

Evaluation and Classification of Water Quality Characteristics of Lakes in Hokkaido

1. Introduction

- Hokkaido has more than 100 diverse natural lakes and marshes.
- Regular water quality monitoring is conducted only for some large lakes (and not sure about current water quality in small and medium sized lakes.).
- Considering water resource governance and the protection of important sectors such as tourism and biodiversity, it is critical to delve into the complex dynamics of lake environments.

The **purpose** of this study is...

- To conduct a comprehensively survey the water quality of small and medium-sized lakes and marshes to determine the current water quality level.
- To evaluate water quality characteristics and classify lakes and marshes according to the regional characteristics of Hokkaido.
- Results can be used to determine factors that shape water quality and trends in long-term changes (including climate change impacts).

2. Methodology

- Target** | 70 small and large natural lakes and marshes (covering an area of 0.01km² or more).
- Field surveys** | At least once across each of the 70 lakes and marshes, during the non-snow seasons from 2021 to 2023. Basic water quality metrics were observed at the center of the lake, and surface water samples were collected.
- Water quality analysis items** | Transparency, pH, total nitrogen (TN), total phosphorus (TN), chemical oxygen demand (COD), suspended solids, chlorophyll-a (Chl-a), dissolved organic carbon (DOC), UV absorbance, and major ions (sodium (Na⁺), potassium (K⁺), magnesium (Mg²⁺), calcium(Ca²⁺), chloride (Cl⁻), nitrate (NO₃⁻), sulfate (SO₄²⁻), and bicarbonate (HCO₃⁻)).
- Statistical analysis step1** | Principal Component Analysis (PCA) using the 17 parameters listed above*1.
- Statistical analysis step2** | Hierarchical Cluster Analysis for both freshwater and brackish lakes utilizing principal component scores*2.

*1 Excluded 2 lakes with multiple outliers.
*2 For freshwater lakes, supplementary explanatory variables such as electrical conductivity (EC) and anion equivalent ratio were introduced.

3. Results

Representation of water quality characteristics by PCA

- 3 components with large eigenvalues were extracte.

Principal Component	High positive loadings	Indication
PC1 (42%)	all major ions	influence of seawater /hot springs
PC2 (32%)	COD, TN,TP, Chl-a	degree of eutrophication
PC3 (8%)	UV-abs.DOC,	influence of humic substances

*Percentage figures indicate the contribution ratio

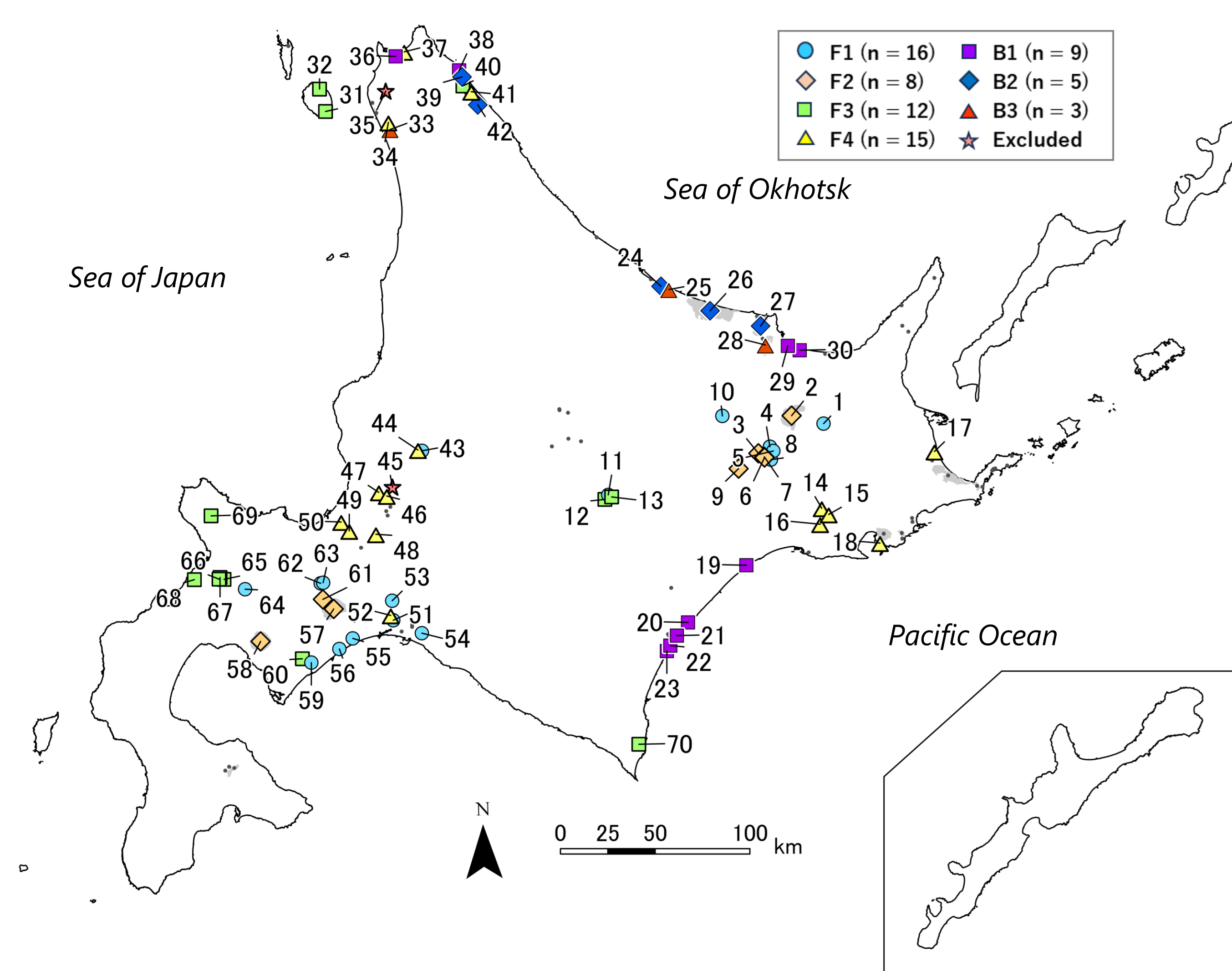
Characterization by Hierarchical Cluster Analysis

- The lakes were classified into 4 clusters of freshwater lakes (F1 – F4) and 3 clusters of brackish lakes (B1 - B3).

	F1	F2	F3	F4	B1	B2	B3
PC1	-0.8	-0.5	-1.4	-1.3	1.7	8.0	-1.0
PC2	-1.7	-2.5	-1.1	2.2	1.7	-0.1	4.2
PC3	-0.3	-0.3	1.2	-0.2	0.1	0.2	-2.4
Notes	HCO ₃ rich	High EC, SO ₄ rich	Low EC, Cl rich				

*Numbers indicate principal component scores, color represents their relative size.

Classification of lakes based on water quality characteristics



F1 | Oligotrophic

1. Lake Masyu

F2 | Volcanic influence

9. Lake Onneto (Akan)

F3 | Humus effect/ Precipitation recharge

31. Otadomari Marsh

F4 | Eutrophic

14. Lake Shirarutoro

B1 | Middle salinity, eutrophic

19. Pashukurutou Marsh

B2 | High salinity, mesotrophic

26. Lake Saroma

B3 | Low salinity, hypertrophic

33. Lake Panke (Sarobetsu)

Excluded (Extreme hypertrophic)

45. Pond Miyajimanuma

4. Discussion & Summary

- A comprehensive water quality survey of 70 lakes and marshes in Hokkaido was conducted and their water quality characteristics were evaluated using statistical methods.
- Lakes were classified according to their geographical and topographical characteristics, trophic level, and salinity environment.

5. Publications & Acknowledgments

- HASEGAWA Y. et al., 2024, Characteristics of water quality and basin environment in 70 lakes and marshes in Hokkaido, Research Institute of Energy, Environment and Geology Bulletin, No.3, pp45 – 59.
- Magazine of Lakes "Lakes of Hokkaido 3rd Edition" will be published in spring 2025!