Annex VI-3

Draft National Report on HAB in Korea

(Submitted in the Second Meeting of NOWPAP WG3)

Table of Content

Ⅰ. INTRODUCTION

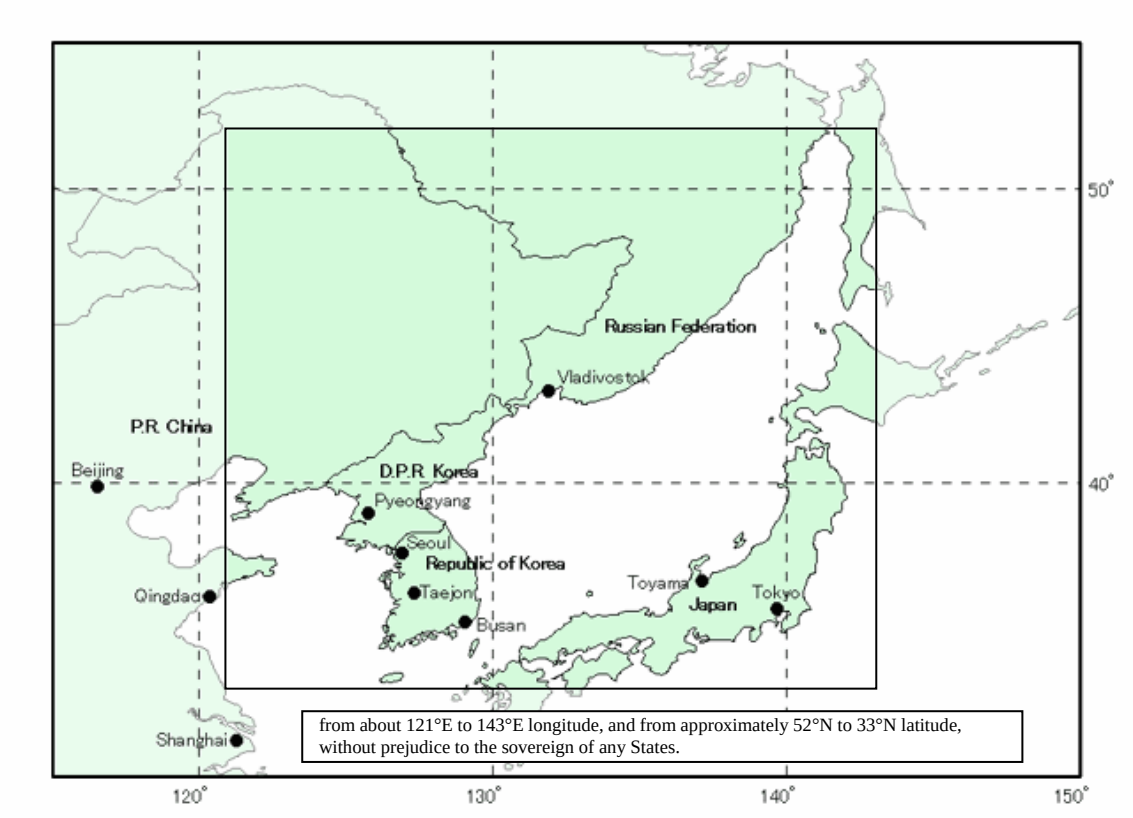
The geographic characteristic of Korea leads river to flow from the east to the west with runoffs discharging into the Yellow Sea and Korean strait. Moreover, the Korean waters are in shallow and semi-closed water system, in which mean water depth of Yellow Sea and the South Sea is 44 and 101m, respectively. Most of their continental shelf is stretched out to the whole seabed except the East Sea whose mean depth is 1, 543m. Such vulnerability of coastal pollution without big water exchanges with offshore, demographic high occupancy of coastal area and voluminous wastewater runoffs make coastal waters eutrophic state of haunting red tides. Harmful Algal Blooms (HABs) by toxic and non-toxic micro algae have gained increasing attention over last three decades in Korea. Because harmful and toxin-producing micro algae have caused serious impact on aquaculture industry through mass mortality of culturing finfish and/or shellfish, and on human health through finfish or shellfish poisoning in Korea.

HABs in this report encompass both harmful and harmless red tides, and toxin-producing micro algal blooms in accordance with the definition of HAB agreed by 1st WG3 meeting in Busan, October 2003.

It is needed to close coordination within WG members in the Region among other things to solve HABs problems in NOWPAP Region. In addition, it is essential to have a common platform to develop the research, mitigation measures and proper political proposals.

The present national report was compiled following the guidelines and format proposed in the WG3 Meeting held in Busan, October 2003. Considering the requirement of the guidelines, this was prepared using existing data and information mainly from National Fisheries and Development Institute (NFRDI) responsible for the HABs monitoring and mitigation.

Since information on HABs in Korean NOWPAP area has not been supplied sufficiently so far, the present report, therefore, can be used as the basis to develop the complete understandings on HABs in NOWPAP Region.



II. DATA AND INFORMATION USED

Data and publications issued by NFRDI and relevant organizations such as Fisheries Extension Service Center under Ministry of Maritime Affairs and Fisheries (MOMAF) and universities were utilized in this report.

1. Situation of HAB Occurrence

Both toxin-producing micro algae and non-toxic micro algae are responsible for red tide in Korea. Both of them are discussed in this report without separation. NFRDI have published the booklet “Situation of red tide in Korean coastal waters” annually or biannually since 1996. It describes red tide events, causative organisms, maximal cell density, locality with mapping, water temperature, etc for all the red tide occurred in Korean coastal waters. The data in the booklet is originated from the reports by either fisheries extension service centers or regional fisheries research institutes of NFRDI, responsible for the red tide monitoring program in Korea.

2. Monitoring

Monitoring activities were summarized based on the national monitoring program by NFRDI, fisheries extension service center and National Maritime police Agency in charge of the red tide monitoring. (See reference no.)

3. Progress of Researches and Studies to Cope with HABs

In order to investigate the progress of researches and studies to cope with HABs in Korea, research papers published by Korean scientists were collected and categorized along with the detail fields. Therein, the progress and future directions of researches and studies to cope with HABs were discussed.

4. Literature Including Newly Obtained Information

Information on HAB literatures was obtained from HAB Reference Database which has been constructed by CEARAC/WG3. Literatures including newly obtained information were collected through either e-library or direct contact with the authors and categorized along with the detail fields.

5. Training Activities to Cope with HABs

Information on the training activities to cope with HABs in Korea were collected from the curriculum of training department belonging to NFRDI. The subject on the management of coastal environment relevant with red tide and shellfish poisoning were discussed among the curriculum.

6. National Priority to Cope with HAB

“National plans for the sustainable marine environment and conservation for 5 years” and “National plans to countermeasure red tide problems in Korea” issued by MOMAF and NFRDI, respectively, were used to discuss the national priority to cope with HAB. (See reference no. and)

7. Suggested Activity for the NOWPAP Region

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

Ⅲ. RESULTS

1. Situation of HAB Occurrence

1.1 Causative Species

A total of 304 red tide events caused by 31 species in Korean coastal area of NOWPAP Region from 1999 to 2003 (Table 1.1.1)

The principal taxonomic groups were dinoflagellates and diatoms (Table 1.1.1). The top five major red tide causative species from 1999 to 2003 were listed in

Table 1.2.2. *Cochlodinium polykrikoides* led to mass mortality of culturing finfish and shellfish, while *Prorocentrum minimum, Gymnodinium sanguineum, Heterosigma akashiwo, , Prorocentrum micans* and *Skeletonema costatum* did not give rise to economic loss.

The representative harmful or toxic species in Korea, *Gymnodinium mikimotoi* and *Alexandrium tamarense* brought about red tide only a few events during 1999-2003 in Korean coastal waters.

Table 1.1.1 Number of red tide events during 1999-2003

	1999	2000	2001	2002	2003
Dinoflagellate	58	55	38	45	38
Diatom	7	6	5	6	5
Mixed algae/ protozo	10	8	13	8	2

Table 1.2.2 Major micro algal species responsible for red tide events during 1999-2003

Species	1999	2000	2001	2002	2003
Cochlodinium polykrikoides	20	9	10	15	20
Prorocentrum minimun	13	14	6	7	6
Gymnodinium sanguineum	10	4	-	5	-
Heterosigma akashiwo	7	12	5	7	5
Skeletonema coastatum	9	5	9	8	4

Source : NFRDI annual/biannual report, “situation of red tide in Korean coastal waters”, 1999-2003

1.2 Cell Density

The highest cell number observed during 1999-2003 was 48,000 cells/ml by *Cochlodinium polykrikoides* in August 2003 in Namhaedo area. The usual number of maximum cell density in the red tide in Korean coastal waters remains at the level of several thousands cells/ml.

Table 1.2 Maximum cell density of red tide causative organisms during 1999-2003

Year	species	Max. cell density (cells/ml)	locality
1999	*Cochlodinium polykrikoides*	43,000	Youngduk
2000	’’	15,000	Tongyoung
2001	’’	32,000	Geojedo
2002	’’	30,000	Kyoungju
2003	’’	48,000	Namhaedo

1.3 Location

Figure 1. (see appendicies) shows the area that experienced red tide events from 1999 to 2003 in Korean coastal waters. This reveals that the red tide events are more frequent in the southern part than in western or eastern part of Korea. The investigated area has suffered from 304 red tide events during 1999-2003. Most of the blooms were mainly observed in embayment and semi-enclosed area such as Jinhaeman, Buksinman, Ulsanman, etc except *Cochlodinium polykrikoides* blooms.

Red tide, in general, begins to occur from February to March almost every year, and shows its peak from August to September during which harmful algae, *Cochlodinium polykrikoides*, makes its blooms. Red tide by dinoflagellates are much more frequent than by diatoms.

Figure 1. 2 shows the location map of *Cochlodinium polykrikoides* blooms from 1999 to 2003. The blooms occurred mostly in the South Sea and/or East sea of NOWPAP Region, except year 1999 and 2000 in which there were blooms in the West Sea around Kunsan coastal area exceptionally.

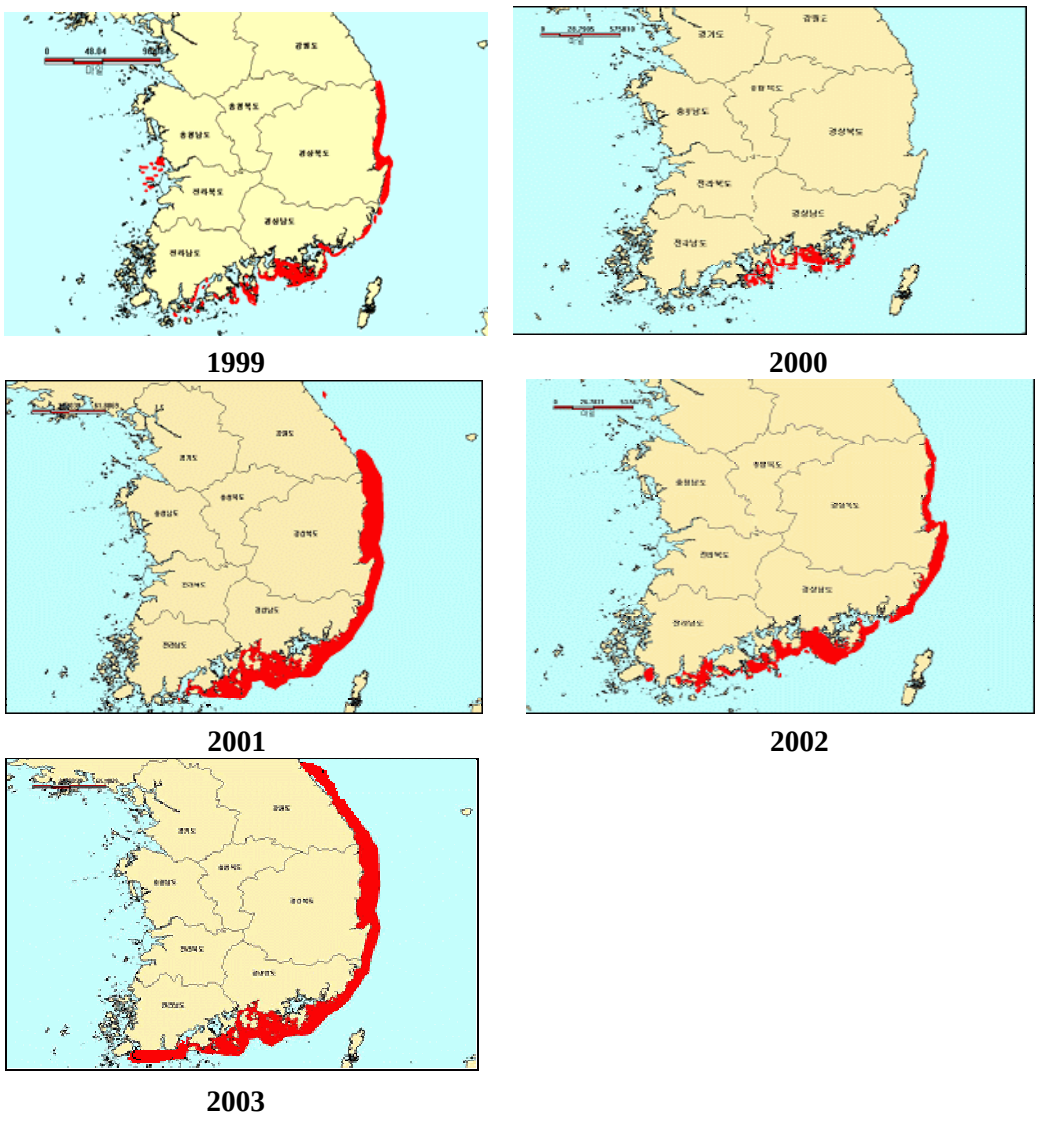


Figure 1. 2. Occurrence of red tide by harmful algae *Cochlodinium polykrikoides* in Korean NOWPAP area from 1999-2003. Red color represents the dimension of affected area by the species.

1.4 Approximate suffered Area

In general, the area that red tides spread varies extremely depending on oceanographic, meteorological, and biological conditions. The dimension of approximately suffered areas by red tides are in most case less than several kilometers except *Cochlodinium polykrikoides* blooms which spread up to several hundred kilometers in the South and/or East Sea of Korea. The red tides that exceed the area of 100 km^2 rarely occur in the Korean coastal waters of NOWPAP Region.

Table 1.2. Number of red tide events depending on the approximate suffered area during 1999-2003

Year	Dimension of red tide suffered area			
	1 Km^2	1- 100 Km^2	>100 Km^2	Total
1999	43	13	20	76
2000	45	16	8	69
2001	35	12	9	56
2002	30	10	15	59
2003	17	8	20	45

1.5 Duration

(1) Duration of red tide events

The duration of red tide by dinoflagellates or diatoms except by *Cochlodinium polykrikoides* is mostly less than 10 days. However, the duration of red tide by *Cochlodinium polykrikoides* is much longer, ranging from 1-2 months 29 days shown in Table 1. 3.

Table 1. 3. The duration of red tide by *Cochlodinium polykrikoides* in Korean coastal waters from 1999 to 2003

	1999	2000	2001	2002	2003
Days of duration	54	29	42	55	62

(2) Seasonal variation of red tide occurrence

The red tides by dinoflagellates and diatoms have been observed almost all the year round irrespective of the season recently. The highest peak season was high water temperature season from June to September. The majority of the events during the high water temperature season were attributed to the *Cochlodinium polykrikoides* blooms.

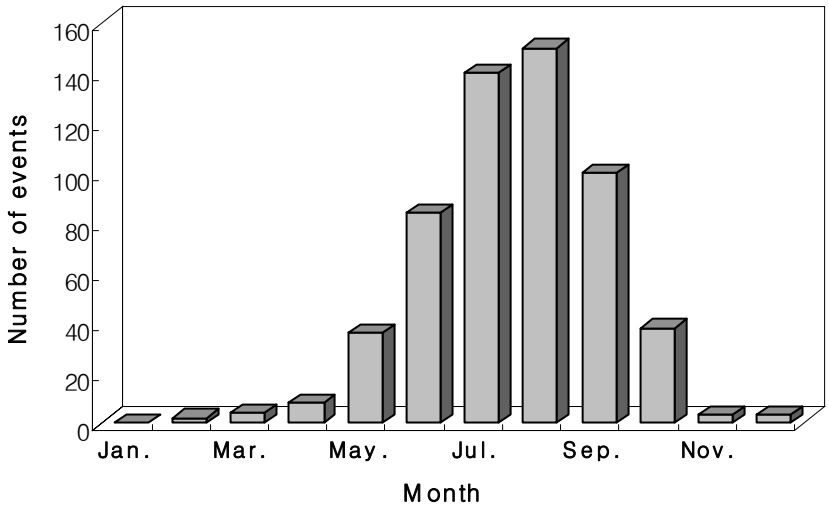


Figure 1. 3. Monthly variation of red tide events in Korean NOWPAP area since 1990.

1.6 Mitigation activity and effectiveness

Clay dispersion is the most popular way of removing the red tides in Korea. Red tide control by yellow clay composed of montmorillonite has been applied to the aquaculture farm since 1996 in order to minimize fisheries damages *Cochlodinium polykrikoides* blooms. It was attributed to reduce the fisheries damage from 95 million US dollars in 1995 to several million dollars thereafter excluding year 2003. Impacts on the ecosystems, particularly on the benthos, by clay dispersion have been assessed. The impact on the aquatic animal was evaluated as negligible although further long term study is needed to be continued.

Special device, Electrolytic Clay Dispenser (ECD) that electrolyzed seawater and clay dispenser combined each other are under propagation in Korea. The device plays a great role in minimizing the clay quantity to be dispersed into the sea.

1.7 Damage

First fisheries damage by red tide occurred in 1981 by harmful algae, *Karenia mikimotoi*. Thereafter, *Cochlodinium polykrikoides* blooms brought about mass mortality of finfish and shellfish almost every year in Korean coastal area since 1993. Particularly, there was huge harmful algal blooms in 1995, resulting in about 95 millions dollar's fisheries damage (Table 1.4). However, the economic impact by the species decreased sharply since then

except year 2003 in which there was unusual bloom in the south-western part of Korean, resulting in mass mortality of abalone exceptionally.

Table 1. 4 Fishery damage by red tide in Korean coastal waters

Year	Species	Economic loss (million dollor)
1981	*Karenia mikimotoi*	1.7
1992	*Gyrodinium sp.*	5
1993	*Cochlodinium polykrikoides*	7
1995	〃	95
1996	〃	1.8
1997	〃	1.2
1998	〃	0.1
1999	〃	0.2
2000	〃	0.2
2001	〃	7
2002	〃	4
2003	〃	18.6

2. Monitoring

National Fisheries Research and Development Institute (NFRDI), Regional Maritime Affairs and Fisheries Office and National Maritime Police Agency (NMPA) under Ministry of Maritime Affairs and Fisheries (MOMAF) are responsible for red tide monitoring. Particularly, NFRDI fisheries extension service center are most responsible for the monitoring around coastal area, while NMPA is in charge of aerial observance by helicopter. Local government is responsible for the mitigation when red tide occurs rather than monitoring.

The regular monitoring stations and frequency are summarized in Figure 2.1. 77 stations and additional 92 stations over the Korean coastal waters are regularly monitored from February to November by NFRDI and fisheries extension service center, respectively. However, once harmful algal blooms initiate, all the relevant agencies including NMPA conduct their daily HAB monitoring. HAB suffered area, cell density of causative organisms, water color, water temperature, salinity are monitored in the survey. All the collected data from field survey and meteorology are sent to HAB Emergency center under NFRDI where daily HAB news letter published.

For the prevention from shellfish poisoning and to sustain safe supply of shellfish products such as oyster, mussel and clam, food sanitation team under NFRDI in collaboration with fisheries extension center conduct regular monitoring on the shellfish culture farm mainly located in the South Sea. More

than 100 stations are weekly or biweekly monitored from February to November. The regular monitoring station for shellfish poisoning is shown in Figure 2.2.

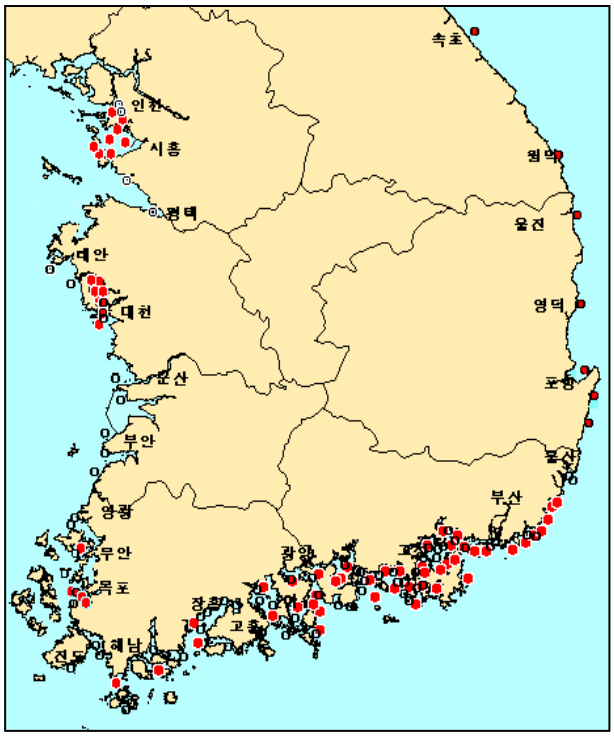


Figure 2. 1. Red tide monitoring station over Korean coastal waters

3. Progress of Researches and Studies to Cope with HAB

3.1 Mechanism of HAB Occurrence

The main target species for the study of HAB occurrence mechanism has been the *Cochlodinium polykrikoides* in addition to toxic micro algae such as *Alexandrium* spp., *Karenia mikimotoi* and *Gymnodinium catenatum* in National Fisheries Research and Institute and University since 1995. This study mainly focused on cyst, bloom dynamics, environment and eco-physiology.

- Reference List -

Chang, M. and Shim, J.H. 1994 An ecological study on the phytoplankton community of the Yellow Sea in February, 1986 Ocean Research 16(2): 95-109

Chang, M., Kim, W.S. and Lee, J.H. 1995 Phytoplankton blooms in the coastal waters of Korea-Red tides in Masan and Chinhae Bays Ocean Research 17(2): 137-156

Cho, K.A., Wui, I.S. and Choi, C.I. 1994 Ecological study of phytoplankton in the Kwang-Yang Bay. Korean J. Environ. Biol. 12(2): 137-150

Han, B.S. and Choi, J.K. 1991. A study on the environmental conditions and phytoplankton ecology in the tidal front area of the Yellow Sea. Yellow Sea Research 4: 39-55

Han, M.S., Kim, S.W. and Kim, Y.O. 1992. Occurrence of dinoflagellate *Alexandrium tamarense*, a causative organisms of paralytic shellfish poisoning in Chinhae Bay, Korea. J. Plankton Research 14(11): 1581-1592

Lee, C.K., Kim, H.C., Lee, S.G., Jung, C.S., Kim, H.G. and Lim, W.A. 2002. Abundance of harmful algae, Cochlodinium polykrikoides, Gyrodinium impudicum and Gymnodinium catenatum in the coastal area of South Sea OF Korea and their effects of temperature, salinity, irradiance and nutrient on the growth in culture. J. Korean Fish. Soc. 34(5), 536-544

Ahn, I.Y., Chung, H.S., Kang, J.S.and Kang, S.H. 1994 Preliminary studies on the ecology of neritic marine diatoms in Maxwell Bay, King George Island, Antarctica The Korean Journal of Phycology 9(1): 37-45

Cho, H.J., Kim, C.H., Moon, C.H. and Matsuok, K. 2003 Dinoflagellate cysts in recent sediments form the southern coastal waters of Korea Botanica Marina 46(4): 332-337.

Lee, J.B. and Yoo, K.I. 1991. Distribution of dinoflagellate cysts in Masan Bay, Korea. The Journal of the Oceanological Society of Korea 26(4): 304-312

Lee, J.B. and Matsuoka, K.1994. Distribution of dinoflagellate cysts from surface sediments in southern Korean waters. Proc. 2nd Int'l Symp. On Mar. Sci. Exploitatio of Marine Resources 1-20.

Park, J.S. and Yoon, Y.H. 2003. Marine environmental characteristics by distribution of dinoflagellate cysts in the southwestern coastal waters of Korea. 1. Spatio-temporal distribution of dinoflagellate cysts in Gamak Bay. J. Kor. Fish. Soc. 36(2): 151-156.

Cho, K.J. and Shin, J.K. 1998 Dynamics of inorganic N.P nutrient and planktonic algae during summer and winter in downstream of the Naktong River. Korean J.Limnol.31(1):67-75

Choi, K.J., Ha, C.H., Han, MS., Jeon, J.K., Kim, K.T., Lee, H.O. and Yoon, M.Y. 1999 Identificaiton and characterization of nitrate reductase in a marine dinoflagellate, *Alexandrium tamarense* Algae 14(3): 189-194

Choi, M.S., Jun, B.O., Kang, Y.H. and Chung, I.K. 1997. Photosynthetic efficiency of a marine picoplankter *Pycnococcus provasolii* Guillard under varous environmental conditions. Algae 12(2): 93-97

Kim, H.C., Lee, C.K., Lee, S.G., Kim, H.G. and Park, C.K. 2001. Physico-chemical factors on the growth of *Cochlodinium polykrikoides* and nutrient utilization. J. Korean Fish. Soc. 34(5): 445-456.

Lee, I.C. and Yoo S.A. 2001. Characterization of 5-aminolevulinic acid dehydratase purifid from *Anabaena cylindrical.* Algae 16(1): 59-65.

Lim, H.J. and Park, S.R. 1998. Fatty acid composition of concentrated phytoplanktons by cold storage and their effects on the larval survival of pacific oyster, *Crassostrea gigas.* J. Korean Fish. Soc. 31(4): 567-573.

Park, M.G. 2002. Physiological ecology of parasitic dinoflagellate *Amoebophrya* and harmful algal blooms. Journal of the Korean Society of Oceanography 7(3): 181-194.

Yang, S.R. 1997. Physiological adaptation of nitrate uptake by phytoplankton under simulated upwelling conditions. Journal of Korean Fish. Soc. 30(5): 709-715

3.2 Toxicity and detection of harmful algae

Studies on the toxicity of newly emerging micro algae and early detection techniques by molecular biological techniques has been the main research outcomes.

- Reference List –

Ahn, D.K., Park, Y.S., Park, J.G., Lee, S.J. and Lee, J.A. 2000 Quantification of DSP toxins in the mussels of the Jinhae Bay by fluorometric HPLC analysis and protein phosphatase inhibiiton assay Algae 15(4): 307-314.

Jung, J.M., Lee, Y.J., Park, H.K., Jung, E.Y. and Joo, G.J. 2003. The analysis of cyanobaterial neurotoxins by high-performance liquid chromatography-mass spectrometry. Algae 18(3): 233-238.

Kim, C.H. and Shin, J.B. 1997. Harmful and toixic red tide algal development and toxins production in Korean coastal waters. Algae 12(4): 269-276.

Kim, C.H., Sako, Y. and Ishida, Y. 1993. Variation of toxin production and composition in axenic cultures of *Alexandrium catenella* and *A. tamarense.* Nippon Suisan Gakkaishi 59(4): 633-639.

Kim, C.S., Lee, S.G., Kim, H.G. and Lee, J.S. 2001. Screening for toxic compounds in the red tide dinoflagellate *Cochlodinium polykrikoides*: Is it toxic plankton? Algae 16(4): 457-462.

Lee, H.O., Cheun, B.S., Watanabe, E. and Han, M.S. 2000. Comparison of HPLC analysis and channel biosensor in the detection of PSP toxin in natural *Alexandrium tamarense* population. Algae 15(1): 61-64.

3. 3 Taxonomic Analysis of Causative Species

Research on the ultra structure and phylogenic tree among the micro algae by molecular biological approach has been the main study subjects.

- Reference List –

Cho, E.S., Kim, G.Y. and Cho, Y.C. 2001. Molecular analysis of morphologically similar dinoflagellates *Cochlodinium polykrikoides*, *Gyrodinium impudicum* and *Gymnodinium catenatum* based on internal transcribed spacer and 5.8S rDNA regions Algae 16(1): 53-57

Cho, K.J. 1995. Fine structure of diatom *Stephanodiscus hantzschii* f. *tenuis* and *S. parvus* from the Naktong River of Korea The Korean Journal of Phycology 10(2): 69-76.

Kim, M.R. and Chang, Y.K. 1997. Taxonomic studies on some species of *Pediastrum* Meyen in Korea. Algae 12(3): 159-165

Lee, J.H., Kim, H.S., Park, C.W. and Chung, J. 1994. Morphological study of *Cyclotella pseudostelligera* Hust. (Bacillariophyeae). The Korean Journal of Phycology 9(2): 111-114

Lee, S.G., Park, J.S. and Kim, H.G. 1993. Taxonomy of marine toxic flagellates occurring in the southern coastal waters of Korea. Bull. Nat. Fish. Res. Dev. Agency 48: 1-24.

Moon, S.G. and Choi, C.M. 2003. A list of important species and distribution of marine phytoplankton in Korea. J. of the Environmental Sciences 12(7): 725-733

Park, M.O. 1992. *In vivo* fluorescence characteristics of pteridine for identification of phytoplankton. Bull. Korean Fish. Soc. 25(3): 219-228

Shim, J.H., Shin, E.Y. and Choi, J.K.1981. A taxonomical study on the dinoflagellates of the coastal waters in the vicinity of Yeosu, Korea. The Journal of the Oceanological Society of Korea16(2): 57-98.

Yang, E.J. and Choi, J.K. 1996. Morphological study of centric diatom *Coscinodiscus oculus-iridis* Ehrenberg. Algae 11(1): 1-7.

Kang, J.S., Kim, H.S. and Lee, J.H. 1996. Morphological variations of the marine diatom *Thalassiosira weissflogii* under culture conditions. Algae 11(1): 23-34.

3. 4 HAB Mitigation and Management

Research on the HAB control by biological or physical techniques (e.g. yellow clay) and impact on the ecosystem has been the studies subjects.

- Reference List –

Cho, E.S., Kang, D.W. and Cho, Y.C. 2000 Impact of crude oil and dispersant on determination of calcium concentration in whole cell from *Cochlodinium polykrikoides* Algae 15(2): 73-79

Jeong, H.J. 1994. Predation effects of the calanoid copepod *Acartia tonsa* on a population of the heterotrophic dinoflagellate *Protoperidinium* cf. *divergens* in the presence of co-occurring red-tide dinoflagellate prey. Mar. Ecol. Prog. Ser. 111: 87-97

Jeong, H.J., Kim, J.S., Yoo, Y.D., Kim, S.T., Kim, T.H., Park, M.G., Lee, C.H., Seong, K.A., Kang, N.S. and Shim, J.H.2003. Feeding by the heterotrophic dinoflagellate *Oxyrrhis marina* on the red-tide Raphidophyte *Heterosigma akashiwo*: a potential biological method to control red tides using mass-cultured grazers. J. Eukaryot. Microbiol. 50(4): 274-282

Jeong, H.J., Park, K.H., Kim, j.s., Kang, H.J., Kim, C.H., Choi, H.J., Kim, Y.S., Park, J.Y. and Park, M.G. 2003. Reduction in the toxicity of the dinoflagellate *Gymnodinium catenatum* when fed on by the heterotrophic dinoflagellate *Polykrikos kofoidii.* Aquat. Microb. Ecol. 31: 307-312.

Kang, J.S., Kang, S.H., Lee, Y.H., Shim, J.H. and Lee, S.H. 2003. UV-B effects on growth and nitrate dynamics in Antarctic marine diatoms *Chaetoceros neogracile* and *Stellarima microtrias.* Algae 18(1): 13-20

Kim, C.S., Bae, H.M. and Cho, Y.C. 2001. Control of harmful algal blooms by clay via photochemical reactions. Algae 16(1): 67-73.

Kim, P.J., Heo, S. and Yun, S.J. 2002. Adsorption and removal mechanism of dissolved inorganic nutrients in seawater by yellow loess. J. Korean Fish. Soc. 35(2): 146-154.

4. Literature Including Newly Obtained Information

Followings show major papers published after 2002, which are stored in HAB Reference Database.（All papers that are published after 2002 and stored in HAB Reference Database.） Section indexes conform to the categories in HAB Reference Database.

- Reference List –

Cysts of Dinoflagellates

Cho, H.J., Kim, C.H., Moon, C.H. and Matsuok, K. 2003 Dinoflagellate cysts in recent sediments form the southern coastal waters of Korea Botanica Marina 46(4): 332-337.

Park, J.S. and Yoon, Y.H. 2003. Marine environmental characteristics by distribution of dinoflagellate cysts in the southwestern coastal waters of Korea. 1. Spatio-temporal distribution of dinoflagellate cysts in Gamak Bay. J. Kor. Fish. Soc. 36(2): 151-156.

Toxicity Analysis

Jung, J.M., Lee, Y.J., Park, H.K., Jung, E.Y. and Joo, G.J. 2003. The analysis of cyanobaterial neurotoxins by high-performance liquid chromatography-mass spectrometry. Algae 18(3): 233-238.

Taxonomic Analysis of Causative Species

Moon, S.G. and Choi, C.M. 2003. A list of important species and distribution of marine phytoplankton in Korea. J. of the Environmental Sciences 12(7): 725-733

Occurrence and Monitoring

Lee, C.K., Kim, H.C., Lee, S.G., Jung, C.S., Kim, H.G. and Lim, W.A. 2002. Abundance of harmful algae, Cochlodinium polykrikoides, Gyrodinium impudicum and Gymnodinium catenatum in the coastal area of South Sea OF Korea and their effects of temperature, salinity, irradiance and nutrient on the growth in culture. J. Korean Fish. Soc. 34(5), 536-544

Ahn, I.Y., Chung, H.S., Kang, J.S.and Kang, S.H. 1994 Preliminary studies on the ecology of neritic marine diatoms in Maxwell Bay, King George Island, Antarctica The Korean Journal of Phycology 9(1): 37-45

Yoo, K.I. and Lee, J.H. 1979. Environmental studies of the Jinhae Bay. 1. Annual cycles of phytoplankton populaiton, 1976-1978. The Journal of the Oceanological Society of Korea 14(10: 26-31

Physiology

Park, M.G. 2002. Physiological ecology of parasitic dinoflagellate *Amoebophrya* and harmful algal blooms. Journal of the Korean Society of Oceanography 7(3): 181-194.

Mitigation and Management

Jeong, H.J., Kim, J.S., Yoo, Y.D., Kim, S.T., Kim, T.H., Park, M.G., Lee, C.H., Seong, K.A., Kang, N.S. and Shim, J.H.2003. Feeding by the heterotrophic dinoflagellate *Oxyrrhis marina* on the red-tide Raphidophyte *Heterosigma akashiwo*: a potential biological method to control red tides using mass-cultured grazers. J. Eukaryot. Microbiol. 50(4): 274-282

Jeong, H.J., Park, K.H., Kim, j.s., Kang, H.J., Kim, C.H., Choi, H.J., Kim, Y.S., Park, J.Y. and Park, M.G. 2003. Reduction in the toxicity of the dinoflagellate *Gymnodinium catenatum* when fed on by the heterotrophic dinoflagellate *Polykrikos kofoidii.* Aquat. Microb. Ecol. 31: 307-312.

Kang, J.S., Kang, S.H., Lee, Y.H., Shim, J.H. and Lee, S.H. 2003. UV-B effects on growth and nitrate dynamics in Antarctic marine diatoms *Chaetoceros neogracile* and *Stellarima microtrias.* Algae 18(1): 13-20

Kim, P.J., Heo, S. and Yun, S.J. 2002. Adsorption and removal mechanism of dissolved inorganic nutrients in seawater by yellow loess. J. Korean Fish. Soc. 35(2): 146-154.

5. Training Activity to Cope with HAB

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

A non-profit organization, Korean International Cooperation Agency (KOICA), has conducted some training courses every year on the aquaculture including red tides to develop the capacity of technicians from developing or under developed countries. KOICA is the only organization that has such a concrete training activity on nation-wide basis in Korea.

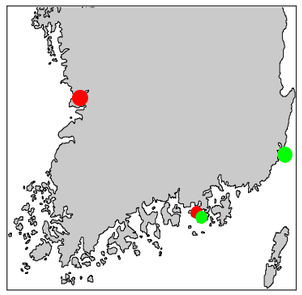
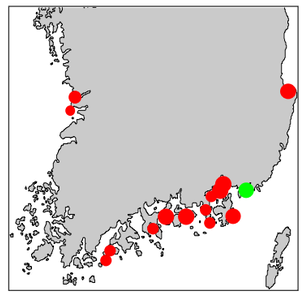
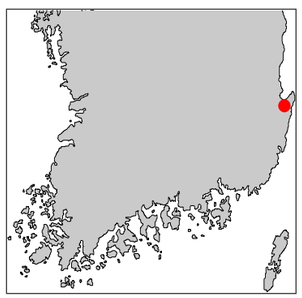
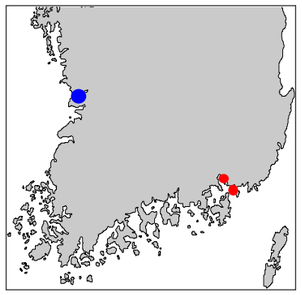
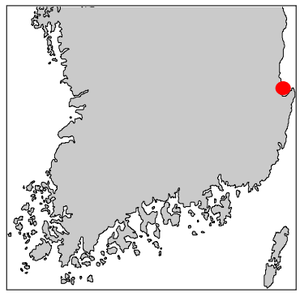
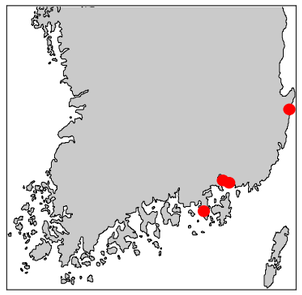
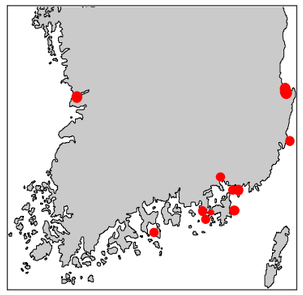
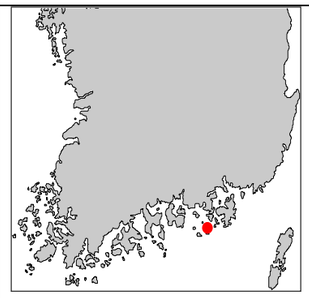
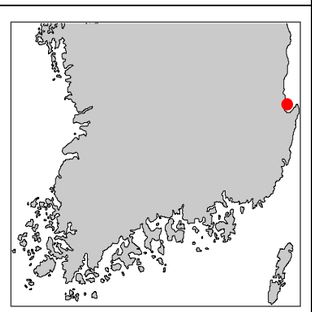
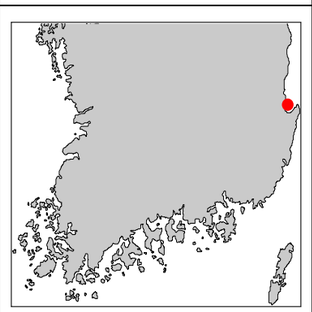
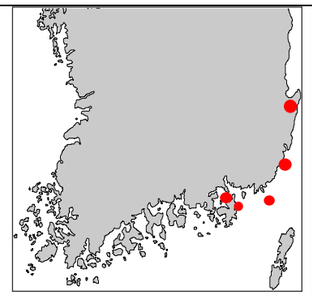
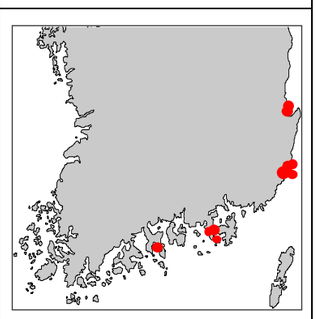
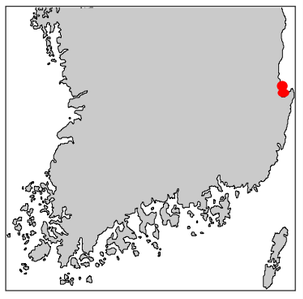
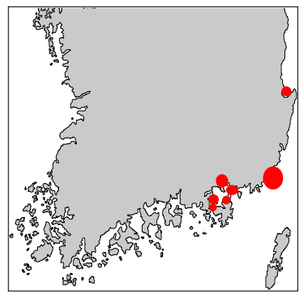
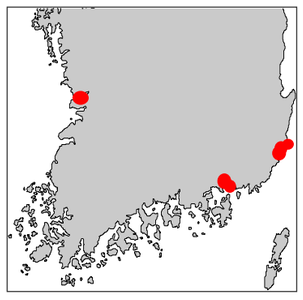
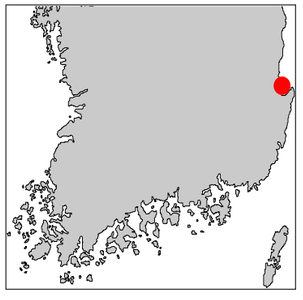
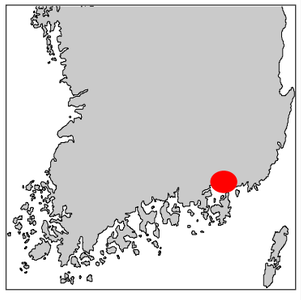
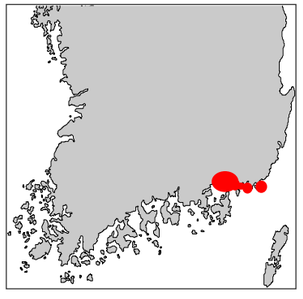
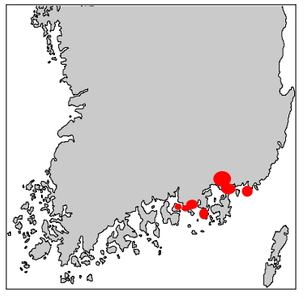
Training department under NFRDI has also carried out training courses to educate the fishermen and governmental official relevant with red tide. In addition, marine harmful organisms research team runs teaching programs including practice on the taxonomy of micro algae for the personnel engaged in HAB monitoring.

6. National Priority to Cope with HAB

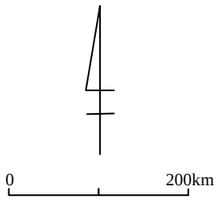
This chapter introduces the activities to cope with HAB on a governmental level such as development of new technology on the early detection of harmful algae by molecular biology and new methodology for the minimization of fisheries impact.

7. Suggested Activity for the NOWPAP Region

This chapter suggests future action against the problem of Cochlodinium, in collaboration with other organization, and promotion of land based activities for NOWPAP region in near future. Because Cochlodinium causes not only give severe fisheries impact on aquacultures in Korea and Japan, but also might possibly suffer the NOWPAP countries in future along the regional current/tide. Hence, it is important for NOWPAP member to work together or exchange information with other international organization.

	Jan	Feb	Mar	Apr	May	Jun
1999						
2000						
2001						
2002						
2003						

: Have a flagellum
: Non flagellum (mainly diatoms)
: Others



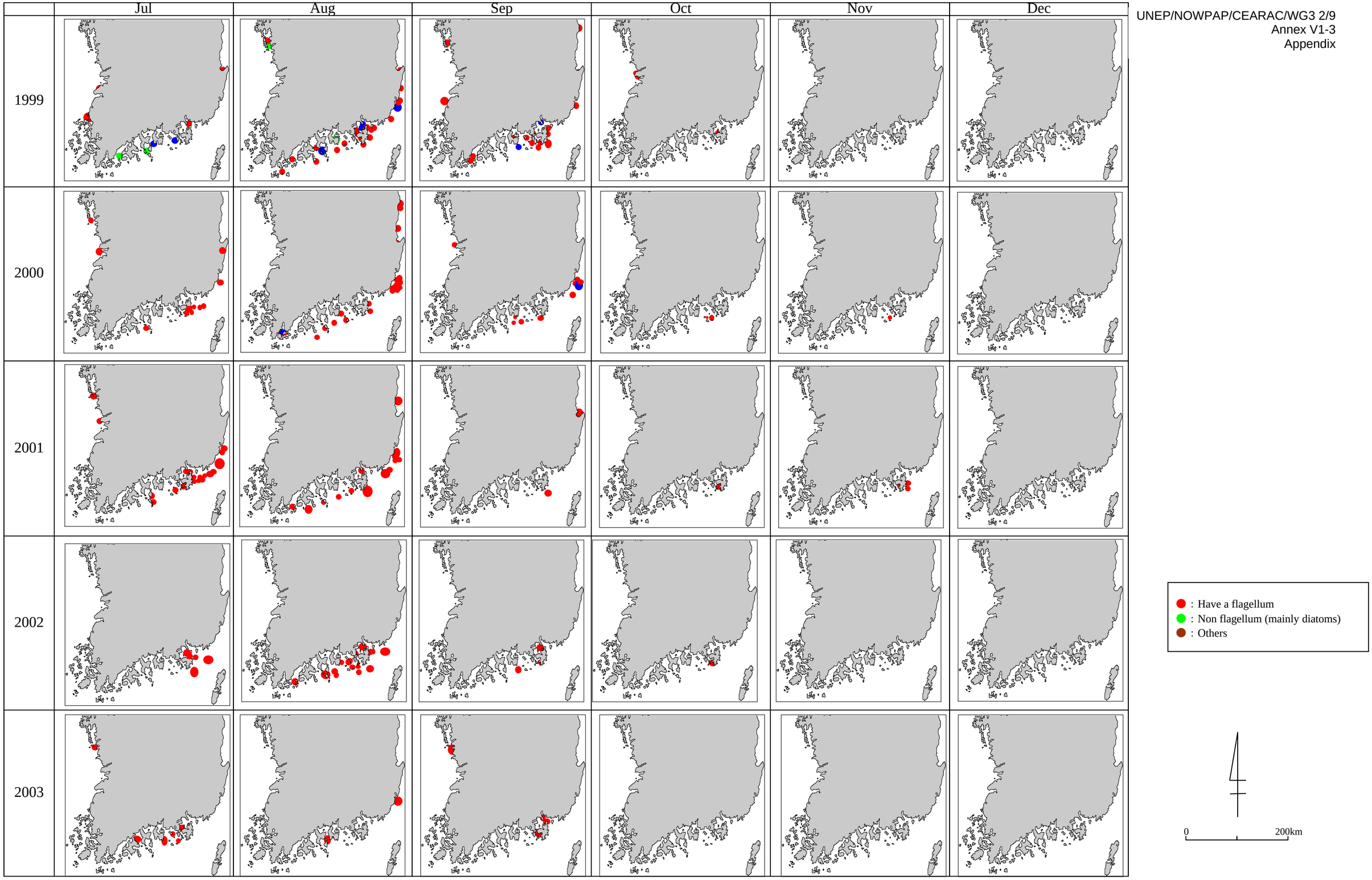


Figure 1. 1. Monthly occurrence of red tide in Korean NOWPAP area from 1999-2003.
(red circle, red tide by dinoflagellates; blue circle, red tide by diatom)

Event No.	Location (name of the sea area)		Duration	Continuous days	Causative species			
	Location 1	Location 2	dd/mm/yy-dd/mm/yy		①	②	③	④
1	Tongyoung buksinman		01-01-99 -		*Heterocapsa triquetra*			
2	Sachun hangchondong		23-01-99 -		*Eutreptiella sp.*			
3	Tongyoung hansanman		28-01-99 -		*Gymnodinium sp.*			
4	Tongyoung kwangdomyoun		19-04-99 -		*Noctiluca sp.*			
5	Masanman sanho		23-04-99 -		*Prorocentrum sp.*			
6	Geoje ilunmyoun		26-04-99 -		*Noctiluca sp.*			
7	Masan nanpo		26-04-99 -		*Eutreptiella gymnastica*			
8	Jinhaeman haengam		28-04-99 -		*Eutreptiella gymnastica*			
9	Gunsan naehang		01-05-99 -		*Mesodinium rubrum*			
10	Jinhaeman haengam		06-05-99 -		*Gymnodinium sanguineum*			
11	Ulsan		13-05-99 -		*Rhizosolenia sp.*			
12	Tongyoung, bubsongman, buksin		15-05-99 -		*Heterosigma akashiwo*	Proro.minimum	Eutreptiella gymnastica	
13	Masanman		24-05-99 -		*Gymnodinium sanguineum*			
14	Tongyoung wonmoonman		24-05-99 -		Mesodinium rubrum			
15	Tongyoung buksinman		28-05-99 -		*Leptocylindrus danicus*	*Gymnodinium sanguineum*		
16	kunsan		02-06-99 -		*Heterosigma akashiwo*			
17	masanman	haengamman	04-06-99 -		*Prorocentrum sp.*	*Heterosigma akashiwo*		
18	Namhaegun		08-06-99 -		*Ceratium furca*			
19	Yeosu gamakmang		09-06-99 -		*Heterosigma akashiwo*			
20	Pohang youngilman		18-06-99 -		*Prorocentrum sp.*	*Ceratium furca*	*Heterosigma sp.*	
21	Tongyoung kwangdomyoun		18-06-99 -		*Prorocentrum sp.*			
22	Geojedo		19-06-99 -		*Prorocentrum sp.*	*Gymnodinium sp.*		
23	Tongyoung buksinman		21-06-99 -		*Prorocentrum triestinum*			
24	Namhae kangjinman		21-06-99 -		*Prorocentrum sp.*			
25	Pusan kadukdo		28-06-99 -		*Prorocentrum sp.*	*Coscinodiscus gigas*	*Thalassiosira decipiens*	
26	Wando		28-06-99 -		*Heterosigma akashiwo*			
27	kunsan		29-06-99 -		*Heterosigma akashiwo*	*Heterocapsa triquetra*		
28	Pohang youngilman		01-07-99 -		*Proro.triquetra*	*Heterosigma akashiwo*	*Chaetoceros sp.*	
29	Junnam young		06-07-99 -		*Noctiluca scintillans*			
30	Tongyoung buksinman		06-07-99 -		*Leptocylindrus danicus*			
31	Yeosu	dolsan	06-07-99 -		*Skeletonema costatum*	*Thalassiosira sp.*	*Ceratium furca*	*Prorocentrum sp.*
32	Namhaedo kangjinman		07-07-99 -		*Chaetoceros sp.*			
33	Junnam		08-07-99 -		*Chaetoceros sp.*	*Coscinodiscus gigas*	*Ceratium furca*	*Prorocentrum sp.*
34	Pohang youngilman		21-07-99 -		*Prorocentrum triestinum*	*Prorocentrum micans*		
35	Buankun widomyoun		22-07-99 -		*Noctiluca scintillans*			
36	Jinhaeman	Masan	22-07-99 -		*Prorocentrum dentatum*	*Ceratium furca*		
37	Gosung		07-08-99 -		*Gymnodinium sp.*			
38	Asanman		08-08-99 -		Mesodinium rubrum			
39	Namhaekun	hadongkun	10-08-99 -		*Heterosigma sp.*	*Chaetoceros sp.*		
40	Yeosu	Kamakman	10-08-99 -		*Chaetoceros sp.*	*Skeletonema costatum*	*Nitzschia sp*	*Rhizosolenia sp.*
41	Ulsan		11-08-99 -		*Skeletonema costatum*	*Chaetoceros sp.*		
42	Chunsuman		11-08-99 -		*Chaetoceros sp.*	*Thalassiosira decipiens*	*Skeletonema costatum*	*Microcystis virdis*
43	Masan, sanho, dukdong		11-08-99 -		*Skeletonema costatum*	*Rhizosolenia fragilissima*		
44	Goheung narodo		11-08-99 -		*Cochlodinium polykrikoides*			
45	Yeosu hwajungmyoun		11-08-99 -		*Cochlodinium polykrikoides*			
46	Pohang youngilman		13-08-99 -		*Prorocentrum sp.*	*Heterosigma sp.*	*Skeletonema costatum*	
47	Namhaekun sangju		14-08-99 -		*Cochlodinium polykrikoides*			
48	Tongyoung		14-08-99 -		*Cochlodinium polykrikoides*			
49	geojedo		16-08-99 -		*Gymnodinium sanguineum*			
50	Ulsan		17-08-99 -		*Chaetoceros sp.*	*Prorocentrum sp.*	*Thalassiosira sp.*	
51	Masan	Jinhaeman	17-08-99		*Gymnodinium sanguineum*	*Ceratium sp.*		
52	Geojedo		18-08-99 -		*Gymnodinium sanguineum*	*Ceratium sp.*		
53	Masanman		19-08-99 -		*Skeletonema costatum*			
54	Jinhaeman		19-08-99 -		*Gymnodinium sanguineum*			
55	Geojedo		21-08-99 -		*Gymnodinium mikimotoi*			
56	Gosung		21-08-99 -		*Cochlodinium polykrikoides*			
57	Wando		24-08-99 -		*Cochlodinium polykrikoides*			
58	Geojedo		25-08-99 -		*Cochlodinium polykrikoides*			
59	Janghueng		25-08-99 -		*Cochlodinium polykrikoides*			
60	Pusan		28-08-99 -		*Cochlodinium polykrikoides*			
61	Ulsan		29-08-99 -		*Cochlodinium polykrikoides*			
62	Kyoungju		29-08-99 -		*Cochlodinium polykrikoides*			
63	Pohang youngilman		31-08-99 -		*Cochlodinium polykrikoides*			
64	Jinhaeman		31-08-99 -		*Cochlodinium polykrikoides*			
65	Pohang		02-09-99 -		*Cochlodinium polykrikoides*			
66	Janghueng		06-09-99 -		*Cochlodinium polykrikoides*	*Gymnodinium sp.*		
67	Namhae		06-09-99 -		*Cochlodinium polykrikoides*	*Chaetoceros sp.*		
68	Geojedo		13-09-99 -		*Gymnodinium sanguineum*	*Cochlodinium polykrikoides*		
69	Gokun		14-09-99 -		*Gymnodinium sp.*			
70	Wonmunman		15-09-99 -		*Prorocentrum triestinum*			
71	Gosung		15-09-99 -		*Gymnodinium sanguineum*	*Gymnodinium fissum*		
72	Kadukdo		15-09-99 -		*Gymnodinium sp.*			
73	Junnam		15-09-99 -		*Gymnodinium sp.*			
74	Masanman		15-09-99 -		*Skeletonema costatum*			
75	Geojedo		15-09-99 -		*Gymnodinium sanguineum*	*Cochlodinium polykrikoides*		
76	Geojedo		15-09-99 -		*Gymnodinium mikimotoi*			
77	Ulsan		10-09-99 -		*Gymnodinium sp.*			
78	Tongyoung		25-09-99 -		*Gymnodinium sanguineum*			
79	Jinhaeman		27-09-99 -		*Prorocentrum sp.*			
80	Namhae		28-09-99 -		*Skeletonema costatum*			
81	Gosungkun		02-10-99 -		*Prorocentrum minimum*			
82	Junbuk		12-10-99 -		*Cochlodinium polykrikoides*			
83	Chungnam		21-10-99 -		*Cochlodinium polykrikoides*			
84	Pohang		17-02-00		*Eutreptiella gymnastica*			
85	kunsan		02-03-00		*Skeletonema costatum*			
86	Jinhaeman		20-03-00		*Heterocapsa triquetra*			
87	Pohang		01-04-00		*Chromonas marina*			
88	kunsan		01-05-00		*Eutreptiella gymnastica*	Mesodinium rubrum		
89	Masanman		02-05-00		*Eutreptiella gymnastica*	*Pseudonitzschia pungens*	*Eutreptiella gymnastica(5.4)*	
90	Masanman		17-05-00		*Prorocentrum sp.*	*Heterocapsa sp.*		
91	Masanman		23-05-00		*Heterosigma akashiwo*			
92	Kyoungju		25-05-00		*Noctiluca scintillans*			
93	Tongyoung		29-05-00		*Heterosigma akashiwo*	*Prorocentrum micans*		
94	Jinhaeman		02-06-00		*Heterosigma akashiwo*	*Gymnodinium sanguineum*		
95	Onsanman	JangsangPohang	07-06-00		*Heterosigma akashiwo*	*Heterosigma akashiwo*		
96	Masanman	Hangamman	14-06-00		*Heterosigma*	*Ceratium furca*	*Proro. Micans*	
97	Buksinman		15-06-00		*Heterosigma*			

CheckBox1

Event No.	Location (name of the sea area)		Duration	Continuous days	Max. cell density (cells/L)								mitigation activity and effectiveness	Damage	
	Location 1	Location 2	dd/mm/yy-dd/mm/yy		①	②	③	④	⑤	⑥	⑦	⑧		Fisheries resource	Human health
1	Tongyoung buksinman		01-01-99 -		5,200,000								N		
2	Sachun hangchondong		23-01-99 -		3,000,000										
3	Tongyoung hansanman		28-01-99 -		780,000										
4	Tongyoung kwangdomyoun		19-04-99 -		830,000										
5	Masanman sanho		23-04-99 -		19,800,000										
6	Geoje ilunmyoun		26-04-99 -		5,450,000										
7	Masan nanpo		26-04-99 -		31,000,000										
8	Jinhaeman haengam		28-04-99 -		16,500,000	1,260									
9	Gunsan naehang		01-05-99 -		800,000										
10	Jinhaeman haengam		06-05-99 -		1,320,000										
11	Ulsan		13-05-99 -		2,000,000	10,000,000									
12	Tongyoung, bubsongman, buksin		15-05-99 -		4,500,000	1,800,000	1,200,000								
13	Masanman		24-05-99 -		3,960,000										
14	Tongyoung wonmoonman		24-05-99 -		6,500,000										
15	Tongyoung buksinman		28-05-99 -		7,300,000	1,460,000									
16	kunsan		02-06-99 -		12,000,000										
17	masanman	haengamman	04-06-99 -		12,500,000	15,000,000									
18	Namhaegun		08-06-99 -		6,000,000										
19	Yeosu gamakmang		09-06-99 -		16,700,000										
20	Pohang youngilman		18-06-99 -		650,000	400,000	920,000								
21	Tongyoung kwangdomyoun		18-06-99 -		6,600,000										
22	Geojedo		19-06-99 -		330,000	760,000									
23	Tongyoung buksinman		21-06-99 -		5,600,000										
24	Namhae kangjinman		21-06-99 -		1,350,000										
25	Pusan kadukdo		28-06-99 -		15,000,000	1,000,000	100,000								
26	Wando		28-06-99 -		13,000,000										
27	kunsan		29-06-99 -		18,000,000	2,000,000									
28	Pohang youngilman		01-07-99 -		600,000	1,500,000	1,600,000	1,500,000							
29	Junnam young		06-07-99 -		1,100,000										
30	Tongyoung buksinman		06-07-99 -		2,500,000										
31	Yeosu	dolsan	06-07-99 -		2,000,000	5,600,000	250,000	1,700,000							
32	Namhaedo kangjinman		07-07-99 -		1,600,000										
33	Junnam		08-07-99 -		1,500,000	2,000,000	1,400,000	300,000							
34	Pohang youngilman		21-07-99 -		6,200,000	1,500,000									
35	Buankun widomyoun		22-07-99 -		1,000,000										
36	Jinhaeman	Masan	22-07-99 -		4,180,000										
37	Gosung		07-08-99 -		15,500,000										
38	Asanman		08-08-99 -		4,537,000										
39	Namhaekun	hadongkun	10-08-99 -		2,000,000	3,000,000									
40	Yeosu	Kamakman	10-08-99 -		16,800,000	11,200,000	3,600,000	1,100,000							
41	Ulsan		11-08-99 -		20,000,000	10,000,000									
42	Chunsuman		11-08-99 -		25,000,000	7,500,000	5,000,000	########							
43	Masan, sanho, dukdong		11-08-99 -		1,760,000	2,840,000									
44	Goheung narodo		11-08-99 -		260,000										
45	Yeosu hwajungmyoun		11-08-99 -		50,000										
46	Pohang youngilman		13-08-99 -		2,500,000	1,500,000	2,000,000								
47	Namhaekun sangju		14-08-99 -		300,000										
48	Tongyoung		14-08-99 -		500,000										
49	geojedo		16-08-99 -		1,870,000										
50	Ulsan		17-08-99 -		200,000	500,000	200,000								
51	Masan	Jinhaeman	17-08-99		5,280,000	1,760,000									
52	Geojedo		18-08-99 -		1,980,000	3,700,000									
53	Masanman		19-08-99 -		3,440,000										
54	Jinhaeman		19-08-99 -		3,080,000										
55	Geojedo		21-08-99 -		7,500,000										
56	Gosung		21-08-99 -		2,700,000										
57	Wando		24-08-99 -		500,000										
58	Geojedo		25-08-99 -		1,700,000										
59	Janghueng		25-08-99 -		4,000,000										
60	Pusan		28-08-99 -		1,100,000										
61	Ulsan		29-08-99 -		4,500,000										
62	Kyoungju		29-08-99 -		3,000,000										
63	Pohang youngilman		31-08-99 -		3,000,000										
64	Jinhaeman		31-08-99 -		7,890,000										
65	Pohang		02-09-99 -		3,800,000										
66	Janghueng		06-09-99 -		1,300,000	4,300,000									
67	Namhae		06-09-99 -		150,000	1,000,000									
68	Geojedo		13-09-99 -		500,000										
69	Gokun		14-09-99 -		2,500,000										
70	Wonmunman		15-09-99 -		3,100,000										
71	Gosung		15-09-99 -		3,000,000										
72	Kadukdo		15-09-99 -		300,000										
73	Junnam		15-09-99 -		265,000										
74	Masanman		15-09-99 -		1,500,000										
75	Geojedo		15-09-99 -		400,000										
76	Geojedo		15-09-99 -		2,300,000										
77	Ulsan		10-09-99 -		3,000,000										
78	Tongyoung		25-09-99 -		1,100,000										
79	Jinhaeman		27-09-99 -		8,500,000										
80	Namhae		28-09-99 -		8,000,000										
81	Gosungkun		02-10-99 -		1,300,000										
82	Junbuk		12-10-99 -		250,000										
83	Chungnam		21-10-99 -		500,000										
84	Pohang		17-02-00		15,000,000										
85	kunsan		02-03-00		25,000,000										
86	Jinhaeman		20-03-00		1,350,000										
87	Pohang		01-04-00		17,600,000										
88	kunsan		01-05-00		75,000,000	1,500,000									
89	Masanman		02-05-00		5,700,000	2,550,000	29,000,000								
90	Masanman		17-05-00		7,700,000										
91	Masanman		23-05-00		15,400,000										
92	Kyoungju		25-05-00		1,500,000										
93	Tongyoung		29-05-00		1,560,000	780,000									
94	Jinhaeman		02-06-00		13,800,000	1,120,000									
95	Onsanman	JangsangPohang	07-06-00		1,150,000	21,000,000									
96	Masanman	Hangamman	14-06-00		6,740,000	1,530,000									
97	Buksinman		15-06-00		700,000										

Event No.	Location (name of the sea area)		Duration	Continuous days	Causative species			
	Location 1	Location 2	dd/mm/yy-dd/mm/yy		①	②	③	④
98	Bubsongman		16-06-00		*Proro. Micans*			
99	Pohang		19-06-00		*Proro. Minimum*	*Proro. Micans*		
100	kunsan		21-06-00		*Noctiluca scintillans*			
101	Yeosu		24-06-00		*Ceratium furca*			
102	Tongyoung		27-06-00		*Heterosigma akashiwo*			
103	Pohang		30-06-00		*Heterosigma akashiwo*			
104	Geojedo		01-07-00		*Proro. Minimum*			
105	Chungbuk		03-07-00		*Ceratium sp.*	*Noctiluca scintillans*		
106	Kamakman		03-07-00		*Heterosigma akashiwo*	*Ceratium sp.*		
107	Geojedo		04-07-00		*Noctiluca scintillans*			
108	Chunsuman		04-07-00		*Proro. Micans*	*Ceratium sp.*		
109	Jinhaeman		05-07-00		*Heterosigma akashiwo*			
110	Pusan		06-07-00		*Heterosigma akashiwo*	*Proro. Micans*		
111	Ulsan		10-0700		*Prorocentrum triestinum*			
112	Geojedo		14-07-00		*Gymnodinium sanguineum*			
113	Jinjuman		14-07-00		*Ceratium furca*			
114	Yeosu		18-07-00		*Chaetoceros sp.*	*Skeletonema costatum*		
115	Tongyoung		18-07-00		*Rhizosolenia sp.*			
116	Masan		18-07-00		*Proro. dentatum*			
117	kunsan		19-07-00		*Noctiluca scintillans*			
118	Inchun		20-07-00		Mesodinium rubrum			
119	Geojedo		20-07-00		*Proro. Minimum*			
120	Junnam		20-07-00		*Heterosigma akashiwo*			
121	kadukdo		27-07-00		*Heterosigma akashiwo*			
122	Ulsan		28-07-00		*Prorocentrum sp.*			
123	Masanman		29-07-00		*Prorocentrum sp.*			
124	Geojedo		02-08-00		*Noctiluca scintillans*			
125	Jinhaeman		07-08-00		*Rhizosolenia sp.*			
126	Haengamman		08-08-00		*Proro. Sp. Thala.decipiems*			
127	Ulsan		08-08-00		*Prorocentrum sp.*			
128	Pohang		08-08-00		*Skeletonema costatum*			
129	Kyoungbuk		08-08-00		*Noctiluca scintillans*			
130	Onsanman		11-08-00		*Prorocentrum sp.*	*Heterosigma akashiwo*		
131	JangsangPohang		14-08-00		*Prorocentrum sp.*			
132	Pohang		17-08-00		*Skeletonema costatum*			
133	Kyoungju		21-08-00		*Ceratium furca*			
134	Ulsan		21-08-00		*Ceratium furca*			
135	Ulsan		22-08-00		*Prorocentrum triestinum*			
136	Junnam		22-08-00		*Chaetoceros sp.*	*Coscinodiscus gigas*		
137	Junnam		22-08-00		*Prorocentrum minimum*			
138	Junnam		22-08-00		*Prorocentrum minimum*			
139	Ulsan		24-08-00		*Prorocentrum minimum*			
140	Onsanman		24-08-00		*Thalassiosira decipiens*			
141	Kyoungbuk		25-08-00		*Ceratium furca*			
142	Onsanman		28-08-00		*Thalassiosira rotula*			
143	Pohang		28-08-00		*Chaetoceros sp.*	*Skeletonema costatum*	*Ceratium furca*	
144	Ulsan		28-08-00		*Pyrocystis sp.*			
145	Ulsan		29-08-00		*Prorocentrum dentatum*	*Thalassiosira rotula*		
146	Yeosu		22-08-00		*Cochlodinium polykrikoides*			
147	Kyoungnam		22-08-00		*Cochlodinium polykrikoides*			
148	Kyoungnam		23-08-00		*Cochlodinium polykrikoides*			
149	Junnam		23-08-00		*Cochlodinium polykrikoides*			
150	Tongyoung		24-08-00		*Cochlodinium polykrikoides*			

Event No.	Location (name of the sea area)		Duration	Continuous days	Max. cell density (cells/L)								mitigation activity and effectiveness	Damage	
	Location 1	Location 2	dd/mm/yy-dd/mm/yy		①	②	③	④	⑤	⑥	⑦	⑧		Fisheries resource	Human health
98	Bubsongman		16-06-00		3,200,000										
99	Pohang		19-06-00		15,000,000	5,000,000									
100	kunsan		21-06-00		10,000,000										
101	Yeosu		24-06-00		1,080,000										
102	Tongyoung		27-06-00		99,600,000										
103	Pohang		30-06-00		5,000,000										
104	Geojedo		01-07-00		300,000										
105	Chungbuk		03-07-00		600,000										
106	Kamakman		03-07-00		2,040,000	320,000									
107	Geojedo		04-07-00		650,000										
108	Chunsuman		04-07-00		3,000,000	300,000									
109	Jinhaeman		05-07-00		12,500,000										
110	Pusan		06-07-00		32,000,000										
111	Ulsan		10-0700		3,000,000										
112	Geojedo		14-07-00		1,300,000										
113	Jinjuman		14-07-00		840,000										
114	Yeosu		18-07-00		5,710,000	1,520,000									
115	Tongyoung		18-07-00		4,300,000										
116	Masan		18-07-00		30,500,000										
117	kunsan		19-07-00		5,000,000										
118	Inchun		20-07-00		5,000,000										
119	Geojedo		20-07-00		750,000										
120	Junnam		20-07-00		47,800,000										
121	kadukdo		27-07-00		4,200,000										
122	Ulsan		28-07-00		1,500,000										
123	Masanman		29-07-00		13,200,000										
124	Geojedo		02-08-00		700,000										
125	Jinhaeman		07-08-00		4,800,000										
126	Haengamman		08-08-00		1,200,000	2,700,000									
127	Ulsan		08-08-00		20,000,000										
128	Pohang		08-08-00		12,000,000										
129	Kyoungbuk		08-08-00		1,000,000										
130	Onsanman		11-08-00		5,000,000	1,000,000									
131	JangsangPohang		14-08-00		2,300,000										
132	Pohang		17-08-00		9,000,000										
133	Kyoungju		21-08-00		1,500,000										
134	Ulsan		21-08-00		450,000										
135	Ulsan		22-08-00		40,000										
136	Junnam		22-08-00		193,000										
137	Junnam		22-08-00		15,000,000										
138	Junnam		22-08-00		4,800,000										
139	Ulsan		24-08-00		10,000,000										
140	Onsanman		24-08-00		30,000,000										
141	Kyoungbuk		25-08-00		180,000										
142	Onsanman		28-08-00		640,000										
143	Pohang		28-08-00		6,800,000	6,000,000	400,000								
144	Ulsan		28-08-00		40,000										
145	Ulsan		29-08-00		84,000	128,000									
146	Yeosu		22-08-00		910,000										
147	Kyoungnam		22-08-00		2,000,000										
148	Kyoungnam		23-08-00		900,000										
149	Junnam		23-08-00		200,000										
150	Tongyoung		24-08-00		900,000										