National Report on HABs in Japan

Table of Contents

I. INTRODUCTION

Marine plankton occasionally appear in high density and give negative consequences to our society and the marine environment by the outbreaks. These events of outbreaks are called “Harmful Algal Blooms (HABs)” in scientific community. HAB species are broadly classified into two groups: high biomass producers which induce red tide and toxin-producing plankton which cause food poisoning. Some planktonic species belong to both groups.

The term “red tide” is generally recognized in public. Most people falsely think all red tide events are harmful for human and the environment. To tell the truth, most red tide events are harmless. Few events, which human perceive as harmful, cause mass mortality of fish by choking fish gills with high dense algae and making anoxic environment. Microbial decay of marine algae consumes oxygen in water column and makes anoxia. Many aspects (e.g. mechanism and causative species) of “harmful” and “harmless” red tides are quit similar. Only their consequences are different for human and the environment. In fact, many reports about HABs introduce red tide including both harmful and harmless ones. Therefore, this report follows this manner.

“Toxin-producing plankton”, as its name, produce toxin inside its cell and contaminate fish and shellfish through food chains. Human is poisoned by eating marine foods contaminated with the produced toxins.

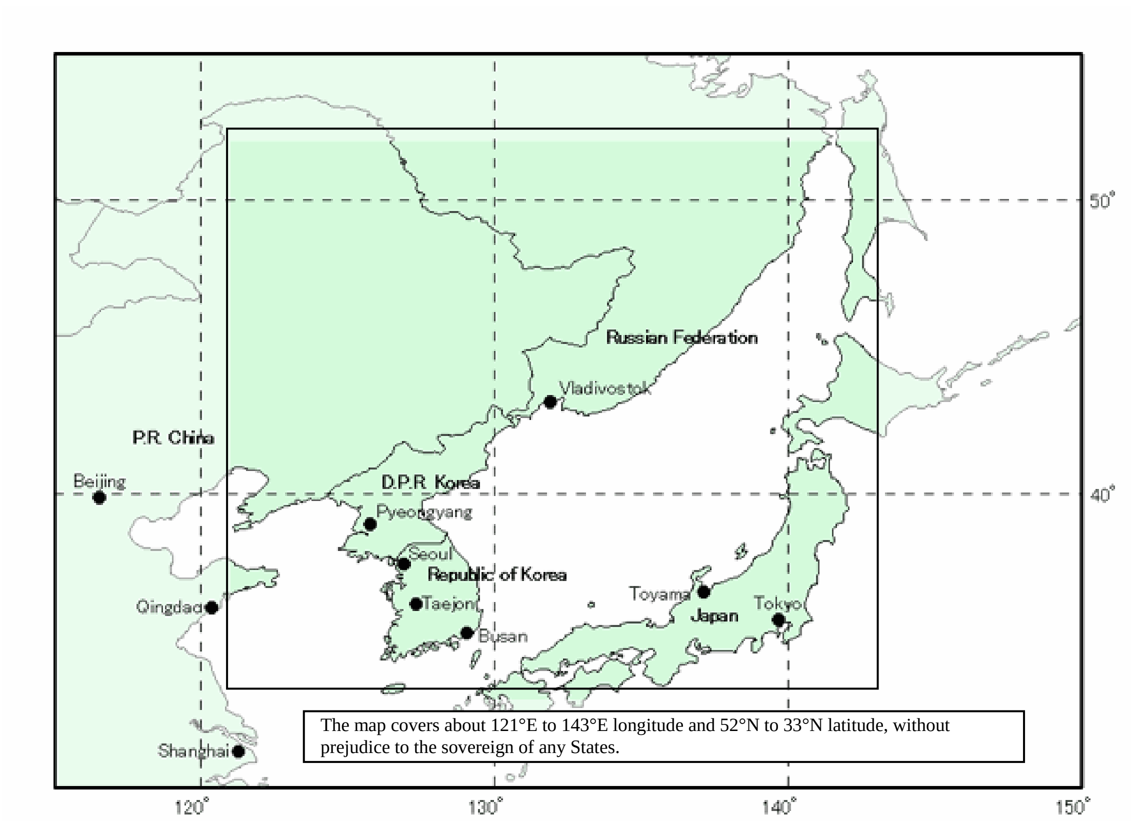
In this report, HABs encompass “red tide” including harmful and harmless ones and “toxin-producing plankton blooms”, which are agreed in the First Meeting of Working Goroup3 (Bussan, October 2003).

HABs generally occur most often in enclosed coastal areas. Within these areas they frequently occur around aquaculture sites, causing serious damage to fishery production through the mass mortality of fish and shellfish. They also impact on human health through fish/shellfish poisoning. The solution of these problems in the Northwest Pacific Action Plan (NOWPAP) region needs close coordination by NOWPAP Members (China, Japan, Korea, and Russia) in the region. It is essential to have a common platform to develop the research, mitigation measures and appropriate political proposals.

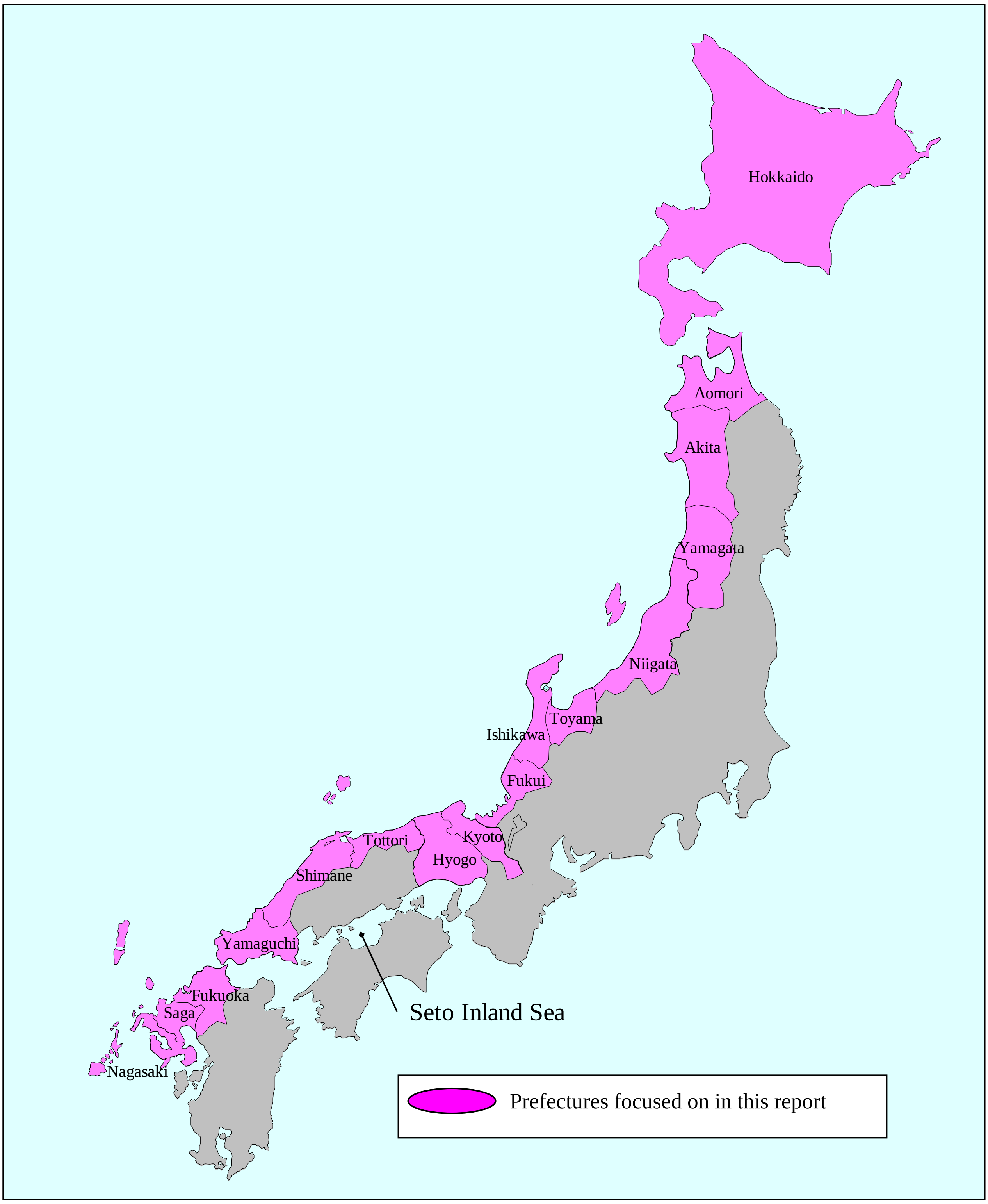
This national report has been prepared in that context. In the WG3 Meeting held in Busan, October 2003, guidelines for preparation of a national report were proposed to prepare the required information in a common format, which may make the compilation of integrated reports easier. The present report was compiled following the guidelines, with some modification. Considering the requirement of the guidelines, this report was prepared using existing data and information, and the results of interviews with researchers and relevant organizations.

There is some potential for eutrophication and HAB occurrence in the NOWPAP Region (geographical coverage of the region is shown in the below figure). This region does not have extensive enclosed sea areas or active aquaculture grounds. Little data or information on HABs have been accumulated for this area, unlike the Seto Inland Sea and the Pacific Ocean side of Japan. Since information on HABs in the NOWPAP region is limited to date, the present report can be used as a basis for understanding HABs in the NOWPAP region.

In this report, the scientific names of the organisms are presented as cited in the source references.



Geographic coverage of the NOWPAP Region
(http://cearac.nowpap.org/nowpap/coverage.html)



Prefectures focused on in this report

II. DATA AND INFORMATION USED

In order to prepare the present report, data and publications issued by relevant organizations were utilized. Some data that had not been publicly disclosed were also provided by the courtesy of such organizations.

1. HAB Occurrence

Two types of HAB are known to occur in the Japanese coastal waters. The first are red tides, some of which cause mass mortality of fish and shellfish. The second are blooms of toxin-producing plankton. In this report, red tides and toxin-producing plankton are discussed separately.

1.1 Red Tides

“Situation of Red Tide in the Seas surrounding Kyushu Island” is a report published annually on red-tide occurrences. It is published from the Kyushu Fishery Coordination Office, in Japanese only, and reports on red-tide events that appear in the coastal waters of Kyushu Island. The data in this report originated from the questionnaires and interviews of local government fishery laboratories in the area.

For other coastal areas of the NOWPAP region of Japan, annual reports issued by fishery laboratories of local governments were also utilized.

1.2 Toxin-producing Plankton

The “Monitoring Report on Shellfish Poisoning in Japanese Fishery Products” was used. It is published annually by the Japan Fisheries Resource Conservation Association (JFRCA), and summarizes the results of shellfish poisoning inspections that are conducted by the relevant local governments. While the report is written only in Japanese, it is very useful because it covers all areas that produce shellfish in Japan.

Annual reports issued by the fishery laboratories of local governments were also utilized.

2. Information on the Monitoring

As introduced above, two types of HAB are known to occur in the Japanese coastal waters: red tides, some of which cause mass mortality of fish and shellfish, and toxin-producing plankton. Hence, as in Section 1 of this report, the monitoring results have been summarized separately for red tides and toxin-producing plankton.

2.1 Red Tides

Monitoring activities are summarized based on the annual reports of fishery laboratories within local governments, which are the main organizations in charge of red-tide monitoring (refs. 3-14).

2.2 Toxin-producing Plankton

Monitoring activities are described based on the “Monitoring Report on Shellfish Poisoning in Japanese Fishery Products”, and annual reports of fishery laboratories of local governments, etc. (refs. 2-14, 19).

3. Progress of Research and Studies to Manage HABs

Interviews with researchers and scientists from relevant fields were conducted. According to the interviews, scientific publications and summaries of information on the current progress of HAB studies were collected (refs. 20-39). In particular, information from the National Research Institute of Fisheries and Environment of the Inland Sea, and the Fisheries White Paper, were useful for identifying future directions for research on HABs.

4. Literature Including New Information

Information derived from literature searches about HABs was obtained using the HAB Reference Database constructed by Coastal Environmental Assessment Regional Activity Center (CEARAC)/WG3. In order to choose topics from enormous amounts of new information, interviews with researchers and scientists in the relevant fields were conducted. Based on these interviews, the relevant literature, including new information, is summarized.

5. Training to Cope with HABs

Interviews with JFRCA personnel and local governments were conducted to determine the on-going training activities for managing red-tide and shellfish-poisoning events.

6. National Activity to Cope with HABs

Interviews with researchers and scientists in the relevant fields were conducted to collect their ideas on the efforts necessary to cope with HABs. Statements from the Fisheries Agency were also integrated into the present report. Data from the Environment White Paper issued by Ministry of the Environment of Japan, and the Fishery White Paper issued by the Fisheries Agency of Japan were also utilized (refs. 17-18).

7. Suggested Activity for the NOWPAP Region

Interviews with researchers and scientists in the relevant fields were conducted to collect their ideas on the efforts involved in finding solutions to HAB problems.

III. RESULTS

1. HAB Occurrence

This chapter introduces situation of HAB in the NOWPAP Region. As mentioned in "INTRODUCTION", there are two groups of HAB species: one that causes red tide and the other that produces toxin. Therefore, "Red Tides (Section 1.1)" and "Toxin-producing Plankton (Section 1.2)" are discussed separately in the context of HAB occurrence.

1.1 Red Tides

1.1.1 Types of Red Tides

The term 'red tide' refers to a phenomenon in which the number of plankton increase to the point where they change or intensify the color of the ocean, and occasionally cause mass mortality of fish and shellfish.

Of the 150 red-tide events in the Kyushu coastal area during 1998-2002, 19 caused mass mortality of fish and shellfish and 131 were harmless. The species that caused damage are summarized in section 1.1.8.

Red tides in the NOWPAP region have not received the attention of those in the Seto Inland Sea and other enclosed seas because they are less frequent and have less impact. For example, there were 509 red-tide events in the Seto Inland Sea during 1998-2002.

1.1.2 Causative Species

A total of 32 species caused red tides in the Kyushu coastal area during 1998-2002. The principal taxonomic groups were dinoflagellates and diatoms.

The five species that frequently caused red tide events are listed in Table 1.1. *Gymnodinium mikimotoi*, *Noctiluca scintillans* and *Heterosigma akashiwo* caused mass mortality of fishery resources, whereas *Mesodinium rubrum* and *Skeletonema costatum* did not result in any economic loss.

The species most notable for their toxicity or harmfulness in Japan, *Chattonella antiqua*, *Alexandrium catenella*, and *Ceratium furca*, each caused red-tide events only once during 1998-2002 in the Kyushu coastal area. *Chattonella marina* did not cause a red tide in the area during that time.

Complete data for red-tide events is unavailable in the Honshu and Hokkaido coastal areas of the NOWPAP region. Some data on causative species were extracted from the latest reports by the fishery laboratories of selected prefectural governments (Table 1.2). The harmful flagellated species that have recently caused red tides along the Honshu or Hokkaido coasts include *Heterocapsa circularisquama*, *Gymnodinium mikimotoi*, *Chattonella antiqua* and *Cochlodinium polykrikoides*.

Table 1.1 Principal species that frequently cause red-tide events (Kyushu)

Species name	Red-tide events 1998-2002
Gymnodinium mikimotoi	23
Noctiluca scintillans	23
Heterosigma akashiwo	19
Mesodinium rubrum	16
Skeletonema costatum	15

Source: Kyushu Fishery Coordination Office, 'Situation of Red Tide in the Seas surrounding Kyushu Island', 1999-2003

Table 1.2 Red-tide species currently reported from the Honshu coastal area

Species name	Prefecture			
	Toyama (2002)	Ishikawa (2002)	Fukui (1998)	Yamaguchi (2000)
Heterocapsa circularisquama			✓	
Gymnodinium mikimotoi		✓	✓	
Gymnodinium sanguineum				✓
Heterosigma akashiwo				✓
Chattonella antiqua		✓		
Chattonella marina		✓		
Cochlodinium polykrikoides				✓
Cochlodinium sp.		✓		
Prorocentrum balticum			✓	
Prorocentrum triestinum			✓	
Chaetoceros curvisetum		✓		
Chaetoceros spp.	✓	✓		
Skeletonema costatum	✓			
Nitzschia sp.		✓		

Source: Annual reports of fishery laboratories within prefectural governments

1.1.3 Cell Density

The highest plankton cell density observed during 1998-2002 was 117,980 cells/mL of *Gymnodinium mikimotoi* in July 2002 in the Kyushu coastal area. The usual maximum cell density in red-tide events is several thousand cells/mL.

1.1.4 Location

The monitoring of red tides in Japan has mostly been conducted by the fishery laboratories of prefectural governments. It is reported that about 10 fishery laboratories carry out regular monitoring. The monitoring area of each fishery laboratory is small and limited to enclosed bays. The frequency of monitoring differs among fishery laboratories. Data are reported from individual fishery laboratories of prefectural governments based on different monitoring schemes. It is, therefore, impossible to draw a monthly map.

Figure 1.1 shows the areas that experienced red-tide events during 1998-2003. This reveals that red-tide events are more common in the western part of the NOWPAP region than in northern Japan.

The occurrence of red tides in the Kyushu area of the NOWPAP region is summarized in Figure 1.2, using the results from “Situation of Red Tide in the Seas surrounding Kyushu Island”. This reference material of the Kyushu Fishery Coordination Office includes information and red-tide occurrence maps. It is prepared monthly by obtaining the information through interviews with fishery laboratories of prefectural governments. Interviews are done only in the Kyushu area and do not cover the northern coast of Japan, but the reference material provides valuable data.

From the figure, it can be seen that each year red tides begin in March or April and peak during June to August. One hundred and fifty red tide events were observed in recent 5 years, mainly in the bays and semi-enclosed coastal waters of northern Kyushu.

The results of regular aerial monitoring of red tides in the Kyushu coastal area during 1998-2002 are shown in Figure 1.3. This monitoring was also conducted by the Kyushu Fisheries Coordination Office. The details of the monitoring are explained in Chapter 2 and Figure 2.2 (see p. 35). The aerial monitoring identified red tides in the northern Kyushu coastal area in more than half of the flights (Figure 1.3). The main HAB occurrence area was Hakata Bay.

Trace monitoring of HABs (tracking a bloom) has been conducted in Akita, Fukui, Yamaguchi, Saga and Nagasaki prefectures. In Obama Bay, Fukui Prefecture, *Heterocapsa circularisquama* red tides occurred during 1997-1999, and were traced for 8-60 days. Saga Prefecture conducted trace monitoring of red tides caused by *H. circularisquama* and *Gymnodinium mikimotoi* four times in 2000.

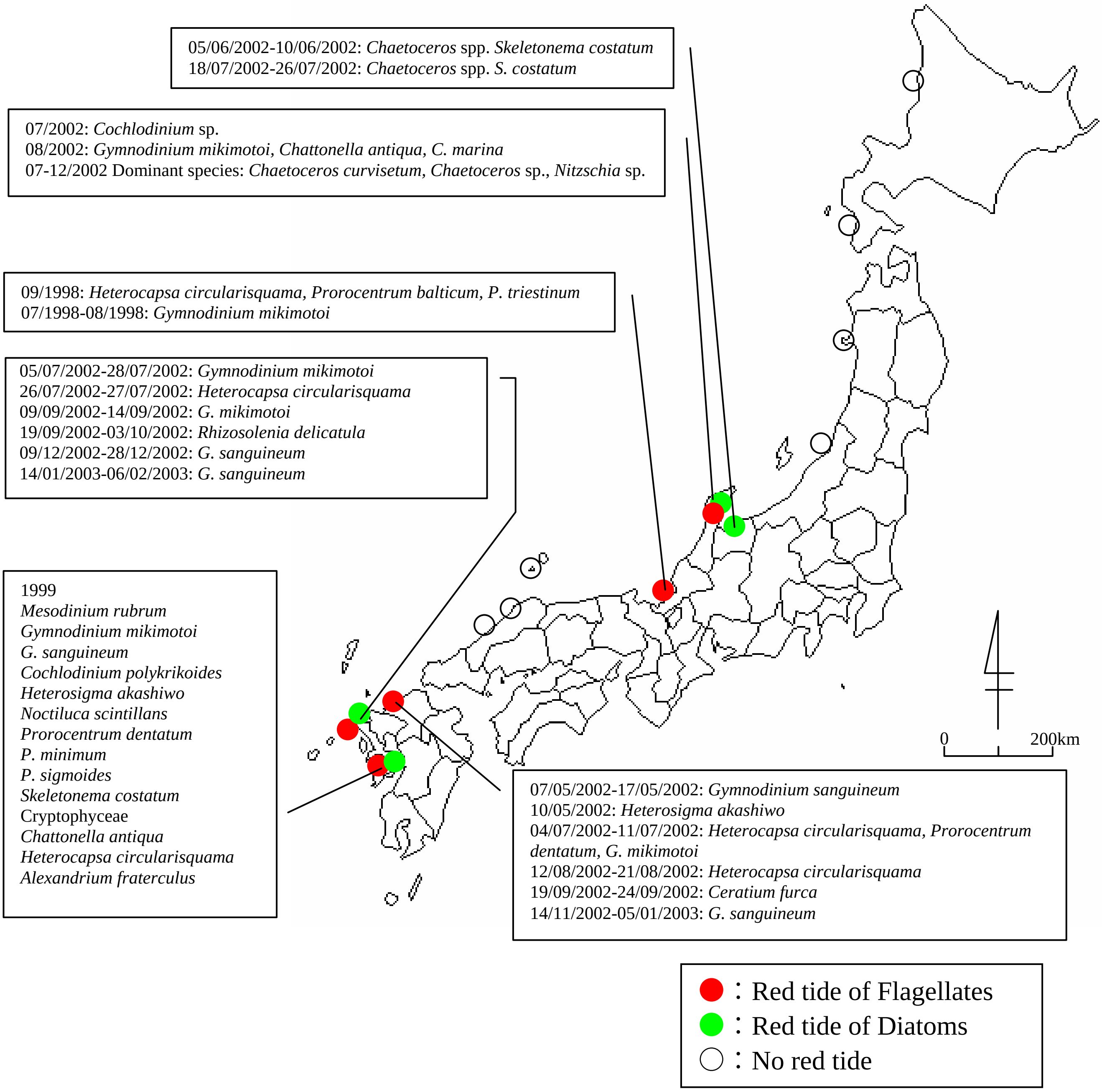


Figure 1.1 Occurrence of red tides in the NOWPAP region during 1998-2003
(Colored and open circles show regular monitoring stations)
Source: Annual reports of fishery laboratories of prefectural governments

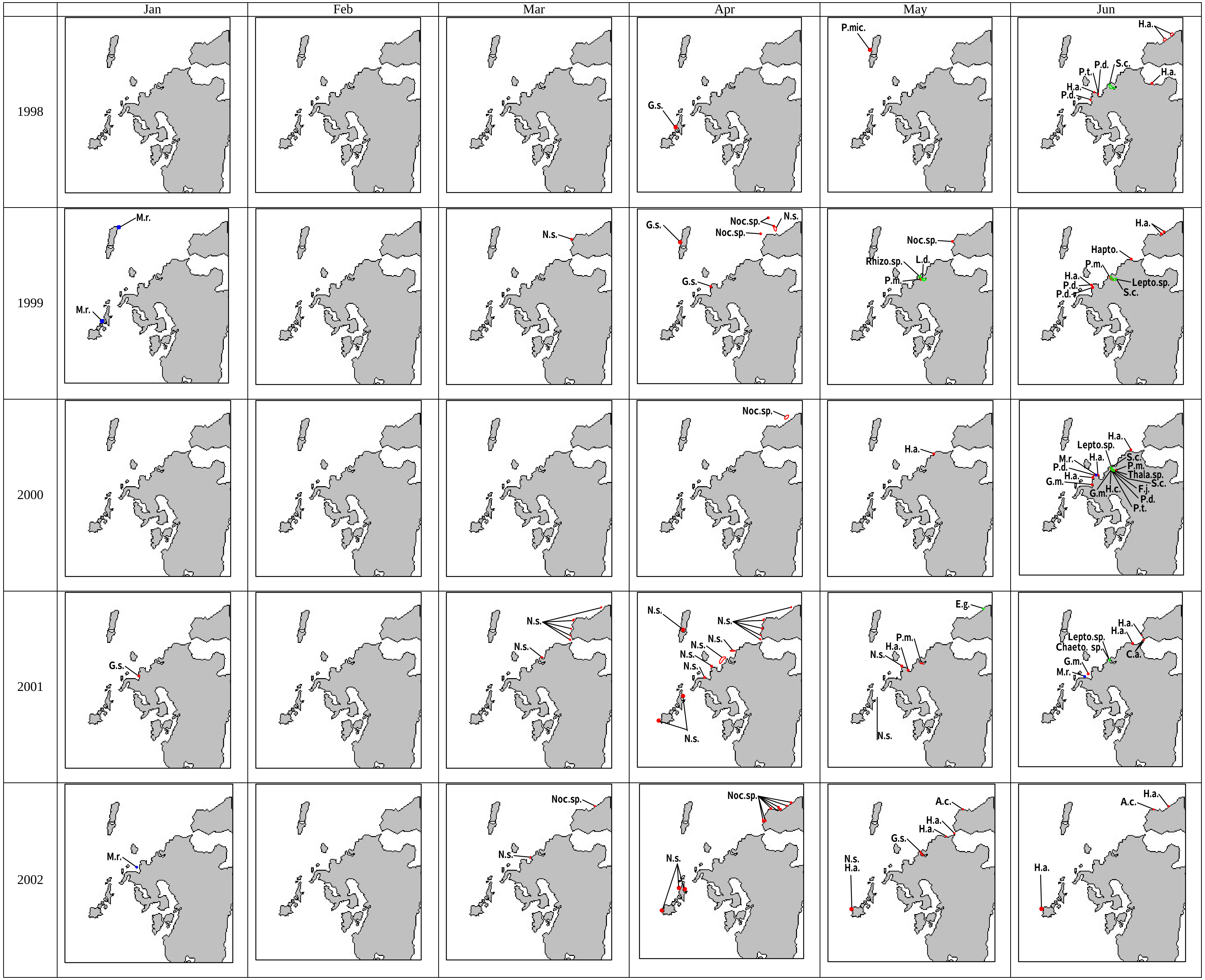
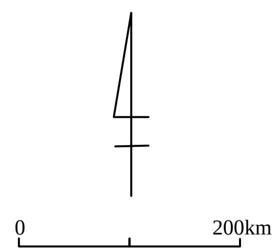


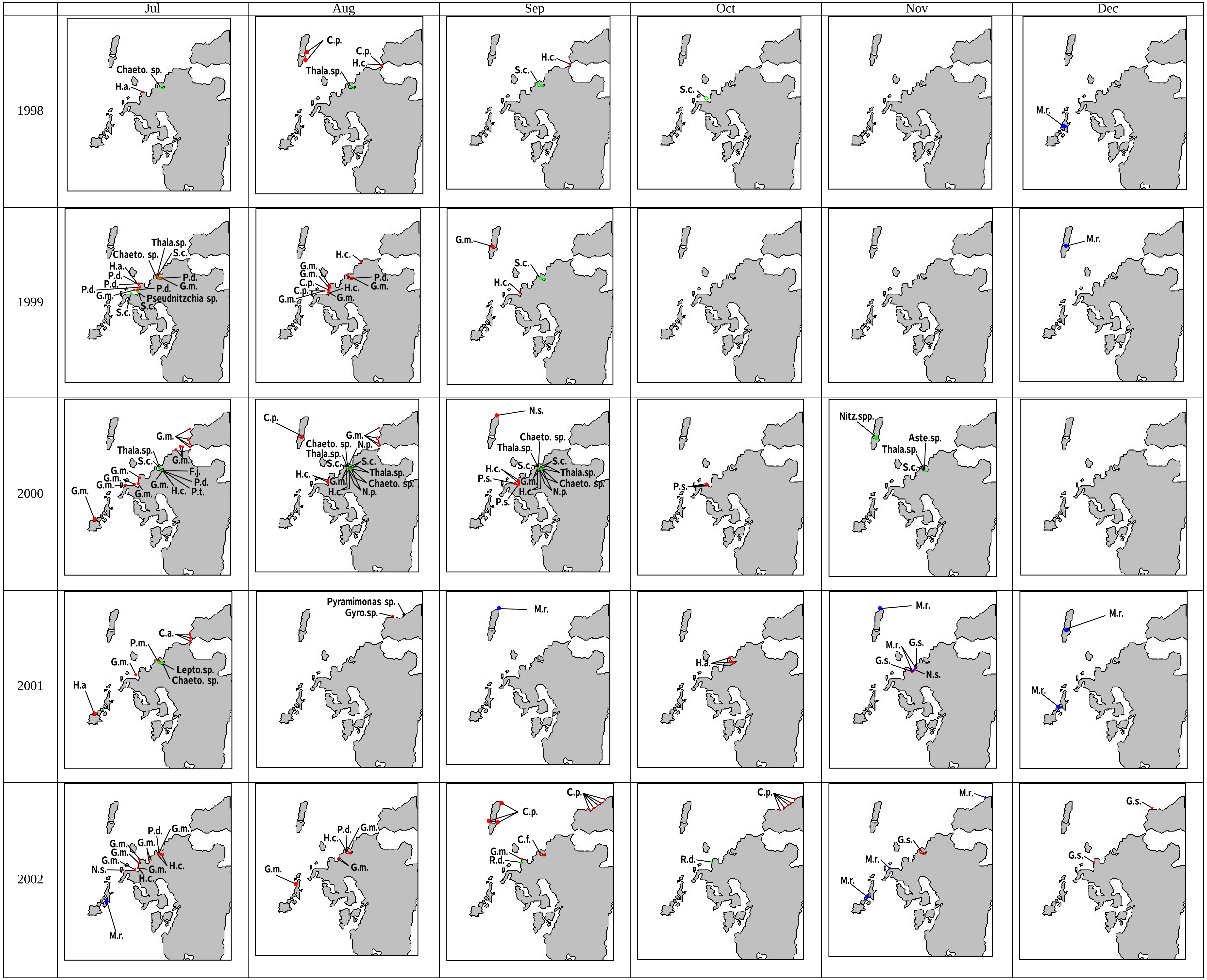
Figure 1.2 (1) Occurrence of red tides in the northern Kyushu coastal area (Only red tides in the NOWPAP region are indicated)
Source: Kyushu Fisheries Coordination Office, ‘Situation of Red Tide in the Seas surrounding Kyushu Island’, 1999-2003

Plankton Taxa

Class	Genus and Species	Abbreviation
Dinophyceae	*Alexandrium catenella*	A.c.
	Ceratium furca	C.f.
	Cochlodinium polykrikoides	C.p.
	Gymnodinium mikimotoi	G.m.
	Gymnodinium sanguineum	G.s.
	Gyrodinium sp.	Gyro.sp.
	Heterocapsa circularisquama	H.c.
	Noctiluca sp.	Noc.sp.
	Noctiluca scintillans	N.s.
	Prorocentrum dentatum	P.d.
	Prorocentrum minimum	P.m.
	Prorocentrum micans	P.mic.
	Prorocentrum sigmoides	P.s.
	Prorocentrum triestinum	P.t.
Raphidophyceae	*Chattonella antiqua*	C.a.
	Heterosigma akashiwo	H.a.
	Fibrocapsa japonica	F.j.
Eugrenophyceae	*Eutreptiella gymnastica*	E.g.
Haptophyceae	Haptophyceae	Hapto.
Bacillariophyceae	*Chaetoceros sp.*	Chaeto. sp.
	Leptocylindrus danicus	L.d.
	Leptocylindrus sp.	Lepto.sp.
	Rhizosolenia delicatula	R.d.
	Rhizosolenia sp.	Rhizo.sp.
	Skeletonema costatum	S.c.
	Thalassiosira sp.	Thala.sp.
	Neodelphineis pelagica	N.p.
	Nitzschia spp.	Nitz.spp.
	Asterionella sp.	Aste.sp.
Ciliata	*Mesodinium rubrum*	M.r.

● : Flagellate red tide
● : Diatom red tide
● : Ciliate red tide





Plankton Taxa

Class	Genus and Species	Abbreviation
Dinophyceae	*Alexandrium catenella*	A.c.
	Ceratium furca	C.f.
	Cochlodinium polykrikoides	C.p.
	Gymnodinium mikimotoi	G.m.
	Gymnodinium sanguineum	G.s.
	Gyrodinium sp.	Gyro.sp.
	Heterocapsa circularisquama	H.c.
	Noctiluca sp.	Noc.sp.
	Noctiluca scintillans	N.s.
	Prorocentrum dentatum	P.d.
	Prorocentrum minimum	P.m.
	Prorocentrum micans	P.mic.
	Prorocentrum sigmoides	P.s.
	Prorocentrum triestinum	P.t.
Raphidophyceae	*Chattonella antiqua*	C.a.
	Heterosigma akashiwo	H.a.
	Fibrocapsa japonica	F.j.
Eugrenophyceae	*Eutreptiella gymnastica*	E.g.
Prasinophyceae	*Pyramimonas* sp.	Pyramimonas sp.
Haptophyceae	Haptophyceae	Hapto.
Bacillariophyceae	*Chaetoceros* sp.	Chaeto. sp.
	Leptocylindrus danicus	L.d.
	Leptocylindrus sp.	Lepto.sp.
	Rhizosolenia delicatula	R.d.
	Rhizosolenia sp.	Rhizo.sp.
	Skeletonema costatum	S.c.
	Thalassiosira sp.	Thala.sp.
	Neodelphineis pelagica	N.p.
	Nitzschia spp.	Nitz.spp.
	Asterionella sp.	Aste.sp.
	Pseudonitzchia sp.	Pseudonitzchia sp.
Ciliata	*Mesodinium rubrum*	M.r.

●：Flagellate red tide
●：Diatom red tide
●：Ciliate red tide

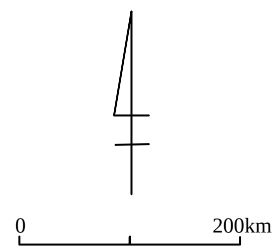


Figure 1.2 (2)　Occurrence of red tides in the northern Kyushu coastal area (Only red tides in the NOWPAP region are indicated)

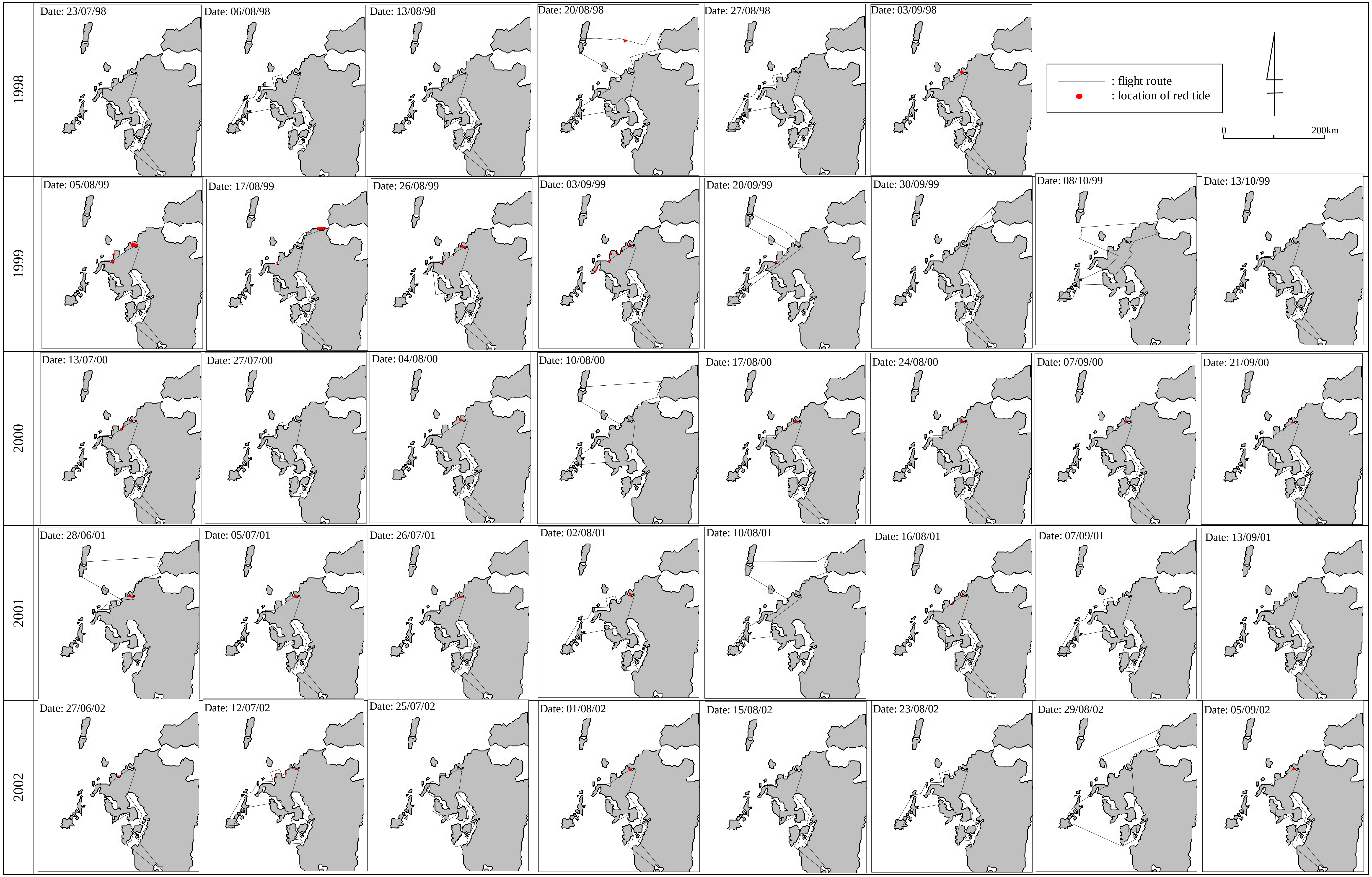


Figure 1.3 Discolored sea areas due to red tides observed by aerial monitoring (Only red tides in the NOWPAP region are indicated)

Source: Kyushu Fisheries Coordination Office, ‘Result of aerial monitoring on red tides’, 1998-2002

1.1.5 Affected Area

The area over which red tides spread is extremely variable, depending on oceanographic, meteorological and biological conditions. Figure 1.4 is a histogram of red-tide events according to area. Red tides that exceed 100 km^2 rarely occur in the NOWPAP region of Kyushu.

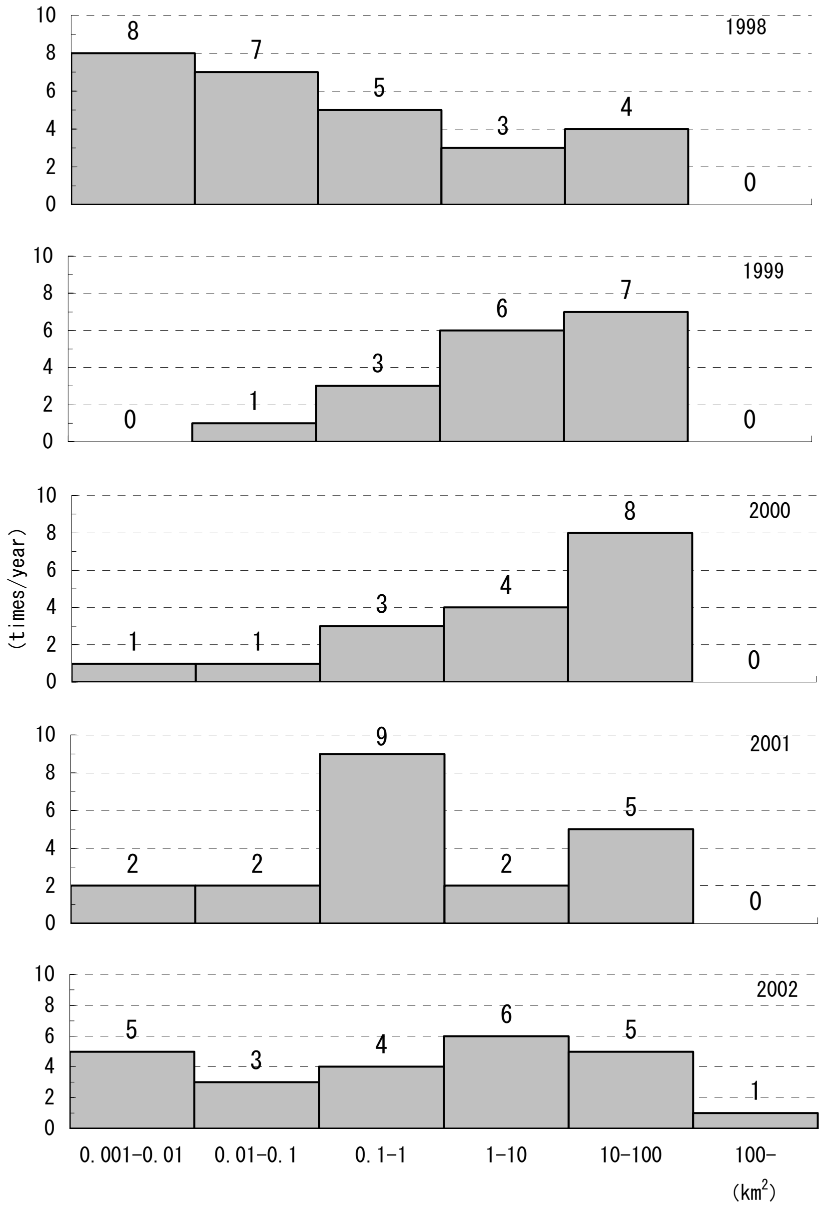


Figure 1.4 Histogram of the red tide areas

Source: Kyushu Fishery Coordination Office, 'Situation of Red Tide in the Seas surrounding Kyushu Island', 1999-2003

1.1.6 Duration

(1) Continuous Days of a Red-tide Event

The annual average number of continuous days of a red tide in the Kyushu area is shown in Table 1.3. Red-tide events tend to last around one week. The number of red-tide events that lasted more than 20 days is shown in Table 1.3.

Table 1.3 Annual average number of continuous days of a red tide and the number of red-tide events that lasted 20 days or more

	1998	1999	2000	2001	2002
Average continuous days	7.8	11.1	10.9	6.2	7.6
Number of red tide events that lasted 20 days or more	0	6	6	2	4

Source: Kyushu Fishery Coordination Office, 'Situation of Red Tide in the Seas surrounding Kyushu Island', 1999-2003

(2) Seasonal Characteristics of Red-tide Occurrence

The monthly change of red tides in the northern Kyushu area is shown in Figure 1.5. Red tides occur throughout the year, occurring with high frequency from April to September. Red tides are most frequent in June and July.

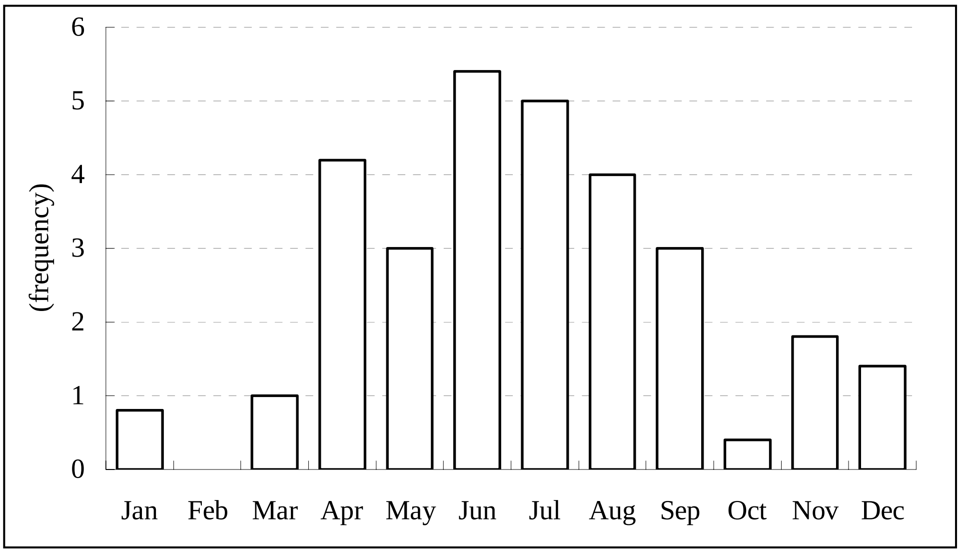


Figure 1.5 Average frequency of red-tide occurrence in the northern Kyushu area during 1998-2002

Source: Kyushu Fishery Coordination Office, 'Situation of Red Tide in the Seas surrounding Kyushu Island', 1999-2003

1.1.7 Mitigation Activity and Effectiveness

(1) Preventive Measures

Since the 1970s, 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. They have implemented effluent control, public education and improvement of sewage systems. These have been effective preventive measures for red tides.

The policy of wastewater control has enforced effluent standards, such as for COD, nitrogen and phosphorous, on facilities specified by central or local governments in order to meet water quality standards of bay areas. As an example, the water quality standards in Toyama Bay are shown in Table 1.4. The effluent control enforcement has successfully reduced nutrients from industries into the marine environment.

Table 1.4 Water Quality Standards of Toyama Bay

Marine Area	Nitrogen (mg/L)	Phosphorous (mg/L)
Area around Oyabe River Mouth	≤ 0.17	≤ 0.016
Area around Jintu River Mouth	≤ 0.23	≤ 0.017
Other Areas	≤ 0.14	≤ 0.010

Governments have promoted public education in order to reduce domestic nutrient effluent. Public education has also contributed to the reduction of organic matter and nutrients from the public sector.

Sewage systems were available to only 16% of the population in 1970. The Japanese Government promoted the installation and modernization of sewage system for bays and inland sea waters to meet the Environmental Quality Standard. As a result of the policy, sewage systems were extended to 65% of the population by the end of the 2002 fiscal year. The modernized sewage system is an essential component for mitigation measures against red tides.

(2) Reactive Measures

Clay-spraying is a practical and reactive measure against red tides. This measure was introduced in the late 1970's to destroy a *Cochlodinium polykrikoides* red tide in an enclosed bay in South Kyushu, and has been applied to fishery and aquaculture grounds to eliminate red tides since then. In 2000, fishermen in a certain prefecture practiced this method to successfully get rid of a *C. polykrikoides* red tide, while the neighboring prefecture lost 4 billion yen without this method. Montmorillonite, a by-product of kaoline refining, is used for this method. Fishermen make muddy water with montmorillonite and spray it directly on the red tide. The particles of montmorillonite adhere to cells of the red tide species and then sink the cells from the sea surface into deep water. This method was transferred to Korea in 1999 to cope with *C. polykrikoides* red tides. However, the impact of this method on the ecosystem has not been determined, and so today is only used in very limited areas.

1.1.8 Damage

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. These species were *Heterosigma akashiwo, Heterocapsa circularisquama, Gymnodinium mikimotoi, Cochlodinium polykrikoides* and *Noctiluca scintillans* (Table 1.5). The most serious damage was caused by *C. polykrikoides* in Imari Bay in August 1999.

Table 1.5 Fishery damage due to red tides in the northern Kyushu coastal area

Month/year	Place	Causative species	Fishery damage		
			Fish/shellfish species	Quantity	Economic loss (1,000 yen)
June 1998	Abu Town, Yamaguchi Pref.	*Heterosigma akashiwo*	Horse mackerel, etc.	Unknown	20-30
Aug. 1998	Hikoshima, Shimonoseki City, Yamaguchi Pref.	*Cochlodinium polykrikoides*	Fishes	Unknown	Unknown
	Tsushima, Nagasaki Pref.	*Cochlodinium polykrikoides*	Amberjacks	340 kg	1122
Mar. 1999	Hohoku Town, Yamaguchi Pref.	*Noctiluca scintillans*	Squids, Octopus, fishes	13 kg	30
Aug. 1999	Imari Bay, Saga Pref.	*Cochlodinium polykrikoides*	Sea bream Yellowtail Puffy fish Others	360,000 inds. 190,000 inds. 150,000 inds. 30,000 inds.	340,000 220,000 180,000 2,000
	Wakinoura, Fukuoka Pref.	*Heterocapsa circularisquama*	Abalone	5,100 inds.	74
May 2000	Ashiya Town, Yamaguchi Pref.	*Heterosigma akashiwo*	Sea bream, Horse mackerel	Unknown	Unknown
June 2000	Hokawazuura, Saga Pref.	*Heterosigma akashiwo*	Amberjacks	400 inds.	400
July 2000	Shimonoseki City and Toyoura Town, Yamaguchi Pref.	*Gymnodinium mikimotoi*	Fishes, Abalone Turban	Unknown 2,800 kg	Unknown
	Offshore, Kitakyushu City, Fukuoka Pref.	*Gymnodinium mikimotoi*	Abalone, Turban	Unknown	Unknown
	Imari Bay, Saga Pref.	*Gymnodinium mikimotoi*	Puffy fish	8,000 inds.	1,600
	Goto Islands, Nagasaki Pref.	*Gymnodinium mikimotoi*	Turban Sea bream	400 kg 120 inds	340 134
Oct. 2001	Hakata Bay, Fukuoka Pref.	*Heterosigma akashiwo*	Puffy fish Amberjacks Yellowtail	226 inds. 6 inds. 3 inds.	230 7 9
July 2002	Kariya Bay, Saga Pref.	*Gymnodinium mikimotoi*	Abalone Turban	56 kg 130 kg	Unknown Unknown
	Kafuri Bay, Fukuoka Pref.	*Gymnodinium mikimotoi*	Abalone	Unknown	Unknown
	Imari Bay, Saga Pref.	*Gymnodinium mikimotoi*	Amberjacks	200 inds.	Unknown
	Imari Bay, Saga Pref.	*Heterocapsa circularisquama*	Pearl shell	5,000 inds.	Unknown
Aug. 2002	Goto Islands, Nagasaki Pref.	*Cochlodinium polykrikoides*	Amberjacks Horse mackerel	9,280 inds. 620 inds.	29,044 1,240
Sep. 2002	Abu Town, Susa Town and Tamagawa Town, Yamaguchi Pref. and Masuda City and Misumi Town, Shimane Pref.	*Cochlodinium polykrikoides*	Yellowtail	2,000 inds.	15,000

Source: Kyushu Fisheries Coordination Office, 'Situation of Red Tide in the Seas surrounding Kyushu Island', 1999-2003

1.2 Toxin-producing Plankton

1.2.1 Type of Toxin-producing Plankton

Most common shellfish poisonings in Japan are Paralytic Shellfish Poisoning (PSP) and Diarrhetic Shellfish Poisoning (DSP). They are caused by bivalves consuming specific toxin-producing plankton, and the symptoms of poisoning appear in humans when these bivalves are consumed. Species known to cause shellfish poisoning include *Alexandrium tamarense* and *A. catenella* for PSP, and *Dinophysis fortii* and *D. acuminate* for DSP. PSP and DSP have been reported in Japan since 1976.

1.2.2 Causative Species

‘Monitoring Report on Shellfish Poisoning in Japanese Fishery Products’ focuses on six species: *Alexandrium tamarense, A.tamiyavanichii, A.catenella* and *Gymnodinium catenatum* for PSP, and *Dinophysis fortii* and *D.acuminata* for DSP.

1.2.3 Cell Density

The cell density of toxic plankton is not being monitored, but the toxicity of shellfish has been recorded. Although cell density is not strictly proportional to toxicity, the toxicity of shellfish seems to be an indicator of plankton cell density.

1.2.4 Location

The Fisheries Agency of Japan has set up guidelines that mandate the toxicity monitoring of aquatic shellfish. The toxicity of harvested shellfish is measured at the production site before shipping. If the toxicity exceeds the permissible level, the shipping of poisoned shellfish is stopped voluntarily. Shipping can be recommenced after clearance to the permissible level for three sequential toxicity analyses over at least 3 weeks.

The occurrence of toxin-producing plankton can be detected through the monitoring of toxicity in harvested shellfish. The production area of poisoned shellfish does not always coincide exactly with the bloom area of the toxin-producing plankton, but shows their approximate distribution area.

Results are summarized separately for PSP and for DSP, as below.

(1) Paralytic Shellfish Poisoning (PSP)

Figure 1.6 shows the Japanese coastal area where poisonous shellfish have been detected through monitoring by prefectural governments. There was no PSP in the NOWPAP region of Japan until 1987, but it became widespread in the northern, southern and western areas of the Sea of Japan after 1988. The poisoned species are the Mediterranean blue mussel, Japanese oyster and noble scallop.

(2) Diarrhetic Shellfish Poisoning (DSP)

DSP was first observed in the northern NOWPAP region of Japan in 1976. Although it appeared in western Japan in the 1980s, the main area of DSP events is the northern NOWPAP region of Japan (Figure 1.7). The scallop is the typical poisoned species.

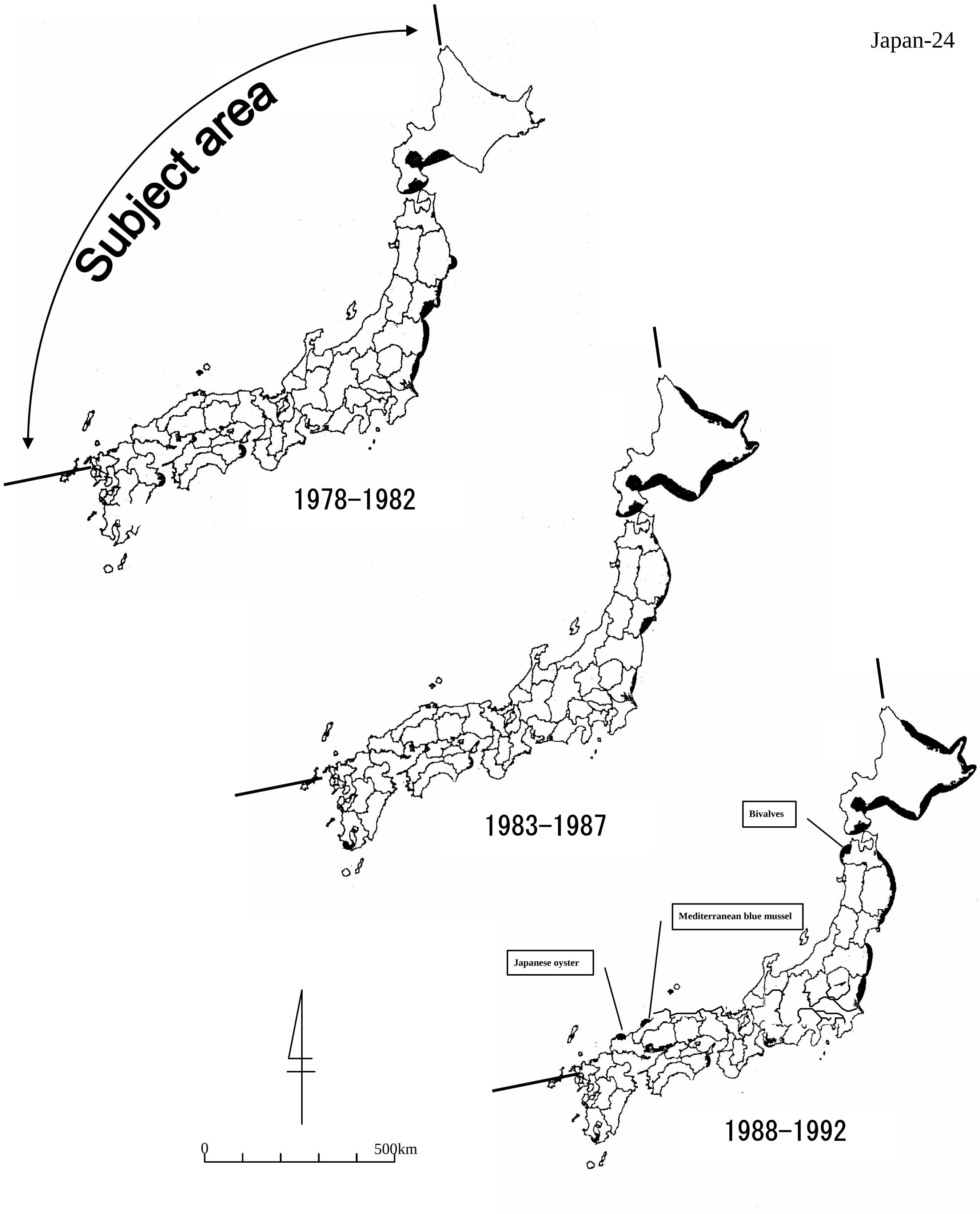


Figure 1.6 (1) Affected areas that experienced voluntary control due to PSP contamination in Japan

Source: Japan Fisheries Resource Conservation Association (JFRCA), 'Monitoring Report on Shellfish Poisoning in Japanese Fishery Products', 1999-2000

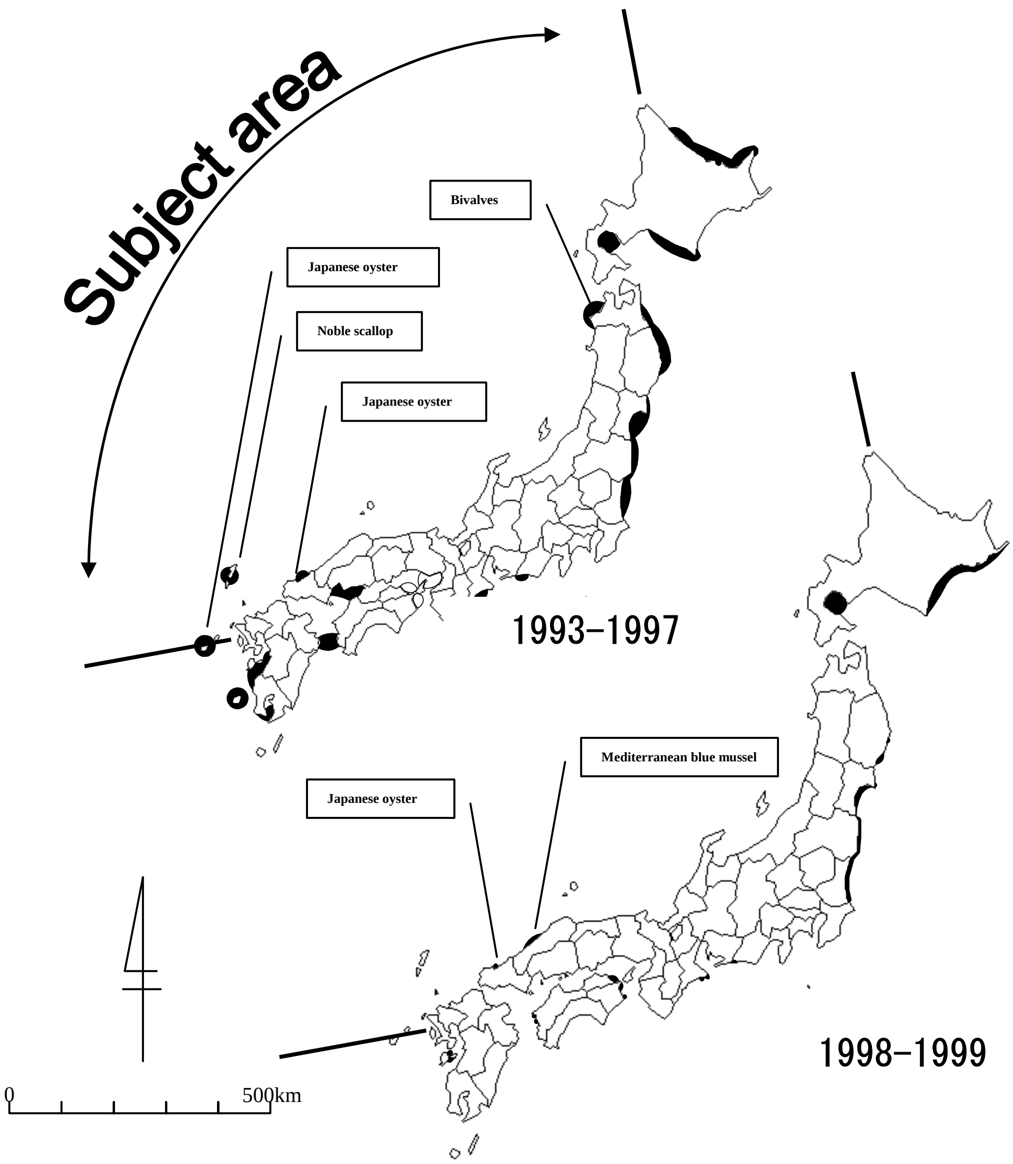


Figure 1.6 (2) Affected areas that experienced voluntary control due to PSP contamination in Japan

Source: Japan Fisheries Resource Conservation Association (JFRCA), ‘Monitoring Report on Shellfish Poisoning in Japanese Fishery Products’, 1999-2000

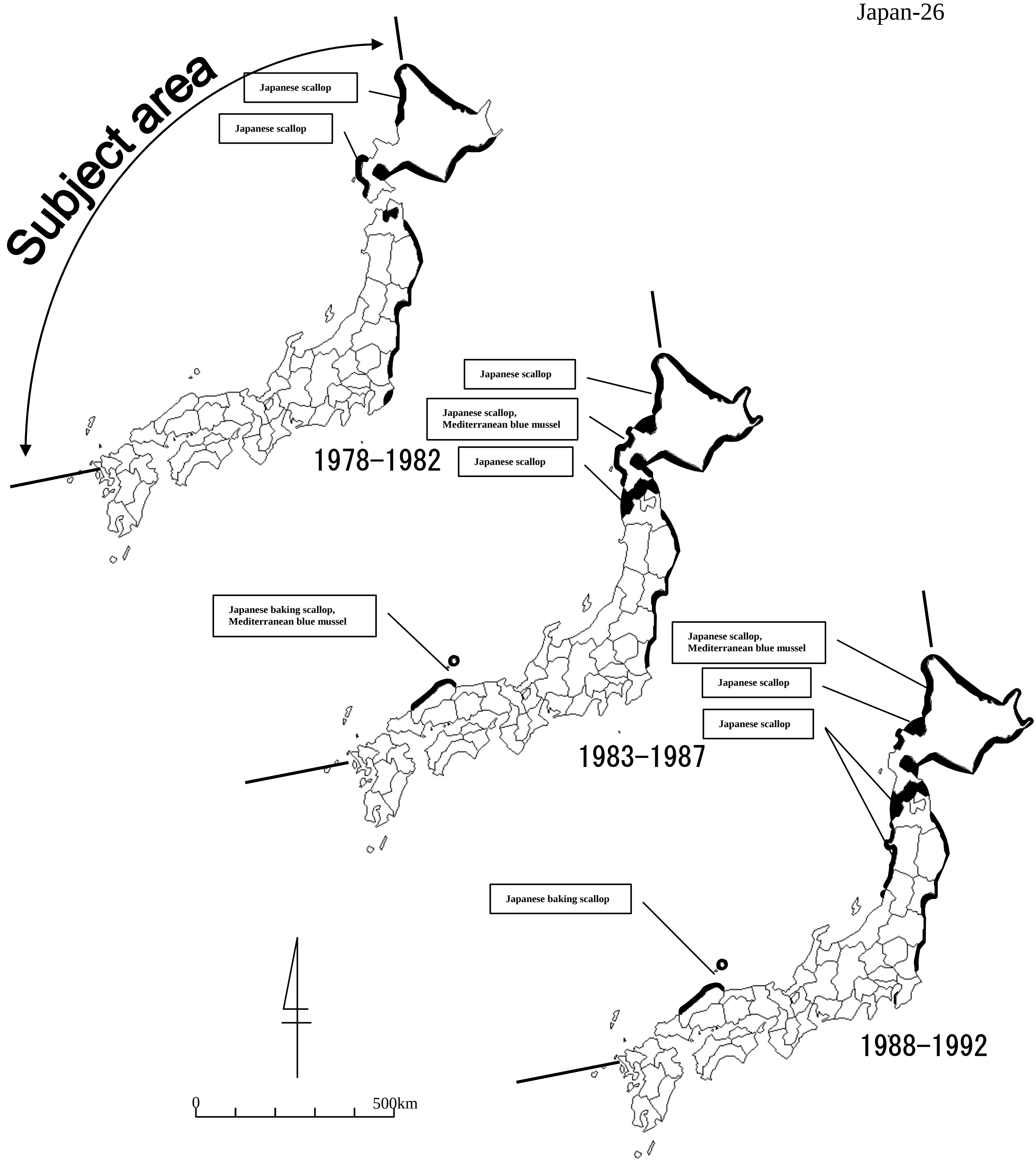


Figure 1.7 (1) Affected areas that experienced voluntary control due to DSP contamination in Japan

Source: Japan Fisheries Resource Conservation Association (JFRCA), 'Monitoring Report on Shellfish Poisoning in Japanese Fishery Products', 1999-2000

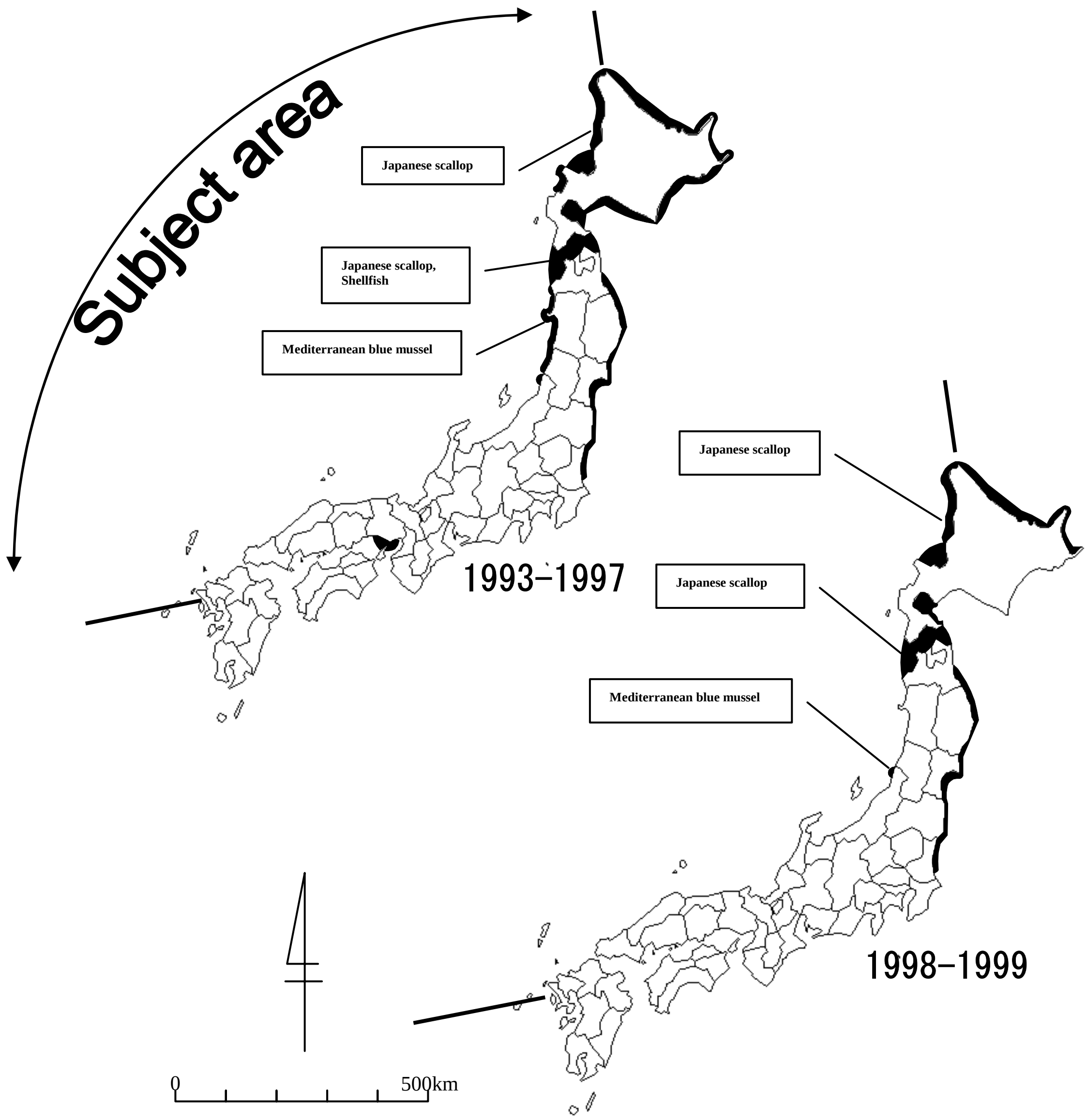


Figure 1.7 (2) Affected areas that experienced voluntary control due to DSP contamination in Japan

Source: Japan Fisheries Resource Conservation Association (JFRCA), 'Monitoring Report on Shellfish Poisoning in Japanese Fishery Products', 1999-2000

1.2.5 Affected Area

Since monitoring is conducted not on plankton density, but on the meat of the shellfish at the production site, the extent of the blooms is unknown.

1.2.6 Duration

(1) Continuous Days of Toxin-producing Plankton Blooms

Although the toxicity of shellfish does not correspond to the cell density of toxin-producing plankton in ambient water, the number of sequential days in which toxin-producing plankton blooms occur seems to be a practical indicator for the duration of a bloom. The duration of toxin-producing plankton blooms may be suggested by the duration of voluntary abstinence of shellfish shipping, although the duration of blooms would be a little shorter.

The shaded period in Table 1.6 represents the duration of voluntary control of harvested shellfish due to PSP events. A total of 20 cases of PSP led to voluntary control during 1978-1999. Most cases had voluntary control of 2-4 months.

Table 1.6 Duration of voluntary control of harvested shellfish shipping due to PSP (Shaded period)

				Month												
Prefecture	Year	Shellfish	Location	Causative species	1	2	3	4	5	6	7	8	9	10	11	12
Hokkaido	1981	Japanese scallop	Tsugaru Strait	*A. tamarense*												
	1983	Japanese scallop	Tsugaru Strait													
	1984	Japanese scallop	Tsugaru Strait													
	1986	Japanese scallop	Tsugaru Strait													
	1989	Japanese scallop	Tsugaru Strait													
Kyoto	1992-1993	Japanese oyster	Kumihama Bay	*Gymnodinium catenatum*												
Shimane	1992	Mediterranean blue mussel	Hamada open sea	*Alexandrium catenella*												
	1998	Mediterranean blue mussel	Hamada	Unknown												
Yamaguchi	1988-1989	Japanese oyster	Senzaki Bay	*G. catenatum*												
	1991-1992	Japanese oyster	Senzaki Bay	*G. catenatum*												
	1995-1996	Japanese oyster	Senzaki Bay	*G. catenatum*												
	1996-1997	Japanese oyster	Senzaki Bay	*G. catenatum*												
	1998	Japanese oyster	Senzaki Bay	*G. catenatum*												
	1998-1999	Japanese oyster	Senzaki Bay	Unknown												
Nagasaki	1994	Noble scallop	Tsushima Is.	Unknown												
	1996	Noble scallop	Tsushima Is.	*A. catenella*												
	1996-1997	Noble scallop	Tsushima Is.	Unknown												
Kumamoto	1998	Japanese oyster	Kawaura	*G. catenatum*												
	1998	Japanese oyster	Kawaura	*G. catenatum*												
	1999	Japanese oyster	Kawaura	*A. catenella, G. catenatum*												

Source: Japan Fisheries Resource Conservation Association (JFRCA), 'Monitoring Report on Shell Poisoning in Japanese Fishery Products', 1999-2000

Similarly, DSP events were tabulated in

Table 1.7. A total of 64 cases of DSP induced voluntary control of shellfish shipping during 1978-1999. The duration of the shipping inhibition caused by DSP was longer than caused by PSP due to PSP, and 26 of 64 cases stopped the shipping of shellfish for 5 months or longer.

Table 1.7 Duration of voluntary control of harvested shellfish shipping caused by DSP

Prefecture	Year	Shellfish	Location	Causative species / Month	1	2	3	4	5	6	7	8	9	10	11	12
Hokkaido	1986	Japanese scallop	Ishikari Bay	*Dinophysis fortii*						■	■	■	■	■		
	1987	Japanese scallop	Ishikari Bay						■	■	■	■	■			
	1988	Japanese scallop	Ishikari Bay					■	■	■	■	■	■			
	1989	Japanese scallop	Ishikari Bay							■	■	■	■			
	1990	Japanese scallop	Ishikari Bay						■	■	■	■	■	■	■	
	1991	Japanese scallop	Ishikari Bay						■	■	■	■	■	■		
	1993	Japanese scallop	Ishikari Bay							■	■	■	■	■	■	
	1994	Japanese scallop	Ishikari Bay							■	■	■	■	■	■	
	1997	Japanese scallop	Ishikari Bay						■	■	■					
	1999	Japanese scallop	Ishikari Bay						■	■						
	1983	Japanese scallop	Tsugaru Strait						■	■	■	■	■	■	■	
	1984	Japanese scallop	Tsugaru Strait							■	■	■	■	■	■	■
	1985	Japanese scallop	Tsugaru Strait						■	■	■	■	■	■		
	1989	Japanese scallop	Tsugaru Strait						■	■	■	■	■			
	1997	Japanese scallop	Tsugaru Strait					■								
	1999	Japanese scallop	Tsugaru Strait								■	■				
	1987	Japanese scallop	central western coast							■	■	■				
	1988	Japanese scallop	central western coast					■	■	■	■	■	■			
	1995	Japanese scallop	central western coast					■	■	■						
	1981	Japanese scallop	north western coast								■	■				
	1982	Japanese scallop	north western coast							■	■	■	■			
	1983	Japanese scallop	north western coast						■	■	■	■	■	■	■	
	1985	Japanese scallop	north western coast								■	■	■	■		
	1986	Japanese scallop	north western coast							■	■	■	■	■		
	1987	Japanese scallop	north western coast						■	■	■	■	■	■		
	1988	Japanese scallop	north western coast					■	■	■	■	■	■	■		
	1989	Mediterranean blue mussel	north western coast								■	■	■	■		
	1989	Japanese scallop	north western coast					■	■	■	■	■	■			
	1990	Japanese scallop	north western coast					■	■	■	■	■	■			
	1991	Japanese scallop	north western coast									■	■	■		
	1992	Japanese scallop	north western coast						■	■	■	■	■			
	1994	Japanese scallop	north western coast					■	■	■	■	■	■	■		
	1999	Japanese scallop	north western coast							■	■					
	1982	Japanese scallop	south western coast							■	■	■				
	1983	Japanese scallop	south western coast						■	■	■	■	■			
	1984	Japanese scallop	south western coast							■	■	■	■			
	1986	Mediterranean blue mussel	south western coast						■	■	■	■	■	■		
Aomori	1992	Bivalves	boreal water area	*D. fortii*							■	■	■			
	1993	Bivalves	boreal water area							■	■	■				
	1986	Japanese scallop	Tsugaru Strait				■	■	■	■	■	■				
	1988	Japanese scallop	Tsugaru Strait							■	■					
	1990	Japanese scallop	Tsugaru Strait						■	■						
	1991	Japanese scallop	Tsugaru Strait								■	■				
	1993	Japanese scallop	Tsugaru Strait					■	■	■	■					
	1994	Japanese scallop	Tsugaru Strait							■	■	■				
	1983	Japanese scallop	Japan Sea (liberation)					■	■	■	■	■	■	■		
	1984	Japanese scallop	Japan Sea (liberation)		■	■			■	■	■	■	■	■	■	■
Akita	1990	Mediterranean blue mussel	whole Akita pref.	*D. fortii*						■	■					
	1991	Mediterranean blue mussel	whole Akita pref.							■	■	■				
	1992	Mediterranean blue mussel	whole Akita pref.							■	■	■				
	1993	Mediterranean blue mussel	whole Akita pref.							■	■					
Yamagata	1990	Mediterranean blue mussel	whole Yamagata pref.	*D. fortii*						■	■					
	1991	Mediterranean blue mussel	whole Yamagata pref.						■	■	■	■				
	1993	Mediterranean blue mussel	whole Yamagata pref.							■	■					
	1994	Mediterranean blue mussel	Tsuruoka City						■	■	■					
Niigata	1990	Mediterranean blue mussel	Yamakita	*D. fortii*					■	■	■	■				
	1991	Mediterranean blue mussel	Yamakita						■	■	■					
	1993	Mediterranean blue mussel	Yamakita							■	■					
	1994	Mediterranean blue mussel	Yamakita						■	■	■	■				
	1995	Mediterranean blue mussel	Yamakita							■	■	■	■			
	1998	Mediterranean blue mussel	Yamakita							■	■	■				
Shimane	1987	Japanese baking scallop	Mainland and Iki	*D. fortii*			■	■	■	■	■					
	1987	Mediterranean blue mussel	Mainland and Iki							■						
	1990	Japanese baking scallop	Mainland and Iki					■								

Source: Japan Fisheries Resource Conservation Association (JFRCA), 'Monitoring Report on Shellfish Poisoning in Japanese Fishery Products', 1999-2000

(2) Seasonal Characteristics of Toxin-producing Plankton Blooms

Voluntary controls are indicators of the seasonal characteristics of toxin-producing plankton blooms. PSP-causing plankton appear to have a different blooming season at different localities, whereas DSP-causing plankton appear to be abundant from early summer to autumn.

1.2.7 Mitigation Activity and Effectiveness

Monitoring shellfish toxicity is mandatory for central and local governments, and is the only substantial mitigation measure applied to shellfish production. The amount of toxins contained in shellfish should be monitored at least twice a week during the period when toxic accumulation is highly probable. If the monitoring results are higher than the quarantine limit （PSP：4 MU/g, DSP：0.05 MU/g）, then the shipping of harvested shellfish from that area should be voluntarily prohibited.

1.2.8 Damage

There was a wide-spread incident of shellfish poisoning in the area around the Tohoku region in the late 1970s. Common symptoms for PSP in humans are numbness around the lips and tongue 30 minutes after consumption, and in severe cases difficulty in moving the body. In the worst cases, death due to suffocation occurs within 12 hours. For DSP, the symptoms occur 3-4 hours after consumption, with complete recovery after 3 days. There have not been any fatal cases of DSP reported.

Around 900 people have suffered from PSP and DSP in Japan since 1976. Several people have died because from PSP. The oldest records of PSP and DSP poisoning were reported in 1948 and 1951, respectively. The careful monitoring of shellfish poisoning and the voluntary control of poisoned shellfish, mentioned in section 1.2.4 (p.22), has resulted in no fatalities since 1980.

2. Information on the Monitoring

Some HABs are identified by red-tide monitoring. HABs are also acknowledged as shell-fish poisonings, which are caused by toxin-producing plankton. Therefore, Monitoring 'Red Tides (Section 1.1)' and 'Toxin-producing Plankton (Section 1.2)' are explained separately in this chapter, as in Chapter 1.

2.1 Red Tides

The Fisheries Agency and Coast Guard are in charge of red tide monitoring in Japan. The Fisheries Agency focuses on coastal sea areas with fishery and aquaculture activities, while the Coast Guard mainly covers offshore areas. Of these agencies, the Fisheries Agency is most responsible for red-tide monitoring to secure the fishery and aquaculture industries.

The Fisheries Agency sometimes commissions the fisheries laboratories within prefectural governments as research organizations to monitor red tides.

Thus, fishery laboratories play a substantial role in implementing red-tide monitoring in Japan.

2.1.1 Regular Monitoring

The monitoring of red tides in Japan has mainly been conducted by the fishery laboratories of prefectural governments. Some fishery laboratories carry out regular monitoring whereas others do not. The scheme of regular monitoring is summarized in Table 2.1 and Figure 2.1. The monitoring area of each fishery laboratory is small and limited to enclosed bays. The monitoring frequency differs among laboratories.

Kyushu Fisheries Coordination Office conducts aerial monitoring surveys using an aircraft. It has four flight routes that cover the entire Kyushu coastal area. Three of them are set in part of the NOWPAP region, as shown in Figure 2.2. There are a total of 6-8 flights 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.

Red-tide monitoring using satellite remote sensing technology has yet to be employed on a practical basis.

2.1.2 Trace Monitoring

When a red tide appears and local people, usually fishermen, notify a fishery laboratory, researchers of the laboratory begin observation and research of the red-tide event. The researchers complete plankton sampling, usually several hours after notification. However, they continuously observe the red-tide event through trace monitoring (tracking) when required.

While the information obtained through such activity is accumulated by the fishery laboratories, it is not always published regularly. Examples of the accomplishment of trace monitoring are shown in Table 2.2.

Table 2.1 Scheme of regular monitoring conducted by selected fishery laboratories of local governments

Monitoring Agency	Monitoring Target	Methodology: Monitoring Method	Methodology: Area or Location	Methodology: Frequency	Methodology: Remarks	Parameters monitored: Causative species	Parameters monitored: Chlorophyll-a	Parameters monitored: Temperature and Salinity	Parameters monitored: Nutrients	Parameters monitored: Other	Monitoring Results	Source
Hokkaido Central Fisheries Experimental Station	Toxic plankton	Fixed points, 4 rayers	Coastal area (see Fig.2.1)	Monthly during April to October		*Dinophysis fortii* *D. acuminata* *Alexandrium tamarense* etc.		○		Toxin-producing plankton	published	Bulletin of Hokkaido Central Fisheries Experimental Station, 2002
Aomori Prefectural Fisheries Research Center Aquaculture Institute	Toxic plankton	Fixed points, multi rayer	Mutsu Bay Tsugaru Strait (see Fig.2.1)	Monthly		*Dinophysis fortii* *D. acuminata* *D. mitra* etc.		○		Shellfish poison	published	Annual Report of Aomori Prefectural Fisheries Research Center Aquaculture Institute, No.33, 2002
Akita Prefectural Fisheries Research and Development Center	Red tides and toxic plankton	Fixed points, 4 rayers	Coastal area (see Fig.2.1)	Weekly from April to August		*Dinophysis fortii* *D. acuminata* *D. mitra*	○	○	○	Phytoplankton etc.	published	Annual Report of Akita Prefectural Fisheries Research and Development Center, 2001
Niigata Prefectural Fisheries and Marine Research Institute	Toxic plankton	Fixed points, 3 layers	Coast of Kuwagawa Sanpoku cho	3 times a month from May to September		*Dinophysis fortii* *D. mitra* etc.		○		Phytoplankton, Shellfish poison	published	Annual Report of Niigata Prefectural Fisheries and Marine Research Institute, 2001
	Toxicity	Fixed points, 3 layers	Coast in Kuwagawa Sanpoku cho (see Fig.2.1)	3 times a month from May to September		*Dinophysis fortii* *D. acuminata* etc.		○		Phytoplankton, Shellfish poison	published	Report on red tide mitigation program, 1991
Toyama Prefectural Fisheries Research Institute	Red tides	Unknown	Toyama Bay	Unknown	05/06/01-10/06/01 18/07/01-26/07/01	*Chaetoceros* spp. *Skeletonema costatum*		○		Phytoplankton	published	Toyama Prefectural Fisheries Research Institute, No.14, 2002
Ishikawa Prefectural Fisheries Research Center	Oyster farms	Fixed points	Nanao Bay (see Fig.2.1)	Monthly from July to December		*Cochlodinium polykrikoides* *Gymnodinium mikimotoi* *Chattonella antjqua* *C. marina* etc.		○		Toxin-producing plankton, Shellfish poison	published	Bulletin of Ishikawa Prefectural Fisheries Research Center, Vol. 3, 2001
Shimane Prefectural Institute of Fisheries	Toxic plankton	Fixed points	Izumo, Iwami, Oki	Monthly		No toxic plankton found		○		Toxin-producing plankton, Shellfish poison	published	Annual Report of Shimane Prefectural Institute of Fisheries, 2002
Fukuoka Fisheries and Marine Technology Research Center	Toxic plankton and red tides	Fixed points, 3 layers	Fukuoka Bay (see Fig.2.1) Karatsu Bay	12 times from April to March		*Gymnodinium sanguineum* *Heterosigma akashiwo* *Heterocapsa circularisquama* *Prorocentrum dentatum* etc.	○	○	○	Phytoplankton composition, Occurrence, Economic loss, Shellfish poison	published	Bulletin of Fukuoka Fisheries Marine Technology Reserch Center, No.12, 2002
Saga Prefectural Genkai Fisheries research and Development Center	Red tides	Fixed points, 5 layers	Kariya Bay (see Fig.2.1)	More than once from May to October		*Gymnodinium mikimotoi*, *Heterocapsa circularisquama*	○	○	○	Toxin-producing plankton	published	
	Toxic plankton	Fixed points, 4 layers	Kariya Bay, Imari Bay, Karatsu Bay, etc. (see Fig.2.1)	6 times from October to March		*Alexandrium catenella* *Lingulodinium poiyedrum* *Dinophysis acuminata* *Gymnodinium catenatum* etc.	○	○	○	Toxin-producing plankton	published	Annual Report of Saga Prefectural Genkai Fisheries Research and Development Center, 2002
	Heterocapsa red tides	Fixed points, 4 layers	Imari Bay (see Fig.2.1)	14 times from May to March		*Heterocapsa circularisquama* *Gymnodinium mikimotoi* *Chattonella marina*	○	○	○		published	
Nagasaki Prefectural Fisheries Research Institute	Toxic plankton and red tides	Fixed points	Imari Bay, Oomura Bay	Unknown	Carried out since 1978	*Cochlodinium polykrikoides* *Gymnodinium mikimotoi* etc.	○	○	○	Toxin-producing plankton, Shellfish poison	published	Bulletin of Nagasaki Prefectural Institute of Fisheries, No. 25, 1999
	Program for the Prediction of *Chattonella* Red Tide occurrences	Fixed points, multi-layer	Tachibana Bay, etc. (see Fig.2.1)	3 times from July to August		*Cochlodinium polykrikoides* *Gymnodinium sanguineum* *Chattonella antiqua* *C. marina* etc.	○	○	○		published	

Source: Annual reports of fishery laboratories of prefectural governments

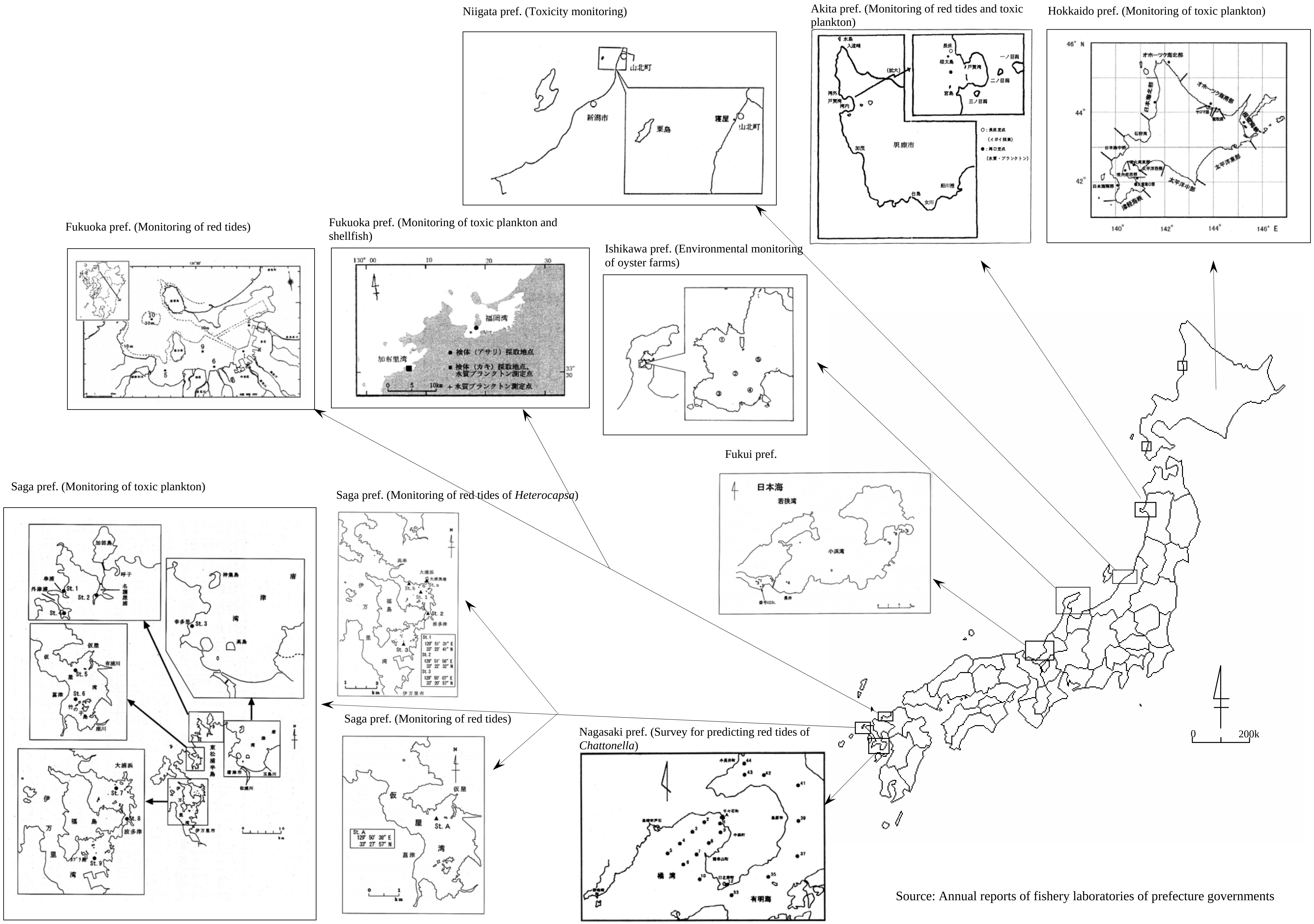


Figure 2.1 Sampling sites of regular monitoring by fishery laboratories of prefectural governments

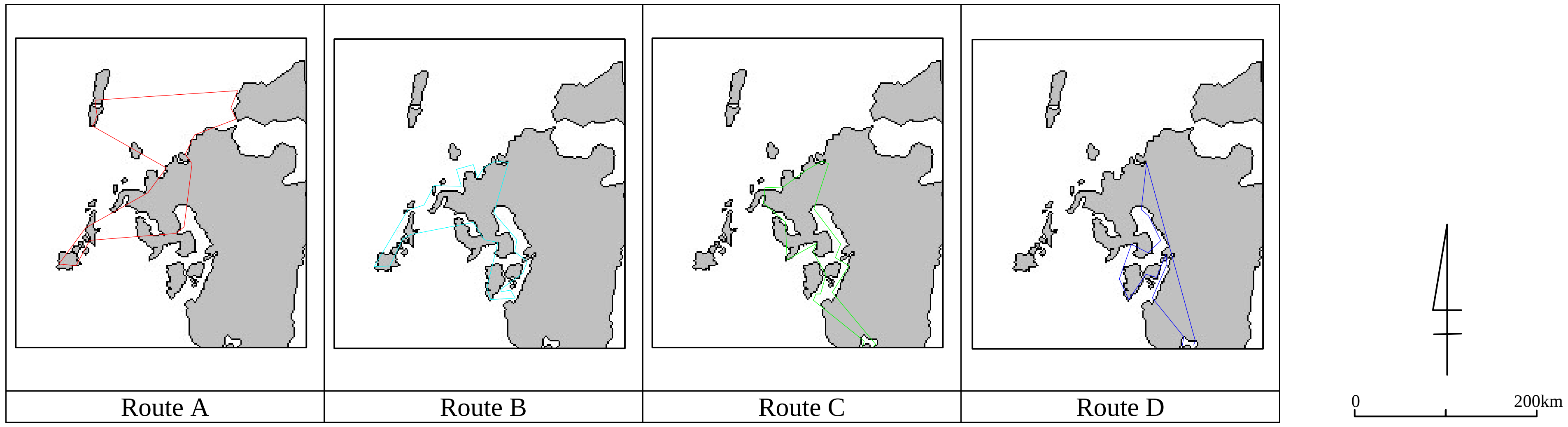


Figure 2.2 Flight routes for aerial monitoring of HABs

Table 2.2 Accomplishment of trace monitoring

Monitoring Agency	Monitoring Target	Date	Area or Location	Causative species	Damage	Initiation	Source
Akita Prefectural Fisheries Research and Development Center	Red tides	No red tide reports in 2000				Reporting by people to the Center	Annual Report of Akita Prefectural Fisheries Research and Development Center, 2001
Fukui Prefectural Institute of Fisheries	—	08/09/97-22/09/97 17/08/98-25/08/98 06/08/99-06/10/99	Obama Bay	*Heterocapsa circularisquama*	Mass mortality of Pearl oysters	Unknown	Annual Report of Fukui Prefectural Institute of Fisheries, 1997, 1998, 1999
Fisheries Division, Yamaguchi Prefectural Government	—	13 times from March to December, 2000	Shimonoseki City to Abu Yuya Hagi City Misumi to Abe Susa	*Cochlodinium polykrikoides* *Heterosigma akashiwo* *Gymnodinium sanguineum* etc.		Reporting by people to the Division	Annual Report of Yamaguchi Pref. Fish. Res. Center, 2002
Genkai Fisheries Research and Development Center, Saga Prefecture	Red tides	14 times 28/5/00- 03/10/00		*Gymnodinium mikimotoi* *Heterocapsa circularisquama* etc.	Record fishery damage documented	Reporting by people to the Center	Annual Report of Genkai Fisheries Research and Development Center, 2002
	Heterocapsa red tides	26/07/02-29/07/02 18/10/02 20/03/03	Imari Bay	*Heterocapsa circularisquama*		Investigation conducted when *Heterocapsa* red tide occurs	
Nagasaki Prefectural Fisheries Research Institute	Phytoplankton that cause red tides						Report on red tide plankton monitoring program Ⅰ–Ⅲ, Nagasaki Prefecture

Source: Annual reports of fishery laboratories of prefectural governments

2.2 Toxin-producing Plankton

The fishery laboratories of prefectural governments conduct regular monitoring of toxic plankton. Those laboratories mainly observe *A. tamarense* and *A. catenella* for PSP, and *D. fortii* and *D. acuminata* for DSP.

In addition to regular monitoring by fishery laboratories, the guidelines of the Fishery Agency indicate that monitoring of shellfish poisoning is to be conducted regularly during the harvest season of shellfish in order to prevent shellfish poisoning and sustain a safe supply of major shellfish products. In 1979, the Director of the Fisheries Agency instructed the prefectural governors to reinforce the guidelines on the monitoring and inspection of shellfish for toxins. Since then, the shellfish toxins monitoring system has been implemented following these guidelines. According to the guidelines, monitoring or inspection stations should be established near the harvesting areas. Monitoring is conducted at least monthly during the harvest season. The frequency of monitoring should be increased to at least weekly if a high risk of poisoning is suspected. Sampling locations and frequency are increased when the toxicity exceeds the criteria shown in Table 2.3. The harvesting and shipping of shellfish is voluntarily stopped if toxicity exceeds the criteria. This is voluntary control, but almost 100% of fishermen follow this guideline.

Table 2.3 Criteria set up by the guidelines for shellfish poisoning

	PSP	DSP
Increase in sampling locations and frequency	-above 20 MU/g of the midgut gland.	-above 0.5 MU/g of the midgut gland of scallop -above 0.3 MU/g of the midgut gland of *M. edulis* and *Chamys farreri akazara*
Stop harvesting and shipping	-above 4 MU/g of whole meat	-above 0.05 MU/g of whole meat

In the case of scallops, its products can be marketed after their midguts are removed at authorized factories. Harvesting and shipping can recommence when the toxicity level remains below the standards for 2 weeks.

The information network for shellfish poisoning was constructed, as shown in Figure 2.3. Laboratories regularly report the results of poisoning tests to the marine product departments of prefectural governments. When the toxicity exceeds the criteria, the marine products department informs the Fisheries Agency, mass media, fish markets and related prefectures to stop harvesting and shipping. The Fisheries Agency forwards information on poisoning to the Ministry of Health and Welfare and the Food Distribution Bureau to supervise fish markets. The Association of Fishery Cooperative, along with the prefectural marine product department, guides fishermen in the cessation of harvesting and shipping of the polluted shellfish.

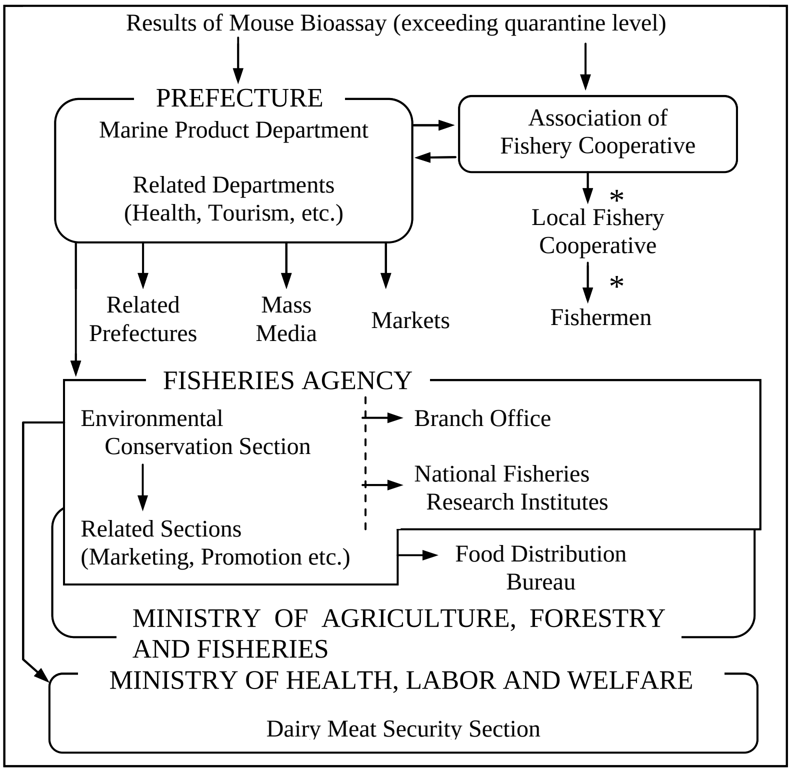


Figure 2.3 Flow diagram of information on shellfish toxins in Japan
(* indicates the implementation of voluntary control)

Source: Yamamoto, M. and Yamasaki, M. (1996) Japanese Monitoring System on Shellfish Toxins

3. Progress of Research and Studies to Manage HABs

According to the Fisheries White Paper and the results of interviews with researchers of the National Fisheries Research Institute, the Fisheries Agency of Japan has identified some issues, as cited below, to be studied in the future. Other governmental organizations and universities are conducting a wide range of studies concerning HAB problems.

3.1 Mechanism of HAB Occurrence

The National Institute of Fisheries Science is studying the mechanism of red tides, targeting *Alexandrium tamarense*, *A. catenella* and *Gymnodinium catenatum*. It is essential to understand the life cycle of the target plankton species, including cyst formation, in order to predict their occurrence.

Some small flagellate species are being studied to clarify their relationship with DSP. These studies will identify the role of small flagellates in bringing about DSP events.

- Reference List -

・ Yamaguchi, M., Itakura, S. and Imai, I. (1995) Vertical and horizontal distribution and abundance of resting cysts of the toxic dinoflagellate *Alexandrium tamarense* and *Alexandrium catenella* in sediments of Hiroshima Bay, the Seto Inland Sea, Japan. Nippon Suisan Gakkaishi, 61(5), 700-706.

・ Yamaguchi, M., Itakura, S., Nagasaki, K. and Imai, I. (1996) Distribution and abundance of resting cysts of the toxic dinoflagellates *Alexandrium tamarense* and *A. catenella* in sediments of the eastern Seto Inland Sea, Japan. in "Harmful and Toxic Algal Blooms (eds by T. Yasumoto, Y. Oshima and Y. Fukuyo)", IOC OF UNESCO, 177-180.

・ Kotani, Y., Koyama, A., Yamaguchi, M. and Imai, I. (1998) Distribution of resting cysts of the toxic dinoflagellates *Alexandrium catenella* and/or *A. tamarense* in the coastal areas of western Shikoku and Kyushu, Japan. Bull. Jpn. Soc. Fish. Oceanogr., 62 (2), 104-111.

・ Itakura, S. and Yamaguchi, M. (2001) Germination characteristics of naturally occurring cysts of *Alexandrium tamarense* (Dinophyceae) in Hiroshima Bay, Inland Sea of Japan. PYCOA., 40, 263-267.

・ Nagai, S. and Imai, I. (2000) Relationships between *Coscinodiscus wailesii* and bacteria promoting its sperm formation in the coastal area, Japan. in "16th International Diatom Symposium, 25 Aug.-1 Sept. 2000, Athens and Aegean Islands Proceedings 2001 (eds by A. Economou-Amilli)", University of Athens, Greece, 601pp., 213-223.

- Yamaguchi, M., Itakura, S., Nagasaki, K. and Kotani, Y. (2002) Distribution and abundance of resting cysts of the toxic *Alexandrium* spp. in sediments of the western Seto Inland Sea, Japan. Fish. Sci., 68, 1012-1019.
- Itakura, S., Yamaguchi, M., Yoshida, M. and Fukuyo. Y. (2002) The seasonal occurrence of *Alexandrium tamarense* (Dinophyceae) vegetative cells in Hiroshima Bay, Japan. Fish. Sci., 68, 77-86.

3.2 Toxicity Analysis

The combination of High Performance Liquid Chromatography (HPLC) and Mass Chromatography enables the highly sensitive and accurate analysis of toxic substances. This technique has found PSP- and DSP-inducing toxic substances of low concentration.

The enzyme-linked-immunosorbent assay (ELISA) method was established and has been disseminated as an easy and rapid analytical practice for DSPs. Since this method has not been authorized as an official analysis method, this should be considered as a potential alternative.

- Reference List -

- Suzuki, T. (1994) High-performance liquid chromatographic resolution of dinophysistoxin-1 and free fatty acids as 9-anthrylmethylesters. J. of Chromatography A, 677. 301-306.
- Suzuki, T. and Matsuyama, Y. (1995) Determination of free fatty acids in marine phytoplankton causing red tides by fluorometric High –performance liquid chromatography. Jaocs., 72 (10), 1211-1214.
- Suzuki, T., Beuzenberg, V., Mackezie, L. and Quilliam, M. A. (2003) Liquid chromatography-mass spectrometry of spiroketal stereoisomers of pectenotoxins and the analysis of novel pectenotoxin isomers in the toxic dinoflagellate *Dinophysis acuta* from New Zealand. J. Chromatogr. A, 992, 141-150.

3.3 Taxonomic Analysis of Causative Species

A molecular biological approach is being developed to distinguish populations of toxic plankton. *Alexandrium tamarense*, which is known to be distributed on the Pacific Ocean side of Japan, occurred recently in the NOWPAP region. Molecular biology may clarify whether the occurrence is due to anthropogenic transportation or natural process.

- Reference List -

- Kim, C. H., Sako, Y. and Ishida, Y. (1993) Comparison of toxin composition between populations of *Alexandrium spp.* from geographically distant areas. Nippon Suisan Gakkaishi, 59 (4), 641-646.
- Oshima, Y., Hayakawa, T., Hashimoto, M., Yasumoto, T., and Kotaki, K. (1982) Classification of *Protogonyaulax tamarensis* from northern Japan into three strains by toxin composition. Bull. Jpn. Soc. Sci. Fish., 48 (6), 851-854.
- Oshima, Y., Blackburn, S. I. and Hallegraeff, G. M. (1993) Comparative study on paralytic shellfish toxin profiles of the dinoflagellate *Gymnodinium catenatum* from three different countries. Mar. Biol., 116 (3), 471-476.
- Kim, D., Sato, Y., Miyazaki, Y., Oda, T, Muramatsu, T., Matsuyama, Y. and Honjo, T. (2002) Comparison of hemolytic activities among strains of *Heterocapsa circularisquama* isolated in various localities in Japan. Biosci. Biotechnol. Biochem., 66 (2), 453-457.
- Nagai, S., Lian, C., Hamaguchi, M., Matsuyama, Y., Itakura, S. and Hogetsu, T. (2004) Development of microsatellite markers in the toxic dinoflagellate *Alexandrim tamarense* (Dinophyceae). Molecular Ecology Notes, 83-85.

3.4 Development of Mitigation Measures

Nagasaki and Tarutani (2001) found that a dinoflagellate species, *Heterocapsa circularisquama*, had two types of enemy viruses. These algicidal viruses propagate themselves in the cytoplasm of *H. 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 effects on the marine ecosystem caused by those biological pesticides.

- Reference List -

- Nagasaki, K., Tarutani, K. and Yamaguchi, M. (1999) Growth characteristics of *Heterosigma akashiwo* virus and its possible use as a microbiological agent for red tide control. App. Environ. Microbiol., 65 (3), 898-902.
- Tarutani, K., Nagasaki, K. and Yamaguchi, M. (2000) Viral impacts on total abundance and clonal composition of the harmful bloom-forming phytoplankton *Heterosigma akashiwo*, App. Environ. Microbiol., 66 (11), 4916-4920.
- Tarutani, K., Nagasaki, K., Itakura, S. and Yamaguchi, M. (2001) Isolation of a virus infecting the novel shellfish-killing dinoflagellate *Heterocapsa circularisquama*, Aquat. Microb. Ecol., vol. 23, 103-111.

- Nagasaki, K., Tamaru, Y., Nakanishi, K., Hata, N., Katanozaka, N. and Yamaguchi, M. (2004) Dynamics of *Heterocapsa circularisquama* (Dinophyceae) and its viruses in Ago Bay, Japan. Aquat. Microb. Ecol., 34, 219-226.
- Tamaru, Y., Tarutani, K., M. Yamaguchi, M. and Nagasaki, K. (2004) Quantitative and qualitative impacts of viral infection on a *Heterosigma akashiwo* (Raphidophyceae) bloom in Hiroshima Bay, Japan. Aquat. Microb. Ecol., 34, 227-238.

3.5 Others

A red-tide prediction method was developed using a neural network technique in an enclosed bay in Japan. This method includes a reenactment model and a prediction model which need data on nutrients and meteorological conditions for about 10 years. The two models have reliabilities of about 80% and 60% respectively.

- Reference List -

- Japan Fisheries Information Service Center, (2002) Studies on prediction method of marine coastal ecosystem utilizing satellite information and neural network. (Sponsored by The Nippon Foundation)

4. Literature Including New Information

The following sections summarize the major papers published after 2000, which are stored in the HAB Reference Database. All papers published after 2000 and stored in the HAB Reference Database are listed in the appendices. Section indexes conform to the categories in the HAB Reference Database.

4.1 Occurrence and Monitoring

Fukuyo et al. (2002) report on past occurrences of red tide and harmful algae blooms in Japan. Their major arguments are on the change in number of red tides between 1970 and 1998, the number of events that damaged a fishery, the economic losses, the history of prohibition of shellfish shipments due to PSP and DPS, and so on.

Yamatogi et al. (2002) report on *Cochlodinium polykrikoides*, which was first identified at Imari Bay in Nagasaki Prefecture in 1998. They report on this plankton as a harmful red tide that caused fish kills, and describe its red-tide and reproductive characteristics. Matsuoka et al. (2004) summarize the number of fisheries known to have been damaged by *C. polykrikoides* in western Japan, based on historical studies.

- Reference List -

- Fukuyo, Y., Imai, I., Kodama, M. and Tamai, K. (2002) Red tides and other harmful algal blooms in Japan., in "Harmful Algal blooms in the PICES Region of the North Pacific (eds by F.J.R."Max" Taylor and V.L. Trainer)", PICES Scientfic Report, No.23, North Pacific Marine Science Organization, 7-20.
- Yamatogi, T., Maruta, H., Ura, K. (2002) Occurrence of *Cochlodinium polykrikoides* Red Tide and its Growth Characteristics in Imari bay in 1999., Bull. Nagasaki Pref. Inst. Fish., 28, 21-26.
- Matsuoka, K., Iwataki, M. (2004) Present status in study on a harmful unarmored dinoflagellate *Cochlodinium polykrikoides* Margalef., Bull. Plankton Soc. Japan, 51 (1), 38-45.

4.2 Mechanism and Environment

Bacteria and viruses coexisting in plankton are involved in the mechanism of red-tide senescence. Tarutani et al. (2000) found that the rapid decrease in the number of cells in red tides caused by *Heterosigma akashiwo* coincides with a rapid increase of HaV (*Heterosigma akashiwo* Virus), which is parasitic of the plankton cells in this red-tide species.

Maki and Imai (2001) showed that the activity of bacteria that live in the cells of *Heterocapsa circularisquama* strongly depend on the activity of the host. Also, Kim et al. (2004) studied the impact of water temperature, salinity and the amount of sunlight on the growth of *Cochlodinium polykrikoides*, and tested 60 patterns of different conditions. Their results showed that the combination that provides the most rapid growth rate is a water temperature of 25°C, salinity of 34 and an irradiance > 90 μ mol $m^{-2}s^{-1}$.

- Reference List -

- Tarutani, K., Nagasaki, K. and Yamaguchi, M. (2000) Viral impacts on total abundance and clonal composition of the harmful bloom-forming phytoplankton *Heterosigma akashiwo*., App. Environ. Microbiol., 66 (11), 4916-4920.
- Maki, T. and Imai, I. (2001) Effects of Harmful Dinoflagellate *Heterocapsa circularisquama* Cells on the Growth of Intracellular Bacteria., Microb. Environ., 16 (4), 234-239.
- Tamaru, Y., Tarutani, K., Yamaguchi, M. and Nagasaki, K. (2004) Quantitative and qualitative impacts of viral infection on a *Heterosigma akashiwo* (Raphidophyceae) bloom in Hiroshima Bay, Japan., Aquat. Microb. Ecol., 34, 227-238.
- Kim, D. I., Matsuyama, Y., Nagasoe, S., Yamaguchi, M., Yoon, Y. H., Oshima, Y., Imada, N., and Honjo, T. (2004) Effects of temperature, salinity and irradiance on the growth of the harmful red tide dinoflagellate *Cochlodinium polykrikoides* Margalef (Dinophyceae)., J. Plankton Res., 26 (1), 1-6.

4.3 Physiology

Nishitani et al. (2003) attempted to culture *Dinophysis caudata*, which is considered a causal species of DPS, but only a little of its physiology and ecology are known. Ground cells of three different kinds of plankton were used for feeding, and growth of *D. caudate* was observed.

Oda et al. (2001) found that the ethanol extract of *Heterocapsa circularisquama* destroys mammalian erythrocytes. This extracted material sets off a morphological change in the unfertilized eggs of the Japanese oyster and kills the micro-zooplankton *Brachionus plicatilis*. The authors suggest that this ethanol-extracted material might be one of the causes of en masse bivalve killing.

- Reference List -

- Nishitani, G., Miyamura, K. and Imai, I. (2003) Trying to cultivation of *Dinophysis caudata* (Dinophyceae) and the appearance of small cells. Plankton Biol. Ecol., 50 (2), 31-36.
- Oda, T., Sato, Y., Kim, D., Muramatsu, T., Matsuyama, Y., Honjo, T. (2001) Hemolytic activity of *Heterocapsa circularisquama* (Dinophyceae) and its possible involvement in shellfish toxicity. J. Phycol., 37 (4). 509-516.

4.4 Taxonomy

Imai (2000) points out the following problems of classification and identification for raphidoflagellates. These are:

- The morphology of raphidoflagellates varies greatly by species, as cells do not hold their shape.
- The cell is fragile and breaks under severe conditions. Fixation is impossible.

For these reasons, classification and identification of raphidoflagellates were difficult until recently. However, in the latest studies, taxonomic methods that use DNA probes or antibodies are now being established, and morphological observation is not necessary. Therefore, the author suggests that these methods may become important as the classification and identification methods of choice for raphidoflagellates.

Nagai et al. (2002) observed the formation process and morphology of cysts of *Polykrikos kofoidii* and *P. schwartzii*, which until now have been difficult to distinguish from each other. Detailed studies were conducted through an incubation experiment, and differences between cysts of these two species were demonstrated.

- Reference List -

- Imai, I. (2000) Current problems in classification and identification of marine raphidoflagellates (raphidophycean flagellates): from the view point of ecological study. Bull. Plankton Soc. Japan, 47 (1), 55-64.
- Nagai, S., Matsuyama, Y., Takayama, H. and Kotani, Y. (2002) Morphology of *Polykrikos kofoidii* and *P. schwartzii* (Dinophyceae, Polykrikaceae) cysts obtained in culture. PYCOA., 41 (4), 319-327.

4.5 Mitigation and Management

Bacteria, viruses and macroalgae have received attention as methods for the mitigation and management of HABs.

Tarutani et al. (2001) successfully isolated a virus in natural seawater that infects *H. circularisquam* and dissolves its cells.

Imai et al. (2001) suggested that the bacteria known to be effective in eliminating *Chattonella*, called '*Cytophaga* sp. J18/M01', might also affect the growth of diatoms.

Imai et al. (2002) found that many bacteria which kill red-tide forming species are attached to *Ulva* sp. and *Gelidium* sp., and suggested that an increase of red tides in culture ponds might be prevented by introducing these macroalgae. Also, Nagayama et al. (2003) found that phlorotannins from *Ecklonia kurome*, a brown alga, has a strong lethal effect on seagrass. This phlorotannins is known to be benign to red sea bream (*Pagrus major*), tiger puffers (*Fugu rubripes*), and larval blue crabs (*Portunus trituberculatus*).

- Reference List -

- Tarutani, K., Nagasaki, K., Itakura, S. and Yamaguchi, M. (2001) Isolation of a virus infecting the novel shellfish-killing dinoflagellate *Heterocapsa circularisquama*. Aquat. Microb. Ecol., 23, 103-111.
- Imai, I., Sunahara, T., Nishikawa, T., Hori, Y., Kondo, R. and Hiroishi, S. (2001) Fluctuations of the red tide flagellates *Chattonella* spp. (Raphidophyceae) and the algicidal bacterium *Cytophaga* sp. in the Seto Inland Sea, Japan. Mar. Biol., 138, 1043-1049.
- Imai, I., Fujimaru, D. and Nisigaki, T. (2002) Co-culture of fish with macroalgae and associated bacteria: A possible mitigation strategy for noxious red tides in enclosed coastal sea. Fish. Sci., 68, (supplement), 493-496.
- Nagayama, K., Shibata, T., Fujimoto, K., Honjo, T., Nakamura, T. (2003) Algicidal effect of phlorotannins from the brown alga *Ecklonia kurome* on red tide microalgae. AQCLAL., 218 (1-4), 601-611.

4.6 Others

Matsuyama et al. (2001) investigated the effect of nine harmful algal species on the survival of trochophore larvae of the Japanese oyster, and showed that the effect of harmful algae on oyster larvae varied greatly among species. Lethal effects were found in larvae exposed to *Alexandrium tamarense*, *A. taylori*, *Gymnodinium mikimotoi* and *Heterocapsa circularisquama* at cell densities of 10^5-10^7cells/L. Exposure to *Cochlodinium polykrikoides* caused extreme retardation of the metamorphosis to D-shaped larva.

Kim et al. (2000) found that living *Heterocapsa circularisquama* was toxic to a microzooplankton and the rotifer *Brachinus plicatilis*, unlike *Chattonella marina*, *Heterosigma akashiwo* and *Cochlodinium polykrikoides*. In addition to the well-known fact that *H. circularisquama* has lethal effects on shellfish, the species has detrimental effects on zooplankton and, consequently, on fish.

- Reference List -

・ Matsuyama, Y., Usuki, H., Uchida, T., and Kotani, Y. (2001) Effects of harmful algae on the early planktonic larvae of the oyster, *Crassostrea gigas*. in "Harmful Algal Blooms 2000 (eds by G. M. Hallegraeff, S. I. Blackburn, C. J. Bolch and R. J. Lewis)", IOC of UNESCO, 411-414.

・ Kim, D., Sato, Y., Oda, T., Muramatsu, T., Matsuyama, Y., and Honjo, T. (2000) Specific toxic effect of dinoflagellate *Heterocapsa circularisquama* on the rotifer *Brachionus plicatilis*. Biosci. Biotech. Biochem. 64 (12), 2719-2722.

5. Training to Cope with HABs

The following section describes the training activities conducted nationally and locally. It also describes the international programs attended by Japanese scientists.

5.1 Training on a Nationwide Basis

The non-profit organization JFRCA has conducted annual training courses to develop the capacity of technicians from fishery laboratories, etc. of concerned prefectural governments (Table 5.1). JFRCA is the only organization that has such a concrete training activity on a nationwide basis in Japan.

5.2 Training by Local Governments

Prefectural governments have also carried out training courses to educate the fishermen and general community. Table 5.2 shows an example of such an effort by a local government in 2004. Other prefectural governments have similar activities.

5.3 Participation in International Programs

Japanese scientists have helped organize and promote international programs for technical training relating to HABs. Some of these scientists give lectures to the trainees, but no Japanese trainees have participated in the international training programs to date. The Training Through Research (TTR) program planned by the Intergovernmental Oceanographic Commission subcommittee for the Western Pacific (IOC/WESTPAC) could be the first program to involve Japanese trainees.

Table 5.1 Training courses held by Japan Fisheries Resource Conservation Association (JFRCA) for technical improvement of red-tide and shell-poisoning research

Course No.	Objective	Trainee	Trainer	Period	Content	Problem
1	• Improvement of techniques • Homogenization of skill level throughout the country • Continuity of technical level	Personnel from local governments in charge of red tides/shellfish poisoning problems Fishermens' leaders	Experienced researchers from institutes of central governments, universities, etc.	5 days during October to December	Lectures • Target species: Dinophyceae, Raphidophyceae • Status of red tide and shellfish poisoning, and consequent damage • State-of-art of studies on red tides and shellfish poisoning • Life cycle and ecological features of causative species • Taxonomy and species identification of plankton Exercise • Sampling, sample preservation and concentration, species identification	• Continuous training is necessary for recently assigned people due to personnel transfers in local government • To consider the local features of red tides and shellfish poisoning • Advanced technology for sampling and analysis • Introduction of conventional methods to ensure continuous and economical performance
2	Dissemination of analytical methods using instruments	Personnel from local governments in charge of shellfish poisoning problem (beginners)	Experienced researchers from institutes of central government	3 days during September to October	Lectures • Status of shellfish poisoning • Analytical methods using instruments Exercise • Analyses using instruments	
3	Follow-up of trained skill	Personnel who had the training	-	30 min	Video explaining manuals for sampling, species identification and counting of cysts	
4	Support of training activity by local government	Personnel from local governments in charge of training of the local fishermen	-	30 min	Video explaining the role and significance of monitoring, and manuals for sampling, species identification and counting of cysts	
5	Support of training activity by local government	Personnel from local governments in charge of training of the local fishermen	-	-	Distribution and explanation of revised textbooks for species identification and analysis using instruments	

Source: Extract from monthly report of activities of the Japan Fisheries Resource Conservation Association

Table 5.2 An example of training activities by local governments

Course No.	Objective	Trainee	Period	Content	Achievement
1	Dissemination of: • Survey activities • Mitigation measures	Fishermen and the general community	3 days	Seminar on red-tide mitigation measures Seminar on the mechanism of red tides Exercise consisting of microscope work and counting of red-tide plankton	• Periodical monitoring commenced based on the monitoring manual and coordination between local government, municipal governments and related fisheries unions • Detection of red tides at early stages possible across extensive areas. • Positive participation of fishermen resulted in better understanding of red tides and minimized economic loss • Positive participation of fishermen became a model for dissemination to other areas
2	Enhancement of mitigation measures and monitoring schemes	Aquaculture operators	1 day	Seminar	
3	Enhancement of mitigation measures and monitoring schemes	Aquaculture operators	2 days	Seminar on fishery damage and mitigation measures using a video Microscope work on red-tide plankton	

Source: Nagasaki Prefecture official homepage (http://www.pref.nagasaki.jp/gyosei) and Ministry of the environment homepage (http://www.env.go.jp/policy/hakusyo/)

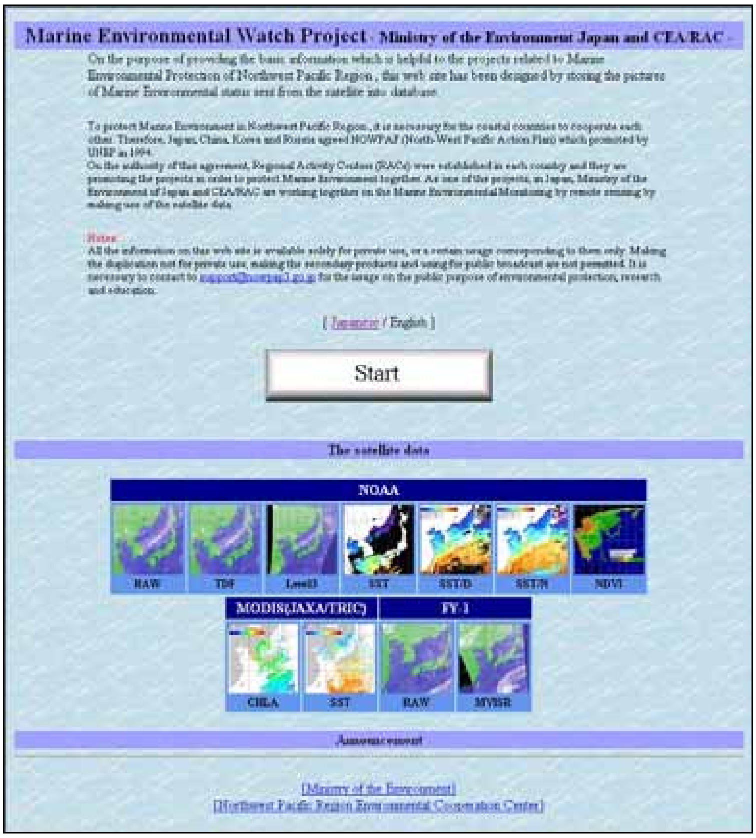
6. National Activity to Cope with HABs

This chapter introduces the activities that need to be taken by the Government of Japan to cope with HABs. These include remote sensing monitoring programs, cooperation with international organizations and so on. Some activities do not contribute to the HAB problem directly but treat HABs indirectly as a part of a wide variety of marine environmental problems. The Government of Japan does not prioritize activities concerning HABs.

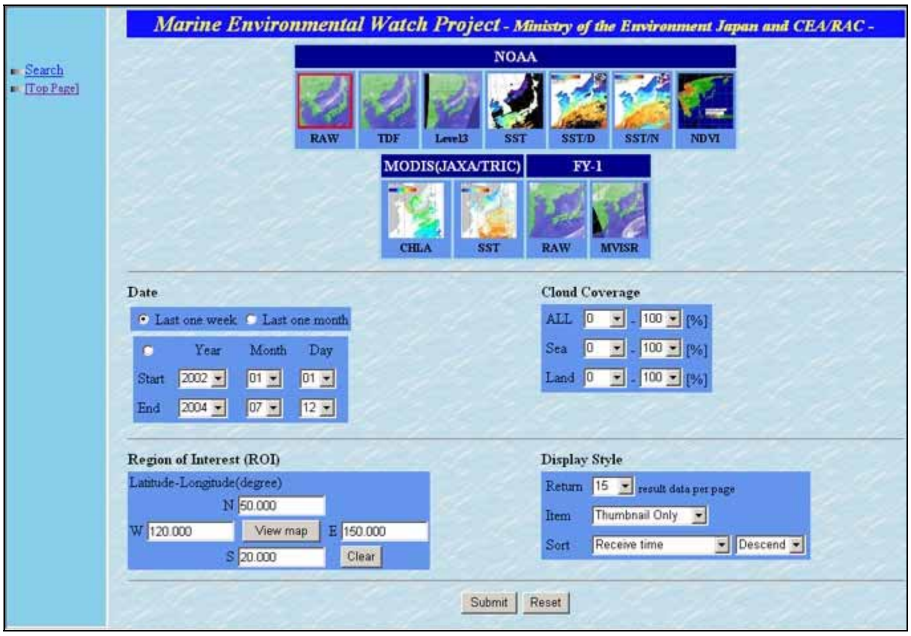
6.1 Promotion of Remote Sensing Monitoring Programs

Although the technology of satellite remote sensing does not currently clearly detect red tides, it is expected that it will become a useful tool for observing HABs. Thus, the Government of Japan promotes remote sensing programs in order to monitor the marine environment widely and to produce data for studying the ability to monitor red tides by satellite remote sensing.

The Ministry of the Environment of Japan (MOEJ) has developed a satellite remote sensing monitoring project called the ‘Marine Environmental Watch Project’, and has monitored the marine environment of the NOWPAP region since 2000. This program provides satellite images of cloud cover, Sea Surface Temperature (SST), Normalized Difference Vegetation Index (NDVI), and chlorophyll-a, which are detected by National Oceanic and Atmospheric Administration (NOAA), Feng Yun-1 (FY-1) and Moderate Resolution Imaging Spectrometer (MODIS). The data are presented in a website (http://www.nowpap3.go.jp/jsw/), as shown in Figure 6.1. MODIS chlorophyll-a and SST products may help in monitoring red tides in the future. MOEJ will utilize this system to help with NOWPAP/CEARAC activities, which treat the problem of HABs.



(a). Home page (http://www.nowpap3.go.jp/jsw/)



(b). Data search (http://www.nowpap3.go.jp/jsw/index.php?lang=en)

Figure 6.1 Marine Environmental Watch Project

The Japanese Coast Guard has also constructed a system to provide marine environmental information related to the red-tide phenomenon. Figure 6.2 shows a website of the database of this system. The system is monitoring seven oceanic indices, including chlorophyll-a concentration (CHLA), water surface temperature, colored dissolved organic matter (CDOM), attenuation coefficient K490, suspended solids (SS), normalized water-leaving radiance (nLw), and surface albedo by the earth observation satellites, Terra and Aqua. Currently, the system provides data of those oceanic indices only in Tokyo Bay. The Japanese Coast Guard is making plans to monitor other areas. Toyama Bay is one candidate area for monitoring in the NOWPAP region.

Figure 6.2 Website of Remote Sensing Database of the Japanese Coast Guard
(http://www1.kaiho.mlit.go.jp/KANKYO/SAISEI2/saisei_html/top.htm) (Only in Japanese)

6.2 Cooperation with International Organizations

The Government of Japan supports the activities of international organizations related to the problem of HABs. The Action Plan for the Protection, Management and Development of the Marine and Coastal Environment of NOWPAP and the Intergovernmental Oceanographic Commission (IOC) have special activities or programs concerning HAB problems.

NOWPAP is one of the Regional Seas Programs of the United Nations Environment Programme (UNEP). NOWPAP established The Special Monitoring & Coastal Environmental Assessment Regional Activity Centre (CEARAC) in 1999 at Toyama, Japan. CEARAC set the first target for the coastal environmental assessment on HABs. MOEJ has contributed human resources to the activity of CEARAC through the Northwest Pacific Region Environmental Cooperation Center (NPEC), which was approved in 1998 as a legally incorporated foundation under the jurisdiction of the MOEJ.

IOC/WESTPAC has a HAB Program. The program aims at providing capacity building and producing documents related to HABs. The Government of Japan supports a series of annual courses for Member States to develop their capacity building and participation in the activities of the program. IOC/WESTPAC also conducts a NEAR-GOOS program, a North-East Asian Regional (NEAR) program of the Global Ocean Observing System (GOOS) implemented by China, Japan, Korea and Russia. The Government of Japan expects the NEAR-GOOS program to help study HABs in the future.

North Pacific Marine Science Organization (PICES) has made various efforts related to HAB problems. Currently, it is very eager to establish a common database for the analysis of coastal HAB events. At a joint PICES/IOC Workshop called ‘Harmful algae blooms – Harmonization of data’ in 2003, PICES member countries accepted an offer from IOC/International Council for the Exploration of the Sea (ICES) to utilize their successful harmful algal event meta-database (HAE-DAT) format. PICES member countries are checking the usability and effectiveness of the HAE-DAT format.

6.3 Other Activities Related to HABs

The Government of Japan has conducted activities concerning HABs, such as the development of an information network system of red tides and shellfish poisoning, and a study on mitigation measures of shellfish poisoning.

The Fisheries Agency of Japan has prepared a network system of information on red tide and shellfish poisoning using the internet (http://turtle.jfrca.or.jp/akashiwo.html). This system provides information on past red tides in selected enclosed bays and inland seas, and the occurrence of shellfish poisoning in all Japanese fisheries and aquaculture industries. The website of the system introduces local governments' websites, and also presents up-to-date information on red tides and shipping prohibitions of poisoned shellfish. Although this system does not cover the whole NOWPAP region, users who are interested in HABs in the region can obtain some information along the coastal areas of four prefectures (red tides: Yamaguchi, Fukuoka, Saga Prefecture; shipping inhibition of poisoned shellfish: Shimane, Fukuoka Prefecture).

In order to develop mitigation measures against shellfish poisoning, the Fisheries Agency of Japan is studying shellfish poisoning mechanisms as well as inspection and monitoring schemes. Some laboratories under the agency investigate viruses to be used against toxin producing plankton as an optional mitigation measure.

7. Suggested Activity for the NOWPAP Region

This chapter suggests action against the problem of *Cochlodinium*, cooperation with other organizations, and promotion of land based activities for the NOWPAP region in the near future. These three kinds of activities are proposed because *Cochlodinium* not only causes adverse effects on fisheries and aquacultures in Japan and Korea, but could possibly affect NOWPAP countries in future. Needless to say, it is important for NOWPAP to work together and exchange information with other organizations. The promotion of effective pollution control on human land-based activity should be considered in conjunction with analyses of HABs in the NOWPAP Region.

7.1 Action Against the Problem of *Cochlodinium*

A working group under CEARAC has agreed that *Cochlodinium* is one of the harmful algae of most concern for the NOWPAP region. This species is causing suffering in the aquaculture industry, especially in Japan and Korea. For example, about 250,000 farmed sea bream in Uwakai (in Ehime Prefecture) and about US$1,000,000 were lost from a *Cochlodinium polykrikoides* bloom on July 22, 2004. The damage to fisheries has been reported not only in the NOWPAP region but also in Southeast Asia. *Cochlodinium* has only recently been recognized as a threat, so that the study of this species is less advanced than that of other toxin-producing plankton. CEARAC, under NOWPAP, established a group to study *Cochlodinium*, called the '*Cochlodinium* Corresponding Group (CCG)'. The aim of this study group is to produce a set of useful information on *Cochlodinium* and help policy makers concerned with coastal fisheries.

7.2 Cooperation with Other Organizations

NOWPAP may cooperate with the other UNEP Action Plans in the Regional Seas Programme, such as the East Asia Seas Action Plan. The problem of *Cochlodinium* has recently appeared in Southeast Asia. *Hetrocapsa circularisquama* is thought to be transported by southern tropical/subtropical seas. Therefore, cooperation with other UNEP Action Plans is useful for NOWPAP.

IOC/WESTPAC is establishing a Training Through Research (TTR) program about HAB species. NOWPAP/CEARAC also has established the

CCG, mentioned in the above section. WESTPAC/TTR and CCG may organize the joint programs to cope with *Cochlodinium*, and to exchange information on the species and related activities.

In addition, NOWPAP has to be careful not to make its activity plan duplicate to that of other organizations. NOWPAP should exchange information with other organizations in order to make efficient plans to cope with HABs.

7.3 Promotion of Measures for Land-based Activities

NOWPAP/CEARAC presently approaches the problem of HABs mostly from the point of view of oceanography and marine ecology. However, it is important to control human land-based activities, which discharge enormous amounts of nutrients into the sea. Japan has the experience to overcome water pollution by implementing appropriate pollution abatement policies and technologies, and has monitored effluents for a long time. Therefore, using the experience and technology of Japan, NOWPAP monitoring plans and pollution prevention policies about human land-based activities should be considered.

ii Red tide events in northern Kyushu coastal waters Inland during 1998-2002 (1)

Event No.	Location (name of the sea area)		Duration	Continuous days	Causative species								Max. cell density (cells/L)							
	Location 1	Location 2	dd/mm/yy-dd/mm/yy		①	②	③	④	⑤	⑥	⑦	⑧	①	②	③	④	⑤	⑥	⑦	⑧
NS-01	remote Island	Tsushima	27/01/98 - 02/02/98	7	*Skeletonema costatum*								3,600							
NS-02	remote Island	Goto	07/04/98 - 25/04/98	19	*Gymnodinium sanguineum*								588							
NS-08	remote Island	Tsushima	16/05/98 - 21/05/98	6	*Prorocentrum micans*								13,000							
FO-03	N	other	01/06/98 - 05/06/98	5	*Heterosigma akashiwo*								10,000							
YG-01	N	other	03/06/98 - 16/06/98	14	*Heterosigma akashiwo*								7,650							
FO-04	N	Fukuokawan	15/06/98 - 17/06/98	3	*Skeletonema costatum*								25,950							
SA-04	N	other	22/06/98 - 03/07/98	12	*Heterosigma akashiwo*								79,070							
SA-05	N	other	24/06/98 - 26/06/98	3	*Prorocentrum triestinum*	*Prorocentrum dentatum*							4,420	1,260						
SA-06	N	Imariwan	24/06/98 - 29/06/98	6	*Prorocentrum dentatum*								5,190							
FO-06	N	Fukuokawan	13/07/98 - 16/07/98	4	*Chaetoceros* sp.								7,200							
YG-02	N	other	11/08/98 - 20/08/98	10	*Cochlodinium polykrikoides*								18,000							
NS-16	remote Island	Tsushima	17/08/98 - 21/08/98	5	*Cochlodinium polykrikoides*								103							
YG-03	N	other	19/08/98 - 02/09/98	15	similar *Heterocapsa circularisquama*								12,780							
NS-17	remote Island	Tsushima	25/08/98 - 26/08/98	2	unknown								119							
FO-08	N	Fukuokawan	27/08/98 - 28/08/98	2	*Thalassiosira* sp.								7,420							
FO-09	N	Fukuokawan	09/09/98 - 10/09/98	2	*Skeletonema costatum* etc.								unknown							
NS-22	N	Imariwan	21/10/98 - 24/10/98	4	*Skeletonema costatum*								2,500							
NS-98-29	remote Island	Goto	17/12/98 - 04/01/99	19	*Mesodinium rubrum*								4,750							
NS-98-30	remote Island	Tsushima	28/12/98 - 06/01/99	10	*Mesodinium rubrum*								699							
NS-01	remote Island	Goto	05/01/99 - 09/01/99	5	*Mesodinium rubrum*								882							
YG-01	N	other	10/03/99 - 12/03/99	3	*Noctiluca scintillans*								2,990							
SA-01	N	other	04/04/99 - 20/04/99	17	*Gymnodinium sanguineum*								2,420							
NS-02	remote Island	Tsushima	19/04/99 - 26/04/99	8	*Gymnodinium sanguineum*								2,256							
YG-02	N	other	20/04/99 - 21/04/99	2	*Noctiluca scintillans*								450							
YG-03	N	other	20/04/99 - 21/04/99	2	*Noctilca* sp.								-							
YG-04	N	other	26/04/99 - 27/04/99	2	*Noctilca* sp.								-							
FO-02	N	Fukuokawan	10/05/99 - 12/05/99	3	*Rhizosolenia* sp.								3,360							
YG-05	N	other	12/05/99 - 14/05/99	3	*Noctilca* sp.								3,699							
FO-03	N	Fukuokawan	31/05/99 - 02/06/99	3	*Leptcylindrus danicus*	*Prorocentrum minimum*							29,899	5,299						
SA-02	N	other	07/06/99 - 05/07/99	29	*Heterosigma akashiwo*	*Prorocentrum dentatum*							29,810	52,820						
FO-04	N	other	08/06/99 - 10/06/99	3	*Haptophyceae*								22,399							
FO-05	N	Fukuokawan	09/06/99 - 14/06/99	6	*Skeletonema costatum*	*Prorocentrum minimum*	*Leptcylindrus* sp.						83,799	2,250	6,599					
SA-03	N	other	20/06/99 - 26/07/99	37	*Prorocentrum dentatum*								71,765							
YG-06	N	other	21/06/99 - 22/06/99	2	*Heterosigma akashiwo*								7,720							
NS-09	N	Imariwan	01/07/99 - 21/07/99	21	*Skeletonema costatum*								18,699							
FO-09	N	Fukuokawan	05/07/99 - 08/07/99	4	*Skeletonema costatum*	*Thalassiosira* sp.	*Chaetoceros* sp.						9,299	4,599	2,250					
SA-04	N	Imariwan	05/07/99 - 29/07/99	25	*Skeletonema costatum*	*Pseudnitzchia* sp.	*Prorocentrum dentatum*						18,670	1,380	78,499					
SA-06	N	other	22/07/99 - 30/07/99	9	*Prorocentrum dentatum*								2,050							
FO-11	N	Fukuokawan	22/07/99 - 22/08/99	32	*Prorocentrum dentatum*	*Gymnodinium mikimotoi*							9,680	40						
NS-11	N	Imariwan	25/07/99 - 06/08/99	13	*Gymnodinium mikimotoi*								4,950							
SA-07	N	Imariwan	03/08/99 - 09/08/99	7	*Gymnodinium mikimotoi*								3,740							
SA-08	N	other	03/08/99 - 09/08/99	7	*Gymnodinium mikimotoi*								11,040							
SA-09	N	other	05/08/99 - 09/08/99	5	*Gymnodinium mikimotoi*								1,940							
NS-13	N	Imariwan	07/08/99 - 12/08/99	6	*Cochlodinium polykrikoides*								11,060							
FO-13	N	other	09/08/99 - 18/08/99	10	*Heterocapsa circularisquama*								7,040							
SA-10	N	Imariwan	10/08/99 - 16/08/99	7	*Cochlodinium polykrikoides*								3,360							
SA-12	N	Imariwan	16/08/99 - 27/09/99	43	*Heterocapsa circularisquama*								4,050							
NS-24	remote Island	Tsushima	06/09/99 - 17/09/99	12	*Gymnodinium mikimotoi*								11,670							
FO-16	N	Fukuokawan	07/09/99 - 13/09/99	7	*Skeletonema costatum*								49,970							
NS-32	remote Island	Tsushima	09/12/99 - 21/12/99	13	*Mesodinium rubrum*								3,990							
YG-01	N	other	05/04/00	1	*Noctilca* sp.								530							
FO-02	N	other	23/05/00 - 26/05/00	4	*Heterosigma akashiwo*								9,170							
FO-04	N	other	01/06/00 - 06/06/00	6	*Heterosigma akashiwo*								28,060							
FO-05	N	Fukuokawan	02/06/00 - 06/06/00	5	*Prorocentrum minimum*								6,090							
FO-06	N	Fukuokawan	13/06/00 - 19/06/00	7	*Skeletonema costatum*	*Leptocylindrus* sp.							38,340	18,600						
SA-03	N	other	15/06/00 - 19/06/00	5	*Heterosigma akashiwo*								54,000							
SA-04	N	other	18/06/00 - 26/06/00	9	*Heterosigma akashiwo*								7,960							
SA-05	N	other	26/06/00 - 30/06/00	5	*Prorocentrum dentatum*	*Mesodinium rubrum*							2,840	500						
SA-06	N	Imariwan	27/06/00 - 27/07/00	31	*Gymnodinium mikimotoi*								10,040							
FO-07	N	Fukuokawan	30/06/00 - 31/07/00	32	*Fibrocapsa japonica*	*Prorocentrum dentatum*	*Prorocentrum triestinum*	*Skeletonema costatum*	*Thalassiosira* sp.	*Heterocapsa circularisquama*	*Gymnodinium mikimotoi*		694	15,500	88	5,700	10,900	96	57	
YG-02	N	other	06/07/00 - 03/08/00	29	*Gymnodinium mikimotoi*								14,800							
SA-07	N	other	10/07/00 - 19/07/00	10	*Gymnodinium mikimotoi*								12,060							
NS-09	N	other	11/07/00 - 12/07/00	2	*Gymnodinium mikimotoi*								20,600							
FO-09	N	other	11/07/00 - 31/07/00	21	*Gymnodinium mikimotoi*								4,710							
NS-10	N	Imariwan	13/07/00 - 22/07/00	10	*Gymnodinium mikimotoi*								17,560							
NS-12	remote Island	Goto	26/07/00 - 17/08/00	23	*Gymnodinium mikimotoi*								37,300							
FO-10	N	Fukuokawan	04/08/00 - 11/08/00	8	*Skeletonema costatum*	*Thalassiosira* sp.	*Chaetoceros* sp.	*Neodelphineis pelagica*					8,800	6,860	5,900	6,610				
SA-10	N	Imariwan	18/08/00 - 11/09/00	25	*Heterocapsa circularisquama*								310							
NS-19	remote Island	Tsushima	21/08/00 - 24/08/00	4	*Cochlodinium polykrikoides*								2,325							
FO-13	N	Fukuokawan	23/08/00 - 01/09/00	10	*Skeletonema costatum*	*Thalassiosira* sp.	*Chaetoceros* sp.	*Neodelphineis pelagica*	*Gymnodinium mikimotoi*	*Heterocapsa circularisquama*			8,220	9,400	3,770	8,260	2,200	230		
FO-14	N	Fukuokawan	08/09/00 - 12/09/00	5	*Skeletonema costatum*	*Thalassiosira* sp.	*Chaetoceros* sp.						16,870	9,360	4,380					
NS-21	remote Island	Tsushima	18/09/00 - 25/09/00	8	*Noctiluca scintillans*								1,476							
SA-11	N	Imariwan	27/09/00 - 29/09/00	3	*Prorocentrum sigmoides*								2,290							
NS-23	N	Imariwan	28/09/00 - 04/10/00	7	*Prorocentrum sigmoides*								1,500							
FO-15	N	Fukuokawan	07/11/00 - 11/11/00	5	*Thalassiosira* sp.	*Skeletonema costatum*	*Asterionella* sp.						2,410	19,100	2,320					
NS-27	remote Island	Tsushima	08/11/00 - 15/11/00	8	*Nitzschia* spp.								3,585							

Source : Kyushu Fishery Coordination Office, “Situation of Red Tide in the Seas surrounding Kyushu Island”, 1999-2003.

ii Red tide events in northern Kyushu coastal waters Inland during 1998-2002 (2)

Event No.	Location (name of the sea area)		Duration	Continuous days	Causative species								Max. cell density (cells/L)							
	Location 1	Location 2	dd/mm/yy-dd/mm/yy		①	②	③	④	⑤	⑥	⑦	⑧	①	②	③	④	⑤	⑥	⑦	⑧
SA-01	N	Imariwan	21/01/01 - 25/01/01	5	*Gymnodinium sanguineum*								334							
YG-01	N	other	20/03/01 - 23/04/01	35	*Noctiluca scintillans*								2,700							
FO-01	N	other	21/03/01 - 22/03/01	2	*Noctiluca scintillans*								75							
FO-03	N	other	06/04/01 - 09/04/01	4	*Noctiluca scintillans*								1,160							
NS-03	remote Island	Goto	07/04/01 - 11/04/01	5	*Noctiluca scintillans*								5,420							
NS-04	N	Imariwan	10/04/01 - 13/04/01	4	*Noctiluca scintillans*								731							
NS-05	remote Island	Iki	17/04/01 - 20/04/01	4	*Noctiluca scintillans*								249							
NS-06	remote Island	Goto	17/04/01 - 18/04/01	2	*Noctiluca scintillans*								unknown							
FO-04	N	other	17/04/01 - 20/04/01	4	*Noctiluca scintillans*								1,220							
NS-07	remote Island	Tsushima	18/04/01 - 19/04/01	2	*Noctiluca scintillans*								1,968							
NS-08	remote Island	Tsushima	18/04/01 - 19/04/01	2	*Noctiluca scintillans*								650							
SA-02	N	other	18/04/01 - 12/05/01	25	*Noctiluca scintillans*								380							
NS-09	remote Island	Iki	27/04/01 - 01/05/01	5	*Noctiluca scintillans*								467							
FO-05	N	Fukuokawan	06/05/01 - 14/05/01	9	*Prorocentrum minimum*								6,450							
SA-03	N	other	07/05/01 - 11/05/01	5	*Heterosigma akashiwo*								19,760							
NS-12	remote Island	Goto	22/05/01 - 23/05/01	2	*Noctiluca scintillans*								672							
YG-02	N	other	28/05/01 - 31/05/01	4	*Eutreptiella gymnastica*								2,025							
NS-14	N	Imariwan	30/05/01 - 31/05/01	2	*Tontonia* sp.								27							
FO-09	N	other	05/06/01 - 11/06/01	7	*Heterosigma akashiwo*								9,530							
YG-03	N	other	15/06/01	1	*Heterosigma akashiwo*								69,000							
NS-19	N	Imariwan	20/06/01 - 26/06/01	7	*Mesodinium rubrum*								1,240							
FO-10	N	Fukuokawan	26/06/01 - 06/07/01	11	*Leptocylindrus* sp.	*Chaetoceros* sp.							1,636	10,800						
YG-04	N	other	27/06/01 - 10/07/01	14	*Chattonella antiqua*								1,350							
NS-21	N	Imariwan	28/06/01 - 08/07/01	11	*Gymnodinium mikimotoi*								2,250							
FO-12	N	Fukuokawan	09/07/01 - 23/07/01	15	*Prorocentrum minimum*								25,000							
NS-25	remote Island	Goto	19/07/01 - 24/07/01	6	*Heterosigma akashiwo*								27,780							
YG-05	N	other	03/08/01	1	*Pyramimonas* sp.								17,900							
YG-06	N	other	06/08/01	1	*Gyrodinium* sp.								5,000							
NS-32	remote Island	Tsushima	06/09/01 - 07/09/01	2	*Mesodinium rubrum*								2,275							
FO-15	N	Fukuokawan	03/10/01 - 11/10/01	9	*Heterosigma akashiwo*								3,650							
FO-16	N	other	01/11/01	1	*Noctiluca scintillans*								571							
NS-40	remote Island	Tsushima	19/11/01 - 23/11/01	5	*Mesodinium rubrum*								105							
FO-18	N	other	21/11/01 - 22/11/01	2	*Mesodinium rubrum*	*Gymnodinium sanguineum*							2,630	111						
NS-41	remote Island	Goto	03/12/01 - 05/12/01	3	*Mesodinium rubrum*								5,983							
NS-42	remote Island	Tsushima	10/12/01	1	*Mesodinium rubrum*								911							
NS-02	N	Imariwan	14/01/02 - 17/01/02	4	*Mesodinium rubrum*								2,010							
YG-01	N	other	13/03/02 - 22/04/02	41	*Noctilca* sp.								unknown							
FO-02	N	other	14/03/02	1	*Noctiluca scintillans*								132							
NS-04	remote Island	Goto	01/04/02 - 02/04/02	2	*Noctiluca scintillans*								462							
NS-06	remote Island	Goto	23/04/02	1	*Noctiluca scintillans*								188							
NS-07	remote Island	Iki	24/04/02 - 26/04/02	3	*Noctiluca scintillans*								150							
NS-10	remote Island	Goto	25/04/02 - 07/05/02	13	*Noctiluca scintillans*								490							
FO-03	N	Fukuokawan	07/05/02 - 17/05/02	11	*Gymnodinium sanguineum*								3,500							
FO-05	N	other	10/05/02 - 13/05/02	4	*Heterosigma akashiwo*								32,000							
YG-02	N	other	14/05/02	1	*Heterosigma akashiwo*								5,000							
NS-12	remote Island	Goto	17/05/02 - 22/05/02	6	*Heterosigma akashiwo*								20,520							
YG-03	N	other	29/05/02 - 05/06/02	8	*Alexandrium catenella*								4,000							
YG-04	N	other	06/06/02	1	*Heterosigma akashiwo*								10,400							
NS-14	remote Island	Goto	10/06/02 - 15/06/02	6	*Heterosigma akashiwo*								1,110							
FO-07	N	Fukuokawan	04/07/02 - 11/07/02	8	*Heterocapsa circularisquama*								135							
SA-06	N	other	05/07/02 - 13/07/02	9	*Gymnodinium mikimotoi*								117,980							
FO-08	N	Fukuokawan	11/07/02 - 11/08/02	32	*Prorocentrum dentatum*	*Gymnodinium mikimotoi*							2,000	15						
FO-09	N	other	11/07/02 - 02/08/02	23	*Gymnodinium mikimotoi*								2,000							
SA-07	N	Imariwan	19/07/02 - 22/07/02	4	*Gymnodinium mikimotoi*								6,660							
NS-17	N	Imariwan	22/07/02	1	*Gymnodinium mikimotoi*								4,480							
NS-20	remote Island	Goto	22/07/02 - 24/07/02	3	*Mesodinium rubrum*								1,600							
SA-08	N	other	26/07/02 - 28/07/02	3	*Gymnodinium mikimotoi*								648							
SA-09	N	Imariwan	26/07/02 - 27/07/02	2	*Heterocapsa circularisquama*								1,840							
NS-23	N	other	30/07/02 - 31/07/02	2	*Noctiluca scintillans*								121							
FO-10	N	Fukuokawan	12/08/02 - 21/08/02	10	*Heterocapsa circularisquama*								770							
NS-26	remote Island	Goto	24/08/02 - 27/08/02	4	*Cochlodinium polykrikoides*								221							
NS-27	remote Island	Tsushima	05/09/02 - 13/09/02	9	*Cochlodinium polykrikoides*								109							
NS-28	remote Island	Tsushima	06/09/02 - 12/09/02	7	*Cochlodinium polykrikoides*								798							
SA-12	N	other	09/09/02 - 14/09/02	6	*Gymnodinium mikimotoi*								194							
NS-29	remote Island	Tsushima	10/09/02 - 13/09/02	4	*Cochlodinium polykrikoides*								358							
FO-12	N	Fukuokawan	19/09/02 - 24/09/02	6	*Ceratium furca*								350							
SA-13	N	other	19/09/02 - 03/10/02	15	*Rhizosolenia delicatula*								33,670							
YG-05	N	other	24/09/02 - 01/10/02	8	*Cochlodinium polykrikoides*								2,600							
NS-33	N	other	09/11/02 - 14/11/02	6	*Mesodinium rubrum*								2,390							
FO-15	N	Fukuokawan	02/11/04		*Gymnodinium sanguineum*								7,000							
YG-06	N	other	28/11/02	1	*Mesodinium rubrum*								1,950							
NS-36	remote Island	Goto	29/11/02 - 01/12/02	3	*Mesodinium rubrum*								7,100							
SA-17	N	other	09/12/02 - 28/12/02	20	*Gymnodinium sanguineum*								478							
YG-07	N	other	21/12/02	1	*Gymnodinium sanguineum*								204							

Source : Kyushu Fishery Coordination Office, “Situation of Red Tide in the Seas surrounding Kyushu Island”, 1999-2003.

ii Red tide events in northern Kyushu coastal waters Inland during 1998-2002 (3)

Event No.	Location (name of the sea area)		Duration	Approximate Area suffered	Fish/shellfish species					Contents					Quantity					Economic loss(thousand yen)				
	Location 1	Location 2	dd/mm/yy-dd/mm/yy	(km×km)	①	②	③	④	⑤	①	②	③	④	⑤	①	②	③	④	⑤	①	②	③	④	⑤
NS-01	remote Island	Tsushima	27/01/98 - 02/02/98	0.75																				
NS-02	remote Island	Goto	07/04/98 - 25/04/98	0.5																				
NS-08	remote Island	Tsushima	16/05/98 - 21/05/98	0.002																				
FO-03	N	other	01/06/98 - 05/06/98	5																				
YG-01	N	other	03/06/98 - 16/06/98	0.06	Jackmackerel, Amberjacks					died					unknown					20〜30				
FO-04	N	Fukuokawan	15/06/98 - 17/06/98	71.1																				
SA-04	N	other	22/06/98 - 03/07/98	unknown																				
SA-05	N	other	24/06/98 - 26/06/98	unknown																				
SA-06	N	Imariwan	24/06/98 - 29/06/98	unknown																				
FO-06	N	Fukuokawan	13/07/98 - 16/07/98	41.5																				
YG-02	N	other	11/08/98 - 20/08/98	0.65	Fishes					died					unknown					unknown				
NS-16	remote Island	Tsushima	17/08/98 - 21/08/98	1	Amberjacks					died					340 kg					1,122				
YG-03	N	other	19/08/98 - 02/09/98	0.65																				
NS-17	remote Island	Tsushima	25/08/98 - 26/08/98	0.015																				
FO-08	N	Fukuokawan	27/08/98 - 28/08/98	40.6																				
FO-09	N	Fukuokawan	09/09/98 - 10/09/98	49																				
NS-22	N	Imariwan	21/10/98 - 24/10/98	3																				
NS-98-29	remote Island	Goto	17/12/98 - 04/01/99	0.995																				
NS-98-30	remote Island	Tsushima	28/12/98 - 06/01/99	0.035																				
NS-01	remote Island	Goto	05/01/99 - 09/01/99	0.285																				
YG-01	N	other	10/03/99 - 12/03/99	-	Squids, Octopus, fishes					died					13 kg					30				
SA-01	N	other	04/04/99 - 20/04/99	-																				
NS-02	remote Island	Tsushima	19/04/99 - 26/04/99	2.51																				
YG-02	N	other	20/04/99 - 21/04/99	-																				
YG-03	N	other	20/04/99 - 21/04/99	0.992																				
YG-04	N	other	26/04/99 - 27/04/99	-																				
FO-02	N	Fukuokawan	10/05/99 - 12/05/99	75																				
YG-05	N	other	12/05/99 - 14/05/99	-																				
FO-03	N	Fukuokawan	31/05/99 - 02/06/99	30																				
SA-02	N	other	07/06/99 - 05/07/99	-																				
FO-04	N	other	08/06/99 - 10/06/99	1																				
FO-05	N	Fukuokawan	09/06/99 - 14/06/99	35																				
SA-03	N	other	20/06/99 - 26/07/99	-																				
YG-06	N	other	21/06/99 - 22/06/99	-																				
NS-09	N	Imariwan	01/07/99 - 21/07/99	4																				
FO-09	N	Fukuokawan	05/07/99 - 08/07/99	47																				
SA-04	N	Imariwan	05/07/99 - 29/07/99	-																				
SA-06	N	other	22/07/99 - 30/07/99	-																				
FO-11	N	Fukuokawan	22/07/99 - 22/08/99	62																				
NS-11	N	Imariwan	25/07/99 - 06/08/99	6																				
SA-07	N	Imariwan	03/08/99 - 09/08/99	-																				
SA-08	N	other	03/08/99 - 09/08/99	-																				
SA-09	N	other	05/08/99 - 09/08/99	-																				
NS-13	N	Imariwan	07/08/99 - 12/08/99	5	Sea bream	Yellowtail	Puffy fish	Horse mackerel		died	died	died	died		360,000 inds.	190,000 inds.	150, 000inds.	30, 000inds.	30, 000inds.	340,000	220,000	180,000	20,000	
FO-13	N	other	09/08/99 - 18/08/99	1	Abalone					died					5,100 inds.					74				
SA-10	N	Imariwan	10/08/99 - 16/08/99	15																				
SA-12	N	Imariwan	16/08/99 - 27/09/99	-																				
NS-24	remote Island	Tsushima	06/09/99 - 17/09/99	0.4																				
FO-16	N	Fukuokawan	07/09/99 - 13/09/99	40																				
NS-32	remote Island	Tsushima	09/12/99 - 21/12/99	0.07																				
YG-01	N	other	05/04/00	0.1																				
FO-02	N	other	23/05/00 - 26/05/00	under 1	Sea bream, Jackmackerel					died					unknown					unknown				
FO-04	N	other	01/06/00 - 06/06/00	unknown																				
FO-05	N	Fukuokawan	02/06/00 - 06/06/00	65																				
FO-06	N	Fukuokawan	13/06/00 - 19/06/00	60																				
SA-03	N	other	15/06/00 - 19/06/00	0.005																				
SA-04	N	other	18/06/00 - 26/06/00	0.3	Amberjacks					died					400 inds.					400				
SA-05	N	other	26/06/00 - 30/06/00	0.125																				
SA-06	N	Imariwan	27/06/00 - 27/07/00	4																				
FO-07	N	Fukuokawan	30/06/00 - 31/07/00	40																				
YG-02	N	other	06/07/00 - 03/08/00	unknown	Fishes, Abalone	Turban	Abalone	Turban	Turban	died	died	died	died	died	unknown		30 inds	800kg	2000kg	unknown				
SA-07	N	other	10/07/00 - 19/07/00	2																				
NS-09	N	other	11/07/00 - 12/07/00	0.01																				
FO-09	N	other	11/07/00 - 31/07/00	unknown	Abalone, Turban					died					unknown					unknown				
NS-10	N	Imariwan	13/07/00 - 22/07/00	16	Puffy fish					died					8,000 inds.					1,600				
NS-12	remote Island	Goto	26/07/00 - 17/08/00	2	Turban					died					400 kg	120 inds.				340	134			
FO-10	N	Fukuokawan	04/08/00 - 11/08/00	70																				
SA-10	N	Imariwan	18/08/00 - 11/09/00	unknown																				
NS-19	remote Island	Tsushima	21/08/00 - 24/08/00	0.2																				
FO-13	N	Fukuokawan	23/08/00 - 01/09/00	35																				
FO-14	N	Fukuokawan	08/09/00 - 12/09/00	unknown																				
NS-21	remote Island	Tsushima	18/09/00 - 25/09/00	0.0005																				
SA-11	N	Imariwan	27/09/00 - 29/09/00	12																				
NS-23	N	Imariwan	28/09/00 - 04/10/00	3																				
FO-15	N	Fukuokawan	07/11/00 - 11/11/00	unknown																				
NS-27	remote Island	Tsushima	08/11/00 - 15/11/00	14																				

Source : Kyushu Fishery Coordination Office, “Situation of Red Tide in the Seas surrounding Kyushu Island”, 1999-2003.

ii Red tide events in northern Kyushu coastal waters Inland during 1998-2002 (4)

Event No.	Location (name of the sea area)		Duration	Approximate Area suffered (km×km)	Fish/shellfish species					Contents					Quantity					Economic loss(thousand yen)				
	Location 1	Location 2	dd/mm/yy-dd/mm/yy		①	②	③	④	⑤	①	②	③	④	⑤	①	②	③	④	⑤	①	②	③	④	⑤
SA-01	N	Imariwan	21/01/01 - 25/01/01	unknown																				
YG-01	N	other	20/03/01 - 23/04/01	unknown																				
FO-01	N	other	21/03/01 - 22/03/01	0.4																				
FO-03	N	other	06/04/01 - 09/04/01	4																				
NS-03	remote Island	Goto	07/04/01 - 11/04/01	2																				
NS-04	N	Imariwan	10/04/01 - 13/04/01	0.1																				
NS-05	remote Island	Iki	17/04/01 - 20/04/01	0.3																				
NS-06	remote Island	Goto	17/04/01 - 18/04/01	58.7																				
FO-04	N	other	17/04/01 - 20/04/01	60																				
NS-07	remote Island	Tsushima	18/04/01 - 19/04/01	0.0025																				
NS-08	remote Island	Tsushima	18/04/01 - 19/04/01	0.01																				
SA-02	N	other	18/04/01 - 12/05/01	0.08																				
NS-09	remote Island	Iki	27/04/01 - 01/05/01	unknown																				
FO-05	N	Fukuokawan	06/05/01 - 14/05/01	70																				
SA-03	N	other	07/05/01 - 11/05/01	0.4																				
NS-12	remote Island	Goto	22/05/01 - 23/05/01	unknown																				
YG-02	N	other	28/05/01 - 31/05/01	unknown																				
NS-14	N	Imariwan	30/05/01 - 31/05/01	0.2																				
FO-09	N	other	05/06/01 - 11/06/01	0.001																				
YG-03	N	other	15/06/01	unknown																				
NS-19	N	Imariwan	20/06/01 - 26/06/01	0.4																				
FO-10	N	Fukuokawan	26/06/01 - 06/07/01	70																				
YG-04	N	other	27/06/01 - 10/07/01	unknown																				
NS-21	N	Imariwan	28/06/01 - 08/07/01	0.1																				
FO-12	N	Fukuokawan	09/07/01 - 23/07/01	80																				
NS-25	remote Island	Goto	19/07/01 - 24/07/01	unknown																				
YG-05	N	other	03/08/01	unknown																				
YG-06	N	other	06/08/01	0.02																				
NS-32	remote Island	Tsushima	06/09/01 - 07/09/01	0.12																				
FO-15	N	Fukuokawan	03/10/01 - 11/10/01	約10	Puffy fish	Amberjacks	Yellowtail	Fishes		died	died	died			226 kg	6 kg	3 kg			230	7	9		
FO-16	N	other	01/11/01	under 1																				
NS-40	remote Island	Tsushima	19/11/01 - 23/11/01	unknown																				
FO-18	N	other	21/11/01 - 22/11/01	under 1																				
NS-41	remote Island	Goto	03/12/01 - 05/12/01	0.15																				
NS-42	remote Island	Tsushima	10/12/01	0.07																				
NS-02	N	Imariwan	14/01/02 - 17/01/02	0.5																				
YG-01	N	other	13/03/02 - 22/04/02	185																				
FO-02	N	other	14/03/02	4																				
NS-04	remote Island	Goto	01/04/02 - 02/04/02	2.4																				
NS-06	remote Island	Goto	23/04/02	unknown																				
NS-07	remote Island	Iki	24/04/02 - 26/04/02	unknown																				
NS-10	remote Island	Goto	25/04/02 - 07/05/02	unknown																				
FO-03	N	Fukuokawan	07/05/02 - 17/05/02	70																				
FO-05	N	other	10/05/02 - 13/05/02	1																				
YG-02	N	other	14/05/02	0.001																				
NS-12	remote Island	Goto	17/05/02 - 22/05/02	0.4																				
YG-03	N	other	29/05/02 - 05/06/02	unknown																				
YG-04	N	other	06/06/02	unknown																				
NS-14	remote Island	Goto	10/06/02 - 15/06/02	unknown																				
FO-07	N	Fukuokawan	04/07/02 - 11/07/02	70																				
SA-06	N	other	05/07/02 - 13/07/02	0.3	Abalone	Turban				died	died				56 kg	130 kg				unknown	unknown			
FO-08	N	Fukuokawan	11/07/02 - 11/08/02	70																				
FO-09	N	other	11/07/02 - 02/08/02	1	Abalone					died					unknown					unknown				
SA-07	N	Imariwan	19/07/02 - 22/07/02	5	Amberjacks					died					200 inds					unknown				
NS-17	N	Imariwan	22/07/02	0.015																				
NS-20	remote Island	Goto	22/07/02 - 24/07/02	0.0025																				
SA-08	N	other	26/07/02 - 28/07/02	0.005																				
SA-09	N	Imariwan	26/07/02 - 27/07/02	0.06	Pearl shell					died					5, 000 inds.					unknown				
NS-23	N	other	30/07/02 - 31/07/02	0.001																				
FO-10	N	Fukuokawan	12/08/02 - 21/08/02	70																				
NS-26	remote Island	Goto	24/08/02 - 27/08/02	unknown	Amberjacks	Horse mackerel				died	died				9,280 inds.	620 inds.				29,044	1,240			
NS-27	remote Island	Tsushima	05/09/02 - 13/09/02	0.005																				
NS-28	remote Island	Tsushima	06/09/02 - 12/09/02	0.35																				
SA-12	N	other	09/09/02 - 14/09/02	0.005																				
NS-29	remote Island	Tsushima	10/09/02 - 13/09/02	0.0006																				
FO-12	N	Fukuokawan	19/09/02 - 24/09/02	70																				
SA-13	N	other	19/09/02 - 03/10/02	6.5																				
YG-05	N	other	24/09/02 - 01/10/02	unknown	Yellowtail					died					2,000 inds.					15,000				
NS-33	N	other	09/11/02 - 14/11/02	0.02																				
FO-15	N	Fukuokawan	02/11/04	70																				
YG-06	N	other	28/11/02	0.001																				
NS-36	remote Island	Goto	29/11/02 - 01/12/02	0.07																				
SA-17	N	other	09/12/02 - 28/12/02	4.16																				
YG-07	N	other	21/12/02	0.005																				

Source : Kyushu Fishery Coordination Office, “Situation of Red Tide in the Seas surrounding Kyushu Island”, 1999-2003.

densities of 10^5-10^7cells/L. Exposure to *Cochlodinium polykrikoides* caused extreme retardation of the metamorphosis to D-shaped larva.

Kim et al. (2000) found that living *Heterocapsa circularisquama* was toxic to a microzooplankton and the rotifer *Brachinus plicatilis*, unlike *Chattonella marina*, *Heterosigma akashiwo* and *Cochlodinium polykrikoides*. In addition to the well-known fact that *H. circularisquama* has lethal effects on shellfish, the species has detrimental effects on zooplankton and, consequently, on fish.

- Reference List -

- Matsuyama, Y., Usuki, H., Uchida, T., and Kotani, Y. (2001) Effects of harmful algae on the early planktonic larvae of the oyster, *Crassostrea gigas*. in "Harmful Algal Blooms 2000 (eds by G. M. Hallegraeff, S. I. Blackburn, C. J. Bolch and R. J. Lewis)", IOC of UNESCO, 411-414.
- Kim, D., Sato, Y., Oda, T., Muramatsu, T., Matsuyama, Y., and Honjo, T. (2000) Specific toxic effect of dinoflagellate *Heterocapsa circularisquama* on the rotifer *Brachionus plicatilis*. Biosci. Biotech. Biochem. 64 (12), 2719-2722.

5. Training to Cope with HABs

The following section describes the training activities conducted nationally and locally. It also describes the international programs attended by Japanese scientists.

5.1 Training on a Nationwide Basis

The non-profit organization JFRCA has conducted annual training courses to develop the capacity of technicians from fishery laboratories, etc. of concerned prefectural governments (Table 5.1). JFRCA is the only organization that has such a concrete training activity on a nationwide basis in Japan.

5.2 Training by Local Governments

Prefectural governments have also carried out training courses to educate the fishermen and general community. Table 5.2 shows an example of such an effort by a local government in 2004. Other prefectural governments have similar activities.

5.3 Participation in International Programs

Japanese scientists have helped organize and promote international programs for technical training relating to HABs. Some of these scientists give lectures to the trainees, but no Japanese trainees have participated in the international training programs to date. The Training Through Research (TTR) program planned by the Intergovernmental Oceanographic Commission subcommittee for the Western Pacific (IOC/WESTPAC) could be the first program to involve Japanese trainees.

Table 5.1 Training courses held by Japan Fisheries Resource Conservation Association (JFRCA) for technical improvement of red-tide and shell-poisoning research

Course No.	Objective	Trainee	Trainer	Period	Content	Problem
1	• Improvement of techniques • Homogenization of skill level throughout the country • Continuity of technical level	Personnel from local governments in charge of red tides/shellfish poisoning problems Fishermens' leaders	Experienced researchers from institutes of central governments, universities, etc.	5 days during October to December	Lectures • Target species: Dinophyceae, Raphidophyceae • Status of red tide and shellfish poisoning, and consequent damage • State-of-art of studies on red tides and shellfish poisoning • Life cycle and ecological features of causative species • Taxonomy and species identification of plankton Exercise • Sampling, sample preservation and concentration, species identification	• Continuous training is necessary for recently assigned people due to personnel transfers in local government • To consider the local features of red tides and shellfish poisoning • Advanced technology for sampling and analysis • Introduction of conventional methods to ensure continuous and economical performance
2	Dissemination of analytical methods using instruments	Personnel from local governments in charge of shellfish poisoning problem (beginners)	Experienced researchers from institutes of central government	3 days during September to October	Lectures • Status of shellfish poisoning • Analytical methods using instruments Exercise • Analyses using instruments	
3	Follow-up of trained skill	Personnel who had the training	-	30 min	Video explaining manuals for sampling, species identification and counting of cysts	
4	Support of training activity by local government	Personnel from local governments in charge of training of the local fishermen	-	30 min	Video explaining the role and significance of monitoring, and manuals for sampling, species identification and counting of cysts	
5	Support of training activity by local government	Personnel from local governments in charge of training of the local fishermen	-	-	Distribution and explanation of revised textbooks for species identification and analysis using instruments	

Source: Extract from monthly report of activities of the Japan Fisheries Resource Conservation Association

Table 5.2 An example of training activities by local governments

Course No.	Objective	Trainee	Period	Content	Achievement
1	Dissemination of: • Survey activities • Mitigation measures	Fishermen and the general community	3 days	Seminar on red-tide mitigation measures Seminar on the mechanism of red tides Exercise consisting of microscope work and counting of red-tide plankton	• Periodical monitoring commenced based on the monitoring manual and coordination between local government, municipal governments and related fisheries unions • Detection of red tides at early stages possible across extensive areas. • Positive participation of fishermen resulted in better understanding of red tides and minimized economic loss • Positive participation of fishermen became a model for dissemination to other areas
2	Enhancement of mitigation measures and monitoring schemes	Aquaculture operators	1 day	Seminar	
3	Enhancement of mitigation measures and monitoring schemes	Aquaculture operators	2 days	Seminar on fishery damage and mitigation measures using a video Microscope work on red-tide plankton	

Source: Nagasaki Prefecture official homepage (http://www.pref.nagasaki.jp/gyosei) and Ministry of the environment homepage (http://www.env.go.jp/policy/hakusyo/)

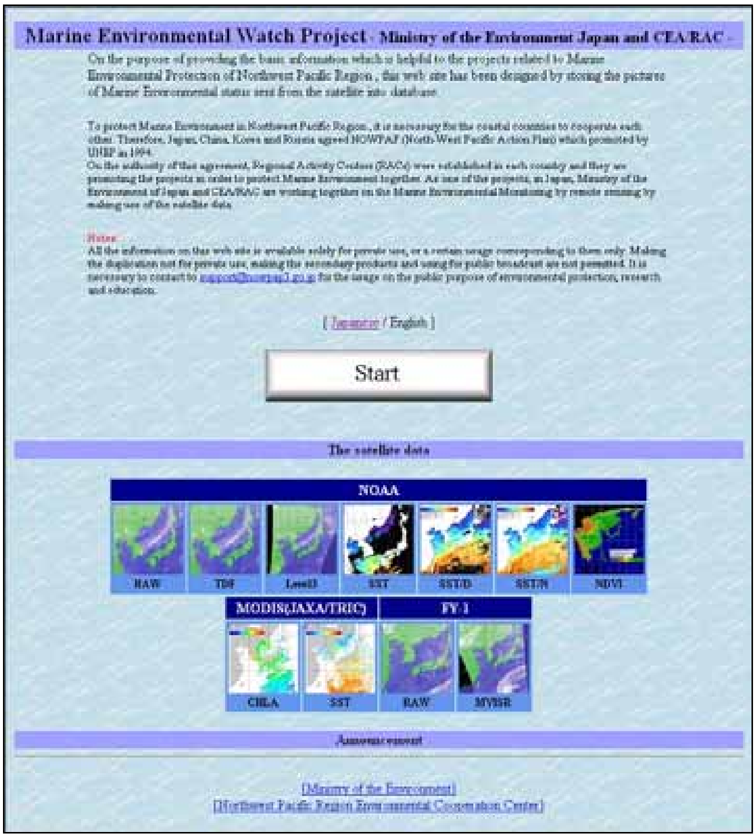
6. National Activity to Cope with HABs

This chapter introduces the activities that need to be taken by the Government of Japan to cope with HABs. These include remote sensing monitoring programs, cooperation with international organizations and so on. Some activities do not contribute to the HAB problem directly but treat HABs indirectly as a part of a wide variety of marine environmental problems. The Government of Japan does not prioritize activities concerning HABs.

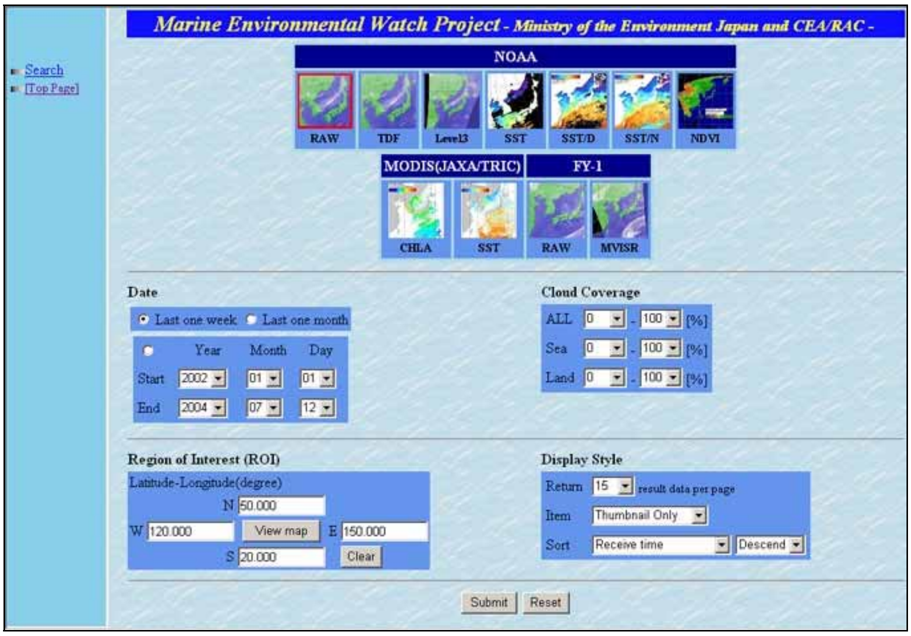
6.1 Promotion of Remote Sensing Monitoring Programs

Although the technology of satellite remote sensing does not currently clearly detect red tides, it is expected that it will become a useful tool for observing HABs. Thus, the Government of Japan promotes remote sensing programs in order to monitor the marine environment widely and to produce data for studying the ability to monitor red tides by satellite remote sensing.

The Ministry of the Environment of Japan (MOEJ) has developed a satellite remote sensing monitoring project called the 'Marine Environmental Watch Project', and has monitored the marine environment of the NOWPAP region since 2000. This program provides satellite images of cloud cover, Sea Surface Temperature (SST), Normalized Difference Vegetation Index (NDVI), and chlorophyll-a, which are detected by National Oceanic and Atmospheric Administration (NOAA), Feng Yun-1 (FY-1) and Moderate Resolution Imaging Spectrometer (MODIS). The data are presented in a website (http://www.nowpap3.go.jp/jsw/), as shown in Figure 6.1. MODIS chlorophyll-a and SST products may help in monitoring red tides in the future. MOEJ will utilize this system to help with NOWPAP/CEARAC activities, which treat the problem of HABs.



(a). Home page (http://www.nowpap3.go.jp/jsw/)



(b). Data search （http://www.nowpap3.go.jp/jsw/index.php?lang=en）

Figure 6.1　Marine Environmental Watch Project

The Japanese Coast Guard has also constructed a system to provide marine environmental information related to the red-tide phenomenon. Figure 6.2 shows a website of the database of this system. The system is monitoring seven oceanic indices, including chlorophyll-a concentration (CHLA), water surface temperature, colored dissolved organic matter (CDOM), attenuation coefficient K490, suspended solids (SS), normalized water-leaving radiance (nLw), and surface albedo by the earth observation satellites, Terra and Aqua. Currently, the system provides data of those oceanic indices only in Tokyo Bay. The Japanese Coast Guard is making plans to monitor other areas. Toyama Bay is one candidate area for monitoring in the NOWPAP region.

Figure 6.2 Website of Remote Sensing Database of the Japanese Coast Guard
(http://www1.kaiho.mlit.go.jp/KANKYO/SAISEI2/saisei_html/top.htm) (Only in Japanese)

6.2 Cooperation with International Organizations

The Government of Japan supports the activities of international organizations related to the problem of HABs. The Action Plan for the Protection, Management and Development of the Marine and Coastal Environment of NOWPAP and the Intergovernmental Oceanographic Commission (IOC) have special activities or programs concerning HAB problems.

NOWPAP is one of the Regional Seas Programs of the United Nations Environment Programme (UNEP). NOWPAP established The Special Monitoring & Coastal Environmental Assessment Regional Activity Centre (CEARAC) in 1999 at Toyama, Japan. CEARAC set the first target for the coastal environmental assessment on HABs. MOEJ has contributed human resources to the activity of CEARAC through the Northwest Pacific Region Environmental Cooperation Center (NPEC), which was approved in 1998 as a legally incorporated foundation under the jurisdiction of the MOEJ.

IOC/WESTPAC has a HAB Program. The program aims at providing capacity building and producing documents related to HABs. The Government of Japan supports a series of annual courses for Member States to develop their capacity building and participation in the activities of the program. IOC/WESTPAC also conducts a NEAR-GOOS program, a North-East Asian Regional (NEAR) program of the Global Ocean Observing System (GOOS) implemented by China, Japan, Korea and Russia. The Government of Japan expects the NEAR-GOOS program to help study HABs in the future.

North Pacific Marine Science Organization (PICES) has made various efforts related to HAB problems. Currently, it is very eager to establish a common database for the analysis of coastal HAB events. At a joint PICES/IOC Workshop called ‘Harmful algae blooms – Harmonization of data’ in 2003, PICES member countries accepted an offer from IOC/International Council for the Exploration of the Sea (ICES) to utilize their successful harmful algal event meta-database (HAE-DAT) format. PICES member countries are checking the usability and effectiveness of the HAE-DAT format.

6.3 Other Activities Related to HABs

The Government of Japan has conducted activities concerning HABs, such as the development of an information network system of red tides and shellfish poisoning, and a study on mitigation measures of shellfish poisoning.

The Fisheries Agency of Japan has prepared a network system of information on red tide and shellfish poisoning using the internet (http://turtle.jfrca.or.jp/akashiwo.html). This system provides information on past red tides in selected enclosed bays and inland seas, and the occurrence of shellfish poisoning in all Japanese fisheries and aquaculture industries. The website of the system introduces local governments' websites, and also presents up-to-date information on red tides and shipping prohibitions of poisoned shellfish. Although this system does not cover the whole NOWPAP region, users who are interested in HABs in the region can obtain some information along the coastal areas of four prefectures (red tides: Yamaguchi, Fukuoka, Saga Prefecture; shipping inhibition of poisoned shellfish: Shimane, Fukuoka Prefecture).

In order to develop mitigation measures against shellfish poisoning, the Fisheries Agency of Japan is studying shellfish poisoning mechanisms as well as inspection and monitoring schemes. Some laboratories under the agency investigate viruses to be used against toxin producing plankton as an optional mitigation measure.

7. Suggested Activity for the NOWPAP Region

This chapter suggests action against the problem of *Cochlodinium*, cooperation with other organizations, and promotion of land based activities for the NOWPAP region in the near future. These three kinds of activities are proposed because *Cochlodinium* not only causes adverse effects on fisheries and aquacultures in Japan and Korea, but could possibly affect NOWPAP countries in future. Needless to say, it is important for NOWPAP to work together and exchange information with other organizations. The promotion of effective pollution control on human land-based activity should be considered in conjunction with analyses of HABs in the NOWPAP Region.

7.1 Action Against the Problem of *Cochlodinium*

A working group under CEARAC has agreed that *Cochlodinium* is one of the harmful algae of most concern for the NOWPAP region. This species is causing suffering in the aquaculture industry, especially in Japan and Korea. For example, about 250,000 farmed sea bream in Uwakai (in Ehime Prefecture) and about US$1,000,000 were lost from a *Cochlodinium polykrikoides* bloom on July 22, 2004. The damage to fisheries has been reported not only in the NOWPAP region but also in Southeast Asia. *Cochlodinium* has only recently been recognized as a threat, so that the study of this species is less advanced than that of other toxin-producing plankton. CEARAC, under NOWPAP, established a group to study *Cochlodinium*, called the ‘*Cochlodinium* Corresponding Group (CCG)’. The aim of this study group is to produce a set of useful information on *Cochlodinium* and help policy makers concerned with coastal fisheries.

7.2 Cooperation with Other Organizations

NOWPAP may cooperate with the other UNEP Action Plans in the Regional Seas Programme, such as the East Asia Seas Action Plan. The problem of *Cochlodinium* has recently appeared in Southeast Asia. *Hetrocapsa circularisquama* is thought to be transported by southern tropical/subtropical seas. Therefore, cooperation with other UNEP Action Plans is useful for NOWPAP.

IOC/WESTPAC is establishing a Training Through Research (TTR) program about HAB species. NOWPAP/CEARAC also has established the

CCG, mentioned in the above section. WESTPAC/TTR and CCG may organize the joint programs to cope with *Cochlodinium*, and to exchange information on the species and related activities.

In addition, NOWPAP has to be careful not to make its activity plan duplicate to that of other organizations. NOWPAP should exchange information with other organizations in order to make efficient plans to cope with HABs.

7.3 Promotion of Measures for Land-based Activities

NOWPAP/CEARAC presently approaches the problem of HABs mostly from the point of view of oceanography and marine ecology. However, it is important to control human land-based activities, which discharge enormous amounts of nutrients into the sea. Japan has the experience to overcome water pollution by implementing appropriate pollution abatement policies and technologies, and has monitored effluents for a long time. Therefore, using the experience and technology of Japan, NOWPAP monitoring plans and pollution prevention policies about human land-based activities should be considered.

References

1. Kyushu Fishery Coordination Office. (1998-2002) Situation of Red Tide in the Seas surrounding Kyushu Island.
2. Japan Fisheries Resource Conservation Association. (1999-2002) Monitoring Report on Shellfish Poisoning in Japanese Fishery Products.
3. Aomori Prefecture. (2002) Annual Report of Aomori Prefectural Fisheries Research Center Aquaculture Institute., No.33.
4. Akita Prefecture. (2001) Annual Report of Akita Prefectural Fisheries Research and Development Center.
5. Niigata Prefecture. (2001) Annual Report of Niigata Prefectural Fisheries and Marine Research Institute.
6. Niigata Prefecture. (1991) Report on red tide mitigation program.
7. Toyama Prefecture. (2002) Bull. Toyama Pref. Fish. Res. Inst., No.14.
8. Ishikawa Prefecture. (2001) Bull. Ishikawa Pref. Fish. Res. Center., 3.
9. Shimane Prefecture. (2002) Annual Report of Shimane Prefectural Institute of Fisheries.
10. Yamaguchi Prefecture. (2002) Annual Report of Yamaguchi Pref. Fish. Res. Center.
11. Fukuoka Prefecture. (2002) Bull. Fukuoka Fisheries Mar. Technol. Res. Cent., No.12.
12. Saga Prefecture. (2002) Annual Report of Saga Prefectural Genkai Fisheries Research and Development Center.
13. Nagasaki Prefecture. (1999) Bulletin of Nagasaki Prefectural Institute of Fisheries., No.25.
14. Kagoshima Prefecture. (2001) Annual Report of Kagoshima Prefectural Institute of Fisheries.
15. Nagasaki Prefecture official homepage. (http://www.pref.nagasaki.jp/gyosei)
16. Ministry of the Environment homepage. (http://www.env.go.jp)
17. Ministry of Environment. (2004) Environment White paper.
18. The Fisheries Agency. (2004) Fisheries White paper.
19. Special Monitoring & Coastal Environmental Assessment Regional Activity Centre (CEARAC) homepage. (http://cearac.nowpap.org/nowpap/coverage.html)
20. Ministry of the Environment and CEARAC, Marine Environmental Watch Project. (http://www.nowpap3.go.jp/jsw/), (http://www.nowpap3.go.jp/jsw/index.php?lang=en)
21. Northwest Pacific Region Environmental Cooperation Center (NPEC) homepage. (http://www.npec.or.jp/)
22. Hydrographic and Oceanographic Department Japan Coast Guard homepage. (http://www1.kaiho.mlit.go.jp/KANKYO/SAISEI2/saisei_html/top.htm)
23. Japan Fisheries Resource Conservation Association, Network System of Information on Red tide and Shellfish Poisoning. (http://turtle.jfrca.or.jp/akashiwo.html)
24. Yamamoto, M. and Yamasaki, M. (1996) Japanese monitoring system on shellfish toxins. in "Harmful and Toxic Algal Blooms (eds by T. Yasumoto, Y. Oshima and Y. Fukuyo)", IOC of UNESCO, 19-22.
25. Yamaguchi, M., Itakura, S. and Imai, I. (1995) Vertical and horizontal distribution and abundance of resting cysts of the toxic dinoflagellate *Alexandrium tamarense* and *Alexandrium catenella* in sediments of Hiroshima Bay, the Seto Inland Sea, Japan. Nippon Suisan Gakkaishi, 61 (5), 700-706.

26. Yamaguchi, M., Itakura, S., Nagasaki, K. and Imai, I. (1996) Distribution and abundance of resting cysts of the toxic dinoflagellates *Alexandrium tamarense* and *A. catenella* in sediments of the eastern Seto Inland Sea, Japan. in "Harmful and Toxic Algal Blooms (eds by T. Yasumoto, Y. Oshima and Y. Fukuyo)", IOC OF UNESCO, 177-180.
27. Kotani, Y., Koyama, A., Yamaguchi, M. and Imai, I. (1998) Distribution of resting cysts of the toxic dinoflagellates *Alexandrium catenella* and/or *A. tamarense* in the coastal areas of western Shikoku and Kyushu, Japan. Bull. Jpn. Soc. Fish. Oceanogr., 62 (2), 104-111.
28. Itakura, S. and Yamaguchi, M. (2001) Germination characteristics of naturally occurring cysts of *Alexandrium tamarense* (Dinophyceae) in Hiroshima Bay, Inland Sea of Japan., PYCOA., 40, 263-267.
29. Nagai, S. and Imai, I. (2001) Relationships between *Coscinodiscus wailesii* and bacteria promoting its sperm formation in the coastal area, Japan., in "Proceedings of the 16th International Diatom symposium, (eds by Economou-Amilli, A.)", University of Athens, Greece, 213-223.
30. Yamaguchi, M., Itakura, S., Nagasaki, K. and Kotani, Y. (2002) Distribution and abundance of resting cysts of the toxic *Alexandrium* spp. in sediments of the western Seto Inland Sea, Japan. Fish. Sci., 68, 1012-1019.
31. Itakura, S., Yamaguchi, M., Yoshida, M. and Fukuyo, Y. (2002) The seasonal occurrence of *Alexandrium tamarense* (Dinophyceae) vegetative cells in Hiroshima Bay, Japan. Fish. Sci., 68, 77-86.
32. Suzuki, T. (1994) High-performance liquid chromatographic resolution of dinophysistoxin-1 and free fatty acids as 9-anthrylmethylesters. J. Chromatogr. A, 677, 301-306.
33. Suzuki, T. and Matsuyama, Y. (1995) Determination of free fatty acids in marine phytoplankton causing red tides by fluorometric High -performance Liquid chromatography. JAOCS., 72 (10), 1211-1214.
34. Suzuki, T., Beuzenberg, V., Mackezie, L. and Quilliam, M. A. (2003) Liquid chromatography-mass spectrometry of spiroketal stereoisomers of pectenotoxins and the analysis of novel pectenotoxin isomers in the toxic dinoflagellate *Dinophysis acuta* from New Zealand. J. Chromatogr. A, 992, 141-150.
35. Kim, C. H., Sako Y. and Ishida, Y. (1992) Comparison of toxin composition between populations of *Alexandrium* spp. from geographically distant areas. Bull. Jpn. Soc. Sci. Fish., 59 (4), 641-646.
36. Oshima, Y., Hayakawa, T., Hashimoto, M., Yasumoto, T. and Kotaki, K. (1982) Classification of *Protogonyaulax tamarensis* from northern Japan into three strains by toxin composition. Bull. Jpn. Soc. Sci. Fish., 48 (6), 851-854.
37. Oshima, Y., Blackburn, S. I., and Hallegraeff, G. M. (1993) Comparative study on paralytic shellfish toxin profiles of the dinoflagellate *Gymnodinium catenatum* from three different countries. Mar. Biol., 116 (3), 471-476.
38. Kim, D., Sato, Y., Miyazaki, Y., Oda, T., Muramatsu, T., Matsuyama, Y., Honjo, T., (2002) Comparison of hemolytic activities among strains of *Heterocapsa circularisquama* isolated in various locatities in Japan. Biosci. Biotechnol. Biochem., 66 (2), 453-457.

39. Nagai, S., Lian, C., Hamaguchi, M., Matsuyama, Y., Itakura, S. and Hogetsu, T., (2004) Development of microsatellite markers in the toxic dinoflagellate *Alexandrim tamarense* (Dinophyceae)., Molecular Ecology Notes, 83-85.
40. Nagasaki, K., Tarutani, K., and Yamaguchi, M. (1999) Growth characteristics of *Heterosigma akashiwo* virus and its possible use as a microbiological agent for red tide control. App. Environ. Microbiol., 65 (3), 898-902.
41. Tarutani, K., Nagasaki, K. and Yamaguchi, M. (2000) Viral impacts on total abundance and clonal composition of the harmful bloom-forming phytoplankton *Heterosigma akashiwo*. App. Environ. Microbiol., 66 (11), 4916-4920.
42. Tarutani, K., Nagasaki, K., Itakura, S. and Yamaguchi, M. (2001) Isolation of a virus infecting the novel shellfish-killing dinoflagellate *Heterocapsa circularisquama*., Aquat. Microb. Ecol., 23, 103-111.
43. Nagasaki, K., Tamaru, Y., Nakanishi, K., Hata, N., Katanozaka, N. and Yamaguchi, M. (2004) Dynamics of *Heterocapsa circularisquama* (Dinophyceae) and its viruses in Ago Bay, Japan. Aquat. Microb. Ecol., 34, 219-226.
44. Tamaru, Y., Tarutani, K., Yamaguchi, M., and Nagasaki, K. (2004) Quantitative and qualitative impacts of viral infection on a *Heterosigma akashiwo* (Raphidophyceae) bloom in Hiroshima Bay, Japan. Aquat. Microb. Ecol., 34, 227-238.
45. Japan Fisheries Information Service Center. (2002) Studies on prediction method of marine coastal ecosystem utilizing satellite information and neural network. (Sponsored by The Nippon Foundation)

Appendices

i Abbreviations
ii Red-tide events in northern Kyushu coastal waters Inland during 1998-2002
iii List of references stored in HAB Reference Database since 2000

i Abbreviations

- CCG: *Cochlodinium* Corresponding Group
- CEARAC: Coastal Environmental Assessment Regional Activity Center
- DSP: Diarrhetic Shellfish Poisoning
- FY-1: Feng Yun-1
- GOOS: Global Ocean Observing System
- HAB: Harmful algae blooms
- ICES: International Council for the Exploration of the Sea
- IOC: Intergovernmental Oceanographic Commission
- JFRCA: Japan Fisheries Resource Conservation Association
- MODIS: Moderate Resolution Imaging Spectrometer
- MOEJ: Ministry of the Environment of Japan
- NEAR-GOOS: North-East Asian Regional Global Ocean Observing System
- NDVI: Normalized Difference Vegetation Index
- NOAA: National Oceanic and Atmospheric Administration
- NOWPAP: Northwest Pacific Action Plan
- PICES: North Pacific Marine Science Organization
- PSP: Paralytic Shellfish Poisoning
- SST: Sea Surface Temperature
- TTR: Training Through Research
- UNEP: United Nations Environment Programme
- WESTPAC: IOC Sub-Commission for the Western Pacific
- WG3: Working Group 3

ii Red-tide events in northern Kyushu coastal waters Inland during 1998-2002 iii List of references stored in the HAB Reference Database since 2000

- Fukuyo, Y., Imai, I., Kodama, M. and Tamai, K. (2002) Red tides and other harmful algal blooms in Japan. in "Harmful Algal blooms in the PICES Region of the North Pacific (eds by F. J. R. "Max" Taylor and V. L. Trainer)", PICES Scientific Report, No.23, North Pacific Marine Science Organization, 7-20.
- Yamasaki, M. and Tomosada, A. (2001) Prediction of blooms of toxic dinoflagellates by evaluating environmental factors. in "Harmful Algal Blooms 2000 (eds by G. M. Hallegraeff, S. I. Blackburn, C. J. Bolch and R. J. Lewis)", IOC of UNESCO, 182-185.
- Khan, S., Ono, K., Haruyama, M., Iwashita, T. and Onoue, Y. (2001) Environmental factors affecting the neurotoxin production of *Chattonella antiqua* (Raphidophyceae). in "Harmful Algal Blooms 2000 (eds by G. M. Hallegraeff, S. I. Blackburn, C. J. Bolch and R. J. Lewis)", IOC of UNESCO, 308-310.
- Oda, T., Kim, D., Nakamura, A., Okamoto, T., Komatsu, N., Iida, T., Ishimatsu, A. and Muramatsu, T. (2001) Involvement of NADPH oxidase-like enzyme in the production of superoxide anion by *Chattonella marina*. in "Harmful Algal Blooms 2000 (eds by G. Hallegraeff, S. I. Blackburn, C. J. Bolch and R. J. Lewis)", IOC of UNESCO, 312-315.
- Suzuki, T., Ota, H. and Yamasaki, M. (2001) Dinophysistoxin-1 and esterified dinophysistoxin-1 in the mussel *Mytilus galloprovincialis* fed on the toxic dinoflagellate *Dinophysis fortii*. in "Harmful Algal Blooms 2000 (eds by G. Hallegraeff, S. I. Blackburn, C. J. Bolch and R. J. Lewis)", IOC of UNESCO, 367-370.
- Ito, E., Satake, M., Ofuji, K., McMahon, T., Silke, J., James, K. and Yasumoto, T. (2001) Small intestinal injuries in mice caused by a new toxin, azaspiracid, isolated from Irish mussel. in "Harmful and Toxic Algal Blooms (eds by T. Yasumoto, Y. Oshima. and Y. Fukuyo)", IOC of UNESCO, 395-398.
- Imada, N., Honjo, T., Shibata, H., Oshima, Y., Nagai, K., Matsuyama, Y. and Uchida, T. (2001) The quantities of *Heterocapsa circularisquama* cells transferred with shellfish consignments and the possibility of its establishment in new areas. in "Harmful Algal Blooms 2000 (eds by G. Hallegraeff, S. I. Blackburn, C. J. Bolch and R. J. Lewis)", IOC of UNESCO, 474-476.
- Matsuyama, Y., Usuki, H., Uchida, T. and Kotani, Y. (2001) Effects of harmful algae on the early planktonic larvae of the oyster, *Crassostrea gigas*. in "Harmful Algal Blooms 2000 (eds by G. Hallegraeff, S. I. Blackburn, C. J. Bolch and R. J. Lewis)", IOC of UNESCO, 411-414.
- Ito, E. and Nagai, H. (2000) Bleeding from the small intestine caused by aplysiatoxin, the causative agent of the red alga *Gracilaria coronopifolia* poisoning. Toxicon, 38, 123-132.
- Ito, E., Satake, M., Ofuji, K., McMahon, T., James, K. and Yasumoto, T. (2000) Multiple organ damage caused by a new toxin azaspiracid, isolated from mussels produced in Ireland. Toxicon, 38, 917-930.
- Nagai, S. and Imai, I. (2000) Relationships between *Coscinodiscus wailesii* and bacteria promoting its sperm formation in the coastal area, Japan 16TH

International Diatom Symposium, 25 Aug.-1 Sept. 2000, Athens & Aegean Islands Proceedings 2001 (A. Economou-Amilli, ED.),601 pp., University of Athens, Greece.

- Imai, I. (2003) Life history of raphidophycean flagellates (Chapter 3 Biological Character of Red-Tide Organisms). in "Red TIdes (eds by T. Okaichi)", 111-127, References 174-176.
- Nishitani, G., Sugioka, H. and Imai, I. (2002) Seasonal distribution of species of the toxic dinoflagellate genus *Dinophysis* in Maizuru Bay (Japan), with comments on their autofluorescence and attachment of picophytoplankton. Harmful Algae, 1, 253-264.
- Imai, I., Sunahara, T., Nishikawa, T., Hori, Y., Kondo, R. and Hiroishi, S. (2001) Fluctuations of the red tide flagellates *Chattonella* spp. (Raphidophyceae) and the algicidal bacterium *Cytophaga* sp. in the Seto Inland Sea, Japan. Mar. Biol., 138, 1043-1049.
- Imai, I., Sugioka, H., Nishitani, G., Mitsuya, T. and Hamano, Y. (2003) Monitoring of DSP toxins in small-sized plankton fraction of seawater collected in Mutsu Bay, Japan, by ELISA method: relation with toxin contamination of scallop. Mar. Pollut. Bull., 47, 114-117.
- Imai, I., Fujimaru, D. and Nisigaki, T. (2002) Co-culture of fish with macroalgae and associated bacteria: A possible mitigation strategy for noxious red tides in enclosed coastal sea. Fish. Sci., 68 (supplement), 493-496.
- Kobayashi, S., Kojima, N., Itakura, S., Imai, I. and Matsuoka, K. (2001) Cyst morphology of a chain-forming unarmored dinoflagellate *Gyrodinium impudicum* Fraga et Bravo. Phycol. Res., 49, 61-65.
- Kondo, R. and Imai, I. (2001) Polymerase chain reaction primers for highly selective detection of algicidal *Proteobacteria*. Fish. Sci., 67 (2), 364-366.
- Nishitani, G., Miyamura, K. and Imai, I. (2003) Trying to cultivation of *Dinophysis caudata* (Dinophyceae) and the appearance of small cells. Plankton Biol. Ecol. 50 (2), 31-36.
- Imai, I. and Nishitani, G. (2000) Attachment of picophytoplankton to the cell surface of the toxic dinoflagellates *Dinophysis acuminata* and *D. fortii*. PYCOA., 39 (5), 456-459.
- Maki, T. and Imai, I. (2001) Relationships between intracellular bacteria and the bivalve killer dinoflagellate *Heterocapsa circulafisquama* (Dinophyceae). Fish. Sci., 67 (5), 794-803.
- Nagasaki, K., Yamaguchi, M. and Imai, I., (2000) Algicidal Activity of a Killer Bacterium against the Harmful Red Tide Dinoflagellate *Heterocapsa circularisquama* Isolated from Ago Bay, Japan. Nippon Suisan Gakkaishi 66(4), 666-673.
- Imai, I. (2000) Current problems in classification and identification of marine raphidoflagellates (raphidophycean flagellates): from the view point of ecological study. Bull. Plankton Soc. Japan, 47 (1), 55-64.
- Maki, T. and Imai, I. (2001) Effects of Harmful Dinoflagellate *Heterocapsa circularisquama* Cells on the Growth of Intracellular Bacteria. Microb. Environ., 16 (4), 234-239.

- Nagayama, K., Shibata, T., Fujimoto, K., Honjo, T., Nakamura, T. (2003) Algicidal effect of phlorotannins from the brown alga *Ecklonia kurome* on red tide microalgae. AQCLAL., 218 (1-4), 601-611.
- Kim, D., Sato, Y., Oda, T., et al. (2000) Specific toxic effect of dinoflagellate *Heterocapsa circularisquama* on the rotifer *Brachionus plicatilis*. Biosci. Biotechnol. Biochem., 64 (12), 2719-2722.
- Matsuoka, K., Iwataki, M. (2004) Present status in study on a harmful unarmored dinoflagellate *Cochlodinium polykrikoides* Margalef. Bull. Plankton Soc. Japan, 51 (1), 38-45.
- Kim, D., Oda, T., Muramatsu, T., Kim, D., Matsuyama, Y. and Honjo, T. (2002) Possible factors responsible for the toxicity of *Cochlodinium polykrikoides*, a red tide phytoplankton. Comp. Biochem. Physiol., 132 (4), 415-423.
- Sengco, M. R. and Anderson, D. M. (2004) Controlling harmful algal blooms through clay flocculation. J. Eukaryot. Microbiol., 51 (2), 169-172.
- Oda, T., Sato, Y., Kim, D., Muramatsu, T., Matsuyama, Y., Honjo, T. (2001) Hemolytic activity of *Heterocapsa circularisquama* (Dinophyceae) and its possible involvement in shellfish toxicity. J. Phycol., 37 (4). 509-516.
- Kim, D. I., Matsuyama, Y., Nagasoe, S., Yamaguchi, M., Yoon, Y. H., Oshima, Y., Imada, N., and Honjo, T. (2004) Effects of temperature, salinity and irradiance on the growth of the harmful red tide dinoflagellate *Cochlodinium polykrikoides* Margalef (Dinophyceae). J. Plankton Res., 26 (1), 1-6.
- Nagai, S., Matsuyama, Y., Takayama, H. and Kotani, Y. (2002) Morphology of *Polykrikos kofoidii* and *P. schwartzii* (Dinophyceae, Polykrikaceae) cysts obtained in culture. PYCOA., 41 (4), 319-327.
- Jeong, S. Y., Ishida, K., Ito, Y., Okada, S. and Murakami, M. (2003) Bacillamide, a novel algicide from the marine bacterium, *Bacillus* sp. SY-1, against the harmful dinoflagellate, *Cochlodinium polykrikoides*. Tetrahedron Lett., 44 (43), 8005-8007.
- Yamatogi, T., Maruta, H., Ura, K. (2002) Occurrence of *Cochlodinium polykrikoides* Red Tide and its Growth Characteristics in Imari bay in 1999. Bull. Nagasaki Pref. Inst. Fish., 28, 21-26.
- Suzuki, T., Beuzenberg, V., Mackezie, L. and Quilliam, M. A. (2003) Liquid chromatography-mass spectrometry of spiroketal stereoisomers of pectenotoxins and the analysis of novel pectenotoxin isomers in the toxic dinoflagellate *Dinophysis acuta* from New Zealand. J. Chromatogr. A, 992, 141-150.
- Tarutani, K., Nagasaki, K. and Yamaguchi, M. (2000) Viral impacts on total abundance and clonal composition of the harmful bloom-forming phytoplankton *Heterosigma akashiwo*. App. Environ. Microbiol., 66 (11), 4916-4920.
- Nagasaki, K., Tamaru, Y., Nakanishi, K., Hata, N., Katanozaka, N. and Yamaguchi, M. (2004) Dynamics of *Heterocapsa circularisquama* (Dinophyceae) and its viruses in Ago Bay, Japan. Aquat. Microb. Ecol., 34, 219-226.
- Tamaru, Y., Tarutani, K., M. Yamaguchi, M. and Nagasaki, K. (2004) Quantitative and qualitative impacts of viral infection on a *Heterosigma akashiwo* (Raphidophyceae) bloom in Hiroshima Bay, Japan. Aquat. Microb. Ecol., 34, 227-238.

- Tarutani, K., Nagasaki, K., Itakura, S. and Yamaguchi, M. (2001) Isolation of a virus infecting the novel shellfish-killing dinoflagellate *Heterocapsa circularisquama.* Aquat. Microb. Ecol., 23, 103-111.