Annex VI-3

Draft National Report on HAB in Korea

(Submitted in the Second Meeting of NOWPAP WG3)

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I. INTRODUCTION

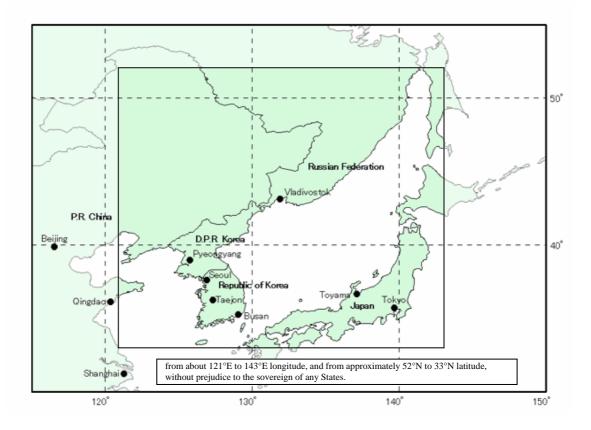
The geographic characteristic of Korea leads river to flow from the east to the west with runoffs discharging into the Yellow Sea and Korean strait. Moreover, the Korean waters are in shallow and semi-closed water system, in which mean water depth of Yellow Sea and the South Sea is 44 and 101m, respectively. 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.

	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 1.1.1 Number of red tide events during 1999-2003

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

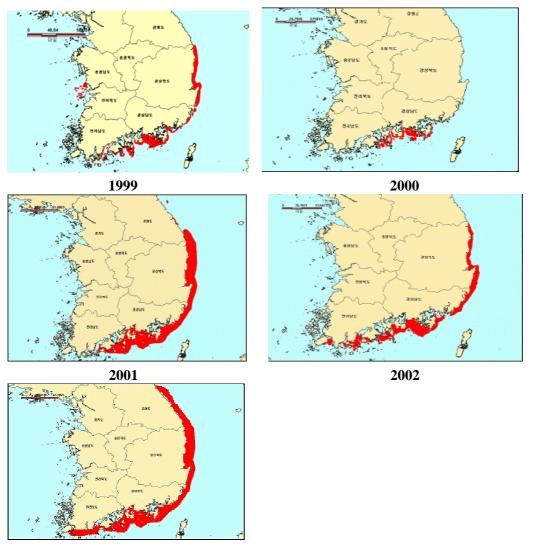
Year	species	Max. cell density	locality
		(cells/ml)	
1999	Cochlodinium	43,000	Youngduk
	polykrikoides		
2000	,,	15,000	Tongyoung
2001	,,	32,000	Geojedo
2002	,,	30,000	Kyoungju
2003	,,	48,000	Namhaedo

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.



2003

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 km² rarely occur in the Korean coastal waters of NOWPAP Region.

Veen	Dimension of red tide suffered area								
Year	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					

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

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.

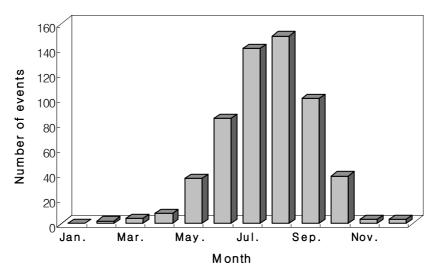


Figure 1. 3. Monthly variation of red tide events in Korean NOWPAP area since 1990.

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.

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

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

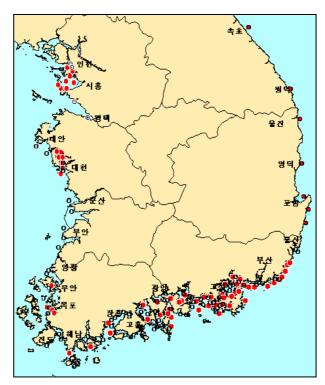


Figure 2. 1. Red tide monitoring station over Korean coastal waters

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.

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4

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- 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 Identification 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 inhibition 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.
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- 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
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- 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
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- 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.

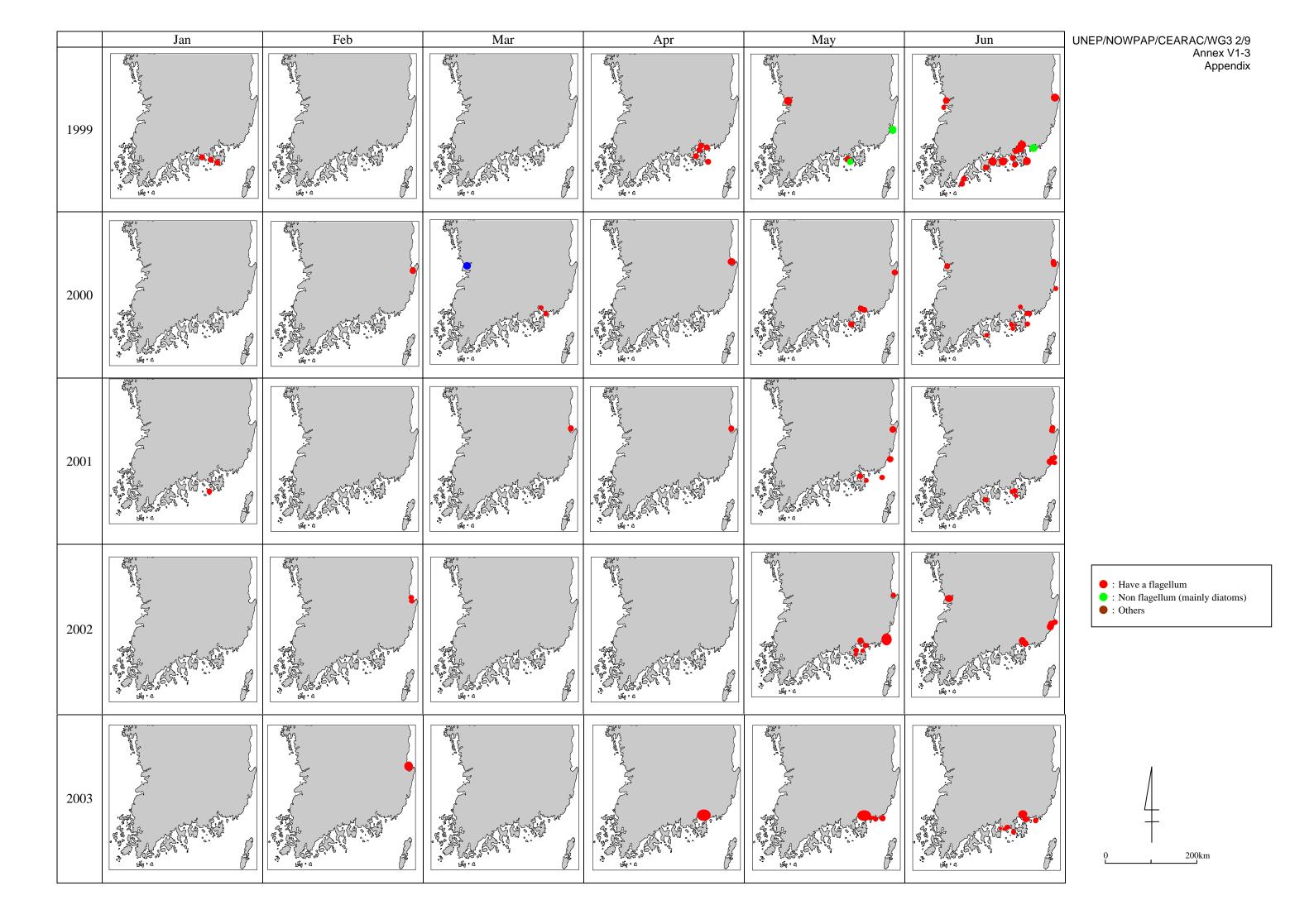
Training department under NFRDI has also carried out training courses to educate the fishermen and governmental official relevant with red tide. In addition, marine harmful organisms research team runs teaching programs including practice on the taxonomy of micro algae for the personnel engaged in HAB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



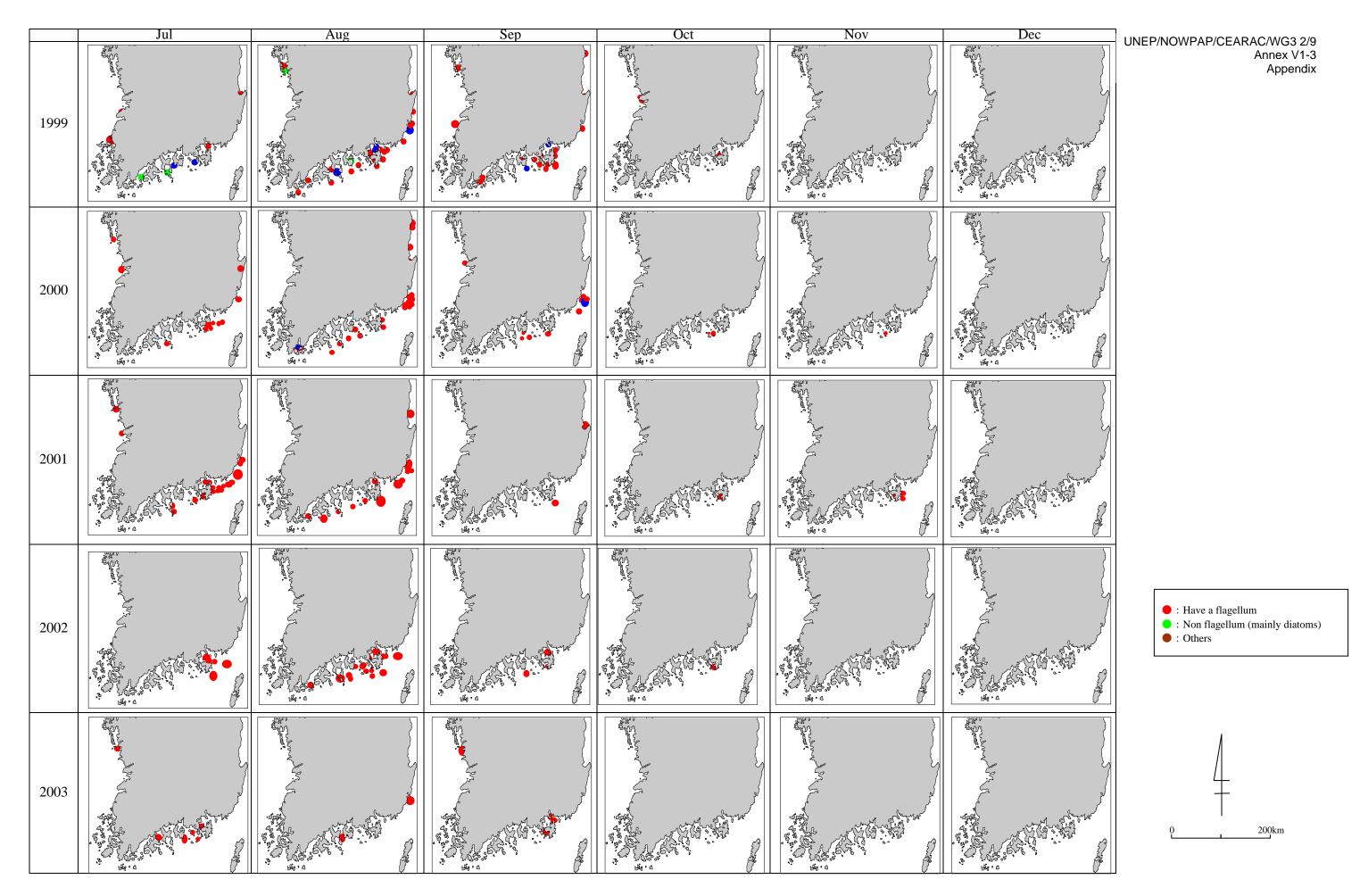


Figure 1. 1. Monthly occurrence of red tide in Korean NOWPAP area from 1999-2003. (red circle, red tide by dinoflagellates; blue circle, red tide by diatom)

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72 Kadukdo 15:09:99 - Gymnodnium sp. Image: Second S	53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 67 68 8 69	Masamman Jinhaeman Geojedo Gosung Wando Geojedo Janghueng Pusan Ulsan Ulsan Ulsan Ulsan Pohang youngilr Jinhaeman Pohang Janghueng Namhae Geojedo Gokun		$\begin{array}{r} 19{-}08{+}99 & .\\ 19{-}08{+}99 & .\\ 21{-}08{+}99 & .\\ 21{-}08{+}99 & .\\ 21{-}08{+}99 & .\\ 24{-}08{+}99 & .\\ 25{-}08{+}99 & .\\ 25{-}08{+}99 & .\\ 25{-}08{+}99 & .\\ 29{-}08{+}99 & .\\ 29{-}08{+}99 & .\\ 29{-}08{+}99 & .\\ 31{-}08{+}99 & .\\ 31{-}08{+}99 & .\\ 31{-}08{+}99 & .\\ 31{-}08{+}99 & .\\ 31{-}08{+}99 & .\\ 31{-}08{+}99 & .\\ 31{-}08{+}99 & .\\ 31{-}08{+}99 & .\\ 31{-}09{+}09{+} & .\\ 31{-}09{+}09{+} & .\\ 31{-}09{+}09{+} & .\\ 31{-}09{+}09{+} & .\\ 31{-}09{+}09{+} & .\\ 31{-}09{+}09{+} & .\\ 31{-}09{+}09{+} & .\\ 31{-}09{+}09{+} & .\\ 31{-}09{+}09{+} & .\\ 31{-}09{+}09{+} & .\\ 31{-}09{+}09{+} & .\\ 31{-}09{+}08{+} & .\\ 31{-}09{+}09{+} & .\\ 31$		Skeletonema costatum Gymnodhinum sanguineum Gymnodhinum mikimotoi Cochlodinium polykrikoides Cochlodinium polykrikoides Gochlodinium polykrikoides Gochlodinium polykrikoides	Gymnodinium sp. Chaetoceros sp.		
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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 Prorocentrum micans 95 Onsamman JangsangPohang 07-06-00 Heterosigma akashiwo Heterosigma akashiwo 96 Masanman 14-06-00 Heterosigma Ceratium furca Proro. Micans	53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 74 777 78 79 80 81 82 83 84 85 86	Masamman Jinhaeman Geojedo Gosung Wando Geojedo Janghueng Pusan Ulsan Ulsan Ulsan Pohang youngin Jinhaeman Pohang youngin Jinhaeman Geojedo Gosung Kadukdo Junnam Masamman Geojedo Ulsan Tongyoung Jinhaeman Tongyoung Jinhaeman Pohang Janghueng Kadukdo Junnam Masamman Geojedo Ulsan Tongyoung Jinhaeman Pohang Kangan Jinhaeman		$\begin{array}{r} 19\-08\-99\-\\ 19\-08\-99\-\\ 19\-08\-99\-\\ 21\-08\-99\-\\ 21\-08\-99\-\\ 21\-08\-99\-\\ 24\-08\-99\-\\ 24\-08\-99\-\\ 24\-08\-99\-\\ 25\-08\-99\-\\ 25\-08\-99\-\\ 25\-08\-99\-\\ 29\-08\-99\-\\ 29\-08\-99\-\\ 29\-08\-99\-\\ 29\-08\-99\-\\ 29\-08\-99\-\\ 29\-08\-99\-\\ 20\-09\-99\-\\ 20\-09\-99\-\\ 20\-08\-99\-\\ 20\-08\-99\-\\ 20\-08\-99\-\\ 20\-08\-99\-\\ 20\-08\-20\-\-20\-20\-\\ 20\-08\-\-20\-\-2$		Skeletonema costatum Gymnodhinum sanguineum Gymnodhinum mikimotoi Cochlodinium polykrikoides Cochlodinium sp. Schleiten Gymnodinium sp. Prorocentrum triestinum Gymnodinium sp. Gymnodinium sp. Skeletonema costatum Prorocentrum minimum Cochlodinium polykrikoides Eutreptiella gymnastica Skeletonema costatum	Gymnodinium sp. Chaetoceros sp. Cochlodinium polykrikoides Gymnodinium fissum		
90 Masanman 17-05-00 Prorocentrum sp. Heterocapsa sp. 91 Masanman 23-05-00 Heterosigma dkashiwo Image: Constraint of the second secon	53 54 55 56 577 58 59 600 61 62 63 64 655 700 711 72 733 74 75 766 777 78 79 800 811 822 833 844 855 866 87	Masamman Jinhaeman Geojedo Gosung Wando Geojedo Janghueng Pusan Ulsan Kyoungju Pohang youngjin Jinhaeman Pohang Geojedo Gokun Moonmunman Geojedo Geojedo Geojedo Ulsan Tongyoung Jinhaeman Masanman Geojedo Geojedo Ulsan Tongyoung Jinhaeman Namhae Gosung Kadukdo Junnam Geojedo Geojedo Geojedo Geojedo Geojedo Geojedo Geojedo Geojedo Jinhaeman Junbuk Chungnam Pohang Jinhaeman Pohang		$\begin{array}{r} 19 - 08 - 99 & . \\ 19 - 08 - 99 & . \\ 21 - 08 - 99 & . \\ 21 - 08 - 99 & . \\ 21 - 08 - 99 & . \\ 22 - 08 - 99 & . \\ 25 - 08 - 99 & . \\ 25 - 08 - 99 & . \\ 25 - 08 - 99 & . \\ 29 - 08 - 99 & . \\ 29 - 08 - 99 & . \\ 29 - 08 - 99 & . \\ 29 - 08 - 99 & . \\ 31 - 08 - 99 & . \\ 31 - 08 - 99 & . \\ 31 - 08 - 99 & . \\ 31 - 08 - 99 & . \\ 06 - 09 - 99 & . \\ 06 - 09 - 99 & . \\ 06 - 09 - 99 & . \\ 06 - 09 - 99 & . \\ 15 - 09 - 99 & . \\ 15 - 09 - 99 & . \\ 15 - 09 - 99 & . \\ 15 - 09 - 99 & . \\ 15 - 09 - 99 & . \\ 15 - 09 - 99 & . \\ 15 - 09 - 99 & . \\ 15 - 09 - 99 & . \\ 15 - 09 - 99 & . \\ 15 - 09 - 99 & . \\ 15 - 09 - 99 & . \\ 15 - 09 - 99 & . \\ 15 - 09 - 99 & . \\ 25 - 09 - 99 & . \\ 25 - 09 - 99 & . \\ 27 - 09 - 99 & . \\ 27 - 09 - 99 & . \\ 28 - 09 - 99 & . \\ 21 - 10 - 99 & . \\ 21 - 10 - 99 & . \\ 21 - 10 - 99 & . \\ 21 - 10 - 99 & . \\ 21 - 10 - 99 & . \\ 21 - 10 - 99 & . \\ 21 - 10 - 99 & . \\ 21 - 10 - 99 & . \\ 21 - 10 - 99 & . \\ 21 - 10 - 99 & . \\ 21 - 10 - 99 & . \\ 21 - 10 - 99 & . \\ 21 - 10 - 99 & . \\ 21 - 10 - 99 & . \\ 21 - 10 - 90 & . \\ 21 - 10 - 10 & . \\ 21 - 10 - 10 & . \\ 21 - 10 - 10 & . \\ 21 - 10 - 10 & . \\ 21 - 10 - 10 & . \\ 21 - 10 - 10 & . \\ 21 - 10 - 10 & . \\ 21 - 10 - 10 & . \\ 21 - 10 - 10 & . \\ 21 - 10 - 10 & . \\ 21 - 10 - 10 & . \\ 21 - 10 - 10 & . \\ 21 - 10 - 10 & . \\ 21 - 10 - 10 & . \\ 21 - 10 - 10 & . \\ 21 - 1$		Skeletonema costatum Gymnodhium sanguineum Gymnodhium mikimotoi Cochlodinium polykrikoides Cochlodinium softwikoides Cochlodinium softwikoides Cochlodinium softwikoides Cochlodinium softwikoides Cochlodinium softwikoides Cochlodinium sanguineum Gymnodinium sanguineum Gymnodinium sp. Skeletonema costatum Gymnodinium sp. Skeletonema costatum Prorocentrum minimum Prorocentrum minimum Prorocentrum minimum Prorocolinium polykrikoides Cochlodinium polykrikoides Cochlodinium polykrikoides Skeletonema costatum Prorocentrum minimum	Gymnodinium sp. Chaetoceros sp. Cochlodinium polykrikoides Gymnodinium fissum Cochlodinium polykrikoides		
91 Masanman 23-05-00 Heterosigma akashiwo 92 Kyoungju 25-05-00 Noctiluca scintillans 93 Tongyoung 29-05-00 Heterosigma akashiwo 94 Jinhaeman 02-06-00 Heterosigma akashiwo 95 Onsamman JangsangPohang 07-06-00 96 Masanman 14-06-00 96 Heterosigma akashiwo Ceratium furca 97 Drozo Heterosigma akashiwo	53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 744 755 76 777 78 799 80 81 82 83 84 855 866 87 887 87	Masamman Jinhaeman Geojedo Gosung Wando Geojedo Janghueng Pusan Ulsan Ulsan Ulsan Pohang youngilr Jinhaeman Pohang Danghueng Namhae Geojedo Geojedo Geojedo Geojedo Geojedo Ulsan Tongyoung Jinhaeman Rasanman Geojedo Geojedo Ulsan Tongyoung Jinhaeman Namhae Chungnam Pohang Kunsan Jinhaeman Pohang Kunsan		$\begin{array}{r} 19\-08\-99\-\\ 19\-08\-99\-\\ 19\-08\-99\-\\ 21\-08\-99\-\\ 21\-08\-99\-\\ 21\-08\-99\-\\ 21\-08\-99\-\\ 25\-08\-99\-\\ 25\-08\-99\-\\ 25\-08\-99\-\\ 25\-08\-99\-\\ 29\-08\-99\-\\ 29\-08\-99\-\\ 29\-08\-99\-\\ 29\-08\-99\-\\ 29\-08\-99\-\\ 29\-08\-99\-\\ 29\-08\-99\-\\ 29\-08\-99\-\\ 20\-09\-99\-\\ 20\-08\-99\-\\ 28\-09\-99\-\-\-20\-00\-\-00\-\-00\-\-00\-\-00\-\-00\00\-\-00\$		Skeletonema costatum Gymnodhinum sanguineum Gymnodhinum mikimotoi Cochlodinium polykrikoides Cochlodinium solykrikoides Cochlodinium solykrikoides Gymnodinium sp. Prorocentrum triestimum Gymnodinium sanguineum Gymnodinium sp. Gymnodinium sp. Skeletonema costatum Prorocentrum sp. Skeletonema costatum Prorocentrum miniuma Cochlodinium polykrikoides Cochlodinium polykrikoides Cochlodinium costatum Heterocapsa triquetra Chromonas marina	Gymnodinium sp. Chaetoceros sp. Cochlodinium polykrikoides Gymnodinium fissum Cochlodinium polykrikoides	Eutreptiella gymnastica(5 4)	
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 96 Masanman Hangamman 14-06-00 Heterosigma Ceratium furca	53 54 55 56 577 58 59 600 61 65 67 68 69 69 700 711 72 733 74 75 766 777 78 799 800 811 82 83 844 855 866 87 889 990	Masamman Jinhaeman Geojedo Gosung Wando Geojedo Janghueng Pusan Ulsan Kyoungju Pohang youngjin Jinhaeman Pohang Janghueng Janghueng Janghueng Mamhae Geojedo Gokun Wonmunman Geojedo Gosung Kadukdo Junnam Geojedo Geojedo Ulsan Tongyoung Jinhaeman Geojedo Gosung kun Jinhaeman Geojedo Gosung kun Junbuk Chungnam Pohang kunsan Jinhaeman Jinhaeman Jinhaeman Danbuk		$\begin{array}{r} 19 \cdot 08 \cdot 99 & . \\ 19 \cdot 08 \cdot 99 & . \\ 21 \cdot 08 \cdot 99 & . \\ 21 \cdot 08 \cdot 99 & . \\ 21 \cdot 08 \cdot 99 & . \\ 22 \cdot 08 \cdot 99 & . \\ 25 \cdot 08 \cdot 99 & . \\ 25 \cdot 08 \cdot 99 & . \\ 25 \cdot 08 \cdot 99 & . \\ 29 \cdot 08 \cdot 99 & . \\ 29 \cdot 08 \cdot 99 & . \\ 29 \cdot 08 \cdot 99 & . \\ 31 \cdot 09 \cdot 00 & . \\ 31 \cdot 00 \cdot 00 & . \\ 31 \cdot 0$		Skeletonema costatum Gymnodhilum sanguineum Gymnodhilum sanguineum Cochlodinium polykrikoides Cochlodinium solykrikoides Cochlodinium solykrikoides Cochlodinium solykrikoides Cochlodinium sanguineum Gymnodinium sanguineum Gymnodinium sanguineum Gymnodinium sanguineum Gymnodinium sanguineum Gymnodinium sanguineum Gymnodinium sanguineum Prorocentrum nikimotoi Gymnodinium sanguineum Prorocentrum mikimotoi Skeletonema costatum Prorocentrum miniumo Cochlodinium polykrikoides Eutreptiella gymnastica Eutreptiella gymnastica	Gymnodinium sp. Chaetoceros sp. Cochlodinium polykrikoides Gymnodinium fissum Cochlodinium polykrikoides Cochlodinium polykrikoides Mesodinium rubrum Pesudoniitzschia pungens	Eutreptiella gymnastica(5.4)	
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 akashiwo Poro. Micans	53 54 55 56 57 58 59 60 61 63 64 65 67 68 69 70 73 74 75 76 777 78 770 78 81 82 83 84 85 866 87 888 899 901 91	Masamman Jinhaeman Geojedo Gosung Wando Geojedo Janghueng Pusan Ulsan Ulsan Ulsan Pohang youngjin Jinhaeman Pohang Janghueng Namhae Geojedo Geojedo Junnam Masamman Geojedo Geojedo Ulsan Tongyoung Jinhaeman Gosung Jinhaeman Pohang Lunsan Chungnam Pohang Kaukato Chungnam Jinhaeman Jinhaeman Jinhaeman Jinhaeman Pohang Kunsan Jinhaeman Pohang Kunsan Masamman Masamman Masamman		$\begin{array}{r} 19\-08\-99\-\\ 19\-08\-99\-\\ 19\-08\-99\-\\ 21\-08\-99\-\\ 21\-08\-99\-\\ 21\-08\-99\-\\ 22\-08\-99\-\\ 25\-08\-99\-\\ 25\-08\-99\-\\ 25\-08\-99\-\\ 25\-08\-99\-\\ 29\-08\-99\-\\ 29\-08\-99\-\\ 29\-08\-99\-\\ 29\-08\-99\-\\ 29\-08\-99\-\\ 29\-08\-99\-\\ 29\-08\-99\-\\ 20\-09\-99\-\\ 20\-09\-99\-\\ 20\-09\-99\-\\ 20\-09\-99\-\\ 20\-09\-99\-\\ 20\-09\-99\-\\ 20\-09\-\\ 20\-09\-\\ 20\-09\-\\ 20\-09\-\\ 20\-00\-\-\-00\-\-\-00\-\-0\-\-00\-\-00\-\-00\-\-$		Skeletonema costatum Gymnodhinum sanguineum Gymnodhinum mikimotoi Cochlodinium polykrikoides Cochlodinium polykrikoides Gymnodinium sp. Prorocentrum triestinum Gymnodinium sp. Gymnodinium sp	Gymnodinium sp. Chaetoceros sp. Cochlodinium polykrikoides Gymnodinium fissum Cochlodinium polykrikoides Cochlodinium polykrikoides Mesodinium rubrum Pesudoniitzschia pungens	Eutreptiella gymnastica(5.4)	
95 Onsanman JangsangPohang 07-06-00 Heterosigma akashiwo 96 Masanman Hangamman 14-06-00 Heterosigma Ceratium furca	53 54 55 56 577 58 599 600 611 62 633 64 655 666 677 78 774 775 778 778 778 788 884 855 886 877 884 85 866 877 900 901 901 921	Masamman Jinhaeman Geojedo Gosung Wando Geojedo Janghueng Pusan Ulsan Kyoungju Pohang youngjir Jinhaeman Pohang Googedo Gokun Wonmunman Geojedo Geojedo Geojedo Geojedo Ulsan Junhaeman Masanman Geojedo Geojedo Ulsan Jinhaeman Jinhaeman Jinhaeman Pohang Jinhaeman Junbuk Chungaam Pohang Jinhaeman Pohang Hunsan Masanman Masanman Masanman Masanman Masanman Masanman Masanman Masanman Masanman Masanman Masanman Masanman Masanman Masanman		$\begin{array}{r} 19\mbox{-}08\mbox{-}99\mbox{-}\\ 19\mbox{-}08\mbox{-}99\mbox{-}\\ 21\mbox{-}08\mbox{-}99\mbox{-}\\ 21\mbox{-}08\mbox{-}99\mbox{-}\\ 25\mbox{-}08\mbox{-}99\mbox{-}\\ 25\mbox{-}08\mbox{-}99\mbox{-}\\ 25\mbox{-}08\mbox{-}99\mbox{-}\\ 29\mbox{-}08\mbox{-}99\mbox{-}\\ 29\mbox{-}08\mbox{-}99\mbox{-}\\ 29\mbox{-}08\mbox{-}99\mbox{-}\\ 29\mbox{-}08\mbox{-}99\mbox{-}\\ 29\mbox{-}08\mbox{-}99\mbox{-}\\ 29\mbox{-}08\mbox{-}99\mbox{-}\\ 29\mbox{-}08\mbox{-}99\mbox{-}\\ 29\mbox{-}08\mbox{-}99\mbox{-}\\ 29\mbox{-}08\mbox{-}99\mbox{-}\\ 20\mbox{-}09\mbox{-}99\mbox{-}\\ 15\mbox{-}09\mbox{-}99\mbox{-}\\ 15\mbox{-}09\mbox{-}99\mbox{-}\\ 15\mbox{-}09\mbox{-}99\mbox{-}\\ 15\mbox{-}09\mbox{-}99\mbox{-}\\ 15\mbox{-}09\mbox{-}99\mbox{-}\\ 15\mbox{-}09\mbox{-}99\mbox{-}\\ 28\mbox{-}09\mbox{-}99\mbox{-}\\ 21\mbox{-}10\mbox{-}99\mbox{-}\\ 21\mbox{-}10\mbox{-}99\mbox{-}\\ 21\mbox{-}10\mbox{-}99\mbox{-}\\ 21\mbox{-}10\mbox{-}99\mbox{-}\\ 21\mbox{-}10\mbox{-}99\mbox{-}\\ 21\mbox{-}10\mbox{-}99\mbox{-}\\ 21\mbox{-}10\mbox{-}00\mbox{-}\\ 22\mbox{-}00\mbox{-}\\ 17\mbox{-}00\mbox{-}\\ 23\mbox{-}00\mbox{-}\\ 25\mbox{-}00\mbox{-}\\ 25\mbox{-}00\mbox{-}\ 25\mbox{-}00\$		Skeletonema costatum Gymnodhinum sanguineum Gymnodhinum mikimotoi Cochlodinium polykrikoides Cochlodinium solykrikoides Cochlodinium spolykrikoides Cochlodinium solykrikoides Cochlodinium sanguineum Gymnodinium sanguineum Gymnodinium sanguineum Gymnodinium sp. Skeletonema costatum Gymnodinium sp. Skeletonema costatum Cochlodinium polykrikoides Cochlodinium polykrikoides Skeletonema costatum Cochlodinium polykrikoides Cochlodinium polykrikoides Cochlodinium polykrikoides Cochlodinium polykrikoides Cochlodinium polykrikoides Cochlodinium sp. Skeletonema costatum Heterocapsa triquetra Chromonas marina Eutreptiella gymnastica Prorocentrum sp. Heterosigma akashiwo Nociliucas scittillans	Gymnodinium sp. Chaetoceros sp. Cochlodinium polykrikoides Gymnodinium fissum Cochlodinium polykrikoides Mesodinium rubrum Pseudonitzschia pungens Heterocapsa sp.	Eutreptiella gymnastica(5.4)	
96 Masanman Hangamman 14-06-00 Heterosigma Ceratium furca Proro. Micans	53 54 55 56 577 58 599 600 611 62 633 644 655 660 770 78 776 776 778 80 81 82 833 844 855 86 877 88 899 900 911 922 93	Masamman Jinhaeman Geojedo Gosung Wando Geojedo Janghueng Pusan Ulsan Ulsan Kyoungju Pohang youngjin Jinhaeman Pohang Janghueng Janghueng Janghueng Gooledo Gokun Gosung Kadukdo Junnam Geojedo Geojedo Geojedo Geojedo Geojedo Ulsan Tongyoung Jinhaeman Namhae Gosunggkun Junbuk Chungaam Pohang kunsan Jinhaeman Pohang kunsan Jinhaeman Pohang kunsan Masamman Kasamman Kasamman Masamman Kasamman Kasamman Kasamman Masamman Kasamman Masamman Kasamman Masamman Masamman Masamman Masamman Masamman Masamman Masamman Masamman Masamman Masamman Masamman Kyoungju Tongyoung		$\begin{array}{r} 19\-08\-99\-\\ 19\-08\-99\-\\ 19\-08\-99\-\\ 21\-08\-99\-\\ 21\-08\-99\-\\ 21\-08\-99\-\\ 22\-08\-99\-\\ 25\-08\-99\-\\ 25\-08\-99\-\\ 25\-08\-99\-\\ 29\-08\-99\-\\ 29\-08\-99\-\\ 29\-08\-99\-\\ 29\-08\-99\-\\ 29\-08\-99\-\\ 29\-08\-99\-\\ 29\-08\-99\-\\ 29\-08\-99\-\\ 20\-09\-99\-\\ 20\-09\-99\-\\ 20\-09\-99\-\\ 20\-09\-99\-\\ 20\-09\-99\-\\ 20\-09\-99\-\\ 20\-09\-\\ 20\-09\-\\ 20\-00\-\-\-00\-\-\-00\-\-0\-\-00\-\-00\-\-00\-\-$		Skeletonema costatum Gymnodhinum sanguineum Gymnodhinum mikimotoi Cochlodinium polykrikoides Cochlodinium songuineum Gymnodinium sanguineum Gymnodinium sanguineum Gymnodinium sanguineum Gymnodinium sanguineum Gymnodinium sp. Skeletonema costatum Prorocentrum mikimotoi Gymnodinium sp. Skeletonema costatum Prorocentrum sp. Skeletonema costatum Prorocentrum mikimotoi Gymnodinium sp. Skeletonema costatum Prorocentrum sp. Skeletonema costatum Prorocentrum sp. Skeletonema costatum Prorocentrum costatum Prorocentrum costatum Prorocentrum sp. Skeletonema costatum Prorocentrum sp. Skeletonema costatum Prorocentrum sp. Skeletonema costatum Prorocentrum sp. Skeletonema costatum Prorocentrum sp. Skeletonema costatum Heterosigma akashiwo Nocilica scintilans	Gymnodinium sp. Chaetoceros sp. Cochlodinium polykrikoides Gymnodinium fissum Cochlodinium polykrikoides Mesodinium rubrum Pseudonitzschia pungens Heterocapsa sp. Prorocentrum micans	Eutreptiella gymnastica(5.4)	
	53 54 55 56 57 58 59 60 61 63 64 65 67 68 69 70 71 74 75 76 777 78 777 78 81 823 84 855 866 877 88 899 900 91 92 93 94	Masamman Jinhaeman Geojedo Gosung Wando Geojedo Janghueng Pusan Ulsan Ulsan Ulsan Pohang youngili Jinhaeman Pohang Janghueng Namhae Geojedo Gosung Kadukdo Junnam Masanman Geojedo Geojedo Ulsan Tongyoung Jinhaeman Pohang Junbuk Chungnam Pohang Junbuk Chungnam Jinhaeman Jinhaeman Masanman		$\begin{array}{r} 19\-08\-99\-\\ 19\-08\-99\-\\ 19\-08\-99\-\\ 21\-08\-99\-\\ 21\-08\-99\-\\ 21\-08\-99\-\\ 22\-08\-99\-\\ 22\-08\-99\-\\ 22\-08\-99\-\\ 22\-08\-99\-\\ 22\-08\-99\-\\ 23\-08\-99\-\\ 23\-08\-99\-\\ 23\-08\-99\-\\ 23\-08\-99\-\\ 23\-08\-99\-\\ 23\-08\-99\-\\ 23\-09\-99\-\\ 23\-00\-\-\\ 23\-00\-\-\-00\-\\ 23\-00\-\-\-00\-\-\-00\-\-\-00\-\-0\0\-\-0\0\-\-0\-\-0\-\-0\0\-\-0\$		Skeletonema costatum Gymnodhinum sanguineum Gymnodhinum mikimotoi Cochlodinium polykrikoides Cochlodinium sp. Schlodinium sp. Prorocentrum triestinum Gymnodinium sp. Gymnodinium polykrikoides Cochlodinium polykrikoides Cochlodini	Gymnodinium sp. Chaetoceros sp. Cochlodinium polykrikoides Gymnodinium fissum Cochlodinium polykrikoides Mesodinium rubrum Pseudonitzschia pungens Heterocapsa sp. Prorocentrum micans Gymnodinium sanguineum	Eutreptiella gymnastica(5.4)	
	53 54 55 56 577 58 59 600 611 62 633 644 655 660 770 78 776 778 779 800 811 82 833 84 855 866 8779 900 911 922 933 944 955 956	Masamman Jinhaeman Geojedo Gosung Wando Geojedo Janghueng Pusan Ulsan Ulsan Pohang youngil Jinhaeman Pohang Geojedo Gokun Wonmunman Geojedo Gokun Wonmunman Geojedo Gieojedo Gieojedo Ulsan Tongyoung Jinhaeman Namhae Gosung Kadukdo Junam Kasanman Masanman	aan aan aa	$\begin{array}{r} 19\-08\-99\-\\ 19\-08\-99\-\\ 19\-08\-99\-\\ 21\-08\-99\-\\ 21\-08\-99\-\\ 21\-08\-99\-\\ 21\-08\-99\-\\ 25\-08\-99\-\\ 25\-08\-99\-\\ 25\-08\-99\-\\ 25\-08\-99\-\\ 29\-08\-99\-\\ 29\-08\-99\-\\ 29\-08\-99\-\\ 29\-08\-99\-\\ 29\-08\-99\-\\ 20\-09\-99\-\\ 20\-09\-99\-\\ 21\-09\-99\-\\ 21\-09\-99\-\\ 25\-09\-99\-\\ 25\-09\-99\-\\ 25\-09\-99\-\\ 28\-09\-\-00\-\\ 28\-00\-\\ 29\-05\-00\-\\ 23\-00\-\\ 29\-05\-00\-\-0\-\-0\-\-0\0\-\-0\0\0\0\$		Skeletonema costatum Gymnodhinum sanguineum Gymnodhinum mikimotoi Cochlodinium polykrikoides Cochlodinium solykrikoides Gymnodinium sanguineum Gymnodinium sanguineum Gymnodinium sp. Prorocentrum triestinum Gymnodinium sp. Skeletonema costatum Prorocentrum sp. Skeletonema costatum Heterosigma akashiwo Heterosigma akashiwo Heterosigma akashiwo	Gymnodinium sp. Chaetoceros sp. Cochlodinium polykrikoides Gymnodinium fissum Cochlodinium polykrikoides Cochlodinium polykrikoides Mesodinium rubrum Pseudonitzschia pungens Heterocapsa sp. Prorocentrum micans Gymnodinium sanguineum		

	*		Duration		<u> </u>								mitigation		
Event	Location (name	of the sea area)	Duration	Continuous	,		Max. cell de	nsity (ce	lls/L)				activity and	Dan	nage
No.	Location 1	Location 2	dd/mm/yy-dd/mm/yy	days				I					effectivenes	Fisheries resource	Human health
1	Tongyoung buks	inman	01-01-99 -		5,200,000				-				N		
	Sachun hangchor		23-01-99 -		3,000,000										
	Tongyoung hans Tongyoung kwar		28-01-99 -		780,000										
	Masanman sanho		19-04-99 - 23-04-99 -		830,000 19,800,000			(+			<u> </u>	'		
	Geoje ilunmyour		26-04-99 -		5,450,000										
	Masan nanpo		26-04-99 -		31,000,000										
	Jinhaeman haeng		28-04-99 -		16,500,000			<u> </u>	<u> </u>			<u> </u>			
	Gunsan naehang Jinhaeman haeng		01-05-99 - 06-05-99 -		800,000 1,320,000						<u> </u>				
	Ulsan	am	13-05-99 -		2,000,000				-	-					
	Tongyoung, bub	songman, buksin			4,500,000										
	Masanman		24-05-99 -		3,960,000										
	Tongyoung won		24-05-99 -		6,500,000 7,300,000						<u> </u>	<u> </u>			
	Tongyoung buks kunsan	inman	28-05-99 - 02-06-99 -		12,000,000						<u> </u>		I		
	masanman	haengamman	04-06-99 -			15,000,000		1	<u> </u>						
	Namhaegun		08-06-99 -		6,000,000										
19	Yeosu gamakma		09-06-99 - 18-06-99 -		16,700,000		020.000				<u> </u>	<u> </u>			
	Pohang youngiln Tongyoung kwar		18-06-99 -		650,000 6,600,000		920,000	(-			<u> </u>	'		
	Geojedo	igdoniyoun	19-06-99 -		330,000				1				-		
	Tongyoung buks		21-06-99 -		5,600,000										
	Namhae kangjim	man	21-06-99 -	L	1,350,000		100.000	—				<u> </u>			
	Pusan kadukdo Wando		28-06-99 - 28-06-99 -	───	15,000,000		100,000				<u> </u>	<u> </u>	'		
	kunsan		29-06-99 -	1	13,000,000			1	1						
28	Pohang youngiln	nan	01-07-99 -		600,000	1,500,000	1,600,000	1,500,000							
	Junnam young		06-07-99 -	<u> </u>	1,100,000				\vdash			\square			
30 31		inman dolsan	06-07-99 - 06-07-99 -	───	2,500,000 2,000,000		250.000	1,700,000				<u> </u>	'		
	Yeosu Namhaedo kangj		06-07-99 -	<u> </u>	2,000,000		230,000	1,700,000							
	Junnam		08-07-99 -		1,500,000	2,000,000	1,400,000	300,000	1	-			-		
34	Pohang youngiln		21-07-99 -	\square	6,200,000	1,500,000									
	Buankun widom		22-07-99 -		1,000,000						<u> </u>		ļ!		
	Jinhaeman Gosung	Masan	22-07-99 - 07-08-99 -		4,180,000										
38	Asanman		08-08-99 -		4,537,000										
39	Namhaekun	hadongkun	10-08-99 -		2,000,000	3,000,000									
		Kamakman	10-08-99 -			11,200,000	3,600,000	1,100,000							
	Ulsan		11-08-99 - 11-08-99 -		20,000,000	10,000,000 7,500,000	5,000,000								
	Chunsuman Masan, sanho, du	ikdong	11-08-99 -		1,760,000		5,000,000		-						
	Goheung narodo	indong	11-08-99 -		260,000			1	1						
	Yeosu hwajungn		11-08-99 -		50,000										
	Pohang youngiln		13-08-99 -		2,500,000		2,000,000	<u> </u>	<u> </u>		<u> </u>	<u> </u>			
	Namhaekun sang Tongyoung	ցս	14-08-99 - 14-08-99 -		300,000 500,000										
49	geojedo		16-08-99 -		1,870,000			1	1						
	Ulsan		17-08-99 -		200,000										
	Masan	Jinhaeman	17-08-99		5,280,000			— —				<u> </u>			
	Geojedo		18-08-99 - 19-08-99 -		1,980,000 3,440,000				-			<u> </u>			
	Masanman Jinhaeman		19-08-99 -		3,080,000						<u> </u>		I		
	Geojedo		21-08-99 -		7,500,000										
	Gosung		21-08-99 -		2,700,000										
	Wando		24-08-99 -		500,000 1,700,000							<u> </u>			
	Geojedo Janghueng		25-08-99 - 25-08-99 -		4,000,000			-			<u> </u>		I		
	Pusan		28-08-99 -		1,100,000				1						
	Ulsan		29-08-99 -		4,500,000										
62	Kyoungju		29-08-99 -	\vdash	3,000,000				<u> </u>			\vdash			
	Pohang youngiln Jinhaeman	nan	31-08-99 - 31-08-99 -	<u> </u>	3,000,000 7,890,000			1			<u> </u>	<u> </u>	┝────┘		
	Pohang		02-09-99 -	1	3,800,000				1						
66	Janghueng		06-09-99 -		1,300,000										
	Namhae		06-09-99 -	L	150,000				<u> </u>						
	Geojedo Gokun		13-09-99 - 14-09-99 -	───	500,000 2,500,000						<u> </u>		'		
	Wonmunman		14-09-99 -	<u> </u>	2,500,000				+			<u> </u>	'		
71	Gosung		15-09-99 -		3,000,000										
72	Kadukdo		15-09-99 -		300,000										
	Junnam		15-09-99 -	───	265,000					<u> </u>		<u> </u>	'		
	Masanman Geojedo		15-09-99 -	───	1,500,000 400,000					<u> </u>	<u> </u>	<u> </u>	'		
76	Geojedo		15-09-99 -		2,300,000										
77	Ulsan		10-09-99 -		3,000,000										
	Tongyoung		25-09-99 -	\vdash	1,100,000				<u> </u>			\vdash	ļ		
	Jinhaeman Namhae		27-09-99 - 28-09-99 -	───	8,500,000 8,000,000			(<u> </u>	<u> </u>	'		
	Gosungkun		02-10-99 -		1,300,000				1						
82	Junbuk		12-10-99 -		250,000										
	Chungnam		21-10-99 -		500,000										
	Pohang kunsan		17-02-00 02-03-00	───	15,000,000 25,000,000						<u> </u>	<u> </u>	<u> </u>		
	kunsan Jinhaeman		20-03-00	<u> </u>	25,000,000			1			<u> </u>	<u> </u>	┟────┘		
	Pohang		01-04-00		17,600,000										
88	kunsan		01-05-00		75,000,000	1,500,000									
89	Masanman		02-05-00	<u> </u>	5,700,000		29,000,000		<u> </u>						
	Masanman Masanman		17-05-00 23-05-00	───	7,700,000					<u> </u>	<u> </u>	<u> </u>			
	Masanman Kyoungju		23-05-00	+	15,400,000										
			29-05-00		1,560,000	780,000									
93	Tongyoung								1						
93 94	Jinhaeman	-	02-06-00		13,800,000										
93 94 95		JangsangPohang Hangamman		<u> </u>	1,150,000	1,120,000 21,000,000 1,530,000									

Event	Location (name	of the sea area)	Duration	Continuous		Causativ	ve species	
No.	Location 1	Location 2	dd/mm/yy-dd/mm/yy	days	_			
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			
	Chungbuk		03-07-00		Ceratium sp.	Noctiluca scintillans		
106	Kamakman		03-07-00		Heterosigma akashiwo	Ceratium sp.		
	Geojedo		04-07-00		Noctiluca scintillans			
	Chunsuman		04-07-00		Proro. Micans	Ceratium sp.		
	Jinhaeman		05-07-00		Heterosigma akashiwo			
	Pusan		06-07-00		Heterosigma akashiwo	Proro. Micans		
	Ulsan		10-0700		Prorocentrum triestinum			
	Geojedo		14-07-00	1	Gymnodinium sanguineum			
	Jinjuman		14-07-00	1	Ceratium furca			
113	Yeosu		18-07-00		Chaetoceros sp.	Skeletonema costatum		
115	Tongyoung		18-07-00		Rhizosolenia sp.	Skeletonenia costatam		
	Masan		18-07-00		Proro, dentatum			
117	kunsan		19-07-00		Noctiluca scintillans			
	Inchun		20-07-00		Mesodinium rubrum			
	Geojedo		20-07-00		Proro. Minimum			
120	Junnam		20-07-00		Heterosigma akashiwo			
120	kadukdo		27-07-00		Heterosigma akashiwo			
121	Ulsan		28-07-00		Prorocentrum sp.			
	Masanman		29-07-00		Prorocentrum sp.			
	Geojedo		02-08-00		Noctiluca scintillans			
	Jinhaeman		07-08-00		Rhizosolenia sp.			
	Haengamman		08-08-00		Proro. Sp. Thala.decipiems			
120	Ulsan		08-08-00		Prorocentrum sp.			
	Pohang		08-08-00		Skeletonema costatum			
	Kyoungbuk		08-08-00		Noctiluca scintillans			
	Onsanman		11-08-00		Prorocentrum sp.	Heterosigma akashiwo		
	JangsangPohang		14-08-00		Prorocentrum sp.	Helerosigma akasniwo		
	Pohang		17-08-00		Skeletonema costatum			
	Ponang Kyoungju		21-08-00		Ceratium furca			
	Ulsan		21-08-00		Ceratium furca			
	Ulsan		22-08-00		Prorocentrum triestinum			
	Junnam		22-08-00		Chaetoceros sp.	Coscinodiscus gigas		
	Junnam Junnam		22-08-00	<u> </u>	Chaetoceros sp. Prorocentrum minimum	Coscinoaiscus gigas		
	Junnam Junnam		22-08-00		Prorocentrum minimum Prorocentrum minimum			
	Ulsan		22-08-00		Prorocentrum minimum Prorocentrum minimum			
			24-08-00 24-08-00		Prorocentrum minimum Thalassiosira decipiens			
	Onsanman Kyoungbuk		24-08-00	<u> </u>	Thalassiosira decipiens Ceratium furca			
	Onsanman		25-08-00 28-08-00	<u> </u>	Ceratium furca Thalassiosira rotula			
				<u> </u>	Thalassiosira rotula Chaetoceros sp.	CI J	C	
	Pohang		28-08-00 28-08-00		Chaetoceros sp. Pyrocystis sp.	Skeletonema costatum	Ceratium furca	
	Ulsan			<u> </u>		Thalassissing notes la		
-	Ulsan		29-08-00 22-08-00	<u> </u>	Prorocentrum dentatum	Thalassiosira rotula		
	Yeosu			<u> </u>	Cochlodinium polykrikoides			
147	Kyoungnam		22-08-00		Cochlodinium polykrikoides			
	Kyoungnam		23-08-00		Cochlodinium polykrikoides			
	Junnam		23-08-00		Cochlodinium polykrikoides			
150	Tongyoung		24-08-00		Cochlodinium polykrikoides	l		1

Event No.	Location (name of the sea area)		Duration	Continuous	Max. cell density (cells/L)								mitigation activity and	Damage	
	Location 1	Location 2	dd/mm/yy-dd/mm/yy	days									effectivenes	isheries resourc	Human health
98	Bubsongman		16-06-00		3,200,000								8		
	Pohang		19-06-00		15,000,000	5,000,000									
	kunsan		21-06-00		10,000,000	2,000,000									
	Yeosu		24-06-00		1,080,000										
101	Tongyoung		27-06-00		99,600,000										
	Pohang		30-06-00		5,000,000										
	Geojedo		01-07-00		300,000										
	Chungbuk		03-07-00		600,000										
105	Kamakman		03-07-00		2.040.000	320,000									
	Geojedo		04-07-00		650,000										
	Chunsuman		04-07-00		3,000,000	300,000									
100	Jinhaeman		05-07-00		12,500,000	200,000									
110	Pusan		06-07-00		32,000,000										
	Ulsan		10-0700		3,000,000										
	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	1,0 20,000									
	Masan		18-07-00		30,500,000										
117	kunsan		19-07-00		5,000,000										
118	Inchun		20-07-00		5,000,000										
	Geojedo		20-07-00		750,000										
120	Junnam		20-07-00		47,800,000										
120	kadukdo		27-07-00		4,200,000										
121	Ulsan		28-07-00		1,500,000										
122	Masanman		29-07-00		13,200,000										
	Geojedo		02-08-00		700,000										
125	Jinhaeman		07-08-00		4,800,000										
	Haengamman		08-08-00		1,200,000	2,700,000									
	Ulsan		08-08-00		20,000,000										
	Pohang		08-08-00		12,000,000										
	Kyoungbuk		08-08-00		1,000,000										
	Onsanman		11-08-00		5,000,000	1,000,000									
131	JangsangPohang		14-08-00		2,300,000										
	Pohang		17-08-00		9,000,000										
133	Kyoungju		21-08-00		1,500,000										
	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										
	Onsanman		28-08-00		640,000										
	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										