# Report on Assessment of Eutrophication Status in Northwest Kyushu Sea Area and Toyama Bay, Japan

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Expert Meeting

Toyama, Japan

# Outline

I. Objectives
II. Selected areas in Japan
III. Methods of the Common Procedures
IV. Results of the assessment in 2 areas
V. Conclusion

# Objectives

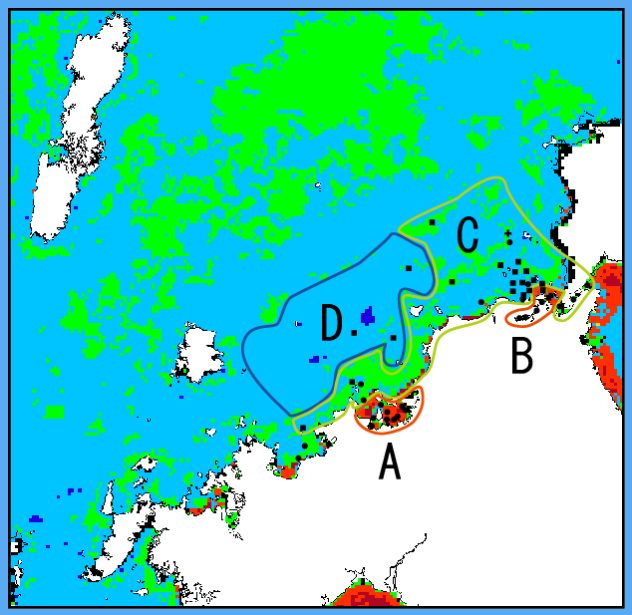
I. The eutrophication assessment based on the NOWPAP Common Procedures.

II. Assessment of Hakata Bay in Northwest Kyushu sea area.

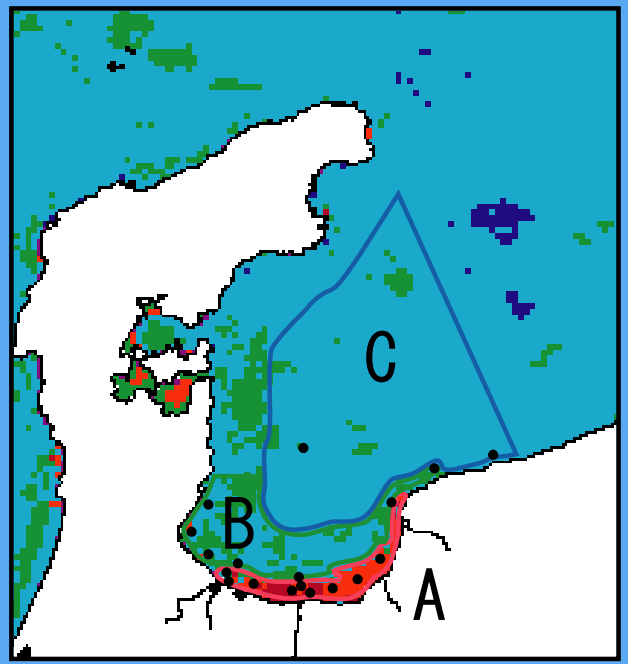
III. Assessment of the Toyama Bay coastal area.

# Selected areas on the eutrophication assessment in Japan

Sub-area setting was conducted based on status and trend analysis of 13 years satellite-derived chl-*a*.




| 1 Northwest Kyushu sea area | |
|---|---|
| Sub-area A | Hakata Bay |
| Sub-area B | Dokai Bay and Kanmon strait |
| Sub-area C | Intermediate area |
| Sub-area D | Offshore area |




| 2 Toyama Bay | |
|---|---|
| Sub-area A | Coastal area |
| Sub-area B | Intermediate area |
| Sub-area C | Offshore area |

# Outline of the Common Procedures

1. 4 categories were set for eutrophication assessment.
2. Parameters were selected in each category.
3. Assessment was conducted using *in situ* monitoring data.

Categorization of parameters

| | |
|---|---|
| Category I | Parameters that indicate degree of nutrient enrichment |
| Category II | Parameters that indicate direct effects of nutrient enrichment |
| Category III | Parameters that indicate indirect effects of nutrient enrichment |
| Category IV | Parameters that indicate other possible effects of nutrient enrichment |

# Assessment parameters and reference values used in category I

| Categories | Assessment parameters | Reference values | areas |
|---|---|---|---|
| I | Riverine input of TN | - | |
| | Riverine input of TP | - | |
| | Sewage plant input of TN | - | |
| | Sewage plant input of TP | - | |
| | TN concentration | 0.3, 0.6 mg/L | Hakata |
| | | 0.3 mg/L | Toyama |
| | TP concentration | 0.03, 0.05 mg/L | Hakata |
| | | 0.03 mg/L | Toyama |
| | Winter DIN concentration | 0.169, 0.338 mg/L | Hakata |
| | | 0.144 mg/L | Toyama |
| | Winter DIP concentration | 0.011, 0.017 mg/L | Hakata |
| | | 0.017 mg/L | Toyama |
| | Winter N/P ratio (DIN/DIP) | 16 | |

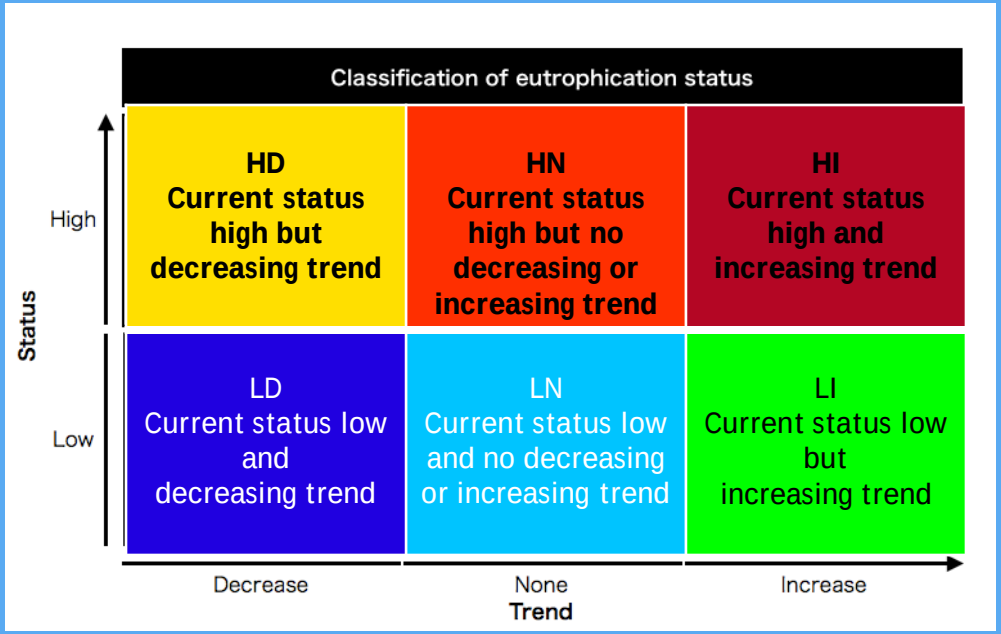
# Assessment parameters and reference values used in category II, III and IV

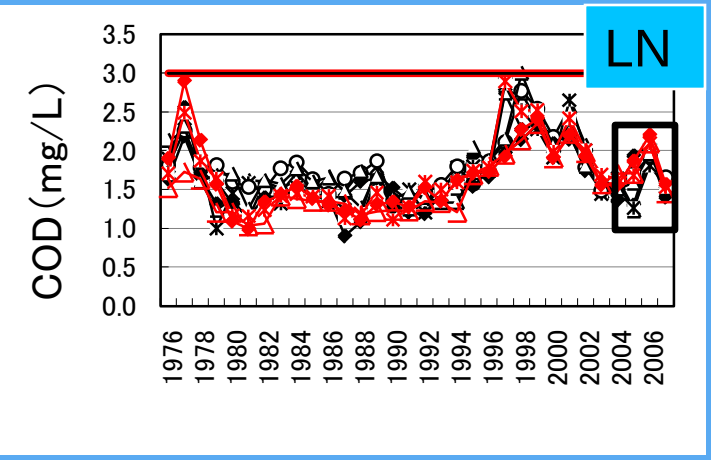
| Categories | Assessment parameters | Reference values |
|---|---|---|
| II | Annual mean of chlorophyll-*a* | 5 µg/L |
| | Annual maximum of chlorophyll-*a* | 20 µg/L |
| | Red tide events (diatom species) | 1 event/year |
| | Red tide events (dinoflagellate species) | 1 event/year |
| III | Dissolved Oxygen (DO) | 6.0 mg/L |
| | Fish kill incidents | 1 event/year |
| | Chemical Oxygen Demand (COD) | 3.0 mg/L |
| IV | Red-tide events (*Noctiluca* sp.) | 3 events/3 year |
| | Shell fish poisoning incidents | 1 event/year |

# Classification of eutrophication status

[Status analysis]

1. **High or low was determined compared the average of recent 3 years and reference values.**




Increasing trends were indicated in 3 stations.
No trends were indicated in 6 stations.
Average concentration in recent 3 years are lower than reference value.

[Trend analysis]

1. **We used a non-parametric Mann-Kendall test for detecting trend in time series of annual data.**
2. **Significance in trend was estimated under 5% probability.**
3. **Increase, Decrease and No trend were indicated by red, blue and black lines in the figures, respectively.**

# Northwest Kyushu sea area, sub-area A (Hakata Bay)

Area: 134.2 km$^2$

Width of the bay mouth: 7.7 km

Max. depth: 23 m

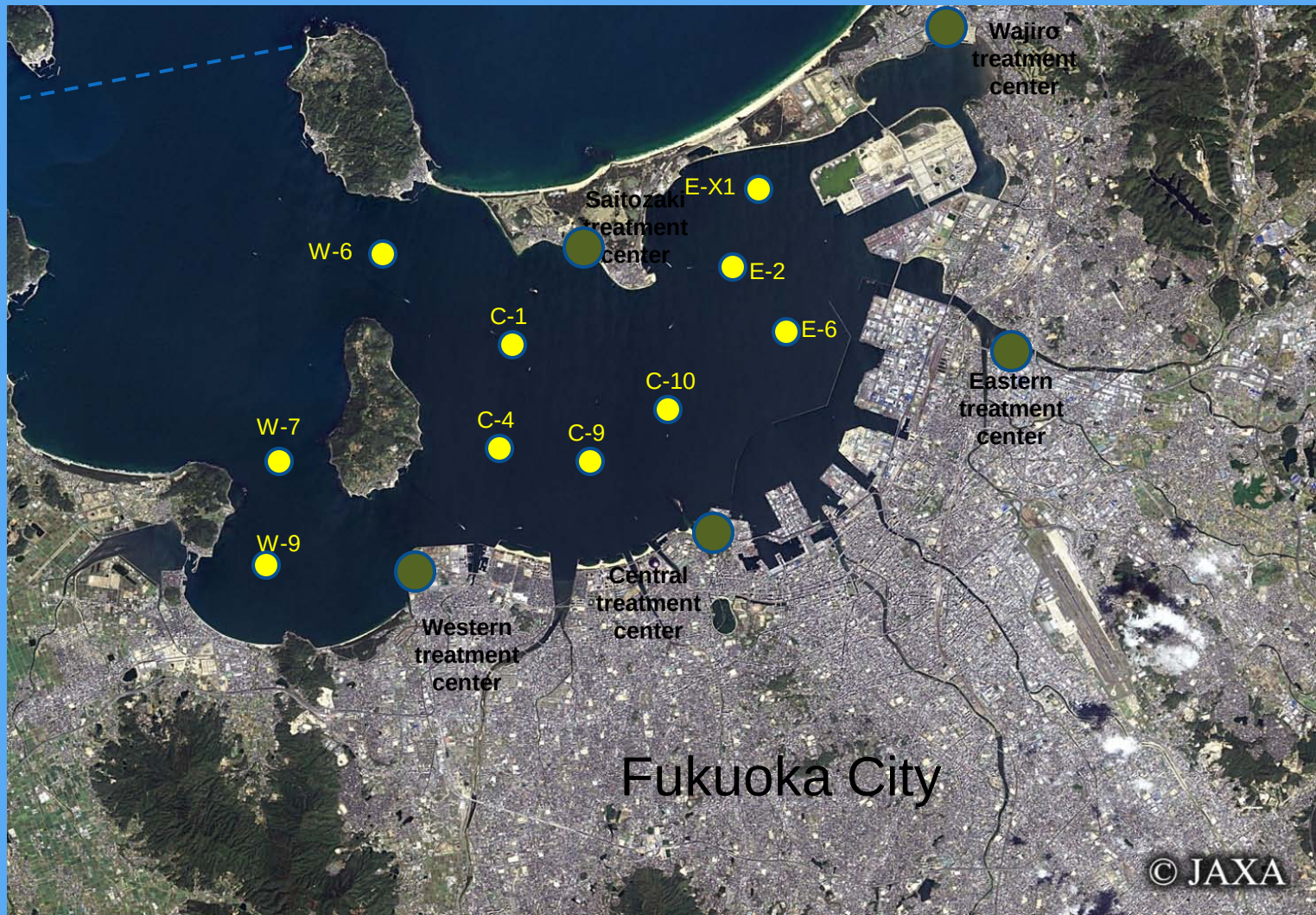
Population: 2 millions

Fukuoka City is the most urbanized in Kyushu island.

Water quality was monitored in 12 rivers inflowing into Hakata Bay.

Five sewage plants (●) directly discharge waste water.

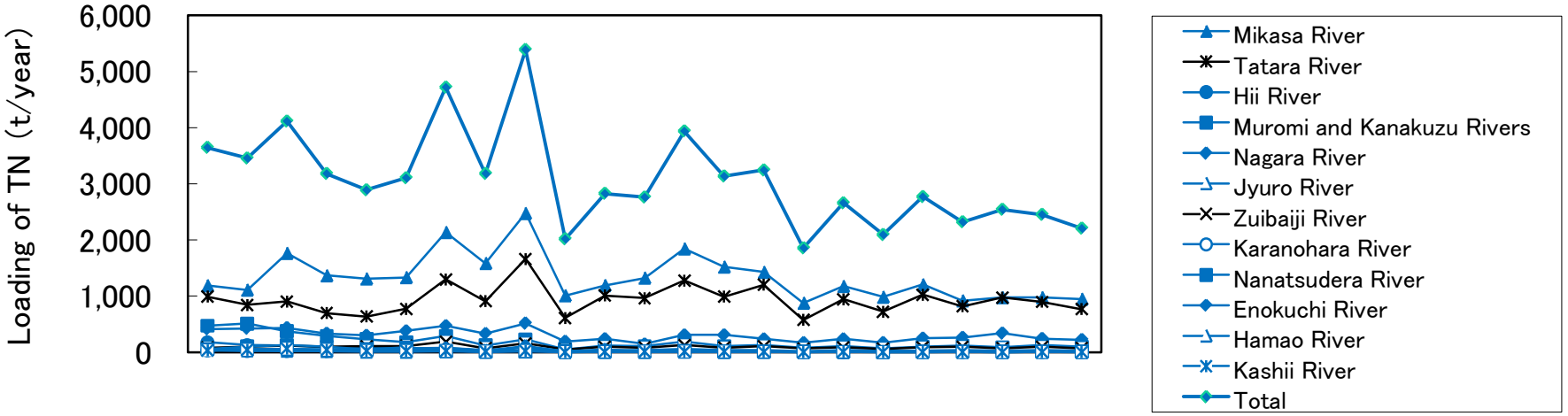
Monitoring is conducted in 10 stations (●) by month.



# Category I

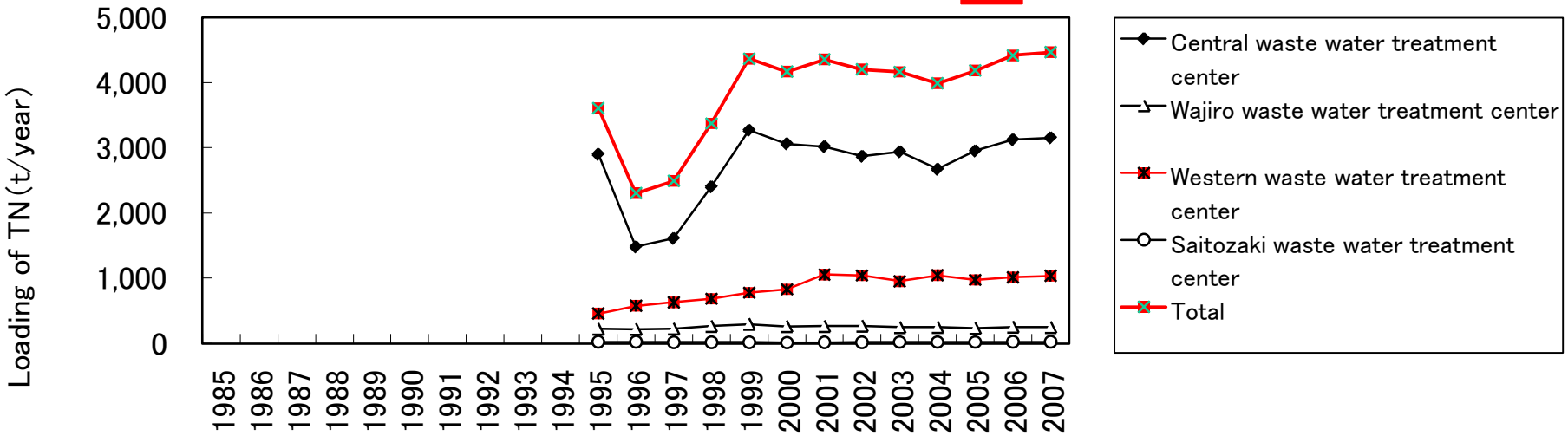
## Riverine inputs of TN D

2,207 t/year in 2007




## Sewage plant inputs of TN I

4,463 t/year in 2007

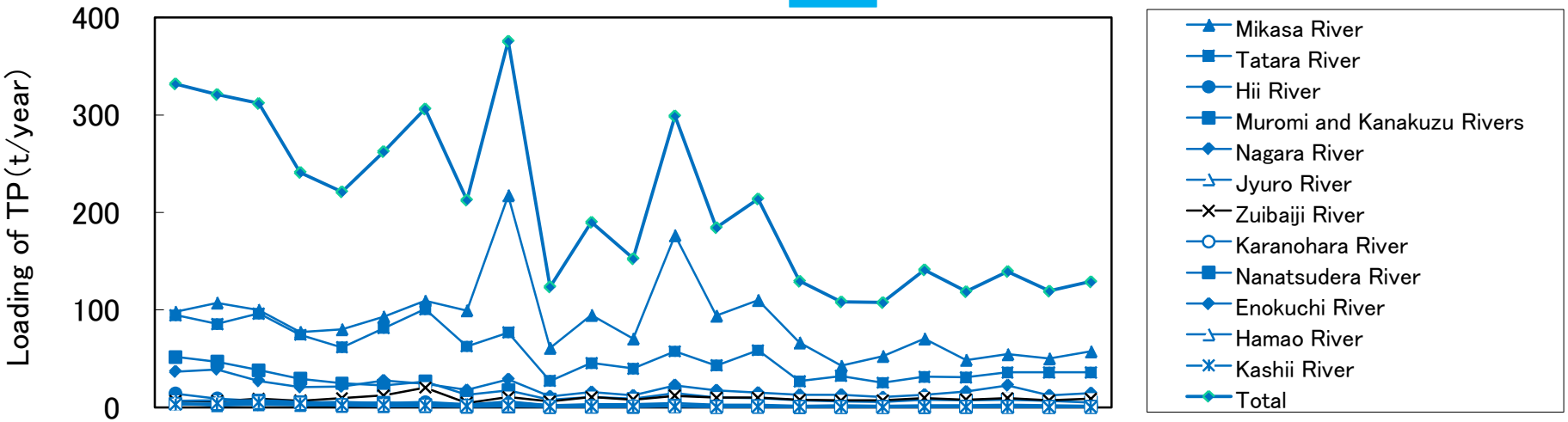


# Category I

## Riverine inputs of TP

D

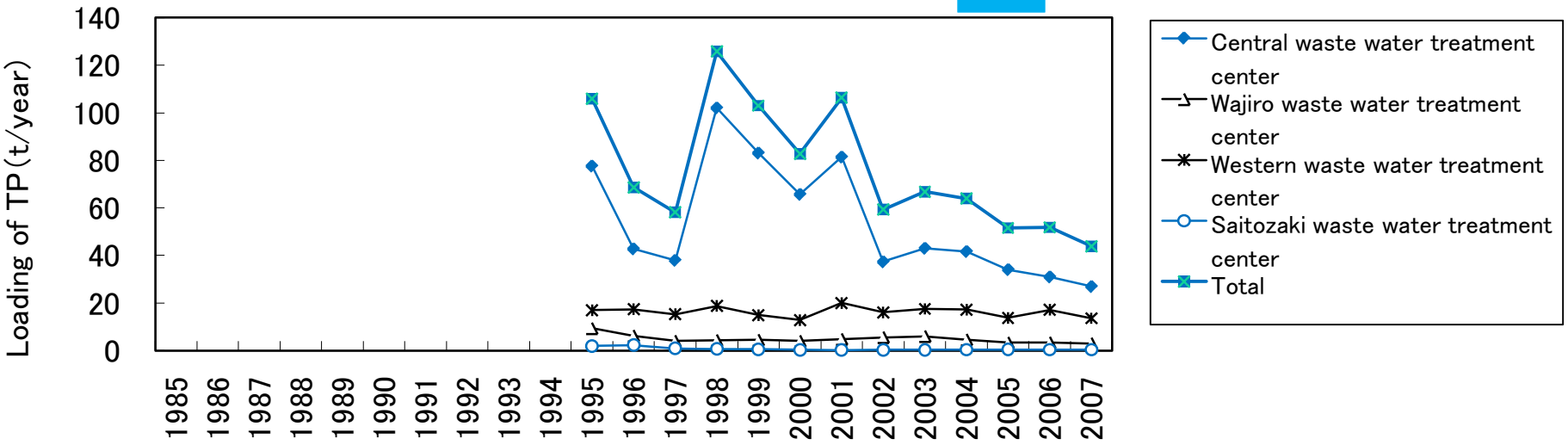
129 t/year in 2007




## Sewage plant inputs of TP

D

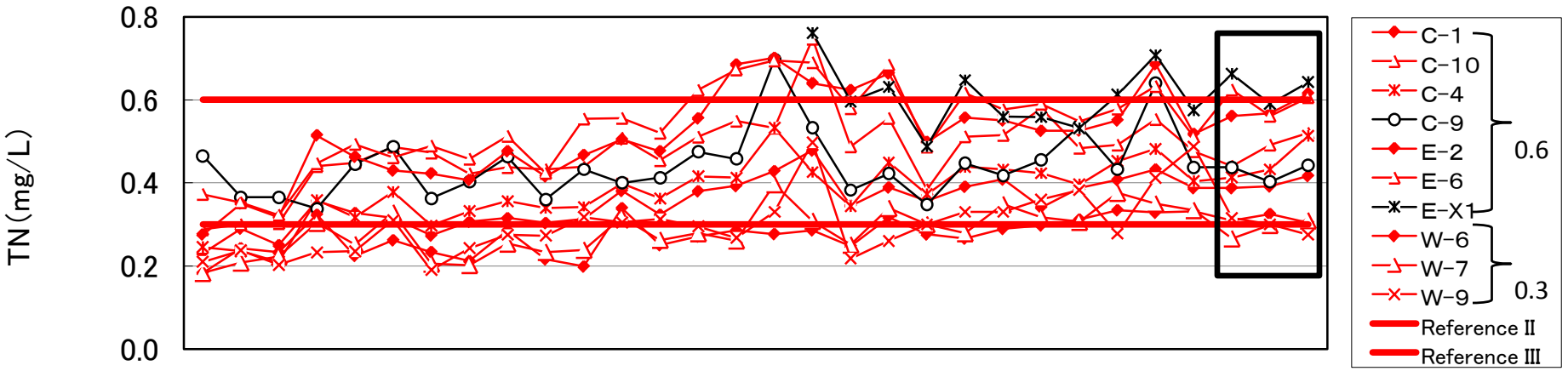
43.9 t/year in 2007



# Category I

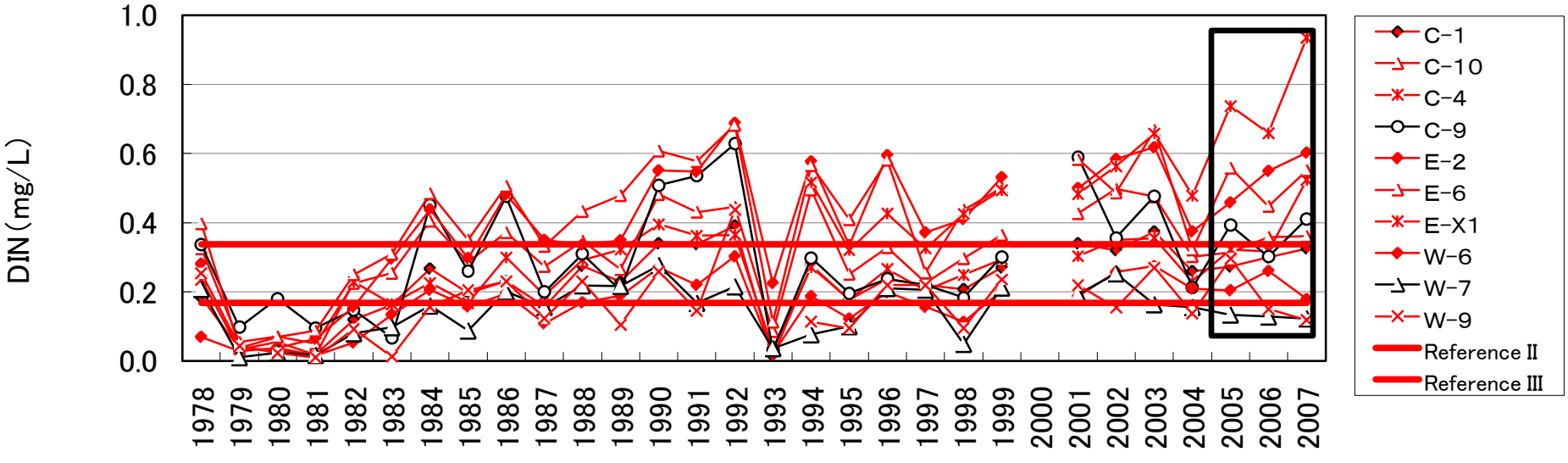
## Change of TN in seawater

LI




## Changes of winter DIN in seawater

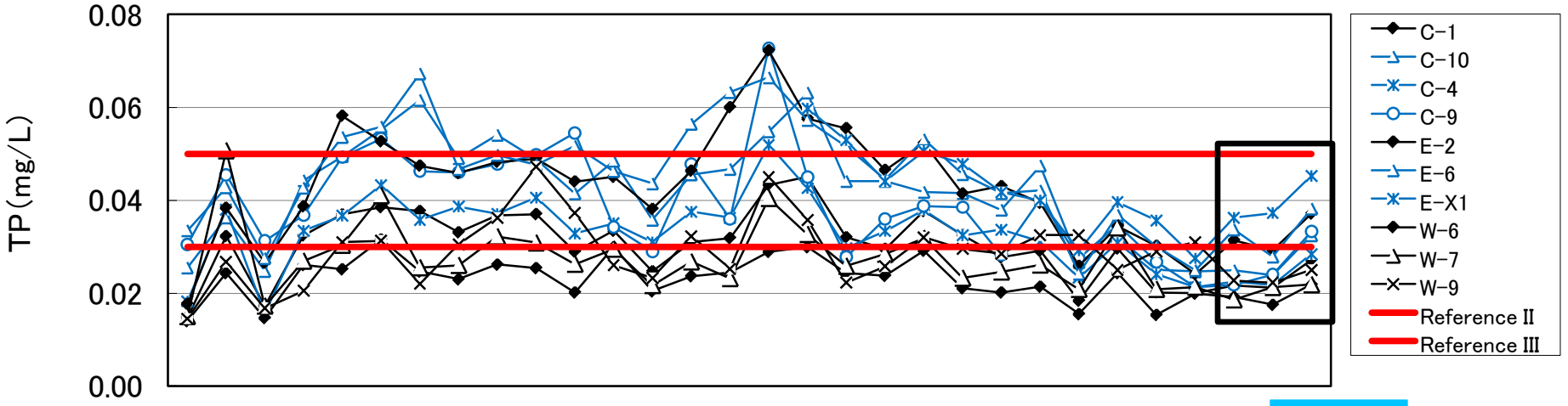
HI



# Category I

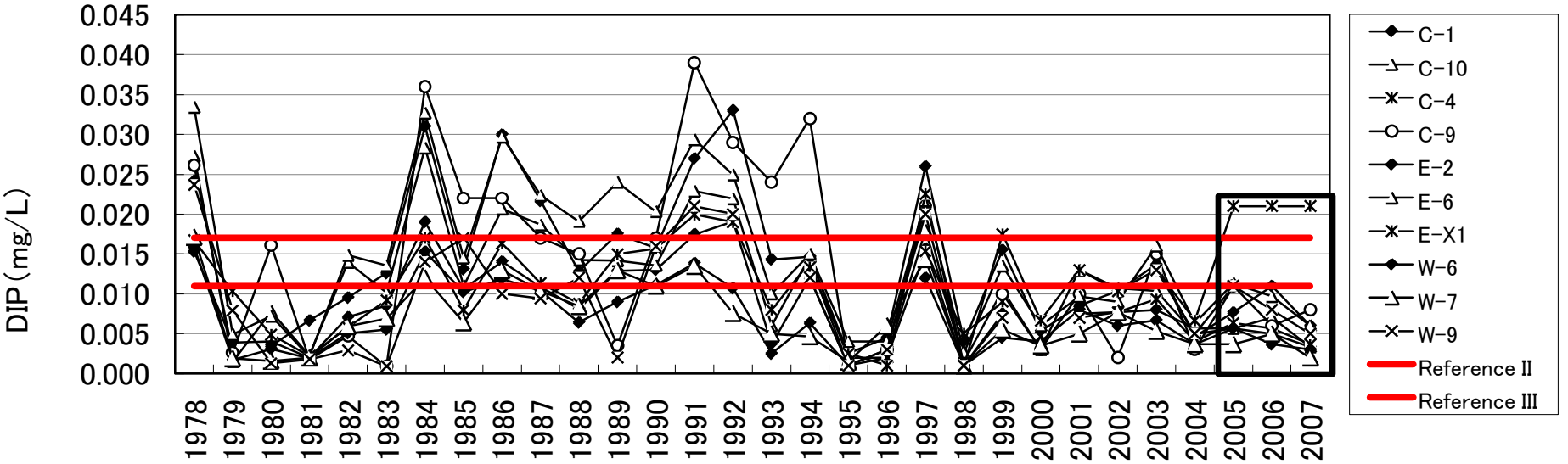
## Changes of TP in seawater

LN




## Changes of winter DIP in seawater

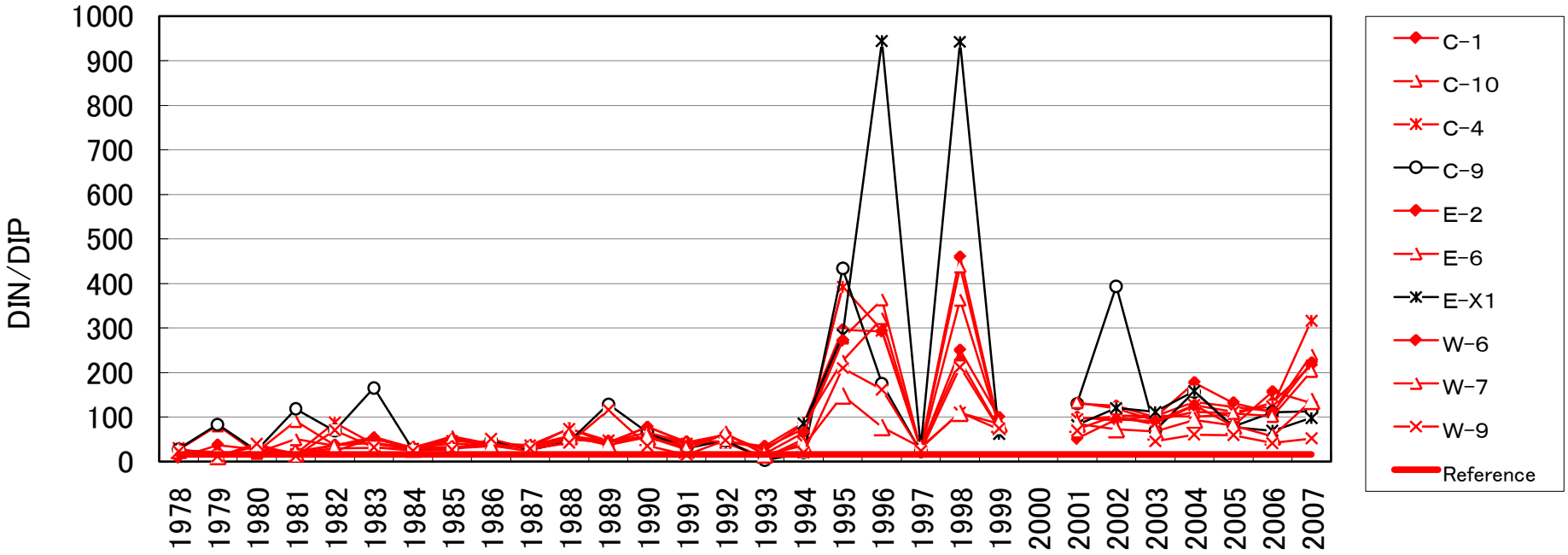
LN



# Category I

## Chang of the DIN/DIP ratio in winter

HI

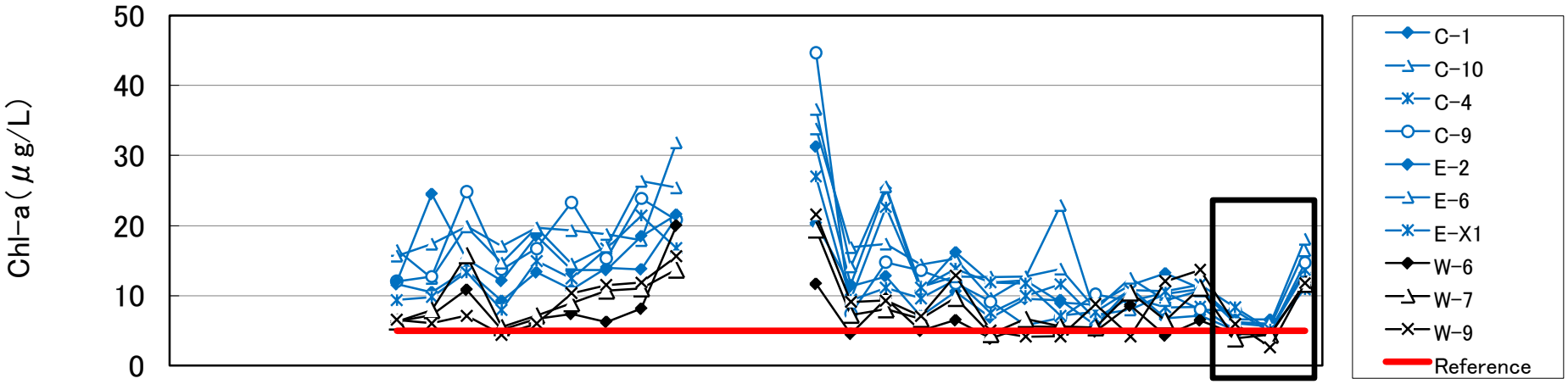



DIN/DIP ratio greatly exceeded the Redfield ratio of 16.
It is necessary to decrease nitrogen and to increase phosphorus.

# Category II

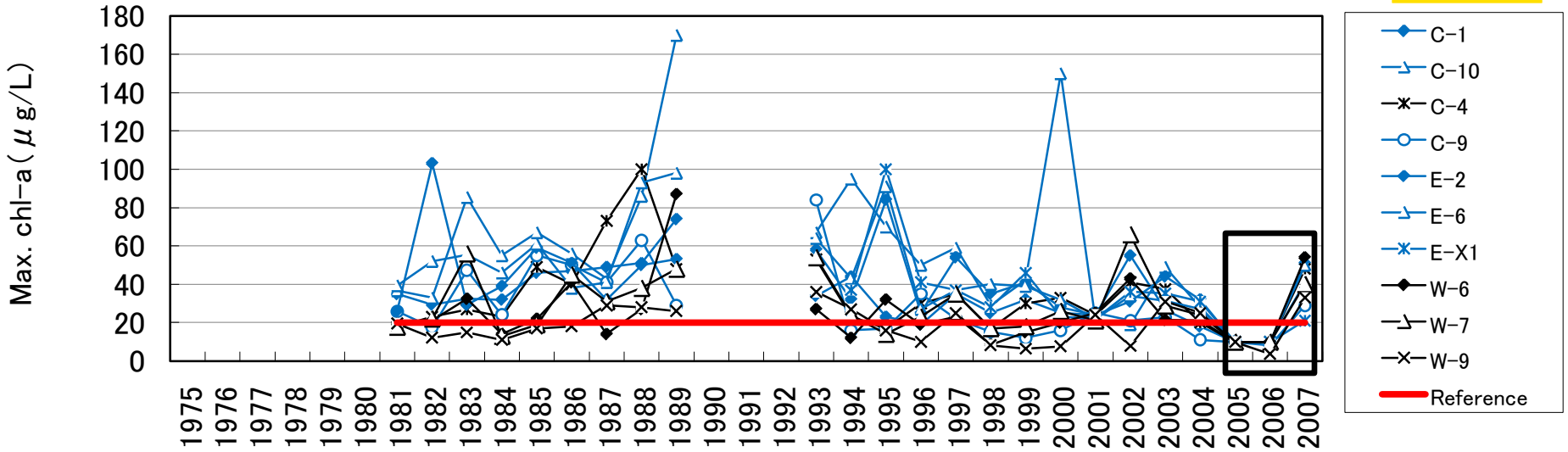
## Changes of the annual mean of chlorophyll-*a*

HD




## Changes of the annual max of chlorophyll-*a*

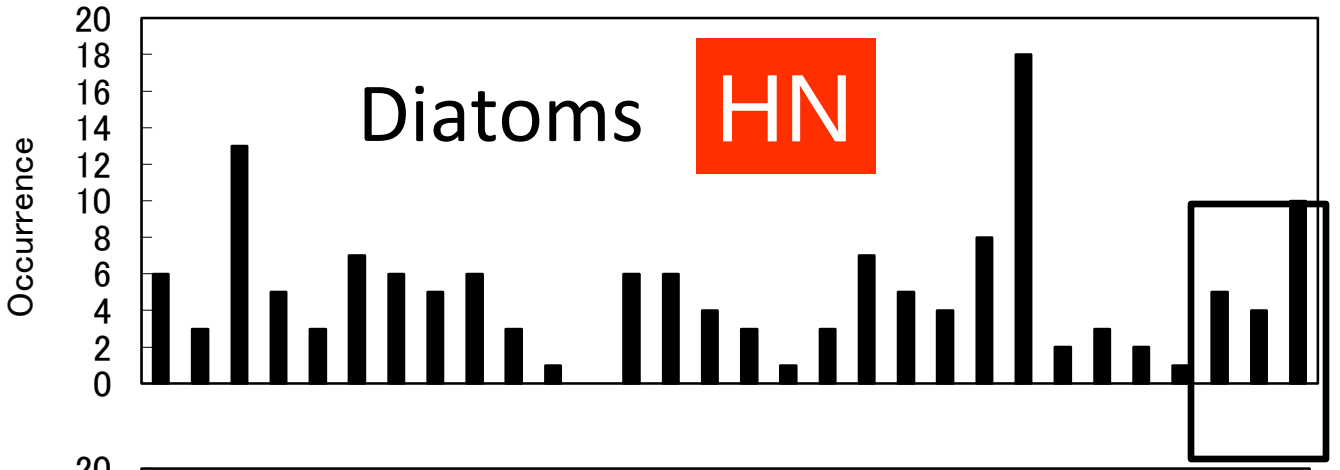
HD

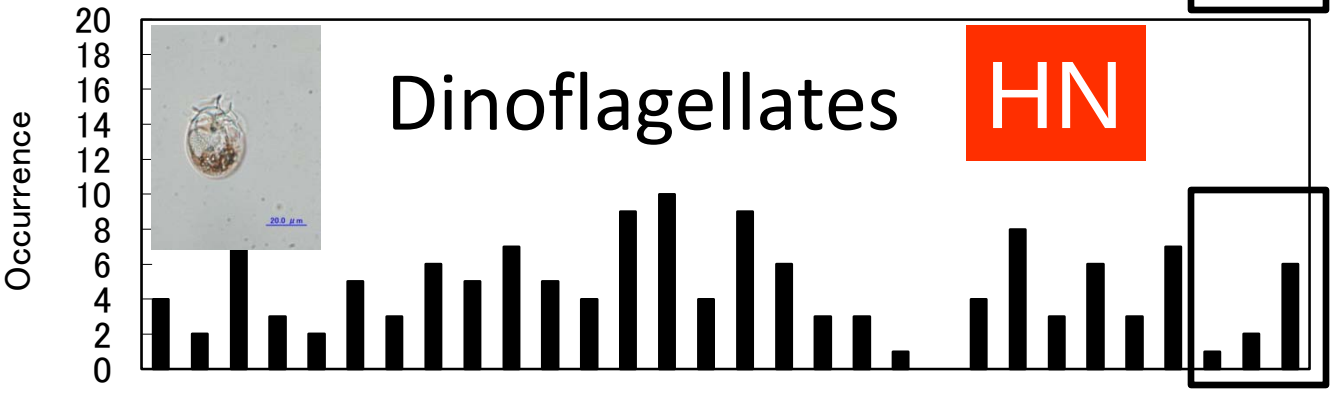


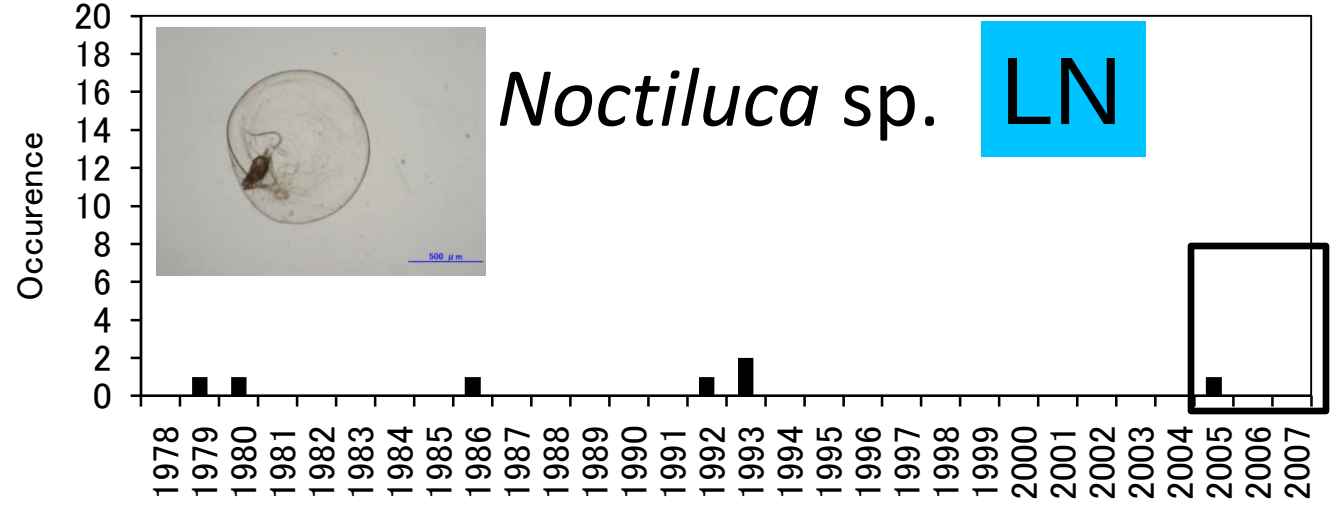
Category II

Red tide events

Category IV



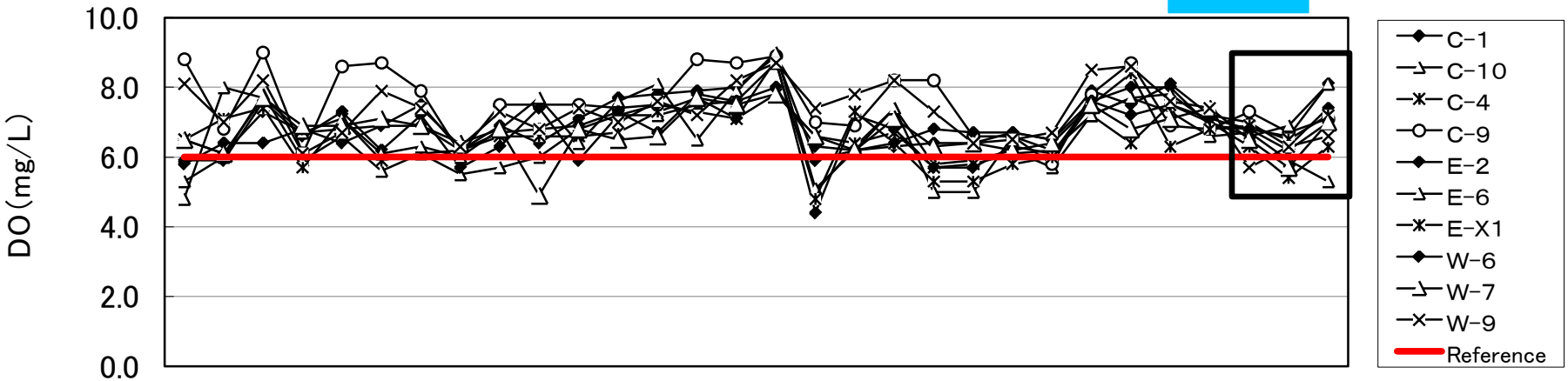



# Category III

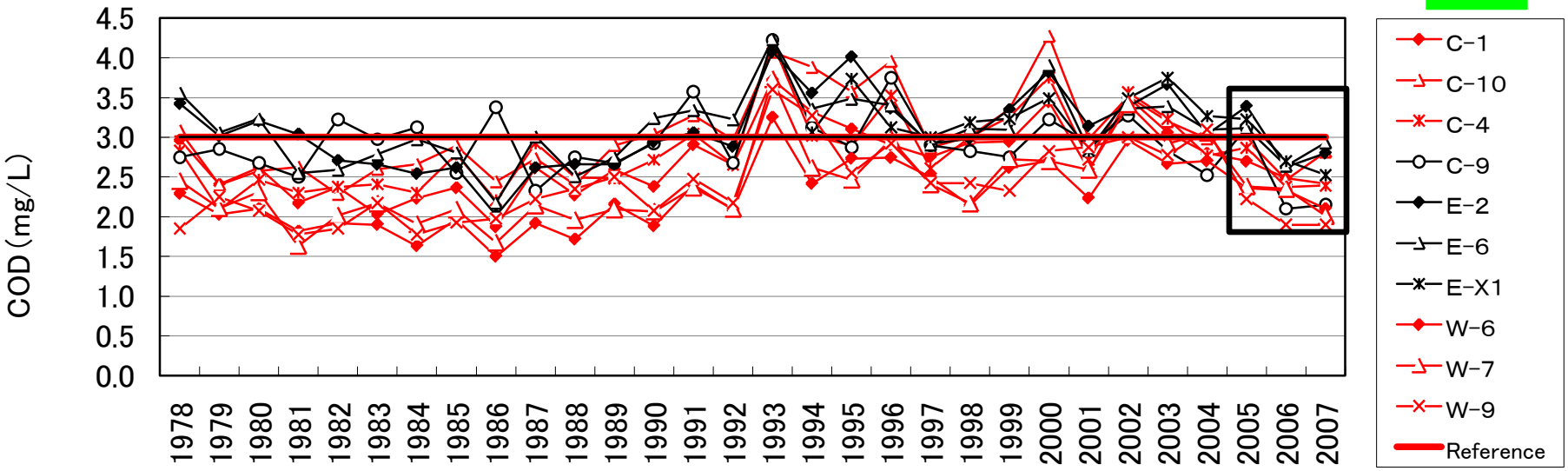
## Changes of dissolved oxygen (DO)

LN




## Changes of chemical oxygen demand (COD)

LI



# Identification of eutrophication status in Northwest Kyushu sea area, sub-area A (Hakata Bay)

| Categories | Assessment parameters | Comparison | Occurrence | Trend | Parameter identification | Category identification |
|---|---|---|---|---|---|---|
| Ⅰ | ①Riverine input of TN | × | × | D | D | LI |
| | ②Riverine input of TP | × | × | D | D | |
| | ③Sewage plant input of TN | × | × | I | I | |
| | ④Sewage plant input of TP | × | × | N | N | |
| | ⑤TN concentration | L | × | I | LI | |
| | ⑥TP concentration | L | × | N | LN | |
| | ⑦Winter DIN concentration | H | × | I | HI | |
| | ⑧Winter DIP concentration | L | × | N | LN | |
| | ⑨Winter DIN/DIP ratio | H | × | I | HI | |
| Ⅱ | ⑩Annual maximum of chlorophyll-*a* | H | × | D | HD | HD / HN |
| | ⑪Annual mean of chlorophyll-*a* | H | × | D | HD | |
| | ⑫Red tide events (diatom sp.) | × | H | N | HN | |
| | ⑬Red tide events (dinoflagellate sp.) | × | H | N | HN | |
| Ⅲ | ⑭Dissolved oxygen (DO) | L | × | N | LN | LN |
| | ⑮Fish kill incidents | × | L | N | LN | |
| | ⑯Chemical oxygen demand (COD) | L | × | I | LI | |
| Ⅳ | ⑰Red tide events (*Noctiluca*) | × | L | N | LN | LN |
| | ⑱Shell fish poisoning incidents | × | L | N | LN | |

# Assessment of Northwest Kyushu sea area, sub-area A (Hakata Bay)

| Categories | Evaluation |
|---|---|
| I: degree of nutrient enrichment | Increasing trend was detected in the sewage plant input of TN. TN and winter DIN in the seawater were over references. However, decreasing trend was detected in riverine and sewage plant inputs of TP. |
| II: direct effects of nutrient enrichment | Annual mean chlorophyll-*a* showed decreasing trend but high status condition.<br>Red tides consist of diatom and dinoflagellate species were observed almost of the years. |
| III: indirect effects of nutrient enrichment | COD showed increasing trend and high status.<br>Fish kill incidents was not found in this area. |
| IV: other possible effects of nutrient enrichment | *Noctiluca* sp. red tide was scarce.<br>Shellfish poisoning was not found in this area. |

**[Recommendation]**

**Concentration of nitrogen and phosphorus should be balanced by adjusting the level of inputs. Occurrence of red tides should also be reduced.**

# Toyama Bay

Area: 2,120 km$^2$

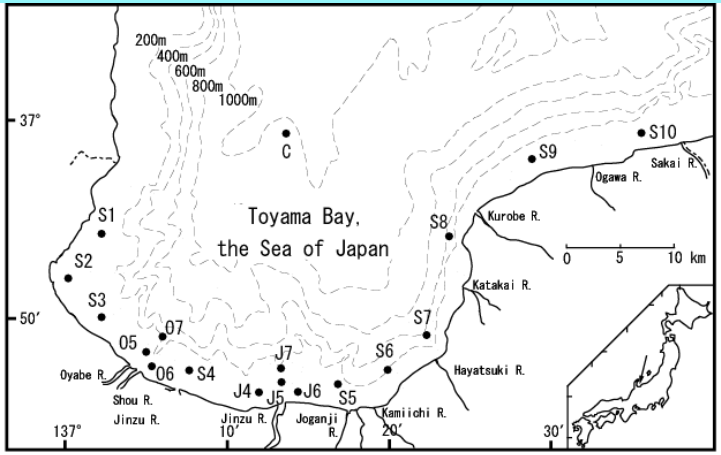
Max. depth: 1,250 m

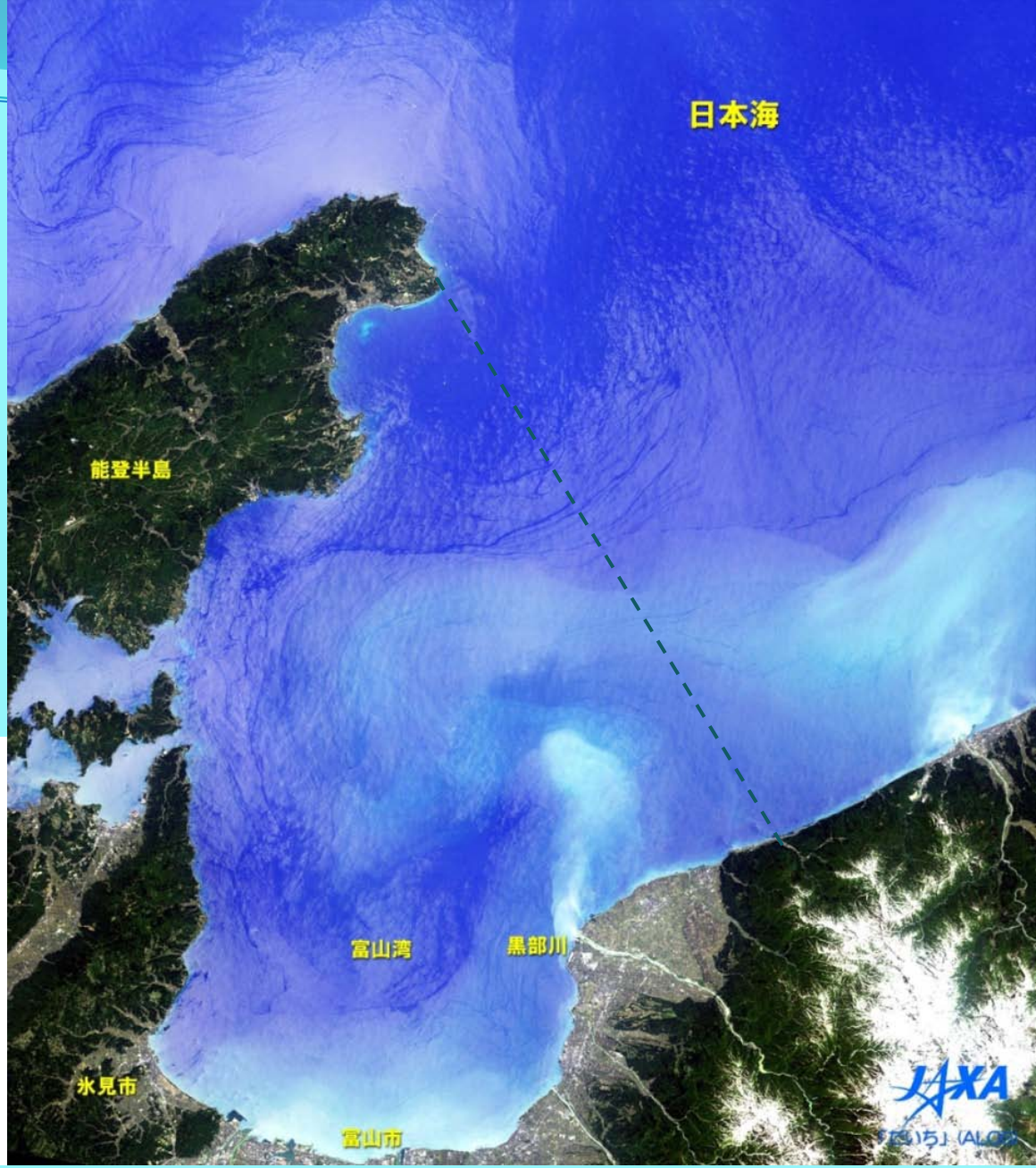
Volume: 1,280 km$^3$

Population: 1 million

A-class rivers: 5

B-class rivers: 29




River plumes were observed in the innermost of the bay.

Satellite image from “Daichi” JAXA (May, 2006）

# Identification of eutrophication status in Toyama Bay, sub-area A (Coastal area)

| Categories | Assessment parameters | Comparison | Occurrence | Trend | Parameter identification | Category identification |
|---|---|---|---|---|---|---|
| Ⅰ | ①Riverine input of TN | × | × | N | N | |
| | ②Riverine input of TP | × | × | D | D | |
| | ③Sewage plant input of TN | × | × | × | – | |
| | ④Sewage plant input of TP | × | × | × | – | |
| | ⑤TN concentration | L | × | N | LN | LN |
| | ⑥TP concentration | L | × | N | LN | |
| | ⑦Winter DIN concentration | L | × | N | LN | |
| | ⑧Winter DIP concentration | L | × | N | LN | |
| | ⑨Winter DIN/DIP ratio | H | × | N | HN* | |
| Ⅱ | ⑩Annual maximum of chlorophyll-*a* | L | × | N | LN | |
| | ⑪Annual mean of chlorophyll-*a* | L | × | N | LN | |
| | ⑫Red tide events (diatom sp.) | × | L | D | LD | LN |
| | ⑬Red tide events (dinoflagellate sp.) | × | L | N | LN | |
| Ⅲ | ⑭Dissolved oxygen (DO) | L | × | N | LN | |
| | ⑮Fish kill incidents | × | L | N | LN | LN |
| | ⑯Chemical oxygen demand (COD) | L | × | N | LN | |
| Ⅳ | ⑰Red tide events (*Noctiluca*) | × | L | N | LN | |
| | ⑱Shell fish poisoning incidents | × | L | N | LN | LN |

*Parameter identification of the winter DIN/DIP ratio was not used for category identification, because winter DIN concentration and winter DIP concentration were lower than reference concentrations.

# Assessment of Toyama Bay, sub-area A (coastal area)

| Categories | Evaluation |
|---|---|
| I: degree of nutrient enrichment | No trend was detected in riverine TN inputs. However, increasing trend was detected in the Jinzu River TN input. |
| II: direct effects of nutrient enrichment | Annual mean/max. chl-*a* were lower than reference values in recent 3 years.<br>Red tides consist of diatoms and dinoflagellates were not observed in recent 3 years. |
| III: indirect effects of nutrient enrichment | DO is satisfied reference value but decreasing trend was seen in 2 of 9 stations.<br>COD is also satisfied reference value but increasing trend was seen 3 of 9 stations. |
| IV: other possible effects of nutrient enrichment | Occurrence of *Noctiluca* sp. red tides were less frequency.<br>Shellfish poisoning incident was not occurred. |

**[Recommendation] : Decreasing trend of DO and increasing trend in COD were shown in some stations. These conditions are recognized as eutrophication symptom. Countermeasures not to increase the nutrient loads are necessary.**

# Conclusion of the eutrophication assessment in Japan

[Action]

- Countermeasures against eutrophication is advanced to some extent under the “Water Pollution Control Law” and local action plans in Japan.
- Restrictions of industrial discharge, construction of sewage facilities and development of water treatment technology are advanced.

[Next step]

- Ecosystem-based management is needed considering high productivity, biodiversity and smooth circulation of materials.

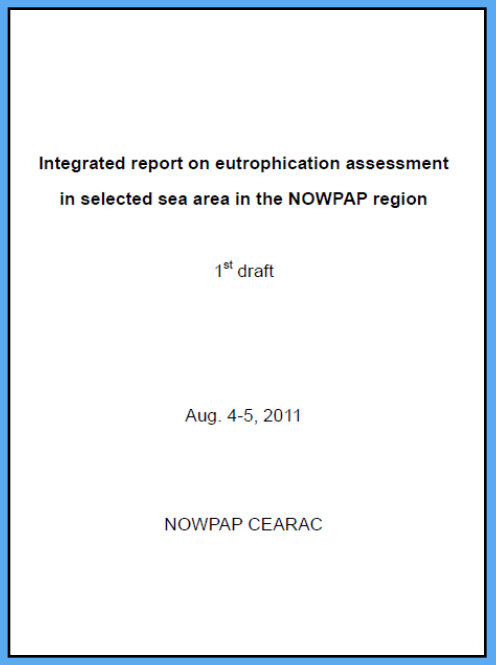

Fukuoka City (2003) Hakata Bay Environmental Conservation Plan


Toyama Prefecture (2003) Clean Water Plan

# Integrated report on eutrophication assessment in selected sea area in NOWPAP region

[Other sub-areas in Japan]

- We have evaluated 2 sub-areas of Hakata Bay and Toyama Bay coastal area.
- Please refer to the integrated report on other sub-areas.




[Integrated report]

- Reports of each selected area have already been accepted.
  1. Changjiang River Estuary and adjacent area, China
  2. Northwest Kyushu sea area, Japan
  3. Toyama Bay, Japan
  4. Jinhae Bay, Korea
  5. Peter the Great Bay, Russia
- Please review the draft integrated report.
- We will prepare the report by December, 2011.