Seasonal Variations in the Structure of Phytoplankton Communities near Nuclear Power Plants

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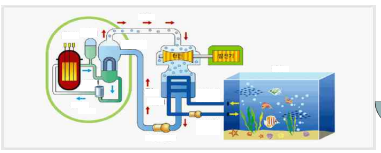
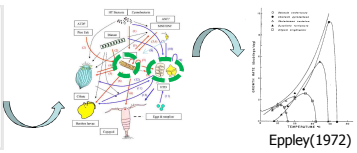
Introduction

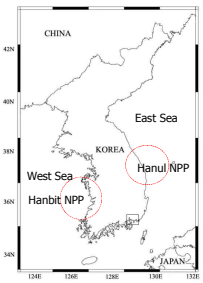
- Marine phytoplankton are known to play important roles as primary producers and each phytoplankton respond rapidly to water temperature changes
- Thermal discharges from nuclear power generation can cause thermal disturbances to ecosystems around power plants
  - Low thermal efficiency : about 32~33%
  - High thermal discharge : > 40~50 m³/unit·sec
- Study goal : Study the effect of thermal discharge effluent on phytoplankton which is primary producer of marine ecosystem.





Eppley(1972)

Materials and Methods



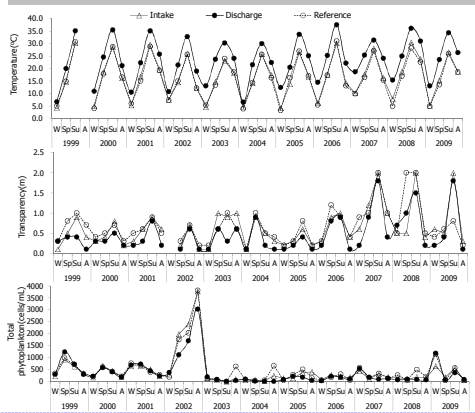
Station Map

- Nuclear Power Plant : Hanbit and Hanul
- Observation period : 1999 ~ 2009 (11 years×4 seasons)
- Station : 3(intake, discharge and reference) in each area
- Physical factors : Temperature, Salinity, Transparency
- Chemical factors : SS, DO, pH, COD, NO_2, NO_3, NH_4, total-N, PO_4, SiO_2
- Biological factors
  - Phytoplankton survey(qualitative/quantitative characteristics)
  - Chlorophyll-a concentration, diversity index
  - Growth inhibition ratio
- Statistical analysis
  - Correlation coefficients between phytoplankton and other factors

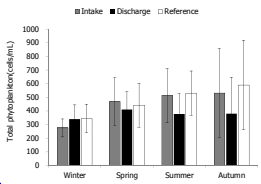
Results

Site | **Phytoplankton and environment factors**

Hanbit

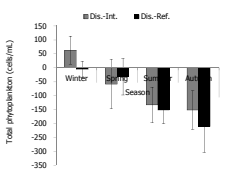


Temperature : 3.3-37.6 ℃
Transparency : 0.1-2.0 m
Suspended solids : 5.7-107.6 mg/L
Total-N : 14.94-377.56 ug/L
Phosphate (PO_4) : 1.5-57.1 ug/L
Silicate (SiO_2) : 23.9-740.0 ug/L
pH : 7.7-8.4
DO : 5.2-15.3 mg/L
COD : 0.48-8.12 mg/L



<Seasonal mean abundance>

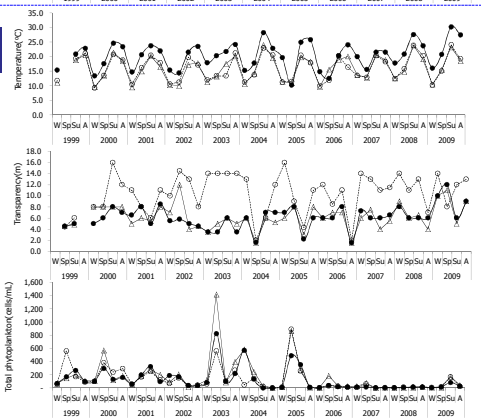
Taxa	T (℃)	pH	DO (mg L⁻¹)	SS (mg L⁻¹)	Abundance (cells ml⁻¹)	Biomass (ng C ml⁻¹)
Total phytoplankton	3.3-37.6	7.7-8.4	5.2-15.9	5.7-107.6	4.3-3,809	0.9-719.4
Bacillariophyceae	3.3-37.6	7.7-8.4	5.2-15.9	5.7-107.6	3.6-3,789	0.9-711.5
Dinophyceae	3.3-37.6	7.9-8.4	5.2-14.0	8.0-45.8	0.07-110.1	0.01-100.5
Dictyochophyceae	3.3-35.5	7.7-8.4	5.2-14.0	9.4-61.3	0.4-36.7	0.14-7.9
Euglenophyceae	3.3-35.5	7.9-8.2	6.4-9.6	8.0-35.3	0.6-94.2	0.03-25.4
Cyanophyceae	14.8-30.3	7.8-8.2	5.9-8.5	6.8-36.0	0.2-5.0	0.005-0.1



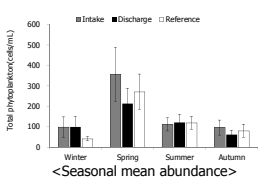
<Mean abundance difference>

Correlation Analysis
Positive correlations : biomass of total phytoplankton and Bacillariophyceae with NO_2
Biomass of Dictyophyceae with SiO_2
Biomass of Euglenophyceae with PO_4
Biomass of Chlorophyceae with Temp.
Suspended solids : 5.7-107.6 mg/L
Negative correlations : biomass of total phytoplankton and Bacillariophyceae with NH_4
Biomass of Dinophyceae with PO_4 and NO_2
Biomass of Chlorophyceae with SS

Hanul

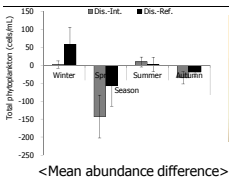


Temperature : 9.3-30.2 ℃
Transparency : 1.5-16.0 m
Suspended solids : 1.8-25.0 mg/L
Total-N : 11.0-229.0 ug/L
Phosphate (PO_4) : 0.1-47.5 ug/L
Silicate (SiO_2) : 13.8-448.1 ug/L
pH : 7.4-8.5
DO : 6.0-13.0 mg/L
COD : 0.3-2.4 mg/L



<Seasonal mean abundance>

Taxa	T (℃)	pH	DO (mg L⁻¹)	SS (mg L⁻¹)	Abundance (cells ml⁻¹)	Biomass (ng C ml⁻¹)
Total phytoplankton	9.3-30.2	7.4-8.5	6.0-13.0	1.8-25.0	1.0-1,417	0.2-197.2
Bacillariophyceae	9.3-30.2	7.4-8.5	6.0-13.0	1.8-25.0	1.0-1,410	0.2-169.9
Dinophyceae	9.3-30.2	7.4-8.5	6.0-13.0	1.8-25.0	0.2-156	0.01-130.3
Dictyochophyceae	9.3-25.8	7.4-8.3	6.1-13.0	2.0-25.0	0.1-127	0.03-69.2
Euglenophyceae	9.7-27.6	7.4-8.5	6.4-13.0	2.4-25.0	0.1-22	0.02-6.0
Cyanophyceae	9.3-23.7	7.6-8.3	6.1-9.3	2.7-23.0	0.3-61	0.01-1.2



<Mean abundance difference>

Correlation Analysis
Positive correlations : biomass of total phytoplankton and Bacillariophyceae with SS
Negative correlations : biomass of total phytoplankton and Bacillariophyceae with transparency and NH_4

Conclusion

1. From 1999 to 2009, sea water temperature varied from 3.3 to 37.6℃ in Hanbit area and from 9.3 to 30.2℃ in Hanul area.
2. The sea water temperature elevation from intake to discharge were 1.8~9.0 ℃ in Hanbit area and 0.9~8.8 ℃ in Hanul area.
3. The results showed that there are no evidence of physical and chemical change around power plant other than temperature increase due to thermal discharge.
4. In both sites, the changes in total phytoplankton coincides with changes of diatom, which is the dominant species. Biomass and abundance of total phytoplankton ranged 4.3-3,809 cells ml^{-1}(0.9-719.4 ng C ml^{-1}) for Hanbit and 1.0-1,417 cells ml^{-1}(0.2-197.2 ng C ml^{-1}) for Hanul.
5. In this study, phytoplankton mean abundances at discharge area was higher than those of intake and reference sites in winter season.
6. The phytoplankton growth inhibition due to cooling system entrainment were 34.5% for Hanbit and 58.5% for Hanul.
7. In addition to water temperature, nutrients contents are important factors for phytoplankton biomass around nuclear power plants. (i.e. Hanbit area, the abundance of dinoflagellates show weak negative correlation with DIP).

Reference

Quarterly reports of environmental survey & assessment around the Hanbit and Hanul nuclear power plant(1999~2009, KHNP)