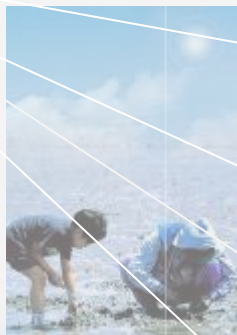


The assessment of Eutrophication Status of Jinhae bay, Republic of Korea

(Including evaluation of land-based sources of nutrients)



Youngtae PARK and Changkyu LEE

Southeast Sea Fisheries Research Institute,
NFRDI, Korea

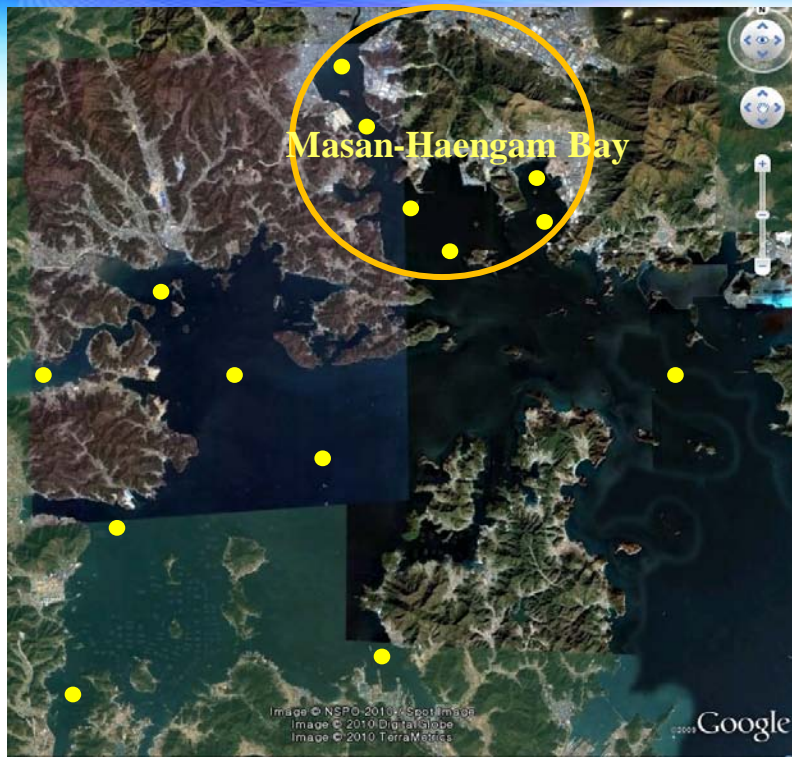


Outline

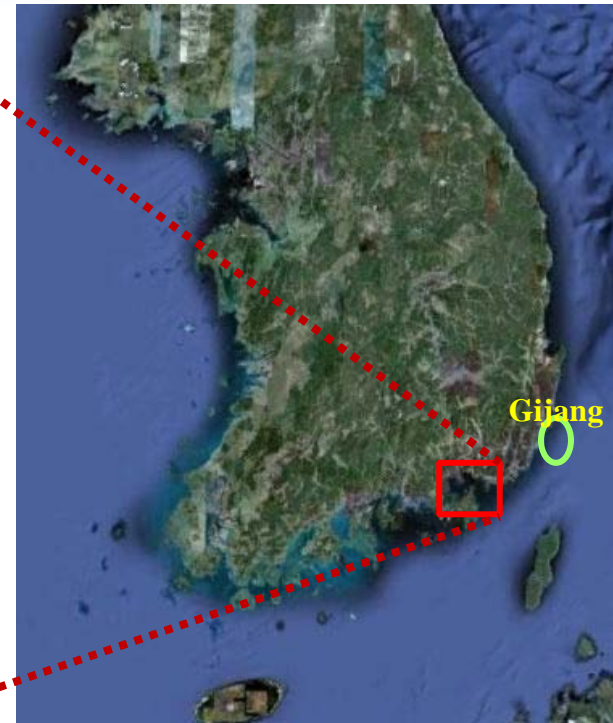


- ❖ **Jinhae bay**
- ❖ **Methods of assessment**
- ❖ **Results of assessment**
 - Category I
 - Category II
 - Category III
 - Category IV
- ❖ **Conclusion and recommendations**

Assessment of Jinhae Bay



Jinhae Bay



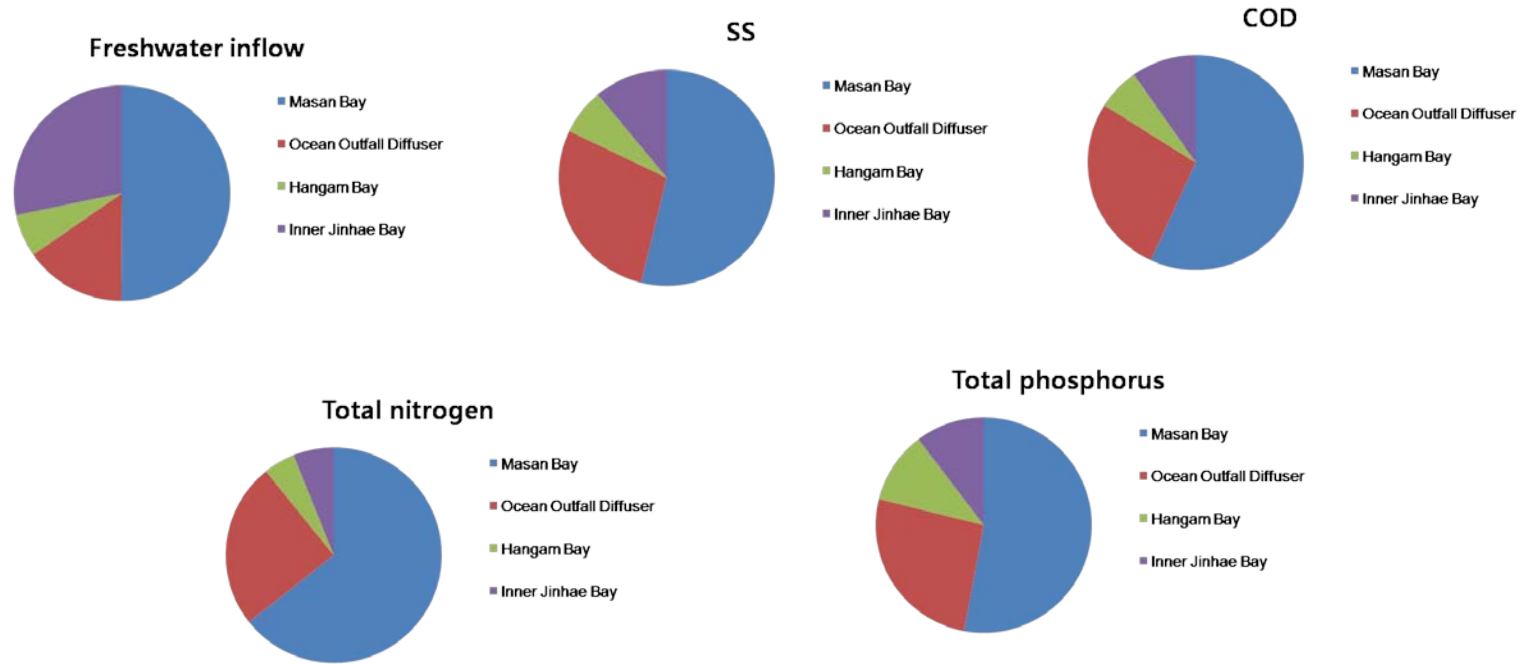
Coastal area of Korea

- Jinhae Bay : including all of small bays such as Goseong, Wonmoon, Jindong, Gohyun, Masan, Haengam Bays
- Masan-Haengam Bay : relatively eutrophicated Bay in Jinhae Bay
- Gijang Coast : Area for obtaining background values

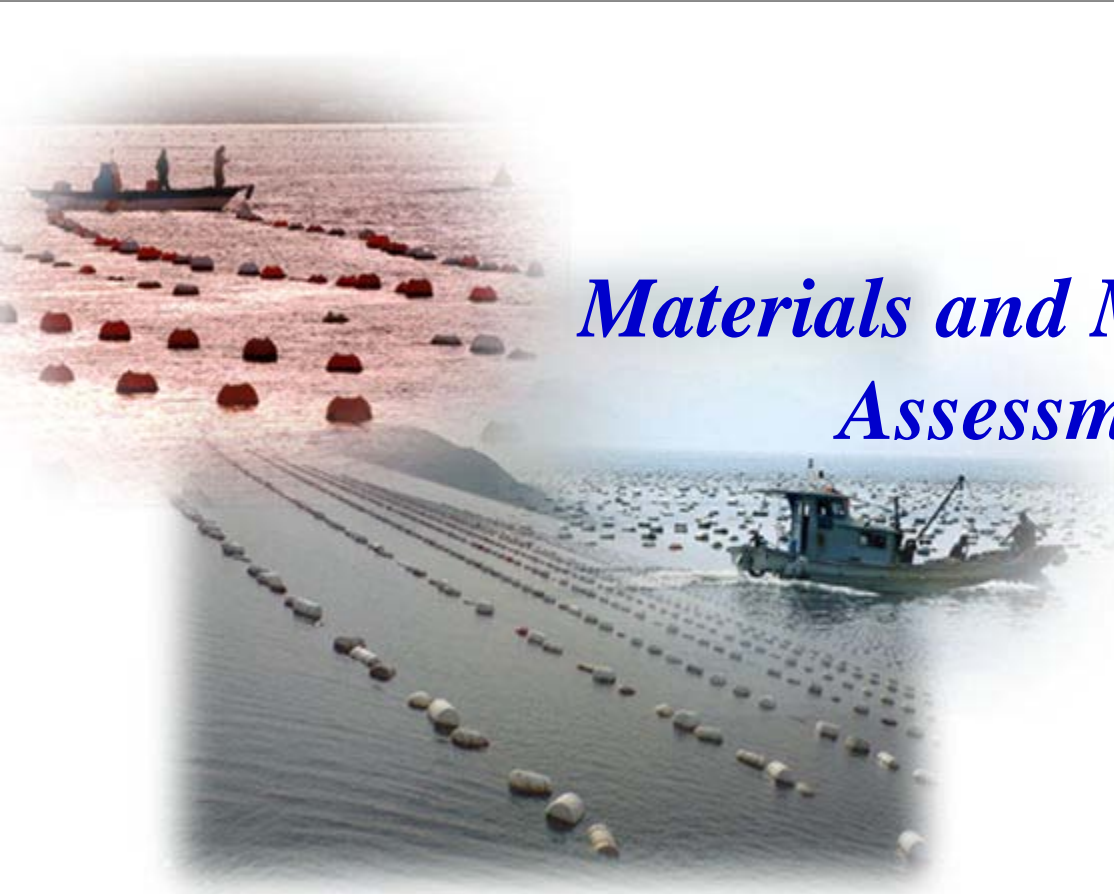
Characteristics of Jinhae Bay



Pollutants loads in Jinhae Bay



Area-wise contribution to the freshwater inflow and pollutants loads in Jinhae Bay (Cho H. Y. and J. W. Chae, 1998).



Materials and Methods for Assessment



Routine monitoring programs related to eutrophication in Korea

Survey area	Governing organization	Survey title	Aim	Survey period	Main survey parameters	Survey frequency	No. of survey points
Jinhae bay (including Masan-Haengam Bay)	NFRDI	Coastal environment monitoring program	Conservation of coastal environment	1984-	Temp. Salinity Transpa. Nutrients COD, pH Chl.-a pollutants	4/year	9-14
		HAB monitoring	HAB warning and prediction to minimize fisheries impact	1979-	Phytoplankt on Nutrients Chl.-a, etc.	1/month	15
		Shellfish toxins monitoring	Detection of shellfish toxin for food safety	1992-	PSP ASP DSP	- 1/month - 1-2/week (depending on toxin level)	19

Note : NFRDI conducts long-term monitoring studies; universities and research institutes conduct short-term and intensive studies.



Used Assessment parameters

Category		Assessment parameter	
I	Degree of nutrient enrichment	Riverine input(T-N, T-P)	1995 - 1996
		Total nitrogen/Total phosphorus (T-N, T-P)	2002 - 2008
		Winter (DIN/DIP) concentration	2002 - 2008
		Winter N/P ratio (DIN/DIP)	2002 - 2008
II	Direct effects of nutrient enrichment	Chlorophyll-a concentration (field data)	2002 - 2008
		Chlorophyll-a concentration (remote sensing data)	Not applicable (low resolution)
		Ratio of area with high Chlorophyll-a concentration (remote sensing data) to the total area	2002 - 2008
		Red –tide events (diatom and dinoflagellate species)	1981 - 2009
III	Indirect effects of nutrient enrichment	Dissolved oxygen (DO)	2002 - 2008
		Abnormal fish kill incidents	- 2008
		Chemical oxygen demand (COD)	2002 - 2008
IV	Other possible effects of nutrient enrichment	Shellfish poisoning incidents	1980-



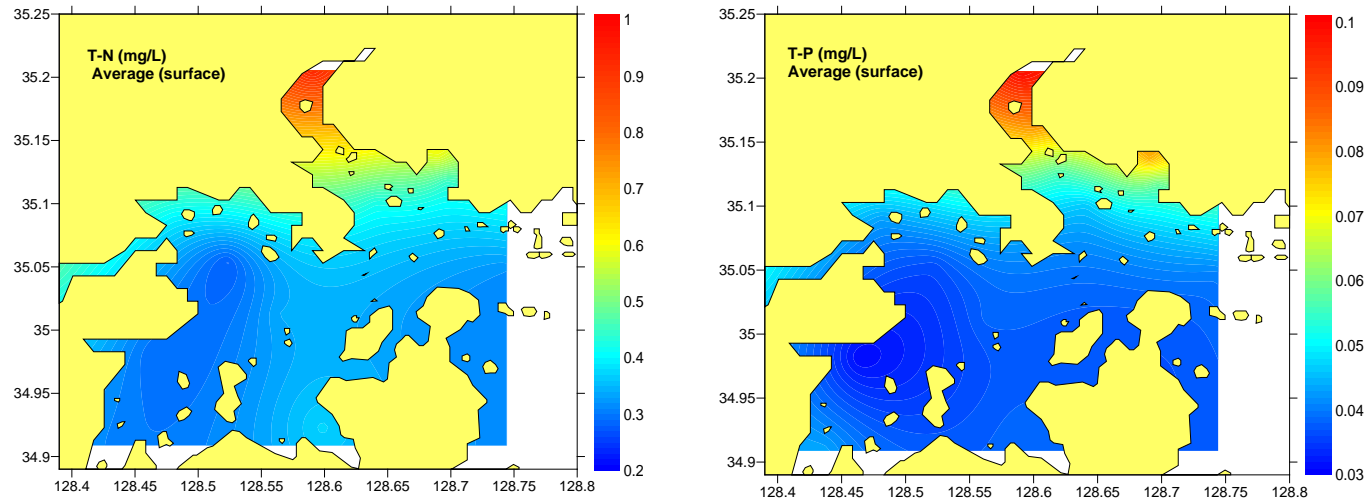
Results and Assessment

Category I : Degree of nutrient enrichment

Total nitrogen/Total phosphorus



The spatial distribution of TN and TP in Jinhae Bay

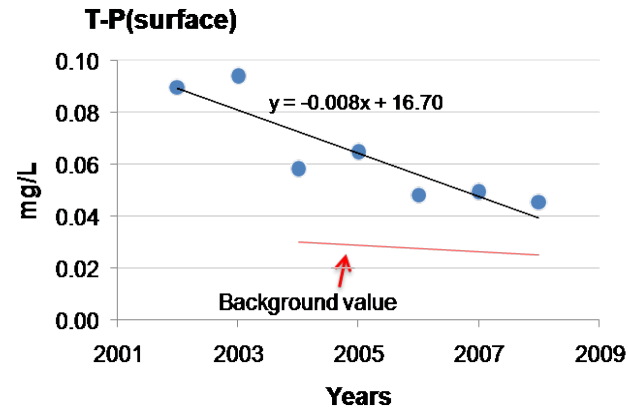
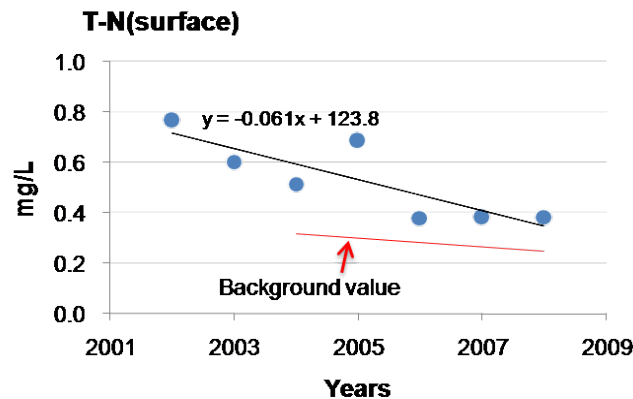


- The mean values of T-N and T-P showed high value in Masan Bay where is directly affected by nearby Masan city

Total nitrogen/Total phosphorus



The variation of TN and TP in Jinhae Bay



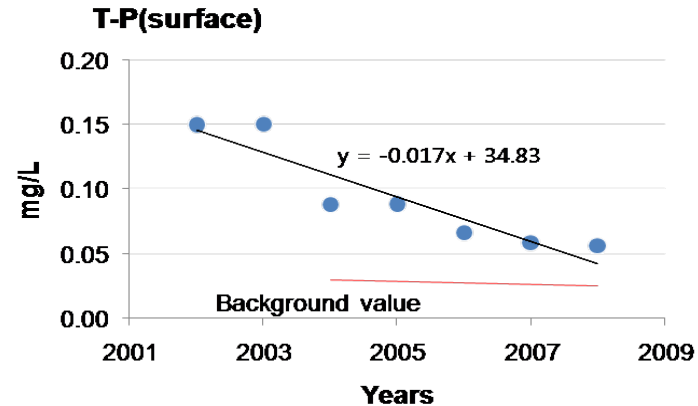
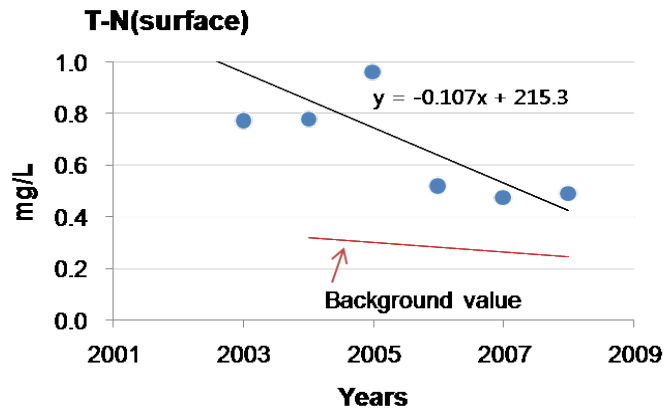
- The annual mean values for T-N and T-P in Jinhae Bay showed slightly decreasing trend since 2002, ranging 0.3~0.7mg/L, 0.04~0.09mg/L in T-N and T-P, respectively.

- The current status of eutrophication in Jinhae Bay was classified as 'high' considering that the mean values of T-N and T-P in Jinhae Bay from 2004 to 2008 showed more than 150% of background values.

Total nitrogen/Total phosphorus



The variation of TN and TP in Masan-Haengam Bay



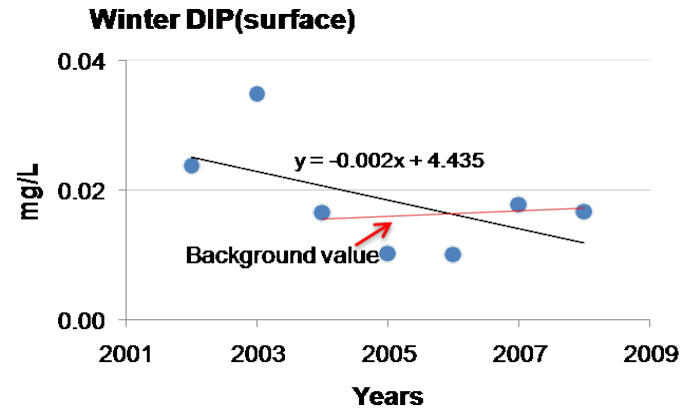
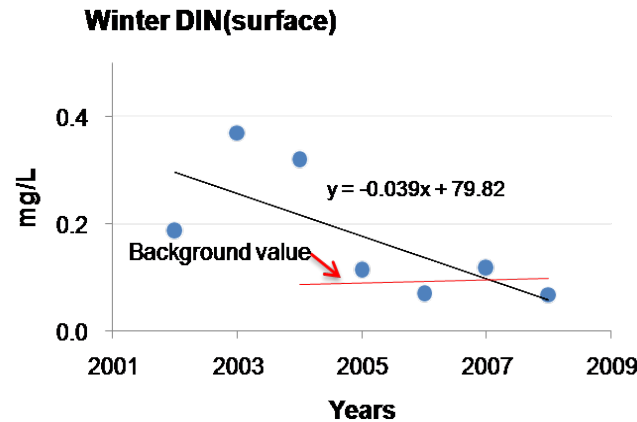
- The annual mean values for T-N and T-P in Masan-Haengam Bay showed slightly decreasing trend since 2002, ranging 0.49~0.21 mg/L, 0.06~0.15 mg/L in T-N and T-P, respectively.

- Current status of eutrophication in Masan-Haengam Bay was classified as 'high' considering that the mean values of T-N and T-P in Masan-Haengam Bay from 2004 to 2008 showed more than 250% of background values.

Winter DIN/DIP concentration



The variation of Winter DIN/DIP concentration in Jinhae Bay



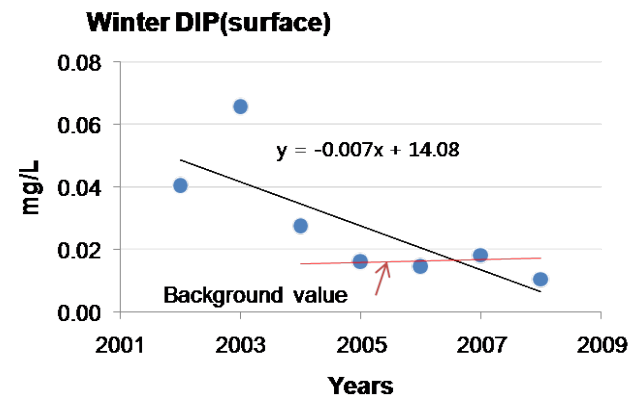
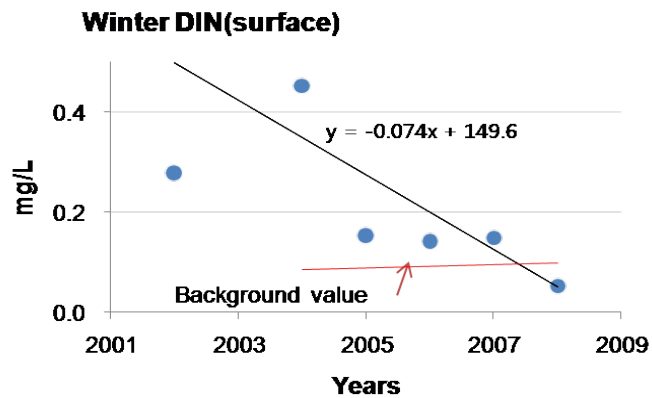
- Winter DIN and DIP level in Jinhae Bay, ranging 0.06~0.36mg/L and 0.01~0.03mg/L, respectively, showed decreasing trend over times since 2002

- Current status of eutrophication in Jinhae Bay was classified as 'low' considering that the mean values of winter DIN and winter DIP was similar or lower than that of background value since 2004 or 2005

Winter DIN/DIP concentration



The variation of Winter DIN/DIP concentration in Masan-Haengam Bay



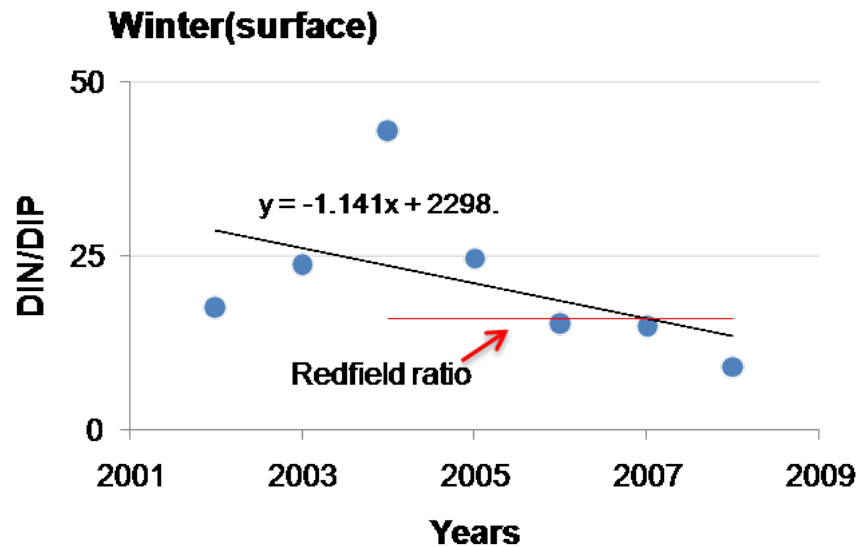
- Winter DIN and DIP level in Masan-Haengam Bay, ranging 0.05~0.45mg/L and 0.01~0.07mg/L, respectively, showed decreasing trend over times since 2002

- In comparison with background values for winter DIN and DIP, current status of eutrophication in Masan-Haengam Bay was classified as 'low'

Winter N/P ratio (DIN/DIP)



● The variation of Winter N/P ratio (DIN/DIP) in Jinhae Bay

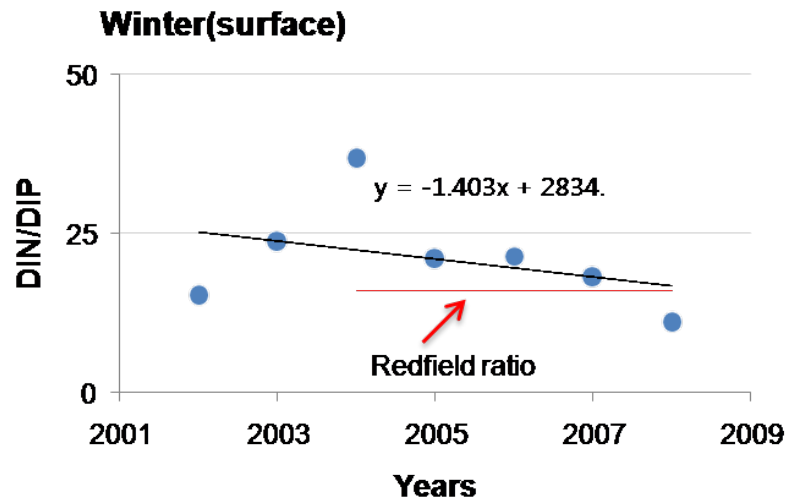


- Winter N/P ratio in Jinhae Bay has shown decreasing trend in recent years.
- In comparison with Red-field ratio for N/P ratio, current status of Jinhae Bay was classified as 'low'

Winter N/P ratio (DIN/DIP)



● The variation of Winter N/P ratio (DIN/DIP) in Masan-Haengam Bay



- Winter N/P ratio has shown slightly decreasing trend in recent years.
- In comparison with Red-field ratio for N/P ratio, current status of Masan-Haengam Bay was classified as 'low'



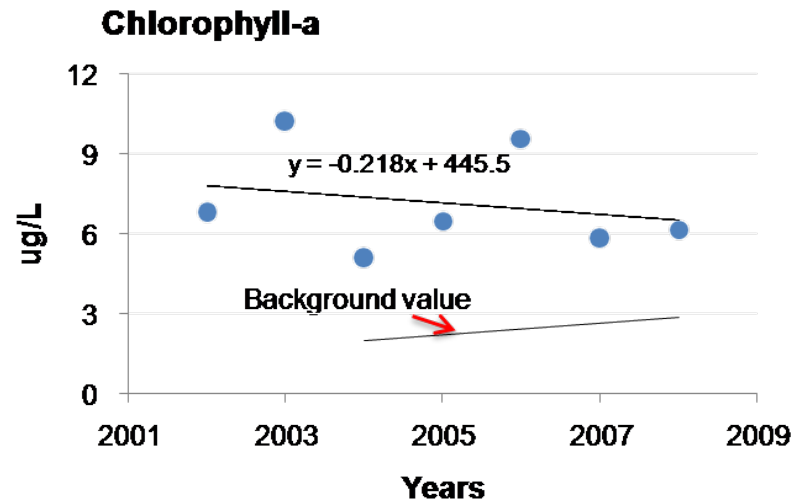
Results and Assessment

Category II : Direct effects of nutrients enrichment

Chlorophyll-a concentration (field data)



The variation of Chlorophyll-a concentration in Jinhae Bay

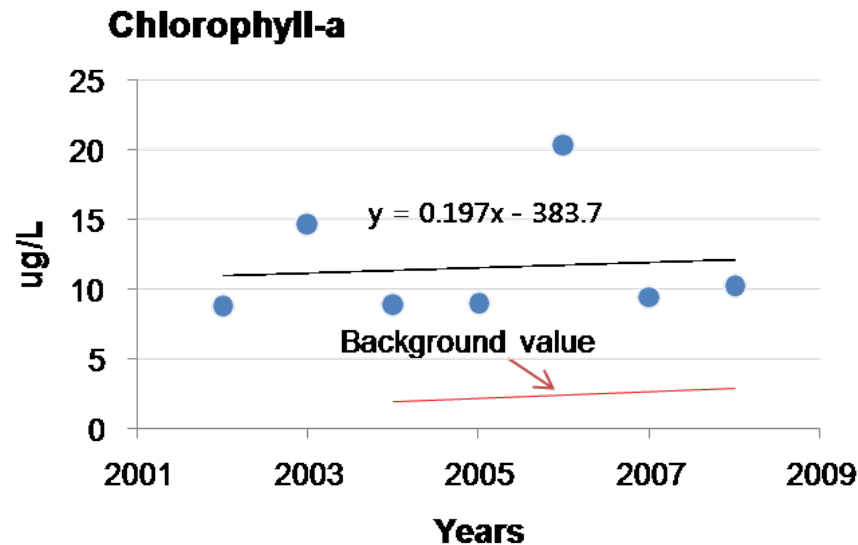


- Chlorophyll-a mean values in Jinhae Bay has shown gradual decreasing trend over time since 2002.
- Chlorophyll-a showed higher value than background value obtained from Gijang area.

Chlorophyll-a concentration (field data)



● The variation of Chlorophyll-a concentration in Masan-Haengam Bay

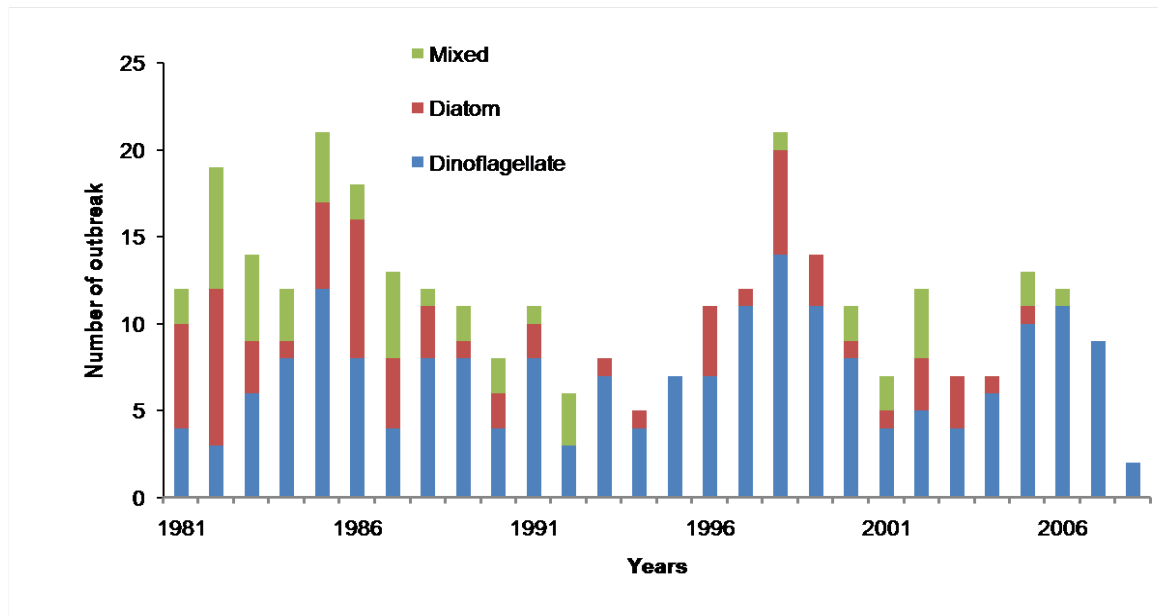


- Chlorophyll-a mean values in Masan-Haengam Bay didn't show any remarkable trend during the period
- Chlorophyll-a showed higher value than background value obtained from Gijang area

Red-tide events



The variation of Red-tide events in Jinhae Bay



- Red-tide events showed higher number in 1980s (mean 14.7 events) than in 1990s (mean 10.6 events) and 2000s (mean 8.9 events) with showing the highest in 1985 (21 events) and the lowest in 2008 (2 events)



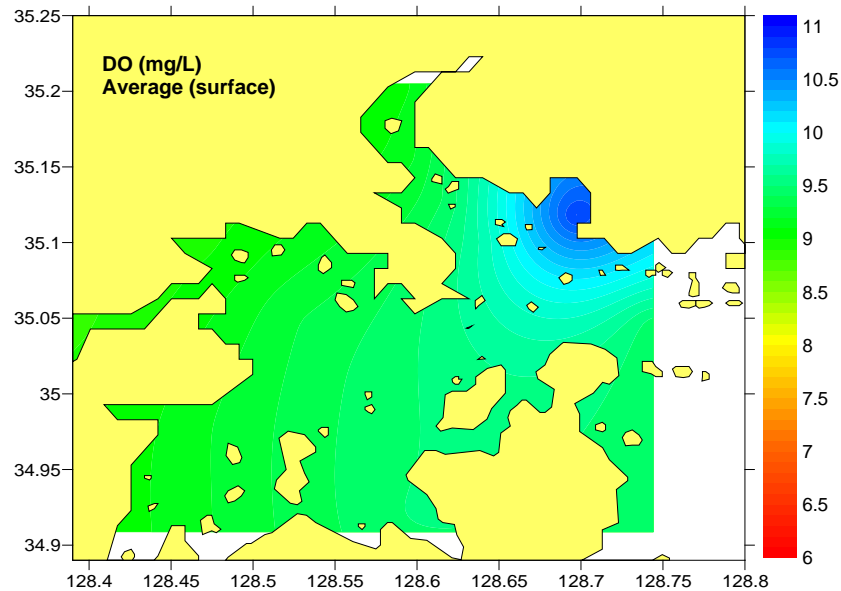
Results and Assessment

Category III: Indirect effects of nutrients enrichment

Dissolved oxygen



The spatial distribution of Dissolved oxygen in Jinhae Bay



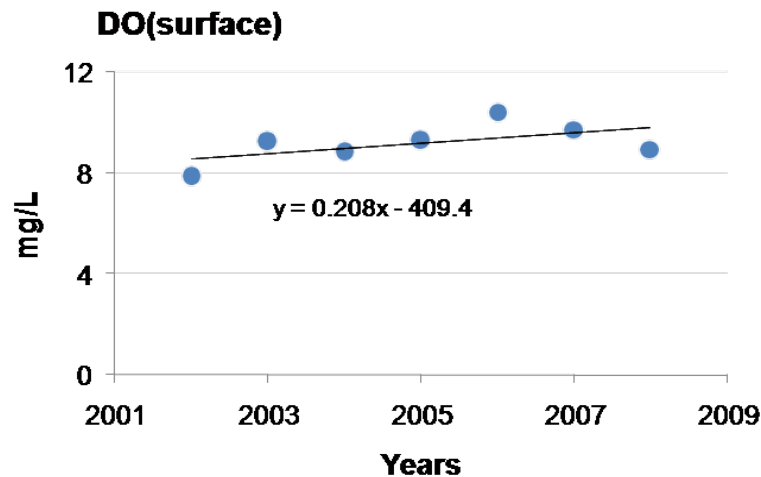
- DO values was the highest (surface, 7.8~10.4mg/L) in Haegam Bay

-The rest of the areas, also, showed relatively high DO values with showing more than 8mg/L in the surface

Chlorophyll-a concentration (field data)



The variation of Dissolved oxygen in Jinhae Bay

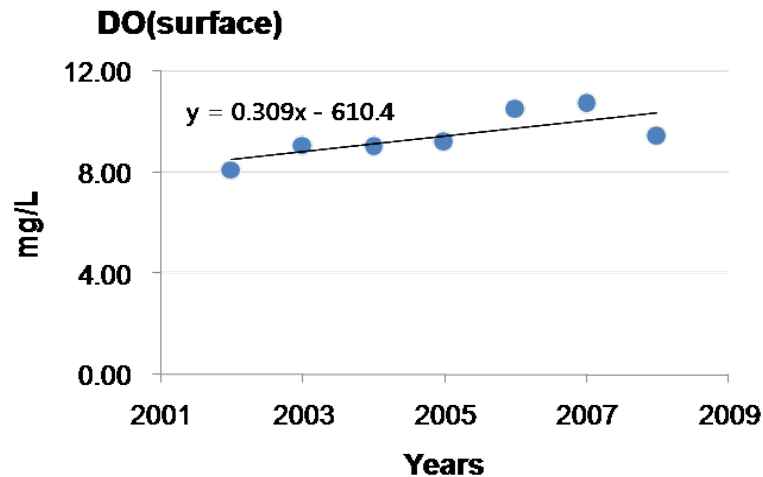


- DO level in the surface layer showed slightly increasing trend
- Mean values of DO was higher in surface by ranging 8~10mg/L, which shows more than critical point of 6mg/L under which marine animals are suffering from oxygen depletion suggested by OSPAR (2005)

Chlorophyll-a concentration (field data)



The variation of Dissolved oxygen in Masan-Haengam Bay

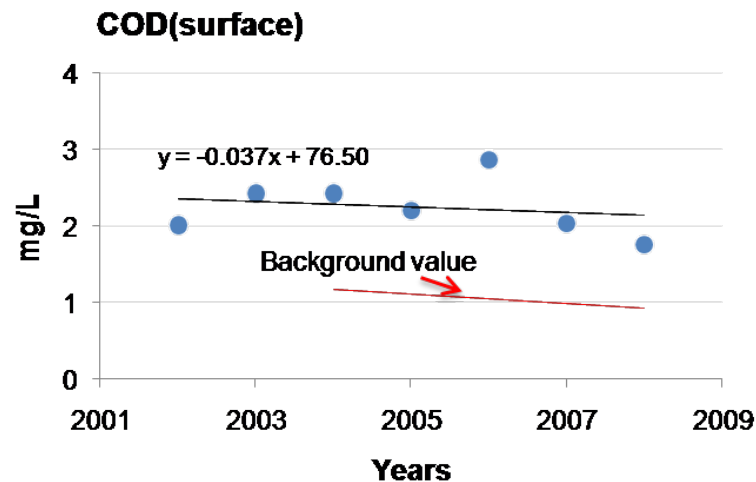


- DO level in the surface layer showed slightly increasing trend
- Mean values of DO was higher in surface by ranging 8~10mg/L, which shows more than critical point of 6mg/L under which marine animals are suffering from oxygen depletion suggested by OSPAR (2005)

Chemical oxygen demand (COD)



● The variation of COD in Jinhae Bay



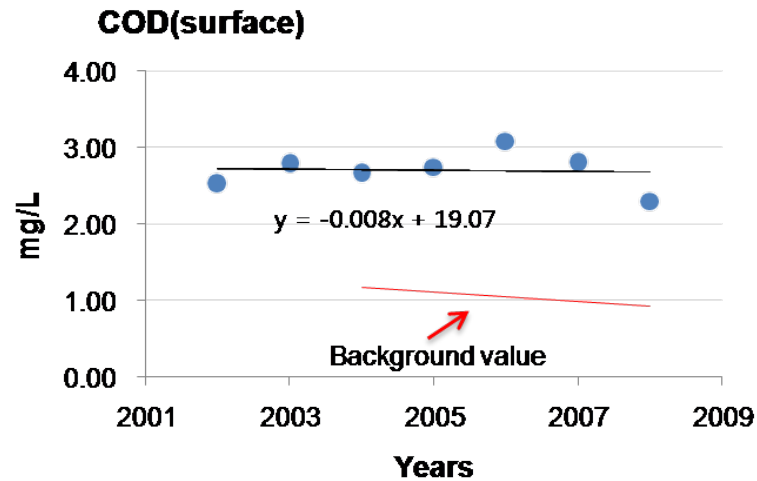
- COD level in the surface layer of Jinhae Bay showed slightly decreasing trend during 2002-2008 likewise in T-N/T-P.

- In comparison with background values for COD, current status of eutrophication in Jinhae Bay was classified as 'High'

Chemical oxygen demand (COD)



The variation of COD in Masan-Haengam Bay



- There was no any remarkable trend in COD mean values in Masan-Haengam Bay for 7 years excluding year 2008 when showed slightly decreased value than previous year.

- In comparison with background values for COD, current status of eutrophication in Masan-Haengam Bay was classified as 'High'



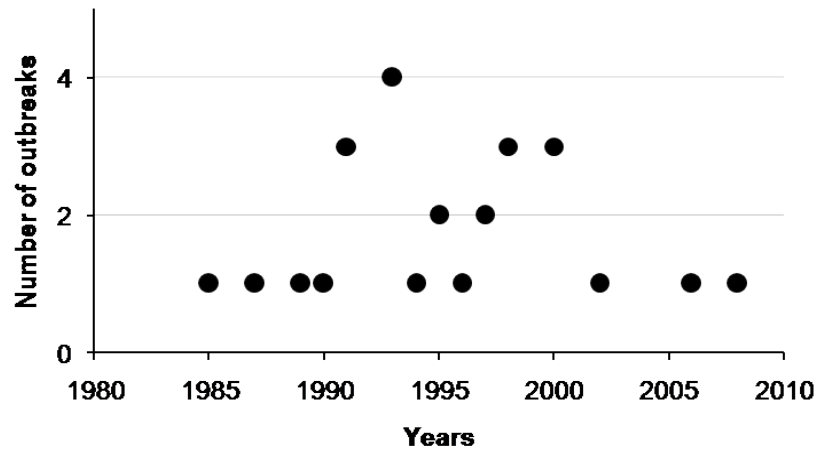
Results and Assessment

Category IV: Other possible effects of nutrient enrichment



Red-tide (*Noctiluca* sp.)

Redtide events by *Noctiluca scintillans* in Jinhae Bay



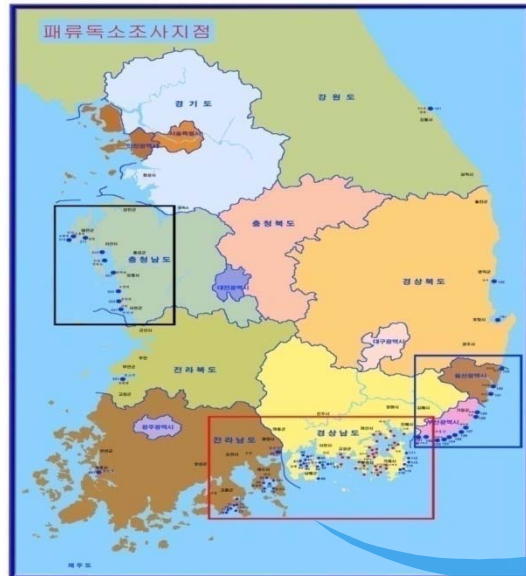
- The trend of red-tide events by *Noctiluca scintillans* in Jinhae Bay has been decreasing since 2000s.

- Particularly, there were only 3 events (2002, 2006, 2008) during 2001-2008.

Shellfish poisoning incidents



PSP monitoring sites in Jinhae Bay



Shellfish poisoning incidents in Jinhae Bay

- There was no any patient reported suffering from PSP intoxication in Jinhae Bay area since 1992.



Summary and Review of Results





Summary of assessment values along with parameters in Jinhae Bay

Category	Assessment parameter	Assessment value	Identification tools			Year
			Comparison	Occurrence	Trend	
I	Riverine input T-N T-P	Annual mean: 29.7ton/day 2.23ton/day			- -	1995~1996
	Total nitrogen Total phosphorus	Annual mean: 0.3~0.7mg/L 0.04~0.09 mg/L	High High		Decrease Decrease	2002~2008
	Winter DIN Winter DIP	Winter mean: 0.06~0.3mg/L 0.01~0.03mg/L	Low Low		Decrease Decrease	2002~2008
	Winter N/P ratio	Winter mean: 9~42.7	Low		Decrease	2002~2008
II	Chlorophyll-a concentration (field data)	Annual mean: 6.2~10.2ug/L	High		Decrease	2002~2008
	Ratio of area with high Chlorophyll-a concentration (field data) to the total area	Annual mean: less than 5% to total area			Non- detectable trend	2002~2008
	Red-tide events (diatom species)	Annual Occurrences		0~9 times	Decrease	1981~2008

※ 1. Comparison : compare annual mean value in 2008 between Jinhae Bay and background value of Gijang area



Summary of assessment values along with parameters in Jinhae Bay

III	Dissolved oxygen (DO)	Annual mean: 8~10mg/L	>6mg/L*		Increase	2002~2008
	Abnormal fish kill incidents	-		No	-	1970-present
	Chemical oxygen demand(COD)	Annual mean: 1.5~2.8mg/L	High		Decrease	2002~2008
IV	Red-tide events (Noctiluca sp.)	Annual occurrences: 0~4 times/yr		0~4 times	Decrease	1981~2008
	Shellfish poisoning incidents	Annual occurrences		No	-	1992-present

2. *: Define oxygen deficiency level when DO level lower than 6mg/L following OSPAR(2005).



Classification of eutrophication status by assessment parameter in Jinhae Bay

Status	Assessment parameter
HD (Current status high but decreasing trend)	Total nitrogen Total phosphorus Chlorophyll-a concentration (field data) Chemical oxygen demand
HN (Current status high but no decreasing or increasing trend)	-
HI (Current status high but increasing trend)	Dissolved oxygen
LD (Current status low but decreasing trend)	Winter DIN Winter DIP Winter N/P ratio
LN (Current status low but no decreasing or increasing trend)	-
LI (Current status low but increasing trend)	-



Classification of eutrophication trend by assessment parameter in Jinhae Bay

Trend	D (Decreasing trend)	N (No decreasing or increasing trend)	I (Increasing trend)
Assessment parameter	Red-tide events (diatom species) Red-tide events (Noctiluca sp.)	-	-



Summary of assessment values along with parameters in Masan-Haengam Bay

Category	Assessment parameter	Assessment value	Identification tools			Year
			Comparison	Occurrence	Trend	
I	Riverine input T-N T-P	Annual mean: 20.5ton/day 1.42ton/day			- -	1995~1996
	Total nitrogen Total phosphorus	Annual mean: 0.5~1.2mg/L 0.05~0.15 mg/L	High High		Decrease Decrease	2002~2008
	Winter DIN Winter DIP	Winter mean: 0.05~0.7mg/L 0.01~0.07mg/L	Low Low		Decrease Decrease	2002~2008
	Winter N/P ratio	Winter mean: 10.9~36.7	Low		Decrease	2002~2008
II	Chlorophyll-a concentration (field data)	Annual mean: 8.6~20.2ug/L	High		No trend	2002~2008
	Ratio of area with high Chlorophyll- a concentration (field data) to the total area					
	Red-tide events (diatom species)					

※ 1. Comparison : compare annual mean value in 2008 between Jinhae Bay and background value of Gijang area



Summary of assessment values along with parameters in Masan-Haengam Bay

III	Dissolved oxygen (DO)	Annual mean: 8-11mg/L	>6mg/L*		Increase	2002~2008
	Abnormal fish kill incidents	-		No	-	1970-present
	Chemical oxygen demand(COD)	Annual mean: 2.5~3.1mg/L	High		No trend	2002~2008
IV	Red-tide events (Noctiluca sp.)	Annual occurrences: 0~1 times/yr		0~1 times	Decrease	1981~2008
	Shellfish poisoning incidents	Annual occurrences		No	-	1992-present

2. *: Define oxygen deficiency level when DO level lower than 6mg/L following OSPAR(2005).



Classification of eutrophication status by assessment in Masan-Hangam Bay

Status	Assessment parameter
HD (Current status high but decreasing trend)	Total nitrogen Total phosphorus Chemical oxygen demand
HN (Current status high but no decreasing or increasing trend)	Chlorophyll-a concentration (field data)
HI (Current status high but increasing trend)	Dissolved oxygen
LD (Current status low but decreasing trend)	Winter DIN Winter DIP Winter N/P ratio
LN (Current status low but no decreasing or increasing trend)	-
LI (Current status low but increasing trend)	-



Classification of eutrophication trend by assessment parameter in Masan-Hangam Bay

Trend	D (Decreasing trend)	N (No decreasing or increasing trend)	I (Increasing trend)
Assessment parameter	Red-tide events (Noctiluca sp.)	-	-



Conclusion and Recommendation





- Based on the assessment results and literatures, it was concluded that current eutrophication status of Jinhae Bay including several small bays was, overall, ‘**Low state**’ and ‘**Decreasing trend**’; Eutrophication status of Masan-Haengam Bay was ‘**High state**’ and ‘**Decreasing trend**’.
- Therein, it is recommended to increase sewage treatment facilities and/or dredge up bottom sediments to improve water quality in Masan-Haengam Bay. Particularly, considering that Masan Bay, among other bays, is relatively high eutrophication status area with frequent algal blooms, it is encouraged to apply tertiary water treatment system to remove inorganic nitrogen and phosphorus level within the treated water substantially.

Thank you very much

