Effect of typhoons on the phytoplankton of Lake Kasumigaura (Japan)

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Introduction

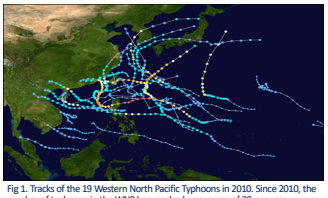


Fig 1. Tracks of the 19 Western North Pacific Typhoons in 2010. Since 2010, the number of typhoons in the WNP has reached an average of 29 per year.

The frequency and intensity of tropical cyclones are on the rise (e.g. Fig.1), and are expected to influence phytoplankton community dynamics in shallow lakes. Lakes are affected by typhoons by direct impacts on resource availability and water column physical features and indirectly by runoff events. The consequences of such impact at the phytoplankton level, however, are still poorly understood.

In this study, we used long-term monitoring data from Station 3 at Lake Kasumigaura (Fig.2) to quantify the effects of typhoons on phytoplankton morpho-functional groups (MFG).

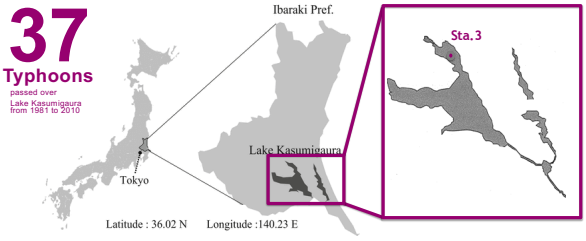


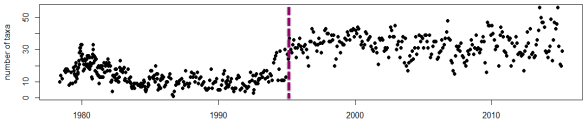
Fig 2. Location of Lake Kasumigaura and the sampling station of the National Institute of Environmental Studies where the sample were collected monthly to biweekly since 1978. The number of typhoons recorded during the studied period (1981-2010) is also provided.

Method

1. Morpho-Functional Group classification

Classification based on the morphological and functional characteristics using the R-package Algae classify

2. Number of taxa identification



TWO separate periods: Before 1995 / After 1995

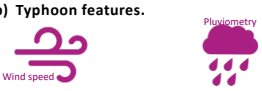
Fig 3: Species richness of Lake Kasumigaura present two clearly distinct periods, before and after 1995. The phytoplankton protocol of Lake Kasumigaura changed around 1995 (from dominant species evaluation to phytoplankton diversity evaluation) resulting in more small diatoms and small potential mixotroph identified after 1995. For the following analysis, we examined each time period separately.

3. Morpho-functional group responses

a) Seasonal characteristics

Typhoon season in Japan spread from May to October. We compared the response of the MFG to typhoons in early (**May - June - July**) and late (**August – September - October**) typhoon season for the two separate periods.

b) Typhoon features.



We compared the MFG responses to typhoons with rain amounts greater than and less than **30 mm/day** & average wind speed greater than and less than **10 m/s.**

For both investigations the response in terms of MFG contribution to the community (increase, decrease, no response) were observed for 4 to 5 sampling events (2 before and 2 after each typhoon, and, when possible, during the typhoon).

Results – Early vs Late typhoon season

Observed responses (% of observation) on the First sampling after each typhoon

Time period	Typhoon Season	Potential mixotroph (small)	*Phytomona -dina*	Colonies	Diatoms (large)	Diatoms (small)
1981-1995	Early	↘ (67%)	↘ (67%)	↗ (100%)	↘ (67%)	↘ (33%)
	Late	↘ (50%)	⊘ (83%)	↘ (67%)	↗ (67%)	⊘ (100%)
1995-2010	Early	↗ (50%)	↗ (50%)	↗ (75%)	↘ (100%)	↘ (75%)
	Late	↗ (80%)	↗ (50%)	↘ (80%)	↗ (80%)	↗ (100%)

Observed responses (% of observation) on the Second sampling after each typhoon

Time period	Typhoon Season	Potential mixotroph (small)	*Phytomona -dina*	Colonies	Diatoms (large)	Diatoms (small)
1981-1995	Early	↘ (100%)	↘ (100%)	↗ (100%)	↘ (100%)	↘ (67%)
	Late	⊘ (50%)	⊘ (83%)	↘ (67%)	↗ (67%)	⊘ (100%)
1995-2010	Early	↗ (75%)	↗ (50%)	↗ (75%)	↘ (100%)	↘ (50%)
	Late	↗ (80%)	⊘ (50%)	↘ (80%)	↗ (80%)	↗ (90%)

Table legend: ↗ Increased proportion; ↘ Decreased proportion; ⊘ No change Observed; (%) Percentage of observed case

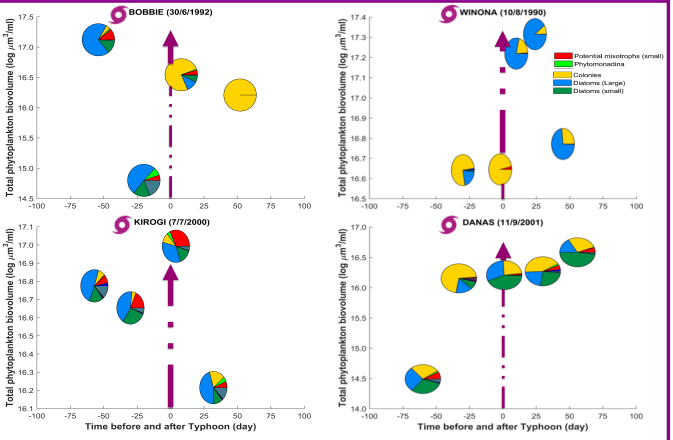


Fig. 4. Typical examples of Morpho Functional Group composition before and after typhoon for the two time periods – pre and post 1995 (top and down) and for the early (left) and late (right) typhoon season.

Results – Response to typhoon features

MFG response to typhoon's heavy rain

Rain condition	Response time	Potential mixotroph (small)	Phytomonadina	Colonies	Diatoms (large)	Diatoms (small)
More than 30 mm/day	1st sampling post typhoon	↗ (92%)	↗ (50%)	↘ (67%)	↗ (67%)	↗ (67%)
	2nd sampling post typhoon	↗ (83%)	↗ (58%)	↘ (92%)	↗ (75%)	↗ (83%)

MFG response to typhoon's wind speed

Observed response at the first sampling after typhoons

Wind condition	Potential mixotroph (small)	Phytomonadina	Colonies	Diatoms (large)	Diatoms (small)
Below 10 m/s	↗ (54%)	⊘ (62%)	↘ (50%)	↘ (54%)	↗ (62%)
Above 10 m/s	↗ (100%)	↗ (55%)	↘ (83%)	↗ (83%)	↗ (83%)

Observed response at the second sampling after typhoons

Wind condition	Potential mixotroph (small)	Phytomonadina	Colonies	Diatoms (large)	Diatoms (small)
Below 10 m/s	↗ (54%)	↗ (46%)	↘ (62%)	↘ (85%)	↗ (54%)
Above 10 m/s	↗ (100%)	↗ (50%)	↘ (100%)	↗ (83%)	↗ (100%)

Table legend: ↗ Increased proportion; ↘ Decreased proportion; ⊘ No change Observed; (%) Percentage of observed case

Examples of MFG response

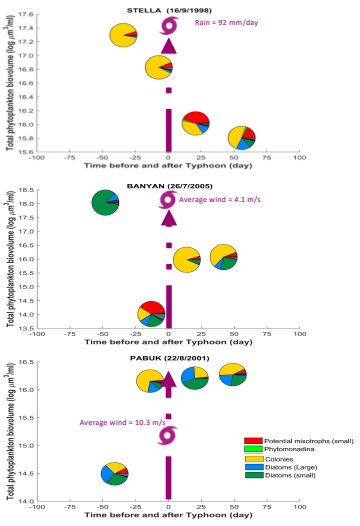


Fig. 5. Typical examples of Morpho Functional Group composition before and after typhoon for heavy rain condition (top), moderate wind (middle), and strong wind (bottom). The track of the typhoons are provided (Inset)

Conclusion & Perspectives

From all of the investigation, we find some differences between the periods before and after 1995.

The stronger responses in the 2nd period were likely a result of better taxonomic resolution.

But in both periods, except diatoms (small and large) all groups increase after a typhoon at the beginning of the typhoon season. In late typhoon season, all groups increase except colonial species.

	Colonies	Diatoms (small and large)
Early typhoon season	↗	↘
Late typhoon season	↘	↗

Colonies and large Diatoms showed opposite result in early and late season. The changes in the MFG group may depend on the variation of temperature (which varies from early to late typhon season) or rainfall.

Typhoon with heavy rainfall and wind speed above 10m/s results in a MFG change similar to late typhoon season.

	Colonies	Other MFG groups
Heavy rainfall & Strong wind	↘	↗

Further investigation will focus on the typhoon vs seasonality effect and on the underlying factors and mechanisms generating the observed responses.

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