Report of HAB Case Study
in the Northwestern Sea Area of Kyushu Region

26 Dec. 2008

Contents

1 Introduction

1.1 Objective

The objective of conducting the HAB case study in the northwestern sea area of Kyushu region (hereinafter abbreviated as ‘case study’) is to establish the most effective and laborsaving ways for sharing among the NOWPAP member states, information on HAB events and associated oceanographic and meteorological conditions.

1.2 Background information of the case study

The case study provides information on the red tides and toxin-producing planktons that have occurred in the northwestern sea area of Kyushu region. As defined by NOWPAP CEARAC (2005), red tides can be merely a water discoloration event or can be harmful and in some cases induce fishery damage. On the other hand, toxin-producing planktons can contaminate fish and shellfish even under low densities. In this case study, HAB refers to blooms of both unharmful/harmful red tides and toxin-producing planktons. Information on toxin-producing planktons is provided through two sources: regular monitoring data of toxin-producing planktons and records of shipment stoppage due to shellfish contamination.

In regards to the scientific names of the HAB species, in principal, the names used in the past CEARAC reports (e.g. Integrated Report) were used. However, updated names or country-specific names were also concurrently listed as far it was possible. The information presented in the case study was mainly based on the published reports and websites of the national or local government monitoring organizations.

The status of HAB events is presented for two time periods. Chapter 4 describes the yearly trend of HAB events from the initiation of HAB monitoring to the present. Chapter 5 describes the HAB events in 2006, which include information such as the season and location of occurrence, and the associated environmental conditions.

In addition, the case study discusses the prospects and issues of using satellite remote sensing technology for red-tide monitoring.

1.3 Overview of the target sea area

1.3.1 Location and boundary

The northwestern sea area of Kyushu region (hereinafter called as ‘target sea area’) was selected for Japan’s HAB case study. The target sea area faces the East China Sea, and includes the sea areas of Nagasaki, Saga and Fukuoka Prefecture, and the Sea of Japan side of Yamaguchi Prefecture. The target sea area was broadly demarcated into the following 4 sea regions: coastal area of Yamaguchi Prefecture, north Kyushu sea area (coastlines of Fukuoka, Saga and part of Nagasaki Prefecture), west Kyushu sea area (Nagasaki Prefecture) and remote islands (Nagasaki Prefecture). Inland seas such as the Ariake Sea, Yatsushiro Sea and Seto Insland Sea were not included. Figure 1.1 shows the locations of the above 4 sea regions. The monitoring areas/sites of each prefecture are described in Section 3.1.

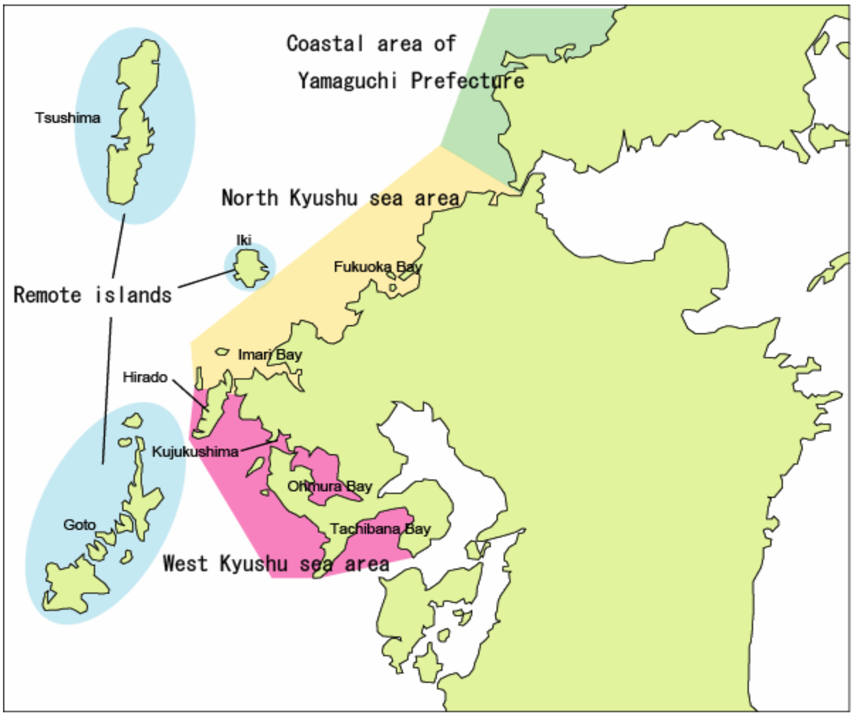


Figure 1.1 Target sea area of Japan's HAB case study

1.3.2 Environmental and geographical characteristics

The target sea area is strongly influenced by the Tsushima Warm Current. The topography of the coastline is complex; comprised of many beaches and small inlets. In some areas, such as in the west Kyushu sea area, numerous small islands (Kujuku-shima Islands) are scattered along the coast. Also there are many remote islands such as the Goto Islands, Tsushima and Iki.

Fishery is a major industry in the coastal areas of the target sea area, and many aquaculture farms operate along the calm inlets. Table 1.1 shows the types of aquaculture product and the amount of aquaculture production in the prefectures of the target sea area. Aquaculture production in each prefectural is calculated based on the reports and the information shown in each web site. Figure 1.2 shows the areas where the fish/shellfish/seaweed aquaculture farms are operated in the target sea area.

The main aquaculture products in Yamaguchi Prefecture (side of Sea of Japan) are seaweed (wakame), amberjack, red seabream and flatfish. In the north Kyushu sea area, the main aquaculture products of Fukuoka Prefecture are oyster, seaweed (wakame) and prawn; and the main aquaculture products of Saga Prefecture are red seabream, amberjack, prawn and pearls. The main aquaculture products of Nagasaki Prefecture are amberjacks, red seabream, pufferfish, oyster and seaweeds (nori, wakame); with particularly high production of amberjacks. Within the 4 prefectures, Nagasaki has the highest aquaculture production (21,424 tons in 2004).

Apart from aquaculture, the coastal fisheries in the target sea area generally target migratory fish species such as sardine, horse mackerel and Pacific mackerel; although there are some variations in the target species between the prefectures.

Table 1.1 The types of aquaculture products and the amount of aquaculture production in the prefectures of the target sea area

Area	Type of aquaculture product	Aquaculture production (ton)	Note
Yamaguchi Pref. (Sea of Japan)	Seaweed (Wakame), Amberjack, Red seabream, Flatfish, Shellfish, etc.	862 (In 2001)	• The following fish/shellfish are mainly caught by the coastal fisheries: Non-migratory species: Rockfish, Chicken grunt, Abalone, etc. Migratory species: Sardine, Horse mackerel, Pacific mackerel, Puffer fish, Tilefish, Squids, etc.
Fukuoka Pref. (North Kyushu sea area)	Oyster, Seaweed (Wakame), Prawn, etc.	199 (In 2004)	• Horse mackerel, Pacific mackerel and shellfish (Japanese littleneck) are mainly caught by the coastal fisheries.
Saga Pref. (North Kyushu sea area)	Red seabream, Amberjack, Prawn, Pearl oyster, etc.	Unknown	• Aquaculture production amounts to 80,460 t, if Nori aquaculture production in Ariake Sea is included. • Red seabream, Flatfish, Flounder, Squid, Tiger prawn are mainly caught by the coastal fisheries.
Nagasaki Pref (West Kyushu sea area, remote islands)	Amberjack, Red seabream, Globefish, Oyster, Seaweed (Nori, Wakame), etc.	21,424 (In 2004)	• Sardine, Horse mackerel, Squid and Pacific mackerel are mainly caught by the coastal fisheries.

Source:
Statistical Yearbook of Yamaguchi Prefecture
(http://www.pref.yamaguchi.jp/gyosei/tokei-b/nenkan/mokuji07.htm)
Fishing Port & Fishing Village of YAMAGUCHI
(http://www.pref.yamaguchi.lg.jp/cms/a16600/port/pdf.html)
Fukuoka Prefecture Web Site
(http://www.pref.fukuoka.lg.jp/d07/fukuoka-gyoko.html)
Kyusyu Regional Agricultural Administration Office Web Site
(http://www.maff.go.jp/kyusyu/index.html)
White Paper on Fisheries of Nagasaki Prefecture F.Y. 2006
(http://www.n-suisan.jp/yumetobi/)
Yamaguchi Prefectural Web Site
(http://www.pref.yamaguchi.lg.jp/cms/a16500/uminari/uminari-top.html)
Saga Prefecture Government Web Site
(http://www.pref.saga.lg.jp/web/gaiyou-gennkai.html)
Nagasaki Prefecture Fisheries Department
(http://www.n-suisan.jp/yumetobi/index.html)

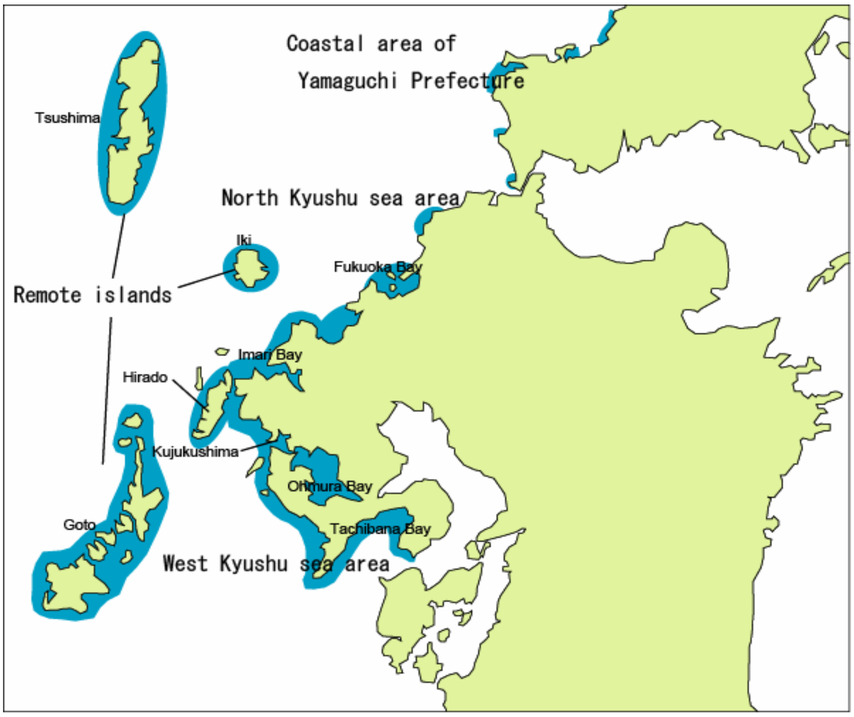


Figure 1.2 Areas where fish/shellfish/seaweed aquaculture farms are operated in the target sea area

2 Definitions of HAB and related regulations and standards

2.1 Definition of a HAB event

2.1.1 Definition of a red-tide event

Most red-tide events that were recorded in the reports of the monitoring organizations resulted from the red-tide surveys that the monitoring organizations conduct after water discoloration or fishery damage event is reported, such as by fishermen. In the above reports, a red-tide event was considered as '1 event' from the initiation to the cessation of water discoloration.

In this case study, the statistics on the red-tide events are based on the reports of the monitoring organizations. The reports also differentiate red-tide events that induced fishery damage, and provide information on the extent of damage caused by each red-tide. The case study, therefore also includes statistics on the red-tide events that induced fishery damage.

2.1.2 Definition of a toxin-producing plankton event

In order to prevent shipment of contaminated shellfish by toxin-producing planktons, monitoring organizations in the target sea area regularly inspect toxin levels in the harvested shellfish and also monitor for the presence of toxin-producing planktons in aquaculture areas. However, there are no established regulatory standards for toxin-producing planktons because shellfish contamination is not necessarily related to the concentration of toxin-producing planktons, i.e. shellfish contamination may occur even under low concentration of toxin-producing planktons. Monitoring organizations conduct the shellfish inspections mainly during the shipment period and stops shipment when the toxin levels exceed the set toxin standards (in Mouse Unit: MU). In Japan, inspections are conducted for toxins of diarrhetic shellfish poisoning (DSP) and paralytic shellfish poisoning (PSP).

In the case study, the monitoring results of the toxin-producing planktons and the status of shipment stoppage are presented.

2.2 Regulations and standards for HAB events

2.2.1 Regulations and standards for red-tide events

In order to prevent fishery damage, monitoring organizations have set 'warning/action standards' against red-tide species known to induce fishery damage. If the concentrations of these species exceed the set warning/action standards, the monitoring organizations issue warnings to fishermen and coastal users. Tables 2.1, 2.2 and 2.3 show the warning/action standards set by Nagasaki, Fukuoka and Yamaguchi Prefecture, respectively. Table 2.4 shows the red-tide species with warning/action standards for each prefecture.

Table 2.1 HAB warning/action standards of Nagasaki Prefecture

Species name	Warning/action standards (cells/mL)		Note (Affected fish/shellfish)
	Warning level*1	Action level*2	
Chattonella antiqua	1	10	Yellowtail, cockles etc.
Chattonella marina	1	10	Yellowtail etc.
Karenia mikimotoi	100	500	Fish, shellfish, crustaceans etc.
Cochlodinium polykrikoides	50	500	Yellowtail, red seabream, pufferfish, striped jack etc.
Heterosigma akashiwo	1,000	10,000	Yellowtail, grouper etc.
Heterocapsa circularisquama	10	50	Shellfish (mainly bivalves)

*1Warning level: Track plankton movement/Stop or prepare to stop feeding/ Move or prepare to move fish-cage

*2Action level: Stop feeding or move fish cage

Source: Nagasaki Prefectural Institute of Fisheries (http://www.marinelabo.nagasaki.nagasaki.jp/news/gyorendayori/H13/1307no75akasio-tyui.pdf)

Table 2.2 HAB warning/action standards of Fukuoka Prefecture

Species name	Warning/action standards (cells/mL)		Note
	Warning level	Action level *1	
Heterosigma akashiwo	-	10,000	

*1 Action level: Levels that could cause fish mortality

Source: Website of Fukuoka Fisheries and Marine Technology Research Center (http://www.sea-net.pref.fukuoka.jp/)

Table 2.3 HAB warning/action standards of Yamaguchi Prefecture

Species name	Warning/action standards (cells/mL)		Note
	Warning level	Action level *1	
Karenia mikimotoi	500	5,000	
Heterosigma akashiwo	5,000	50,000	

*1 Action level: Levels that could cause fish mortality

Source: Yamaguchi Prefectural (http://www.pref.yamaguchi.lg.jp/cms/a16500/uminari/uminari-top.html)

Table 2.4 Red-tide species with warning/action standards by each prefecture

Species name	Nagasaki	Saga	Fukuoka	Yamaguchi
Dinophyceae				
Karenia mikimotoi	✔	✔	✔	✔
Cochlodinium polykrikoides	✔	✔		
Heterocapsa circularisquama	✔	✔	✔	
Raphidophyceae				
Chattonella antiqua	✔			
Chattonella marina	✔	✔		
Heterosigma akashiwo	✔	✔	✔	✔

Source:
Fukuoka Fisheries and Marine Technology Research Center (2007)
(http://www.sea-net.pref.fukuoka.jp/gaiyo/oshirase.htm)
Nagasaki Prefectural Institute of Fisheries (2007)
(http://www.marinelabo.nagasaki.nagasaki.jp/news/gyorendayori/H13/1307no75akasio-tyui.pdf)
Saga Prefectural Genkai Fisheries Promotion Center (2007)
Yamaguchi Prefectural Fisheries Research Center (2007)
(http://www.pref.yamaguchi.lg.jp/cms/a16500/uminari/uminari-top.html)

2.2.2 Regulations and standards for shellfish contamination

As described previously, there are no regulatory standards against toxin-producing planktons because shellfish contamination occurs even under low concentration of toxin-producing planktons. However, monitoring organizations regularly monitor for the presence of several toxin-producing plankton species during the shellfish harvest seasons. Table 2.5 shows the toxin-producing plankton species that are monitored by each prefecture.

Table 2.5 Toxin-producing plankton species that are regularly monitored by each prefecture

Species name	Nagasaki	Saga	Fukuoka	Yamaguchi
Dinophyceae				
Dinophysis spp. (*Dinophysis fortii*, *Dinophysis acuminata, Dinophysis caudata*)	✔	✔	✔	✔
Gymnodinium catenatum	✔	✔	✔	✔
Alexandrium spp. (*Alexandrium catenella*, *Alexandrium tamarense*)	✔	✔	✔	✔

Source:
Fukuoka Fisheries and Marine Technology Research Center (2007)
Nagasaki Prefectural Institute of Fisheries (2007)
Saga Prefectural Genkai Fisheries Promotion Center (2007)
Yamaguchi Prefectural Fisheries Research Center (2007)

In order to prevent shipment and harvesting of contaminated shellfish, monitoring organizations conduct regular inspections of shellfish that are produced at the shellfish farming areas. If the toxin level in the shellfish exceeds the regulatory standards, shipment will be stopped voluntarily. Warnings will also be sent to recreational shellfish diggers via the media. The regulatory standard is expressed in terms of per unit gram of wet shellfish meat, which is based on the notifications of the Ministry of Agriculture, Forestry and Fisheries and Ministry of Health, Labour and Welfare. The regulatory standards are 4 MU/g wet weight for PSP and 0.05 MU/g wet weight for DSP. In principal, shipment of shellfish will be stopped until the toxin levels return to acceptable levels for 3 consecutive inspections.

For reference: Website of Ministry of Agriculture, Forestry and Fisheries (http://www.maff.go.jp/fisheat/fish-top.htm)

3 Framework and parameters of HAB monitoring

3.1 Monitoring framework

3.1.1 Framework of red-tide monitoring

To prevent fishery damages from red tides, monitoring organizations of each prefecture conduct 'regular red-tide monitoring' and 'post red-tide monitoring'. Post red-tide monitoring is conducted after receiving reports of red-tide events from fishery associations. Table 3.1 lists the sea areas that are regularly monitored by the monitoring organizations of each prefecture. Figures 3.1-3.3 show the locations of the regular red-tide monitoring sites in Fukuoka, Saga and Nagasaki Prefecture, respectively. Figure 3.4 shows the locations of the fishery associations in Nagasaki Prefecture that report on red-tide events to the monitoring organizations.

Table 3.1 Sea areas that are regularly monitored by the monitoring organizations of each prefecture (red tide)

Monitoring organization	Monitored sea area
Nagasaki Prefectural Institute of Fisheries (http://www.marinelabo.nagasaki.nagasaki.jp/)	Northern Kyushu Imari Bay, Hirado (Usuka/Furue Bay) Western Kyushu Ohmura Bay, Tachibana Bay, coasts of Kitamatsu, Kujukushima, coast of Seihi, Ariake Sea Remote Islands Goto, Iki, Tsushima
Saga Prefectural Genkai Fisheries Promotion Center (http://www.pref.saga.lg.jp/at-contents/shigoto/suisan/gensui/)	Northern Kyushu Karatsu Bay, Nagoyaura, Kariya Bay, Imari Bay
Fukuoka Fisheries and Marine Technology Research Center (http://www.sea-net.pref.fukuoka.jp/)	Northern Kyushu Fukuoka Bay, Karatsu Bay, Genkai Sea, Hibiki Sea
Yamaguchi Prefectural Fisheries Research Center (http://www.pref.yamaguchi.lg.jp/cms/a16500/uminari/uminari-top.html)	Coastal area of Yamaguchi Pref. (Sea of Japan)

Note: Regular red-tide monitoring is conducted in the sea areas enclosed by square line

Source:
Fukuoka Fisheries and Marine Technology Research Center (2007)
Nagasaki Prefectural Institute of Fisheries (2007)
Saga Prefectural Genkai Fisheries Promotion Center (2007)
Yamaguchi Prefectural Fisheries Research Center (2007)

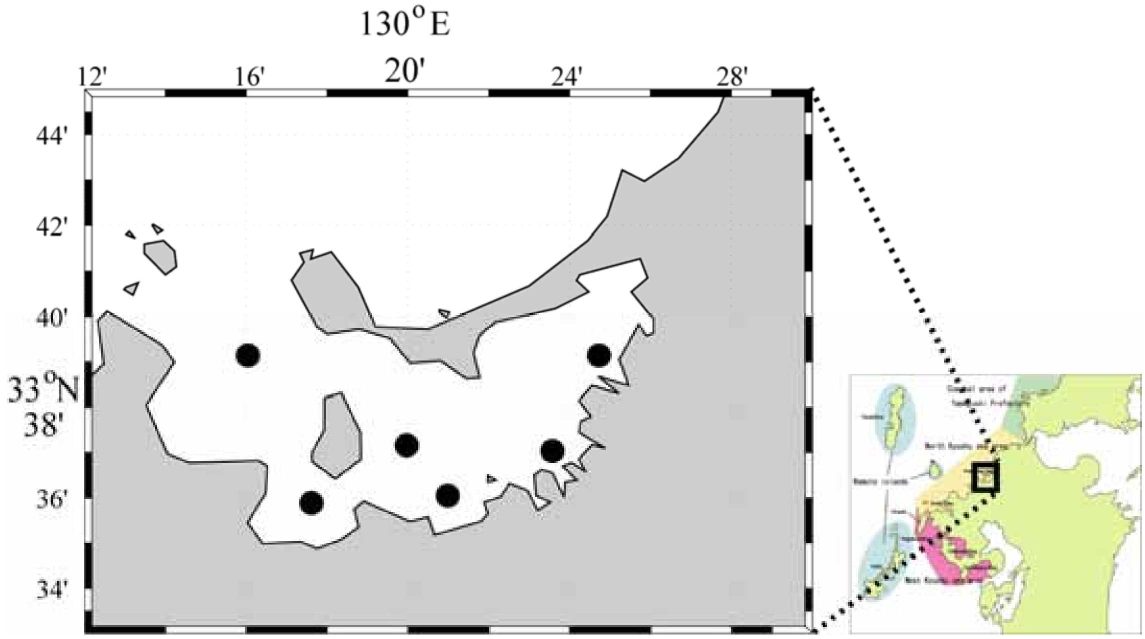


Figure 3.1 Regular red-tide monitoring sites in Fukuoka Prefecture
Source: Fukuoka Fisheries and Marine Technology Research Center (2007)

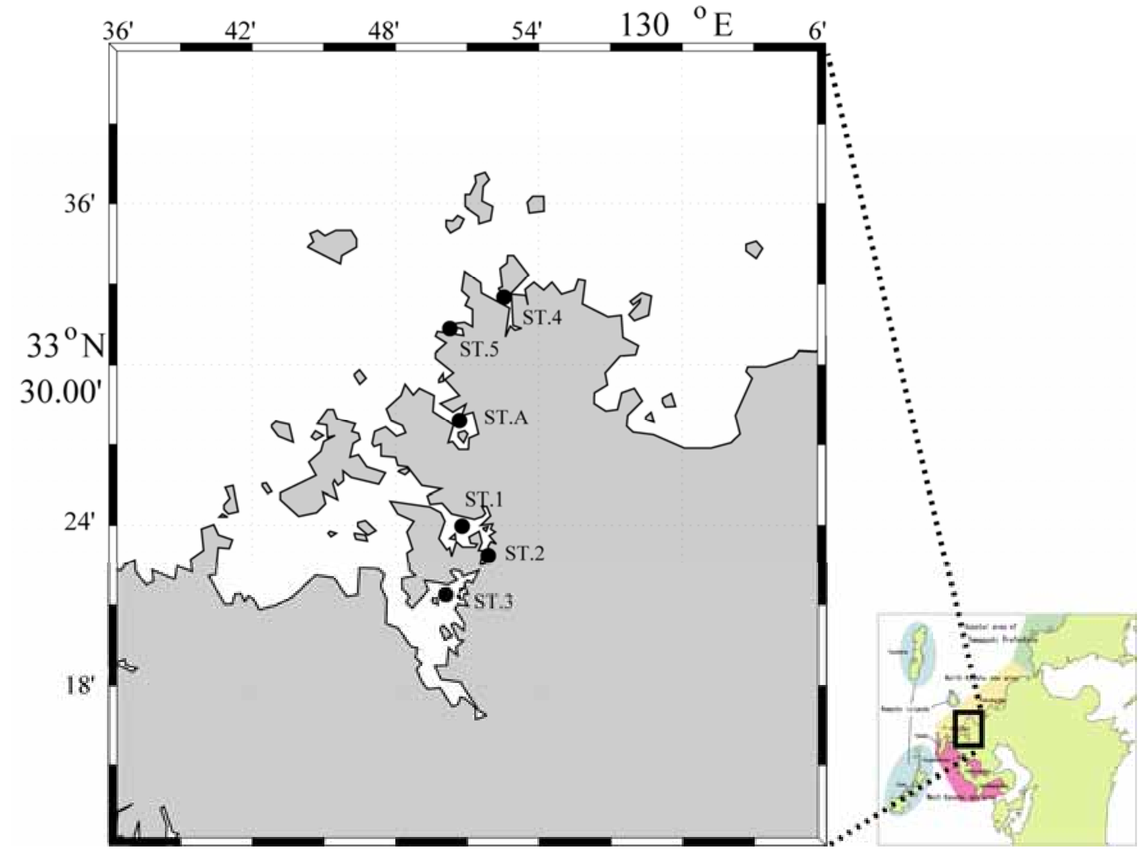


Figure 3.2 Regular red-tide monitoring sites in Saga Prefecture
Source: Saga Prefectural Genkai Fisheries Promotion Center (2007)

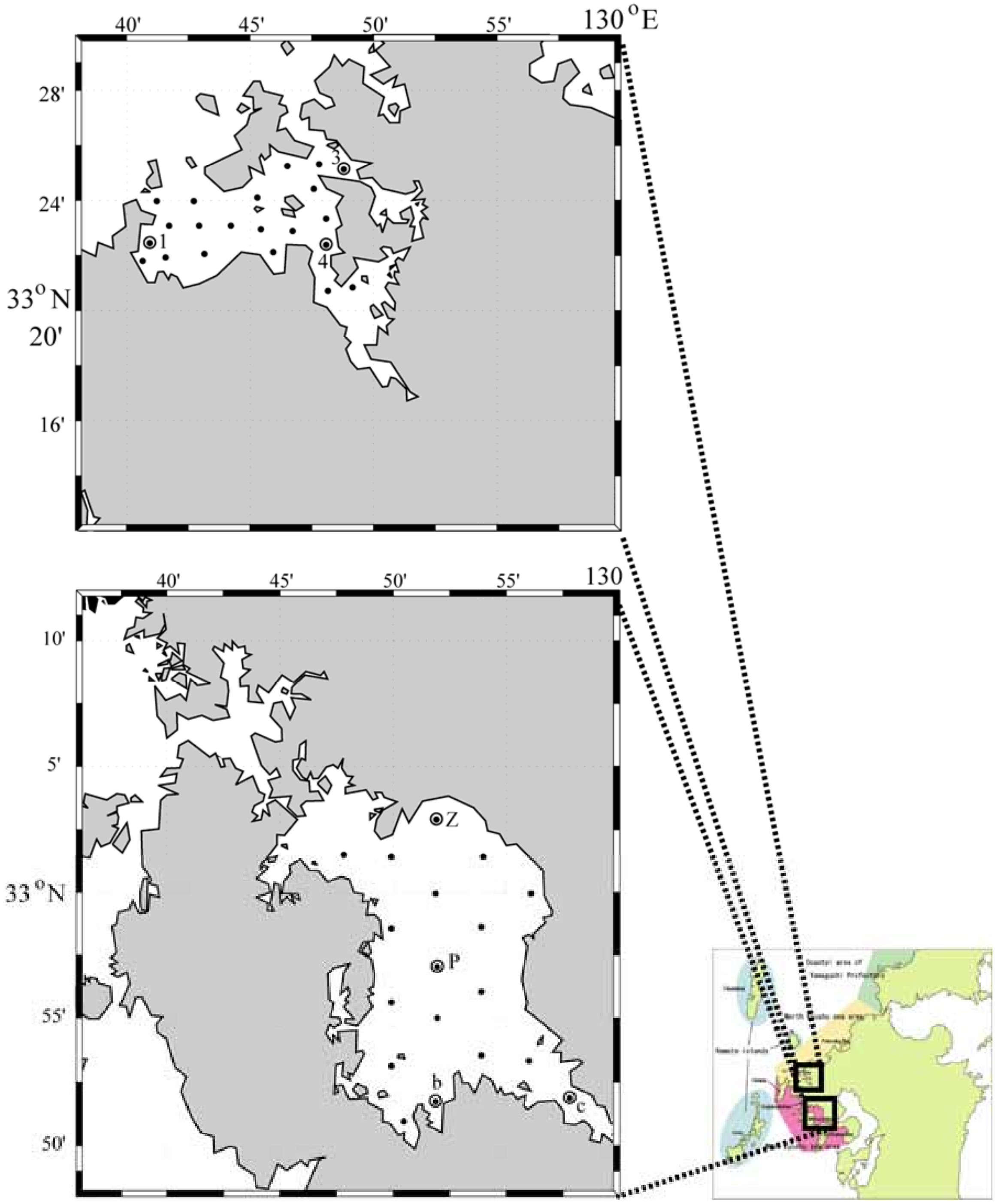


Figure 3.3 Regular red-tide monitoring sites in Nagasaki Prefecture

Circles indicate monitoring sites, double circles indicate monitoring sites which are conducted detailed survey
Source: Nagasaki Prefectural Institute of Fisheries (2007)

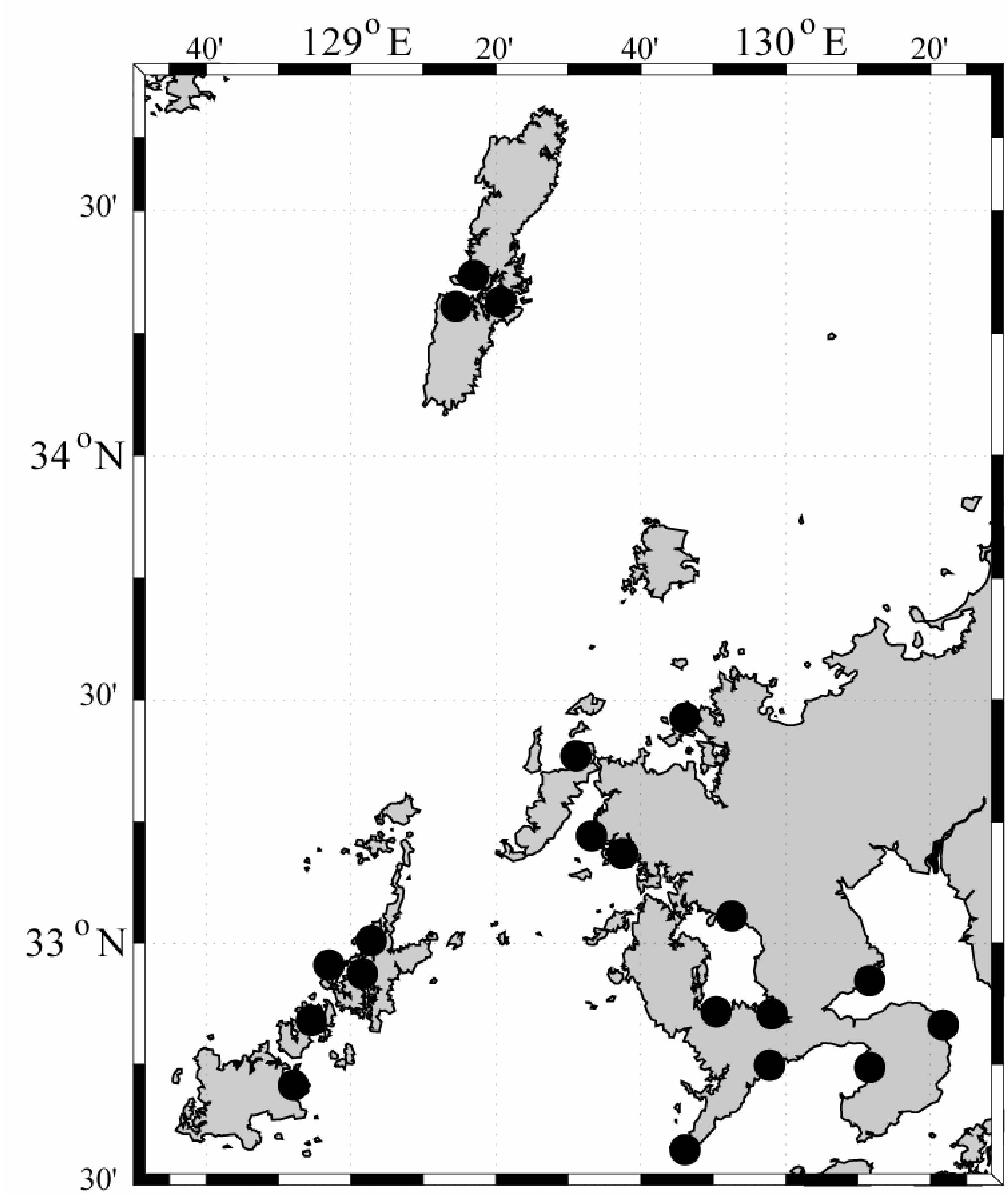


Figure 3.4 Locations of the fishery associations in Nagasaki Prefecture that cooperate in red-tide monitoring (the black dots indicate the locations of the fishery associations)

Source: Nagasaki Prefectural Institute of Fisheries (2007)

3.1.2 Framework of shellfish and toxin-producing plankton monitoring

In order to prevent shipment of contaminated shellfish by toxin-producing planktons, monitoring organizations conduct 'regular shellfish-contamination monitoring', which include inspections of toxin levels in shellfish and monitoring for the presence of toxin-producing planktons in the aquaculture areas. Table 3.2 lists the sea areas that are monitored by the monitoring organizations of each prefecture. Figures 3.5-3.8 show the locations of shellfish sampling and toxin-producing plankton monitoring sites in Yamaguchi, Fukuoka, Saga and Nagasaki Prefecture, respectively.

Table 3.2 Sea areas that are monitored by the monitoring organizations of each prefecture (shellfish and toxin-producing planktons)

Monitoring organization	Monitored sea area
Nagasaki Prefectural Institute of Fisheries (http://www.marinelabo.nagasaki.nagasaki.jp/)	Western Kyushu Tachibana bay Remote Islands Tsushima
Saga Prefectural Genkai Fisheries Promotion Center (http://www.pref.saga.lg.jp/at-contents/shigoto/suisan/gensui/)	Northern Kyushu Karatsu Bay, Nagoyaura, Kariya Bay, Imari Bay
Fukuoka Fisheries and Marine Technology Research Center (http://www.sea-net.pref.fukuoka.jp/)	Northern Kyushu Fukuoka Bay, Karatsu Bay
Yamaguchi Prefectural Fisheries Research Center (http://www.pref.yamaguchi.lg.jp/cms/a16500/uminari/uminari-top.html)	Coastal area of Sea of Japan Sensaki Bay

Source:
Fukuoka Fisheries and Marine Technology Research Center (2007)
Nagasaki Prefectural Institute of Fisheries (2007)
Saga Prefectural Genkai Fisheries Promotion Center (2007)
Yamaguchi Prefectural Fisheries Research Center (2007)

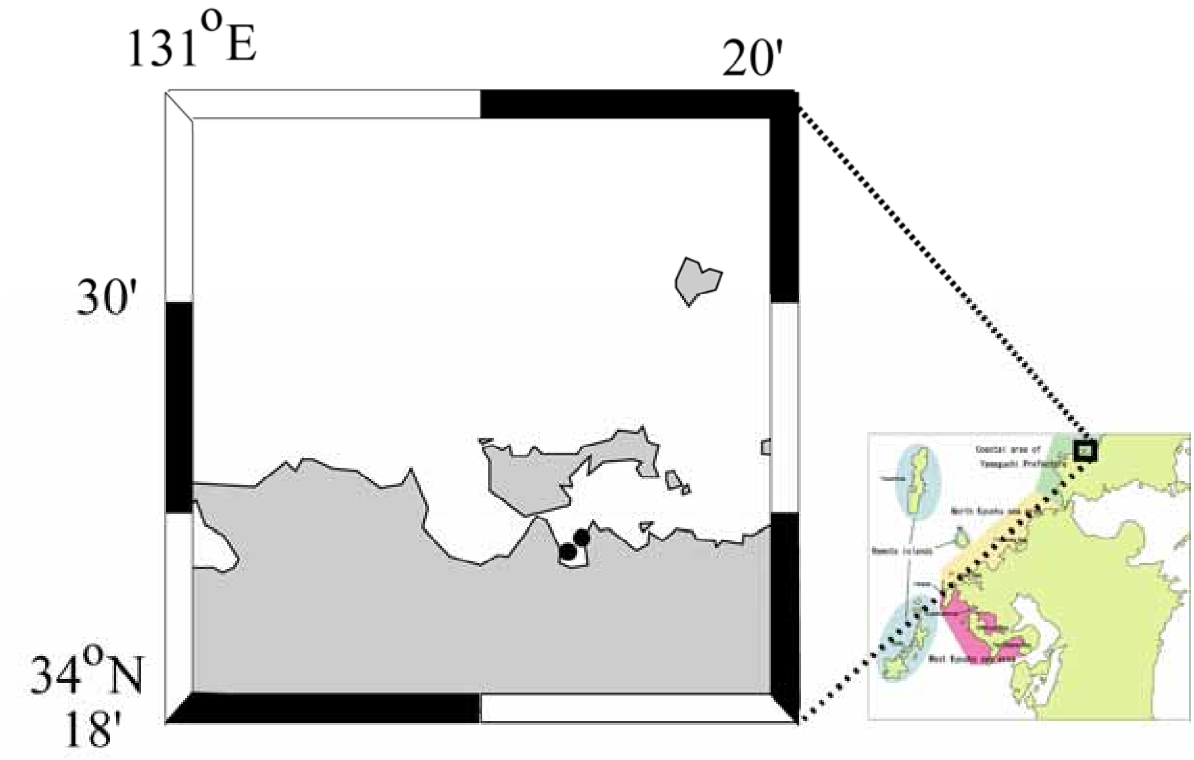


Figure 3.5　Locations of shellfish sampling and toxin-producing plankton monitoring sites in Yamaguchi Prefecture

Source: Yamaguchi Prefectural Fisheries Research Center (2007)

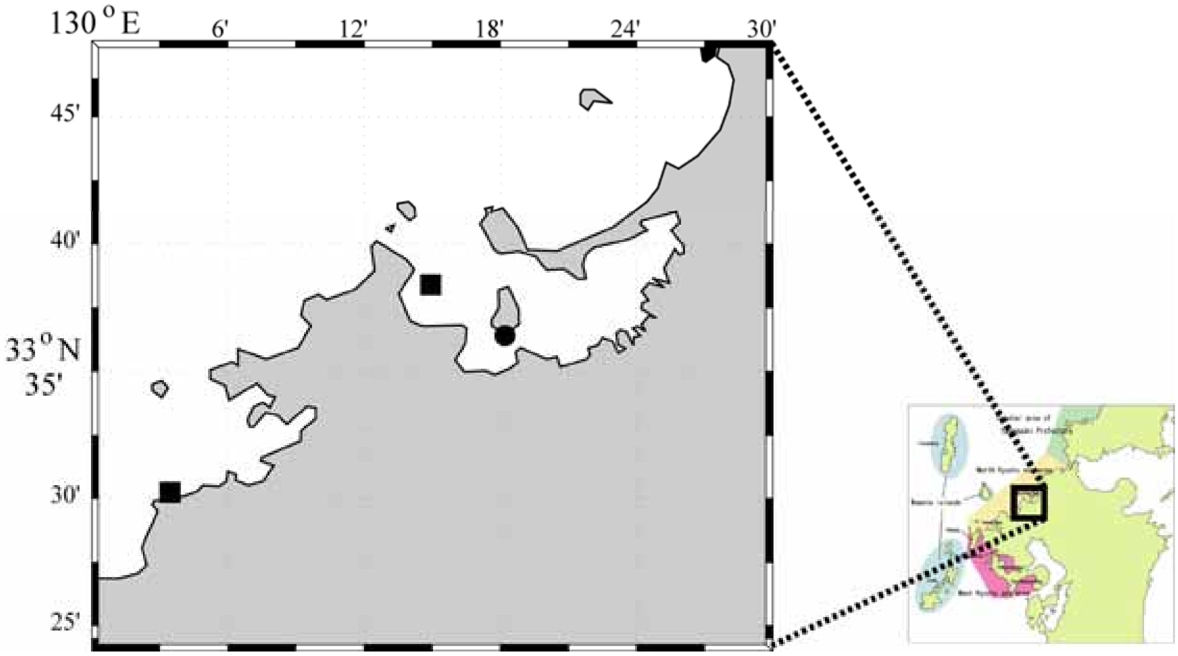


Figure 3.6　Locations of shellfish sampling and toxin-producing plankton monitoring sites in Fukuoka Prefecture

Black circle indicates location of shellfish poisoning monitoring (*Ruditapes philippinarum*), black squares indicate location of shellfish poisoning monitoring (oyster).

Source: Fukuoka Fisheries and Marine Technology Research Center (2007)

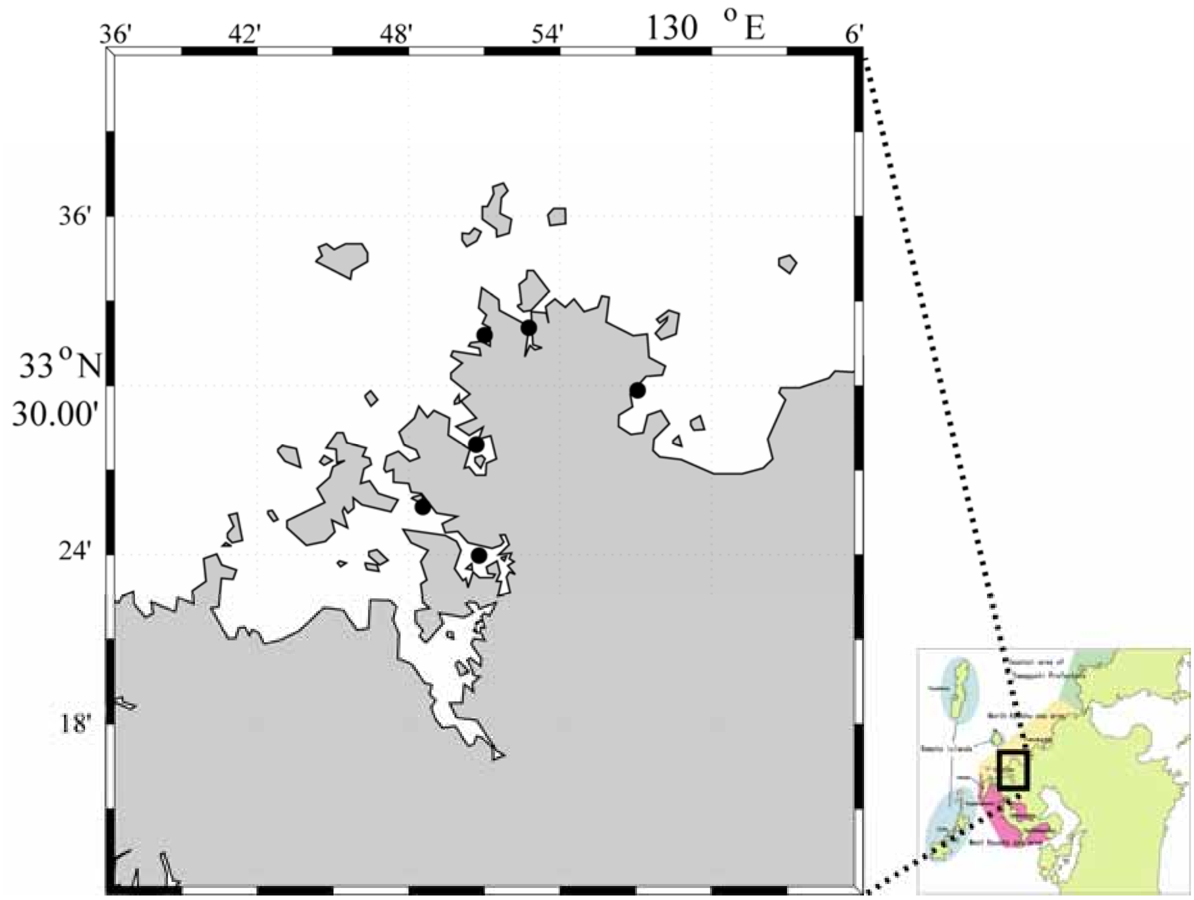


Figure 3.7 Locations of shellfish sampling and toxin-producing plankton monitoring sites in Saga Prefecture

Source: Saga Prefectural Genkai Fisheries Promotion Center (2007)

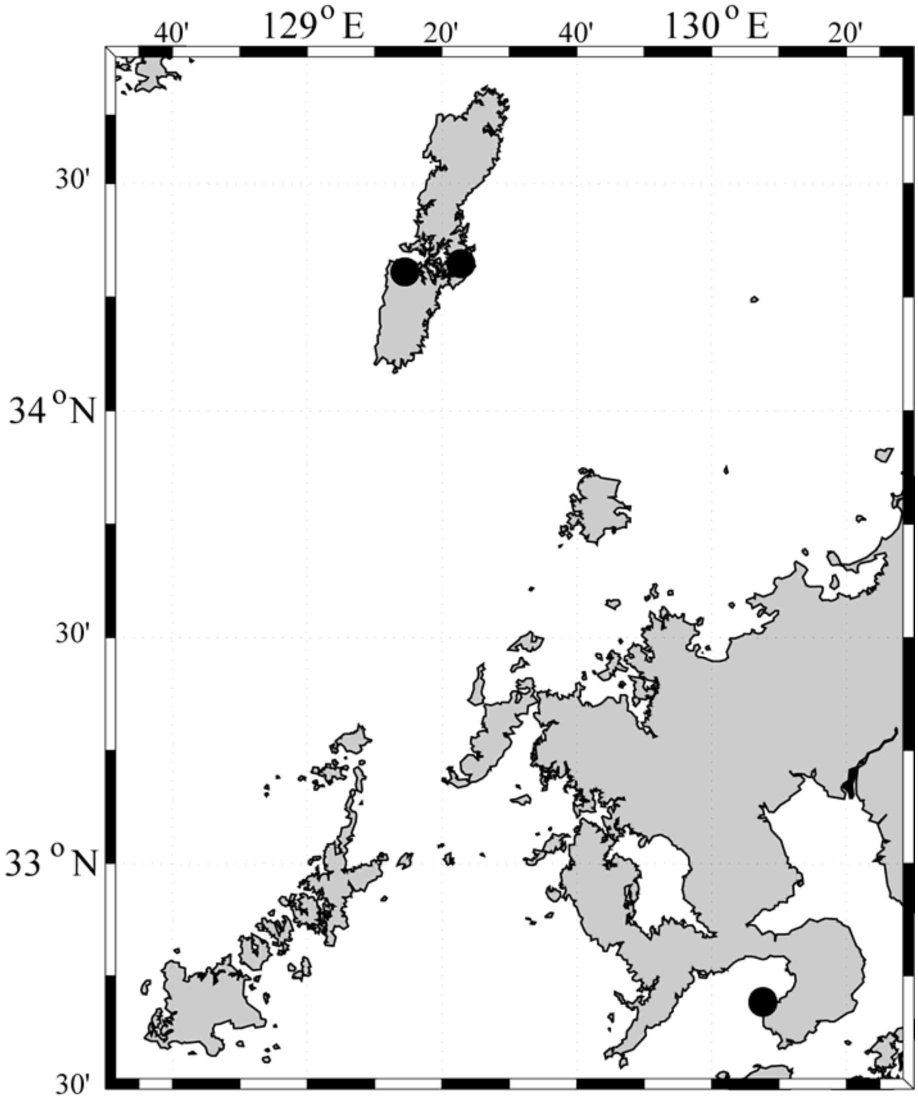


Figure 3.8 Locations of shellfish sampling and toxin-producing plankton monitoring sites in Nagasaki Prefecture

Source: Nagasaki Prefectural Institute of Fisheries (2007)

3.2 Monitoring parameters

As described in Section 3.1, the following three types of HAB related monitoring are conducted in the target sea area: post red-tide monitoring, regular red-tide monitoring and regular shellfish-contamination monitoring. Table 3.3 shows the objectives and monitoring parameters of the above monitoring types.

Post red-tide monitoring is conducted only after water discoloration or fishery damage is reported. Regular red-tide monitoring and regular shellfish-contamination monitoring are conducted regularly at fixed locations, irrespective of any HAB events.

Table 3.3 Objectives and monitoring parameters of the HAB monitoring

Monitoring type	Main objectives	Monitoring parameter				Monitoring frequency
		HAB	Water quality	Meteorology	Others	
Post red-tide monitoring	To minimize fishery damage by tracing red tides	-Type of red-tide spp. (priority/causative spp.) -Cell concentration -Bloom area -Water color -Fishery damage	-Water temp. -Salinity -DO	None		Immediately after water discoloration or fishery damage is reported
Regular red-tide monitoring	To check presence of red-tide spp.	-Type of red-tide spp. -Cell concentration -Water color -Sedimentation	-Water temp. -Salinity -DO -pH -COD -Transparency -Nutrients -Chlorophyll-a	-Weather -Cloud cover -Wind direction/speed -Precipitation -Daylight time	Sediment quality	Fukuoka : 1/month Saga :1/month (May-October) Nagasaki : 1/month (June-October)
Regular shellfish-contamination monitoring	To check presence of toxin-producing plankton spp.	-Type of toxin-producing plankton spp. -Cell concentration -Water color	-Water temp. -Salinity -DO -pH -Transparency -Nutrients -Chlorophyll-a			12-16/year (approx. 1/month)
	To check shellfish contamination				Toxin levels in shellfish (MU/g)	1/week until toxin levels in shellfish satisfy the regulatory standards

Source:
Nagasaki Prefectural Institute of Fisheries (2007)
Saga Prefectural Genkai Fisheries Promotion Center (2007)
Fukuoka Fisheries and Marine Technology Research Center (2007)
Yamaguchi Prefectural Fisheries Research Center (2007)

3.3 Data and information used in the HAB case study

Information and data on HAB events were mainly collected from the following sources:

・ Reports published by organizations that conduct HAB monitoring in the target sea area

・ Reports of the Fisheries Agency Kyushu regional office

Since the monitored parameters are slightly different between the monitoring organizations, the non-monitored parameters are left blank to indicate that there are no data.

Table 3.4 shows the monitoring parameters that will be referred in the case study.

Table 3.4 Monitoring parameters referred in the case study

	Monitoring parameter	Information/data source
HAB	-HAB species (priority/causative spp.) -Cell concentration -Bloom area -Fishery damage	Post red-tide monitoring
Water quality	-Water temperature -Salinity -DO	Post red-tide monitoring
Others	-Water quality Transparency, nutrients, chlorophyll-a -Meteorology Weather, cloud cover, wind direction/speed	Regular red-tide monitoring Regular shellfish-contamination monitoring

4 Status of HAB events

4.1 Status of red-tide events from 1979-2006

4.1.1 Number of red-tide events

Figure 4.1 shows the number of red-tide events that occurred in the target sea area from 1979-2006. A total of 1,311 red-tide events were recorded during this period, in which 115 events induced fishery damage.

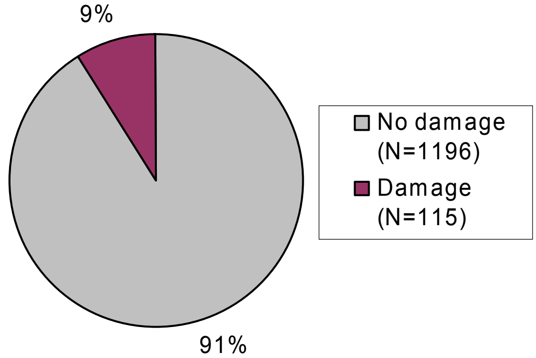


Figure 4.1　Number of red-tide events in the target sea area from 1979-2006

Note: Data of 1979-2005 year of Yamaguchi Prefecture are not included.

4.1.2 Number of red-tide events by year

Figure 4.2 shows the number of red-tide events by year in the target sea area. The annual number of red-tide events fluctuated between 29-92 events, and was highest in 1980 and lowest in 1997. The annual number of red-tide events that induced fishery damage fluctuated between 1-12 events. High number of events occurred in 1991 (10 events) and 2000 (12 events). The dinoflagellate *Karenia mikimotoi* was the main causative species of fishery damage in 1991 and 2000.

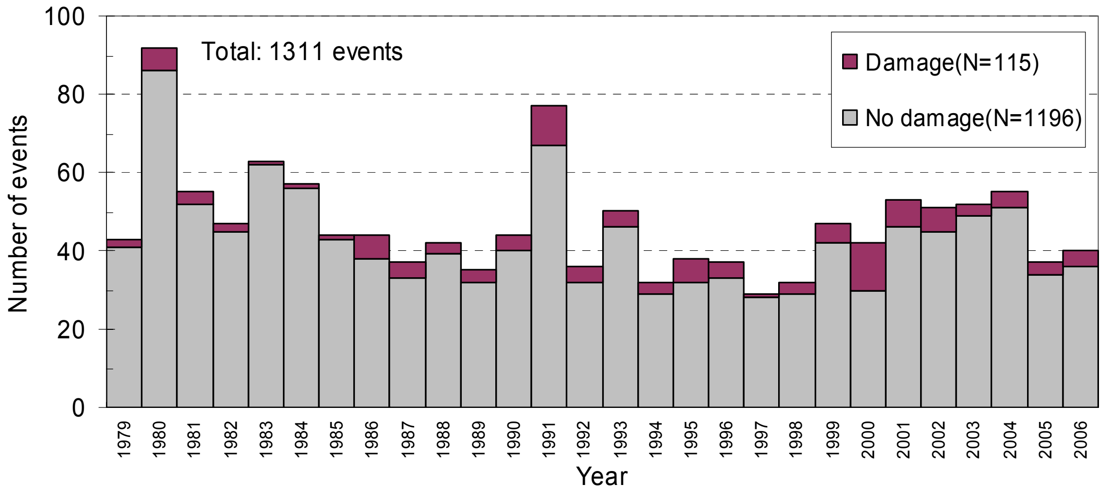


Figure 4.2　Number of red-tide events by year in the target sea area (1979-2006)

Note: Data of 1979-2005 year of Yamaguchi Prefecture are not included.
Source: Fisheries Agency (2006)

4.1.3 Number of red-tide events by month

Figure 4.3 shows the number of red-tide events by month in the target sea area. Approximately 50% of red-tide events occurred during June-August. Fishery damage occurred most frequently during July-August.

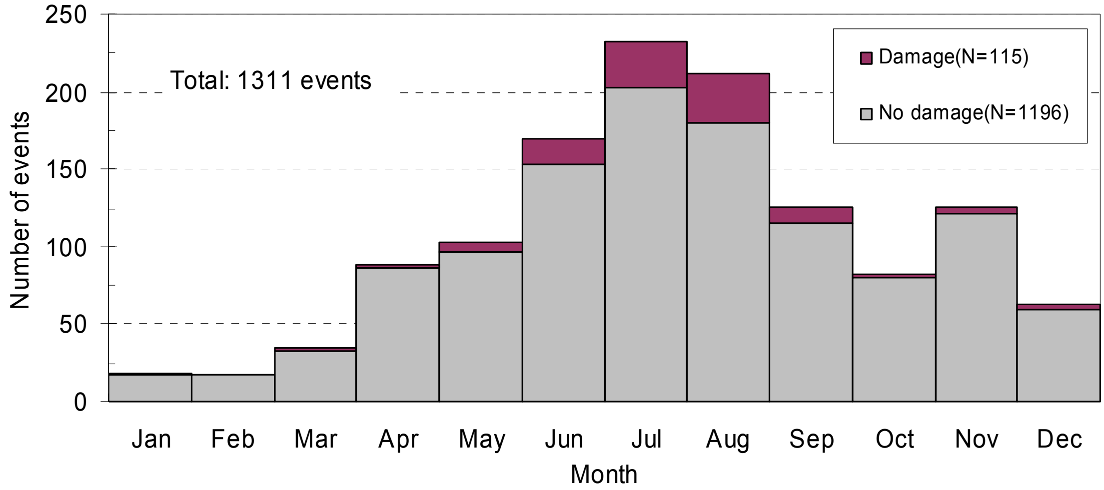


Figure 4.3 Number of red-tide events by month in the target sea area (1979-2006)

Note: Data of 1979-2005 year of Yamaguchi Prefecture are not included.
Source: Fisheries Agency (2006)

4.1.4 Types of red-tide species

Table 4.1 shows the red-tide species that were recorded in the target sea area and their frequency of occurrences from 1979-2006. A total of 98 red-tide species were recorded and were comprised from the following groups: dinoflagellates (35 species), diatoms (32 species), Raphidophyceae (7 species) and others (24 species). The following 7 species were recorded 50 or more times during 1979-2006: the dinoflagellates *Prorocentrum dentatum*, *Karenia mikimotoi* (=*Gymnodinium mikimotoi*), *Akashiwo sanguinea* (=*Gymnodinium sanguineum*), *Noctiluca scintillans;* the diatom *Skeletonema costatum*; the Raphidophyceae *Heterosigma akashiwo*; and the ciliate *Mesodinium rubrum*.

In regards to the red-tide species that are known to induce fishery damage (refer to Section 2.2), *Cochlodinium polykrikoides* was recorded 40 times and its frequency has increased over recent years. *Karenia mikimotoi* was recorded 149 times and has been constantly being recorded from 1979-2006. *Heterocapsa circularisquama* was recorded 16 times and was all after 1996. *Chattonella antique* was recorded 10 times and was all after 1990. *Chattonella marina* was recorded twice each in 1990 and 1992. *Heterosigma akashiwo* was recorded 90 times and has been constantly being recorded from 1985 onwards.

Table 4.1 Red-tide species recorded in the target sea area and their frequency of occurrences from 1979-2006

Genus and Species	1979 -1980	1981 -1985	1986 -1990	1991 -1995	1996 -2000	2001 -2005	2006	Total
Cyanophyceae								
Microcystis sp.			1					1
Trichodesmium erythraeum		1		1				2
Trichodesmium sp.		1						1
Cryptophyceae								
Cryptomonas sp.			1					1
Cryptophyceae							1	1
Dinophyceae								
Prorocentrum balticum				1				1
Prorocentrum compressum				1				1
Prorocentrum dentatum	2	6	16	21	16	3		64
Prorocentrum micans	2	3	2	2	1			10
Prorocentrum minimum	2	1			5	2	1	11
Prorocentrum sigmoides		19	5	8	6	6	2	46
Prorocentrum triestinum	3	8	9	10	3	1	3	37
Prorocentrum sp.	11	8	2	6	1	4	2	34
Cochlodinium polykrikoides				3	8	27	2	40
Cochlodinium sp.	5	5	4			9		23
Gymnodinium breve(=Karenia brevis)				5	1	1		7
Gymnodinium mikimotoi(=Karenia mikimotoi)	26	20	28	20	32	16	7	149
Gymnodinium sanguineum(=Akashiwo sanguinea)	4	6	6	18	6	12		52
Gymnodinium catenatum				1		1		2
Gymnodinium sp.(midorishio)		9	2	5				16
Gymnodinium sp.	8	20	6	8	4	5		51
Gyrodinium sp.	1		1	1	1	1		5
Pheopolykrikos hartmannii			1	4	2	2		9
Polykrikos sp.	3	4		1				8
Noctiluca scintillans	13	20	23	38	19	43	2	158
Noctiluca sp.		2			3	16	2	23
Heterocapsa circularisquama					8	8		16
Heterocapsa triquetra	2	1	2	1	1			7
Heterocapsa sp.				2	1	1		4
Peridinium quinquecorne				2				2
Peridinium sp.		1	1					2
Alexandrium affine				8				8
Alexandrium catenella						3		3
Alexandrium sp.			1	2				3
Gonyaulax polygramma	4			2				6
Gonyaulax sp.		1	1					2
Ceratium furca	4	1	2	6	4	1	3	21
Ceratium fusus	1	1						2
Ceratium sp.	1	1						2
Haptophyceae								
Emiliania huxleyi						1		1
Gephyrocapsa oceanica						2		2
Prymnesium sp.			1					1
Haptophyceae					1			1
Chrysophyceae								
Dictyocha fibula		1			1			2
Dictyocha sp.		1				1		2
Distephanus speculum			1					1
Distephanus sp.						1		1

Bacillariophyceae								
Skeletonema costatum	17	17	12	13	21	2	1	83
Skeletonema sp.		1			1	3		5
Thalassiosira diporocyclus						1		1
Thalassiosira sp.	11	3	3	8	10	2	1	38
Leptocylindrus danicus	1		2		2			5
Leptocylindrus minimus	1		2					3
Leptocylindrus sp.			1		2	1		4
Rhizosolenia alata	1							1
Rhizosolenia delicatula						1		1
Rhizosolenia sp.		2		1	2			5
Cerataulina bicornis		1	1					2
Cerataulina pelagica		1						1
Cerataulina sp.	1	1						2
Eucampia zodiacus				1				1
Chaetoceros affine		1						1
Chaetoceros curvisetum			1					1
Chaetoceros didymum		1	1					2
Chaetoceros lauderi		1						1
Chaetoceros pendulum	1							1
Chaetoceros subsecundum			1					1
Chaetoceros sp.	2	7	6	4	8	5		32
Lithodesmium variabile					1			1
Odontella sp.	1							1
Asterionella glacialis	1	2						3
Asterionella sp.					1			1
Neodelphineis pelagica		2	1		2			5
Pseudo-nitzschia pungens				1		1		2
Pseudo-nitzschia seriata	1							1
Pseud-nitzschia sp.					1			1
Nitzschia sp.		1	1		3			5
Diatoms (mixture of several spp.)							5	5
Raphidophyceae								
Chattonella antique			1	3	1	5		10
Chattonella globosa						2		2
Chattonella marina			2	2				4
Chattonella sp.			2		2			4
Fibrocapsa japonica			2	3	2	1		8
Heterosigma akashiwo		3	19	24	21	20	3	90
Heterosigma sp.		9	6	1				16
Olisthodiscus sp	12	8	1					21
Euglenophyceae								
Eutreptiella gymnastica						1		1
Eutreptiella sp.	2	3	1					6
Prasinophyceae								
Pyramimonas sp.						1		1
Tetraselmis sp.		1						1
Others								
Mesodinium rubrum	16	58	37	22	21	48	4	206
Mesodinium sp.	2					7		9
Unknown micro-flagellates					1	1		2
Stromdinium sp.							1	1
Tontonia sp.						1		1
Oithona brevicornis	1							1
Unidentified	14	22	5	4	1			46

Note:
*1: The underlined species indicate red-tide species that are known to induce fishery damage (refer to Section 2.2)
*2: Data of 1979-2005 year of Yamaguchi Prefecture are not included.
Source:
Fisheries Agency Kyushu regional office (1979-2006)
Fukuoka Fisheries and Marine Technology Research Center (2007)
Nagasaki Prefectural Institute of Fisheries (2007)
Saga Prefectural Genkai Fisheries Promotion Center (2007)
Yamaguchi Prefectural Fisheries Research Center (2007)

4.2 Status of shipment stoppage and the causative toxin-producing planktons

Table 4.2 shows the status of shipment stoppage caused by shellfish contamination in the target sea area. Shipment of shellfish has stopped 10 times during 1978-1999, and their duration ranged between 22-367 days. Shipment stoppage occurred in Senzaki Bay (coastal area of Yamaguchi Prefecture), Tsushima and Goto (both Nagasaki Prefecture). The contaminated shellfish were bivalves such as Japanese oyster and noble scallops, and were all contaminated by PSP-inducing toxins. The toxin levels in their meat ranged between 7.8-135 MU/g. The causative toxin-producing plankton species were *Gymnodinium catenatum* (at Senzaki Bay) and *Alexandrium catenella* (at Tsushima). Information on the status (e.g. cell concentration) of the causative species was not available.

Table 4.2 Status of shipment stoppage caused by shellfish contamination in the target sea area (1978-1999)

Date	Duration (day)	Region	Spot	Contaminated species	Toxin level (MU/g whole meet)		Causative species
					PSP	DSP	
24 Nov., 1988 - 10 Jan., 1989	48	Coastal area of Yamaguchi Pref.	Sensaki Bay	Japanese oyster	Unknown	-	*Gymnodinium catenatum*
27 Nov., 1991 - 14 Jan., 1992	49	Coastal area of Yamaguchi Pref.	Sensaki Bay	Japanese oyster	Unknown	-	*Gymnodinium catenatum*
6 Dec., 1995 - 23 Jan., 1996	49	Coastal area of Yamaguchi Pref.	Sensaki Bay	Japanese oyster	Unknown	-	*Gymnodinium catenatum*
4 Dec., 1996 - 21 Jan., 1997	49	Coastal area of Yamaguchi Pref.	Sensaki Bay	Japanese oyster	Unknown	-	*Gymnodinium catenatum*
7 Jan., 1998 - 28 Jan., 1998	22	Coastal area of Yamaguchi Pref.	Sensaki Bay	Japanese oyster	Unknown	-	*Gymnodinium catenatum*
22 Dec., 1998 - 9 Mar., 1999	78	Coastal area of Yamaguchi Pref.	Sensaki Bay	Japanese oyster	Unknown	-	Unknown
20 Jan., 1994 - 28 Apr., 1994	99	Offshore island	Tsushima	Noble scallop	7.8	-	Unknown
9 Feb., 1996 - 25 May., 1996	106	Offshore island	Tsushima	Noble scallop	17.5	-	*Alexandrium catenella*
17 Dec., 1996 - 8 Feb., 1997	54	Offshore island	Tsushima	Noble scallop	33.9	-	Unknown
31 Mar., 1997 - 1 Apr., 1998	367	Offshore island	Tsushima	Bivalves such as oysters	135	-	Unknown

Source: Japan Fisheries Resource Conservation Association (JFRCA) (2001)

5 Status of recent HAB events and the associated environmental conditions

5.1 Status of red-tide events in 2006

5.1.1 Number of red-tide events

In 2006, a total of 40 red-tide events were recorded in the target sea area, in which 4 events induced fishery damage.

5.1.2 Number of red-tide events by month

Figure 5.1 shows the number of red-tide events that occurred in the target sea area by month. Red-tide events were recorded during February-March and May-November. The number of events was highest in July (15 events). Four events that occurred during July-August induced fishery damage.

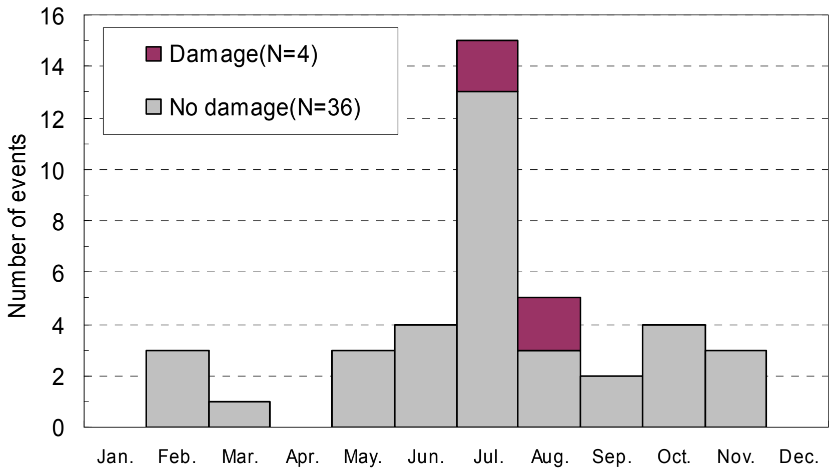


Figure 5.1 Number of red-tide events by month in the target sea area (2006)

Source:
Fukuoka Fisheries and Marine Technology Research Center (2007)
Nagasaki Prefectural Institute of Fisheries (2007)
Saga Prefectural Genkai Fisheries Promotion Center (2007)
Yamaguchi Prefectural Fisheries Research Center (2007)

5.1.3 Duration of red-tide events

Table 5.1 shows the number of red-tide events by duration (no. of days). Within the 39 events that were recorded in 2006 (the diatom red tide that occurred in July 2006 in Fukuoka Bay was excluded from the total as its duration was unknown), 20 events were under 5 days, 8 events between 6-10 days, 9 events between 11-30 days and 2 events were over 31 days. The longest duration was 45 days by *Heterosigma akashiwo*, which occurred in Ohumra Bay during May-June.

Table 5.1 Number of red-tide events by duration (2006)

Region	≤ 5 days	6-10 days	11-30 days	≥ 31 days	Total	Longest duration (days)
Coastal area of Yamaguchi Pref.	3	2(1)	1(1)		6(2)	23
Northern Kyushu	11	3	2(1)	1	17	21
Western Kyushu	5	2(1)	5	1	13(2)	45
Remote islands	1	1	1		3	12
Total	20	8(2)	9(2)	2	39 (4)	-

Note:
*1: The numbers in the parenthesis show the number of events that induced fishery damage
*2: The diatom red tide that occurred in July 2006 in Fukuoka Bay was excluded from the total as its duration was unknown
Source:
Fukuoka Fisheries and Marine Technology Research Center (2007)
Nagasaki Prefectural Institute of Fisheries (2007)
Saga Prefectural Genkai Fisheries Promotion Center (2007)
Yamaguchi Prefectural Fisheries Research Center (2007)

5.1.4 Location of red-tide events

Table 5.2 shows the number of red-tide events by sea area and the causative species. Figure 5.2 shows the location of the red-tide events and the causative species. Figure 5.3 shows the location of the red-tide events by months. In 2006, 6 events occurred in the coastal area of Yamaguchi Prefecture, 18 events in the north Kyushu sea area, 13 events in the west Kyushu sea area and 3 events in the remote islands. Red-tide events were particularly frequent in Imari Bay (north Kyushu sea area), Ohmura Bay and Kujyuku Island (both in west Kyushu sea area).

Table 5.2 Number of red-tide events by sea area (2006)

Year	Sea area		No. of events	Causative species	Note
	Region	Spot			
2006	Coastal area of Yamaguchi Pref.	Between the coast of Shimonoseki and Hagi City	6(2)	*Noctiluca scintillans, Noctiluca* sp. *Karenia mikimotoi, Mesodinium rubrum*	
	North Kyushu sea area	Fukuoka Bay	3	Diatoms	
		Karatsu Bay	2	*Mesodinium rubrum, Thalassiosira* sp.	
		Kariya Bay	1	*Skeletonema costatum*	
		Imari Bay	9(1)	*Ceratium furca, Karenia mikimotoi, Prorocentrum sigmoides*, *Prorocentrum triestinum*, Diatoms	
		Hirado (Usuka/Furue Bay)	1	*Cochlodinium polykrikoides*	
		Others	2	*Noctiluca scintillans, Karenia mikimotoi*	Chikuzen Sea, North Kyushu (Kanmon Straits)
	West Kyushu sea area	Ohmura Bay	7	Cryptophyceae*, Heterosigma akashiwo, Karenia mikimotoi , Prorocentrum sigmoides, Prorocentrum* spp.	
		Tachibana Bay	1	*Ceratium furca*	
		Kujuku Island	5(1)	*Strombidium* sp., *Prorocentrum* spp., *Mesodinium rubrum, Karenia mikimotoi, Prorocentrum minimum*	
	Remote islands	Goto Island	1	*Heterosigma akashiwo*	
		Tsushima	2	*Cochlodinium polykrikoides, Mesodinium rubrum*	
	Total		40(4)		

Note: The numbers in the parenthesis show the number of events that induced fishery damage
Source:
Fukuoka Fisheries and Marine Technology Research Center (2007)
Nagasaki Prefectural Institute of Fisheries (2007)
Saga Prefectural Genkai Fisheries Promotion Center (2007)
Yamaguchi Prefectural Fisheries Research Center (2007)

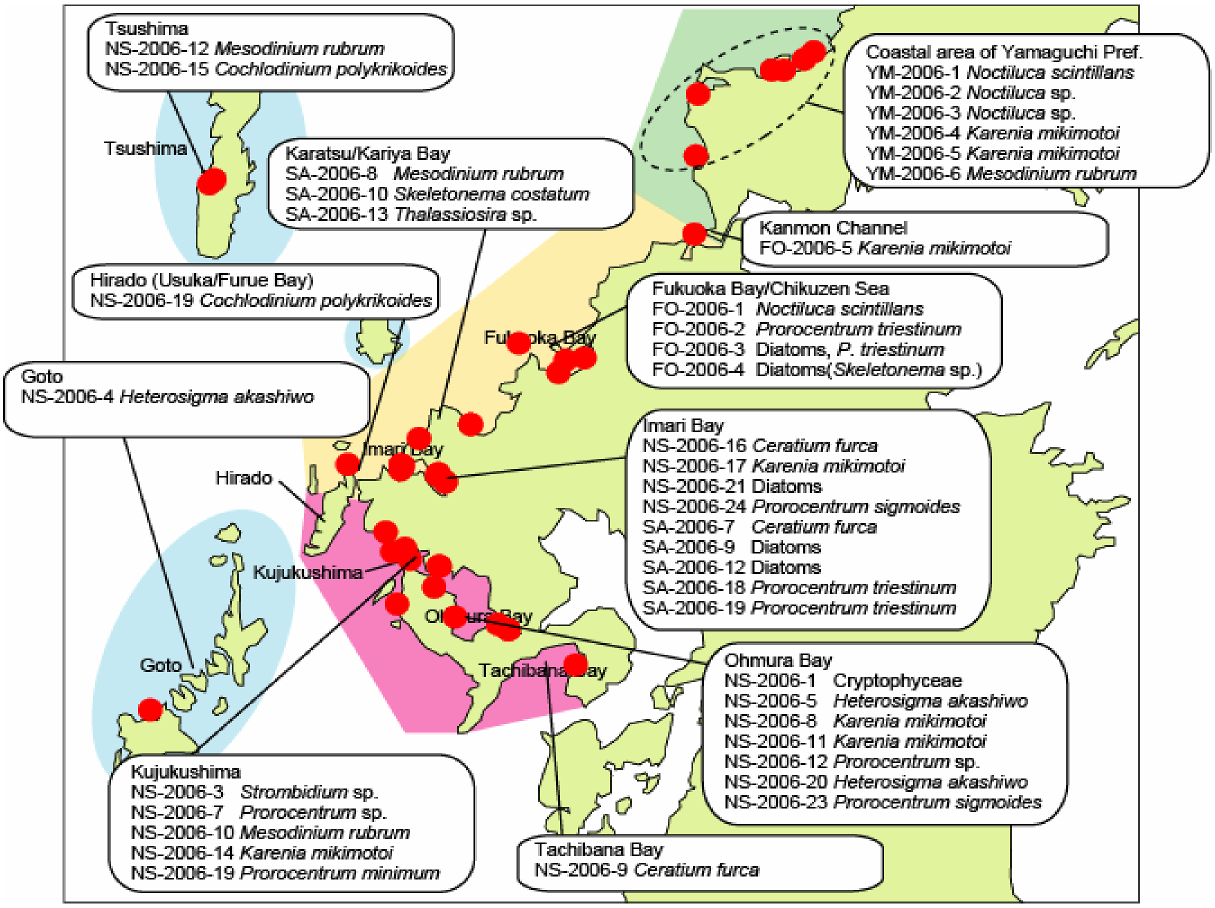


Figure 5.2 Location of red-tide events in 2006 (red dots show the location)

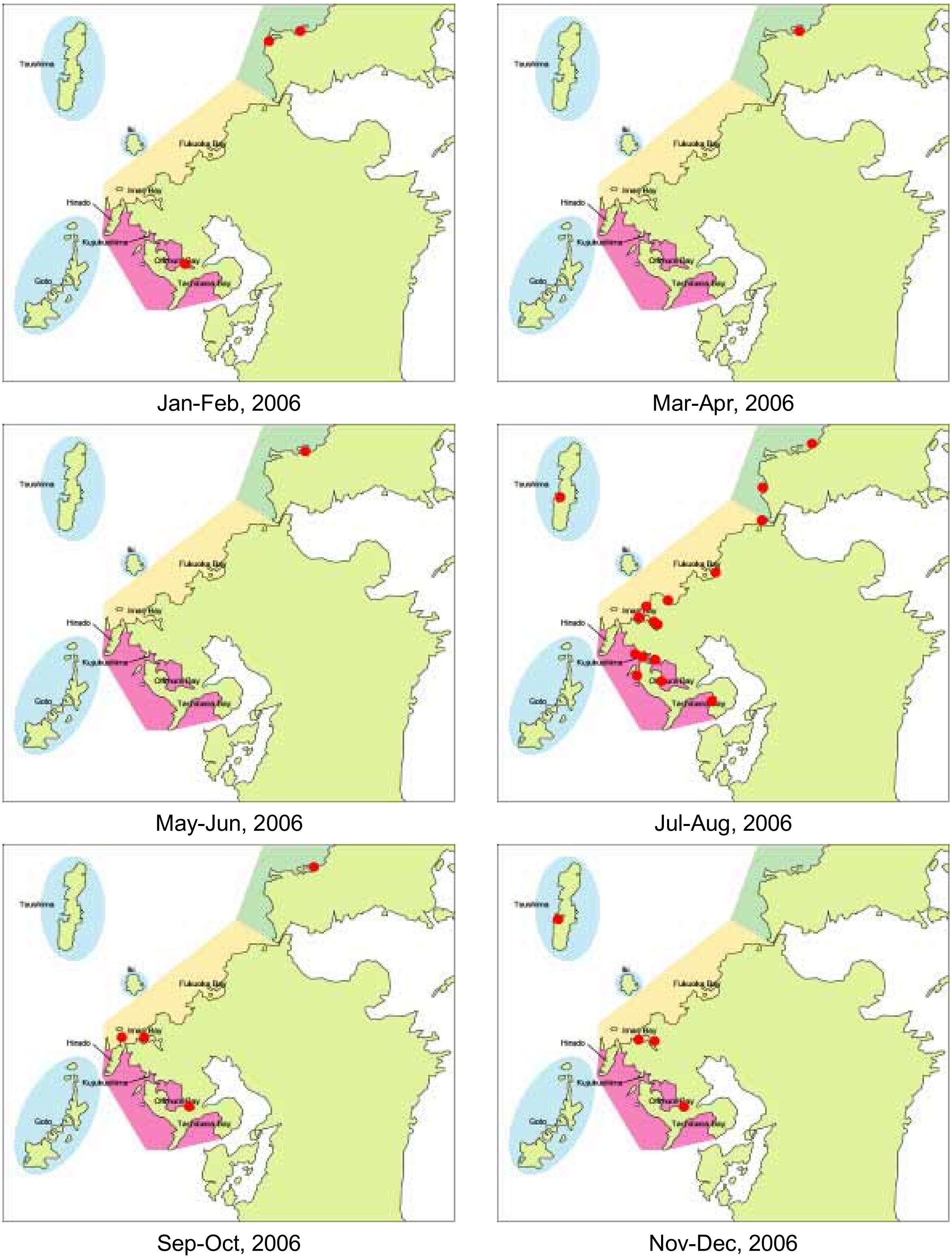


Figure 5.3 Location of red-tide events by months in 2006
(red dots show the location)

5.1.5 Types of red-tide species

Table 5.3 shows the red-tide species that were recorded in the target sea area in 2006 and their frequency of occurrences. In 2006, a total of 15 red-tide species were recorded and were comprised from the following classes: Dinophyceae (9 species), Bacillariophyceae (2 species), Raphidophyceae (1 species) and others (3 species). Several red tides were caused by a mixture of diatom species. The most frequently recorded red-tide species were the dinoflagellate *Karenia mikimotoi* and diatom species. *Karenia mikimotoi* was also the only species that induced fishery damage in 2006.

Table 5.3 Red-tide species recorded in the target sea area and their frequency of occurrences (2006)

Genus and Species	Coastal area of Yamaguchi Pref.	North Kyushu sea area	West Kyushu sea area	Remote islands	Total
Dinophyceae					
Prorocentrum minimum			1		1
Prorocentrum sigmoides		1	1		2
Prorocentrum riestinum		3			3
Prorocentrum spp.			2		2
<u>*Cochlodinium polykrikoides*</u>		1		1	2
<u>*Karenia mikimotoi*</u>	2(2)	2(1)	3(1)		7(4)
Ceratium furca		2	1		3
Noctiluca scintillans	1	1			2
Noctiluca sp.	2				2
Bacillariophyceae					
Skeletonema costatum		1			1
Thalassiosira sp.		1			1
Diatoms (mixture of several spp.)		5			5
Raphidophyceae					
<u>*Heterosigma akashiwo*</u>			2	1	3
Others					
Cryptophyceae			1		1
Mesodinium rubrum	1	1	1	1	4
Strombidium sp.			1		1
合計	6(2)	18(1)	13(1)	3	40(4)

Note:
*1: The numbers in the parenthesis show the number of events that induced fishery damage
*2: The underlined species are known to cause fishery damage
Source:
Fukuoka Fisheries and Marine Technology Research Center (2007)
Nagasaki Prefectural Institute of Fisheries (2007)
Saga Prefectural Genkai Fisheries Promotion Center (2007)
Yamaguchi Prefectural Fisheries Research Center (2007)

5.1.6 Maximum cell concentration of red-tide events

Table 5.4 shows the maximum cell concentration of each red-tide event that occurred in the target sea area in year 2006. The highest maximum cell concentration was recorded in May 2006 at Ohmura Bay (west Kyushu sea area) by *Heterosigma akashiwo*, which reached up to 225,000 cells/mL.

Table 5.4 Maximum cell concentration of each red-tide event that occurred in the target sea area (2006)

Year	Event No.	Causative species	Density (cells or inds/mL)
2006	YM-2006-1	*Noctiluca scintillans*	2,150
2006	YM-2006-2	*Noctiluca* sp.	Unknown
2006	YM-2006-3	*Noctiluca* sp.	Unknown
2006	YM-2006-4	*Karenia mikimotoi*	57,500
2006	YM-2006-5	*Karenia mikimotoi*	4,900
2006	YM-2006-6	*Mesodinium rubrum*	68
2006	FO-2006-1	*Noctiluca scintillans*	200
2006	FO-2006-2	*Prorocentrum triestinum*	10,060
2006	FO-2006-3	*Skeletonema* sp. *Leptocylindrus* sp. *Chaetoceros* sp. other Diatom *Prorocentrum triestinum*	25,240 11,800 1,710 740 14,090
2006	FO-2006-4	*Skeletonema* sp. *Chaetoceros* sp. other Diatom	47,110 2,020 1,200
2006	FO-2006-5	*Karenia mikimotoi*	43,100
2006	SA-2006-7	*Ceratium furca*	340
2006	SA-2006-8	*Mesodinium rubrum*	1,180
2006	SA-2006-9	*Nitzschia* sp. *Thalassiosira* sp.	13,900 5,940
2006	SA-2006-10	*Skeletonema costatum*	11,140
2006	SA-2006-12	*Thalassiosira* sp. *Skeletonema costatum*	2520 1400
2006	SA-2006-13	*Thalassiosira* sp.	2,022
2006	SA-2006-18	*Prorocentrum triestinum*	7,240
2006	SA-2006-19	*Prorocentrum triestinum*	2,940
2006	NS-2006-1	Cryptophyceae	148,000
2006	NS-2006-3	*Strombidium* sp.	55
2006	NS-2006-4	*Heterosigma akashiwo*	11,800
2006	NS-2006-5	*Heterosigma akashiwo*	225,000
2006	NS-2006-7	*Prorocentrum* sp.	3,400
2006	NS-2006-8	*Karenia mikimotoi*	15,800
2006	NS-2006-9	*Ceratium furca*	6,650
2006	NS-2006-10	*Mesodinium rubrum*	13,570
2006	NS-2006-11	*Karenia mikimotoi*	92,200
2006	NS-2006-12	*Prorocentrum* spp.	721
2006	NS-2006-14	*Karenia mikimotoi*	8,504
2006	NS-2006-15	*Cochlodinium polykrikoides*	135
2006	NS-2006-16	*Ceratium furca*	667
2006	NS-2006-17	*Karenia mikimotoi*	16,100
2006	NS-2006-19	*Prorocentrum minimum*	12,800
2006	NS-2006-20	*Heterosigma akashiwo*	11,500
2006	NS-2006-21	Diatoms	16,220
2006	NS-2006-22	*Cochlodinium polykrikoides*	646
2006	NS-2006-23	*Prorocentrum sigmoides*	160
2006	NS-2006-24	*Prorocentrum sigmoides*	14,980
2006	NS-2006-25	*Mesodinium rubrum*	490

5.1.7 Status of red-tide induced fishery damage

Table 5.5 shows the fishery damages that were caused by the red tides in the target sea area in year 2006. Fishery damage occurred 4 times in 2006 and was all during July-August. All incidents were caused by *Karenia mikimotoi*. The fishery damages occurred in the coastal area of Yamaguchi Prefecture, Kujukuri Island (west Kyushu sea area) and Imari Bay (north Kyushu sea area). Cultured fish such as amberjack and puffer fish were affected and the financial losses ranged between 120,000-10,350,000 yen. Fishery damage by *Karenia mikimotoi* has also been reported from the Kanon Straits in July 2006 (Fukuoka Prefecture, 2007), but its details are unknown.

Table 5.5 Fishery damages caused by red-tides in the target sea area (2006)

Month/ Year	Event No.	Region	Spot	Causative Species	Fishery damage		
					Fish/Shellfish Species	Quantity	Economic loss (1,000 yen)
July, 2006	YM-2006-4	Coastal area of Yamaguchi Pref.	Coastline of Shimonoseki City	*Karenia mikimotoi*	Amberjack etc.	Amberjack 360 ind.	1,800
July, 2006	NS-2006-14	West Kyushu sea area	Kujuku island	*Karenia mikimotoi*	Puffer fish Red seabream	Puffer fish: 1,000 ind. Red seabream: 70 ind.	184
July, 2006	NS-2006-17	North Kyushu sea area	Imari Bay	*Karenia mikimotoi*	Puffer fish	6,900 ind.	10,350
Aug, 2006	YM-2006-5	Coastal area of Yamaguchi Pref.	Between Hagi City and Abu Town	*Karenia mikimotoi*	Kingfish	Kingfish 60 ind.	120

Source:
Nagasaki Prefectural Institute of Fisheries (2007)
Yamaguchi Prefectural Fisheries Research Center (2007)

5.2 Status of toxin-producing planktons and shipment stoppage in 2006

5.2.1 Status of toxin-producing planktons

Table 5.6 shows the concentration of PSP- and DSP-inducing species that were recorded in the target sea area in F.Y. 2006. The highest concentration of *Gymnodinium catenatum* was 1,211 cells/L, and was recorded in 17 January 2007 at Station 1 of Senzaki Bay. The highest concentration of *Alexandrium* spp. was 20,084 cells/L, and was recorded in May 30th, 2006 at Station 4 of Kariya Bay. The highest concentration of *Dinophysis* spp. was 512 cells/L, and was recorded in May 30th, 2006 at Station 1 of Kartsu Bay.

Table 5.6 Concentration of PSP- and DSP-inducing species that were recorded in the target sea area in F.Y. 2006 (Water depth: 0 m)

Monitoring date	Monitoring organization	Spot	Station	PSP-inducing species (cells/L)		DSP-inducing species (cells/L)
				Gymnodinium catenatum	*Alexandrium* spp.	*Dinophysis* spp.
2006.10.26	Yamaguchi .	Sensaki Bay	1	0	0	0
2006.11.6	Yamaguchi .	Sensaki Bay	1	16	0	0
2006.11.13	Yamaguchi .	Sensaki Bay	1	4	23	0
2006.11.27	Yamaguchi .	Sensaki Bay	1	164	152	0
2006.11.30	Yamaguchi .	Sensaki Bay	1	29	7	0
2006.12.6	Yamaguchi .	Sensaki Bay	1	114	0	0
2006.12.15	Yamaguchi .	Sensaki Bay	1	43	6	0
2006.12.22	Yamaguchi .	Sensaki Bay	1	77	0	0
2007.1.5	Yamaguchi .	Sensaki Bay	1	74	12	0
2007.1.12	Yamaguchi .	Sensaki Bay	1	0	4	0
2007.1.17	Yamaguchi .	Sensaki Bay	1	1211	115	0
2007.1.24	Yamaguchi .	Sensaki Bay	1	57	0	0
2007.1.31	Yamaguchi .	Sensaki Bay	1	12	0	0
2007.2.7	Yamaguchi .	Sensaki Bay	1	12	0	0
2007.2.19	Yamaguchi .	Sensaki Bay	1	0	0	0
2007.2.26	Yamaguchi .	Sensaki Bay	1	0	0	0
2006.10.26	Yamaguchi .	Sensaki Bay	2	0	0	0
2006.11.6	Yamaguchi .	Sensaki Bay	2	0	12	0
2006.11.13	Yamaguchi .	Sensaki Bay	2	4	10	0
2006.11.27	Yamaguchi .	Sensaki Bay	2	425	667	0
2006.11.30	Yamaguchi .	Sensaki Bay	2	341	216	0
2006.12.6	Yamaguchi .	Sensaki Bay	2	235	15	0
2006.12.15	Yamaguchi .	Sensaki Bay	2	32	0	0
2006.12.22	Yamaguchi .	Sensaki Bay	2	86	18	0
2007.1.5	Yamaguchi .	Sensaki Bay	2	58	14	0
2007.1.12	Yamaguchi .	Sensaki Bay	2	92	0	0
2007.1.17	Yamaguchi .	Sensaki Bay	2	16	0	0
2007.1.24	Yamaguchi .	Sensaki Bay	2	102	0	0
2007.1.31	Yamaguchi .	Sensaki Bay	2	39	0	0
2007.2.7	Yamaguchi .	Sensaki Bay	2	0	0	0
2007.2.19	Yamaguchi .	Sensaki Bay	2	0	0	0
2007.2.26	Yamaguchi .	Sensaki Bay	2	0	0	0
2006.4.11	Fukuoka .	Fukuoka Bay	1	0	0	1
2006.5.17	Fukuoka .	Fukuoka Bay	1	0	0	0
2006.6.7	Fukuoka .	Fukuoka Bay	1	0	0	0
2006.7.11	Fukuoka .	Fukuoka Bay	1	0	0	0
2006.8.10	Fukuoka .	Fukuoka Bay	1	0	0	0

2006.9.14	Fukuoka .	Fukuoka Bay	1	0	0	0
2006.10.12	Fukuoka .	Fukuoka Bay	1	0	0	37
2006.11.15	Fukuoka .	Fukuoka Bay	1	0	0	0
2006.12.12	Fukuoka .	Fukuoka Bay	1	0	0	70
2007.1.10	Fukuoka .	Fukuoka Bay	1	0	0	0
2007.2.9	Fukuoka .	Fukuoka Bay	1	0	0	36
2007.3.8	Fukuoka .	Fukuoka Bay	1	0	0	0
2006.4.11	Saga .	Karatsu Bay	1	0	0	0
2006.5.2	Saga .	Karatsu Bay	1	0	40	0
2006.5.23	Saga .	Karatsu Bay	1	0	4800	128
2006.5.30	Saga .	Karatsu Bay	1	0	0	512
2006.6.8	Saga .	Karatsu Bay	1	0	712	0
2006.8.8	Saga .	Karatsu Bay	1	0	296	0
2006.8.13	Saga .	Karatsu Bay	1	0	8	18
2006.8.20	Saga .	Karatsu Bay	1	10	58	0
2006.8.27	Saga .	Karatsu Bay	1	0	0	24
2006.7.3	Saga .	Karatsu Bay	1	0	0	80
2006.8.2	Saga .	Karatsu Bay	1	0	0	16
2006.9.4	Saga .	Karatsu Bay	1	0	0	0
2006.10.5	Saga .	Karatsu Bay	1	192	120	0
2006.11.2	Saga .	Karatsu Bay	1	48	0	0
2006.11.20	Saga .	Karatsu Bay	1	64	0	0
2006.12.1	Saga .	Karatsu Bay	1	0	32	40
2007.1.8	Saga .	Karatsu Bay	1	0	72	0
2007.1.16	Saga .	Karatsu Bay	1	0	48	0
2007.1.18	Saga .	Karatsu Bay	1	64	0	32
2007.1.22	Saga .	Karatsu Bay	1	0	0	48
2007.1.25	Saga .	Karatsu Bay	1	0	0	8
2007.2.2	Saga .	Karatsu Bay	1	0	0	56
2007.3.2	Saga .	Karatsu Bay	1	0	208	80
2006.10.2	Saga .	Nagoyaura	2	0	98	0
2006.11.1	Saga .	Nagoyaura	2	0	32	0
2006.12.4	Saga .	Nagoyaura	2	0	0	0
2007.1.4	Saga .	Nagoyaura	2	0	0	0
2007.1.12	Saga .	Nagoyaura	2	0	6488	0
2007.1.16	Saga .	Nagoyaura	2	0	1056	0
2007.1.18	Saga .	Nagoyaura	2	0	180	0
2007.1.22	Saga .	Nagoyaura	2	0	224	0
2007.1.25	Saga .	Nagoyaura	2	32	224	0
2007.2.2	Saga .	Nagoyaura	2	0	80	0
2007.3.1	Saga .	Nagoyaura	2	0	16	0
2006.10.2	Saga .	Kushiura	3	16	0	0
2006.11.1	Saga .	Kushiura	3	0	32	8
2006.12.4	Saga .	Kushiura	3	0	0	0
2007.1.4	Saga .	Kushiura	3	0	0	0
2007.1.16	Saga .	Kushiura	3	0	0	0
2007.1.18	Saga .	Kushiura	3	0	0	0
2007.1.22	Saga .	Kushiura	3	0	0	0
2007.1.20	Saga .	Kushiura	3	0	0	0
2007.2.1	Saga .	Kushiura	3	0	0	0
2007.3.1	Saga .	Kushiura	3	0	0	0
2006.5.24	Saga .	Kariya Bay	4	0	104	68
2006.5.30	Saga .	Kariya Bay	4	0	20084	16
2006.8.2	Saga .	Kariya Bay	4	0	788	16
2006.8.6	Saga .	Kariya Bay	4	0	72	8
2006.9.8	Saga .	Kariya Bay	4	0	0	0
2006.9.13	Saga .	Kariya Bay	4	0	0	8
2006.9.20	Saga .	Kariya Bay	4	0	0	0
2006.9.27	Saga .	Kariya Bay	4	0	0	0

2006.10.3	Saga .	Kariya Bay	4	88	40	0
2006.11.2	Saga .	Kariya Bay	4	0	0	48
2006.12.5	Saga .	Kariya Bay	4	0	0	0
2007.1.5	Saga .	Kariya Bay	4	0	0	0
2007.1.22	Saga .	Kariya Bay	4	0	0	0
2007.2.2	Saga .	Kariya Bay	4	0	8	0
2007.3.2	Saga .	Kariya Bay	4	0	0	8
2006.5.24	Saga .	Imari Bay	5	0	0	16
2006.5.30	Saga .	Imari Bay	5	0	0	16
2006.6.2	Saga .	Imari Bay	5	0	0	8
2006.6.8	Saga .	Imari Bay	5	0	0	0
2006.6.9	Saga .	Imari Bay	5	0	0	0
2006.6.13	Saga .	Imari Bay	5	0	0	24
2006.6.21	Saga .	Imari Bay	5	0	0	0
2006.10.2	Saga .	Imari Bay	5	0	0	0
2006.11.1	Saga .	Imari Bay	5	320	0	0
2006.12.4	Saga .	Imari Bay	5	0	0	0
2007.1.4	Saga .	Imari Bay	5	0	0	0
2007.1.22	Saga .	Imari Bay	5	0	0	18
2007.2.1	Saga .	Imari Bay	5	0	0	326
2007.3.1	Saga .	Imari Bay	5	0	0	0
2006.4.3	Saga .	Imari Bay	6	0	0	0
2006.5.1	Saga .	Imari Bay	6	0	0	0
2006.5.24	Saga .	Imari Bay	6	0	0	0
2006.5.30	Saga .	Imari Bay	6	0	0	0
2006.6.2	Saga .	Imari Bay	6	0	0	144
2006.6.8	Saga .	Imari Bay	6	0	24	32
2006.6.9	Saga .	Imari Bay	6	0	0	8
2006.6.13	Saga .	Imari Bay	6	0	0	72
2006.6.21	Saga .	Imari Bay	6	0	0	0
2006.6.28	Saga .	Imari Bay	6	0	0	0
2006.7.3	Saga .	Imari Bay	6	0	0	32
2006.8.1	Saga .	Imari Bay	6	0	0	0
2006.9.1	Saga .	Imari Bay	6	0	0	0
2006.12.5	Saga .	Imari Bay	6	0	0	8
2007.1.4	Saga .	Imari Bay	6	0	0	0
2007.1.22	Saga .	Imari Bay	6	0	0	24
2007.2.1	Saga .	Imari Bay	6	0	0	58
2007.3.1	Saga .	Imari Bay	6	0	0	96
2006.4.13	Nagasaki ..	Tsushima	Terashima	0	0	0
2006.5.16	Nagasaki ..	Tsushima	Terashima	0	0	0
2006.6.19	Nagasaki ..	Tsushima	Terashima	0	0	0
2006.7.12	Nagasaki ..	Tsushima	Terashima	0	0	0
2006.8.22	Nagasaki ..	Tsushima	Terashima	0	0	0
2006.9.19	Nagasaki ..	Tsushima	Terashima	0	0	0
2006.10.10	Nagasaki ..	Tsushima	Terashima	0	0	0
2006.11.13	Nagasaki ..	Tsushima	Terashima	0	0	0
2006.12.6	Nagasaki ..	Tsushima	Terashima	0	0	0
2007.1.15	Nagasaki ..	Tsushima	Terashima	0	0	0
2007.2.13	Nagasaki ..	Tsushima	Terashima	0	0	0
2007.3.12	Nagasaki ..	Tsushima	Terashima	0	0	0
2006.4.17	Nagasaki ..	Tsushima	Hetajima	0	0	0
2006.5.16	Nagasaki ..	Tsushima	Hetajima	0	0	0
2006.6.19	Nagasaki ..	Tsushima	Hetajima	0	0	0
2006.7.12	Nagasaki ..	Tsushima	Hetajima	10	0	0
2006.8.22	Nagasaki ..	Tsushima	Hetajima	0	0	0
2006.9.19	Nagasaki ..	Tsushima	Hetajima	4	0	0
2006.10.10	Nagasaki ..	Tsushima	Hetajima	0	2	0
2006.11.13	Nagasaki ..	Tsushima	Hetajima	0	0	0

2006.12.6	Nagasaki ..	Tsushima	Hetajima	0	0	0
2007.1.18	Nagasaki ..	Tsushima	Hetajima	0	0	0
2007.2.19	Nagasaki ..	Tsushima	Hetajima	0	0	0
2007.3.12	Nagasaki ..	Tsushima	Hetajima	0	0	0
2006.4.18	Nagasaki .	Tachibana Bay	South Kushiyama	0	2	0
2006.5.8	Nagasaki .	Tachibana Bay	South Kushiyama	0	0	0
2006.6.6	Nagasaki .	Tachibana Bay	South Kushiyama	0	0	0
2006.7.12	Nagasaki .	Tachibana Bay	South Kushiyama	0	0	0
2006.8.16	Nagasaki .	Tachibana Bay	South Kushiyama	0	0	0
2006.9.13	Nagasaki .	Tachibana Bay	South Kushiyama	0	0	0
2006.10.18	Nagasaki .	Tachibana Bay	South Kushiyama	0	0	6
2006.11.22	Nagasaki .	Tachibana Bay	South Kushiyama	0	0	0
2006.12.13	Nagasaki .	Tachibana Bay	South Kushiyama	0	0	0
2007.1.24	Nagasaki .	Tachibana Bay	South Kushiyama	0	0	0
2007.2.21	Nagasaki .	Tachibana Bay	South Kushiyama	0	0	0
2007.3.9	Nagasaki .	Tachibana Bay	South Kushiyama	0	0	0

Source:
Fukuoka Fisheries and Marine Technology Research Center (2007)
Nagasaki Prefectural Institute of Fisheries (2007)
Saga Prefectural Genkai Fisheries Promotion Center (2007)
Yamaguchi Prefectural Fisheries Research Center (2007)

5.2.2 Status of shipment stoppage

Table 5.7 shows the status of shipment stoppage by shellfish contamination in the target sea area in F.Y. 2006. Shipment of Japanese oyster was stopped in Senzaki Bay, Yamaguchi Prefecture from December 2006-February 2007. During the shipment stoppage, the toxin levels in the Japanese oyster’s meat ranged between 6.18-12.2MU/g. The causative species was the PSP-inducing *Gymnodinium catenatum*, and its maximum cell density reached up to 1,211 cells/L during the shipment stoppage.

Table 5.7 Status of shipment stoppage by shellfish contamination in the target sea area (F.Y. 2006)

Date	Region	Spot	Affected Species	Toxin level (MU/g whole meet)		Causative species
				PSP	DSP	
26 Dec., 2006 - 21 Feb., 2007	Coastal area of Yamaguchi Pref.	Sensaki Bay	Japanese oyster	6.18 - 12.2	-	*Gymnodinium catenatum* (Max. concentration during shipment stoppage: 1,211 cells/L)

Source: Yamaguchi Prefectural Fisheries Research Center (2007)

5.3 Status of red-tide species that cause fishery damage in 2006

Monitoring organizations regularly monitor several red-tide species that are known to be particularly harmful to fisheries (refer to Section 2.2). Within the monitored species, the status of the following red-tide species is presented in this section, namely: the dinoflagellates *Karenia mikimotoi*, *Cochlodinium polykrikoides* and the Raphidophyceae *Heterosigma akashiwo*.

5.3.1 *Karenia mikimotoi*

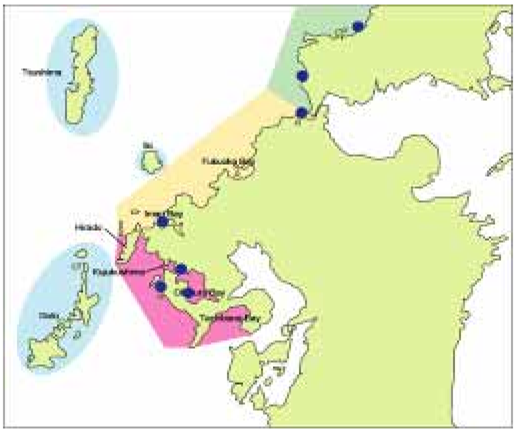
In 2006, *Karenia mikimotoi* blooms were recorded 7 times and were all during July-August. The blooms occurred throughout the target sea area, such as: the coast of Shimonoseki City, the coast between Hagi City and Abu Town, Kanmon Straits, Imari Bay and Ohmura Bay. Figure 5.4 shows the locations of the *Karenia mikimotoi* blooms. The cell concentration during the blooms ranged between 8,504-92,200 cells/mL. Mortality of cultured fish was reported 4 times out of the 7 blooms.

5.3.2 *Cochlodinium polykrikoides*

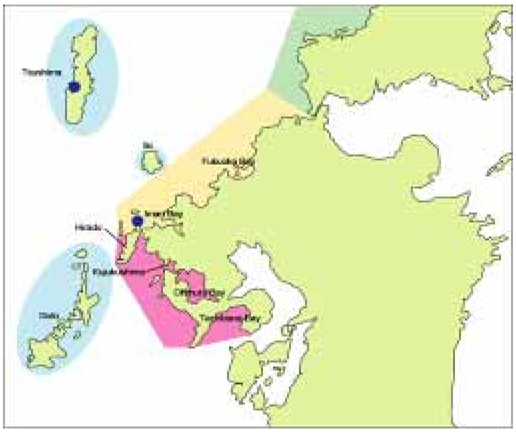
In 2006, *Cochlodinium polykrikoides* blooms were recorded once each in July (Tsushima) and October (Hirato). Figure 5.4 shows the locations of the *Cochlodinium polykrikoides* blooms. The cell concentration during the blooms ranged between 135-646 cells/mL. There were no fishery damages reported through the *Cochlodinium polykrikoides* blooms.

5.3.3 *Heterosigma akashiwo*

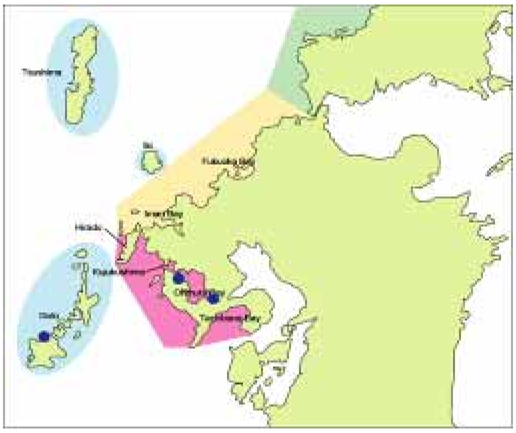
In 2006, *Heterosigma akashiwo* blooms were recorded once each in May (Goto Islands), June and September (Ohmura Bay). Figure 5.4 shows the locations of the *Heterosigma akashiwo* blooms. The cell concentration during the blooms ranged between 11,500-225,000 cells/mL. There were no fishery damages reported through the *Cochlodinium polykrikoides* blooms.



Karenia mikimotoi



Cochlodinium polykrikoides



Heterosigma akashiwo

Figure 5.4 Location of blooms of harmful red-tide species in the target sea area in 2006 (blue dots show the location)

5.4 Environmental conditions during post red-tide monitoring

During the post red-tide monitoring, sea surface temperature (SST), salinity and DO are measured. Table 5.8 shows the SST, salinity and DO values obtained during the post red-tide monitoring in the target sea area in 2006. According to the monitoring results, SST ranged between 10.0-28.2 C°; salinity ranged between 26.3-34.9; and DO ranged between 5.2-14.5 mg/L.

Table 5.8 SST, salinity and DO values obtained during the post red-tide monitoring in the target sea area (2006)

Year	Event No.	Duration	Spot	SST	Salinity	DO
2006	YM-2006-1	2.20-2.27	Between Yuya Bay, Nagato City and the coast of Yoshimo, Shimonoseki City	10.0	-	-
2006	YM-2006-2	2.25-2.28	Coast of Nagato City (Sensaki Bay, Fukagawa Bay)	-	-	-
2006	YM-2006-3	3.27-3.29	Coast of Nagato City (Sensaki Bay)	-	-	-
2006	YM-2006-4	7.13-8.4	Coast of Shimonooseki City (Gaikai）	25.4	-	-
2006	YM-2006-5	8.2-8.11	Between Hagi City and the coast of Abu Town	28.2	-	-
2006	YM-2006-6	10.16-10.19	Nagato City (Nohase fishery port)	23.0	-	-
2006	FO-2006-1	6.5-6.12	West area of Chikuzen sea	-	-	-
2006	FO-2006-2	6.21-6.27	Fukuoka Bay	-	-	-
2006	FO-2006-3	6.29-?.?	Fukuoka Bay	-	-	-
2006	FO-2006-4	7.11-7.31	Fukuoka Bay	-	-	-
2006	FO-2006-5	7.18-7.26	Kanmon (North Kyushu)	-	-	-
2006	SA-2006-7	7.20-7.22	Imari Bay	-	-	-
2006	SA-2006-8	7.20-7.23	Karatsu Bay	-	-	-
2006	SA-2006-9	7.26-7.30	Imari Bay	-	-	-
2006	SA-2006-10	7.27-7.30	Kariya Bay	-	-	-
2006	SA-2006-12	8.21-8.25	Imari Bay	-	-	-
2006	SA-2006-13	8.22-8.23	Karatsu Bay	-	-	-
2006	SA-2006-18	11.20-11.22	Imari Bay	-	-	-
2006	SA-2006-19	11.27-11.28	Imari Bay	-	-	-
2006	NS-2006-1	2.24-3.15	Ohmura Bay	12.7	27.4	14.5
2006	NS-2006-3	5.1-5.2	Kujukushima	17.7	33.8	8.6
2006	NS-2006-4	5.15-5.26	Goto	19.5	27.0	9.5
2006	NS-2006-5	5.16-6.29	Ohmura Bay	-	-	-
2006	NS-2006-7	6.1-6.3	Kujukushima	-	-	-
2006	NS-2006-8	7.3-7.14	Ohmura Bay	-	-	-
2006	NS-2006-9	7.4-7.12	Tachibana Bay	-	-	-
2006	NS-2006-10	7.9-7.11	Kujukushima	-	-	-
2006	NS-2006-11	7.8-7.31	Ohmura Bay	-	-	-
2006	NS-2006-12	7.14-7.18	Ohmura Bay	25.3	29.1	8.1
2006	NS-2006-14	7.20-7.25	Kujukushima	-	-	-
2006	NS-2006-15	7.20-7.25	Tsushima	22.8	26.3	5.2
2006	NS-2006-16	7.21-7.23	Imari Bay	26.0	-	-
2006	NS-2006-17	7.25-8.11	Imari Bay	-	-	-
2006	NS-2006-19	8.21-8.25	Kujukushima	26.1	31.9	10.1
2006	NS-2006-20	9.6-9.21	Ohmura Bay	27.5	30.1	-
2006	NS-2006-21	9.22-9.26	Imari Bay	23.0	-	-
2006	NS-2006-22	10.11-10.13	Hirado(Usuka/Furue Bay)	23.0	33.0	7.9
2006	NS-2006-23	10.26-11.6	Ohmura Bay	-	-	-
2006	NS-2006-24	10.30-12.7	Imari Bay	-	-	-
2006	NS-2006-25	11.1-11.3	Tsushima	22.5	34.9	5.8

Source:
Fukuoka Fisheries and Marine Technology Research Center (2007)
Nagasaki Prefectural Institute of Fisheries (2007)
Saga Prefectural Genkai Fisheries Promotion Center (2007)
Yamaguchi Prefectural Fisheries Research Center (2007)

5.5 Environmental conditions during regular HAB monitoring

5.5.1 Environmental conditions during regular red-tide monitoring

During regular red-tide monitoring, water quality parameters such as transparency, nutrients and chlorophyll-a are measured in addition to the parameters (SST, salinity and DO) measured during post red-tide monitoring. Table 5.9 shows the water-quality values obtained during the regular red-tide monitoring in the target sea area in 2006.

In Fukuoka Prefecture, regular red-tide monitoring was conducted at Fukuoka Bay during April-December. In Saga Prefecture, regular red-tide monitoring was conducted at Imari Bay, Kariya Bay, Nagoyaura and Hokawazu Bay during June-October. In Nagasaki Prefecture, regular red-tide monitoring was conducted at Imari Bay and Ohmura Bay during June-October. The above regular red-tide monitoring were conducted approximately once a month.

Table 5.9 Water-quality values obtained during the regular red-tide monitoring in the target sea area in 2006 (Water depth: 0 m)

Monitoring date	Organization	Spot	Station	Transparency (m)	SST (C°)	Salinity	DO (mg/L)	DIN (μM)	NO3-N (μM)	NO2-N (μM)	NH4-N (μM)	PO4-P (μM)	Chl.a (μg/L)
2006.4.-	Fukuoka	Fukuoka Bay	-	-	14.6	27.9	-	19.46	-	-	-	0.32	-
2006.5.-	Fukuoka	Fukuoka Bay	-	-	17.6	31.1	-	30.35	-	-	-	0.53	-
2006.6.-	Fukuoka	Fukuoka Bay	-	-	21.7	31.3	-	19.59	-	-	-	0.09	-
2006.7.-	Fukuoka	Fukuoka Bay	-	-	23.8	31.6	-	10.93	-	-	-	0.46	-
2006.8.-	Fukuoka	Fukuoka Bay	-	-	30.1	29.9	-	10.92	-	-	-	0.10	-
2006.9.-	Fukuoka	Fukuoka Bay	-	-	24.4	29.9	-	16.06	-	-	-	0.57	-
2006.10.-	Fukuoka	Fukuoka Bay	-	-	22.5	31.6	-	11.42	-	-	-	0.12	-
2006.11.-	Fukuoka	Fukuoka Bay	-	-	17.6	32.3	-	13.30	-	-	-	0.22	-
2006.12.-	Fukuoka	Fukuoka Bay	-	-	14.3	32.2	-	36.34	-	-	-	0.65	-
2006.5.1	Saga	Imari Bay	1	4.3	16.9	32.0	8.4	5.41	2.01	0.91	2.49	0.09	1.7
2006.5.1	Saga	Imari Bay	2	4.1	17.0	31.6	8.2	2.17	0.61	0.22	1.33	0.05	1.9
2006.5.1	Saga	Imari Bay	3	4.5	17.2	31.7	8.9	1.73	0.69	0.18	0.86	0.09	2.2
2006.6.1	Saga	Imari Bay	1	5.7	21.5	31.7	7.9	2.47	1.45	0.06	0.96	0.15	1.2
2006.6.1	Saga	Imari Bay	2	3.9	21.9	31.4	8.1	2.13	0.67	0.06	1.40	0.11	4.1
2006.6.1	Saga	Imari Bay	3	4.7	21.4	31.4	8.4	1.79	0.85	0.07	0.87	0.08	1.2
2006.7.3	Saga	Imari Bay	1	2.9	25.6	25.0	8.9	4.03	2.40	0.09	1.54	0.12	8.9
2006.7.3	Saga	Imari Bay	2	2.8	25.6	25.2	8.4	2.26	0.83	0.09	1.34	0.25	7.3
2006.7.3	Saga	Imari Bay	3	2.8	25.2	25.3	8.3	1.79	0.67	0.07	1.05	0.12	10.3
2006.8.1	Saga	Imari Bay	1	4.8	29.9	26.3	7.8	1.29	1.28	0.01	0.00	0.06	2.1
2006.8.1	Saga	Imari Bay	2	4.5	29.9	26.6	7.8	0.77	0.74	0.03	0.00	0.04	1.9
2006.8.1	Saga	Imari Bay	3	3.9	29.7	27.0	8.1	0.59	0.57	0.02	0.00	0.06	1.5
2006.9.1	Saga	Imari Bay	1	7.3	26.8	30.1	6.9	4.10	1.32	0.02	2.76	0.05	3.9
2006.9.1	Saga	Imari Bay	2	6.6	26.9	29.2	6.5	4.81	1.68	0.13	3.01	0.24	1.5
2006.9.1	Saga	Imari Bay	3	7.8	28.5	29.6	6.3	6.42	4.30	0.06	2.05	0.24	1.3
2006.10.2	Saga	Imari Bay	1	4.7	23.4	30.9	6.3	2.82	1.79	0.09	0.94	0.19	5.9
2006.10.2	Saga	Imari Bay	2	3.8	23.3	30.9	6.0	1.29	58.00	0.11	0.60	0.23	7.1
2006.10.2	Saga	Imari Bay	3	4.2	23.1	30.1	6.9	5.27	1.37	0.08	3.83	0.07	2.8
2006.5.8	Saga	Kariya Bay	A	7.5	16.9	32.2	8.0	6.48	2.24	0.50	3.74	0.10	3.3
2006.6.2	Saga	Kariya Bay	A	4.8	20.3	32.7	9.1	4.79	3.10	0.08	1.61	0.11	7.3
2006.7.4	Saga	Kariya Bay	A	6.0	23.7	24.7	8.3	23.51	20.98	0.30	2.23	0.09	6.9
2006.8.2	Saga	Kariya Bay	A	8.5	29.1	28.8	8.2	7.52	7.08	0.11	0.32	0.07	2.8
2006.9.4	Saga	Kariya Bay	A	2.7	27.2	26.5	9.1	11.82	7.39	0.13	4.30	0.00	7.9
2006.10.3	Saga	Kariya Bay	A	5.2	23.0	31.2	5.7	6.81	2.26	0.34	4.21	0.12	9.2
2006.5.15	Saga	Nagoyaura	4	8.6	16.8	31.6	8.2	10.66	8.17	0.49	2.00	0.26	1.0
2006.6.1	Saga	Nagoyaura	4	6.2	19.4	33.7	9.2	5.84	1.19	0.11	4.55	0.16	1.6
2006.7.3	Saga	Nagoyaura	4	7.9	23.0	31.0	7.2	12.30	9.37	0.25	2.67	0.26	2.6
2006.8.1	Saga	Nagoyaura	4	7.5	26.7	29.0	8.4	7.01	5.94	0.17	0.90	0.11	2.9

2006.9.1	Saga	Nagoyaura	4	10.6	25.1	31.6	6.4	3.66	1.41	0.09	2.16	0.20	0.6
2006.10.2	Saga	Nagoyaura	4	6.7	23.1	31.7	6.1	5.26	3.62	0.21	1.44	0.07	5.2
2006.5.1	Saga	Sototsu	5	6.0	16.9	32.8	9.0	2.28	1.02	0.23	1.03	0.31	3.1
2006.6.1	Saga	Sototsu	5	5.5	20.8	33.4	8.6	1.54	0.49	0.08	0.97	0.11	3.7
2006.7.3	Saga	Sototsu	5	3.9	24.0	39.1	8.5	24.64	20.28	0.25	4.11	0.09	4.3
2006.8.2	Saga	Sototsu	5	6.2	28.0	31.8	9.1	3.29	2.30	0.09	0.90	0.05	2.2
2006.9.4	Saga	Sototsu	5	4.3	26.4	31.2	7.3	3.94	2.46	0.08	1.40	0.07	2.7
2006.10.3	Saga	Sototsu	5	5.1	23.3	31.0	7.1	7.05	5.61	0.22	1.22	0.18	3.6
2006.6.21	Nagasaki	Imari Bay	1	9.0	22.0	33.4	5.0	0.66	0.25	0.01	0.40	0.01	0.9
2006.6.21	Nagasaki	Imari Bay	3	5.0	23.5	32.7	5.0	0.26	0.04	0.03	0.19	0.06	1.5
2006.6.21	Nagasaki	Imari Bay	4	6.0	23.5	32.7	5.2	0.41	0.05	0.06	0.30	0.02	1.6
2006.7.18	Nagasaki	Imari Bay	1	8.0	24.1	32.7	5.2	-	-	-	-	-	2.7
2006.7.18	Nagasaki	Imari Bay	3	7.0	26.8	31.8	4.7	-	-	-	-	-	2.1
2006.7.18	Nagasaki	Imari Bay	4	7.0	25.9	32.3	4.9	-	-	-	-	-	2.3
2006.8.7	Nagasaki	Imari Bay	1	7.5	29.3	32.2	5.6	1.75	1.37	0.07	0.31	0.02	2.0
2006.8.7	Nagasaki	Imari Bay	3	7.0	30.1	31.0	5.1	0.70	0.24	0.05	0.41	0.03	0.6
2006.8.7	Nagasaki	Imari Bay	4	7.0	28.6	31.7	5.4	0.44	0.08	0.04	0.32	0.03	1.0
2006.10.18	Nagasaki	Imari Bay	1	5.0	23.5	33.1	5.0	0.96	0.23	0.06	0.67	0.07	4.8
2006.10.18	Nagasaki	Imari Bay	3	3.5	22.9	32.8	4.7	0.37	0.05	0.04	0.28	0.13	6.3
2006.10.18	Nagasaki	Imari Bay	4	4.5	22.7	32.9	4.8	0.95	0.67	0.06	0.22	0.07	4.0
2006.8.29	Nagasaki	Ohmura Bay	b	2.5	28.0	30.1	4.5	0.52	0.19	0.04	0.29	0.05	3.9
2006.8.29	Nagasaki	Ohmura Bay	c	3.0	28.5	30.0	4.2	1.65	0.17	0.07	1.41	0.04	2.7
2006.8.29	Nagasaki	Ohmura Bay	P	3.0	30.2	29.6	5.3	1.41	0.10	0.07	1.24	0.07	3.1
2006.8.29	Nagasaki	Ohmura Bay	Z	3.0	29.5	29.7	4.9	0.44	0.04	0.07	0.33	0.12	3.0
2006.9.20	Nagasaki	Ohmura Bay	b	3.5	25.6	29.5	5.0	4.65	3.98	0.34	0.33	0.07	18.7
2006.9.20	Nagasaki	Ohmura Bay	c	3.5	26.5	31.0	5.0	0.73	0.23	0.05	0.45	0.06	3.7
2006.9.20	Nagasaki	Ohmura Bay	P	5.0	26.5	31.6	4.5	0.99	0.39	0.12	0.48	0.17	3.9
2006.9.20	Nagasaki	Ohmura Bay	Z	4.5	26.5	31.6	4.6	1.24	0.42	0.24	0.58	0.22	9.5

Note:
1*: The values of Fukuoka Prefecture are the average of 6 monitoring stations.
2*: The nutrient concentration units of Saga Prefecture are in μg/L.

Source:
Fukuoka Fisheries and Marine Technology Research Center (2007)
Nagasaki Prefectural Institute of Fisheries (2007)
Saga Prefectural Genkai Fisheries Promotion Center (2007)

5.5.2 Environmental conditions during regular toxin-producing plankton monitoring

Table 5.10 shows the water-quality values obtained during the regular toxin-producing plankton monitoring in the target sea area in 2006.

Table 5.10 Water-quality values obtained during the regular toxin-producing plankton monitoring in the target sea area in 2006 (Water depth: 0 m)

Monitoringdate	Organiz-atoin	Spot	Survey point	Trans parency (m)	SST (C°)	Salinity	DO (mg/L)	DIN (μM)	NO3-N (μM)	NO2-N (μM)	NH4-N (μM)	PO4-P (μM)	Chl.a (μg/L)
2006.10.26	Yamaguchi	Sensaki Bay	1	-	20.5	32.8	-	-	-	-	-	-	-
2006.11.6	Yamaguchi	Sensaki Bay	1	-	20.0	32.6	-	-	-	-	-	-	-
2006.11.13	Yamaguchi	Sensaki Bay	1	-	17.9	31.1	-	-	-	-	-	-	-
2006.11.27	Yamaguchi	Sensaki Bay	1	-	17.2	32.8	-	-	-	-	-	-	-
2006.11.30	Yamaguchi	Sensaki Bay	1	-	17.4	33.1	-	-	-	-	-	-	-
2006.12.6	Yamaguchi	Sensaki Bay	1	-	15.0	33.2	-	-	-	-	-	-	-
2006.12.15	Yamaguchi	Sensaki Bay	1	-	15.3	33.3	-	-	-	-	-	-	-
2006.12.22	Yamaguchi	Sensaki Bay	1	-	14.8	33.5	-	-	-	-	-	-	-
2007.1.5	Yamaguchi	Sensaki Bay	1	-	13.5	33.9	-	-	-	-	-	-	-
2007.1.12	Yamaguchi	Sensaki Bay	1	-	13.3	33.8	-	-	-	-	-	-	-
2007.1.17	Yamaguchi	Sensaki Bay	1	-	13.3	33.9	-	-	-	-	-	-	-
2007.1.24	Yamaguchi	Sensaki Bay	1	-	13.6	34.3	-	-	-	-	-	-	-
2007.1.31	Yamaguchi	Sensaki Bay	1	-	9.1	28.9	-	-	-	-	-	-	-
2007.2.7	Yamaguchi	Sensaki Bay	1	-	12.5	33.6	-	-	-	-	-	-	-
2007.2.19	Yamaguchi	Sensaki Bay	1	-	13.3	34.1	-	-	-	-	-	-	-
2007.2.26	Yamaguchi	Sensaki Bay	1	-	12.5	33.7	-	-	-	-	-	-	-
2006.10.26	Yamaguchi	Sensaki Bay	2	-	21.1	33.1	-	-	-	-	-	-	-
2006.11.6	Yamaguchi	Sensaki Bay	2	-	20.0	32.7	-	-	-	-	-	-	-
2006.11.13	Yamaguchi	Sensaki Bay	2	-	18.9	33.2	-	-	-	-	-	-	-
2006.11.27	Yamaguchi	Sensaki Bay	2	-	17.8	33.1	-	-	-	-	-	-	-
2006.11.30	Yamaguchi	Sensaki Bay	2	-	16.8	32.8	-	-	-	-	-	-	-
2006.12.6	Yamaguchi	Sensaki Bay	2	-	15.0	33.2	-	-	-	-	-	-	-
2006.12.15	Yamaguchi	Sensaki Bay	2	-	15.2	32.9	-	-	-	-	-	-	-
2006.12.22	Yamaguchi	Sensaki Bay	2	-	14.4	33.4	-	-	-	-	-	-	-
2007.1.5	Yamaguchi	Sensaki Bay	2	-	13.9	33.9	-	-	-	-	-	-	-
2007.1.12	Yamaguchi	Sensaki Bay	2	-	13.2	33.9	-	-	-	-	-	-	-
2007.1.17	Yamaguchi	Sensaki Bay	2	-	13.4	33.9	-	-	-	-	-	-	-
2007.1.24	Yamaguchi	Sensaki Bay	2	-	13.0	34.1	-	-	-	-	-	-	-
2007.1.31	Yamaguchi	Sensaki Bay	2	-	12.5	34.1	-	-	-	-	-	-	-
2007.2.7	Yamaguchi	Sensaki Bay	2	-	12.9	34.2	-	-	-	-	-	-	-

2007.2.19	Yamaguchi	Sensaki Bay	2	-	13.2	34.0	-	-	-	-	-	-	-
2007.2.26	Yamaguchi	Sensaki Bay	2	-	13.3	34.2	-	-	-	-	-	-	-
2006.4.11	Fukuoka	Fukuoka Bay	1	-	14.4	33.0	-	-	-	-	-	-	-
2006.5.17	Fukuoka	Fukuoka Bay	1	-	18.0	30.3	-	-	-	-	-	-	-
2006.6.7	Fukuoka	Fukuoka Bay	1	-	21.9	32.3	-	-	-	-	-	-	-
2006.7.11	Fukuoka	Fukuoka Bay	1	-	24.1	32.5	-	-	-	-	-	-	-
2006.8.10	Fukuoka	Fukuoka Bay	1	-	30.6	30.4	-	-	-	-	-	-	-
2006.9.14	Fukuoka	Fukuoka Bay	1	-	24.0	28.6	-	-	-	-	-	-	-
2006.10.12	Fukuoka	Fukuoka Bay	1	-	23.2	32.0	-	-	-	-	-	-	-
2006.11.15	Fukuoka	Fukuoka Bay	1	-	17.4	32.8	-	-	-	-	-	-	-
2006.12.12	Fukuoka	Fukuoka Bay	1	-	13.8	32.3	-	-	-	-	-	-	-
2007.1.10	Fukuoka	Fukuoka Bay	1	-	10.2	33.6	-	-	-	-	-	-	-
2007.2.9	Fukuoka	Fukuoka Bay	1	-	11.7	33.7	-	-	-	-	-	-	-
2007.3.8	Fukuoka	Fukuoka Bay	1	-	11.3	33.8	-	-	-	-	-	-	-
2006.4.11	Saga	Karatsu Bay	1	7.9	14.1	32.6	8.2	1.20	0.60	0.20	0.49	0.04	-
2006.5.2	Saga	Karatsu Bay	1	7.8	15.7	33.0	8.0	1.99	0.60	0.37	1.02	0.13	-
2006.7.3	Saga	Karatsu Bay	1	4.0	23.1	32.0	7.9	2.10	0.37	0.11	1.62	0.08	3.7
2006.8.2	Saga	Karatsu Bay	1	8.0	27.2	32.4	8.5	3.40	1.29	0.07	2.04	0.03	0.7
2006.9.4	Saga	Karatsu Bay	1	5.0	27.2	29.4	8.3	1.07	0.27	0.05	0.76	0.09	12.6
2006.11.2	Saga	Karatsu Bay	1	5.0	21.4	33.3	7.7	3.41	1.15	0.02	2.25	0.03	1.9
2006.12.1	Saga	Karatsu Bay	1	3.0	17.2	33.5	7.1	11.97	5.90	1.78	4.31	0.56	1.3
2007.1.8	Saga	Karatsu Bay	1	3.0	13.1	33.8	8.5	7.01	4.14	1.23	1.05	0.28	1.0
2007.2.2	Saga	Karatsu Bay	1	8.5	12.2	32.1	7.9	3.25	1.10	0.79	1.36	0.13	0.6
2007.3.2	Saga	Karatsu Bay	1	3.0	12.5	33.6	8.6	4.01	1.63	0.68	1.71	0.20	1.2
2006.10.2	Saga	Nagoyaura	2	8.7	23.1	31.7	8.1	5.26	3.62	0.21	1.44	0.07	5.2
2006.11.1	Saga	Nagoyaura	2	4.8	21.8	32.3	8.5	2.51	0.83	0.37	1.31	0.11	3.1
2006.12.4	Saga	Nagoyaura	2	8.5	18.0	32.7	8.1	6.72	2.70	1.38	2.80	0.30	1.0
2007.1.4	Saga	Nagoyaura	2	7.5	15.6	33.1	7.1	4.85	1.86	0.88	1.91	0.29	0.7
2007.3.1	Saga	Nagoyaura	2	7.8	13.9	32.8	8.1	3.92	1.78	0.55	1.58	0.14	0.7
2006.10.2	Saga	Kushiura	3	4.5	22.9	31.5	8.0	5.33	2.07	0.32	2.04	0.20	1.2
2006.11.1	Saga	Kushiura	3	4.0	21.8	32.2	8.4	9.59	3.28	0.72	5.61	0.20	1.3
2006.12.4	Saga	Kushiura	3	5.7	17.8	32.9	8.4	5.17	2.58	1.47	1.14	0.32	1.6
2007.1.4	Saga	Kushiura	3	5.7	15.7	33.3	7.1	9.99	3.33	1.19	6.47	0.30	0.6
2007.2.1	Saga	Kushiura	3	5.4	13.3	33.1	7.2	6.84	2.33	1.12	3.18	0.30	0.5
2007.3.1	Saga	Kushiura	3	6.6	13.9	33.1	8.2	8.70	3.17	0.51	5.02	0.64	0.6
2006.10.3	Saga	Karitya Bay	4	4.3	22.6	29.9	7.3	-	-	-	-	-	-
2006.11.2	Saga	Karitya Bay	4	5.2	20.8	30.9	7.2	9.41	6.71	0.15	2.56	3.78	3.8
2006.12.5	Saga	Karitya Bay	4	7.1	16.4	32.0	7.4	-	-	-	-	-	-
2007.1.5	Saga	Karitya Bay	4	7.5	13.4	32.3	7.5	10.82	6.15	2.39	2.28	0.87	0.9
2007.2.2	Saga	Karitya Bay	4	8.0	12.1	32.6	7.7	4.81	2.20	1.00	1.61	1.78	1.8
2007.3.2	Saga	Karitya Bay	4	8.7	14.1	32.5	8.2	2.30	1.50	0.43	0.37	0.95	1.0
2006.10.2	Saga	Imari Bay	5	4.7	23.4	30.0	8.3	2.82	1.79	0.09	0.94	0.19	6.0
2006.11.1	Saga	Imari Bay	5	3.8	21.3	31.5	8.1	1.74	0.49	0.03	1.22	0.17	4.2
2006.12.4	Saga	Imari Bay	5	6.8	14.4	31.9	8.9	8.79	2.33	0.49	3.97	0.37	2.2
2007.1.4	Saga	Imari Bay	5	7.5	11.6	31.4	8.6	1.60	0.15	0.87	0.79	0.13	0.8

2007.2.1	Saga	Imari Bay	5	8.5	11.8	32.5	7.7	4.57	1.68	0.81	2.08	0.17	1.3
2007.3.1	Saga	Imari Bay	5	11.6	12.8	32.5	8.3	2.86	0.93	0.37	1.68	0.14	0.5
2007.1.4	Saga	Imari Bay	6	9.0	15.4	32.8	7.6	-	-	-	-	-	-
2007.2.1	Saga	Imari Bay	6	8.9	13.3	32.8	7.4	-	-	-	-	-	-
2007.3.1	Saga	Imari Bay	6	11.0	13.6	32.9	8.1	-	-	-	-	-	-
2006.4.13	Nagasaki	Tsushima	Terashima	9.2<	14.7	34.6	-	-	-	-	-	-	-
2006.5.16	Nagasaki	Tsushima	Terashima	8.0	16.5	34.7	-	-	-	-	-	-	-
2006.6.19	Nagasaki	Tsushima	Terashima	5.0	20.6	34.0	-	-	-	-	-	-	-
2006.7.12	Nagasaki	Tsushima	Terashima	2.5	22.5	31.7	-	-	-	-	-	-	-
2006.8.22	Nagasaki	Tsushima	Terashima	4.0	27.2	32.0	-	-	-	-	-	-	-
2006.9.19	Nagasaki	Tsushima	Terashima	4.0	24.3	31.5	-	-	-	-	-	-	-
2006.10.10	Nagasaki	Tsushima	Terashima	5.5	22.8	34.5	-	-	-	-	-	-	-
2006.11.13	Nagasaki	Tsushima	Terashima	8.0	20.1	35.2	-	-	-	-	-	-	-
2006.12.6	Nagasaki	Tsushima	Terashima	10.1	17.7	35.6	-	-	-	-	-	-	-
2007.1.15	Nagasaki	Tsushima	Terashima	9.0	15.5	35.8	-	-	-	-	-	-	-
2007.2.13	Nagasaki	Tsushima	Terashima	9.9<	14.6	34.3	-	-	-	-	-	-	-
2007.3.12	Nagasaki	Tsushima	Terashima	9.4<	13.9	34.3	-	-	-	-	-	-	-
2006.4.17	Nagasaki	Tsushima	Hetajima	9.5	14.6	34.3	-	-	-	-	-	-	-
2006.5.16	Nagasaki	Tsushima	Hetajima	7.0	16.6	34.8	-	-	-	-	-	-	-
2006.6.19	Nagasaki	Tsushima	Hetajima	10.0	20.9	33.6	-	-	-	-	-	-	-
2006.7.12	Nagasaki	Tsushima	Hetajima	2.5	22.2	31.1	-	-	-	-	-	-	-
2006.8.22	Nagasaki	Tsushima	Hetajima	8.0	26.6	31.5	-	-	-	-	-	-	-
2006.9.19	Nagasaki	Tsushima	Hetajima	1.3	24.9	31.2	-	-	-	-	-	-	-
2006.10.10	Nagasaki	Tsushima	Hetajima	9.0	23.1	34.5	-	-	-	-	-	-	-
2006.11.13	Nagasaki	Tsushima	Hetajima	11.0	20.9	35.1	-	-	-	-	-	-	-
2006.12.6	Nagasaki	Tsushima	Hetajima	19.0	18.9	35.5	-	-	-	-	-	-	-
2007.1.18	Nagasaki	Tsushima	Hetajima	12.0	16.0	35.7	-	-	-	-	-	-	-
2007.2.19	Nagasaki	Tsushima	Hetajima	11.5	15.3	34.2	-	-	-	-	-	-	-
2007.3.12	Nagasaki	Tsushima	Hetajima	5.0	14.7	34.3	-	-	-	-	-	-	-
2006.4.18	Nagasaki	Tachibana Bay	South Kushiyama	11.0	16.2	33.6	-	-	-	-	-	-	-
2006.5.8	Nagasaki	Tachibana Bay	South Kushiyama	12.0	17.9	33.4	-	-	-	-	-	-	-
2006.6.6	Nagasaki	Tachibana Bay	South Kushiyama	11.0	20.9	33.0	-	-	-	-	-	-	-
2006.7.12	Nagasaki	Tachibana Bay	South Kushiyama	9.0	24.5	31.1	-	-	-	-	-	-	-
2006.8.16	Nagasaki	Tachibana Bay	South Kushiyama	8.0	29.2	30.6	-	-	-	-	-	-	-
2006.9.13	Nagasaki	Tachibana Bay	South Kushiyama	7.0	24.8	33.0	-	-	-	-	-	-	-
2006.10.18	Nagasaki	Tachibana Bay	South Kushiyama	11.0	23.3	33.2	-	-	-	-	-	-	-
2006.11.22	Nagasaki	Tachibana Bay	South Kushiyama	6.0	20.0	33.6	-	-	-	-	-	-	-
2006.12.13	Nagasaki	Tachibana Bay	South Kushiyama	9.0	17.7	34.4	-	-	-	-	-	-	-
2007.1.24	Nagasaki	Tachibana Bay	South Kushiyama	11.0	13.6	34.7	-	-	-	-	-	-	-
2007.2.21	Nagasaki	Tachibana Bay	South Kushiyama	10.0	13.5	34.8	-	-	-	-	-	-	-
2007.3.9	Nagasaki	Tachibana Bay	South Kushiyama	10.0	13.4	34.9	-	-	-	-	-	-	-

Note: The nutrient concentration units of Saga Prefecture are in μg/L.

Source:
Fukuoka Fisheries and Marine Technology Research Center (2007)
Nagasaki Prefectural Institute of Fisheries (2007)
Saga Prefectural Genkai Fisheries Promotion Center (2007)

5.6 Meteorological conditions during regular red-tide monitoring

The reports of the monitoring organizations of Saga and Nagasaki Prefectures provide information on the meteorological conditions observed during the regular red-tide monitoring. Table 5.11 shows the meteorological conditions observed during the regular red-tide monitoring in the target sea area in 2006.

Table 5.11 Meteorological conditions observed during the regular red-tide monitoring in the target sea area (2006)

Monitoring date	Organi-zation	Spot	Survey point	Observation time	Weather	Cloud cover	Wind direction	Wind speed (Beaufort scale)
2006.5.1	Saga	Imari Bay	1	9:45	Cloudy	10	SW	1
2006.5.1	Saga	Imari Bay	2	9:55	Cloudy	10	SW	1
2006.5.1	Saga	Imari Bay	3	10:10	Cloudy	10	SW	3
2006.6.1	Saga	Imari Bay	1	9:41	Cloudy	10	N	1
2006.6.1	Saga	Imari Bay	2	9:55	Cloudy	10	N	1
2006.6.1	Saga	Imari Bay	3	10:11	Cloudy	10	N	1
2006.7.3	Saga	Imari Bay	1	9:25	Rainy	10	SW	1
2006.7.3	Saga	Imari Bay	2	9:36	Rainy	10	SW	1
2006.7.3	Saga	Imari Bay	3	9:49	Cloudy	10	NW	1
2006.8.1	Saga	Imari Bay	1	9:10	Sunny	1	NW	1
2006.8.1	Saga	Imari Bay	2	9:25	Sunny	1	N	1
2006.8.1	Saga	Imari Bay	3	9:37	Sunny	1	N	1
2006.9.1	Saga	Imari Bay	1	9:20	Cloudy	8	NE	1
2006.9.1	Saga	Imari Bay	2	9:35	Cloudy	10	NE	2
2006.9.1	Saga	Imari Bay	3	9:46	Cloudy	10	NE	2
2006.10.2	Saga	Imari Bay	1	9:12	Sunny	7	N	2
2006.10.2	Saga	Imari Bay	2	9:23	Sunny	5	N	1
2006.10.2	Saga	Imari Bay	3	9:35	Sunny	5	N	2
2006.5.8	Saga	Kariya Bay	A	10:14	Cloudy	10	NE	1
2006.6.2	Saga	Kariya Bay	A	10:18	Cloudy	10	E	2
2006.7.4	Saga	Kariya Bay	A	10:03	Cloudy	10	S	1
2006.8.2	Saga	Kariya Bay	A	10:10	Sunny	8	NW	1
2006.9.4	Saga	Kariya Bay	A	10:11	Sunny	4	NE	1
2006.10.3	Saga	Kariya Bay	A	9:58	Sunny	3	NE	2
2006.5.15	Saga	Nagoyaura	4	11:20	Cloudy	10	SW	1
2006.6.1	Saga	Nagoyaura	4	11:50	Cloudy	10	NE	1
2006.7.3	Saga	Nagoyaura	4	11:30	Cloudy	10	NE	1
2006.8.1	Saga	Nagoyaura	4	11:05	Sunny	1	N	1
2006.9.1	Saga	Nagoyaura	4	11:07	Sunny	7	N	1
2006.10.2	Saga	Nagoyaura	4	11:04	Sunny	2	NE	1
2006.5.1	Saga	Sototsu	5	11:40	Cloudy	10	SW	2
2006.6.1	Saga	Sototsu	5	11:11	Cloudy	10	NW	1
2006.7.3	Saga	Sototsu	5	11:01	Cloudy	10	NE	1
2006.8.2	Saga	Sototsu	5	10:42	Sunny	8	NW	1
2006.9.4	Saga	Sototsu	5	10:38	Sunny	7	N	1
2006.10.3	Saga	Sototsu	5	10:53	Sunny	4	NE	2
2006.6.21	Nagasaki	Imari Bay	1	8:31	Cloudy	10	SW	4
2006.6.21	Nagasaki	Imari Bay	3	10:56	Sunny	7	W	4
2006.6.21	Nagasaki	Imari Bay	4	11:04	Sunny	6	SW	3
2006.7.18	Nagasaki	Imari Bay	1	11:57	Cloudy	10	SW	3
2006.7.18	Nagasaki	Imari Bay	3	13:22	Cloudy	10	SW	5
2006.7.18	Nagasaki	Imari Bay	4	13:04	Cloudy	10	SW	4
2006.8.7	Nagasaki	Imari Bay	1	13:42	Sunny	2	N	5
2006.8.7	Nagasaki	Imari Bay	3	16:39	Sunny	3	NW	4

2006.8.7	Nagasaki	Imari Bay	4	16:53	Sunny	3	N	6
2006.10.18	Nagasaki	Imari Bay	1	11:32	Sunny	5	NE	2
2006.10.18	Nagasaki	Imari Bay	3	14:54	Sunny	5	NW	5
2006.10.18	Nagasaki	Imari Bay	4	15:08	Sunny	5	N	5
2006.8.29	Nagasaki	Ohmura Bay	b	9:47	Cloudy	10	SW	2
2006.8.29	Nagasaki	Ohmura Bay	c	10:45	Sunny	7	NE	2
2006.8.29	Nagasaki	Ohmura Bay	P	12:30	Sunny	7	SW	6
2006.8.29	Nagasaki	Ohmura Bay	Z	13:36	Cloudy	8	E	1
2006.9.20	Nagasaki	Ohmura Bay	b	10:26	Sunny	1	-	-
2006.9.20	Nagasaki	Ohmura Bay	c	10:51	Sunny	1	-	-
2006.9.20	Nagasaki	Ohmura Bay	P	11:32	Sunny	2	-	-
2006.9.20	Nagasaki	Ohmura Bay	Z	12:05	Sunny	2	-	-

Source:
Fukuoka Fisheries and Marine Technology Research Center (2007)
Nagasaki Prefectural Institute of Fisheries (2007)
Saga Prefectural Genkai Fisheries Promotion Center (2007)
Yamaguchi Prefectural Fisheries Research Center (2007)

6 Monitoring with satellite remote sensing images

6.1 Utilization status of satellite remote sensing chlorophyll images in local fisheries agencies

Since 2004, Yamaguchi Prefecture Fisheries Research Center has been developing red-tide monitoring methods by using satellite chlorophyll-a images (Yamaguchi Prefecture, 2007).

Distribution of chlorophyll-a concentration in the coastal area of Yamaguchi Prefecture before and during a *Karenia mikimotoi* bloom in August 2006 was estimated from satellite remote sensing images (Fig. 6.1). Areas of high chlorophyll-a concentration were observed on the coast of Hohoku Town and along the coast between Hagi City and Abu Town by satellite, and red-tide warnings were announced during the above *Karenia mikimotoi* bloom. These satellite chlorophyll images used in the above analysis were obtained from the website of JAXA's Earth Observation Research Center (EORC).

Satellite chlorophyll-a images were also used to understand the movement of red tide. Miyahara et al. (2005) reported that the movement of *Cochlodinium polykrikoides* bloom from Korean Peninsula was traced by referring to the satellite images of chlorophyll-a concentration observed by MODIS, and the existence of *C. polykrikoides* was confirmed by a field survey. In this way, local fisheries agencies have been using satellite chlorophyll images to determine monitoring sites based on the movement of high chlorophyll-a patches. This utilization is useful for mitigation of red tide and announcement of warning.

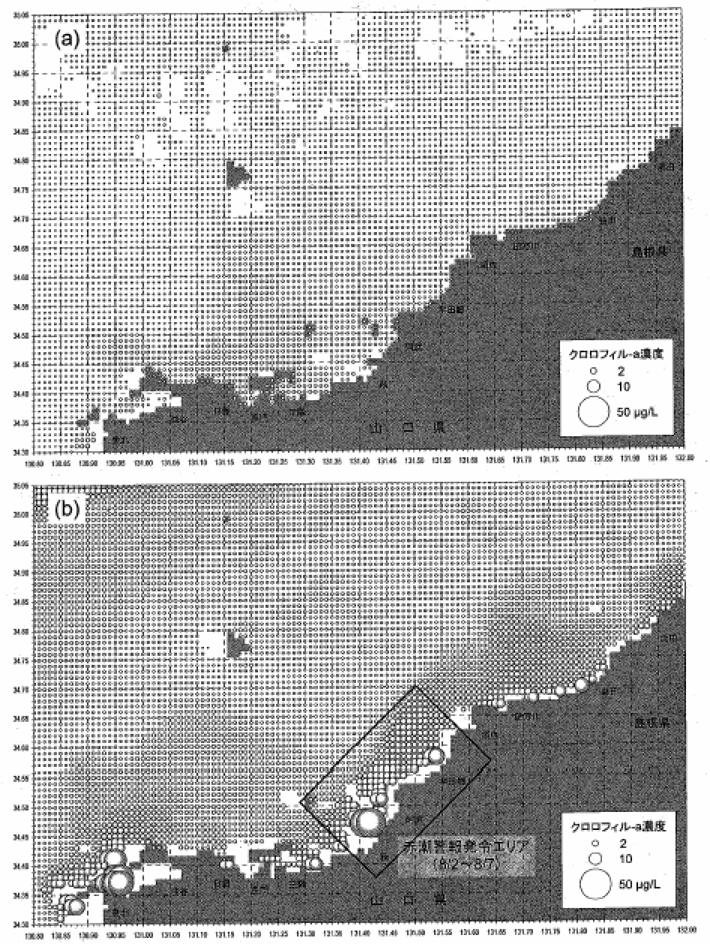


Figure 6.1 Distribution of chlorophyll-a concentration in the coastal area of Yamaguchi Prefecture before and during a *Karenia mikimotoi* bloom in August 2006 (estimated from satellite remote sensing images)

Source: Yamaguchi Prefectural Fisheries Research Center (2007)

6.2 Utilization status of satellite remote sensing chlorophyll images in local fisheries agencies

Two organizations provide satellite chlorophyll data in the northwest sea area in Kyushu region. The information of those provided data is shown in Table 6.1.

Table 6.1 Information of provided data by Marine Environmental Watch website and MODIS Near Real Time Database website

Data source	Management	Provided sea area	Resolution	Sensor	Satellite
Marine Environmental Watch	Ministry of the Environment/ Northwest Pacific Region Environmental Cooperation Center (NPEC)	32.4-35N 128.5-131.5W	1Km (Image and binary data)	MODIS	Aqua and Terra
MODIS Near Real Time Database	Japan Aerospace Exploration Agency (JAXA)	32-34.75N 128.5-131W	1km (Image and Binary data)/ 500m (image)	MODIS	Aqua and Terra

Most of red tide occurred in the northwest sea area in Kyushu region. They are usually observed near the coast in inner part of bay and their scales are very often very small (10-100 m^2). It is difficult to pinpoint the location by using upper resolution of satellite. However, satellite images can detect high chlorophyll-a concentration around red tide area when red tide occurred in comparatively wide scale.

Figure 6.2 shows the location of red tide in Fukuoka Bay during 11-31 July 2006 and Figure 6.3 shows the satellite chlorophyll image on 26 July 2006. In the right image, high chlorophyll concentration patch is detected in Fukuoka Bay where red tide was observed by fisheries agency. Additionally, distribution of high chlorophyll water mass from Fukuoka Bay is shown in these satellite images.

Satellite images are useful tool to understand the distribution of high chlorophyll concentration and that’s movement.

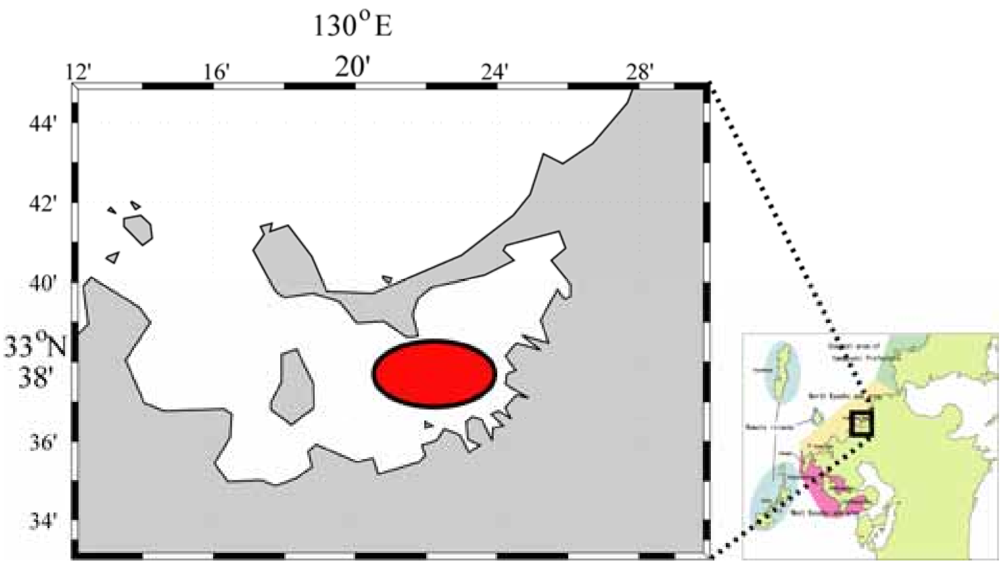


Figure 6.2 Location of red tide which occurred in Fukuoka Bay during 11-31 July 2006. Red circle indicates area where water discoloration was observed by fisheries agencies.

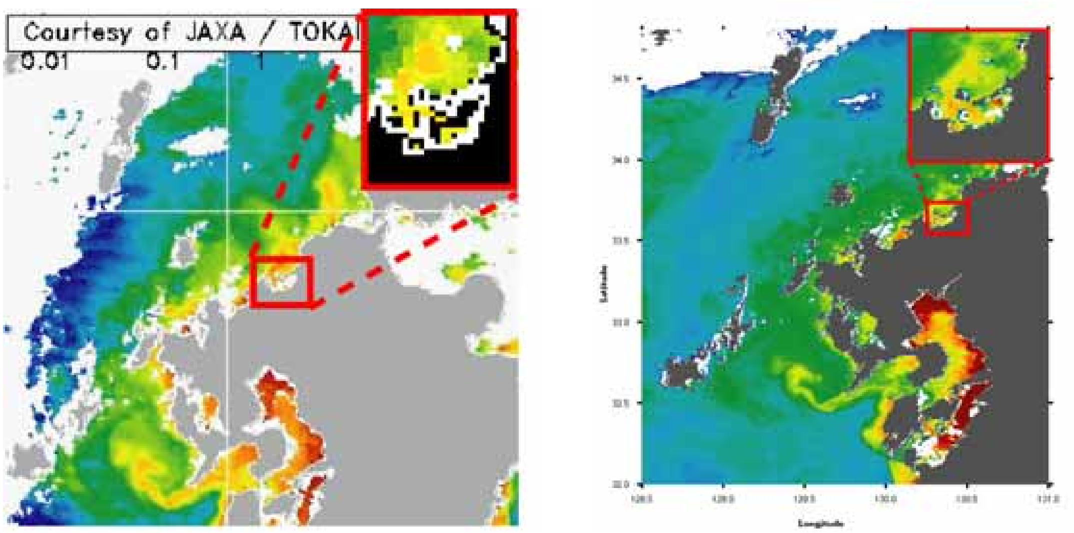


Figure 6.3 Satellite chlorophyll images (MODIS/Terra) on 26 July 2006. Left image is provided by Marine Environmental Watch (Resolution: 1km). Right image is provided by MODIS Near Real Time Database (Resolution: 500m). Picture in red square indicates enlarged image of Fukuoka Bay.

7 Conclusion

7.1 Status of recent HAB events in the target sea area

During the recent years, there have been no major variations in the number of red-tide events in the target sea area, with around 50 red-tide events occurring each year. Fishery damages by red-tide events have also occurred every year.

Since monitoring started in 1979, around four (20 events/5 year) *Karenia mikimotoi* blooms have been recorded every year, and is still one of the major species that cause fishery damage. Apart from *Karenia mikimotoi*, blooms of *Cochlodinium polykrikoides*, *Heterocapsa circularisquama*, *Chattonella antique*, *Chattonella marina* and *Heterosigma akashiwo* have also been occurring continuously. Within these species, *Cochlodinium polykrikoides* is considered as a high priority species in the NOWPAP region; and websites and pamphlets have been developed specifically for this species. *Cochlodinium polykrikoides* does not only bloom and remain in the coastal area but is reported to transport to other regions with the ocean currents (NOWPAP CEARAC, 2005). It is therefore necessary to continue the observations on *Cochlodinium polykrikoides*.

During 1978-1999, shipment of shellfish has been stopped 10 times due to contamination by toxin-producing planktons; shipment was stopped once in 2006. Although shipment stoppage in the target sea area is less frequent than it is in the Hokkaido and Tohoku regions, toxin-producing planktons are still recorded every year in the target sea area. Prior to the 1980's, shellfish contamination was not a common event in the target sea area; however, despite yearly variations, shipment stoppage has become more frequent since the 1980's. Therefore it is necessary to continue with the information collection activities on shellfish contamination and the causative toxin-producing planktons.

Monitoring organizations of each prefecture monitor planktons that cause significant fishery damage such as *Karenia mikimotoi*, *Cochlodinium polykrikoides*, *Heterosigma akashiwo*, *Chattonella antique*, *Chattonella marina* and *Heterocapsa circularisquamai*, and notify the local fishermen when the cell concentration of these species exceeds the set warning/action standards. PSP- and DSP-inducing speceis (*Dinophysis* spp., *Alexandrium* spp., and *Gymnodinium catenatum*) are also monitored regularly. These species should also be considered as high priority species as in the case with *Cochlodinium polykrikoides*, and information should be collected and shared among the NOWPAP members.

7.2 Environmental conditions during HAB events

During post red-tide survey, SST, salinity and DO are measured to understand the environmental conditions during red-tide events. Regular red-tide monitoring is also conducted in addition to the post red-tide monitoring. During regular red-tide monitoring, red-tide related environmental parameters such as nutrients and chlorophyll-a are also measured in addition to SST, salinity and DO. However, the reports of the monitoring organizations have not made any detailed analysis on the relationship between red-tide events and the measured environmental conditions.

Data on HABs in the target sea area will be collected continuously through the HAB case study and are planned to be presented in an integrated manner. The collected and integrated data should hopefully then be useful for the understanding of HAB mechanisms in the target sea area. For future activities, it is necessary to collect and share information (e.g. scientific literatures) that investigates the relationship between HAB events and environmental conditions.

7.3 Red tide monitoring with satellite remote sensing images

Satellite images can provide extensive sea surface information. In recent years, resolution of satellite images has become higher. For example JAXA has provided MODIS 500m resolution images since April 2006. However, most of red tide events in Japan are 10- 100m scale, and it is difficult to identify small red tide events only with satellite Images yet. On the other hand, in case of red tide in large scale, satellite remote sensing is one of the useful tools. Ishizaka et al. (2006) reported the availability of satellite chlorophyll image for detection of large red tide in Ariake Bay. They mentioned that the algorithms require improvement to accurately estimate chlorophyll in highly turbid water and in red tide areas.

Since 2006, some high resolution satellite images in this region have been available. NASA (MODIS Rapid Response System: http://rapidfire.sci.gsfc.nasa.gov/subsets/) has provided daily true color satellite images with 250m resolution since 7 September 2006. These images cover East China Sea and are available for free of charge.

JAXA provides the satellite images of ALOS which have a spatial resolution of 10 m, starting 24 January 2006 (http://www.eorc.jaxa.jp/about/distribution/index.html). Resolution of 10 m enables detection of small red tides. Some red tide events observed by ALOS are introduced in the website of EORC, JAXA. For example, red tide of *Prorocentrum minimum* in Tokyo Bay on 1 June 2006 and red tide of *Noctiluca scintillans* in Kagoshima Bay on 7 April 2006, red tide of *Gephyrocapsa oceanica* in Hakata Bay on 20 April 2007 etc. were shown with vivid clarity by ALOS image (http://www.eorc.jaxa.jp/ALOS/img_up/ex_akashio2006/jakashio_01.htm, http://www.eorc.jaxa.jp/ALOS/img_up/jav2_070515.htm).

High resolution satellite images are very useful for monitoring red tide. In near future, ALOS will be a very effective tool for red tide detection.

7.4 Information sharing among the NOWPAP members

The target sea area is located close to the HAB hot spots of East China Sea and southern coast of Korea. Recent HAB events in the target sea area are known to be partly triggered by the transboundary transport of HAB species from the above mentioned HAB hot spots. Therefore, in order to advance measures against HABs in the target sea area, it is necessary to understand the status of HAB events in the other sea areas of the NOWPAP region. Finally, it is hoped that information sharing of HAB events will be promoted through the HAB case studies, and consequently lead to the reduction of HAB events in not only the target sea area, but the whole NOWPAP region as well.

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Annex1 Proposed format for recording of HAB events

Event No.			Duration(Start)			Duration(End)			Continuous days	Locatio of occurrence		Causative species	Maximum density (cells・inds./mL)	Fishery damage			Environmental parameters			Size of bloom (km^2)
Pref. Code	Year	No.	Year	Month	day	Year	Month	day		Region	Spot			Fish/Shellfish species	Quantity	Economic loss (1,000 yen)	Temp. (℃)	Salinity	DO (mg/L)	
YM	2006	1	2006	2	20	2006	2	27	8	Coastal area of Yamaguchi	Between Aburaya Bay and coastline of Yoshibo	Noctiluca scintillans	2,150				10.0	-	-	-
YM	2006	2	2006	2	25	2006	2	28	4	Coastal area of Yamaguchi	Coastline of Nagato City(Sensaki Bay, Fukagawa Bay)	Noctiluca sp.	?				-	-	-	-
YM	2006	3	2006	3	27	2006	3	29	3	Coastal area of Yamaguchi	Coastline of Nagato City(Sensaki Bay)	Noctiluca sp.	?				-	-	-	0.3
YM	2006	4	2006	7	13	2006	8	4	23	Coastal area of Yamaguchi	Coastline of Shimonoseki City	Karenia mikimotoi	57,500	**Amberjack etc.**	Amberjack 370 ind.	1,800	25.4	-	-	50.0
YM	2006	5	2006	8	2	2006	8	11	10	Coastal area of Yamaguchi	Between Hagi City and Abu Town	Karenia mikimotoi	4,900	**Kingfish**	Kingfish 60 ind.	120	28.2	-	-	-
YM	2006	6	2006	10	16	2006	10	19	4	Coastal area of Yamaguchi	Nowase fishing port	Mesodinium rubrum	68				23.0	-	-	0.0001
FO	2006	1	2006	6	5	2006	6	12	8	North Kyushu	West region of Chikuzen Sea	Noctiluca scintillans	200				?	?	?	?
FO	2006	2	2006	6	21	2006	6	27	7	North Kyushu	Fukuoka Bay	Prorocentrum triestinum	10,060				?	?	?	?
FO	2006	3	2006	6	29	2006	?	?	?	North Kyushu	Fukuoka Bay	Skeletonema sp. Leptocylindrus sp. Chaetoceros sp. other Diatom Prorocentrum triestinum	25240 11800 1710 740 14090				?	?	?	?
FO	2006	4	2006	7	11	2006	7	31	21	North Kyushu	Fukuoka Bay	Skeletonema sp. Chaetoceros sp. other Diatom	47110 2020 1200				?	?	?	?
FO	2006	5	2006	7	18	2006	7	26	9	North Kyushu	Kanmon	Karenia mikimotoi	43,100	**Damaged(The details were not known.)**			?	?	?	?
SA	2006	1	2006	7	20	2006	7	22	3	North Kyushu	Imari Bay	Ceratium furca	340				-	-	-	-
SA	2006	2	2006	7	20	2006	7	23	4	North Kyushu	Karatsu Bay	Mesodinium rubrum	1,180				-	-	-	-
SA	2006	3	2006	7	26	2006	7	30	5	North Kyushu	Imari Bay	Nitzschia sp. Thalassiosira sp.	13900 5940				-	-	-	-
SA	2006	4	2006	7	27	2006	7	30	4	North Kyushu	Kariya Bay	Skeletonema costatum	11,140				-	-	-	-
SA	2006	5	2006	8	21	2006	8	25	5	North Kyushu	Imari Bay	Thalassiosira sp. Skeletonema costatum	2520 1400				-	-	-	-
SA	2006	6	2006	8	22	2006	8	23	2	North Kyushu	Karatsu Bay	Thalassiosira sp.	2,022				-	-	-	-
SA	2006	7	2006	11	20	2006	11	22	3	North Kyushu	Imari Bay	Prorocentrum triestinum	7,240				-	-	-	-
SA	2006	8	2006	11	27	2006	11	28	2	North Kyushu	Imari Bay	Prorocentrum triestinum	2,940				-	-	-	-
NS	2006	1	2006	2	24	2006	3	15	20	West Kyushu	Ohmura Bay	Cryptophyceae	148,000				12.7	27.4	14.5	-
NS	2006	3	2006	5	1	2006	5	2	2	West Kyushu	Kujuku island	Strombidium sp.	55				17.7	33.8	8.6	0.00005
NS	2006	4	2006	5	15	2006	5	26	12	Remote Is.	Goto	Heterosigma akashiwo	11,800				19.5	27.0	9.5	0.005
NS	2006	5	2006	5	16	2006	6	29	45	West Kyushu	Ohmura Bay	Heterosigma akashiwo	225,000				-	-	-	-
NS	2006	7	2006	6	1	2006	6	3	3	West Kyushu	Kujuku island	Prorocentrum sp.	3,400				-	-	-	0.0001
NS	2006	8	2006	7	3	2006	7	14	12	West Kyushu	Ohmura Bay	Karenia mikimotoi	15,800				-	-	-	-
NS	2006	9	2006	7	4	2006	7	12	9	West Kyushu	Tachibana Bay	Ceratium furca	6,650				-	-	-	0.44
NS	2006	10	2006	7	9	2006	7	11	3	West Kyushu	Kujuku island	Mesodinium rubrum	13,570				-	-	-	-
NS	2006	11	2006	7	8	2006	7	31	24	West Kyushu	Ohmura Bay	Karenia mikimotoi	92,200				-	-	-	-
NS	2006	12	2006	7	14	2006	7	18	5	West Kyushu	Ohmura Bay	Prorocentrum spp.	721				25.3	29.1	8.1	0.5
NS	2006	14	2006	7	20	2006	7	25	6	West Kyushu	Kujuku island	Karenia mikimotoi	8,504	**Puffer fish Red seabream**	Puffer fish 1000 ind. Red seabream 70 ind.	184	-	-	-	-
NS	2006	15	2006	7	20	2006	7	25	6	Remote Is.	Tsushima	Cochlodinium polykrikoides	135				22.8	26.3	5.2	-
NS	2006	16	2006	7	21	2006	7	23	3	North Kyushu	Imari Bay	Ceratium furca	667				26.0	-	-	-
NS	2006	17	2006	7	25	2006	8	11	18	North Kyushu	Imari Bay	Karenia mikimotoi	16,100	**Puffer fish**	Puffer fish 6900 ind.	10,350	-	-	-	-
NS	2006	19	2006	8	21	2006	8	25	5	West Kyushu	Kujuku island	Prorocentrum minimum	12,800				26.1	31.9	10.1	-
NS	2006	20	2006	9	6	2006	9	21	16	West Kyushu	Ohmura Bay	Heterosigma akashiwo	11,500				27.5	30.1	-	-
NS	2006	21	2006	9	22	2006	9	26	5	North Kyushu	Imari Bay	Diatoms	16,220				23.0	-	-	-
NS	2006	22	2006	10	11	2006	10	13	3	North Kyushu	Hirado(Usuka/Furue Bay)	Cochlodinium polykrikoides	646				23.0	33.0	7.9	0.25
NS	2006	23	2006	10	26	2006	11	6	12	West Kyushu	Ohmura Bay	Prorocentrum sigmoides	160				-	-	-	5.3
NS	2006	24	2006	10	30	2006	12	7	39	North Kyushu	Imari Bay	Prorocentrum sigmoides	14,980				-	-	-	2.1
NS	2006	25	2006	11	1	2006	11	3	3	Remote Is.	Tsushima	Mesodinium rubrum	490				22.5	34.9	5.8	-