Annex VI-2

Draft National Report on HAB in Japan

(Submitted in the Second Meeting of NOWPAP WG3)

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Ⅰ. INTRODUCTION

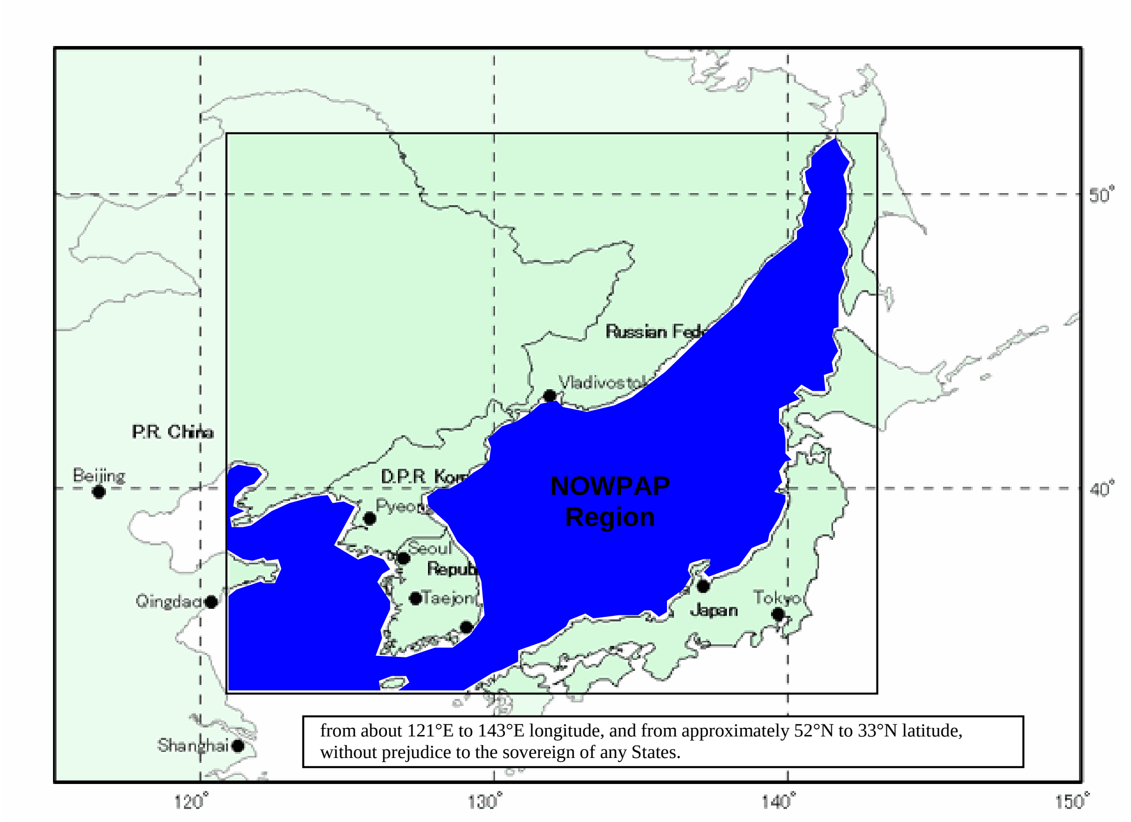
Harmful Algal Blooms (HABs) include red tides and toxin-producing plankton blooms. Most of red tides are harmless in terms of the survival of the aquatic lives. Harmless red tides, however, cause the deterioration of the aquatic environment indirectly through the decrease of dissolved oxygen in the bottom layer due to the decomposition of the dead plankton by bacteria. HABs in this report, therefore, encompass both harmful and harmless red tides, and toxin-producing plankton blooms. This is in accordance with the definition of HAB that was agreed by WG3 Members at the meeting in Busan, October 2003.

HABs tend to occur in the enclosed coastal area more often, and to be observed in the aquaculture area more frequently, causing serious damage on fishery production through mass mortality of fish and shellfish, and on human health through fish/shellfish poisoning. The solution of these problems in NOWPAP Region needs close coordination within WG Members in the Region. It is essential to have a common platform to develop the research, mitigation measures and proper political proposals.

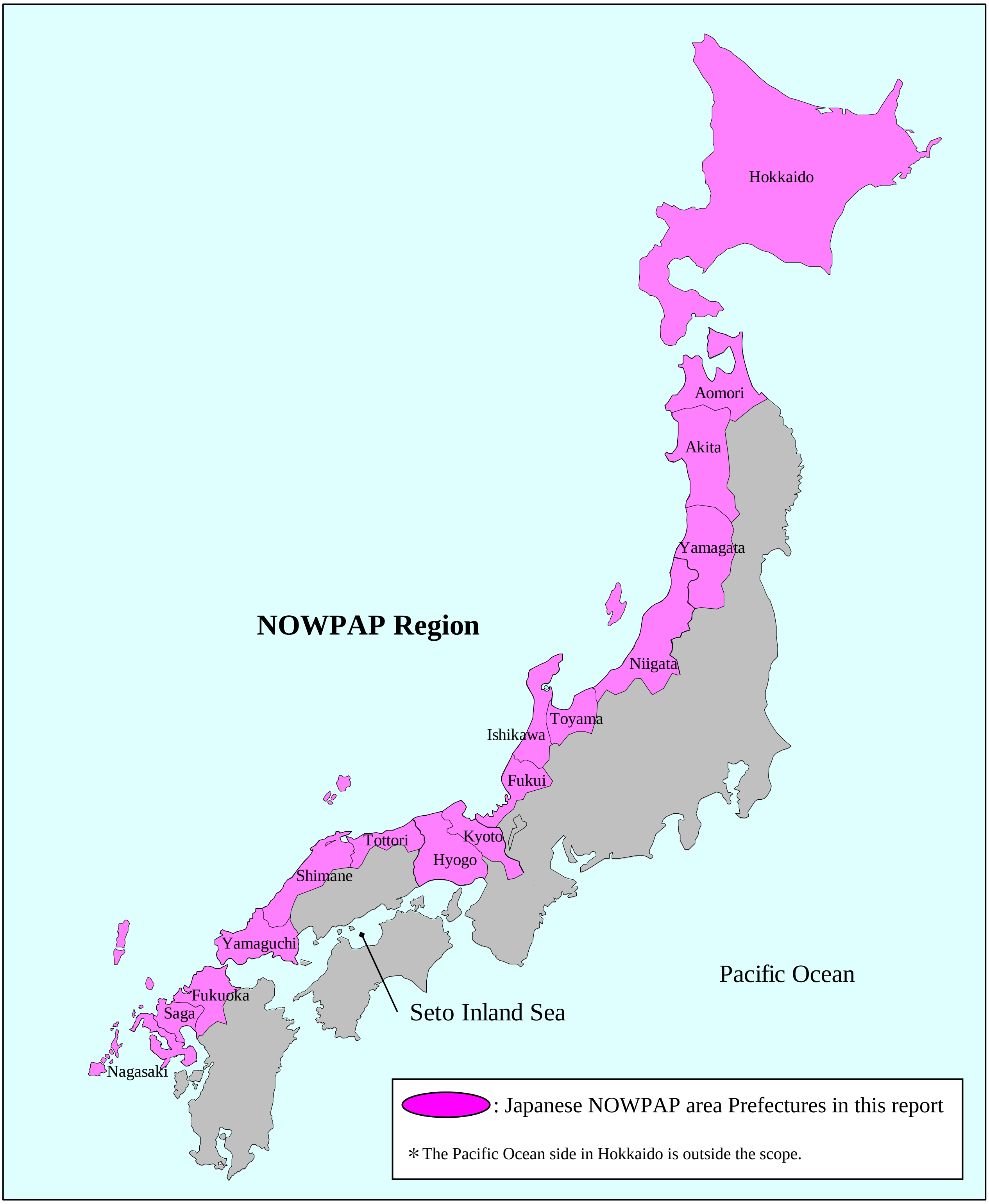
The national report is prepared in this context. In the WG 3 Meeting held in Busan, October 2003, guidelines for preparation of national report were proposed to prepare required information in a common format, which may make the compilation of Integrated Report easier. The present report was compiled following the guidelines with some modification. Considering the requirement of the guidelines, this was prepared using existing data and information, and results of interviews with researchers and relevant organizations.

There are some possibilities of eutrophication and HAB occurrence in the Japanese NOWPAP area, although, as shown in figure in the next page, the area does not have extensive enclosed sea areas nor active aquaculture grounds that much data and information on HAB are tend to be accumulated, unlike in Seto Inland Sea and the Pacific Ocean side of Japan. Since information on HABs in Japanese NOWPAP area has not been supplied sufficiently so far, the present report, therefore, can be used as the basis to develop the complete understandings on HABs in NOWPAP Region.

In this report, the scientific name of the organisms that the source reference used were cited as they were.



Geographic coverage of NOWPAP Region


Hokkaido
Aomori
Akita
Yamagata
NOWPAP Region
Niigata
Toyama
Ishikawa
Fukui
Kyoto
Tottori
Hyogo
Shimane
Yamaguchi
Fukuoka
Saga
Nagasaki
Seto Inland Sea
Pacific Ocean
: Japanese NOWPAP area Prefectures in this report
＊The Pacific Ocean side in Hokkaido is outside the scope.

Map of Japan

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 disclosed were also provided by courtesy of such organizations.

1. Situation of HAB Occurrence

Two types of HAB are known to occur in the Japanese coastal waters. The first type is red tide, some of which cause mass mortality of fish and shellfish. The second type is blooming of toxin-producing phytoplankton. In this report, Red tide and Toxin-producing Plankton are discussed separately.

1.1 Red Tide

"Situation of Red Tide in the Seas surrounding Kyushu Island" is a report published annually on the red tide occurrence. It is published from Kyushu Fishery Coordination Office annually, though in Japanese only, covering red tide events that appear in coastal waters of Kyushu Island. The data of this report is originated from the questionnaire/interviews to fishery laboratories of local governments 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

"Monitoring Report on Shellfish Poisoning in Japanese Fishery Products" was used. It is published by Japan Fisheries Resource Conservation Association (JFRCA) annually, and summarizes the results of inspection of shellfish poisoning which is obliged to relevant local governments. Though the report is written in Japanese only, it is very useful because it covers all areas that produces shellfish in Japan.

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

2. Information of Monitoring

As previously mentioned, two types of HAB are known to occur in the Japanese coastal waters. The first type is red tide, some of which cause mass mortality of fish and shellfish. The second type is blooming of toxin-producing phytoplankton. Hence, similarly to Section 1 of this report, the monitoring results were summarized separately for Red Tide and for Toxin-producing Plankton.

2.1 Red Tide

Monitoring activities were summarized based on annual reports of fishery laboratories of local governments that are main organizations in charge of the red tide monitoring. (See reference no.3-14)

2.2 Toxin-producing Plankton

Monitoring activities were described based on “Monitoring Report on Shellfish Poisoning in Japanese Fishery Products”, and annual reports of fishery laboratories of local governments, etc. (See reference no. 2-14, 19)

3. Progress of Researches and Studies to Cope with HABs

Interviews with researchers and scientists of the relevant fields were conducted. According to interviews, scientific publications and summaries of information on the current progress of HAB studies were collected. (See reference no. 20-39) Especially information from National Research Institute of Fisheries and Environment of Inland Sea, and Fisheries White Paper were useful for recognizing the directions of researches and studies of HAB in the future.

4. Literature Including Newly Obtained Information

Information of literatures about HAB was obtained by using HAB Reference Database which has been constructed by CEARAC/WG3. In order to choose topics among enormous new information, interviews with researchers and scientists of the relevant fields were conducted. Literatures including newly obtained information were summarized based on their interviews.

5. Training Activity to Cope with HAB

Interviews with JFRCA personnel and local governments were conducted in order to know the on-going training activities for red tides and shellfish poisoning events.

6. National Activity to Cope with HAB

Interviews with researchers and scientists of the relevant field were conducted to collect their ideas on necessary efforts to cope with HABs. Statements of Fisheries Agency were also integrated into the present report. Data from Environment White Paper issued by Ministry of Environment of Japan, and Fishery White Paper issued by Fisheries Agency of Japan were also utilized. (See reference no. 17 and 18)

7. Suggested Activity for the NOWPAP Region

Interviews with researchers and scientists of the relevant field were conducted to collect their ideas on necessary efforts to promote the solution of HAB problems.

III. RESULTS

1. Situation of HAB Occurrence

This chapter introduces situation of HAB in Japanese NOWPAP region. Some of HABs are recognized by red tide monitoring. HABs are also acknowledged as shell-fish poisonings, which are caused by toxin-producing plankton. Therefore, “Red Tide (Section 1.1)” and “Toxin-producing Plankton (Section 1.2)” are discussed separately for considering the situation of HAB occurrence.

1.1 Red Tide

1.1.1 Type of HAB

Red tide refers to phenomena in which the number of plankton increases and the coloring of sea area is observed due to the increase, causing mass mortality of fish and shellfish occasionally.

A total of 19 red tide events out of 150 cases caused mass mortality of fish and shellfish during 1998–2002 in Kyushu coastal area. Other 131 cases were harmless. The species that brought about the damage are introduced in section 1.1.8.

The red tide in NOWPAP region has not been paid attention compared to that in Seto Inland Sea and other enclosed sea areas, because of the low frequency of occurrence and less fishery damage. For example, Seto Inland Sea counted a total of 509 red tide events during 1998-2002.

1.1.2 Causative Species

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

Five (5) principal species that caused frequently red tide events were listed in Table 1. 1. *Gymnodinium mikimotoi, Noctiluca scintillans,* and *Heterosigma akashiwo* caused mass mortality of fishery resources, while *Mesodinium rubrum* and *Skeletonema costatum* did not give rise to economic loss.

The famous species for their toxicity or harmfulness in Japan, *Chattonella antiqua*, *Alexandrium catenella*, and *Ceratium furca* brought about red tide events only once each during 1998-2002 in this area. *Chattonella marina* did not cause red tide at all in Kyushu coastal area.

In Japanese NOWPAP coastal area other than Kyushu, i.e. Honshu and Hokkaido coastal areas, the complete data for red tide events is not available. Some data on causative species was extracted from the latest reports by fishery laboratories of selected prefecture governments (Table 1. 2). Flagellates species including harmful species such as *Heterocapsa circularisquama* , *Gymnodinium mikimotoi*, *Chattonella antiqua*, and *Cochlodinium polykrikoides* caused red tides.

Table 1. 1 Principal species caused frequently red tide events (Kyushu area)

Species name	Red tide events in 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 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 of prefecture governments.

1.1.3 Cell Density

The highest density observed in 1998-2002 was 117,980 cells/ml of *Gymnodinium mikimotoi* in July 2002 in Kyushu coastal area. The usual number of maximum cell density in the red tide events in this area remains at the level of several thousands cells/ml.

1.1.4 Location

In Japan, monitoring on red tide occurrence has mainly been conducted by fishery laboratories of prefecture governments. About ten (10) fishery laboratories are reported to carry out the regular monitoring, while others are not. Monitoring area of each fishery laboratory is small and limited to enclosed bays. Frequency of the monitoring differs from fishery laboratories. Data is reported from individual fishery laboratories of prefecture governments based on different monitoring schemes from each other. It is, therefore, impossible to draw a map on a monthly basis.

Figure 1. 1 shows the area that experienced red tide events in 2002. This reveals that the red tide events are more popular in the western part of Japanese NOWPAP area than in northern Japan.

The occurrence of red tide in Kyushu area in NOWPAP region was summarized as in Figure 1. 2, using the results from “Situation of Red Tide in the Seas surrounding Kyushu Island”. This reference material of Kyushu Fishery Coordination Office prepares red tide occurrence map by month based on the information obtained through interviews with fishery laboratories of prefecture governments. Though interviews were done only in Kyushu area, and did not cover the northern coast of Japan, the reference material provides valuable data.

From the figure, it can be observed that red tide begins to occur in March to April every year, and peaks during June to August. 150 red tide events in recent five years were observed mainly in bays and semi-enclosed coastal waters in northern Kyushu.

Results of aerial regular monitoring of red tides in Kyushu coastal area from 1998 to 2002 are shown in Figure 1. 3. This aerial monitoring survey has also been conducting by Kyushu Fisheries Coordination Office. The detail of aerial monitoring is explained in chapter2 and Figure 2. 2 (see p. 36). The aerial monitoring found red tides in northern Kyushu coastal area in more than half of the flights (Figure 1. 3). The main HAB occurrence area was Hakata Bay.

Trace monitoring on HAB has been conducted in Akita, Fukui, Yamaguchi, Saga, and Nagasaki prefectures. In Obama Bay, Fukui Prefecture, *Heterocapsa circularisquama* red tides occurred sometimes during 1997 – 1999, and were traced for 8 – 60 days. Saga Prefecture conducted trace monitoring on red tides of *H. circularisquama* and *Gymnodinium mikimotoi* 4 times in 2000.

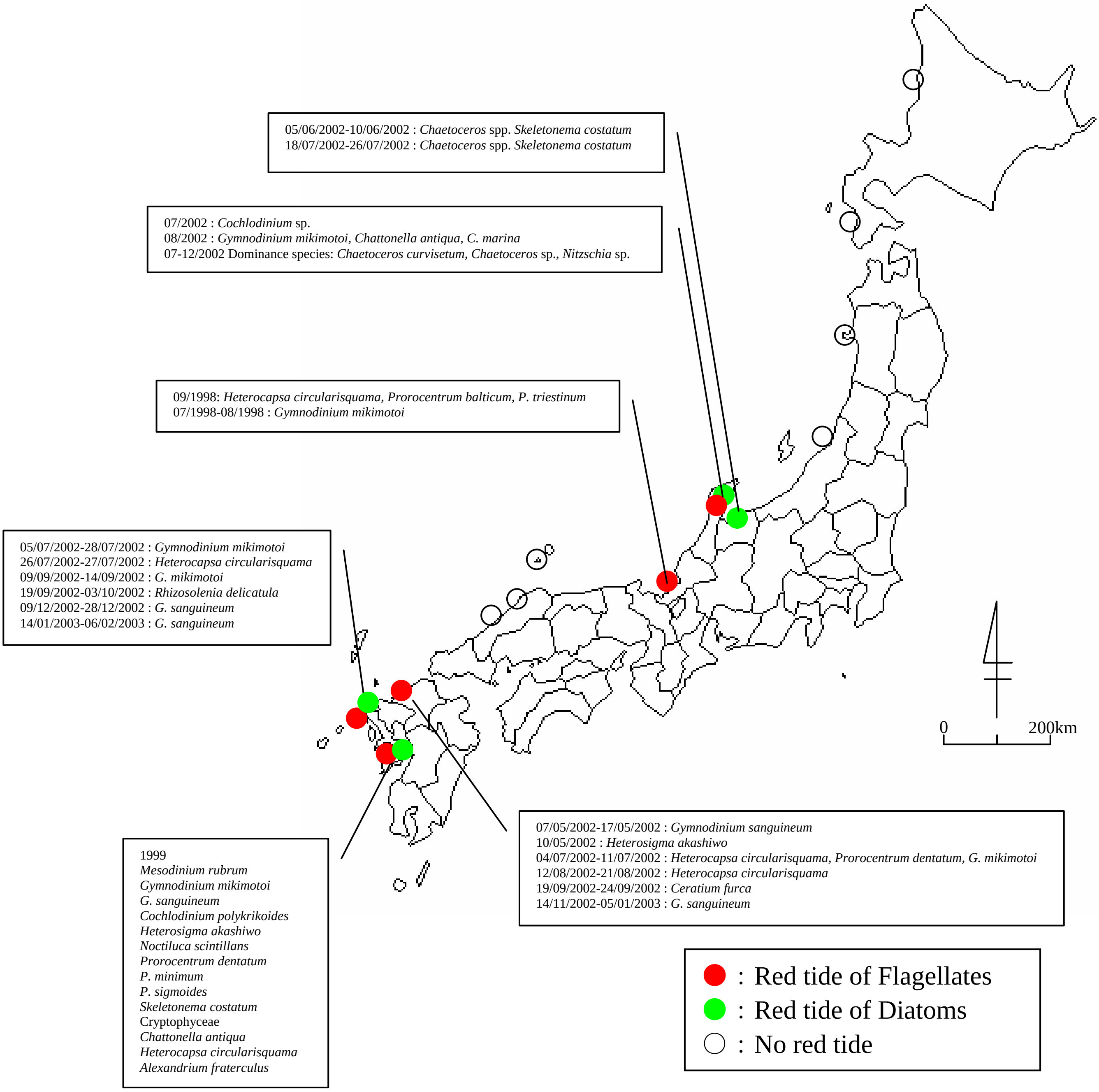


Figure 1. 1 Occurrence of red tide in Japanese NOWPAP area during 1999-2002. Colored and open circles show regular monitoring stations.
Source : Annual reports of fishery laboratories of prefecture governments.

Introductory Remark

Class	Species Name	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.

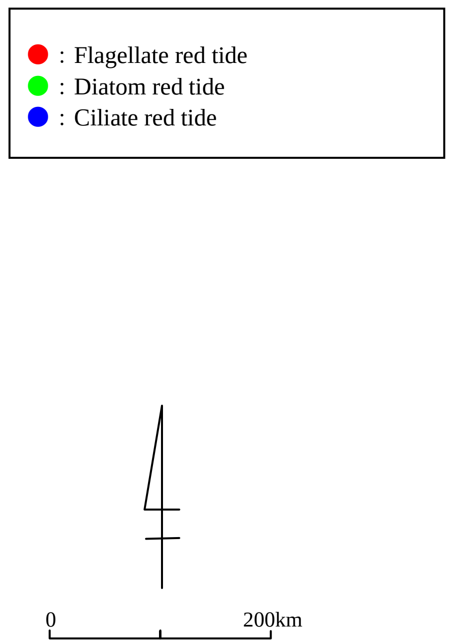
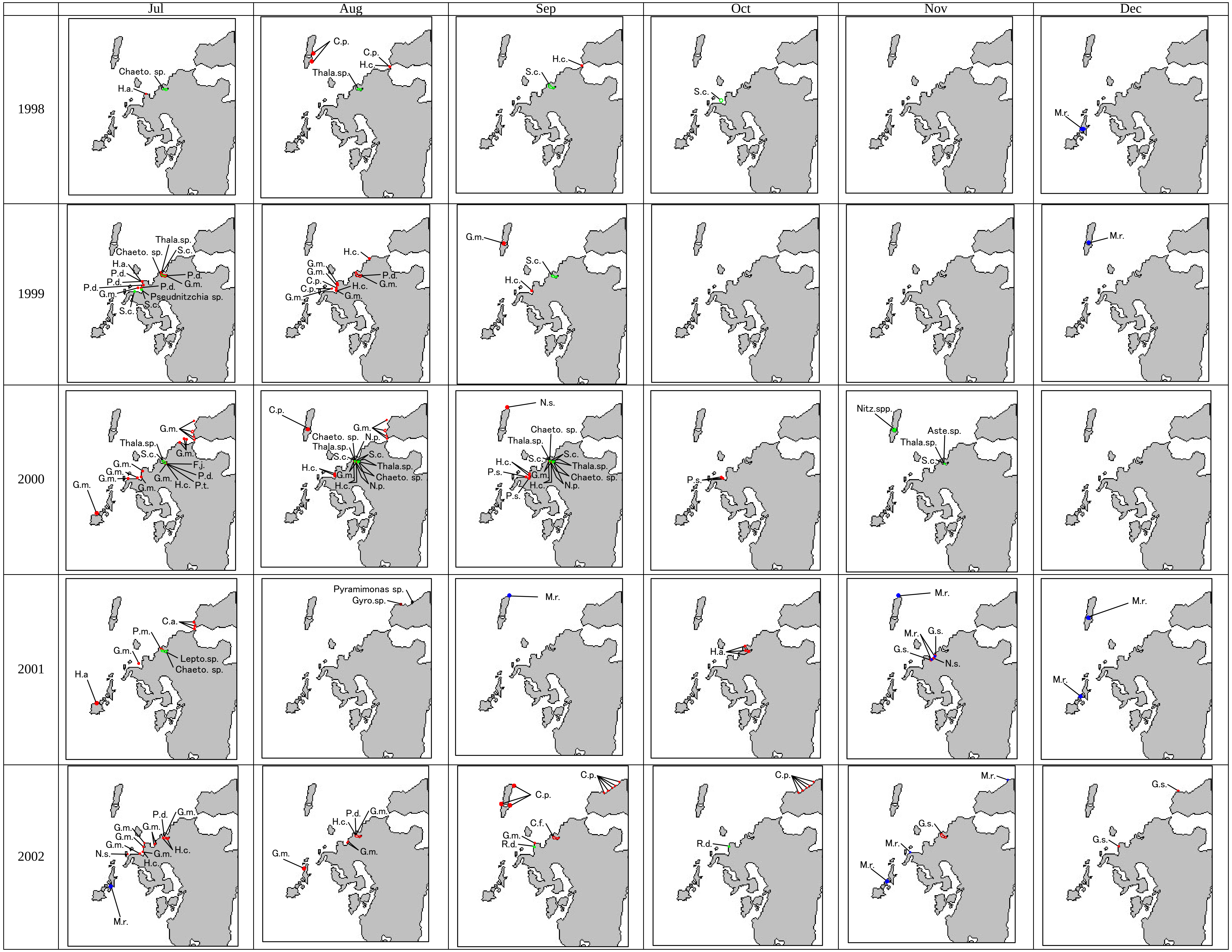


Figure 1. 2 (1) Occurrence of red tide in northern Kyushu coastal area. Red tides only in the NOWPAP area were indicated.
Source : Kyushu Fisheries Coordination Office, “Situation of Red Tide in the Seas surrounding Kyushu Island”, 1999-2003.



Introductory Remark

Class	Species Name	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

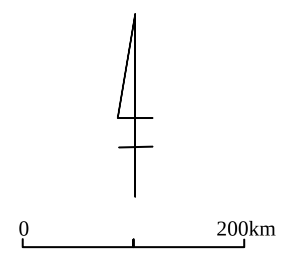


Figure 1. 2(2) Occurrence of red tide in northern Kyushu coastal area. Red tides only in the NOWPAP area were indicated.

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

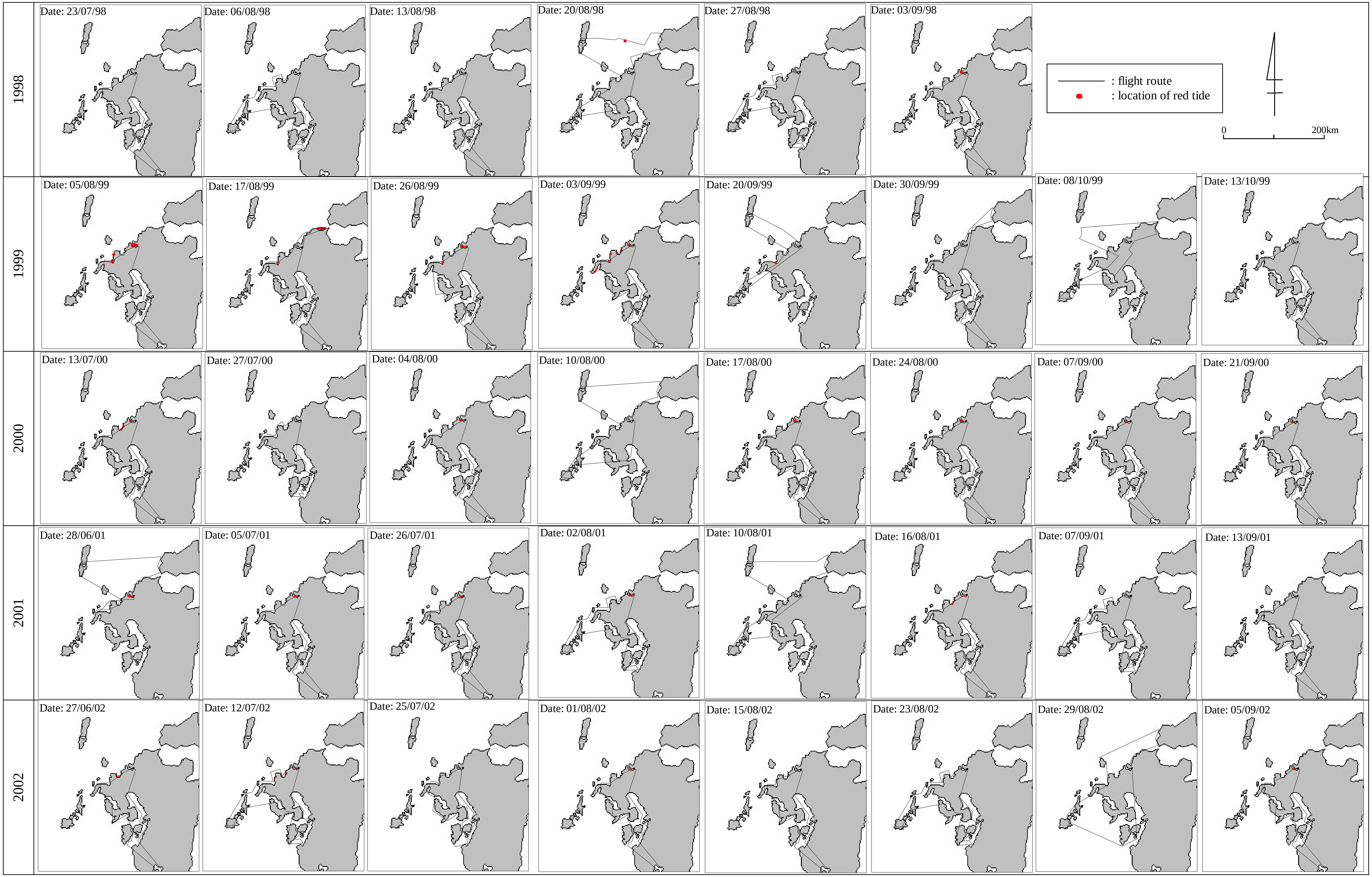


Figure 1. 3 Discolored sea area due to red tides observed in the aerial monitoring. Red tides only in the NOEPAP area were indicated.
Source: Kyushu Fisheries Coordination Office, Result of aerial monitoring on red tides, 1998-2002.

1.1.5 Approximate suffered Area

The area that red tides spread varies extremely depending on oceanographic, meteorological, and biological conditions. Figure 1. 4 is a histogram of the red tide events divided into the areas. The red tides that exceed the area of 100 km^2 rarely occurs in the Japanese NOWPAP Region in Kyushu area.

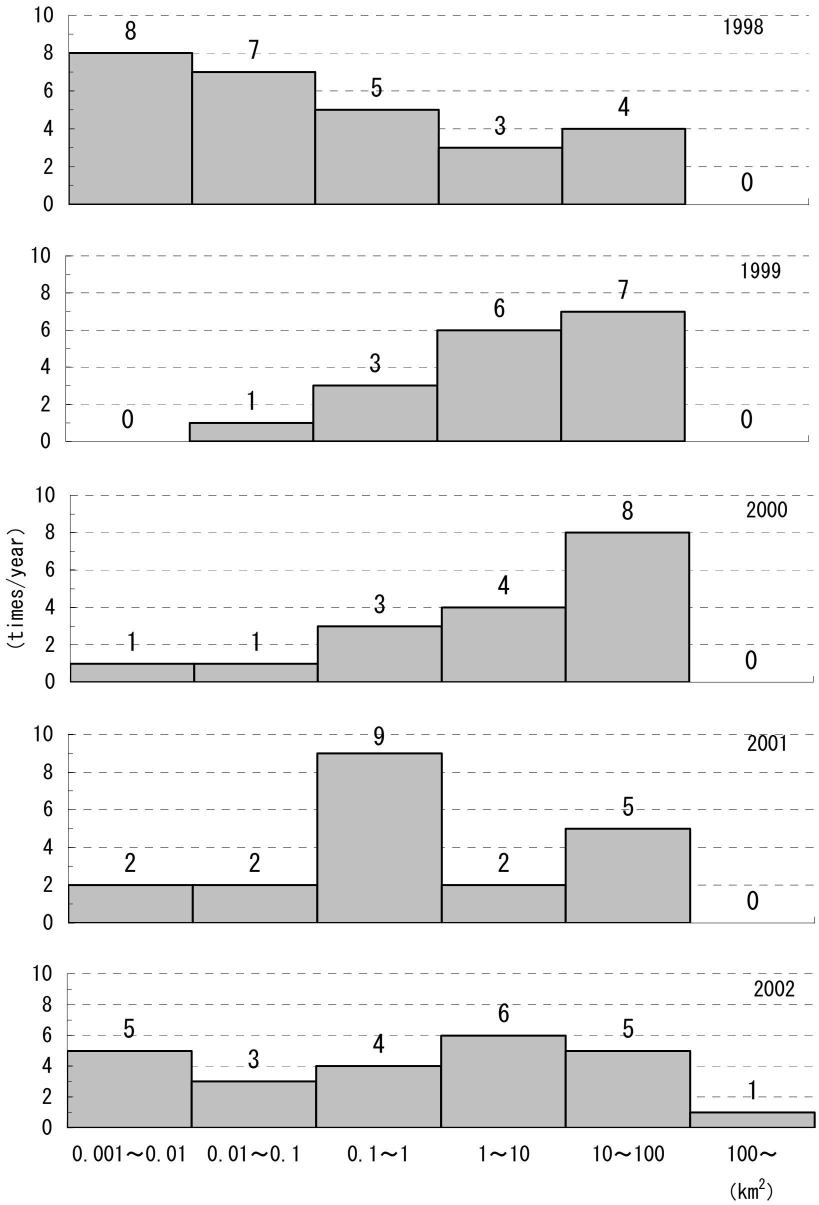


Figure 1. 4 Histogram of the red tide area

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 red tide event

Yearly average of continuous days of red tide in 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 was revealed in Table 1. 3 .

Table 1. 3 Yearly average of continuous days of red tide and a number of red tide events that lasted 20 days or more

	1998	1999	2000	2001	2002
Averaged 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

Monthly change of red tide occurrence in Kyushu NOWPAP area was revealed in Figure 1. 5. Red tides occur throughout the year with high frequency from April to September. June and July is the most frequent season of the red tide occurrence.

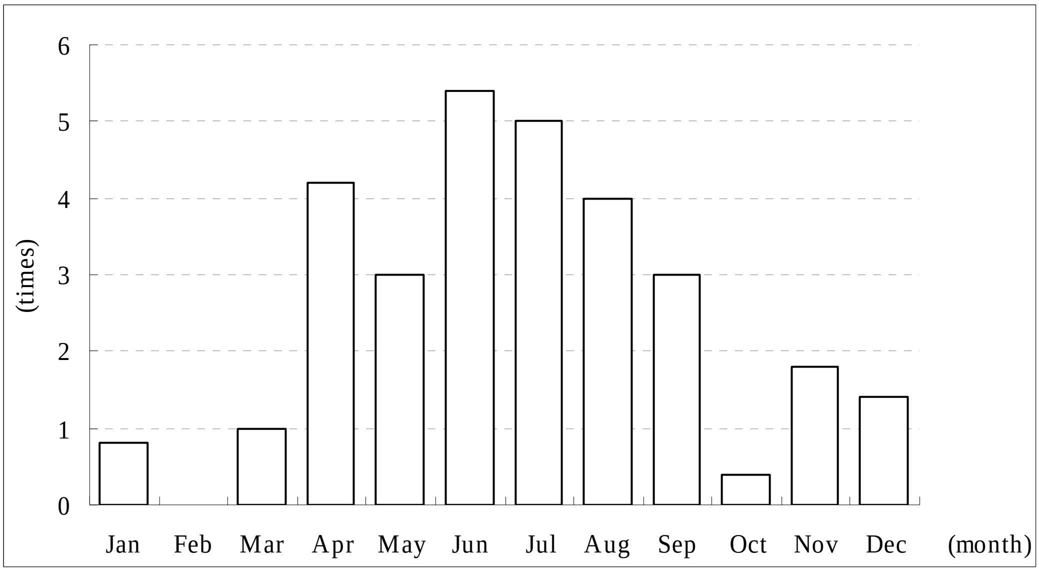


Figure 1. 5 Averaged occurrence frequency in Kyushu coastal area during 1998-2002

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

Japanese central and local governments have made great efforts to control effluent of organic matters and nutrients from land for reducing eutrophication and red tide occurrences since 1970's. They have implemented effluent control, public education, and improvement of sewage system. These were effective preventive measures from red tides.

The policy of wastewater control has enforced effluent standards such as COD, nitrogen, and phosphorous on facilities specified by central or local governments in order to meet water quality standards of bay areas. For example, water quality standards in Toyama Bay, which is a part of Japanese NOWPAP region, are shown in Figure 1. 4. The effluent control enforcement successfully reduced pollutants 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 or less	0.016 or less
Area around Jintu River Mouth	0.23 or less	0.017 or less
Other Areas	0.14 or less	0.010 or less

In order to reduce nutrient effluent from domestics, governments have promoted public education. The policy of public education has also contributed reduction of organic matters and nutrients from public sector.

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

(2) Reactive measures

Clay–spraying is a practical and reactive measure against red tides. This measures was introduced in late 1970 to terminate *Cochlodinium polykrikoides* red tide in an enclosed bay in South Kyushu; and has been applied to the fishery /aquaculture grounds to eliminate the red tides since then. In 2000, fishermen in a certain prefecture practiced this method to get rid of *C. polykrikoides* red tide successfully, 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 to the red tide. The particles of montmorillonite adhere cells of the red tide species and then take the species out of sea surface into deep layer. This method was transferred to Korea in 1999 to cope with *C. polykrikoides* red tides. The impact on the ecosystem of this method is, however, unclear so that this method is used today in very limited area.

1.1.8 Damage

In Kyushu coastal area, five (5) species brought about mass mortality of fish and shellfish resulting in economic loss of fishery industry; *Heterosigma akashiwo, Heterocapsa circularisquama, Gymnodinium mikimotoi, Cochlodinium polykrikoides,* and *Noctiluca scintillans* (Figure 1. 4). The most serious damage was caused by *C. polykrikoides* in Imari Bay in August 1999.

Table 1. 5 Fishery damage due to red tide in northern Kyushu coastal area

Month/year	Causative species	Fishery damage		
		Fish /shellfish species	Quantity	Economic loss (thousand yen)
June 1998	*Heterosigma akashiwo*	Horse mackerel, etc.	Unknown	20～30
Aug. 1998	*Cochlodinium polykrikoides*	Fishes	Unknown	Unknown
	Cochlodinium polykrikoides	Amberjacks	340kg	1122
Mar. 1999	*Noctiluca scintillans*	Squids, Octopus, fishes	13 kg	30
Aug. 1999	*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
	Heterocapsa circularisquama	Abalone	5,100 inds.	74
May 2000	*Heterosigma akashiwo*	Sea bream, horse mackerel	Unknown	Unknown
June 2000	*Heterosigma akashiwo*	Amberjacks	400 inds.	400
July 2000	*Gymnodinium mikimotoi*	Fishes, Abalone Turban	Unknown 2,800 kg	Unknown
	Gymnodinium mikimotoi	Abalone, Turban	Unknown	Unknown
	Gymnodinium mikimotoi	Puffy fish	8,000 inds.	1,600
	Gymnodinium mikimotoi	Abalone, Sea bream	400kg 120 inds	340 134
Oct. 2001	*Heterosigma akashiwo*	Puffy fish Amberjacks Yellowtail	226 inds. 6 inds. 3 nds.	230 7 9
July 2002	*Gymnodinium mikimotoi*	Abalone Turban	56 kg 130 kg	Unknown Unknown
	Gymnodinium mikimotoi	Abalone	Unknown	Unknown
	Gymnodinium mikimotoi	Amberjacks	200 inds.	Unknown
	Heterocapsa circularisquama	Pearl shell	5,000 inds.	Unknown
Aug. 2002	*Cochlodinium polykrikoides*	Amberjacks Horse mackerel	9,280 inds. 620 inds.	29,044 1,240
Sep. 2002	*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 HAB

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 planktons, and symptoms of intoxication would appear when these bivalves are consumed by humans. Species known to cause shellfish poisoning include *Alexandrium tamarense, A. catenella* for PSP, and *Dinophysis fortii, D. acuminate* for DSP. PSP and DSP have been observed in Japan since 1976.

1.2.2 Causative Species

"Monitoring Report on Shellfish Poisoning in Japanese Fishery Products" focuses on 6 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

Cell density of toxic plankton is not being monitored, while the toxicity of shellfish has been recorded. Though cell density is not propotional to the toxicity, the toxicity of shellfish seems to be an indicator of the cell density.

1.2.4 Location

The Fisheries Agency of Japan has set up guidelines to mandate the toxicity monitoring of aquatic shellfish. The toxicity of harvested shellfish is investigated at the production site before shipping them. If the toxicity exceeds the permissible level, the shipping of poisoned shellfish is stopped as the voluntary control. The control of shipping is cancelled after the clearance of the permissible level at three (3) sequent toxicity analyses that needs at least three weeks.

The occurrence of toxin-producing plankton can be detected through the monitoring of toxicity of shellfish harvested and unloaded. The production area of poisoned shellfish does not always coincide exactly with the blooming area of 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 production area of poisoned shellfish in the entire Japanese coastal area that were detected through the monitoring of shellfish poisoning conducted by prefecture governments. There was no PSP in NOWPAP area of Japan till 1987. However, it comes to be observed in northern, southern and western Sea of Japan after 1988. The species of poisoning are mediterranean blue mussel, oyster, and noble scallop.

(2)Diarrhetic Shellfish Poisoning (DSP)

DSP was observed in northern NOWPAP area of Japan first in 1976. Though it appeared in western Japan in 1980s, the main area of DSP events is the northern NOWPAP area of Japan (Figure 1. 7). Scallop is the typical species of poisoning.

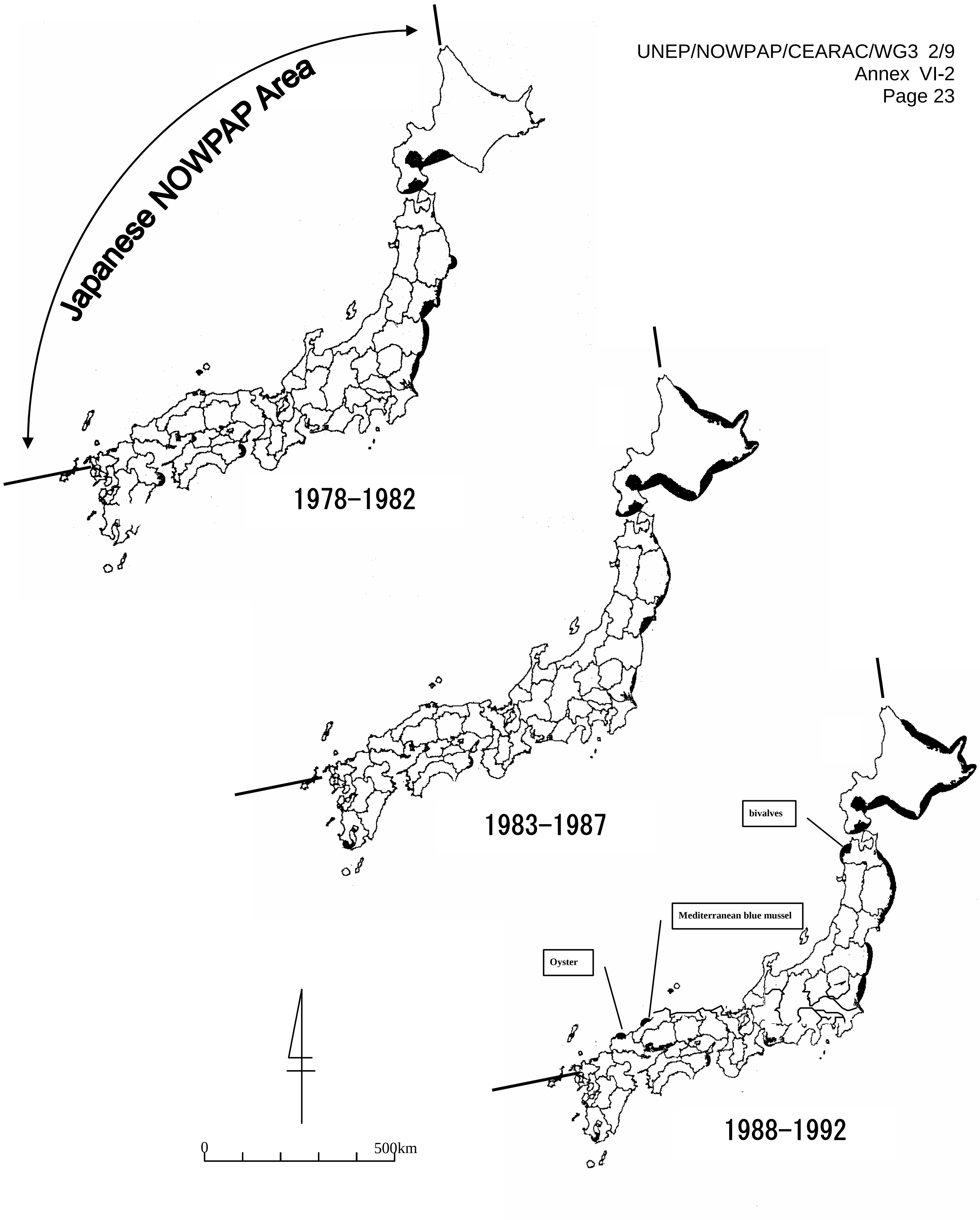


Figure 1. 6 (1) Affected area that experienced voluntary control due to PSP contamination in Japan

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

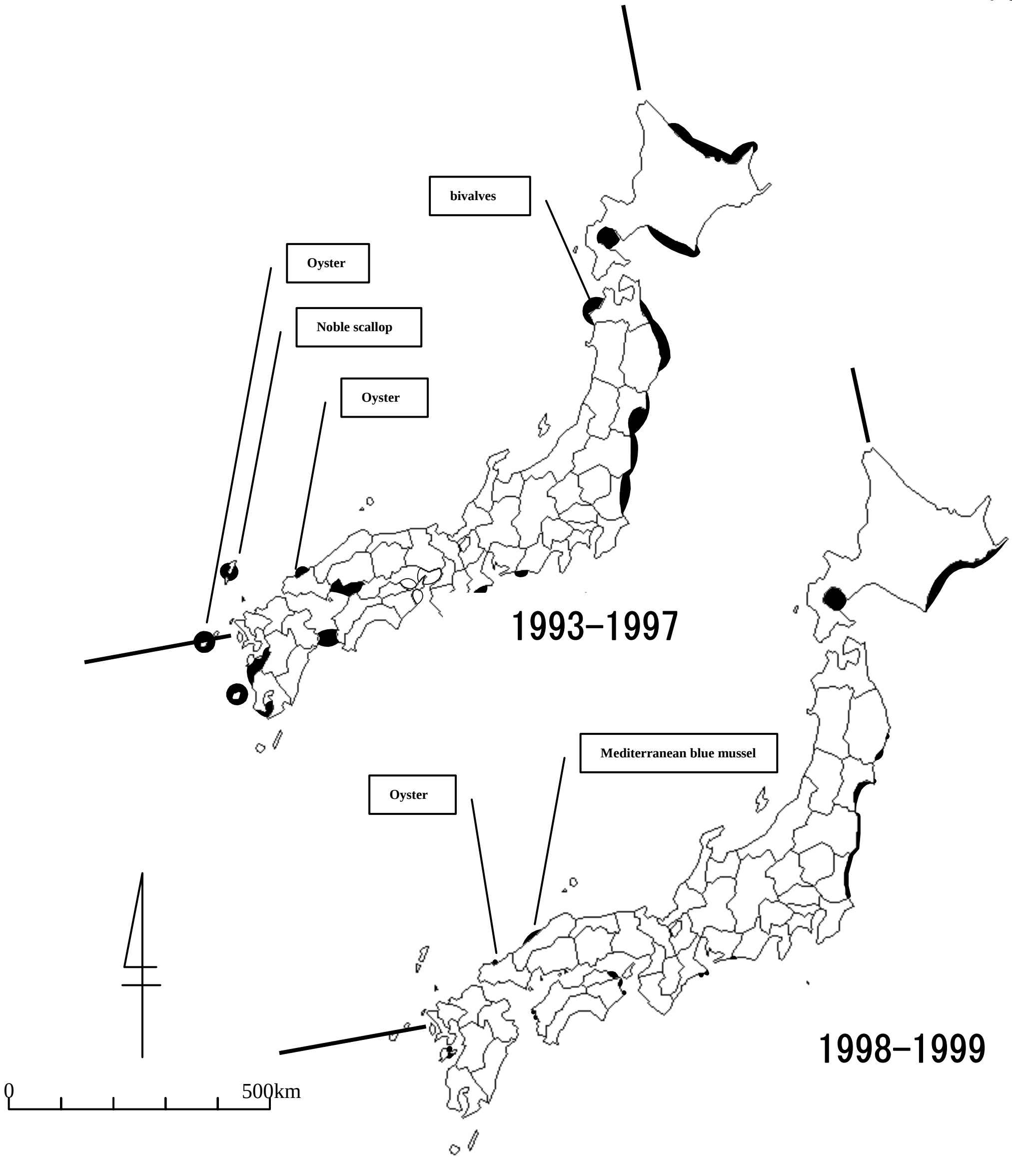


Figure 1. 6(2) Affected area that experienced voluntary control due to PSP contamination in Japan

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

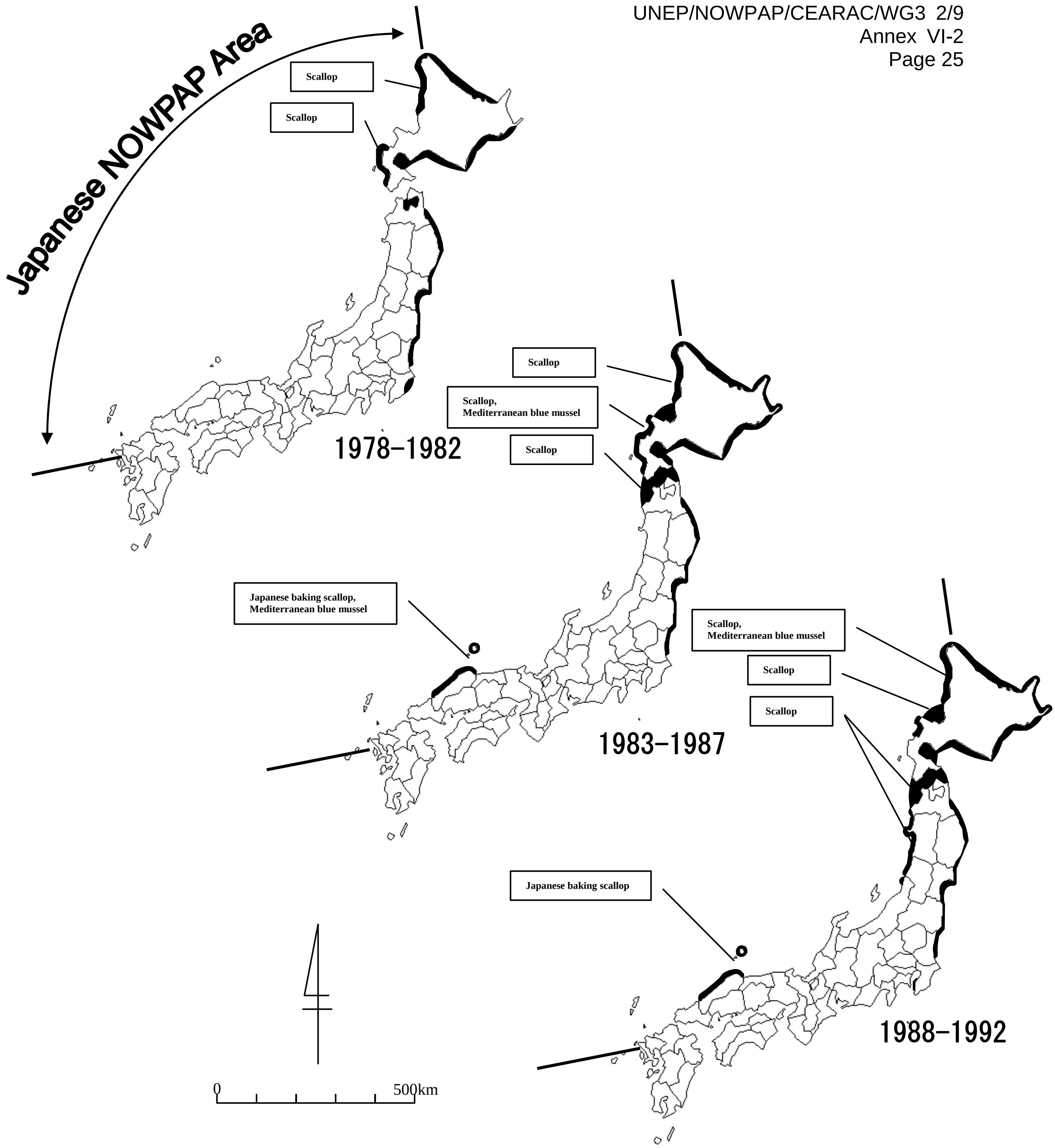


Figure 1. 7 (1) Affected area that experienced voluntary control due to DSP contamination in Japan

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

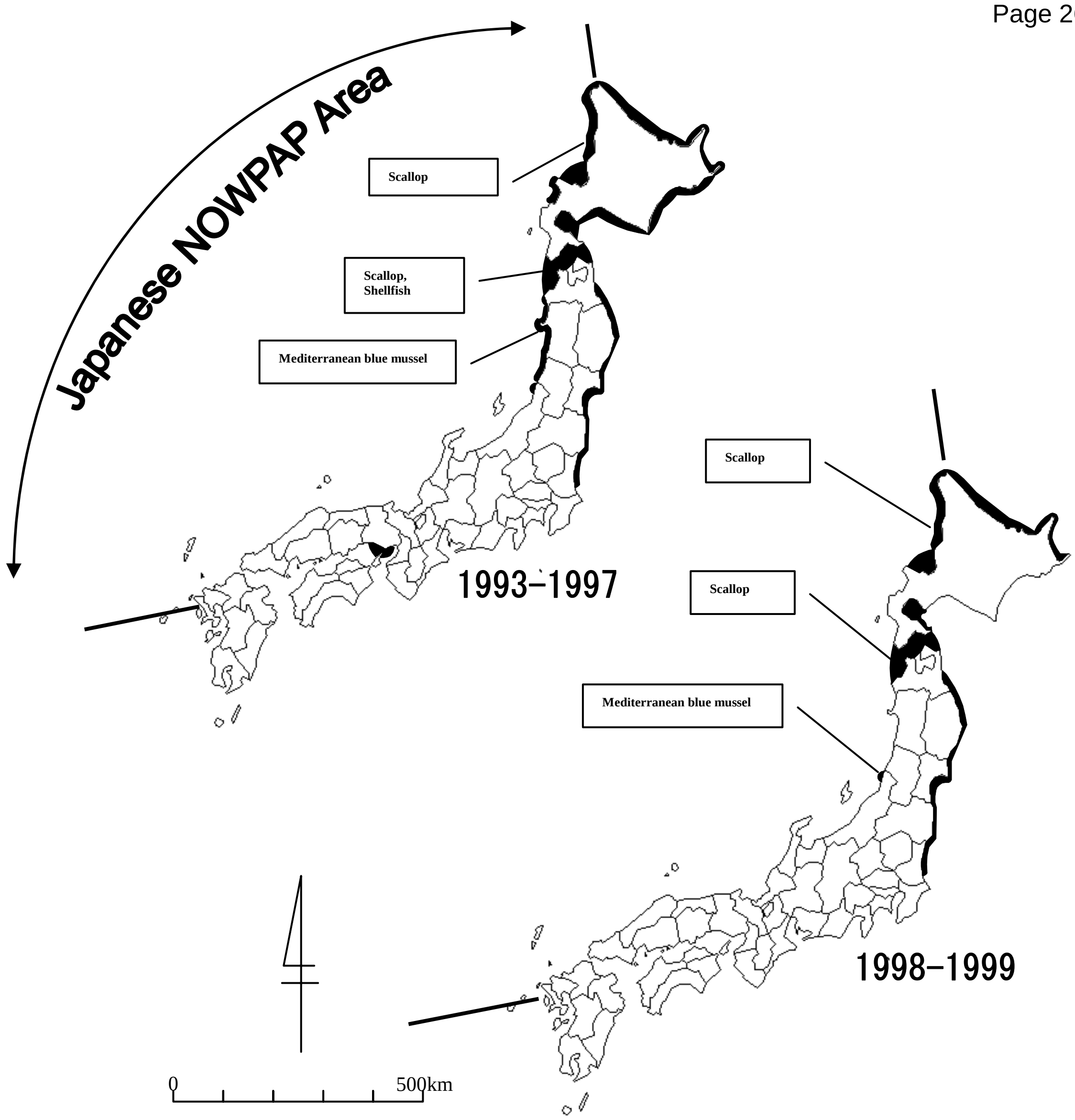


Figure 1. 7 (2) Affected area that experienced voluntary control due to DSP contamination in Japan

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

1.2.5 Approximate suffered area

Since the monitoring is being conducted not on the plankton density, but on the meat of the shellfish at the production site, extensiveness of the bloom itself is unknown.

1.2.6 Duration

(1)Continuous days of toxin-producing plankton blooms

Though the toxicity of shellfish does not correspond to the cell density of toxin-producing plankton in the ambient water, number of repeated days in which toxin-producing plankton blooms occurred seems to be a practical indicator for the duration of the blooms. Duration of toxin-producing plankton blooms may be suggested by the duration of voluntary discontinuation of shellfish shipping, through it would be a little shorter.

The shaded period of 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 the 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)

Prefecture	Year	Shellfish	Location	Month Causative species	1	2	3	4	5	6	7	8	9	10	11	12
Hokkaido	1981	Scallop	Tsugaru Strait	*A. tamarense*							■	■	■			
	1983	Scallop	Tsugaru Strait									■	■			
	1984	Scallop	Tsugaru Strait									■	■	■	■	
	1986	Scallop	Tsugaru Strait									■	■	■	■	
	1989	Scallop	Tsugaru Strait		■	■				■	■	■	■			
Kyoto	1992-1993	Oyster	Kumihama Bay	*Gymnodinium catenatum*	■											■
Shimane	1992	Mediterranean blue mussel	Hamada open sea	*Alexandrium catenella*						■	■					
	1998	Mediterranean blue mussel	Hamada	Unknown					■	■						
Yamaguchi	1988-1989	Oyster	Senzaki Bay	*G.catenatum*	■										■	■
	1991-1992	Oyster	Senzaki Bay	*G.catenatum*	■										■	■
	1995-1996	Oyster	Senzaki Bay	*G.catenatum*	■											■
	1996-1997	Oyster	Senzaki Bay	*G.catenatum*	■											■
	1998	Oyster	Senzaki Bay	*G.catenatum*	■											
	1998-1999	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	Oyster	Kawaura	*G.catenatum*		■	■									
	1998	Oyster	Kawaura	*G.catenatum*						■	■					
	1999	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 the voluntary control of shellfish shipping during 1978-1999. Duration of the shipping inhibition was longer than that due to PSP, and 26 out of 64 cases stopped shipping of shellfish for 5 months or longer.

Table 1. 7 Duration of voluntary control of harvested shellfish shipping due to DSP

Pefecture	Year	Shellfish	Location	Causative species	1	2	3	4	5	6	7	8	9	10	11	12
Hokkaido	1986	Scallop	Ishikari Bay	Dinophysis fortii						■	■	■	■	■		
	1987	Scallop	Ishikari Bay						■	■	■	■	■			
	1988	Scallop	Ishikari Bay					■	■	■	■	■	■			
	1989	Scallop	Ishikari Bay							■	■	■	■			
	1990	Scallop	Ishikari Bay						■	■	■	■	■	■	■	
	1991	Scallop	Ishikari Bay						■	■	■	■	■	■		
	1993	Scallop	Ishikari Bay							■	■	■	■	■	■	
	1994	Scallop	Ishikari Bay							■	■	■	■	■	■	
	1997	Scallop	Ishikari Bay						■	■	■					
	1999	Scallop	Ishikari Bay						■	■						
	1983	Scallop	Tsugaru Strait						■	■	■	■	■	■	■	
	1984	Scallop	Tsugaru Strait							■	■	■	■	■	■	■
	1985	Scallop	Tsugaru Strait						■	■	■	■	■	■		
	1989	Scallop	Tsugaru Strait						■	■	■	■	■			
	1997	Scallop	Tsugaru Strait					■								
	1999	Scallop	Tsugaru Strait								■	■				
	1987	Scallop	central western coast							■	■	■				
	1988	Scallop	central western coast					■	■	■	■	■	■			
	1995	Scallop	central western coast					■	■	■						
	1981	Scallop	north western coast								■	■				
	1982	Scallop	north western coast							■	■	■	■			
	1983	Scallop	north western coast						■	■	■	■	■	■	■	
	1985	Scallop	north western coast								■	■	■	■		
	1986	Scallop	north western coast							■	■	■	■	■		
	1987	Scallop	north western coast						■	■	■	■	■	■		
	1988	Scallop	north western coast					■	■	■	■	■	■	■		
	1989	Mediterranean blue mussel	north western coast								■	■	■	■		
	1989	Scallop	north western coast					■	■	■	■	■	■			
	1990	Scallop	north western coast					■	■	■	■	■	■			
	1991	Scallop	north western coast									■	■	■		
	1992	Scallop	north western coast						■	■	■	■	■			
	1994	Scallop	north western coast					■	■	■	■	■	■	■		
	1999	Scallop	north western coast							■	■					
	1982	Scallop	south western coast							■	■	■				
	1983	Scallop	south western coast						■	■	■	■	■			
	1984	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	Scallop	Tsugaru Strait				■	■	■	■	■	■				
	1988	Scallop	Tsugaru Strait							■	■					
	1990	Scallop	Tsugaru Strait						■	■						
	1991	Scallop	Tsugaru Strait								■	■				
	1993	Scallop	Tsugaru Strait					■	■	■	■					
	1994	Scallop	Tsugaru Strait							■	■	■				
	1983	Scallop	Japan Sea (liberation)					■	■	■	■	■	■	■		
	1984	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

The voluntary control may suggest the seasonal characteristics of toxin-producing plankton blooms. PSP-causing plankton may have different blooming season at different localities, while DSP-causing plankton seems to be abundant from early summer to autumn.

1.2.7 Mitigation activity and effectiveness

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

1.2.8 Damage

In Japan, there was a wide spread of shellfish intoxication in the area around Tohoku region in late 1970's. Common symptoms for PSP are numbness around lips and tongues after 30 minutes of consumption, and in severe conditions difficulties in moving bodies. In worst cases, it leads to death due to suffocation within 12 hours. For DSP, the symptoms are observed 3-4 hours after consumption, but it will be completely recovered after 3 days. There has not been any fatal case reported.

Around 900 persons have suffered from PSP and DSP since 1976 when the first patient was reported. Several people died because of the PSP. The oldest records of PDP occurred in Aichi Prefecture in 1948, DSP occurred Miyagi Prefecture in 1951. The oldest records of PSP and DSP which occurred in Aichi Prefecture in 1948 and Miyagi Prefecture in 1951, respectively. The careful monitoring on shellfish poisoning and voluntary control of the poisoned shellfish mentioned in section 1.2.4 (see p. 22) achieved no fatal case since 1980.

2. Information of Monitoring

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

2.1 Red Tide

In Japan, Fisheries Agency, Coast Guard, and Japan Meteorological Agency are in charge of red tide monitoring. Fisheries Agency focuses coastal sea areas with fishery/aquaculture activities, while other mainly covers offshore area. Among these agencies, Fisheries Agency is most responsible for red tide monitoring to secure the fishery/aquaculture industry.

Fisheries Agency sometimes commissions to conduct the red tide monitoring to prefecture governments that have fishery laboratories as an actual research organization. Thus in Japan, fishery laboratories substantially implement the red tide monitoring.

2.1.1 Regular Monitoring on HAB

In Japan, monitoring on red tide occurrence has mainly been conducted by fishery laboratories of prefecture governments. Some fishery laboratories are carrying out the regular monitoring, while others are not. The scheme of the regular monitoring is summarized in Table 2. 1 and Figure 2. 1. Monitoring area of each fishery laboratory is small and limited to enclosed bays. Frequency of the monitoring differs from fishery laboratories.

Kyushu Fisheries Coordination Office is conducting aerial monitoring survey using an aircraft. It has four (4) flight routes to cover the whole Kyushu coastal area. Three (3) of them are set in some part of NOWPAP area as shown in Figure 2. 2. A total of 6-8 flight are done in a year (only during June-October). Water color and water temperature are monitored in the aerial survey through visual observation and infrared monitoring system, respectively. The aerial survey is also being carried out in Seto Inland Sea by Seto Inland Sea Fisheries Coordination Office.

Red tide monitoring using satellite remote sensing technology has not been employed yet on practical basis.

2.1.2 HAB Trace Monitoring

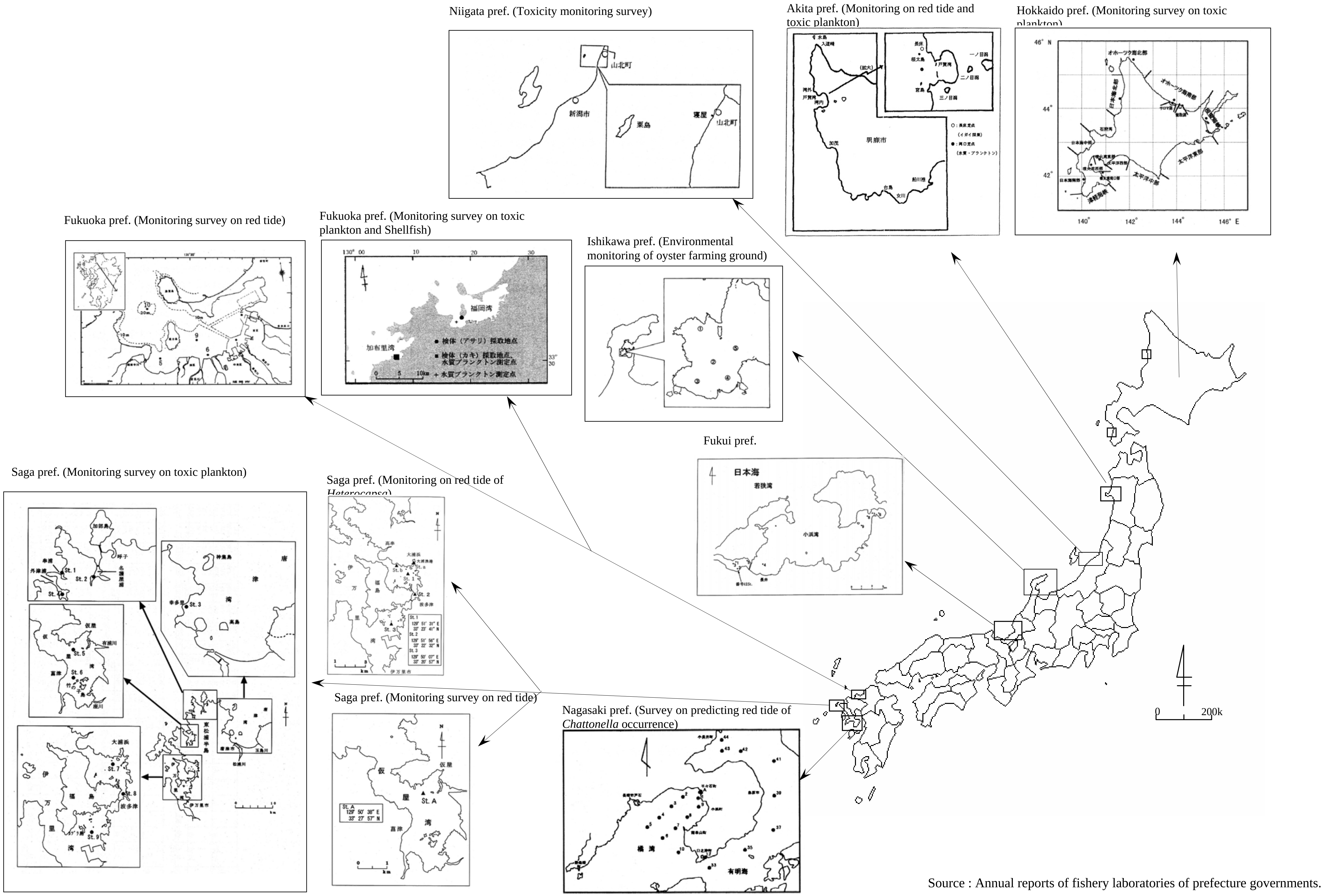
When a red tide appears and local people, usually fishermen, notify a fishery laboratory of prefecture government of a red tide occurrence, researchers of the laboratory begin the observation and research on the red tide event. The researchers complete plankton sampling usually in several hours after the notification. And when the situation requires the continuous observation of the red tide event, the fishery laboratory conducts trace monitoring.

Though information obtained through such an activity is accumulated by fishery laboratories, it is not always published regularly. Examples of accomplishment of the trace monitoring are shown in Table 2. 2.

Table 2. 1 Scheme of the regular monitoring conducted by selected fishery laboratories of local governments

Monitoring Executing Agency	Monitoring name	Methodology				Parameters monitored					Results of the monitoring	Source
		Monitoring Method	Area or Location	Frequency	Remarks	Causative species	Chlorophyll-a	Temperature and Salinity	Nutrients	Others		
Hokkaido Central Fisheries Experimental Station	Monitoring survey on toxic plankton	Fixed points, 4 rayers	Coastal area (Map attached)	One time in a month 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	Monitoring survey on toxic plankton	Fixed points, multi rayer	Mutsu Bay Tsugaru Strait (Map attached)	One time in a month.		*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	Monitoring on red tide and toxic plankton	Fixed points, 4 rayers	Coastal area (Map attached)	One time in a week during 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	Monitoring survey on toxic plankton	Fixed points, 3 rayers	Coast in Kuwagawa Sanpoku cho	3 times in a month during May to September.		*Dinophysis fortii*, *D. mitra* etc.		○		Phytoplankton, Shellfish poison	published	Annual Report of Niigata Prefectural Fisheries and Marine Research Institute, 2001.
	Toxicity monitoring survey	Fixed points, 3 rayers	Coast in Kuwagawa Sanpoku cho (Map attached)	3 times in a month during May to September.		*Dinophysis fortii*, *D. acuminata* etc.		○		Phytoplankton, Shellfish poison	published	Report on red tide mitigation program, 1991.
Toyama Prefectural Fisheries Research Institute	Monitoring on red tide	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	Environmental monitoring of oyster farming ground	Fixed points	Nanao Bay (Map attached)	One time in a month during 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 monitoring	Fixed points	Izumo, Iwami, Oki	One time in a month.		Toxic plankton was not generate.		○		Toxin-producing plankton, Shellfish poison	published	Annual Report of Shimane Prefectural Institute of Fisheries, 2002.
Fukuoka Fisheries and Marine Technology Research Center	Monitoring survey on toxic plankton and red tide	Fixed points, 3 rayers	Fukuoka Bay (Map attached) Karatsu Bay	12 times during April to March.		*Gymnodinium sanguineum*, *Heterosigma akashiwo*, *Heterocapsa circularisquama*, *Prorocentrum dentatum* etc.	○	○	○	Phytoplankton composition, Occurrence area, Economic loss, Shellfish poison	published	Bulletin of Fukuoka Fisheries Marine Technology Reserch Center, No.12, 2002.
Saga Prefectural Genkai Fisheries research and Development Center	Monitoring survey on red tide	Fixed points, 5 rayers	Kariya Bay (Map attached)	More than one time during May to October.		*Gymnodinium mikimotoi*, *Heterocapsa circularisquama*,	○	○	○	Toxin-producing plankton	published	Annual Report of Saga Prefectural Genkai Fisheries Research and Development Center, 2002.
	Monitoring survey on toxic plankton	Fixed points, 4 rayers	Kariya Bay, Imari Bay, Karatsu Bay, etc. (Map attached)	6 times during October to March.		*Alexandrium catenella*, *Lingulodinium poiyedrum*, *Dinophysis acuminata*, *Gymnodinium catenatum* etc.	○	○	○	Toxin-producing plankton	published	
	Monitoring on red tide of *Heterocapsa*	Fixed points, 4 rayers	Imari Bay (Map attached)	14 times during May to March.		*Heterocapsa circularisquama*, *Gymnodinium mikimotoi*, *Chattonella marina*	○	○	○		published	
Nagasaki Prefectural Fisheries Research Institute	Monitoring on red tide and toxic plankton	Fixed points	Imari Bay, Oomura Bay	Unknown	Carrying out from 1978.	*Cochlodinium polykrikoides* , *Gymnodinium mikimotoi* etc.	○	○	○	Toxin-producing plankton, Shellfish poison	published	Bulletin of Nagasaki Prefectural Institute of Fisheries, No.25, 1999.
	Program for Prediction of red tide *Chattonella* occurrence	Fixed points, multi rayer	Tachibana Bay, etc. (Map attached)	3 times during July to August.		*Cochlodinium polykrikoides* , *Gymnodinium sanguineum* , *Chattonella antiqua*, *C. marina* etc.	○	○	○		published	

Source : Annual reports of fishery laboratories of prefecture governments.



Source : Annual reports of fishery laboratories of prefecture governments.

Figure 2. 1 Sampling site of regular monitoring by fishery laboratories of prefecture governments.

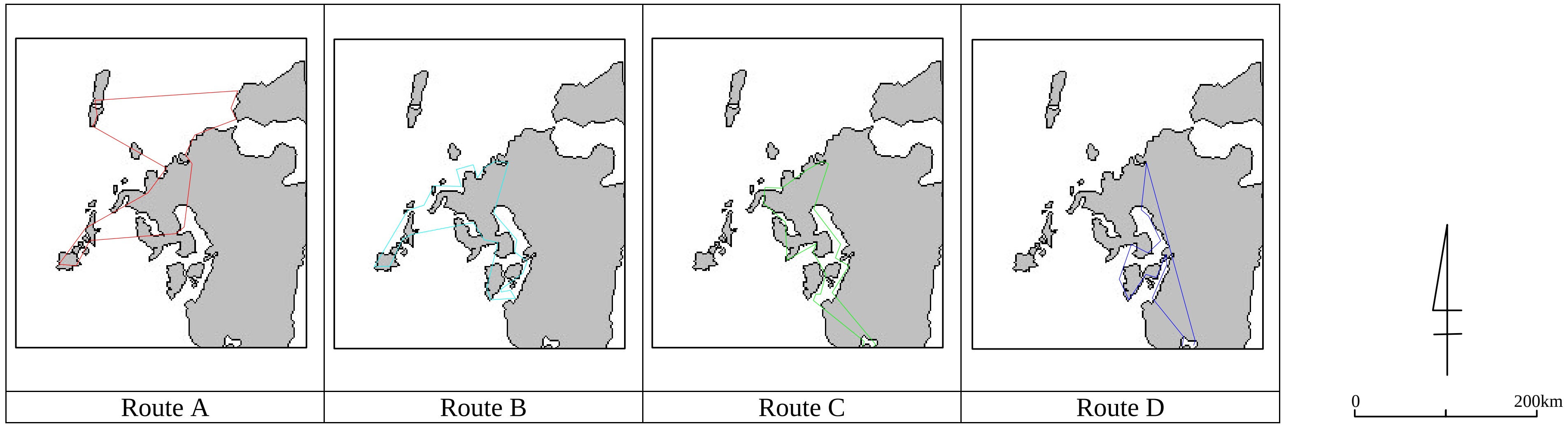


Figure 2. 2 Flight routes for aerial monitoring on HAB

Table 2. 2 Accomplishment of trace monitoring

Monitoring Executing Agency	Monitoring name	Date	Area or Location	Causative species	Damage	Initiation	Source
Akita Prefectural Fisheries Research and development Center	Monitoring survey on red tide	no red tide report 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 oyster	Unknown	Annual Report of Fukui Prefectural Institute of Fisheries, 1997, 1998, 1999.
Fisheries Division, Yamaguchi Prefectural Government	—	13 times during March to December in 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	Monitoring survey on red tide	4 times from 2000 May 28th in October 3rd.		*Gymnodinium mikimotoi*, *Heterocapsa circularisquama* , etc.	Record of fishery damages is written.	reporting by people to the Center	Annual Report of Genkai Fisheries Research and Development Center, 2002.
	Monitoring on red tide of *Heterocapsa*	26/07/02-29/07/02 18/10/02 20/03/03	Imari Bay	*Heterocapsa circularisquama*		When red tides of *Heterocapsa* occur, the investigation is conducted.	
Nagasaki Prefectural Fisheries Research Institute	Monitoring survey on phytoplankton causing red tide						Report on red tide plankton monitoring program, Ⅰ～Ⅲ., Nagasaki Prefecture

Source : Annual reports of fishery laboratories of prefecture governments.

2.2 Toxin-producing Plankton

Fishery laboratories of prefecture governments are conducting 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 the regular monitoring by fishery laboratories, the guidelines of the Fishery Agency indicated that monitoring of shellfish poisoning be conducted regularly in harvest season of shellfish in order to prevent shellfish poisoning and sustain safe supply of major shellfish products. The Director of the Fisheries Agency noticed for the first time the prefectural governors to reinforce the guidelines on monitoring and inspection of shellfish toxins in 1979. Since then the shellfish toxins monitoring system has been implemented following the guidelines. According to the guidelines, monitoring or inspection stations should be established near the harvesting areas. Monitoring is conducted at least once a month in harvest season. Frequency of mentoring should be increased at least once a week if the high risk of poisoning is doubted. Sampling locations and frequency are increased when the toxicity exceeds the criteria shown in Table 2. 3. Harvesting and shipping of shellfish are voluntarily stopped if toxicity becomes higher than the criteria. This is voluntary control but almost 100% of fishermen follow this guidelines.

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 of 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 marked after the midguts of scallops are removed at authorized factories. Harvesting and shipping can be restarted when the toxicity level keeps below the standards for two weeks.

The information network for shellfish poisoning was constructed as shown in Figure 2. 3. Laboratories regularly report the result of poisoning test to the marine product department of prefecture governmenmt. When the toxicity exceeds the criteria, the marine product department informs the Fisheries Agency, mass media, fish market, and related prefectures to stop harvesting and shipping. The Fisheries Agency forwards information of poisoning to the Ministry of Health and Welfare and the Food Distribution Bureau to supervise fish markets. Association of Fishery Cooperative with the prefectural marine product department guides fishermen to stop harvesting and shipping the polluted shellfish.

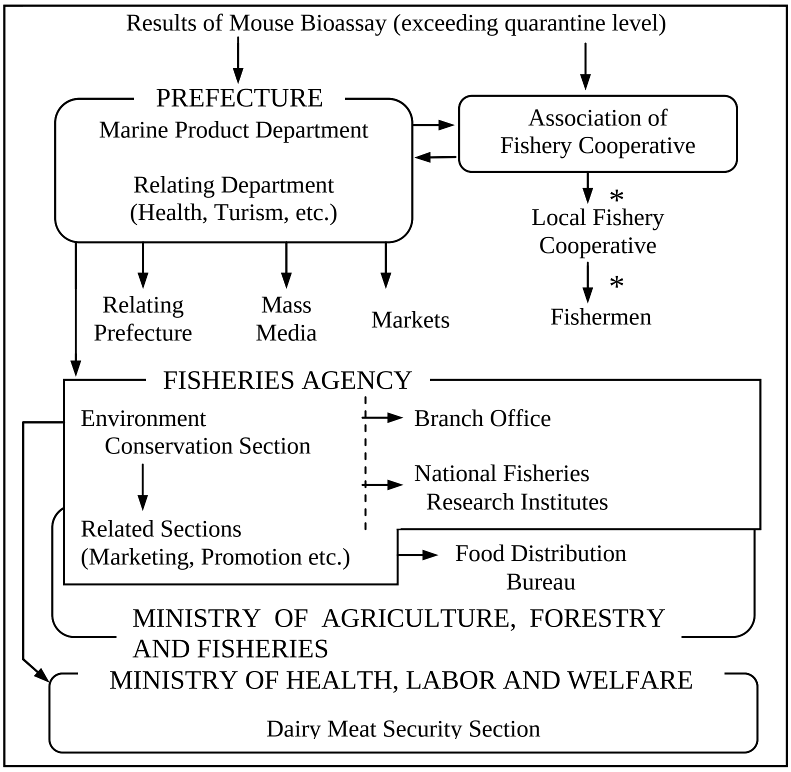


Figure 2. 3 Flow of information on shellfish toxins in Japan
∗ indicates in the instruction of voluntary control.

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

3. Progress of Researches and Studies to Cope with HAB

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

3.1 Mechanism of HAB Occurrence

National Institute of Fisheries Science is studying the mechanism of red tide occurrence 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 the occurrence.

Some small dinoflagellate species are being studied to clarify the relationship with DSP. The study will show the role of such small dinoflagellates to bring about the DSP events.

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・ 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. Bulletin of the Japanese Society of Fisheries Oceanography, 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. Phycologia, 40, 263-267.

・ Nagai, S. and Imai, I. (2001) Relationships between *Coscinodiscus wailesii* and bacteria promoting its sperm formation in the coastal area, Japan. In Economou-Amilli, A. (Ed), Proceedings of the 16th International Diatom symposium, University of Athens, Greece, 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. Fisheries Science, 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. Fisheries Science, 68, 77-86.

3.2 Toxicity Analysis

The combination of High Performance Liquid Chromatograph (HPLC) and Mass Chromatograph achieved highly sensitive and accurate analysis of toxic substances. This technique found PSP- and DSP-inducing toxic substance of low concentration from Japanese NOWPAP area.

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

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3.3 Taxonomic Analysis of Causative Species

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

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3.4 Development of Mitigation Measures

Nagasaki and Tarutani (2001) found that a dinoflagellate species, *Heterocapsa circularisquama*, had two types of enemy virus. These algicidal viruses propagate themselves in the cytoplasm of *H. circularisquama* and kill the host. Algicidal viruses could be applied to terminate the bloom of toxin-producing plankton after careful examination of adverse effects on the marine ecosystem.

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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. Two models have reliability of 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 Newly Obtained Information

Following sections show summaries of major papers published after 2000, which are stored in HAB Reference Database.（All papers that are published after 2000 and stored in HAB Reference Database are listed in appendices.） Section indexes conform to the categories in HAB Reference Database.

4.1 Occurrence and Monitoring

Fukuyo et al. (2002) reports on past occurrences of red tide and harmful algae blooms in Japan. Its major arguments are on secular change of number of red tide appearance in 1970 to 1998, number of damages to fishery, economic loses, history of prohibition of shellfish shipment due to PSP and DPS, and so on.

Yamato et al. (2002) reports about *Cochlodinium polykrikoides,* which was first identified at Imari Bay in Nagasaki Prefecture in 1998. It reports *Cochlodinium polykrikoides* as a harmful red tide causing fish kill, and describes about the situation of red tide caused by *Cochlodinium polykrikoides* and its reproduction characteristics. Concerning this species, Matsuoka et al. (2004) also summarize on number of damages to fishery observed in west Japan, based on historical studies.

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・ Yamato, T., Maruta, H., Uraga, J. (2002) Occurrence of *Cochlodinium polykrikoides* Red Tide and its Growth Characteristics in Imari bay in 1999., Bulletin of Nagasaki Prefectural Institute Fisheries. 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/or virus coexisting in cells of plankton are known to cause red tide or of harmful algae and it is said that these bacteria and/or virus has close relationship to the mechanism of blooming red tide. Tarutani et al. (2000)

found that the rapid decrease in the number of cells in red tide caused by *Heterosigma akashiwo* coincides with rapid increase of HaV（*Heterosigma akashiwo* Virus）, which is parasitic in this species.

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

- Reference List -

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・ Kim, D.I., Matsuyama, Y., Nagasoe, S., et al. (2004) Effects of temperature, salinity and irradiance on the growth of the harmful red tide dinoflagellate *Cochlodinium polykrikoides* Margalef (Dinophyceae)., Journal of Plankton Research, 26(1),1-6.

4.3 Physiology

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

Oda et al. (2001) found the ethanol extract of *Heterocapsa circularisquama* have solubility to mammalian erythrocytes. This ethanol-extracted material sets off the morphological change of unfertilized egg of Japanese oyster and kills micro-zooplancton, *Brachionus plicatilis.* The authors suggest that this ethanol-extracted material might be one of the causes of bivalve killing en mass.

- 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., Journal of Phycology 37 (4) : 509-516.

4.4 Taxonomy

Imai (2000) points out following problems of classification and identification for raphidoflagellates. That is;

- The morphology of raphidoflagellates varies greatly by species as it does not hold shells.
- Cell is fragile and breaks under severe conditions. Fixation is impossible.

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

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

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- Nagai, S., Matsuyama, Y., Takayama, H. and Kotani, Y. (2002) Morphology of *Polykrikos kofoidii* and *P. schwartzii* (Dinophyceae, Polykrikaceae) cysts obtained in culture., PHYCOLOGIA 41 (4): 319-327 JUL.

4.5 Mitigation and Management

The methods using bacteria, virus or macroalgae have drawn attentions as methods for mitigation and management.

Tarutani et al. (2001) found a virus in natural sea area that infects *H. circularisquam* and dissolves its cells, and succeeded in isolating it.

Imai et al. (2001) suggests a possibility that the bacteria known to be effective in eliminating *Chattonella*, called "*Cytophaga* sp. J18/M01", also affects on growth of diatoms.

Imai et al. (2001) found that many bacteria that kill red tide forming species are attached to *Ulva* sp.and *Gelidium* sp, and suggested that increase of red tide sea grass may be prevented by introducing them into culture ponds. Also, Nagayama et al. (2003) found that phlorotannins from *Ecklonia kurome, a* brown alga, has strong lethal effect to sea grass. This phlorotannins is know to be unharmful to red sea bream (*Pagrus major*), tiger puffer (*Fugu rubripes*), and larval blue crab (*Portunus trituberculatus*).

- Reference List -

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4.6 Others

Matsuyama et al. (2001) investigated the effect of 9 harmful algal species on the survival of trochophore larvae of 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*, *Heterocapsa circularisquama* at cell densities of 105-107cells/L. Exposure to *Cochlodinium polykrikoides* extremely retarded the metamorphosis to D- shaped larva.

Kim et al. (2000) found that living *Heterocapsa circularisquama* was toxic to a microzooplankton, a 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 -

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- 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, DEC. 2000.

5. Training Activity to Cope with HAB

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

5.1 Training Activity on Nation-wide Basis

A non-profit organization, named Japan Fisheries Resource Conservation Association (JFRCA), has conducted some training courses every year to develop the capacity of technicians from fishery laboratories, etc. of concerned prefecture governments (Table 5. 1). JFRCA is the only one organization that has such a concrete training activity on nation-wide basis in Japan.

5.2 Training Activity by Local Governments

Prefecture governments have also carried out training courses to educate the fishermen and ordinary people. Table 5. 2 shows an example of such an effort by a certain local government in 2004. Other prefecture governments have similar activities as this case.

5.3 Participation in International Program

Japanese scientists have participated in the international programs for technical training relating to HAB to organize, and promote them. Some of them give lectures to the trainee. No Japanese trainee, however, has participated in the international training programs. The Training Through Research (TTR) program planed by IOC–WESTPAC could be the first case to involve Japanese trainee.

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 tide / shell poisoning problems Fishermen's leader	Experienced researchers from Institute of central government, universities, etc.	5 days during October to December	Lectures • Target species; Dinophyceae, Raphidophyceae • Status quo of red tide and shell poisoning, and consequent damage • State of Art of studies on red tide and shell poisoning • Life cycle and ecological features of causative species • Taxonomy and species identification of plankton and cyst to be cared Exercise • Sampling, sample preservation and concentration, species identification	• Continuous training is necessary for newly assigned person due to personnel transfers in local government • To consider the local features of red tide / shell poisoning • Advanced technology for sampling and analysis • Introduction of conventional methods to ensure continuous and economical performance
2	Dissemination of analytical method using instruments	Personnel from local governments in charge of shell poisoning problem (beginners)	Experienced researchers from Institute of central government	3 days during September to October	Lectures • Status quo of shell poisoning • Analytical method using instruments Exercise • Analyses using instruments	
3	Follow-up of trained skill	Personnel who has once experienced the training	-	30 minutes	Video show 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 minutes	Video show explaining 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 for analysis using instruments	

Source: Extractive from monthly report of activities of 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 ordinary people	3 days	Seminar on mitigation measures against red tide Seminar on mechanism of red tide occurrence Exercise of microscope works 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 tide at early stage became possible in extensive area. • Positive participation of fishermen resulted in better understanding on red tide and minimized economic loss. • Positive participation of fishermen became a model to be disseminated to other area.
2	Enhancement of mitigation measures and monitoring scheme	Aquaculture operators	1 day	Seminar	
3	Enhancement of mitigation measures and monitoring scheme	Aquaculture operators	2 days	Seminar on fishery damage and mitigation measures using a video. Microscopic work on red tide plankton	

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

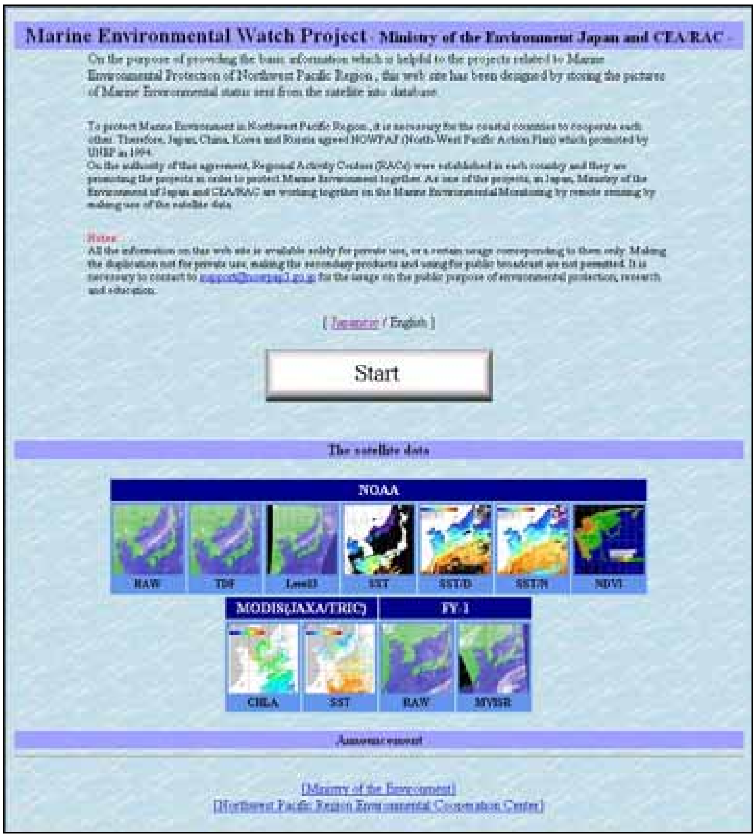
6. National Activity to Cope with HAB

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

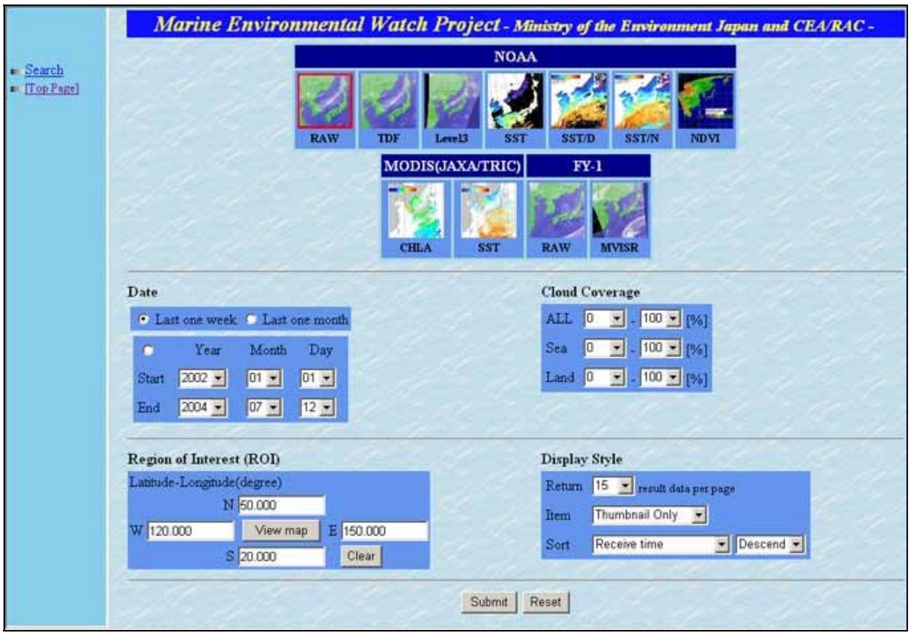
6.1 Promotion of Remote Sensing Monitoring Programs

Although presently the technology of satellite remote sensing does not clearly detect phenomena of red tide, it is expected to become a useful tool to observe HAB. Thus the Government of Japan promotes remote sensing programs in order to monitor marine environment widely and produce data for studying the ability to monitor red tide occurrence by satellite remote sensing.

Ministry of Environment of Japan has developed a satellite remote sensing monitoring project called “Marine Environmental Watch Project” in order to monitor the marine environment of NOWPAP area since the year of 2000. This program provides satellite images of cloud cover, SST, NDVI, and chlorophyll-a detected by NOAA, FY-1, and MODIS in a website (http://www.nowpap3.go.jp/jsw/) as shown in Figure 6. 1. MODIS chlorophyll-a and SST products may help monitoring red tide in the future. Ministry of Environment of Japan will utilize this system to help coastal environmental assessment including the problem of HAB.



(a). Main(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

Japan Coast Guard has also constructed the system to provide marine environmental information related to 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 solid (SS), normalized water leaving radiance (nLw), and surface albedo by earth observation satellites, Terra and Aqua. Currently the system provides data of those oceanic indices only in Tokyo Bay. Japan Coast Guard is making plans to monitor other areas. Toyama Bay is one of the candidates of monitoring area in the Japanese NOWPAP area.

Figure 6. 2 Website of Remote Sensing Database of Japan 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 support the activities of international organizations related to the problem of HAB. The Action Plan for the Protection, Management and Development of the Marine and Coastal Environment of the Northwest Pacific Region (NOWPAP) and Intergovernmental Oceanographic Commission (IOC) have special activities or programs concerning HAB problems.

NOWPAP is one of the Regional Seas Programme of the United Nations Environment Programme (UNEP). NOWPAP established The Special Monitoring & Coastal Environmental Assessment Regional Activity Centre (CEARAC) in 1999 in Toyama, Japan. CEARAC set the first target for coastal environmental assessment on HAB. The Ministry of Environment of Japan has contributed financial support and human resources to the activity of CEARAC through Northwest Pacific Region Environmental Cooperation Center (NPEC) which was established by the Ministry of Environment of Japan in 1998 in Toyama, Japan. The ministry also provides “Marine Environmental Watch System” for monitoring chloropllyl-a mentioned above.

The IOC subcommittee for the Western Pacific (IOC/WESTPAC) has Harmful Algal Blooms Program. The program aims at providing capacity building and producing documents related to HAB. The Government of Japan supports a series of annual courses for Member States to develop their capacity building and participates in the activities of the program. IOC/WESTPAC also conducts NEAR GOOS program, a regional program of the Global Ocean Observing System (GOOS) implemented by China, Japan, Koran, and Russia. The Government of Japan expects NEAR GOOS program to help study HAB in the future.

PICES has made various efforts related to HAB problems. Currently, it is very eager to establish a common database for analysis of coastal HAB events. At a joint PICES/IOC Workshop on “Harmful algae blooms – Harmonization of data” in 2003, PICES member countries accepted an offer from IOC/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 for HAB

The Government of Japan has conducted the activities concerning HAB such as development of an information network system of red tide and shellfish poisoning and study on mitigation measures against shellfish poisoning.

The Fisheries Agency of Japan has prepared a network system of information on red tide and shellfish poisoning in using Internet (http://turtle.jfrca.or.jp/akashiwo.html). This system provides information on past red tide occurrence in selected enclosed bays and inland seas, and occurrence of shellfish poisoning in the entire Japanese fishery/aquaculture grounds. The website of the system introduces local government's websites which also presents up-to-dated information on red tide occurrence and shipping inhibition of poisoned shellfish. Although this system does not cover whole Japanese NOWPAP area, users who are interested in HAB in Japanese NOWPAP area can obtain some information along coastal area of 4 prefectures (red tide occurrence: Yamaguchi, Fukuoka, Saga Prefecture/ shipping inhibition of poisoned shellfish: Shimane, Fukuoka Prefecture).

In order to develop mitigation measures against shellfish poising, the Fisheries Agency of Japan is studying the shellfish poisoning mechanism and inspection/monitoring scheme. Some laboratories under the agency investigate enemy virus against toxic producing plankton as a option of mitigation measure.

7. Suggested Activity for the NOWPAP Region

This chapter suggests action against the problem of *Cochlodinium*, cooperation with other organization, and promotion of land based activities as the activities for NOWPAP region in near future. These three kind of activities are proposed because: *Cochlodinium* causes not only the adverse effect on fisheries and aquacultures in Japan and Korea but might possibly affect the NOWPAP countries in future; needless to say, it is important for NOWPAP to work together or exchange information with other organization; and effective pollution control in human land-based activity should be considered with analysis of HAB in the ocean.

7.1 Action against the Problem of *Cochlodinium*

A working group under CEARAC has agreed that *Cochlodinium* is one of the most concerned harmful algae in NOWPAP region. This species is suffering aquaculture especially in Japan and Korea. For example, about 250,000 sea breams in aquaculture in Uwagkai (in Ehime Prefecture) and about US$1,000,000 were lost by *Cochlodinium polykrikoides* in July 22, 2004. The damage of fishery is reported not only in NOWPAP area but also in the Southeast Asia. *Cochlodinium* has been recently recognized so that the study of this species is less advanced than that of other toxic-producing plankton. CEARAC under NOWPAP established a group to study *Cochlodinium*, called "*Cochlodinium* Corresponding Group (CCG)". The aim of this study group is to make a set of useful information on *Cochlodinium* and help policy makers concerning coastal fisheries.

7.2 Cooperation with Other Organizations

NOWPAP may cooperate with the other UNEP Regional Action Plans (RAS), for example, East Asia Seas Action Plan. *Cochlodinium* is recently appeared in the area of the East Asia Seas Action Plan. *Hetrocapsa circularisquama* is though to be transported from southern tropical/subtropical seas. Therefore, cooperation with other UNEP RASs is useful for NOWPAP.

ICO/WESTPAC will establish Training Trough Research program (TTR) about *Cochlodinium* in late 2004. NOWPAP/CEARAC also has established CCG mentioned in the above section. WESTPAC/TTR and CCG may organize the joint program to cope with *Cochlodinium* or exchange information on the species and related activities.

In addition, NOWPAP have to be careful not to make its activity plan identical to the one other organizations have. NOWPAP should exchange information with other organization in order to make efficient plans to cope with HAB.

7.3 Promotion of Land Based Activities

NOWPAP/CEARAC presently has approached the problem of HAB mostly from the point of view of oceanography and marine ecology. It is, however, important for us to control human land based activity producing enormous amount of pollutants into the sea. Japan has experience to have overcome the water pollution to implement appropriate pollution abatement policies and technologies. Japan has also monitored effluents for longtime. Therefore, using the experience and technology of Japan, NOWPAP/CEARAC monitoring plans and pollution prevention policies about human land based activity should be considered.

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Appendices

i Abbreviation
ii Red tide events in northern Kyushu coastal waters Inland during 1998-2002
iii List of references stored in HAB Reference Database, from period after 2000

i Abbreviation

- CCG: *Cochlodinium* Corresponding Group
- CEARAC: Coastal Environmental Assessment Regional Activity Center
- DSP: Diarrhetic Shellfish Poisoning
- 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
- NOWPAP: North-west Pacific Action Plan
- PICES: North Pacific Marine Science Organization
- PSP: Paralytic Shellfish Poisoning
- TTR: Training Through Research
- UNEP: United Nations Environment Programme
- WESTPAC: IOC Sub-Commission for the Western Pacific

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

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 ①-④			
	Location 1	Location 2	dd/mm/yy-dd/mm/yy		①	②	③	④
NS-01	remote Island	Tsushima	27/01/98 - 02/02/98	7	*Skeletonema costatum*			
NS-02	remote Island	Goto	07/04/98 - 25/04/98	19	*Gymnodinium sanguineum*			
NS-08	remote Island	Tsushima	16/05/98 - 21/05/98	6	*Prorocentrum micans*			
FO-03	N	other	01/06/98 - 05/06/98	5	*Heterosigma akashiwo*			
YG-01	N	other	03/06/98 - 16/06/98	14	*Heterosigma akashiwo*			
FO-04	N	Fukuokawan	15/06/98 - 17/06/98	3	*Skeletonema costatum*			
SA-04	N	other	22/06/98 - 03/07/98	12	*Heterosigma akashiwo*			
SA-05	N	other	24/06/98 - 26/06/98	3	*Prorocentrum triestinum*	*Prorocentrum dentatum*		
SA-06	N	Imariwan	24/06/98 - 29/06/98	6	*Prorocentrum dentatum*			
FO-06	N	Fukuokawan	13/07/98 - 16/07/98	4	*Chaetoceros* sp.			
YG-02	N	other	11/08/98 - 20/08/98	10	*Cochlodinium polykrikoides*			
NS-16	remote Island	Tsushima	17/08/98 - 21/08/98	5	*Cochlodinium polykrikoides*			
YG-03	N	other	19/08/98 - 02/09/98	15	similar *Heterocapsa circularisquama*			
NS-17	remote Island	Tsushima	25/08/98 - 26/08/98	2	unknown			
FO-08	N	Fukuokawan	27/08/98 - 28/08/98	2	*Thalassiosira* sp.			
FO-09	N	Fukuokawan	09/09/98 - 10/09/98	2	*Skeletonema costatum* etc.			
NS-22	N	Imariwan	21/10/98 - 24/10/98	4	*Skeletonema costatum*			
NS-98-29	remote Island	Goto	17/12/98 - 04/01/99	19	*Mesodinium rubrum*			
NS-98-30	remote Island	Tsushima	28/12/98 - 06/01/99	10	*Mesodinium rubrum*			
NS-01	remote Island	Goto	05/01/99 - 09/01/99	5	*Mesodinium rubrum*			
YG-01	N	other	10/03/99 - 12/03/99	3	*Noctiluca scintillans*			
SA-01	N	other	04/04/99 - 20/04/99	17	*Gymnodinium sanguineum*			
NS-02	remote Island	Tsushima	19/04/99 - 26/04/99	8	*Gymnodinium sanguineum*			
YG-02	N	other	20/04/99 - 21/04/99	2	*Noctiluca scintillans*			
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.			
YG-05	N	other	12/05/99 - 14/05/99	3	*Noctilca* sp.			
FO-03	N	Fukuokawan	31/05/99 - 02/06/99	3	*Leptcylindrus danicus*	*Prorocentrum minimum*		
SA-02	N	other	07/06/99 - 05/07/99	29	*Heterosigma akashiwo*	*Prorocentrum dentatum*		
FO-04	N	other	08/06/99 - 10/06/99	3	*Haptophyceae*			
FO-05	N	Fukuokawan	09/06/99 - 14/06/99	6	*Skeletonema costatum*	*Prorocentrum minimum*	*Leptcylindrus* sp.	
SA-03	N	other	20/06/99 - 26/07/99	37	*Prorocentrum dentatum*			
YG-06	N	other	21/06/99 - 22/06/99	2	*Heterosigma akashiwo*			
NS-09	N	Imariwan	01/07/99 - 21/07/99	21	*Skeletonema costatum*			
FO-09	N	Fukuokawan	05/07/99 - 08/07/99	4	*Skeletonema costatum*	*Thalassiosira* sp.	*Chaetoceros* sp.	
SA-04	N	Imariwan	05/07/99 - 29/07/99	25	*Skeletonema costatum*	*Pseudnitzchia* sp.	*Prorocentrum dentatum*	
SA-06	N	other	22/07/99 - 30/07/99	9	*Prorocentrum dentatum*			
FO-11	N	Fukuokawan	22/07/99 - 22/08/99	32	*Prorocentrum dentatum*	*Gymnodinium mikimotoi*		
NS-11	N	Imariwan	25/07/99 - 06/08/99	13	*Gymnodinium mikimotoi*			
SA-07	N	Imariwan	03/08/99 - 09/08/99	7	*Gymnodinium mikimotoi*			
SA-08	N	other	03/08/99 - 09/08/99	7	*Gymnodinium mikimotoi*			
SA-09	N	other	05/08/99 - 09/08/99	5	*Gymnodinium mikimotoi*			
NS-13	N	Imariwan	07/08/99 - 12/08/99	6	*Cochlodinium polykrikoides*			
FO-13	N	other	09/08/99 - 18/08/99	10	*Heterocapsa circularisquama*			
SA-10	N	Imariwan	10/08/99 - 16/08/99	7	*Cochlodinium polykrikoides*			
SA-12	N	Imariwan	16/08/99 - 27/09/99	43	*Heterocapsa circularisquama*			
NS-24	remote Island	Tsushima	06/09/99 - 17/09/99	12	*Gymnodinium mikimotoi*			
FO-16	N	Fukuokawan	07/09/99 - 13/09/99	7	*Skeletonema costatum*			
NS-32	remote Island	Tsushima	09/12/99 - 21/12/99	13	*Mesodinium rubrum*			
YG-01	N	other	05/04/00	1	*Noctilca* sp.			
FO-02	N	other	23/05/00 - 26/05/00	4	*Heterosigma akashiwo*			
FO-04	N	other	01/06/00 - 06/06/00	6	*Heterosigma akashiwo*			
FO-05	N	Fukuokawan	02/06/00 - 06/06/00	5	*Prorocentrum minimum*			
FO-06	N	Fukuokawan	13/06/00 - 19/06/00	7	*Skeletonema costatum*	*Leptocylindrus* sp.		
SA-03	N	other	15/06/00 - 19/06/00	5	*Heterosigma akashiwo*			
SA-04	N	other	18/06/00 - 26/06/00	9	*Heterosigma akashiwo*			
SA-05	N	other	26/06/00 - 30/06/00	5	*Prorocentrum dentatum*	*Mesodinium rubrum*		
SA-06	N	Imariwan	27/06/00 - 27/07/00	31	*Gymnodinium mikimotoi*			
FO-07	N	Fukuokawan	30/06/00 - 31/07/00	32	*Fibrocapsa japonica*	*Prorocentrum dentatum*	*Prorocentrum triestinum*	*Skeletonema costatum*
YG-02	N	other	06/07/00 - 03/08/00	29	*Gymnodinium mikimotoi*			
SA-07	N	other	10/07/00 - 19/07/00	10	*Gymnodinium mikimotoi*			
NS-09	N	other	11/07/00 - 12/07/00	2	*Gymnodinium mikimotoi*			
FO-09	N	other	11/07/00 - 31/07/00	21	*Gymnodinium mikimotoi*			
NS-10	N	Imariwan	13/07/00 - 22/07/00	10	*Gymnodinium mikimotoi*			
NS-12	remote Island	Goto	26/07/00 - 17/08/00	23	*Gymnodinium mikimotoi*			
FO-10	N	Fukuokawan	04/08/00 - 11/08/00	8	*Skeletonema costatum*	*Thalassiosira* sp.	*Chaetoceros* sp.	*Neodelphineis pelagica*
SA-10	N	Imariwan	18/08/00 - 11/09/00	25	*Heterocapsa circularisquama*			
NS-19	remote Island	Tsushima	21/08/00 - 24/08/00	4	*Cochlodinium polykrikoides*			
FO-13	N	Fukuokawan	23/08/00 - 01/09/00	10	*Skeletonema costatum*	*Thalassiosira* sp.	*Chaetoceros* sp.	*Neodelphineis pelagica*
FO-14	N	Fukuokawan	08/09/00 - 12/09/00	5	*Skeletonema costatum*	*Thalassiosira* sp.	*Chaetoceros* sp.	
NS-21	remote Island	Tsushima	18/09/00 - 25/09/00	8	*Noctiluca scintillans*			
SA-11	N	Imariwan	27/09/00 - 29/09/00	3	*Prorocentrum sigmoides*			
NS-23	N	Imariwan	28/09/00 - 04/10/00	7	*Prorocentrum sigmoides*			
FO-15	N	Fukuokawan	07/11/00 - 11/11/00	5	*Thalassiosira* sp.	*Skeletonema costatum*	*Asterionella* sp.	
NS-27	remote Island	Tsushima	08/11/00 - 15/11/00	8	*Nitzschia* spp.			
SA-01	N	Imariwan	21/01/01 - 25/01/01	5	*Gymnodinium sanguineum*			
YG-01	N	other	20/03/01 - 23/04/01	35	*Noctiluca scintillans*			
FO-01	N	other	21/03/01 - 22/03/01	2	*Noctiluca scintillans*			
FO-03	N	other	06/04/01 - 09/04/01	4	*Noctiluca scintillans*			
NS-03	remote Island	Goto	07/04/01 - 11/04/01	5	*Noctiluca scintillans*			
NS-04	N	Imariwan	10/04/01 - 13/04/01	4	*Noctiluca scintillans*			
NS-05	remote Island	Iki	17/04/01 - 20/04/01	4	*Noctiluca scintillans*			
NS-06	remote Island	Goto	17/04/01 - 18/04/01	2	*Noctiluca scintillans*			
FO-04	N	other	17/04/01 - 20/04/01	4	*Noctiluca scintillans*			
NS-07	remote Island	Tsushima	18/04/01 - 19/04/01	2	*Noctiluca scintillans*			
NS-08	remote Island	Tsushima	18/04/01 - 19/04/01	2	*Noctiluca scintillans*			
SA-02	N	other	18/04/01 - 12/05/01	25	*Noctiluca scintillans*			
NS-09	remote Island	Iki	27/04/01 - 01/05/01	5	*Noctiluca scintillans*			
FO-05	N	Fukuokawan	06/05/01 - 14/05/01	9	*Prorocentrum minimum*			
SA-03	N	other	07/05/01 - 11/05/01	5	*Heterosigma akashiwo*			
NS-12	remote Island	Goto	22/05/01 - 23/05/01	2	*Noctiluca scintillans*			

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	Causative species ⑤-⑥			
	Location 1	Location 2	dd/mm/yy-dd/mm/yy	⑤	⑥	⑦	⑧
NS-01	remote Island	Tsushima	27/01/98 - 02/02/98				
NS-02	remote Island	Goto	07/04/98 - 25/04/98				
NS-08	remote Island	Tsushima	16/05/98 - 21/05/98				
FO-03	N	other	01/06/98 - 05/06/98				
YG-01	N	other	03/06/98 - 16/06/98				
FO-04	N	Fukuokawan	15/06/98 - 17/06/98				
SA-04	N	other	22/06/98 - 03/07/98				
SA-05	N	other	24/06/98 - 26/06/98				
SA-06	N	Imariwan	24/06/98 - 29/06/98				
FO-06	N	Fukuokawan	13/07/98 - 16/07/98				
YG-02	N	other	11/08/98 - 20/08/98				
NS-16	remote Island	Tsushima	17/08/98 - 21/08/98				
YG-03	N	other	19/08/98 - 02/09/98				
NS-17	remote Island	Tsushima	25/08/98 - 26/08/98				
FO-08	N	Fukuokawan	27/08/98 - 28/08/98				
FO-09	N	Fukuokawan	09/09/98 - 10/09/98				
NS-22	N	Imariwan	21/10/98 - 24/10/98				
NS-98-29	remote Island	Goto	17/12/98 - 04/01/99				
NS-98-30	remote Island	Tsushima	28/12/98 - 06/01/99				
NS-01	remote Island	Goto	05/01/99 - 09/01/99				
YG-01	N	other	10/03/99 - 12/03/99				
SA-01	N	other	04/04/99 - 20/04/99				
NS-02	remote Island	Tsushima	19/04/99 - 26/04/99				
YG-02	N	other	20/04/99 - 21/04/99				
YG-03	N	other	20/04/99 - 21/04/99				
YG-04	N	other	26/04/99 - 27/04/99				
FO-02	N	Fukuokawan	10/05/99 - 12/05/99				
YG-05	N	other	12/05/99 - 14/05/99				
FO-03	N	Fukuokawan	31/05/99 - 02/06/99				
SA-02	N	other	07/06/99 - 05/07/99				
FO-04	N	other	08/06/99 - 10/06/99				
FO-05	N	Fukuokawan	09/06/99 - 14/06/99				
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				
FO-09	N	Fukuokawan	05/07/99 - 08/07/99				
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				
NS-11	N	Imariwan	25/07/99 - 06/08/99				
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				
FO-13	N	other	09/08/99 - 18/08/99				
SA-10	N	Imariwan	10/08/99 - 16/08/99				
SA-12	N	Imariwan	16/08/99 - 27/09/99				
NS-24	remote Island	Tsushima	06/09/99 - 17/09/99				
FO-16	N	Fukuokawan	07/09/99 - 13/09/99				
NS-32	remote Island	Tsushima	09/12/99 - 21/12/99				
YG-01	N	other	05/04/00				
FO-02	N	other	23/05/00 - 26/05/00				
FO-04	N	other	01/06/00 - 06/06/00				
FO-05	N	Fukuokawan	02/06/00 - 06/06/00				
FO-06	N	Fukuokawan	13/06/00 - 19/06/00				
SA-03	N	other	15/06/00 - 19/06/00				
SA-04	N	other	18/06/00 - 26/06/00				
SA-05	N	other	26/06/00 - 30/06/00				
SA-06	N	Imariwan	27/06/00 - 27/07/00				
FO-07	N	Fukuokawan	30/06/00 - 31/07/00	*Thalassiosira* sp.	*Heterocapsa circularisquama*	*Gymnodinium mikimotoi*	
YG-02	N	other	06/07/00 - 03/08/00				
SA-07	N	other	10/07/00 - 19/07/00				
NS-09	N	other	11/07/00 - 12/07/00				
FO-09	N	other	11/07/00 - 31/07/00				
NS-10	N	Imariwan	13/07/00 - 22/07/00				
NS-12	remote Island	Goto	26/07/00 - 17/08/00				
FO-10	N	Fukuokawan	04/08/00 - 11/08/00				
SA-10	N	Imariwan	18/08/00 - 11/09/00				
NS-19	remote Island	Tsushima	21/08/00 - 24/08/00				
FO-13	N	Fukuokawan	23/08/00 - 01/09/00	*Gymnodinium mikimotoi*	*Heterocapsa circularisquama*		
FO-14	N	Fukuokawan	08/09/00 - 12/09/00				
NS-21	remote Island	Tsushima	18/09/00 - 25/09/00				
SA-11	N	Imariwan	27/09/00 - 29/09/00				
NS-23	N	Imariwan	28/09/00 - 04/10/00				
FO-15	N	Fukuokawan	07/11/00 - 11/11/00				
NS-27	remote Island	Tsushima	08/11/00 - 15/11/00				
SA-01	N	Imariwan	21/01/01 - 25/01/01				
YG-01	N	other	20/03/01 - 23/04/01				
FO-01	N	other	21/03/01 - 22/03/01				
FO-03	N	other	06/04/01 - 09/04/01				
NS-03	remote Island	Goto	07/04/01 - 11/04/01				
NS-04	N	Imariwan	10/04/01 - 13/04/01				
NS-05	remote Island	Iki	17/04/01 - 20/04/01				
NS-06	remote Island	Goto	17/04/01 - 18/04/01				
FO-04	N	other	17/04/01 - 20/04/01				
NS-07	remote Island	Tsushima	18/04/01 - 19/04/01				
NS-08	remote Island	Tsushima	18/04/01 - 19/04/01				
SA-02	N	other	18/04/01 - 12/05/01				
NS-09	remote Island	Iki	27/04/01 - 01/05/01				
FO-05	N	Fukuokawan	06/05/01 - 14/05/01				
SA-03	N	other	07/05/01 - 11/05/01				
NS-12	remote Island	Goto	22/05/01 - 23/05/01				

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	Max. cell density (cells/L)							
	Location 1	Location 2	dd/mm/yy-dd/mm/yy	(km×km)	①	②	③	④	⑤	⑥	⑦	⑧
NS-01	remote Island	Tsushima	27/01/98 - 02/02/98	0.75	3,600							
NS-02	remote Island	Goto	07/04/98 - 25/04/98	0.5	588							
NS-08	remote Island	Tsushima	16/05/98 - 21/05/98	0.002	13,000							
FO-03	N	other	01/06/98 - 05/06/98	5	10,000							
YG-01	N	other	03/06/98 - 16/06/98	0.06	7,650							
FO-04	N	Fukuokawan	15/06/98 - 17/06/98	71.1	25,950							
SA-04	N	other	22/06/98 - 03/07/98	unknown	79,070							
SA-05	N	other	24/06/98 - 26/06/98	unknown	4,420	1,260						
SA-06	N	Imariwan	24/06/98 - 29/06/98	unknown	5,190							
FO-06	N	Fukuokawan	13/07/98 - 16/07/98	41.5	7,200							
YG-02	N	other	11/08/98 - 20/08/98	0.65	18,000							
NS-16	remote Island	Tsushima	17/08/98 - 21/08/98	1	103							
YG-03	N	other	19/08/98 - 02/09/98	0.65	12,780							
NS-17	remote Island	Tsushima	25/08/98 - 26/08/98	0.015	119							
FO-08	N	Fukuokawan	27/08/98 - 28/08/98	40.6	7,420							
FO-09	N	Fukuokawan	09/09/98 - 10/09/98	49	unknown							
NS-22	N	Imariwan	21/10/98 - 24/10/98	3	2,500							
NS-98-29	remote Island	Goto	17/12/98 - 04/01/99	0.995	4,750							
NS-98-30	remote Island	Tsushima	28/12/98 - 06/01/99	0.035	699							
NS-01	remote Island	Goto	05/01/99 - 09/01/99	0.285	882							
YG-01	N	other	10/03/99 - 12/03/99	-	2,990							
SA-01	N	other	04/04/99 - 20/04/99	-	2,420							
NS-02	remote Island	Tsushima	19/04/99 - 26/04/99	2.51	2,256							
YG-02	N	other	20/04/99 - 21/04/99	-	450							
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	3,360							
YG-05	N	other	12/05/99 - 14/05/99	-	3,699							
FO-03	N	Fukuokawan	31/05/99 - 02/06/99	30	29,899	5,299						
SA-02	N	other	07/06/99 - 05/07/99	-	29,810	52,820						
FO-04	N	other	08/06/99 - 10/06/99	1	22,399							
FO-05	N	Fukuokawan	09/06/99 - 14/06/99	35	83,799	2,250	6,599					
SA-03	N	other	20/06/99 - 26/07/99	-	71,765							
YG-06	N	other	21/06/99 - 22/06/99	-	7,720							
NS-09	N	Imariwan	01/07/99 - 21/07/99	4	18,699							
FO-09	N	Fukuokawan	05/07/99 - 08/07/99	47	9,299	4,599	2,250					
SA-04	N	Imariwan	05/07/99 - 29/07/99	-	18,670	1,380	78,499					
SA-06	N	other	22/07/99 - 30/07/99	-	2,050							
FO-11	N	Fukuokawan	22/07/99 - 22/08/99	62	9,680	40						
NS-11	N	Imariwan	25/07/99 - 06/08/99	6	4,950							
SA-07	N	Imariwan	03/08/99 - 09/08/99	-	3,740							
SA-08	N	other	03/08/99 - 09/08/99	-	11,040							
SA-09	N	other	05/08/99 - 09/08/99	-	1,940							
NS-13	N	Imariwan	07/08/99 - 12/08/99	5	11,060							
FO-13	N	other	09/08/99 - 18/08/99	1	7,040							
SA-10	N	Imariwan	10/08/99 - 16/08/99	15	3,360							
SA-12	N	Imariwan	16/08/99 - 27/09/99	-	4,050							
NS-24	remote Island	Tsushima	06/09/99 - 17/09/99	0.4	11,670							
FO-16	N	Fukuokawan	07/09/99 - 13/09/99	40	49,970							
NS-32	remote Island	Tsushima	09/12/99 - 21/12/99	0.07	3,990							
YG-01	N	other	05/04/00	0.1	530							
FO-02	N	other	23/05/00 - 26/05/00	under 1	9,170							
FO-04	N	other	01/06/00 - 06/06/00	unknown	28,060							
FO-05	N	Fukuokawan	02/06/00 - 06/06/00	65	6,090							
FO-06	N	Fukuokawan	13/06/00 - 19/06/00	60	38,340	18,600						
SA-03	N	other	15/06/00 - 19/06/00	0.005	54,000							
SA-04	N	other	18/06/00 - 26/06/00	0.3	7,960							
SA-05	N	other	26/06/00 - 30/06/00	0.125	2,840	500						
SA-06	N	Imariwan	27/06/00 - 27/07/00	4	10,040							
FO-07	N	Fukuokawan	30/06/00 - 31/07/00	40	694	15,500	88	5,700	10,900	96	57	
YG-02	N	other	06/07/00 - 03/08/00	unknown	14,800							
SA-07	N	other	10/07/00 - 19/07/00	2	12,060							
NS-09	N	other	11/07/00 - 12/07/00	0.01	20,600							
FO-09	N	other	11/07/00 - 31/07/00	unknown	4,710							
NS-10	N	Imariwan	13/07/00 - 22/07/00	16	17,560							
NS-12	remote Island	Goto	26/07/00 - 17/08/00	2	37,300							
FO-10	N	Fukuokawan	04/08/00 - 11/08/00	70	8,800	6,860	5,900	6,610				
SA-10	N	Imariwan	18/08/00 - 11/09/00	unknown	310							
NS-19	remote Island	Tsushima	21/08/00 - 24/08/00	0.2	2,325							
FO-13	N	Fukuokawan	23/08/00 - 01/09/00	35	8,220	9,400	3,770	8,260	2,200	230		
FO-14	N	Fukuokawan	08/09/00 - 12/09/00	unknown	16,870	9,360	4,380					
NS-21	remote Island	Tsushima	18/09/00 - 25/09/00	0.0005	1,476							
SA-11	N	Imariwan	27/09/00 - 29/09/00	12	2,290							
NS-23	N	Imariwan	28/09/00 - 04/10/00	3	1,500							
FO-15	N	Fukuokawan	07/11/00 - 11/11/00	unknown	2,410	19,100	2,320					
NS-27	remote Island	Tsushima	08/11/00 - 15/11/00	14	3,585							
SA-01	N	Imariwan	21/01/01 - 25/01/01	unknown	334							
YG-01	N	other	20/03/01 - 23/04/01	unknown	2,700							
FO-01	N	other	21/03/01 - 22/03/01	0.4	75							
FO-03	N	other	06/04/01 - 09/04/01	4	1,160							
NS-03	remote Island	Goto	07/04/01 - 11/04/01	2	5,420							
NS-04	N	Imariwan	10/04/01 - 13/04/01	0.1	731							
NS-05	remote Island	Iki	17/04/01 - 20/04/01	0.3	249							
NS-06	remote Island	Goto	17/04/01 - 18/04/01	58.7	unknown							
FO-04	N	other	17/04/01 - 20/04/01	60	1,220							
NS-07	remote Island	Tsushima	18/04/01 - 19/04/01	0.0025	1,968							
NS-08	remote Island	Tsushima	18/04/01 - 19/04/01	0.01	650							
SA-02	N	other	18/04/01 - 12/05/01	0.08	380							
NS-09	remote Island	Iki	27/04/01 - 01/05/01	unknown	467							
FO-05	N	Fukuokawan	06/05/01 - 14/05/01	70	6,450							
SA-03	N	other	07/05/01 - 11/05/01	0.4	19,760							
NS-12	remote Island	Goto	22/05/01 - 23/05/01	unknown	672							

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	Fish/shellfish species				
	Location 1	Location 2	dd/mm/yy-dd/mm/yy	①	②	③	④	⑤
NS-01	remote Island	Tsushima	27/01/98 - 02/02/98					
NS-02	remote Island	Goto	07/04/98 - 25/04/98					
NS-08	remote Island	Tsushima	16/05/98 - 21/05/98					
FO-03	N	other	01/06/98 - 05/06/98					
YG-01	N	other	03/06/98 - 16/06/98	Jackmackerel, Amberjacks				
FO-04	N	Fukuokawan	15/06/98 - 17/06/98					
SA-04	N	other	22/06/98 - 03/07/98					
SA-05	N	other	24/06/98 - 26/06/98					
SA-06	N	Imariwan	24/06/98 - 29/06/98					
FO-06	N	Fukuokawan	13/07/98 - 16/07/98					
YG-02	N	other	11/08/98 - 20/08/98	Fishes				
NS-16	remote Island	Tsushima	17/08/98 - 21/08/98	Amberjacks				
YG-03	N	other	19/08/98 - 02/09/98					
NS-17	remote Island	Tsushima	25/08/98 - 26/08/98					
FO-08	N	Fukuokawan	27/08/98 - 28/08/98					
FO-09	N	Fukuokawan	09/09/98 - 10/09/98					
NS-22	N	Imariwan	21/10/98 - 24/10/98					
NS-98-29	remote Island	Goto	17/12/98 - 04/01/99					
NS-98-30	remote Island	Tsushima	28/12/98 - 06/01/99					
NS-01	remote Island	Goto	05/01/99 - 09/01/99					
YG-01	N	other	10/03/99 - 12/03/99	Squids, Octopus, fishes				
SA-01	N	other	04/04/99 - 20/04/99					
NS-02	remote Island	Tsushima	19/04/99 - 26/04/99					
YG-02	N	other	20/04/99 - 21/04/99					
YG-03	N	other	20/04/99 - 21/04/99					
YG-04	N	other	26/04/99 - 27/04/99					
FO-02	N	Fukuokawan	10/05/99 - 12/05/99					
YG-05	N	other	12/05/99 - 14/05/99					
FO-03	N	Fukuokawan	31/05/99 - 02/06/99					
SA-02	N	other	07/06/99 - 05/07/99					
FO-04	N	other	08/06/99 - 10/06/99					
FO-05	N	Fukuokawan	09/06/99 - 14/06/99					
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					
FO-09	N	Fukuokawan	05/07/99 - 08/07/99					
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					
NS-11	N	Imariwan	25/07/99 - 06/08/99					
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	Sea bream	Yellowtail	Puffy fish	Horse mackerel	
FO-13	N	other	09/08/99 - 18/08/99	Abalone				
SA-10	N	Imariwan	10/08/99 - 16/08/99					
SA-12	N	Imariwan	16/08/99 - 27/09/99					
NS-24	remote Island	Tsushima	06/09/99 - 17/09/99					
FO-16	N	Fukuokawan	07/09/99 - 13/09/99					
NS-32	remote Island	Tsushima	09/12/99 - 21/12/99					
YG-01	N	other	05/04/00					
FO-02	N	other	23/05/00 - 26/05/00	Sea bream, Jackmackerel				
FO-04	N	other	01/06/00 - 06/06/00					
FO-05	N	Fukuokawan	02/06/00 - 06/06/00					
FO-06	N	Fukuokawan	13/06/00 - 19/06/00					
SA-03	N	other	15/06/00 - 19/06/00					
SA-04	N	other	18/06/00 - 26/06/00	Amberjacks				
SA-05	N	other	26/06/00 - 30/06/00					
SA-06	N	Imariwan	27/06/00 - 27/07/00					
FO-07	N	Fukuokawan	30/06/00 - 31/07/00					
YG-02	N	other	06/07/00 - 03/08/00	Fishes, Abalone	Turban	Abalone	Turban	Turban
SA-07	N	other	10/07/00 - 19/07/00					
NS-09	N	other	11/07/00 - 12/07/00					
FO-09	N	other	11/07/00 - 31/07/00	Abalone, Turban				
NS-10	N	Imariwan	13/07/00 - 22/07/00	Puffy fish				
NS-12	remote Island	Goto	26/07/00 - 17/08/00	Turban				
FO-10	N	Fukuokawan	04/08/00 - 11/08/00					
SA-10	N	Imariwan	18/08/00 - 11/09/00					
NS-19	remote Island	Tsushima	21/08/00 - 24/08/00					
FO-13	N	Fukuokawan	23/08/00 - 01/09/00					
FO-14	N	Fukuokawan	08/09/00 - 12/09/00					
NS-21	remote Island	Tsushima	18/09/00 - 25/09/00					
SA-11	N	Imariwan	27/09/00 - 29/09/00					
NS-23	N	Imariwan	28/09/00 - 04/10/00					
FO-15	N	Fukuokawan	07/11/00 - 11/11/00					
NS-27	remote Island	Tsushima	08/11/00 - 15/11/00					
SA-01	N	Imariwan	21/01/01 - 25/01/01					
YG-01	N	other	20/03/01 - 23/04/01					
FO-01	N	other	21/03/01 - 22/03/01					
FO-03	N	other	06/04/01 - 09/04/01					
NS-03	remote Island	Goto	07/04/01 - 11/04/01					
NS-04	N	Imariwan	10/04/01 - 13/04/01					
NS-05	remote Island	Iki	17/04/01 - 20/04/01					
NS-06	remote Island	Goto	17/04/01 - 18/04/01					
FO-04	N	other	17/04/01 - 20/04/01					
NS-07	remote Island	Tsushima	18/04/01 - 19/04/01					
NS-08	remote Island	Tsushima	18/04/01 - 19/04/01					
SA-02	N	other	18/04/01 - 12/05/01					
NS-09	remote Island	Iki	27/04/01 - 01/05/01					
FO-05	N	Fukuokawan	06/05/01 - 14/05/01					
SA-03	N	other	07/05/01 - 11/05/01					
NS-12	remote Island	Goto	22/05/01 - 23/05/01					

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 (5)

Event No.	Location (name of the sea area)		Duration	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
NS-01	remote Island	Tsushima	27/01/98 - 02/02/98															
NS-02	remote Island	Goto	07/04/98 - 25/04/98															
NS-08	remote Island	Tsushima	16/05/98 - 21/05/98															
FO-03	N	other	01/06/98 - 05/06/98															
YG-01	N	other	03/06/98 - 16/06/98	died					unknown					20〜30				
FO-04	N	Fukuokawan	15/06/98 - 17/06/98															
SA-04	N	other	22/06/98 - 03/07/98															
SA-05	N	other	24/06/98 - 26/06/98															
SA-06	N	Imariwan	24/06/98 - 29/06/98															
FO-06	N	Fukuokawan	13/07/98 - 16/07/98															
YG-02	N	other	11/08/98 - 20/08/98	died					unknown					unknown				
NS-16	remote Island	Tsushima	17/08/98 - 21/08/98	died					340 kg					1,122				
YG-03	N	other	19/08/98 - 02/09/98															
NS-17	remote Island	Tsushima	25/08/98 - 26/08/98															
FO-08	N	Fukuokawan	27/08/98 - 28/08/98															
FO-09	N	Fukuokawan	09/09/98 - 10/09/98															
NS-22	N	Imariwan	21/10/98 - 24/10/98															
NS-98-29	remote Island	Goto	17/12/98 - 04/01/99															
NS-98-30	remote Island	Tsushima	28/12/98 - 06/01/99															
NS-01	remote Island	Goto	05/01/99 - 09/01/99															
YG-01	N	other	10/03/99 - 12/03/99	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															
YG-02	N	other	20/04/99 - 21/04/99															
YG-03	N	other	20/04/99 - 21/04/99															
YG-04	N	other	26/04/99 - 27/04/99															
FO-02	N	Fukuokawan	10/05/99 - 12/05/99															
YG-05	N	other	12/05/99 - 14/05/99															
FO-03	N	Fukuokawan	31/05/99 - 02/06/99															
SA-02	N	other	07/06/99 - 05/07/99															
FO-04	N	other	08/06/99 - 10/06/99															
FO-05	N	Fukuokawan	09/06/99 - 14/06/99															
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															
FO-09	N	Fukuokawan	05/07/99 - 08/07/99															
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															
NS-11	N	Imariwan	25/07/99 - 06/08/99															
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	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	died					5,100 inds.					74				
SA-10	N	Imariwan	10/08/99 - 16/08/99															
SA-12	N	Imariwan	16/08/99 - 27/09/99															
NS-24	remote Island	Tsushima	06/09/99 - 17/09/99															
FO-16	N	Fukuokawan	07/09/99 - 13/09/99															
NS-32	remote Island	Tsushima	09/12/99 - 21/12/99															
YG-01	N	other	05/04/00															
FO-02	N	other	23/05/00 - 26/05/00	died					unknown					unknown				
FO-04	N	other	01/06/00 - 06/06/00															
FO-05	N	Fukuokawan	02/06/00 - 06/06/00															
FO-06	N	Fukuokawan	13/06/00 - 19/06/00															
SA-03	N	other	15/06/00 - 19/06/00															
SA-04	N	other	18/06/00 - 26/06/00	died					400 inds.					400				
SA-05	N	other	26/06/00 - 30/06/00															
SA-06	N	Imariwan	27/06/00 - 27/07/00															
FO-07	N	Fukuokawan	30/06/00 - 31/07/00															
YG-02	N	other	06/07/00 - 03/08/00	died	died	died	died	died	unknown		30 inds	800kg	2000kg	unknown				
SA-07	N	other	10/07/00 - 19/07/00															
NS-09	N	other	11/07/00 - 12/07/00															
FO-09	N	other	11/07/00 - 31/07/00	died					unknown					unknown				
NS-10	N	Imariwan	13/07/00 - 22/07/00	died					8,000 inds.					1,600				
NS-12	remote Island	Goto	26/07/00 - 17/08/00	died					400 kg	120 inds.				340	134			
FO-10	N	Fukuokawan	04/08/00 - 11/08/00															
SA-10	N	Imariwan	18/08/00 - 11/09/00															
NS-19	remote Island	Tsushima	21/08/00 - 24/08/00															
FO-13	N	Fukuokawan	23/08/00 - 01/09/00															
FO-14	N	Fukuokawan	08/09/00 - 12/09/00															
NS-21	remote Island	Tsushima	18/09/00 - 25/09/00															
SA-11	N	Imariwan	27/09/00 - 29/09/00															
NS-23	N	Imariwan	28/09/00 - 04/10/00															
FO-15	N	Fukuokawan	07/11/00 - 11/11/00															
NS-27	remote Island	Tsushima	08/11/00 - 15/11/00															
SA-01	N	Imariwan	21/01/01 - 25/01/01															
YG-01	N	other	20/03/01 - 23/04/01															
FO-01	N	other	21/03/01 - 22/03/01															
FO-03	N	other	06/04/01 - 09/04/01															
NS-03	remote Island	Goto	07/04/01 - 11/04/01															
NS-04	N	Imariwan	10/04/01 - 13/04/01															
NS-05	remote Island	Iki	17/04/01 - 20/04/01															
NS-06	remote Island	Goto	17/04/01 - 18/04/01															
FO-04	N	other	17/04/01 - 20/04/01															
NS-07	remote Island	Tsushima	18/04/01 - 19/04/01															
NS-08	remote Island	Tsushima	18/04/01 - 19/04/01															
SA-02	N	other	18/04/01 - 12/05/01															
NS-09	remote Island	Iki	27/04/01 - 01/05/01															
FO-05	N	Fukuokawan	06/05/01 - 14/05/01															
SA-03	N	other	07/05/01 - 11/05/01															
NS-12	remote Island	Goto	22/05/01 - 23/05/01															

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 (6)

Event No.	Location (name of the sea area)		Duration	Continuous days	Causative species ①-④			
	Location 1	Location 2	dd/mm/yy-dd/mm/yy		①	②	③	④
YG-02	N	other	28/05/01 - 31/05/01	4	*Eutreptiella gymnastica*			
NS-14	N	Imariwan	30/05/01 - 31/05/01	2	*Tontonia* sp.			
FO-09	N	other	05/06/01 - 11/06/01	7	*Heterosigma akashiwo*			
YG-03	N	other	15/06/01	1	*Heterosigma akashiwo*			
NS-19	N	Imariwan	20/06/01 - 26/06/01	7	*Mesodinium rubrum*			
FO-10	N	Fukuokawan	26/06/01 - 06/07/01	11	*Leptocylindrus* sp.	*Chaetoceros* sp.		
YG-04	N	other	27/06/01 - 10/07/01	14	*Chattonella antiqua*			
NS-21	N	Imariwan	28/06/01 - 08/07/01	11	*Gymnodinium mikimotoi*			
FO-12	N	Fukuokawan	09/07/01 - 23/07/01	15	*Prorocentrum minimum*			
NS-25	remote Island	Goto	19/07/01 - 24/07/01	6	*Heterosigma akashiwo*			
YG-05	N	other	03/08/01	1	*Pyramimonas* sp.			
YG-06	N	other	06/08/01	1	*Gyrodinium* sp.			
NS-32	remote Island	Tsushima	06/09/01 - 07/09/01	2	*Mesodinium rubrum*			
FO-15	N	Fukuokawan	03/10/01 - 11/10/01	9	*Heterosigma akashiwo*			
FO-16	N	other	01/11/01	1	*Noctiluca scintillans*			
NS-40	remote Island	Tsushima	19/11/01 - 23/11/01	5	*Mesodinium rubrum*			
FO-18	N	other	21/11/01 - 22/11/01	2	*Mesodinium rubrum*	*Gymnodinium sanguineum*		
NS-41	remote Island	Goto	03/12/01 - 05/12/01	3	*Mesodinium rubrum*			
NS-42	remote Island	Tsushima	10/12/01	1	*Mesodinium rubrum*			
NS-02	N	Imariwan	14/01/02 - 17/01/02	4	*Mesodinium rubrum*			
YG-01	N	other	13/03/02 - 22/04/02	41	*Noctilca* sp.			
FO-02	N	other	14/03/02	1	*Noctiluca scintillans*			
NS-04	remote Island	Goto	01/04/02 - 02/04/02	2	*Noctiluca scintillans*			
NS-06	remote Island	Goto	23/04/02	1	*Noctiluca scintillans*			
NS-07	remote Island	Iki	24/04/02 - 26/04/02	3	*Noctiluca scintillans*			
NS-10	remote Island	Goto	25/04/02 - 07/05/02	13	*Noctiluca scintillans*			
FO-03	N	Fukuokawan	07/05/02 - 17/05/02	11	*Gymnodinium sanguineum*			
FO-05	N	other	10/05/02 - 13/05/02	4	*Heterosigma akashiwo*			
YG-02	N	other	14/05/02	1	*Heterosigma akashiwo*			
NS-12	remote Island	Goto	17/05/02 - 22/05/02	6	*Heterosigma akashiwo*			
YG-03	N	other	29/05/02 - 05/06/02	8	*Alexandrium catenella*			
YG-04	N	other	06/06/02	1	*Heterosigma akashiwo*			
NS-14	remote Island	Goto	10/06/02 - 15/06/02	6	*Heterosigma akashiwo*			
FO-07	N	Fukuokawan	04/07/02 - 11/07/02	8	*Heterocapsa circularisquama*			
SA-06	N	other	05/07/02 - 13/07/02	9	*Gymnodinium mikimotoi*			
FO-08	N	Fukuokawan	11/07/02 - 11/08/02	32	*Prorocentrum dentatum*	*Gymnodinium mikimotoi*		
FO-09	N	other	11/07/02 - 02/08/02	23	*Gymnodinium mikimotoi*			
SA-07	N	Imariwan	19/07/02 - 22/07/02	4	*Gymnodinium mikimotoi*			
NS-17	N	Imariwan	22/07/02	1	*Gymnodinium mikimotoi*			
NS-20	remote Island	Goto	22/07/02 - 24/07/02	3	*Mesodinium rubrum*			
SA-08	N	other	26/07/02 - 28/07/02	3	*Gymnodinium mikimotoi*			
SA-09	N	Imariwan	26/07/02 - 27/07/02	2	*Heterocapsa circularisquama*			
NS-23	N	other	30/07/02 - 31/07/02	2	*Noctiluca scintillans*			
FO-10	N	Fukuokawan	12/08/02 - 21/08/02	10	*Heterocapsa circularisquama*			
NS-26	remote Island	Goto	24/08/02 - 27/08/02	4	*Cochlodinium polykrikoides*			
NS-27	remote Island	Tsushima	05/09/02 - 13/09/02	9	*Cochlodinium polykrikoides*			
NS-28	remote Island	Tsushima	06/09/02 - 12/09/02	7	*Cochlodinium polykrikoides*			
SA-12	N	other	09/09/02 - 14/09/02	6	*Gymnodinium mikimotoi*			
NS-29	remote Island	Tsushima	10/09/02 - 13/09/02	4	*Cochlodinium polykrikoides*			
FO-12	N	Fukuokawan	19/09/02 - 24/09/02	6	*Ceratium furca*			
SA-13	N	other	19/09/02 - 03/10/02	15	*Rhizosolenia delicatula*			
YG-05	N	other	24/09/02 - 01/10/02	8	*Cochlodinium polykrikoides*			
NS-33	N	other	09/11/02 - 14/11/02	6	*Mesodinium rubrum*			
FO-15	N	Fukuokawan	02/11/04		*Gymnodinium sanguineum*			
YG-06	N	other	28/11/02	1	*Mesodinium rubrum*			
NS-36	remote Island	Goto	29/11/02 - 01/12/02	3	*Mesodinium rubrum*			
SA-17	N	other	09/12/02 - 28/12/02	20	*Gymnodinium sanguineum*			
YG-07	N	other	21/12/02	1	*Gymnodinium sanguineum*			

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 (7)

Event No.	Location (name of the sea area)		Duration	Causative species ⑤-⑥			
	Location 1	Location 2	dd/mm/yy-dd/mm/yy	⑤	⑥	⑦	⑧
YG-02	N	other	28/05/01 - 31/05/01				
NS-14	N	Imariwan	30/05/01 - 31/05/01				
FO-09	N	other	05/06/01 - 11/06/01				
YG-03	N	other	15/06/01				
NS-19	N	Imariwan	20/06/01 - 26/06/01				
FO-10	N	Fukuokawan	26/06/01 - 06/07/01				
YG-04	N	other	27/06/01 - 10/07/01				
NS-21	N	Imariwan	28/06/01 - 08/07/01				
FO-12	N	Fukuokawan	09/07/01 - 23/07/01				
NS-25	remote Island	Goto	19/07/01 - 24/07/01				
YG-05	N	other	03/08/01				
YG-06	N	other	06/08/01				
NS-32	remote Island	Tsushima	06/09/01 - 07/09/01				
FO-15	N	Fukuokawan	03/10/01 - 11/10/01				
FO-16	N	other	01/11/01				
NS-40	remote Island	Tsushima	19/11/01 - 23/11/01				
FO-18	N	other	21/11/01 - 22/11/01				
NS-41	remote Island	Goto	03/12/01 - 05/12/01				
NS-42	remote Island	Tsushima	10/12/01				
NS-02	N	Imariwan	14/01/02 - 17/01/02				
YG-01	N	other	13/03/02 - 22/04/02				
FO-02	N	other	14/03/02				
NS-04	remote Island	Goto	01/04/02 - 02/04/02				
NS-06	remote Island	Goto	23/04/02				
NS-07	remote Island	Iki	24/04/02 - 26/04/02				
NS-10	remote Island	Goto	25/04/02 - 07/05/02				
FO-03	N	Fukuokawan	07/05/02 - 17/05/02				
FO-05	N	other	10/05/02 - 13/05/02				
YG-02	N	other	14/05/02				
NS-12	remote Island	Goto	17/05/02 - 22/05/02				
YG-03	N	other	29/05/02 - 05/06/02				
YG-04	N	other	06/06/02				
NS-14	remote Island	Goto	10/06/02 - 15/06/02				
FO-07	N	Fukuokawan	04/07/02 - 11/07/02				
SA-06	N	other	05/07/02 - 13/07/02				
FO-08	N	Fukuokawan	11/07/02 - 11/08/02				
FO-09	N	other	11/07/02 - 02/08/02				
SA-07	N	Imariwan	19/07/02 - 22/07/02				
NS-17	N	Imariwan	22/07/02				
NS-20	remote Island	Goto	22/07/02 - 24/07/02				
SA-08	N	other	26/07/02 - 28/07/02				
SA-09	N	Imariwan	26/07/02 - 27/07/02				
NS-23	N	other	30/07/02 - 31/07/02				
FO-10	N	Fukuokawan	12/08/02 - 21/08/02				
NS-26	remote Island	Goto	24/08/02 - 27/08/02				
NS-27	remote Island	Tsushima	05/09/02 - 13/09/02				
NS-28	remote Island	Tsushima	06/09/02 - 12/09/02				
SA-12	N	other	09/09/02 - 14/09/02				
NS-29	remote Island	Tsushima	10/09/02 - 13/09/02				
FO-12	N	Fukuokawan	19/09/02 - 24/09/02				
SA-13	N	other	19/09/02 - 03/10/02				
YG-05	N	other	24/09/02 - 01/10/02				
NS-33	N	other	09/11/02 - 14/11/02				
FO-15	N	Fukuokawan	02/11/04				
YG-06	N	other	28/11/02				
NS-36	remote Island	Goto	29/11/02 - 01/12/02				
SA-17	N	other	09/12/02 - 28/12/02				
YG-07	N	other	21/12/02				

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 (8)

Event No.	Location (name of the sea area)		Duration	Approximate Area suffered	Max. cell density (cells/L)							
	Location 1	Location 2	dd/mm/yy-dd/mm/yy	(km×km)	①	②	③	④	⑤	⑥	⑦	⑧
YG-02	N	other	28/05/01 - 31/05/01	unknown	2,025							
NS-14	N	Imariwan	30/05/01 - 31/05/01	0.2	27							
FO-09	N	other	05/06/01 - 11/06/01	0.001	9,530							
YG-03	N	other	15/06/01	unknown	69,000							
NS-19	N	Imariwan	20/06/01 - 26/06/01	0.4	1,240							
FO-10	N	Fukuokawan	26/06/01 - 06/07/01	70	1,636	10,800						
YG-04	N	other	27/06/01 - 10/07/01	unknown	1,350							
NS-21	N	Imariwan	28/06/01 - 08/07/01	0.1	2,250							
FO-12	N	Fukuokawan	09/07/01 - 23/07/01	80	25,000							
NS-25	remote Island	Goto	19/07/01 - 24/07/01	unknown	27,780							
YG-05	N	other	03/08/01	unknown	17,900							
YG-06	N	other	06/08/01	0.02	5,000							
NS-32	remote Island	Tsushima	06/09/01 - 07/09/01	0.12	2,275							
FO-15	N	Fukuokawan	03/10/01 - 11/10/01	約10	3,650							
FO-16	N	other	01/11/01	under 1	571							
NS-40	remote Island	Tsushima	19/11/01 - 23/11/01	unknown	105							
FO-18	N	other	21/11/01 - 22/11/01	under 1	2,630	111						
NS-41	remote Island	Goto	03/12/01 - 05/12/01	0.15	5,983							
NS-42	remote Island	Tsushima	10/12/01	0.07	911							
NS-02	N	Imariwan	14/01/02 - 17/01/02	0.5	2,010							
YG-01	N	other	13/03/02 - 22/04/02	185	unknown							
FO-02	N	other	14/03/02	4	132							
NS-04	remote Island	Goto	01/04/02 - 02/04/02	2.4	462							
NS-06	remote Island	Goto	23/04/02	unknown	188							
NS-07	remote Island	Iki	24/04/02 - 26/04/02	unknown	150							
NS-10	remote Island	Goto	25/04/02 - 07/05/02	unknown	490							
FO-03	N	Fukuokawan	07/05/02 - 17/05/02	70	3,500							
FO-05	N	other	10/05/02 - 13/05/02	1	32,000							
YG-02	N	other	14/05/02	0.001	5,000							
NS-12	remote Island	Goto	17/05/02 - 22/05/02	0.4	20,520							
YG-03	N	other	29/05/02 - 05/06/02	unknown	4,000							
YG-04	N	other	06/06/02	unknown	10,400							
NS-14	remote Island	Goto	10/06/02 - 15/06/02	unknown	1,110							
FO-07	N	Fukuokawan	04/07/02 - 11/07/02	70	135							
SA-06	N	other	05/07/02 - 13/07/02	0.3	117,980							
FO-08	N	Fukuokawan	11/07/02 - 11/08/02	70	2,000	15						
FO-09	N	other	11/07/02 - 02/08/02	1	2,000							
SA-07	N	Imariwan	19/07/02 - 22/07/02	5	6,660							
NS-17	N	Imariwan	22/07/02	0.015	4,480							
NS-20	remote Island	Goto	22/07/02 - 24/07/02	0.0025	1,600							
SA-08	N	other	26/07/02 - 28/07/02	0.005	648							
SA-09	N	Imariwan	26/07/02 - 27/07/02	0.06	1,840							
NS-23	N	other	30/07/02 - 31/07/02	0.001	121							
FO-10	N	Fukuokawan	12/08/02 - 21/08/02	70	770							
NS-26	remote Island	Goto	24/08/02 - 27/08/02	unknown	221							
NS-27	remote Island	Tsushima	05/09/02 - 13/09/02	0.005	109							
NS-28	remote Island	Tsushima	06/09/02 - 12/09/02	0.35	798							
SA-12	N	other	09/09/02 - 14/09/02	0.005	194							
NS-29	remote Island	Tsushima	10/09/02 - 13/09/02	0.0006	358							
FO-12	N	Fukuokawan	19/09/02 - 24/09/02	70	350							
SA-13	N	other	19/09/02 - 03/10/02	6.5	33,670							
YG-05	N	other	24/09/02 - 01/10/02	unknown	2,600							
NS-33	N	other	09/11/02 - 14/11/02	0.02	2,390							
FO-15	N	Fukuokawan	02/11/04	70	7,000							
YG-06	N	other	28/11/02	0.001	1,950							
NS-36	remote Island	Goto	29/11/02 - 01/12/02	0.07	7,100							
SA-17	N	other	09/12/02 - 28/12/02	4.16	478							
YG-07	N	other	21/12/02	0.005	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 (9)

Event No.	Location (name of the sea area)		Duration	Fish/shellfish species				
	Location 1	Location 2	dd/mm/yy-dd/mm/yy	①	②	③	④	⑤
YG-02	N	other	28/05/01 - 31/05/01					
NS-14	N	Imariwan	30/05/01 - 31/05/01					
FO-09	N	other	05/06/01 - 11/06/01					
YG-03	N	other	15/06/01					
NS-19	N	Imariwan	20/06/01 - 26/06/01					
FO-10	N	Fukuokawan	26/06/01 - 06/07/01					
YG-04	N	other	27/06/01 - 10/07/01					
NS-21	N	Imariwan	28/06/01 - 08/07/01					
FO-12	N	Fukuokawan	09/07/01 - 23/07/01					
NS-25	remote Island	Goto	19/07/01 - 24/07/01					
YG-05	N	other	03/08/01					
YG-06	N	other	06/08/01					
NS-32	remote Island	Tsushima	06/09/01 - 07/09/01					
FO-15	N	Fukuokawan	03/10/01 - 11/10/01	Puffy fish	Amberjacks	Yellowtail	Fishes	
FO-16	N	other	01/11/01					
NS-40	remote Island	Tsushima	19/11/01 - 23/11/01					
FO-18	N	other	21/11/01 - 22/11/01					
NS-41	remote Island	Goto	03/12/01 - 05/12/01					
NS-42	remote Island	Tsushima	10/12/01					
NS-02	N	Imariwan	14/01/02 - 17/01/02					
YG-01	N	other	13/03/02 - 22/04/02					
FO-02	N	other	14/03/02					
NS-04	remote Island	Goto	01/04/02 - 02/04/02					
NS-06	remote Island	Goto	23/04/02					
NS-07	remote Island	Iki	24/04/02 - 26/04/02					
NS-10	remote Island	Goto	25/04/02 - 07/05/02					
FO-03	N	Fukuokawan	07/05/02 - 17/05/02					
FO-05	N	other	10/05/02 - 13/05/02					
YG-02	N	other	14/05/02					
NS-12	remote Island	Goto	17/05/02 - 22/05/02					
YG-03	N	other	29/05/02 - 05/06/02					
YG-04	N	other	06/06/02					
NS-14	remote Island	Goto	10/06/02 - 15/06/02					
FO-07	N	Fukuokawan	04/07/02 - 11/07/02					
SA-06	N	other	05/07/02 - 13/07/02	Abalone	Turban			
FO-08	N	Fukuokawan	11/07/02 - 11/08/02					
FO-09	N	other	11/07/02 - 02/08/02	Abalone				
SA-07	N	Imariwan	19/07/02 - 22/07/02	Amberjacks				
NS-17	N	Imariwan	22/07/02					
NS-20	remote Island	Goto	22/07/02 - 24/07/02					
SA-08	N	other	26/07/02 - 28/07/02					
SA-09	N	Imariwan	26/07/02 - 27/07/02	Pearl shell				
NS-23	N	other	30/07/02 - 31/07/02					
FO-10	N	Fukuokawan	12/08/02 - 21/08/02					
NS-26	remote Island	Goto	24/08/02 - 27/08/02	Amberjacks	Horse mackerel			
NS-27	remote Island	Tsushima	05/09/02 - 13/09/02					
NS-28	remote Island	Tsushima	06/09/02 - 12/09/02					
SA-12	N	other	09/09/02 - 14/09/02					
NS-29	remote Island	Tsushima	10/09/02 - 13/09/02					
FO-12	N	Fukuokawan	19/09/02 - 24/09/02					
SA-13	N	other	19/09/02 - 03/10/02					
YG-05	N	other	24/09/02 - 01/10/02	Yellowtail				
NS-33	N	other	09/11/02 - 14/11/02					
FO-15	N	Fukuokawan	02/11/04					
YG-06	N	other	28/11/02					
NS-36	remote Island	Goto	29/11/02 - 01/12/02					
SA-17	N	other	09/12/02 - 28/12/02					
YG-07	N	other	21/12/02					

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 (10)

Event No.	Location (name of the sea area)		Duration	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
YG-02	N	other	28/05/01 - 31/05/01															
NS-14	N	Imariwan	30/05/01 - 31/05/01															
FO-09	N	other	05/06/01 - 11/06/01															
YG-03	N	other	15/06/01															
NS-19	N	Imariwan	20/06/01 - 26/06/01															
FO-10	N	Fukuokawan	26/06/01 - 06/07/01															
YG-04	N	other	27/06/01 - 10/07/01															
NS-21	N	Imariwan	28/06/01 - 08/07/01															
FO-12	N	Fukuokawan	09/07/01 - 23/07/01															
NS-25	remote Island	Goto	19/07/01 - 24/07/01															
YG-05	N	other	03/08/01															
YG-06	N	other	06/08/01															
NS-32	remote Island	Tsushima	06/09/01 - 07/09/01															
FO-15	N	Fukuokawan	03/10/01 - 11/10/01	died	died	died			226 kg	6 kg	3 kg			230	7	9		
FO-16	N	other	01/11/01															
NS-40	remote Island	Tsushima	19/11/01 - 23/11/01															
FO-18	N	other	21/11/01 - 22/11/01															
NS-41	remote Island	Goto	03/12/01 - 05/12/01															
NS-42	remote Island	Tsushima	10/12/01															
NS-02	N	Imariwan	14/01/02 - 17/01/02															
YG-01	N	other	13/03/02 - 22/04/02															
FO-02	N	other	14/03/02															
NS-04	remote Island	Goto	01/04/02 - 02/04/02															
NS-06	remote Island	Goto	23/04/02															
NS-07	remote Island	Iki	24/04/02 - 26/04/02															
NS-10	remote Island	Goto	25/04/02 - 07/05/02															
FO-03	N	Fukuokawan	07/05/02 - 17/05/02															
FO-05	N	other	10/05/02 - 13/05/02															
YG-02	N	other	14/05/02															
NS-12	remote Island	Goto	17/05/02 - 22/05/02															
YG-03	N	other	29/05/02 - 05/06/02															
YG-04	N	other	06/06/02															
NS-14	remote Island	Goto	10/06/02 - 15/06/02															
FO-07	N	Fukuokawan	04/07/02 - 11/07/02															
SA-06	N	other	05/07/02 - 13/07/02	died	died				56 kg	130 kg				unknown	unknown			
FO-08	N	Fukuokawan	11/07/02 - 11/08/02															
FO-09	N	other	11/07/02 - 02/08/02	died					unknown					unknown				
SA-07	N	Imariwan	19/07/02 - 22/07/02	died					200 inds					unknown				
NS-17	N	Imariwan	22/07/02															
NS-20	remote Island	Goto	22/07/02 - 24/07/02															
SA-08	N	other	26/07/02 - 28/07/02															
SA-09	N	Imariwan	26/07/02 - 27/07/02	died					5, 000 inds.					unknown				
NS-23	N	other	30/07/02 - 31/07/02															
FO-10	N	Fukuokawan	12/08/02 - 21/08/02															
NS-26	remote Island	Goto	24/08/02 - 27/08/02	died	died				9,280 inds.	620 inds.				29,044	1,240			
NS-27	remote Island	Tsushima	05/09/02 - 13/09/02															
NS-28	remote Island	Tsushima	06/09/02 - 12/09/02															
SA-12	N	other	09/09/02 - 14/09/02															
NS-29	remote Island	Tsushima	10/09/02 - 13/09/02															
FO-12	N	Fukuokawan	19/09/02 - 24/09/02															
SA-13	N	other	19/09/02 - 03/10/02															
YG-05	N	other	24/09/02 - 01/10/02	died					2,000 inds.					15,000				
NS-33	N	other	09/11/02 - 14/11/02															
FO-15	N	Fukuokawan	02/11/04															
YG-06	N	other	28/11/02															
NS-36	remote Island	Goto	29/11/02 - 01/12/02															
SA-17	N	other	09/12/02 - 28/12/02															
YG-07	N	other	21/12/02															

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

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