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Supplement of

Rates and timing of chlorophyll-*a* increases and related environmental variables in global temperate and cold-temperate lakes

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Sensitivity test on the threshold rate of change in chlorophyll-*a* concentration used to indicate the start of a PCI

We performed an investigation into the sensitivity of the period of chlorophyll-*a* increase (PCI) dataset to the threshold rate of change in the smoothed chlorophyll-a concentration we used to define the start of the increase period (originally defined as 0.05 μgL^{-1}). We tested the response of the generated data to threshold values between 0-0.9 $\mu gL^{-1}d^{-1}$ as this captured the full range of sensitivity of the dataset (Figures S1-S3). As the threshold value increases, the start day occurs later in the year and the PCI shortens. After a critical threshold value is reached, the start day occurs earlier, and the PCI lengthens. This symmetry occurs because if the threshold value is not met, the start day is set to the first day with a positive rate of change in chlorophyll-a concentration, and as the threshold rate is increased, fewer years meet that threshold, and the dataset becomes more like a threshold rate of 0 $\mu gL^{-1}d^{-1}$.

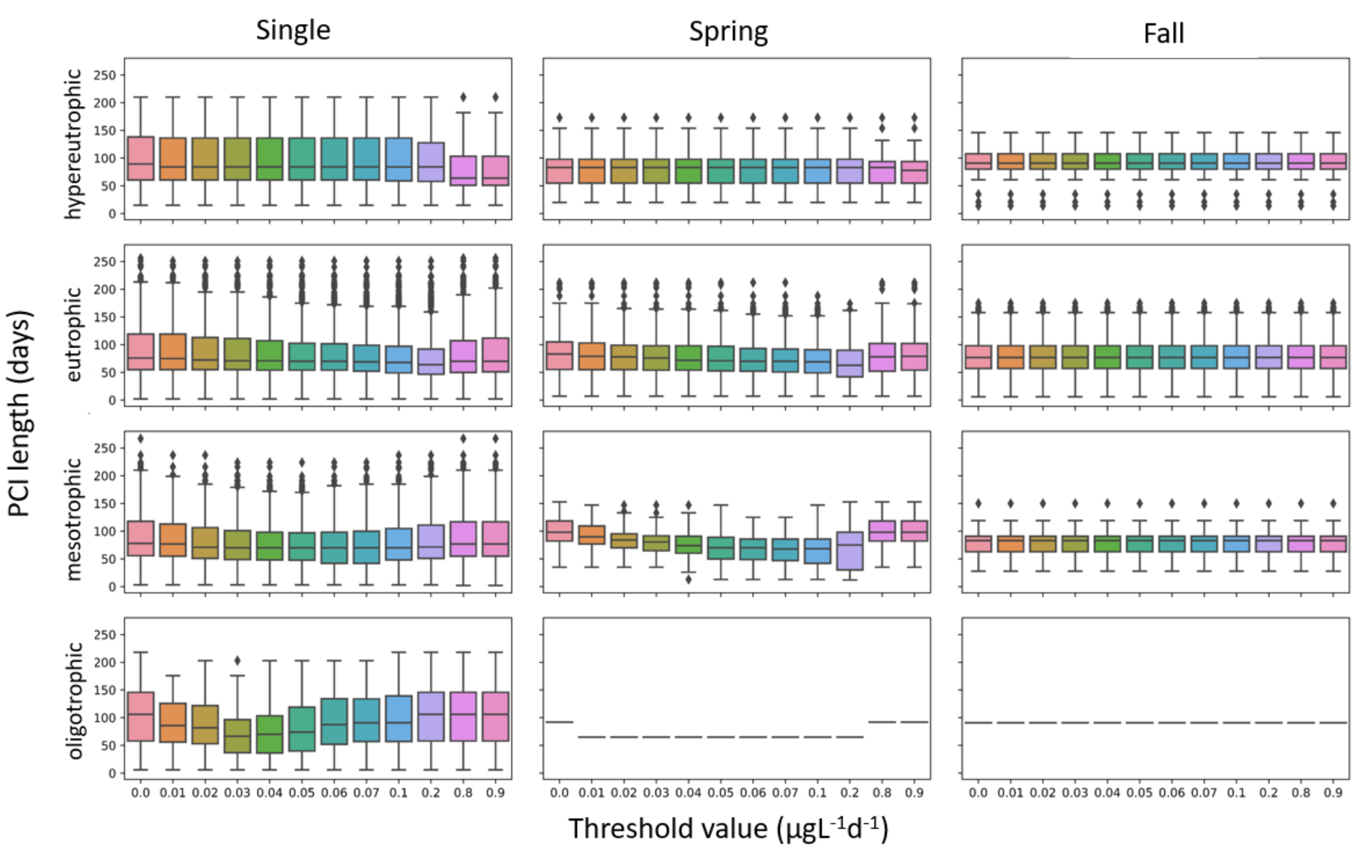

Figure S1: Sensitivity of the length of the period of chlorophyll-a increase (PCI) with changing threshold values on the rate of change in the smoothed chlorophyll-a data. Data are grouped by trophic class and season when the PCI occurred.

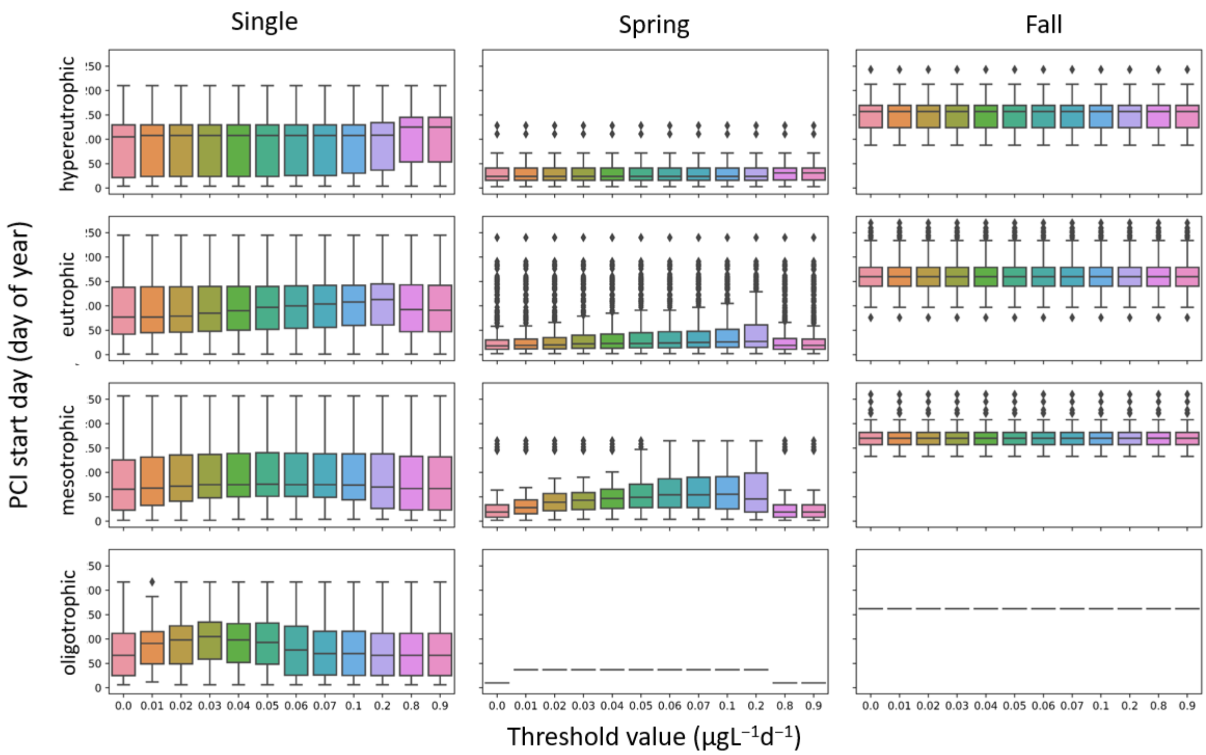

Figure S2: Sensitivity of the start day of the period of chlorophyll-a increase (PCI) to changing threshold values on the rate of change in the smoothed chlorophyll-a data.

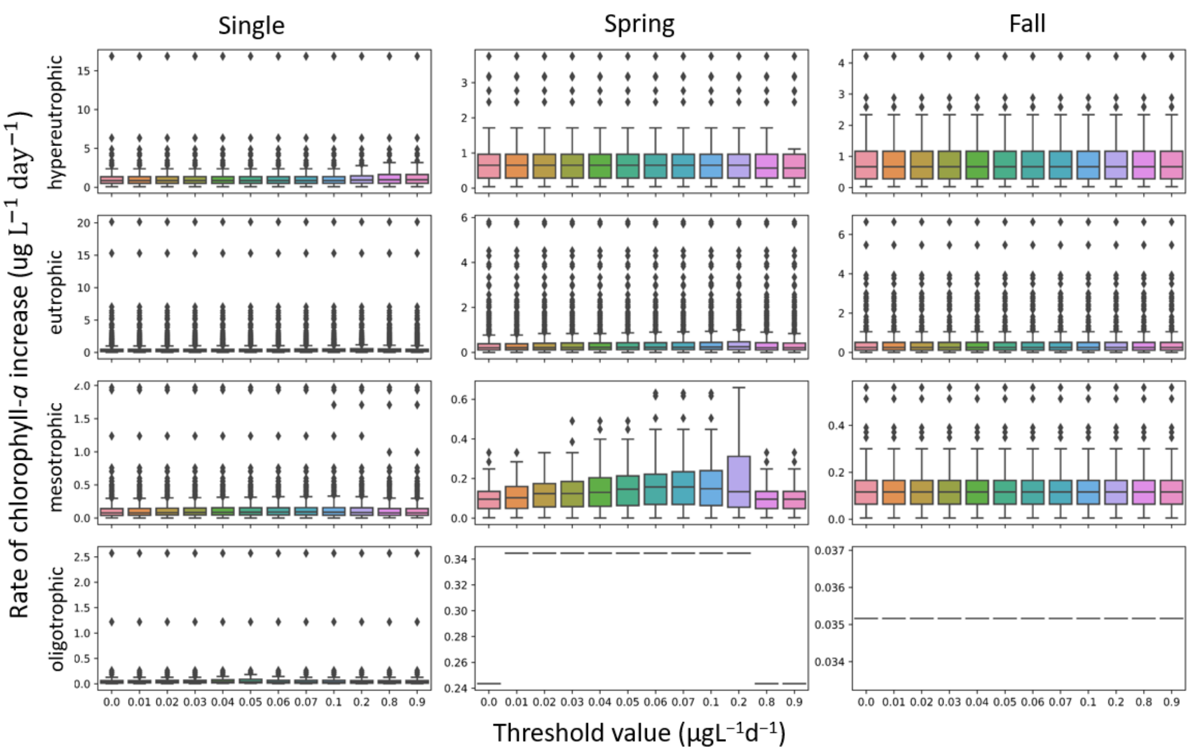

Figure S3: Sensitivity of the rate of chlorophyll-a increase (RCI) during the period of chlorophyll-a increase (PCI) to changing threshold values on the rate of change in the smoothed chlorophyll-a data.

A Kruskal-Walis test on each subgroup of data (grouped by trophic class and season) shows that there is a significant difference in PCI length, start day, and rate of chlorophyll-*a* increase (RCI) when different threshold values are used (Table S1). Note that a significant result occurs when any two groups are significantly different from each other.

Table S1: results from the Kruskal-Walis test on the period of chlorophyll-a increase (PCI) length, start day, and rate of chlorophyll-a increase (RCI). The test was performed on the mean value for each subset of the dataset indicated for each row (grouped by trophic status and season) across the range of threshold values used on the chlorophyll-a rate of change.

Trophic status	Variable	Season	Kruskal-Walis statistic	p-value	Significant (* if yes; alpha=0.05)
Oligotrophic	PCI length	single	19.18	0.058	
		spring	11.00	0.443	
		fall	all_equal	all_equal	
	PCI start day	single	16.54	0.122	
		spring	11.00	0.443	
		fall	all_equal	all_equal	
	RCI	single	5.09	0.927	
		spring	11.00	0.443	
		fall	all_equal	all_equal	
Mesotrophic	PCI length	single	47.00	0.000	*
		spring	187.21	0.000	*
		fall	0.00	1.000	
	PCI start day	single	55.24	0.000	*
		spring	178.73	0.000	*
		fall	0.00	1.000	
	RCI	single	10.28	0.505	
		spring	41.35	0.000	*
		fall	0.00	1.000	
Eutrophic	NCIP length	single	87.64	0.000	*
		spring	75.47	0.000	*
		fall	0.00	1.000	
	PCI start day	single	67.71	0.000	*
		spring	135.82	0.000	*
		fall	0.00	1.000	
	RCI	single	18.09	0.080	
		spring	11.70	0.387	
		fall	0.00	1.000	
Hypereutrophic	PCI length	single	20.22	0.017	*
		spring	0.49	1.000	
		fall	0.00	1.000	

	PCI start day	single	13.46	0.143
		spring	1.25	0.999
		fall	0.00	1.000
	RCI	single	3.17	0.923
		spring	0.01	1.000
		fall	0.00	1.000

We also tested the sensitivity of the dataset when the start day of the PCI was determined based on the normalized rate of change in chlorophyll-a concentration by dividing the rate of change in chlorophyll-*a* by the chlorophyll-*a* concentration. Using this normalized metric means that the differences in phytoplankton standing stock (and chlorophyll-*a* concentration by proxy) between lakes of different trophic classes are accounted for.

We performed the sensitivity test for threshold values between 0-1.2 d^{-1} (Figures S4-S6). This resulted in a similar trend across the range of threshold values tested, but the results were similar between trophic levels (indicating the normalization was effective).

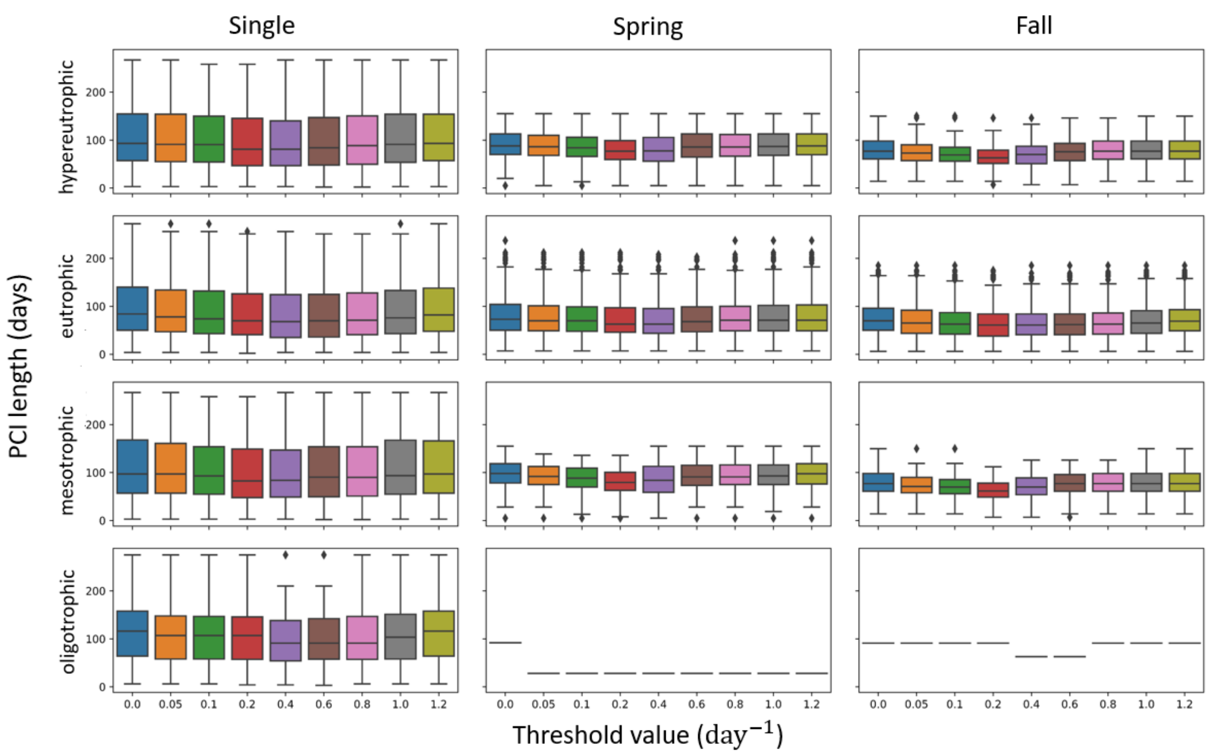

Figure S4: Sensitivity of the start day of the period of chlorophyll-a increase (PCI) to changing threshold values on the normalized rate of change in the chlorophyll-a data.

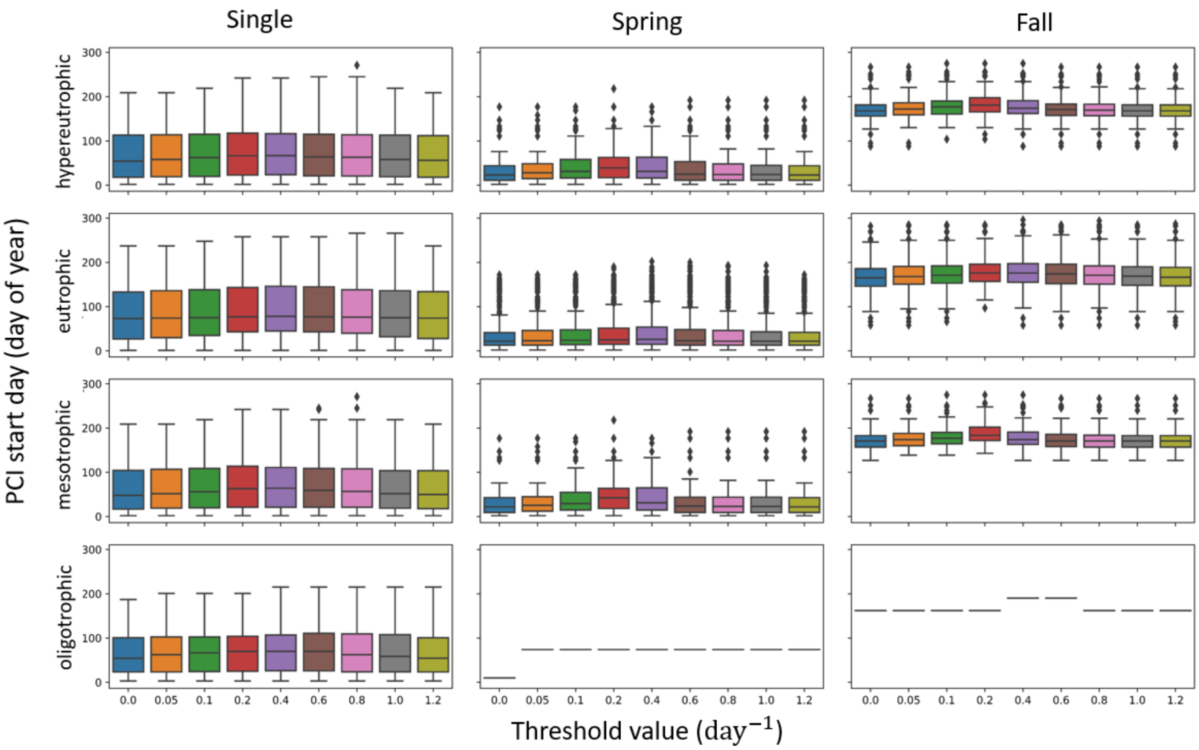

Figure S5: Sensitivity of the length of the period of chlorophyll-a increase (PCI) with changing threshold values on the normalized rate of change in the chlorophyll-a data.

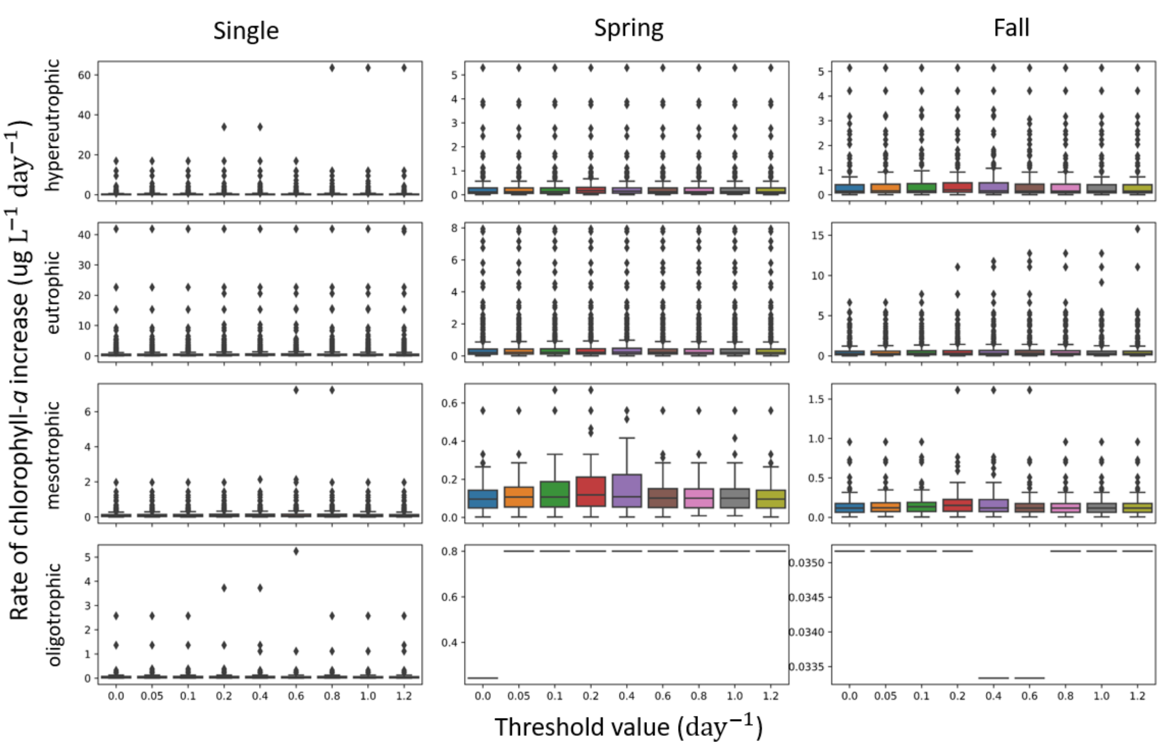

Figure S6: Sensitivity of the chlorophyll-a net rate during the period of chlorophyll-a increase (PCI) with changing threshold values on the normalized rate of change in the chlorophyll-a data.

A Kruskal-Walis test on each subgroup of data (grouped by trophic class and season) shows that there is a significant difference in net chlorophyll-a increase period (NCIP), start day, and chlorophyll-a net rate of increase when different threshold values are used on the normalized chlorophyll-a rate (NCR) (Table S2). Note that a significant result occurs when any two groups are significantly different from each other.

Table S2: results from the Kruskal-Walis test on period of chlorophyll-a increase (PCI) length, start day, and rate of chlorophyll-a increase (RCI). The test was performed on the mean value for each subset of the dataset indicated for each row (grouped by trophic status and season) across the range of threshold values used on the normalized chlorophyll-a rate.

Trophic status	Variable	Season	Kruskal-Walis statistic	p-value	Significant (* if yes; alpha=0.05)
Oligotrophic	PCI length	single	2.37	0.967	
		spring	8.00	0.433	
		fall	8.00	0.433	
	PCI start day	single	3.44	0.904	
		spring	8.00	0.433	
		fall	8.00	0.433	
	RCI	single	0.60	1.000	
		spring	8.00	0.433	
		fall	8.00	0.433	
Mesotrophic	PCI length	single	12.73	0.121	
		spring	22.74	0.004	*
		fall	29.71	0.000	*
	PCI start day	single	16.94	0.031	*
		spring	23.43	0.003	*
		fall	33.87	0.000	*
	RCI	single	4.99	0.758	
		spring	5.51	0.702	
		fall	6.75	0.564	
Eutrophic	PCI length	single	63.97	0.000	*
		spring	20.65	0.008	*
		fall	44.41	0.000	*
	PCI start day	single	52.28	0.000	*
		spring	27.10	0.001	*
		fall	49.26	0.000	*
	RCI	single	33.66	0.000	*
		spring	3.85	0.871	
		fall	5.09	0.748	
Hypereutrophic	PCI length	single	15.84	0.045	*
		spring	15.26	0.054	

		fall	37.11	0.000	*
	PCI start day	single	18.76	0.016	*
		spring	16.91	0.031	*
		fall	38.88	0.000	*
	RCI	single	3.72	0.882	
		spring	2.76	2.760	
		fall	4.64	0.796	

Since the results show that the data changes significantly depending on the threshold used, we chose to use a threshold of 0.4 d^{-1} for determining the start of each PCI. As shown in Figures S3-S6, this higher threshold is the most conservative approach as it selects for the shortest PCI, and since the threshold is based on a normalized rate of change it can be generalized to lakes in different trophic classes. By using a more conservative threshold rate value to define the start of the increase period, we reduce the occurrence of erroneously capturing lead-up time in our definition of the increase period. Thus, the resulting calculated rate is more reflective of the exponential increase period.