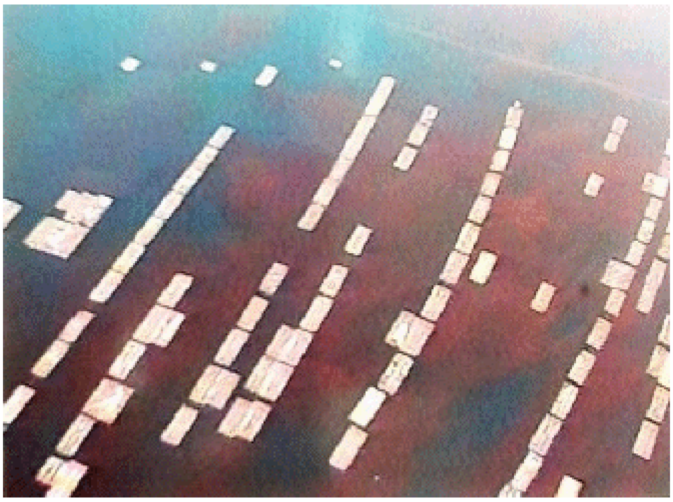


Fig. 新型赤潮生物ヘテ・遷プサ(www.feis.fra.affrc.go.jp).

(2) The impacts of HABs on sustainable fisheries

Outbreaks of red tide were once generally characterized by their occurrence on a relatively small scale during the summer season in partially enclosed or sheltered bodies of water such as the Seto Inland Sea, Ise Bay, Mikawa Bay and Tokyo Bay (FAO, 1976). In more recent times, twenty-seven cases of red tide-related damage were reported in 1973, costing a total of 591 million yen (approx. US$1.97 million). Although it is staggering, it does represent a decrease in comparison to 1972, when 33 cases costing 7 386 million yen (approx. US$24.6 million) were reported (FAO, 1976).

In the Kyushu coastal area, five species brought about mass mortality of fish and shellfish during 1998-2002, resulting in economic loss for the fishing industry (www.cerac-project.org). These species were *H. akashiwo, He. circularisquama, K. mikimotoi, C. polykrikoides* and *N. scintillans.* The most serious damage was caused by *C. polykrikoides* in Imari Bay in August 1999.

3) Management and mitigation

(1) Precautionary prevention

Based on the Japanese report to CERAC/NOWPAP (**www.cerac.nowpap.org**), Japanese central and local governments have made great efforts to control the release of organic matter and nutrients from land in order to reduce eutrophication and red tides Since the 1970s. Japan has implemented effluent control, public education and improvement of sewage systems for effective preventive measures for red tides.

However in Japan, the incidence of fish killing HABs are increasing in frequency and duration. Recent HABs are becoming the urgent and compelling issues in Japan, and it needs to take appropriate measures to minimize the damages from HABs. Based on the report (Fukuyo et al., 2002), the counteraction techniques in Japan are roughly divided into two categories, indirect and direct methods. Indirect methods are basically important as prevention of red tide occurrences on a long-term scale. When fish killing bloom occur and in danger of outbreaks, JRA and Prefectural Government issued HABs alert and ask aquaculturists to take precautionary actions, for examples, transfer of net cages from red tide-prone areas and to stop feeding cultured fish just before and during red tides. This effectively reduces the mortality of fish in the cages, especially of yellowtail(Fukuyo et al., 2002).

(2) Control of HABs

In Japan (Fukuyo et al., 2002), the direct control of red tides had been attempted before 1985, but no physical and chemical control was successful as a whole owing to secondary effects on marine ecosystem. Shirota (1989) suggested that one promising strategy could be to treat red tides with flocculants such as clay, which scavenge particles, including algal cells, from seawater and carry them to bottom sediments. At present in Japan, treatment with clay is not practically applied because of high costs and the possible bad effects on marine organisms mentioned above.

Several projects for the control of dinoflagellates blooms using biological agents such as bacteria, viruses have been undertaken by JRA and some universities. Since the first study on the temporal fluctuation of algicical microorganisms acting on the raphidophytes in Seto Inland Sea (Imai et al., 1998), they found many species of algicidal bacteria against marine harmful microalgae such as *C. antique, H. akahsiwo, and Hetecapsa circularisquama*. They also found that the algicidal bacteria are abundant on the seaweed beds.

□ **National Research Institute of Fisheries and Environment of Inland Sea (FEIS)**

The Harmful Algae Control Section in the National Research Institute of Fisheries and environment of Inland Sea (FEIS) of Fisheries Research Agency (FRA) are working to find a method of controlling algal blooms by using the "function" of marine microorganisms. Their research interests are as followings;

- Viral impacts on harmful algal blooms
- Red tide disintegration mechanism
- Diversity of host algae and their viruses
- Microalgal viruses (focusing on viruses that infect *Heterosigma akashiwo, Heterocapsa circularisquama, Rhizosolenia setigera, Chaetoceros salsugineum, Chaetoceros spp., Microcystis aeruginosa)*
- Virus genomic analysis
- Cyanobacterial bloom termination mechanism
- Inhibition of cyst formation and germination of harmful algal species
- Studies on phages infecting harmful bloom forming blue-green algae (ex. *Microcystis aeruginosa*)

So far, this institute has reported several papers on the control of harmful algae such as *H. akashiwo* and *He. circularisquama* by using algicidal bacteria and virus. Nagasaki and Tarutani (2001) found that a dinoflagellate, *He. circularisquama*, had two types of enemy viruses. These algicidal viruses propagate themselves in the cytoplasm of *He. circularisquama* and kill their host. Algicidal viruses could be applied to eradicate blooms of toxin-producing plankton. The further study on this method, however, is required to evaluate adverse

□ **Kyoto University, Marine Environmental Microbiology of Graduate School of Agriculture**

This university has done also much of scientific works on the algicidal control of aquatic algae. Based on their findings such as the abundance of algicidal bacteria on the lake reeds and seaweeds bed, they propose this algicidal technology as one of promising strategies especially in fin fish aquaculture areas through co-culturing of seaweeds and/or reed barrier to provide more of algicidal bacteria to the water columns. They believe that many algicidal bacteria will be released from the seaweeds and reed barrier into seawater, and can remove and reduce cell densities of harmful microalgae.

This can be enhanced by establishing artificial habitats of algicidal bacteria such as reed forest in the lake and seaweed beds in the coastal areas. They found this technique might be one effective controlling agents in semi-enclosed and small inlets. The benefit through this method is that there is no negative image for aquaculturists and consumers. Furthermore, seaweeds such as *Ulva* sp. is actually being utilized food for red seabream in some cage cultures in Mie and Ehine Prefectures in Japan.

III. International and Bilateral Cooperation for HABs research

Korea and Japan, as a member of international organizations and neighboring countries, must cooperate on the management of red tides and/or HABs to manage efficiently affected marine resources, protect public and marine ecosystem health. Because, it can not only encourage and support a development of marine industries, and but also contribute to policy decisions on coastal issues, scientific exchange, and integrated management of marine ecosystem for stable and sustainable use.

Taking into account present status of HABs in both countries, the interesting topics for bilateral cooperation would be on mitigation study, and whose potential cooperating title can be **"A Japan-Korea Project to mitigate HABs with Clay and Algicidal Bacteria.**" The other topic will be exchanges of scientific findings and data pertaining to understand the initiation and subsequent development of harmful dinoflagellates blooms. In additions, both countries have to cooperate and co-ordinate bilaterally, regionally, and internationally to take relevant working for the management of HABs.

1. Interesting topics for joint scientific study

1) Clay and algicidal bacteria to mitigate HABs

In Korea, clay dispersal has been used as one of practical mitigations to remove fish-killing dinoflagellate, especially against *C. polykrikoides* blooms since 1996 (NFRDI, 2002, Kim, 2005). The clay can remove dinoflagellages cells from the water column by flocculation and sunken to bottom, which can mitigate fisheries damages especially at intensive fish cage culture (Kim, 2005, 2006; Kim et al., 1997; NFRDI, 2002). Imai et al(1998, 2001) found that algicidal bacteria specially associated with the rapid termination of the red tides in the Seto Inland Sea. The algicidal bacteria were flourished onto the surface of seaweeds (Imai et al., 2002) such as Zostera(*Zostera marina*) leaves. They recommend a restoration of seaweed vegetation to prevent red tide outbreaks in the coastal areas (Imai et al., 2006). Therefore, algicidal bacteria would be used as one of tools for biological control of red tides based on their decadal study of mitigation. When it is possible to inoculate algicidal bacteria on clay, this coupled clay and algicidal bacteria can be one of biochemical mitigative agents. This is why the bilateral cooperation is needed to develop one of new coupled mitigative agents.

2) Appropriate methodology for the implementation of joint work

NFRDI and Kyoto University can make a good cooperative works because two organizations have already sustained bilateral cooperation for the exchange of scientific findings and information on this works. Thus joint study can be carried out based on the bilateral cooperation. If it works well, we can have one of promising biochemical mitigation agents. It will be synergistic agent theoretically to remove dinoflagellate cells from the water column, and might be applicable in near future. This work should be witnessed through bilateral experiment to get approval for practical application. For this study, the potential subjects to be studied will be ;

(1) Choice of relevant natural bacteria,
(2) A method of bacteria implant on the clay,
(3) Mutual interaction between the clay and bacteria,
(4) The impacts of bacteria on the coastal flora and fauna,
(5) Removal efficiency of this new technology.

3) Time-schedule in advance

The first joint meeting between interesting scientists of NFRDI, Korea and Kyoto University, in Japan can be held in Jeju, Korea, October 2009 taking advantage of the 18th Pacific International Commission for the Exploration of the Sea (PICES, originated from North Pacific Marine Science Organization) annual meeting. During this meeting, scientific planning and cooperation will be discussed and made by the participants from both countries for agreements. This project terms can be three years periods of 2010 - 2012.

2. Joint cooperation for international organizations

1) Cooperation on the international HABs platform

Acknowledging that HAB problems are expanding and they have many impacts on the marine ecosystem and public health, Korea and Japan have been working together in the international and regional organizations and programs such Global Ecology and Oceanography of Harmful Algal Blooms (GEOHAB), International Society for the Study of Harmful Algae (ISSHA), PICES, Northwest Pacific Action Plan (NOWPAP/UNEP), Asia and Pacific Economic Commission (APEC), and Intergovernmental Oceanographic Commission (IOC). The general purpose of international program, for example GEOHAB, is to *Foster international co-operative research on HABs in ecosystem types sharing common features, comparing the key species involved and the oceanographic processes that influence their population dynamics* (www.geohab.info). In late 1997, the Scientific Committee on Oceanic Research (SCOR) and IOC agreed to form a partnership to develop such a programme. Finally, a plan for co-ordinated scientific research and co-operation to develop international capabilities for assessment, prediction and mitigation entitled "Global Ecology and Oceanography of Harmful Algal Blooms(GEOHAB)" has been emerged as unique international HABs project (GEOHAB, 2001, 2003). Korea (Dr. Hakgyoon Kim) and Japanese scientists (Drs. Ichiro Imai and Yasuwo Fukuyo) had participated in that initiative meeting of SCOR/IOC/UNESCO held in Haverehem, Copenhagen, 1998. With conforming to the aims, both countries are working together on those international programs of GEOHAB directly and/or through Asian HABs (ASIAHAB) and East Asian Study Team on HABS (EASTHAB). The first ASIAHAB meeting was held in Tokyo, March 15-16, 2007. The East Asian Study Team on HAB (EASTHAB) from three countries, China, Japan, and Korea, had five consecutive workshop and meetings since 2004. The 1st Workshop was held on Dec.10-12, 2004, Jeju, Korea, and followed by 2nd meeting on Nov. 25-27, 2005, Quindao, China; the 3rd meeting on Mar. 14-15, 2006, Nagasaki, Japan; the 4rd meeting on 7-8 Dec. 2007, Changwon, Korea, and the 5th meeting on Oct. 29-31, 2008, Hangzhu, China. Their high priorities are given to the exchanges of scientific findings on the outbreaks of dinoflagellate blooms such as *C. Polykrikoides*, *K. mikimotoi*, and *H. akashiwo.*

The PICES formed a Section of "Ecology of Harmful Algal Blooms in the North Pacific (HAB-Section) in 2003, under the Marine Environmental Quality (MEQ) committee. This section coordinates exchanges of national reports of HABs incidents and developments in order to inform researchers and managers about new toxins, issues and approaches to mitigate HAB occurrences and their effects. As a member of PICES, Korean and Japanese scientists are joining HAB-Section activities every year since its establishments. In 2009, this meeting will be held in October, Jeju, Korea, and can have very wide and deep exchanges on their scientific findings and HABs data. For CEARAC/NOWPAP, both countries are working together in the Working Group 3 and 4.

2) Regional and bilateral cooperation for HABs works

Harmful algal blooms make serious damages on fisheries, coastal aesthetics, and even to public health. However up to this 21th century, the real-time monitoring and prediction systems are not yet developed to support practical application. Therefore, regional and bilateral organizations are working together to develop practical monitoring and management of HABs.

V. Conclusions

The coastal and marine resources are economically important because they generate a varying flow of services, benefits or utilities to individuals and society. However in recent, subsequent results of coastal pollution such as HABs and the aestival anoxia threaten sustainable productivity in most of the coastal areas. Over the last several decades, Korea and Japan have experienced an escalating and worrisome trend in the incidence of those problems. Their impacts include mass mortalities of farmed fish and shellfish, and sometimes human illness from intoxicated shellfish.

So far, the cost efficient and environmentally kind mitigation agents are not yet developed for practical use even some clay and prevention methods are available. It is a time to develop efficient mitigation agent because the HABs are increasing trends in the global ocean, and sometimes cause economic loss and public health problems. This trend will be increase in intensity and frequency. Japan and Korea should cooperate to take appropriate measures to minimize their impacts on fisheries and public health from harmful and toxic algal blooms.

Meanwhile, the mechanism on the initiation and subsequent development of fish-killing dinoflagellate, especially on *C. polykrikoides*, is still not figure out due to short of oceanographic properties in the western pacific and East China Sea whose properties might influence on the initiation and transportation. This issue can be solved when both countries have bilateral cooperation on the exchange of oceanographic and ecological data and information in order to understand the likely route for the transport of *C. polykrikoides* species. Where possible, the most efficient approach of cooperative and collaborative regional monitoring on such issue is to establish joint oceanographic observations on the relevant seas. It is apparent that precise and quantified information on the HABs predictions and mitigations to control HABs should be available to provide real-time prediction and to minimize fisheries damages in the coastal aquaculture. Such bilateral cooperation surely mitigate the fisheries loss from HABs, shellfish intoxications, and intangible economic loss caused by environmental deterioration. However we should understand, all is come true when we monitor, predict, and take appropriate measures together.

What is clearly needed for our future HABs research is a cooperation and collaboration to establish bilateral scientific program on the ecology and oceanography of HABs that incorporates the full participation of numerous scientists from both countries. It can be implemented through bilateral meetings, or through regional and international organizations such as GEOHAB, NOWPAP, PICES, EASTHAB, International Conference of Harmful algae (ISSHA), and Asian GEOHAB meetings.

References

Cho, C. H. 1981. On the *Gymnodinium* red tide in Jinhae Bay. *Bull. Korean Fish. Soc.*, 14(4), 227-232.

FAO, 1976. An assessment of the effects of pollution on fisheries and aquaculture in Japan. *FAO Fisheries Technical Paper* (FIR/T 163), No. 163.

Fukuyo, Y., I. Imai, M. Kodama, and K. Tamai, 2002. Red tides and other harmful algal blooms in Japan. PICES Scientific Report No. 23.

GEOHAB, 2001. Global Ecology and Oceanography of Harnmful Algal Blooms, Science Plan. P. Glibert and G. Pitcher (eds.), SCOR and IOC, Baltimore and Paris. 86 pp.

GEOHAB, 2003. Global Ecology and Oceanography of Harmful Algal Blooms, Implementation Plan. P. Gentien, G. Pitcher, A. Cembella, P. Glibert (eds.) SCOR and IOC, Baltimore and Paris, 36 pp.

GEOHAB, 2006. Global Ecology and Oceanography of Harmful Algal Blooms, Harmful Algal Bloomss in Eutrophic Systems. P. Gilbert (eds.). IOC and SCOR, Paris and Baltimore, 74pp.

Imai, I., M.C. Kim, K. Nagasaki, S. Itakura, and Y. Ishida, 1998. Relationship between dynamic of red tide-causing raphidophycean flagellates and algicidal micro-organisms in the coastal sea of Japan. *Phycol. Res*. 46:139-146.

Imai, I., T. Sunahara, T. Nishigaki, Y. Hori, R. Kondo, S. Hiroishi, 2001. *Mar. Biol.* 138; 1043-1049.

Imai, I., D. Fujimaru, and T. Nishigaki, 2002. *Fisheries Sci.*, 68(Supplement): 493-496.

Imai, I., M. Yamaguchi, and Y. Hori, 2006. *Plankton Benthos Res.*. 1: 71-84.

Kim, H.G. 2005. Harmful Algal Blooms in the Sea. Dasum Publishing Co., Busan, Korea, 467pp.

Kim, H.G. 2006. Mitigation and controls of HABs. 327-338. In : Ecology of Harmful Algae. E, Granéli and J. T. Turner (eds.). Ecological Studies, Vol. 189. Springer-Verlag Berlin Heidelberg. 413pp.

Kim, H.G., W.J. Choi, Y.G. Jung, C.S. Jung, J.S. Park, K.H. An and C.I. Baek. 1999. Initiation of *Cochlodinium polykrikoides* blooms and its environmental characteristics around the Narodo Island in the western part of South Sea of Korea. *Bull. Nat,l, Fish. Res. Dev. Korea* 57, 119-129.

Kim, H.G, S.G. Lee, K.H. An et al.,(1997). Recent Red Tides in Korean Coastal Waters. *National Fisheries Research & Development Institute*. pp.280.

Kim, H.G., J.S. Park, Y. Fukuyo, H. Takayama, K.H. An and J.M. Shim. 1995. Noxious dinoflagellate bloom of an undescribed species of *Gyrodinium* in Chungmu coastal waters, Korea . Harmful Marine Algal Blooms. Lavoisier, 59-63.

NFRDI. 2002. Red tides and mitigation (in Korean). 23pp.

Park, J. S. 1982. Studies on the characteristics of red tide and environmental conditions in Jinhae Bay. *Bull. Fish. Res. Dev. Agency,* 28, 55-88 (in Korean).

Shirota, A. 1989. Red tide problem and countermeasures (2). Int. J. Aq. Fish. Technol. 1, 1`95-223.

Websites

www.fra.affrc.go.jp

www.feis.affrc.go.jp

www.cerac-project.org

Detection of Bruise on Red Tomatoes with Machine Vision

Collaborative Research Work by
Sang Ha Noh, Professor of Seoul National University

Background and Objectives:

During handling and transportation of fruits from the orchard to the sorting line in packing house, some of the fruits are bruised and the quality of fruits is degraded. Problem is that bruises are usually not detected visually for a while after bruising. Colors of the bruised tissues are getting darker in general when time is being elapsed.

The objective of this study was to investigate feasibility of detection of the bruised tissues of tomatoes with color images and near infrared (NIR) images.

Materials and Methods:

Two sample groups were used for test runs. The first group is color image data of 6 tomatoes which were obtained at sorting line with a color vision system by a sorting company in Japan.

The 2nd group is consisted of 12 red tomatoes which were artificially bruised by hands and 4 normal red tomatoes. NIR filter images were taken with those 16 tomatoes. Filter images were captured with an experimental apparatus which is composed of a

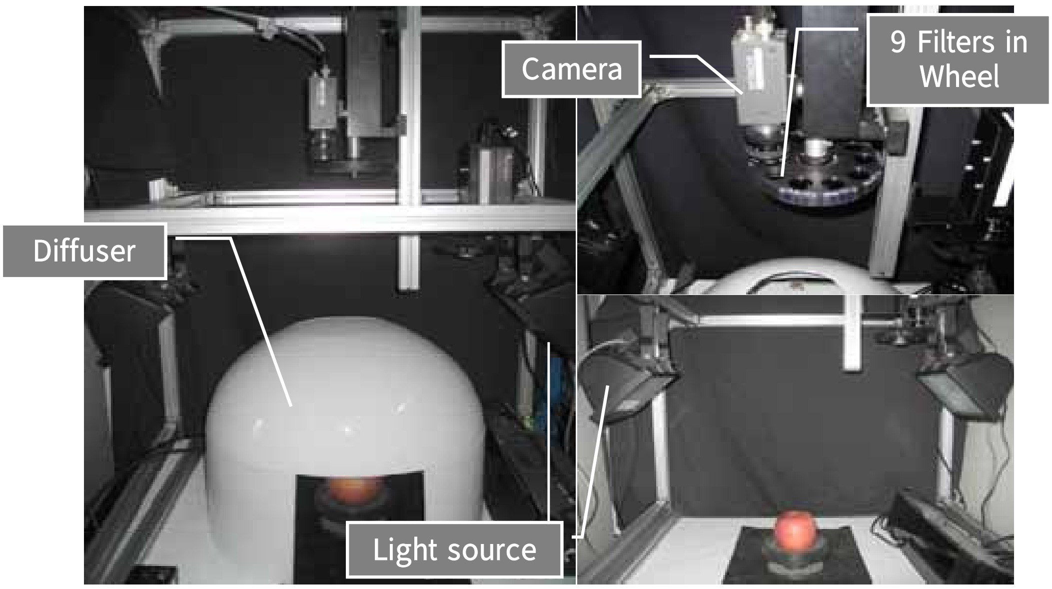


Fig. 1 Image capturing device consisted with a NIR camera, light source, diffuser and a filter wheel

HITACH NIR camera, illumination light source, and a filter wheel in which NIR filters can be mounted (Fig. 1). Ten band pass filters having peak wavelengths of 700, 730, 760, 790, 830, 860, 900, 940, 980 and 1000 nm were adopted for taking NIR filter images. Ten filter Images for each tomato sample were taken about 4 hours after bruising.

Results and Discussion

1. Detection of bruised parts from color images:

In order to select a suitable threshold value in detecting the bruised parts, distribution of averages and standard deviations of color values of the normal and bruised tissues were investigated. The window size used for computing those values were 15 x 15 pixels, and number of sampling points were more than 15 on each color image. The color values examined were R, G, B, r, g and b.

Fig. 2 shows the distributions of averages and standard deviations of each color values representing the windows sampled from the normal and bruised parts in color

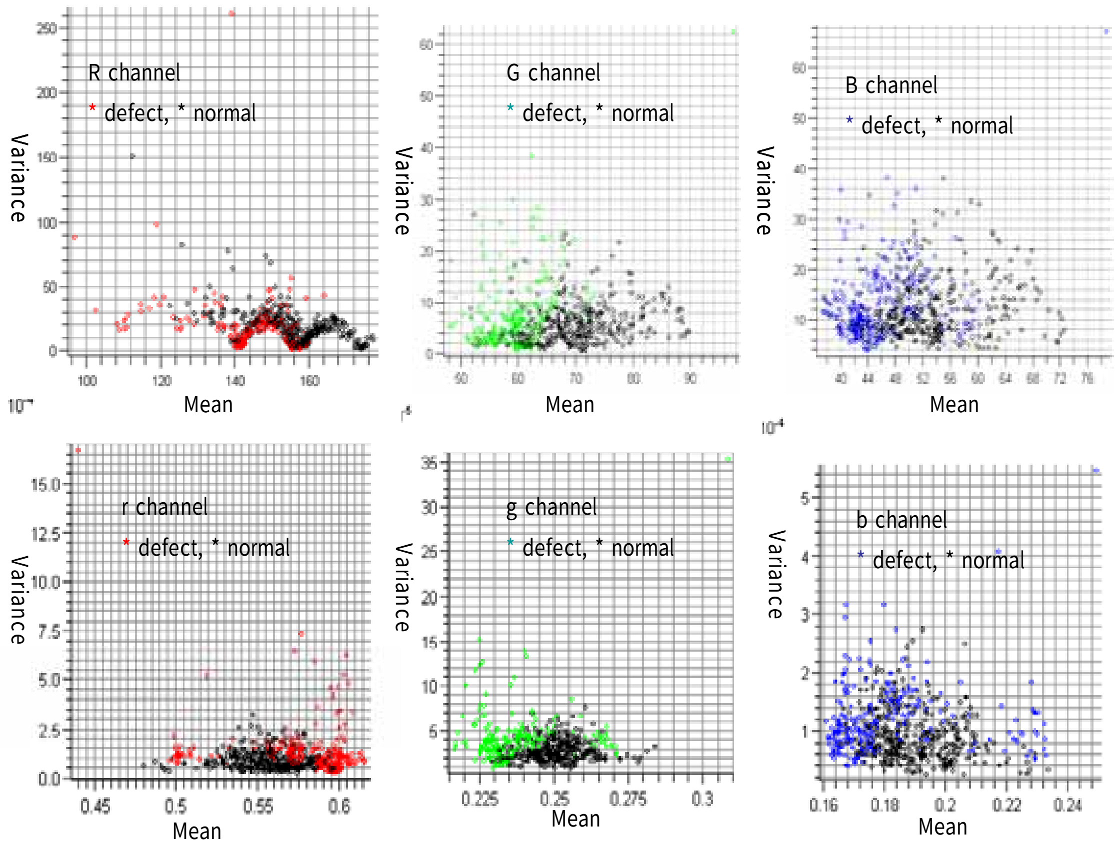
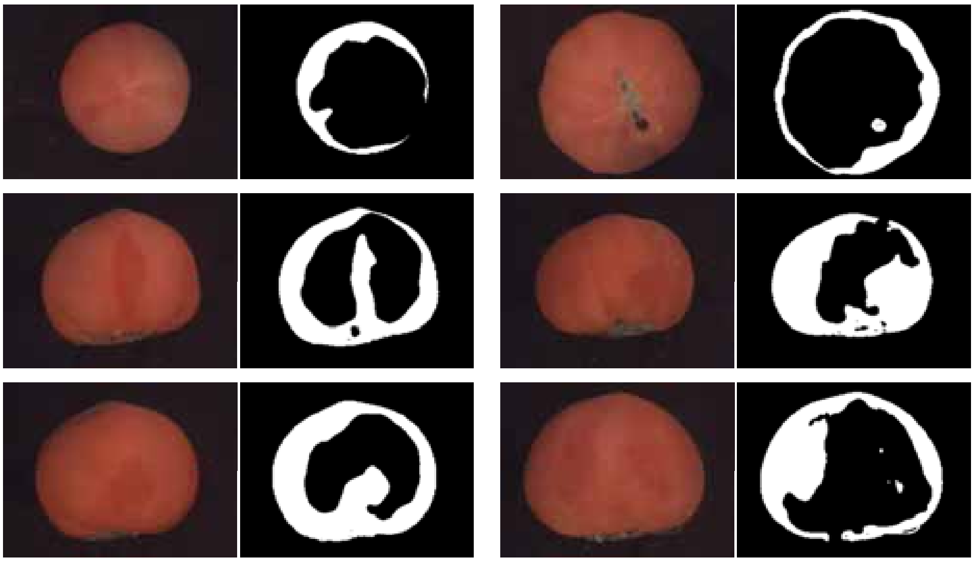


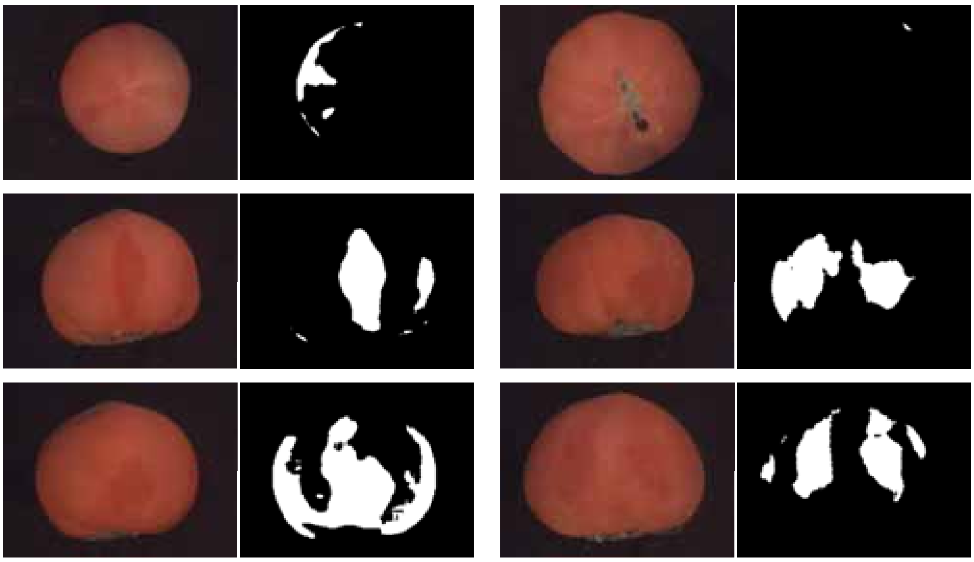
Fig. 2 Distributions of averages and variances of color values(R, G, B, r, g, and b) of the bruised and normal tissues in tomato samples

images. Based on this result, it was concluded that the best thresholding method is to use G or g values because a separation line could be drawn more easily to divide the normal and the bruised.

Fig. 3 is showing the images thresholded by G and g values, respectively. It is noted that g value is better than G in detecting the bruised tissues in red tomatoes since the boundary areas of the binary images in Fig. 3(b) are recognized as bruised tissues. The reason is thought to be that G value includes not only the color characteristics but also brightness.



(A)



(B)

Fig. 3 Color images and their thresholded images with G value (A) and with g value (B). White color in the binary images indicate the bruised tissues in color image

2. Detection of the bruised tissues with NIR filter images:

Representative filter images of a bruised red tomato are shown in Fig. 4. It is noticed that the bruised tissues are a little darker than the normal in general

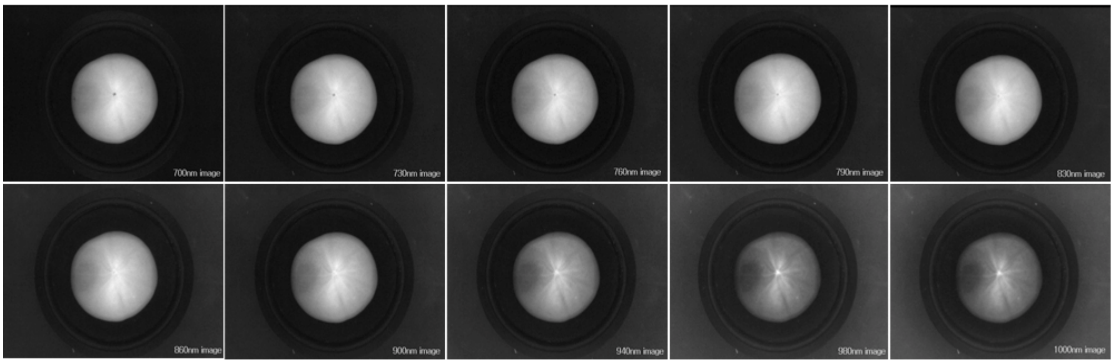
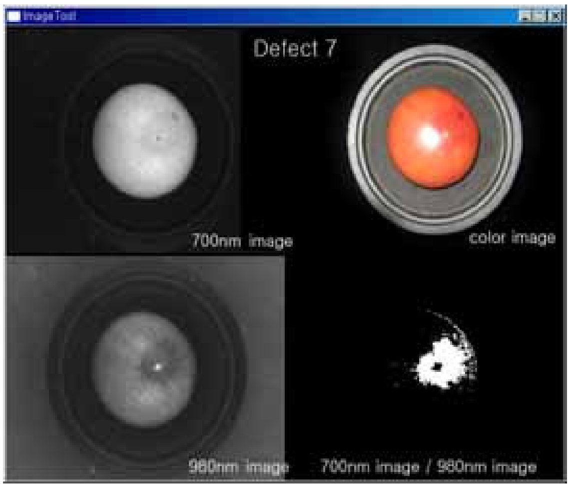
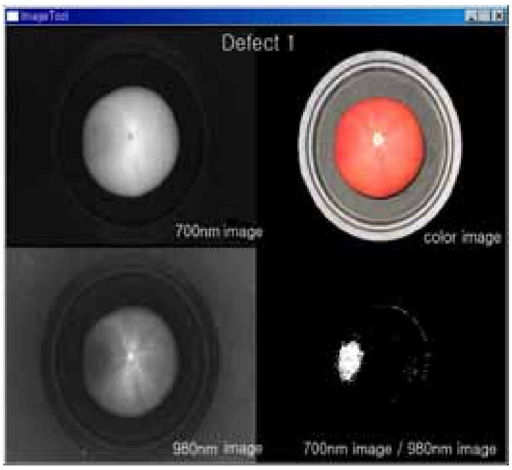


Fig. 4 Filter images of a bruised red tomato using 700, 730, 760, 790, 830, 860, 900, 940, 980 and 1000nm band pass filters, respectively (from the top left).

A few algorithms such as image subtractions (subtraction of filter image i from filter image j and thresholding the resulted image), image ratios (dividing image i by image j and thresholding the resulted image), etc were tried to find out the most effective method in detecting the bruised tissues. Finally, it was decided that the most useful algorithm is to use ratios of 700 nm and 980 nm filter images. Preliminary detection results with 12 bruised and 4 normal red tomato samples are shown in Table 1, indicating overall accuracy was about 81.3 %.





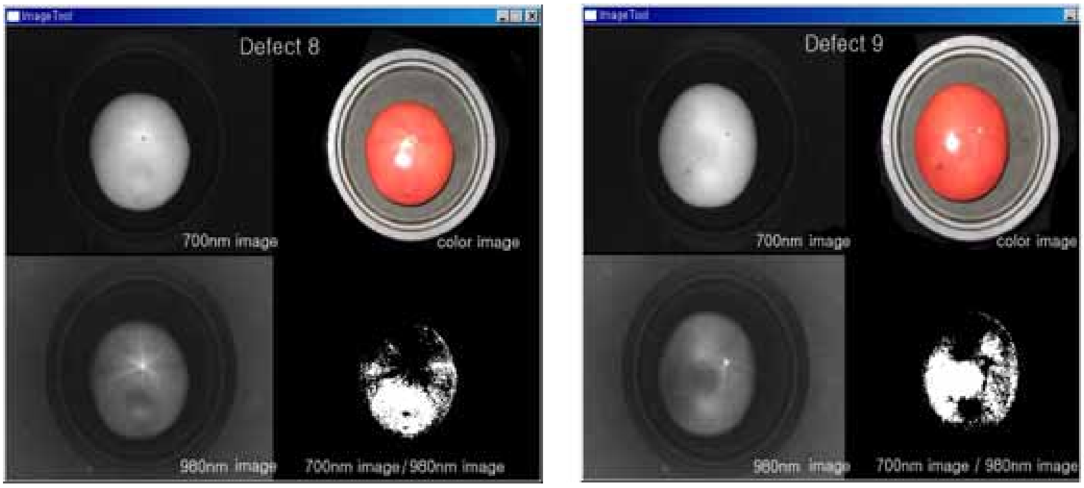


Fig. 5 Representative images showing detection of bruised tissues on red tomatoes using ratio of 700 nm- and 980 nm- filter images.

Table 1 Confusion matrix indicating detection result of bruised tomatos by using ratio of 700 nm- and 980- filter images

		Actual		
		Bruised	Normal	
Predicted	Bruised	10	1	11
	Normal	2	3	5
		12	4	

Conclusions and Remarks

On the basis of preliminary analysis with very limited image data, it was possible to detect bruised tissues on red tomatoes using the color value g in thresholding the color images, and further research is recommended to estimate detection rate with many image data captured under various environments.

NIR filter images were also gave possibility in detecting the bruised tissues. One of the best algorithms is to use ratio images obtained with 700 nm- and 980 nm filter images. One of the difficulties using this method for on-line detection is to develop a camera with which two images at different wave bands can be captured at the same time.

Research Report

Dr. Darwin W. Anderson
Guest Professor
February to May, 2009

My appointment as a Guest Professor in the Soil Science Laboratory of the Division of Enviromental Science and Technology began on February 2 and ended on May 1, 2009. The time at Kyoto University was three months, making it difficult to undertake a research program involving experimental work. The time, however, was quite beneficial to me and my work as a Professor of Soil Science at the University of Saskatchewan. Hopefully, I have been able to contribute to research and knowledge here through the activities listed in this report.

The interactions with the people in Soil Science have been both enjoyable and good for me from a science perspective. I learned about some of the research by providing editorial advice on papers that were being written in English. Carefully reviewing and offering suggestions results in a good understanding of the content. I particularly appreciate working with Dr. K. Fujii on his paper dealing with dissolved organic carbon in tropical soils, a new area for me.

I attended the ‘scientific English’ class at which the students read one of my articles, “The Effect of Parent Material and Soil Development on Nutrient Cycling in Temperate Ecosystems”. It was published in Biogeochemistry in 1988, Volume 5, pages 71 to 97. This was an interesting and beneficial experience for me, demonstrating how easy it is for small errors to slip by authors, reviewers and editors. The careful reading and translation by the students indicated the importance of science writing that is clear, straightforward, and does not use jargon that may be well-known locally but poorly understood by readers in a different country and/or language.

One of the purposes of my stay here was to familiarize students with the soils of Western Canada. The Canadian soils are quite similar to the soils of Central Asia, the location of field research by the faculty and students of the Soil Science Laboratory. There was consistent attendance at, and interest in, the three lectures on Canadian soils given in April to the graduate students. The first was on the soils of the grasslands, the second on the soils of forest regions, and the third on the soils of wetlands and permafrost regions. The final lecture entitled The Transformation of Agriculture in Western Canada discussed the change from summer fallow-based cropping systems to conservation tillage and continuous cropping. The similarity in soils and farming systems in Western Canada and the Chernozem zone in Kazakhstan is remarkable.

The Symposium of the Japanese Pedology Society on April 3 was one of the scientific highlights. My invited presentation was on the The Soils of the Central Interior Plains of Canada, consistent with the theme of the symposium, Soils of Continental Interiors. There were interesting papers by others, and an opportunity to meet both new and old friends. Dr. Shindo of Yamaguchi University, who was a visiting researcher at my university in about 1982, was at the symposium, and it was good to see him again.. The field excursion following the symposium that was organized by Professor Funakawa permitted me to see the soils and landscapes of Wayakama Prefecture and the Kinki Peninsula . We observed the Brown Forest soils characteristic of this high rainfall area. Some of the trip was cultural in that we visited the Koya Temple and Ise Shrine, and stayed at traditional Japanese inns.

There were two excursions to research centers that were quite beneficial. The first, to the National Institute of Agro-Environmental Science in Tsukuba with Dr. Fujii was particularly valuable. Two Andosol soil profiles were observed, with good discussion of their formation by Dr. T. Ohkura. The National Soils Museum was visited, impressive for the large number of displays with soil monoliths, and for the technique for taking soil monoliths. The second excursion was to the Fukushima Agricultural Technology Center in Koriyama, to visit with a former student, Dr. Masae Takeda. The Center is impressive, both beautiful in design and practical. Related to this visit was a field excursion an organic rice farm, and an opportunity to observe the rice seeding, and observe soils in the region. The mechanized planting of rice was observed in Tetayama, on a week-end excursion with Dr. Fujii.

In summary, the three months spent at Kyoto University have been both enjoyable and scientifically beneficial for me. I trust that my interaction with the faculty and students in Soil Science has been beneficial for them, and wish them every success in future research endeavors.