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“Algae? This is a color?”

Albert Einstein

TABLE OF CONTENTS

Abstract 7
Introduction 9
Materials and methods 13
Experimental setup *13*
Experimental phase I – constant temperatures *14*
Experimental phase II – temperature peaks *16*
Sampling and analysis *16*
Data processing and statistical analyses *17*
Growth rates, resource use efficiency, and stoichiometry *17*
Biodiversity calculations *17*
Results 19
Community performance *19*
Growth rates *19*
Resource use efficiency *19*
C:P *19*
POP *20*
Mechanisms: complementarity and selection *22*
Biodiversity effects of peak temperatures *22*
Monoculture growth rates, POP, and C:P ratios *24*
Algal response factor – relative changes in biovolume fractions *25*
Discussion 29
Positive biodiversity effects at constant temperatures and after temperature peaks on growth, resource use efficiency, and stoichiometry *29*
Complementarity and selection explain diversity effects on phytoplankton growth *29*
Negative effects of high temperatures on phytoplankton diversity *30*
Individual temperature-dependent growth responses of single taxa vs. clear functional group behavior *31*
Conclusion 33

References 35
Acknowledgements 41

APPENDIX
German summary v
Data collection vii
Curriculum vitae xlix

LIST OF TABLES

Table 1 Phytoplankton cultures analyzed in monocultures and used to create communities

Table 2 25 mixed communities of 5 species richness levels (2, 3, 6, 9, and 12)

Table 3 Variation coefficients for POC and POP of all mixtures per species richness level

Table 4 Variables of Michaelis-Menten (hyperbolic) regression curves as well as of linear regression curves for community growth rates (*r*), resource use efficiency (RUE), molar C:P ratios, and POP as a function of initial species richness

Table 5 Variables of linear regressions including standard errors, as well as r^2-values and P-values for diversity (*H*) at t_2 as a function of diversity at t_1

Table 6 Variables of one-way ANOVAs between monocultures and their functional groups for growth rate (*r*), molar C:P ratios and POP

LIST OF FIGURES

Figure 1 Experimental setup

Figure 2 **(a)** Daily growth rates, **(b)** resource use efficiency (RUE), **(c)** molar C:P ratio, and **(d)** POP as a function of initial species richness

Figure 3 **(a)** Net biodiversity effect, **(b)** complementarity effect, and **(c)** selection effect as a function of species richness

Figure 4 Diversity (Shannon Index, *H*) after temperature peaks (t_2) as a function of diversity (*H*) after two weeks of constant temperatures (t_1)

Figure 5 Daily growth rates of monocultures as a function of temperature

Figure 6 Algal response factors as means of mixtures per species richness level (SR) as a function of temperature (ln-transformed)

Abstract

Biodiversity has been shown to serve as an insurance to regulate responses to environmental changes by enhancing productivity and resource use efficiency and thus the resistance and resilience of ecosystems. However, as a consequence to climate change, phytoplankton diversity is at risk due to increasing water temperatures and extreme heat events, especially in small- to medium-scale water bodies such as ponds, shallow lakes, little streams, or river floodplain backwaters. In this study, we investigated the combined effects of temperature and species diversity on phytoplankton growth performance, nutrient dynamics, and community composition. In a controlled lab experiment, monocultures of 15 freshwater phytoplankton taxa from the functional groups Chlorophyceae, Cyanophyceae, and Bacillariophyceae, as well as 25 mixed communities of different species richness (2, 3, 6, 9, and 12 species) and taxa composition were adapted to 12°C, 18°C, and 24°C, and thereafter exposed to short-term daily temperature peaks of +4°C to simulate extreme heat events.

Growth rates, molar C:P ratios, and resource use efficiency were determined as a function of temperature and diversity, respectively. Increased species richness had a positive, enhancing effect on all parameters measured at all temperature levels, with the medium growth temperature of 18°C being most beneficial to the communities. Diversity enhanced community performance most strongly after short-term temperature peaks and due to complementary traits. However, temperature peaks had an overall negative effect on diversity and higher temperatures increasingly selected for cyanobacteria as the most heat-tolerant experimental group. This reduction in species diversity and the accompanying shift in community composition were most obvious in communities adapted to cooler base temperatures. This study revealed a significant double negative impact of increased water temperatures by diminishing phytoplankton diversity and, as a consequence, minimizing the potential to mitigate extreme heat events in sensitive aquatic systems.

Introduction

Biodiversity is an essential prerequisite for the maintenance of ecosystem services providing manifold benefits to human well-being (MA 2005). With regard to phytoplankton biodiversity, these benefits may reach from supporting primary productivity and provisioning food (via the trophic cascade) to regulating water quality and climate (nutrient and carbon fixation, oxygen production), as well as aesthetic and health aspects (e.g. preventing cyanobacteria dominance and blooms in water bodies used for recreational purposes). Moreover, biodiversity serves as an insurance to minimize negative responses to environmental changes by enhancing the resistance and resilience of ecosystems (McNaughton 1977; Naeem & Li 1997; Chapin *et al.* 2000). However, biodiversity is decreasing at a rapid pace (Hooper *et al.* 2005; Worm *et al.* 2006) and this decrease is further accelerated by man-made climate change and associated rising temperatures on a global scale (IPCC 2002; Lovejoy & Hannah 2006). Temperature is among the major determinants influencing phytoplankton growth, quality, as well as spatial and temporal distribution in freshwater systems. In combination with their dependence on variable factors such as nutrient availability, light, or grazing pressure, taxa of a given natural phytoplankton community respond differently to different temperature regimes (e.g. Canale & Vogel 1974; Rhee & Gotham 1981; Butterwick *et al.* 2005). Among other temperature-dependent consequences, heat stress in primary producers may affect various photosynthetic processes as well as enzyme activity, and alter membrane lipid composition (Raven & Geider 1988; Davison 1991; Murata & Los 1997).

With global average surface temperatures projected to increase by 1.1 to 6.4°C within the next one hundred years (IPCC 2007), water temperatures will follow this trend and lead to alterations in the thermal regime of many freshwater habitats (e.g. Webb & Nobilis 2007). For instance, the annual mean water temperature of the Austrian Danube has increased by 0.1°C per decade since the 1950s (following an air temperature increase of 0.2°C per decade within the same period; Zweimüller *et al.* 2008). Water bodies in floodplains accompanying a river represent an example of notably temperature-driven aquatic systems as they feature a natural gradient of water temperature due to vast differences in their water bodies' morphology (especially water depth) and connectivity to the main channel (Tockner *et al.* 2000). Therefore, for these backwaters, global warming may pose even more of a key pressure than for the river itself due to the missing buffering function inherent to water bodies of larger volume and due to missing a frequent cooling effect by incoming water from the main

channel. Small water bodies like floodplain pools, as well as any other comparable small- to medium-size and/or shallow water bodies including lakes, ponds and little streams respond directly to changing and extreme weather and climate conditions and are therefore especially vulnerable to temperature fluctuations (Gerten & Adrian 2000; Schär *et al.* 2004).

Despite representing only 0.2% of global primary producer biomass, phytoplankton holds responsible for about half of the world's primary production and is thus a key player in the global carbon cycle (Field *et al.* 1998; Geider *et al.* 2001). This high productivity is made possible by comparably fast turnover rates of aquatic primary producers (usually a few days), which, however, may also help to explain the extreme sensitivity and immediate reaction of phytoplankton systems towards external environmental forces (Falkowski *et al.* 1998). In the light of a changing global climate it is of particular interest whether biodiversity, as well as performance and resistance can also be sustained in phytoplankton communities that experience stress conditions like long-term temperature increase due to global warming or sudden temperature peaks due to short extreme events.

According to the diversity-stability hypothesis (McCann 2000), taxonomic, functional, and genetic (Reusch *et al.* 2005) diversity exert stabilizing effects on ecosystem functions like productivity or resource use efficiency. Ever since the issue of diversity-stability was first raised (MacArthur 1955; Elton 1958), the positive effect of diversity on ecosystem functioning has been treated manifold and today receives broad support, predominantly through studies with a focus on terrestrial plant ecology (Tilman *et al.* 1996; Hector *et al.* 1999; Tilman *et al.* 2006; Zavaleta *et al.* 2010). The number of studies dealing with diversity-stability relationships in aquatic systems lags behind, but ongoing research is testing whether the rather well-studied principles for terrestrial ecosystems hold true within one or across several trophic levels at the basis of freshwater and marine food webs (McGrady-Steed *et al.* 1997; Naeem & Li 1997; Petchey *et al.* 2004; Steiner *et al.* 2005; Ptacnik *et al.* 2008; Striebel *et al.* 2009a). In compliance with the diversity-stability hypothesis, algal communities of high species and functional richness lead to increased productivity and resource use efficiency (Ptacnik *et al.* 2008; Striebel *et al.* 2009b; Cardinale 2011).

In general, two major mechanisms are suggested to be responsible for increased productivity at high diversity: (1) complementarity and (2) selection for species with particular traits (Tilman *et al.* 1997; Loreau 2000; Loreau & Hector 2001). Complementarity results from niche differentiation between species due to complementary traits and can thus increase the performance of communities compared to the performance expected from the individual species (overyielding) until a saturation of complementary traits has been reached (Loreau &

Hector 2001; Flombaum & Sala 2008). Selection, on the other hand, occurs when certain species in a mixture become dominant due to beneficial trait combinations, and in turn constitute the bulk of the community biomass. Both selection and complementarity also entail a sampling effect, according to which the chance for a community to contain the most competitive species for a resource or the chance to contain a combination of species with complementary traits is higher the higher the number of different species in this community (Loreau 2000).

The temperature-related responses of phytoplankton have been studied from various perspectives for marine and freshwater systems. A number of studies have focused on investigating the optimal temperature range for growth of various monocultures in laboratory cultures in order to estimate maximum expected growth in nature (e.g. Eppley 1972; Butterwick *et al.* 2005), or on examining interaction effects of temperature and other limiting variables such as nutrients (e.g. Rhee & Gotham 1981; Moss 2010) or light (e.g. Dauta *et al.* 1990; Striebel 2008). Others have looked at impacts of changing temperatures on the dominance of certain functional groups, or at effects on whole phytoplankton communities in natural aquatic systems (e.g. Cairns 1956; Konopka & Brock 1978; Winder *et al.* 2009; Yvon-Durocher *et al.* 2010). Numerous studies deal with changes in plankton structure or carbon and nutrient dynamics in relation to global warming (e.g. Beaugrand & Reid 2003; Mooij *et al.* 2007; Trochine *et al.* 2010; van de Waal *et al.* 2010), only few with the potential consequences of climate change for biodiversity in aquatic systems (e.g. Stachowicz *et al.* 2002; Burgmer 2009).

In this study, the combined effects of temperature and species diversity on phytoplankton growth performance, nutrient dynamics, and community composition were investigated based on the following hypotheses:

(i) Independent of temperature, growth rates, resource use efficiency, and C:P ratios of phytoplankton communities are expected to increase with increasing diversity.

(ii) Communities of higher diversity are expected to show a positive net biodiversity effect (overyielding) due to complementarity at lower temperatures and until a saturation of complementary traits has been reached, and increasingly due to selection beyond the saturation point as well as at higher temperatures.

(iii) Due to selection for certain phytoplankton groups or species over others, increased temperature stress should lead to an overall negative effect on diversity.

(iv) Based on the distinctive temperature-dependent growth performance of different functional phytoplankton groups, a temperature-related shift in community composition due to selection for more heat-tolerant groups at higher temperatures can be expected.
In a combined experiment, both the effects of temperature on freshwater phytoplankton monocultures and on the performance and composition of phytoplankton communities of different diversity were tested. Under controlled laboratory conditions 15 freshwater taxa from three different functional groups, as well as 25 artificial communities of different species richness and composition were grown at three constant temperature levels. This adaptation phase to constant temperatures was followed by a period of repeated short-term temperature peaks to simulate extreme heat events and thus to cause sudden heat stress to an existing community. Growth rates, resource use efficiency, and C:P ratios of monocultures and communities alike were determined to reveal temperature- and diversity-dependent effects on growth performance and nutrient stoichiometry, as well as on community composition.

Materials and methods

Experimental set-up

Laboratory experiments were performed with 15 pre-cultured phytoplankton species from three functional groups (Chlorophyceae (henceforth green algae), Cyanophyceae (henceforth cyanobacteria), Bacillariophyceae (henceforth diatoms)) (Table 1). These species were chosen from a pool of species that occur in the Danube floodplains near Vienna, Austria, a system exposed to a natural temperature gradient (Görnet *et al.* 2008; Schagerl *et al.* 2009). Cultures were obtained from various algal culture collections and allowed to grow in WC growth medium (Guillard & Lorenzen 1972) for at least three weeks prior to the start of the experiment (at 18°C). Nutrient concentration in the medium was set to a saturated level (TP of ca. 7 µmol L^{-1}) in order to eliminate phosphorous or silica limitation as influencing variables. During the last week prior to the start of the experiment, the cultures were gradually (ca. -1°C d^{-1}) cooled down to a water temperature of 12°C, the lowest of three experimental temperature levels, which was chosen in accordance with the mean annual water temperature of the Danube River (12°C; station Hainburg an der Donau (Lebensministerium 2009)).

Table 1 Phytoplankton cultures analyzed in monocultures and used to create communities. Sources of algae cultures: [1]Culture collection of the University of Munich, Germany; [2]Culture Collection of Algae Göttingen (SAG), Germany; [3]Culture Collection of Autotrophic Organisms (CCLA), Třeboň, Czech Republic.

Species	Group	Order	Taxa name abbreviation
Chlamydomonas reinhardtii[1]	Chlorophyceae	Volvocales	Chl
Pediastrum simplex[1]	Chlorophyceae	Chlorococcales	Ped
Scenedesmus obliquus[1]	Chlorophyceae	Chlorococcales	Sce
Spirogyra sp.[1]	Chlorophyceae	Zygnematales	Spi
Staurastrum tetracerum[1]	Chlorophyceae	Desmidiales	Sta
Anabaena cylindrica[1]	Cyanophyceae	Nostocales	Ana
Aphanizomenon gracile[2]	Cyanophyceae	Nostocales	Aph
Chroococcus minutus[1]	Cyanophyceae	Chroococcales	Chr
Leptolyngbya fragilis[3]	Cyanophyceae	Oscillatoriales	Lep
Oscillatoria limosa[2]	Cyanophyceae	Oscillatoriales	Osc
Asterionella formosa[1]	Bacillariophyceae	Pennales	Ast
Fragilaria crotonensis[1]	Bacillariophyceae	Pennales	Fra
Navicula pelliculosa[1]	Bacillariophyceae	Pennales	Nav
Skeletonema subsalsum[2]	Bacillariophyceae	Centrales	Ske
Stephanodiscus minutulus[2]	Bacillariophyceae	Centrales	Ste

For the experiment, three basic temperature levels were established: 12°C, 18°C, and 24°C, according to a naturally occurring temperature range in the Danube floodplains. 250 mL cell culture flasks were used as experimental units, shaken twice a day in order to reduce sinking

losses and to ensure even temperature distribution, and positions of culture flasks were permuted randomly to guarantee equal conditions. The semi-batch cultures (medium exchange of 10% d^{-1}) were exposed to a light:dark cycle of 16:8 h at a light intensity of about 100 µmol m^{-2} s^{-1} (measured in water). Light intensity and water temperature were controlled through continuous data logging (HOBO) in culture flasks filled with tap water.

Experimental phase I – adaptation to constant temperatures

In phase I of the experiment, 200 mL of each of the 15 monocultures (with three replicates each) were transferred to 250 mL cell culture flasks at equal initial biovolume ($3*10^6$ μm^3 mL^{-1}, a value comparable to natural phytoplankton concentrations) and grown for 14 days to adapt to constant 12°C, 18°C, and 24°C, respectively, under the conditions described above. Additionally, a total of 25 communities of different species richness and composition were created by randomly selecting from the 15 taxa available and by mixing at equivalent initial chlorophyll content (5µg L^{-1}, measured by means of multiwavelength-excitation PAM chlorophyll fluorometry). This way, 5 species richness levels (2, 3, 6, 9, or 12 species), each with 5 mixtures of different species composition, were established (Table 2). In order to keep the sample number low, yet to guarantee a minimum of statistical control, one mixture (no. 5, see Table 2) from each species richness level was randomly chosen to be replicated three times, while the remaining mixtures were not replicated. Variance of both POC (Particulate Organic Carbon) and POP (Particulate Organic Phosphorous) within the three replicates of mixture no. 5 was lower than variance within the four non-replicated treatments and one randomly chosen replicated treatment in 26 out of a total of 30 cases (Table 3). Thus, for further data analysis, instead of replicate means the one randomly chosen replicate from the total of three replicates was used. As the monocultures, the communities were grown at constant 12°C, 18°C, and 24°C, respectively, for two weeks under the conditions described above.

At the start of phase I and after these first two weeks of incubation at constant temperatures, samples were taken as described in the section *Sampling and analysis* below.

Table 2 25 mixed communities of 5 species richness levels (2, 3, 6, 9, and 12 species). At each species richness level, five mixtures of different community composition were created by random selection of species from the 15 monocultures available. SR=species richness. M=Mixture. Taxa name abbreviations see Table 1.

SR	M												
2	1	Chl	Ped										
2	2	Sce	Lep										
2	3	Ped	Nav										
2	4	Sce	Ana										
2	5	Sta	Ske										
3	1	Sce	Lep	Nav									
3	2	Aph	Fra	Ske									
3	3	Chl	Spi	Lep									
3	4	Aph	Lep	Nav									
3	5	Sce	Ped	Chr									
6	1	Spi	Sce	Chr	Aph	Fra	Ske						
6	2	Chl	Spi	Sce	Sta	Osc	Nav						
6	3	Chl	Ped	Osc	Lep	Fra	Nav						
6	4	Spi	Sce	Osc	Chr	Aph	Nav						
6	5	Chl	Spi	Ana	Aph	Lep	Fra						
9	1	Chl	Spi	Sce	Sta	Chr	Aph	Fra	Ast	Nav			
9	2	Chl	Sce	Sta	Osc	Ana	Aph	Fra	Nav	Ste			
9	3	Chl	Spi	Sce	Osc	Chr	Aph	Lep	Fra	Nav			
9	4	Chl	Sce	Osc	Aph	Lep	Fra	Ast	Ste	Ske			
9	5	Chl	Spi	Sce	Ana	Aph	Lep	Fra	Nav	Ske			
12	1	Chl	Spi	Sce	Sta	Ped	Ana	Chr	Aph	Lep	Fra	Nav	Ske
12	2	Chl	Spi	Sce	Sta	Ped	Osc	Ana	Aph	Lep	Fra	Nav	Ske
12	3	Chl	Spi	Sce	Ped	Osc	Ana	Chr	Aph	Lep	Fra	Nav	Ske
12	4	Chl	Spi	Sce	Sta	Ped	Osc	Ana	Chr	Aph	Fra	Nav	Ske
12	5	Chl	Spi	Sce	Sta	Ped	Ana	Chr	Aph	Lep	Fra	Nav	Ske

Table 3 Variation coefficients (in %) for POC and POP of all mixtures per species richness level (including the randomly chosen replicate of mixture no. 5, excluding the remaining two replicates) and of the three replicates per mixture no. 5 (see Table 2) after two weeks of constant temperatures at t_1 and after an additional week of short-term temperature peaks at t_2 calculated as standard deviation divided by mean. SR=species richness.

		t_1					t_2				
		SR2	**SR3**	**SR6**	**SR9**	**SR12**	**SR2**	**SR3**	**SR6**	**SR9**	**SR12**
POC mixtures	12°C	34.7	30.7	18.0	14.5	6.3	93.7	75.5	37.2	3.2	1.7
	18°C	36.8	48.9	17.6	12.8	6.9	39.5	51.5	28.2	9.7	5.5
	24°C	30.5	56.1	20.7	5.7	9.4	40.3	34.2	9.2	4.7	29.7
POC replicates	12°C	2.2	2.0	2.0	3.0	4.3	6.2	3.9	5.0	4.8	6.9
	18°C	3.0	0.8	4.3	2.4	0.6	6.7	1.1	3.3	5.6	6.3
	24°C	3.9	1.0	4.2	32.1	3.7	9.3	3.9	5.5	4.0	8.8
POP mixtures	12°C	14.8	14.2	36.0	11.6	31.7	50.5	33.0	29.2	8.1	3.8
	18°C	22.2	8.7	13.7	29.2	26.5	55.6	49.1	36.9	17.7	9.7
	24°C	6.7	15.7	51.8	36.6	18.5	39.6	51.2	34.1	18.9	31.2
POP replicates	12°C	6.2	2.5	2.2	14.4	6.3	6.0	4.3	4.3	4.3	7.1
	18°C	1.1	4.7	10.2	5.1	5.4	12.0	6.5	14.3	6.6	13.5
	24°C	2.6	9.7	5.2	5.2	17.8	3.7	2.1	2.0	21.3	17.2

Experimental phase II – temperature peaks

Starting on day 15 (after the cultures had reached their stationary growth phase), water temperature for both the monocultures and the communities was increased by 4°C over a period of 7 h per day to reach 16°C, 22°C, and 28°C, respectively. These temperature peaks were repeated daily for 7 days (Figure 1). Again, after these 7 days, samples were taken as outlined below.

To avoid confusion due to a total of six different temperature levels, I will hereafter refer to the initial three temperature levels in phase I as 12°C, 18°C, and 24°C, or collectively as 'constant temperatures' and employ the term 'temperature peaks' for treatments in phase II of the experiment.

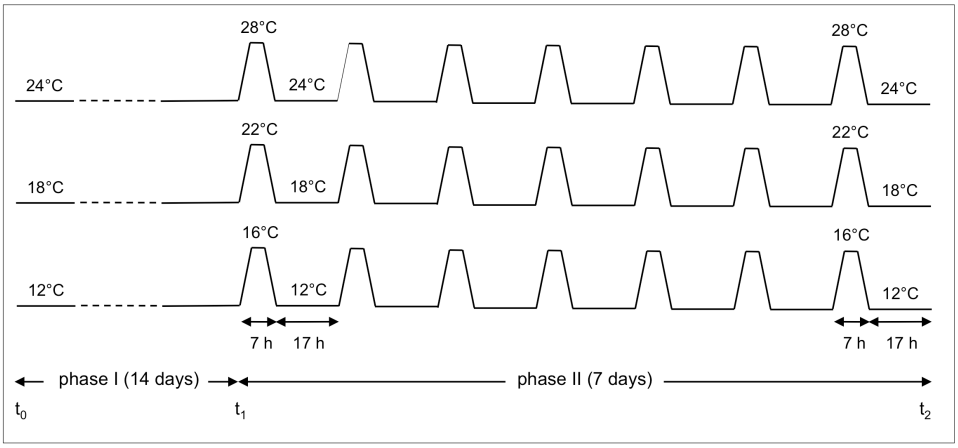

Figure 1 Experimental setup. Phase I: 14-day incubation at constant temperatures (12°C, 18°C, 24°C). Phase II: 7-day incubation including daily 7-hour peaks of +4°C to reach 16°C, 22°C, and 28°C. t_0, t_1 and t_2: measure points at the start, after phase I, and after phase II.

Sampling and analysis

As proxies for biomass and nutrient uptake, respectively, samples for POC (Particulate Organic Carbon) and POP (Particulate Organic Phosphorous) analysis were filtrated onto precombusted and acid-washed glass-fibre filters (Whatman GF/C) at the start (t_0), after phase I (t_1), and again after phase II (t_2). POC was measured by infrared spectrometry (C-Mat 500, Ströhlein). POP was determined by molybdate reaction after sulfuric acid digestion (Murphy & Riley 1962).

To determine cell numbers and biovolumes, community samples were taken at t_0, t_1, and t_2, and were fixed with Lugol's solution to be counted under an inverted microscope (Utermöhl 1958). Species-specific cell volumes were calculated by approximation to simple geometrical

bodies (Hillebrand *et al.* 1999). Community biovolumes were calculated as the product of single cell volumes with corresponding cell densities derived from Utermöhl counting.

Data processing and statistical analyses

Growth rates, resource use efficiency, and stoichiometry – Daily growth rates (r) of monocultures and communities were calculated based on POC according to Equation 1:

$$r = (LN(POC_{t_{end}}) - LN(POC_{t_0}))/t, \quad (1)$$

where t_{end} is the POC mean end value at t_1 or t_2 of a certain taxon or end value of a community, respectively, t_0 is the respective mean POC start value and t the days of incubation (t=14 at t_1, t=21 at t_2).

Molar carbon-to-phosphorous (C:P) ratios were calculated from POC and POP. Resource use efficiency (RUE) was calculated by relating biomass (as mg POC L^{-1}) to the total P concentration (mg TP L^{-1}) per sample (Ptacnik *et al.* 2008).

A one-way ANOVA (confidence interval (CI) of 95%) was performed to detect differences in daily growth rates, POP, and C:P between same-temperature monoculture treatments at both t_1 and t_2. Two-sided independent t-tests (CI=95%) between t_1 and t_2 monoculture growth rates, POP, and C:P across all temperatures were performed to detect the influence of peak temperatures on growth rates. Generally, wherever data failed normal distribution, a Mann-Whitney Rank Sum Test was applied instead. Since no control treatments were run at constant temperatures during phase II, it could be argued that the effects of time and peak temperature on growth and biomass development cannot be separated. However, before entering phase II, it was made sure that all cultures had reached their stationary growth phase by the end of phase I. Therefore, the time effect is assumed to be minimal and the peak temperature effect to make out the major part of the responses observed. Also, as results will show, compared to the t_1 measurements, t_2 responses were too distinct to be solely attributed to time alone.

Due to an expected saturation of complementary traits at a certain species richness level (Loreau & Hector 2001; Flombaum & Sala 2008) a Michaelis-Menten relation (hyperbolic function: $y=a*x/(b+x)$) was assumed between community growth rates and species richness and was tested against a linear regression ($y=a+b*x$) in an ANOVA. A significantly lower residual sum of squares (CI=95%) decided for the hyperbolic function as the better fit. Wherever curves did not significantly differ, the linear model with one additional degree of freedom was preferred. A multifactorial ANOVA (CI=95%) delivered effects of species richness and temperature (as a factor) on growth rate, as well as interacting effects between

these two parameters. RUE, POP, and C:P as a function of species richness were also tested for hyperbolic and linear relationships, and tested for species richness and temperature effects.

Biodiversity calculations – Diversity H of communities was calculated as the Shannon Index:

$$H = -\sum_{i=1}^{n} p_i * \ln p_i, \quad (2)$$

with n being species richness and p_i being one species' fraction of biovolume of the community biovolume. Since diversity at the start of the experiment correlated well with initial species richness (R=0.92), our parameters measured and calculated were displayed as a function of initial species richness for reasons of more visual clarity of this reference variable. Net biodiversity effects (potential overyielding effects) of communities were determined after two (t_1) and again after three weeks of incubation (t_2) as the difference between the observed (measured) yield (POC) of the community and its expected yield as calculated from the sum of expected yields (based on monoculture growth rates) of the single taxa the community was composed of (Loreau & Hector 2001).

To separate the effects leading to the observed responses of biomass development to changes in species diversity, the net biodiversity effect was partitioned into a complementarity effect and a selection effect as suggested by Loreau and Hector (2001) (additive partitioning). Biodiversity effects were plotted against species richness, and again, a hyperbolic versus a linear function was tested.

To find out about the effect of temperature on community composition and relative biovolume development, an algal response factor was calculated on a functional group level (Sarnelle 1992). In our case, this response factor can be defined as the biovolume fraction of one functional group of the community at the end of phase I (t_1) and phase II (t_2), respectively, divided by the group's initial share of biovolume at t_0. A multifactorial ANOVA was again used to reveal temperature and species richness effects as well as interactive effects of these two variables.

Results

Community performance

Growth rates – Both after constant (t_1) and after peak temperature treatments (t_2), growth rate showed a positive relationship with species richness at all temperature levels (Figure 2a, Table 4) best described by a hyperbolic (saturation) function (compared to a linear function). A multifactorial ANOVA revealed significant effects of species richness on growth rate at both t_1 ($P<0.001$, $F_{5,102}=5.611$) and t_2 ($P<0.001$, $F_{5,102}=11.11$). A significant temperature effect could only be detected for t_1 ($P<0.01$, $F_{2,102}=6.18$), while there was no interactive effect of species richness and temperature at either t_1 or t_2. At both t_1 and t_2, saturation constants (*a*) were highest at 18°C (Table 4), and generally slightly higher at t_2.

Resource use efficiency – For resource use efficiency (RUE), the hyperbolic function was the better fit than the linear model in all treatments (Figure 2b and Table 4). RUE significantly increased with increasing species richness at t_1 and t_2; in all temperature treatments, saturation constants were higher at t_2 than at t_1. Besides the positive species richness effects (t_1: $P<0.001$, $F_{5,102}=24.91$; t_2: $P<0.001$, $F_{5,102}=44.32$), the temperature effect was significant at t_1 ($P<0.001$, $F_{2,102}=17.30$), but was not significant at t_2 ($P<0.1$, $F_{2,102}=2.85$). t_1 also revealed a positive interactive effect of species richness and temperature ($P<0.001$, $F_{10,102}=3.84$). The 18°C treatment showed the strongest interaction with species richness at both t_1 and t_2; at t_1, the 12°C treatment curve was lowest, while at t_2 it was the 24°C treatment that showed the lowest saturation constant.

C:P ratios – At t_1, molar C:P ratios showed a negative response (hyperbolic function) to species richness at 12°C (as a result of the relation between carbon assimilation and phosphorus uptake) and a positive, yet non-significant response at the remaining temperatures (multifactorial ANOVA; species richness effect across all temperatures: $P<0.001$, $F_{5,102}=5.26$; Figure 2c, Table 4). At t_2, C:P significantly increased with increasing species richness ($P<0.001$, $F_{5,102}=6.89$), in a linear relationship at 12°C and 18°C, and with a hyperbolic function as the better fit at 24°C. The temperature effect was significant at both t_1 ($P<0.001$, $F_{2,102}=6.99$) and at t_2 ($P<0.001$, $F_{2,102}=3.39$). Here, the species richness-dependent response was highest at 24°C at t_1 and at t_2, followed by the 18°C treatments. Communities grown at 12°C delivered the least pronounced species richness effect on C:P ratios at both t_1 and t_2

(with a negative relationship at t_1). A significantly positive species richness*temperature effect was detected at t_1 ($P<0.01$, $F_{10,102}=2.81$).

POP – POP significantly increased with increasing species richness at t_1 and at t_2 (Figure 2d, Table 4). t_1 showed significant species richness effects ($P<0.001$ $F_{5,102}=22.99$), but no significant temperature effect. t_2 revealed both significant species richness ($P<0.001$ $F_{5,102}=20.84$) and temperature effects ($P<0.05$, $F_{2,102}=3.88$). At t_2, the response of the 12°C treatment was most pronounced, closely followed by the 18°C treatment; the 24°C treatment showed the lowest saturation constant.

Table 4 Variables of Michaelis-Menten (hyperbolic) regression curves (model 1: *y=a*x/(b+x)*; n=40, CI=95%) as well as, where applicable (see Methods), of linear regression curves (model 2: *y=a+bx*; n=40, CI=95%) including standard errors for variables a and b for community growth rates (*r*), resource use efficiency (RUE), molar C:P ratios, and POP as a function of initial species richness after two weeks of constant temperatures at t_1 and after an additional week of short-term temperature peaks at t_2 (Figure 2). Significant P-values in bold.

	t_1			**t_2**		
	12°C	**18°C**	**24°C**	**12°C**	**18°C**	**24°C**
r	model 1	model 1	model 1	model 1	model 1	model 1
a	0.13±0.01	0.18±0.01	0.17±0.01	0.19±0.01	0.19±0.01	0.18±0.01
b	0.06±0.15	0.33±0.15	0.26±0.15	0.60±0.18	0.42±0.12	0.42±0.15
r^2	0.01	0.15	0.10	0.35	0.33	0.18
P	0.58	**<0.05**	**<0.05**	**<0.001**	**<0.001**	**<0.001**
RUE	model 1	model 1	model 1	model 1	model 1	model 1
a	30.33±2.46	56.37±7.27	45.15±5.15	131.20±23.3	141.21±15.8	95.13±11.15
b	1.08±0.32	1.59±0.65	1.29±0.50	4.57±1.84	3.76±1.02	2.13±0.72
r^2	0.42	0.39	0.38	0.61	0.73	0.55
P	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**
C:P	model 1	model 2	model 1	model 2	model 2	model 1
a	32.88±4.43	60.10±8.67	62.57±9.28	45.60±5.19	57.31±6.85	97.45±11.42
b	-0.43±0.10	1.58±1.47	0.05±0.24	2.71±0.88	2.48±1.16	0.74±0.37
r^2	0.20	0.03	0.002	0.20	0.11	0.19
P	**<0.01**	0.19	0.81	**<0.01**	**<0.05**	**<0.01**
POP	model 1	model 1	model 1	model 1	model 1	model 1
a	486.77±52.6	418.59±49.1	445.16±41.6	829.36±71.0	803.29±90.3	573.71±62.7
b	1.48±0.51	0.77±0.38	1.33±0.41	2.36±0.56	1.64±0.57	1.18±0.45
r^2	0.42	0.23	0.46	0.69	0.43	0.34
P	**<0.001**	**<0.01**	**<0.001**	**<0.001**	**<0.001**	**<0.001**

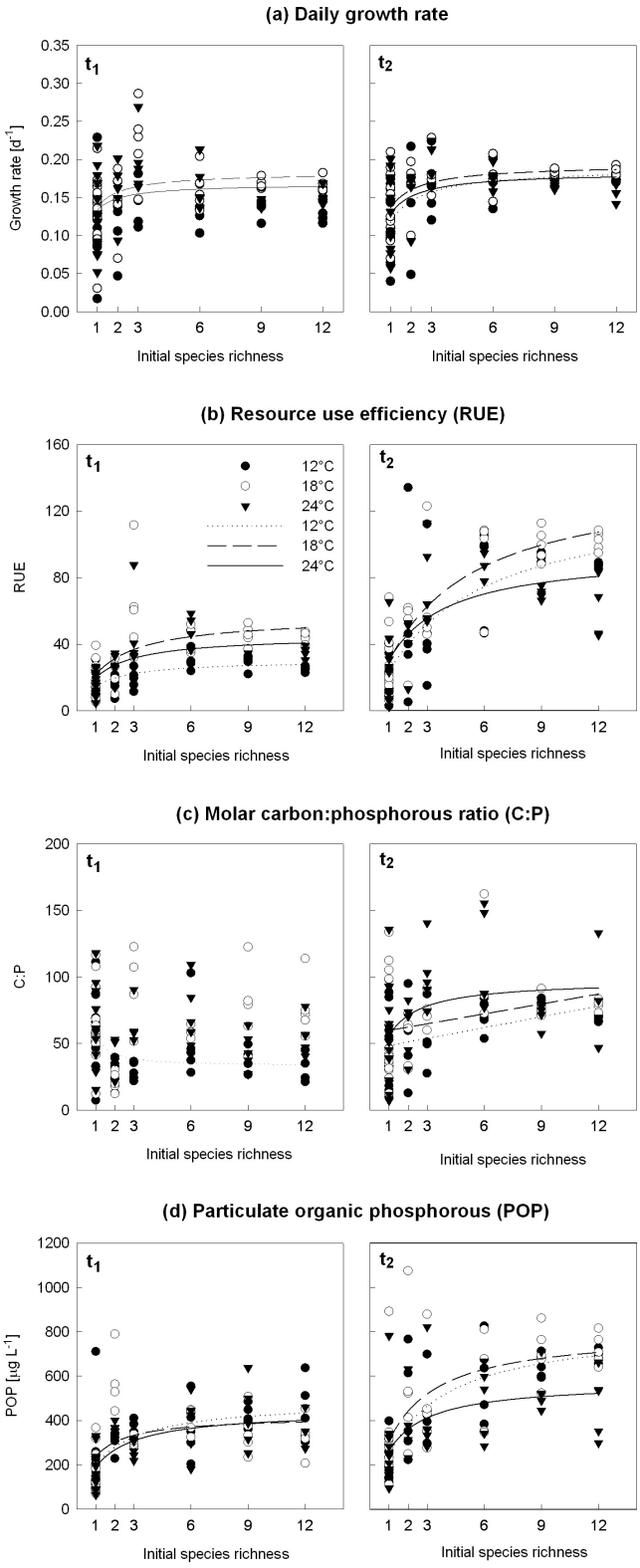

Figure 2 (a) Daily growth rates, **(b)** resource use efficiency (RUE), **(c)** molar C:P ratio, and **(d)** POP as a function of initial species richness after two weeks of constant temperatures at t_1 (●) and after an additional week of short-term temperature peaks at t_2 (○) including significant hyperbolic functions (model 1: *y=a*x/(b+x)*; n=40, CI=95%) and, where applicable, linear regression curves (model 2: *y=a+b*x*; n=40, CI=95%). Regression variables see Table 4.

Mechanisms: complementarity and selection

The net biodiversity effect across all species richness levels was significantly positive for all treatments at both t_1 and t_2 (one-sample t-test: grand mean significantly different from zero), except for the t_1 12°C treatment where the grand mean was negative (but not statistically significant) (Figure 3). Two-sample independent t-tests (or Mann-Whitney Rank Sum Tests) across grand means of complementarity and selection revealed that the net biodiversity effect could largely be explained by the complementarity effect (Figure 3b) with the grand mean of the complementarity effect greater than the grand mean of the selection effect (significantly in all but the t_1 12°C and the t_2 24°C treatments) (Figure 3c). Means of the t_2 net effect were significantly higher than t_1 means at each temperature; complementarity was significantly higher at t_2 compared to t_1 (except for the 24°C treatment which was also higher at t_2, but not significantly), while the selection effect at t_2 was not significantly different from t_1. Neither the linear nor the hyperbolic model delivered significant regressions as a function of species richness except for the t_2 selection effect at 18°C which showed a significant positive linear relationship ($P<0.01$, $r^2=0.28$). However, the overall species richness effect was significant for the net effect at t_1 ($P<0.001$, $F_{4,60}=7.68$), the complementarity effect at t_1 ($P<0.001$, $F_{4,60}=8.63$) and t_2 ($P<0.05$, $F_{4,60}=3.12$), and the selection effect at t_2 ($P<0.05$, $F_{4,60}=2.85$). Complementarity tended to (linearly) increase with increasing species richness at 12°C and (linearly) decrease at 18°C and 24°C, while selection showed the opposite tendency at 18°C and 24°C, especially at t_2. A significant effect of temperature could only be observed on the t_1 net effect ($P<0.001$, $F_{2,60}=8.82$) and the t_1 complementarity effect ($P<0.01$, $F_{2,60}=5.57$). Grand means for all effects at t_1 were highest at 18°C and lowest at 12°C (significant differences between 12°C and 18°C, as well as between 12°C and 24°C of the net effect and the complementarity effect). t_2 showed no significant temperature effects.

Biodiversity effects of peak temperatures

Diversity *H* (Shannon Index) was generally significantly lower after the short-term temperature peaks than after two weeks of constant temperature incubation at all three temperature levels (Figure 4; ANCOVA: $F_{1,144}=12.13$, $P=0.001$). Specifically, the decrease in diversity from t_1 to t_2 was most pronounced at 12°C ($F_{1,48}=8.45$, $P=0.006$) and diversity at t_2 was still significantly lower at 18°C ($F_{1,48}=4.18$, $P=0.046$), while at 24°C the decrease in diversity after the temperature peaks was only marginal ($F_{1,48}=1.10$, $P=0.3$; Table 5).

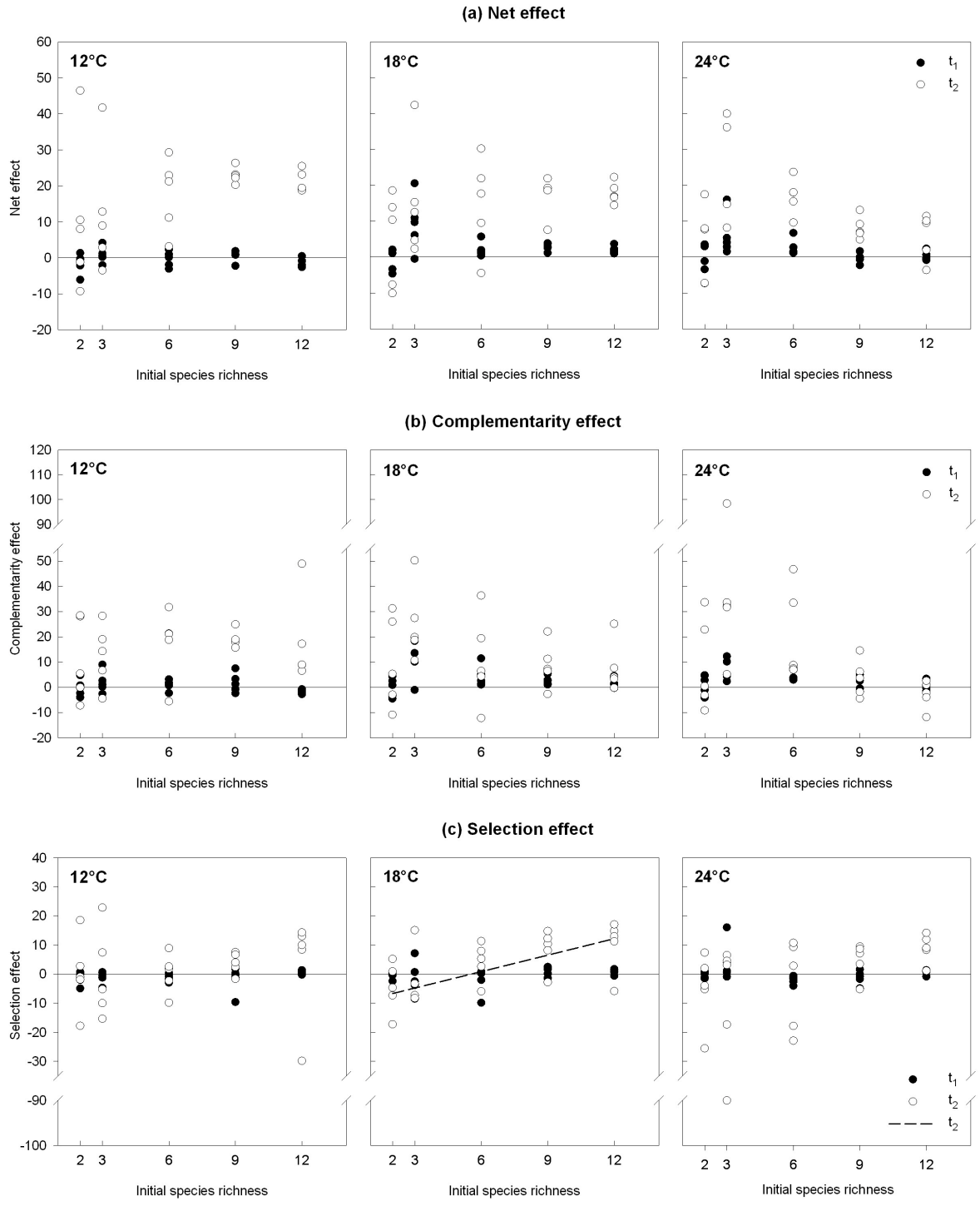

Figure 3 (a) Net biodiversity effect, **(b)** complementarity effect, and **(c)** selection effect as a function of species richness after two weeks of constant temperatures at t_1 (●) and after an additional week of short-term temperature peaks at t_2 (○) including significant linear regressions for t_2 (no significant regressions at t_1; CI=95%). Curve fits were tested for hyperbolic functions (model 1: $y=a*x/(b+x)$, n=25, CI=95%) and linear regression curves (model 2: $y=a+b*x$; n=25, CI=95%) (see text).

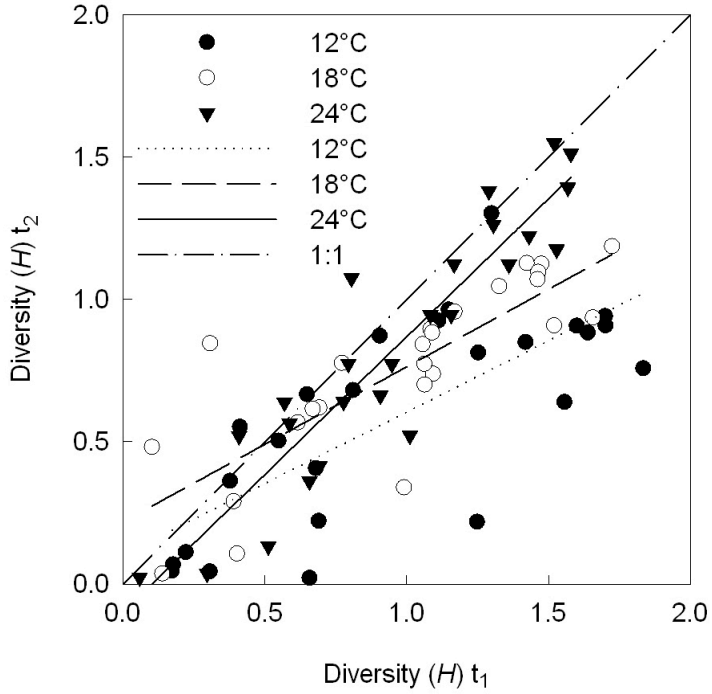

Figure 4 Diversity *H* (Shannon Index) after temperature peaks (t_2) as a function of diversity (*H*) after two weeks of constant temperatures (t_1) for the three experimental temperatures 12°C, 18°C, and 24°C including linear regressions (regression variables see Table 4). Graph includes 1:1 line.

Table 5 Variables of linear regressions ($y=a+bx$; n=25, df=23) including standard errors, as well as r^2-values and P-values for diversity (Shannon Index, *H*) after temperature peaks (t_2) as a function of diversity (*H*) after constant temperature incubation (t_1) (Figure 4). Significant P-values (CI=95%) in bold.

	12°C	**18°C**	**24°C**
a	0.10±0.10	0.22±0.09	-0.10±0.09
b	0.50±0.09	0.54±0.08	0.97±0.08
r^2	0.55	0.67	0.85
P	**<0.001**	**<0.001**	**<0.001**

Monoculture growth rates, POP, and C:P ratios

After two weeks of incubation at constant temperatures (t_1), single algal taxa showed distinguished daily growth rates at each of the three temperature levels (Figure 5). A one-way ANOVA (CI=95%) comparing all taxa of one temperature level delivered significant global growth rate differences with P<0.001 at each of the three temperatures (Table 6).

After the short-term temperature peaks (t_2), growth rates resulted in a similarly heterogeneous picture: P<0.001 at each of the three temperatures (one-way ANOVA; Table 6, Figure 5).

Growth rate differences between the functional groups examined were less pronounced than differences between single taxa within one temperature treatment (ANOVA between functional groups; Table 6).

Particulate Organic Phosphorous (POP) as well as C:P ratios were as variable among algal taxa as growth rates were (one-way ANOVA between taxa of one temperature treatment), and again, differences between functional groups within one temperature treatment did not turn out as relevant as differences between single algal taxa (Table 6).

Algal response factor – relative changes in biovolume fractions

The algal response factor was calculated to detect relative changes in community composition based on shifts in functional group biovolume fractions. The response factor reflected a clear general tendency, if not statistically detectable, towards a reduction of the green algae fraction in the communities alongside an increase of the cyanobacteria fraction with increasing temperature at all species richness levels (Figure 6). However, response factors (means per temperature) for green algae were predominantly positive (80% of all means), especially at 12°C (100%), and either remained positive or became slightly negative at 18°C and/or 24°C. Cyanobacteria showed the opposite reaction with most mixtures (63%) showing mean negative response factors and the most negative values at the lowest temperature (90% of all 12°C factors), and at best slightly positive factors at 18°C and/or 24°C. Diatoms seemed rather unaffected by temperature with a slight tendency of their response factors to decrease with rising temperature, showed comparatively great standard errors, and 93% of all mean factors were negative for this group of algae.

When plotting the response factor as a function of species richness, the linear model fitted better than the hyperbolic model in all cases except the cyanobacteria t_1 12°C treatments. A multifactorial ANOVA revealed that species richness had a significant effect on the green algae fraction at t_1 ($P<0.05$, $F_{4,54}=3.38$) and t_2 ($P<0.001$, $F_{4,52}=5.28$), temperature had a significant positive effect on the cyanobacteria fraction at t_1 ($P<0.01$, $F_{2,51}=5.15$) and t_2 ($P<0.001$, $F_{2,51}=12.70$), while no significant interactive effects of species richness with temperature were found.

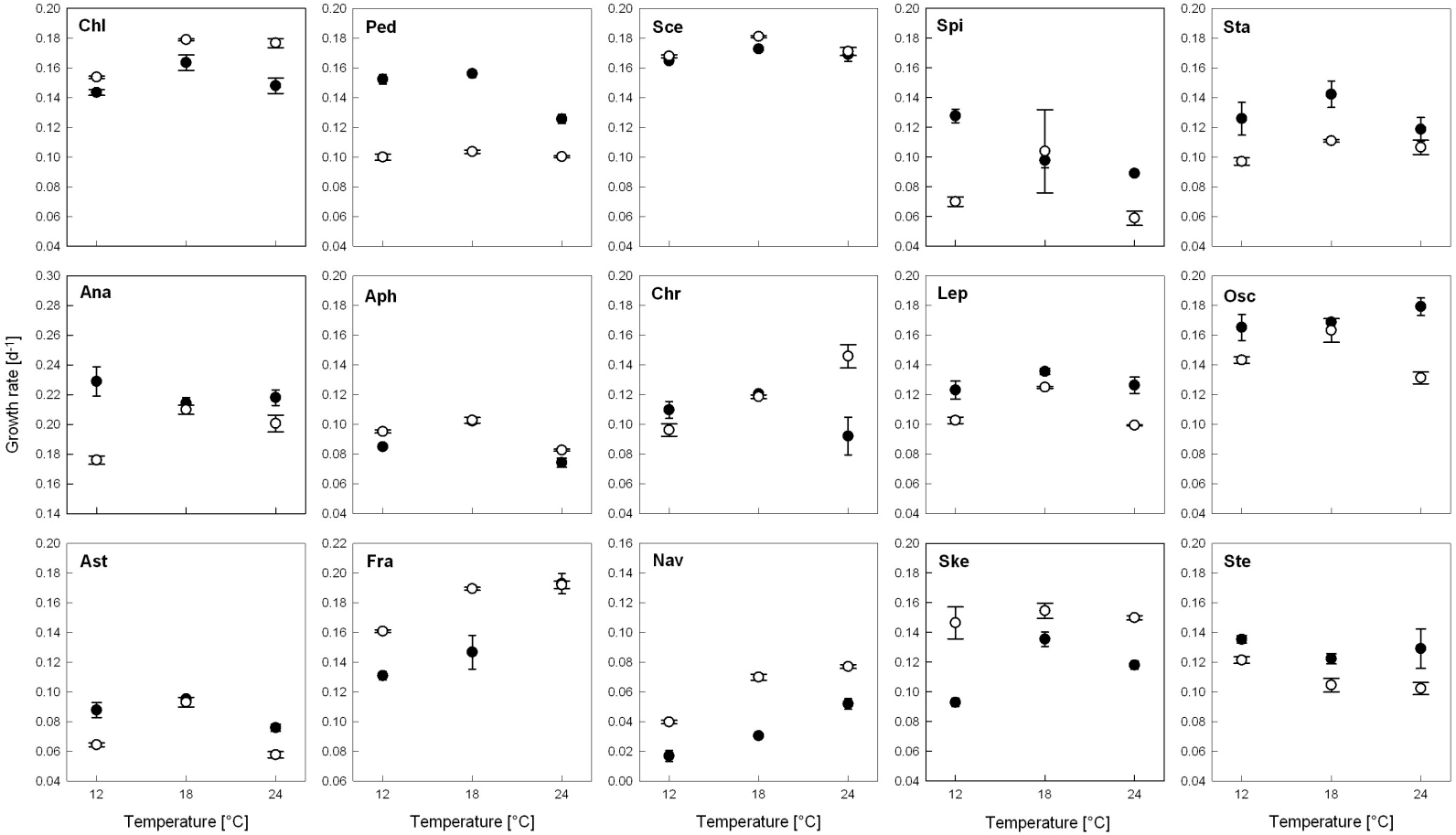

Figure 5 Daily growth rates of monocultures as a function of temperature after two weeks of constant temperatures at t_1 (●) and after an additional week of short-term temperature peaks at t_2 (○) including standard error bars of the three replicates per taxon and temperature level. Note different y-axis scales. Upper row: Chlorophyceae; middle row: Cyanophyceaea; bottom row: Bacillariophyceae. Taxa name abbreviations see Table 1.

Table 6 Variables of one-way ANOVAs between monocultures (Figure 5) and their functional groups (FG), respectively, of each of the three temperature treatments for growth rate (*r*), molar C:P ratios and POP after two weeks of constant temperatures (t_1) and after an additional week of short-term temperature peaks (t_2). CI=95%. Significant P-values in bold.

	t_1			t_2		
	12°C	**18°C**	**24°C**	**12°C**	**18°C**	**24°C**
r						
F	$F_{18,38}$=139.73	$F_{18,37}$=129.82	$F_{18,37}$=56.81	$F_{18,38}$=174.90	$F_{18,38}$=93.12	$F_{18,38}$=179.59
r^2	0.99	0.98	0.97	0.99	0.94	0.99
P	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**
r_{FG}						
F	$F_{5,51}$=18.65	$F_{5,51}$=12.34	$F_{5,51}$=6.37	$F_{5,51}$=3.24	$F_{5,51}$=3.80	$F_{5,51}$=2.70
r^2	0.65	0.55	0.39	0.24	0.27	0.21
P	**<0.001**	**<0.001**	**<0.001**	**<0.05**	**<0.01**	**<0.05**
C:P						
F	$F_{18,38}$=41.20	$F_{18,37}$=18.57	$F_{18,38}$=11.98	$F_{18,38}$=19.56	$F_{18,38}$=21.24	$F_{18,38}$=17.70
r^2	0.95	0.90	0.85	0.90	0.91	0.89
P	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**
$C:P_{FG}$						
F	$F_{4,52}$=10.26	$F_{4,51}$=5.21	$F_{4,52}$=9.40	$F_{4,52}$=0.90	$F_{4,52}$=1.51	$F_{4,52}$=1.11
r^2	0.44	0.29	0.42	0.07	0.10	0.08
P	**<0.001**	**0.001**	**<0.001**	0.472	0.214	0.361
POP						
F	$F_{18,38}$=66.15	$F_{18,38}$=22.25	$F_{18,38}$=10.30	$F_{18,38}$=12.95	$F_{18,38}$=56.53	$F_{18,38}$=29.67
r^2	0.97	0.01	0.83	0.86	0.96	0.93
P	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**
POP_{FG}						
F	$F_{5,51}$=0.76	$F_{5,51}$=0.94	$F_{5,51}$=1.29	$F_{5,51}$=2.73	$F_{5,51}$=2.33	$F_{5,51}$=1.98
r^2	0.07	0.09	0.11	0.21	0.19	0.16
P	0.581	0.461	0.284	**<0.05**	0.055	0.098

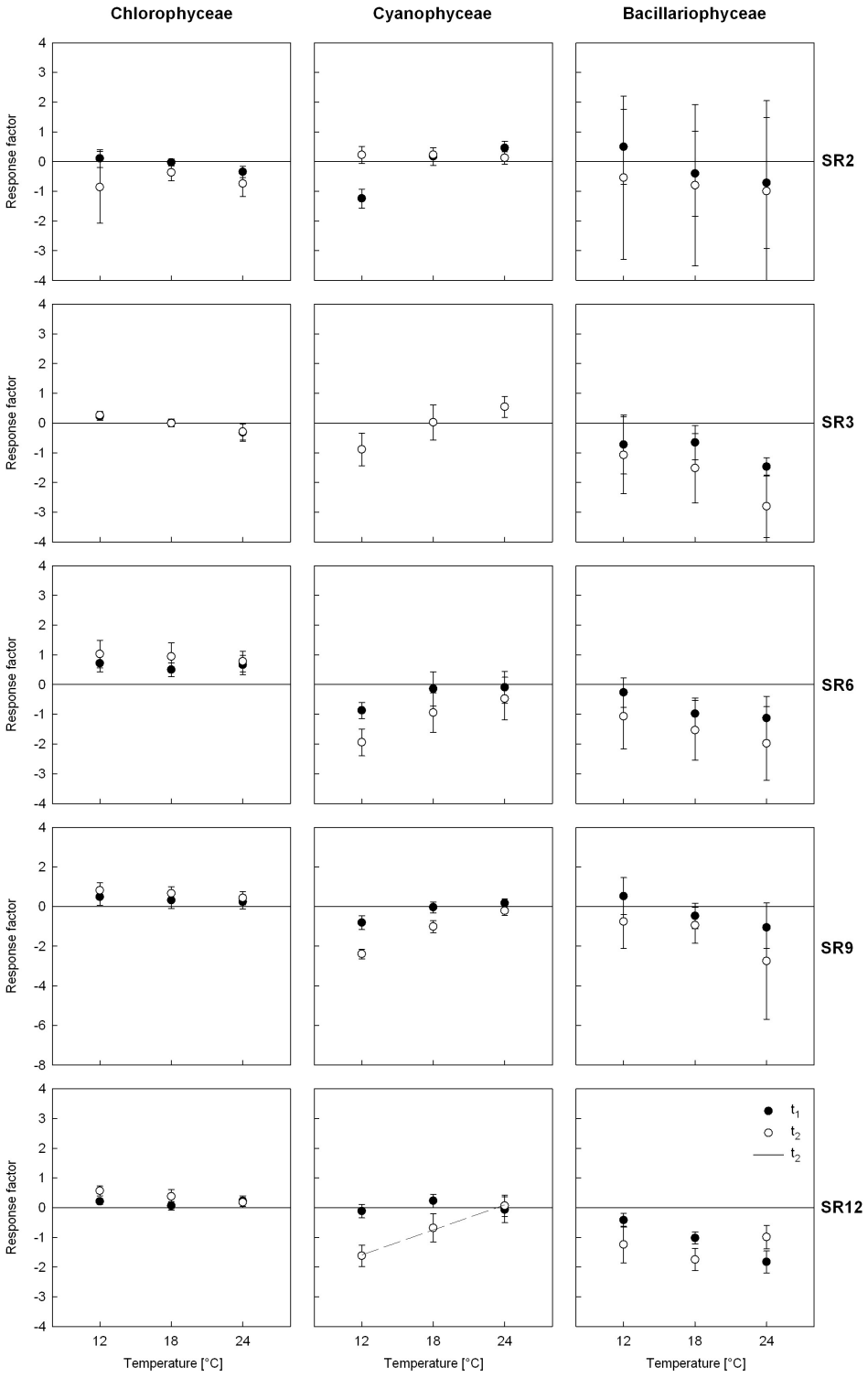

Figure 6 Algal response factors as means (n=3) of mixtures per species richness level (SR) as a function of temperature (ln-transformed) with standard error bars on a functional group basis after two weeks of constant temperatures at t_1 (●) and after an additional week of short-term temperature peaks at t_2 (○) including significant linear regressions (n=18-23 depending on occurrence of functional groups in mixtures; mixture SR6M5 non-calculable due to LN(0); CI=95%). Note the different y-axis scaling of SR9.

Discussion

Positive biodiversity effects at constant temperatures and after temperature peaks on growth, resource use efficiency, and stoichiometry

The expected positive effect of species richness on growth rates, RUE, POP, and C:P ratios was confirmed in our study at both constant temperature levels and after temperature peaks. A strong species richness-dependent increase in phytoplankton performance (growth rates, RUE, and POP) tended to come into effect most strongly when communities adapted to a constant intermediate temperature level (18°C), followed by the lowest experimental temperature level (12°C), experienced a sudden short-term elevation of temperature, while effects were still positive, but weaker in communities adapted to a warmer base temperature (24°C). Across all parameters measured, species richness effects after temperature peaks turned out more pronounced than after the constant temperature treatments. Biodiversity as a productivity-enhancing variable may thus play a more essential role in cool to moderately tempered waters experiencing sudden, relatively high temperature increases.

It has been shown that light use efficiency increases with increasing species and functional diversity due to the correlation with high pigment diversity (Striebel *et al.* 2009a; Behl *et al.* 2011). Increased light use efficiency leads to enhanced C-fixation, yet does not necessarily promote P-uptake efficiency. This imbalance results in increasing C:P ratios with increasing diversity (Striebel *et al.* 2009b). In our study, not only POC, but also POP increased with increasing diversity until saturation was reached. Diversity-dependent increases of POP may suggest that complementary processes other than light use efficiency influence nutrient uptake in phytoplankton communities of higher diversity. However, the clear increase in C:P ratios after the temperature peaks suggests that the complementary effects of light use may be more pronounced compared to potential other complementary processes involved in nutrient uptake.

Complementarity and *selection explain diversity effects on phytoplankton growth*

Following the numerous diversity-stability studies of grassland communities (e.g. Tilman *et al.* 2006; Zavaleta *et al.* 2010), Ptacnik *et al.* (2008) and Striebel *et al.* (2009b) showed that resource use and, in turn, biomass production are also directly and positively linked to diversity in phytoplankton communities. Complementary traits or niche differentiation was identified as the key mechanism behind the productivity enhancing effect of species and/or functional diversity in terrestrial plant communities (Loreau & Hector 2001; Fargione *et al.*

2007; Flombaum & Sala 2008) and could also be confirmed for heterotrophic organisms in aquatic systems (Cardinale *et al.* 2002), as well as for phytoplankton (Striebel *et al.* 2009b). Complementarity leading to an enhancement of primary production in highly diverse phytoplankton communities can, at least partly, be explained by partitioning of the available photosynthetic active radiation through an increased taxa-specific variety of antenna pigment composition. This results in facilitated species coexistence and increased light use efficiency (Stomp *et al.* 2004; Stomp *et al.* 2007; Striebel *et al.* 2009a). Selection, on the other hand, would point to the successful establishment of certain species of particularly beneficial attributes and was found to be of minor importance in these studies. Our study partly supports these previous findings: An explicit effect of overyielding was detected at all temperature levels and especially after temperature peaks, and the major part of the net biodiversity effect could be explained by complementarity among species in a community. However, complementarity showed a positive relationship with species richness at the lowest temperature, yet a negative effect when temperature was increased. This decrease in complementarity at higher species richness in combination with higher temperature can be explained by two separate processes: On the one hand, having reached a certain level of diversity, saturation of the community with complementary traits gave way to an increased contribution of the selection effect. On the other hand, the enhanced selection effect at higher temperatures is most probably related to competitive advantages of taxa able to deal better with warmer conditions (cyanobacteria). In addition, the relative importance of the mechanisms responsible for overyielding also shifted with the form of temperature impact: Compared to constant temperatures, peak temperatures triggered an enhanced selection effect, again most likely as a positive response of cyanobacteria to extreme temperature conditions. However, these interactive effects could not be confirmed statistically.

Negative effects of high temperatures on phytoplankton diversity

Diversity had significantly decreased after the short-term temperature peaks. This effect was strongest in those communities adapted to the coolest experimental temperature of 12°C. A temperature increase of +4°C thus might have a less dramatic effect if algae are already adapted to warmer temperatures, while +4°C seem to be enough to induce a strong reaction for those communities grown at lower base temperatures.

The pronounced negative impact of temperature peaks on biodiversity goes hand in hand with a selection for certain heat tolerant taxa or functional groups (cyanobacteria) over others, which were less competitive under temperature stress conditions.

Individual temperature-dependent growth responses of single taxa vs. clear functional group behavior

As expected, the 15 taxa from the three functional groups examined showed distinguished reactions in terms of all parameters measured, namely growth rate (based on POC), POP, as well as molar C:P ratios calculated thereof. When it comes to temperature-dependent behavior decoupled from other growth-inducing parameters like light, nutrients, or interactions with higher trophic levels and co-occurring phytoplankton species, the single taxa examined in this study could not clearly be clustered into the classical functional groups of Chlorophyceae, Cyanophyceae, and Bacillariophyceae. This outcome seems obvious as pigment composition, which forms the basis for the common functional group categorization, is not necessarily coupled with temperature. Nevertheless, a number of studies support the common view that in natural communities, diatoms prefer cooler waters, while cyanobacteria have high temperature optima for growth, and green algae perform better at intermediate temperatures (Canale & Vogel 1974; Tilman *et al.* 1986; Robarts & Zohary 1987). It is, however, also known that few species are limited to grow within a narrow optimum temperature range (Reynolds 1984) and that many are able to grow and survive well below or beyond this optimum spread (Tang *et al.* 1997; Vincent 2000). For instance, Patrick (1971) notes that most diatoms have been found to grow within the large range of 0-35°C. Temperature-dependent monoculture growth rates of *Fragilaria* or *Navicula* in our study confirm that diatoms may perform just as well at higher temperatures as, for instance, some cyanobacteria do. In nature, however, synergistic effects of temperature with competition for nutrients and light, grazing pressure, flow or thermal stratification contribute more significantly to algal growth rate patterns than the effect of temperature alone (Konopka & Brock 1978; Reynolds 1984; Tilman *et al.* 1986; Robarts & Zohary 1987). In our study, even though monocultures did not consistently reflect the expected functional group behavior in terms of temperature-dependent growth and stoichiometry, communities did show rather clear temperature-related functional group patterns. Cyanobacteria tended to perform better at higher temperatures, as was reflected in an increase of their relative biovolume fraction, and both green algae and diatoms responded with a slight decrease of their relative biovolume fraction to increasing temperature. However, it has to be considered that the overall response factor of cyanobacteria and diatoms was negative as compared to the overall response of green algae. Thus, it can be concluded that all in all, green algae managed to increase their biovolume fraction relative to the start at practically all species richness levels and at all temperatures with slightly higher increases at the lower end of the temperature scale. Cyanobacteria, on the

other hand, mostly developed negatively compared to their start biovolume (especially after experiencing temperature peaks), but their performance was better and even positive at higher temperatures, which is probably due to their superior competitive abilities at warmer temperatures in phosphorous-rich environments (Tilman *et al.* 1986). These results confirm that competitive behavior in communities of various phytoplankton taxa is a key factor for growth and stoichiometric behavior of the single functional groups contained in the mixture.

Conclusion

This study emphasized that biodiversity in terms of species and functional richness is an important factor determining phytoplankton community performance under varying temperature conditions. While increased species richness had a positive, enhancing effect on all parameters measured at all temperature levels, the medium growth temperature of 18°C seemed most beneficial to the communities. Short-term peak temperatures led to substantially more distinctive community reactions than constant temperatures. Overyielding, which could almost exclusively be explained by facilitation among species with complementary traits, was particularly high after temperature peaks. Additionally, a reduction in species diversity was most obvious in communities adapted to cooler base temperatures before experiencing sudden temperature increases. A shift in community composition at higher temperatures led to an increased performance of cyanobacteria relative to a decrease of the fraction of green algae and diatoms.

Higher diversity increases phytoplankton growth and productivity. However, if water temperature substantially increases as a response to sudden (and repeated) heat events, some algal taxa may approach or reach beyond the maximum of their optimum range and might be outcompeted by others. These taxa-specific effects of increasing water temperatures are likely to be most pronounced in disconnected floodplain water bodies, in small lakes, ponds, and streams, as well as in any comparable aquatic systems of relatively shallow depth and high exposition to solar radiation. Consequently, in these systems, diversity would decrease and in turn, its potential to mitigate negative effects of high temperature stress would be diminished. In addition, community composition would be prone to change in favor of heat-tolerant algal groups like cyanobacteria. One of the negative consequences of increased cyanobacteria dominance on an ecosystem level could be inefficient energy transfer up to higher trophic levels due to this algal group's low nutritional quality (Brett *et al.* 2000; Elert *et al.* 2003; Caramujo *et al.* 2008).

In order to grasp the full range of potential consequences of rising water temperatures in small- to medium-size and shallow water bodies, which dominate the Earth's total lake area (Downing *et al.* 2006), interactions of temperature increase with other abiotic and biotic parameters like light intensity, discharge, stratification, or the role of other trophic levels, as well as factors which could indirectly promote phytoplankton growth via increased water temperatures need to be understood. For instance, phosphorous may become more easily available at higher temperatures due to higher mineralization and release (Mooij *et al.* 2007),

and nitrate loads are expected to follow altered seasonal discharge patterns (Zweimüller *et al.* 2008).

Isolating single effects of altered temperature regimes in controlled laboratory experiments and in artificial phytoplankton communities of rather low species richness is an important contribution to the understanding of the principles behind global warming effects on aquatic ecosystems; in the next steps, however, the issue needs to be taken to the level of natural communities of greater diversity and more complex interaction potential.

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APPENDIX

TABLE OF CONTENTS

German summary **v**
Data collection **vii**
Curriculum vitae **xlix**

LIST OF TABLES

Table A1	Particulate Organic Carbon (POC) of monocultures	**vii**
Table A2	Particulate Organic Phosphorous (POP) of monocultures	**x**
Table A3	Molar carbon-to-phosphorous (C:P) ratios of monocultures	**xiii**
Table A4	Mean daily growth rates of monocultures	**xvi**
Table A5	Particulate Organic Carbon (POC) of communities	**xviii**
Table A6	Particulate Organic Phosphorous (POP) of communities	**xxi**
Table A7	Molar carbon-to-phosphorous (C:P) ratios of communities	**xxiv**
Table A8	Daily growth rates of communities	**xxvii**
Table A9	Resource Use Efficiency (RUE) of monocultures and communities	**xxx**
Table A10	Community diversity (*H*) calculated as the Shannon Index	**xxxiii**
Table A11	Net biodiversity effect, complementarity effect, and selection effect	**xxxv**
Table A12	Biovolumes of each taxon contained in the communities	**xxxvii**
Table A13	Response factor calculated on a functional group level	**xlvii**

German summary

Biodiversität ist eine Grundvoraussetzung dafür, dass Ökosysteme so genannte „ecosystem services“ oder Ökosystemdienstleistungen, welche für das menschliche Leben und Wohlergehen unerlässlich sind, bereitstellen können. Jene Ökosystemdienstleistungen, zu welchen die Diversität von Phytoplankton maßgeblich beiträgt, reichen von der Primärproduktion und der Bereitstellung von Nahrung entlang der aquatischen Nahrungskette über die Regulierung der Wasserqualität und des Klimas (Nährstoff- und Kohlenstofffixierung, Sauerstoffproduktion) bis hin zu ästhetischen und gesundheitlichen Aspekten (zum Beispiel das Verhindern von „Blaualgenblüten“ in Gewässern, die für Freizeitaktivitäten und zur Erholung genutzt werden). Darüber hinaus konnte bereits in vielen verschiedenen terrestrischen und aquatischen Ökosystemen gezeigt werden, dass Biodiversität das Potential besitzt, negative Effekte externer Umwelteinflüsse und -veränderungen durch gesteigerte Produktion und Ressourcennutzungskapazität und die daraus resultierende Erhöhung der Resilienz und Resistenz eines Ökosystems zu regulieren. In Folge des global stattfindenden Klimawandels ist die Diversität von Phytoplanktongemeinschaften jedoch stark gefährdet, unter anderem aufgrund steigender Wassertemperaturen und verstärkt auftretender extremer Hitzeereignisse. Dies trifft vor allem auf Gewässer kleiner bis mittlerer Größe, wie Teiche, seichte Seen, kleine Bäche oder die morphologisch variablen Wasserkörper von Flussauen zu.

Basierend auf diesen Überlegungen wurden in dieser Studie die interaktiven Effekte von Temperatur und Artenvielfalt („species richness“) beziehungsweise Diversität auf das Wachstum, die Nährstoffdynamik, sowie auf die Artenzusammensetzung von Phytoplankton untersucht. Unter kontrollierten Laborbedingungen wurden Monokulturen von 15 Süßwasser-Phytoplanktontaxa der funktionellen Gruppen Chlorophyceae (Grünalgen), Cyanophyceae (Cyanobakterien, „Blaualgen“) und Bacillariophyceae (Kieselalgen), sowie 25 gemischte Gemeinschaften unterschiedlicher Artenanzahl (2, 3, 6, 9, und 12 Arten) und Artenzusammensetzung zwei Wochen lang an die drei experimentellen Temperaturen von 12°C, 18°C und 24°C adaptiert. Nach dieser Anpassungsphase wurden sowohl die Monokulturen als auch die Gemeinschaften über 7 Tage hinweg täglichen 7-stündigen Temperaturerhöhungen (Peaks) um +4°C ausgesetzt um die Einwirkung extremer Hitzeereignisse zu simulieren. Wachstumsraten, molare C:P-Verhältnisse und die Ressourcennutzungseffizienz des Phytoplankton wurden als

Funktion der Temperatur beziehungsweise der Diversität bestimmt. Höhere Artenzahlen in den Gemeinschaften hatten einen positiven, stimulierenden Effekt auf alle gemessene Parameter und auf allen Temperaturstufen. Die mittlere Wachstumstemperatur von 18°C stellte sich dabei als die günstigste Temperaturstufe für die Gemeinschaften heraus. Der positive Effekt der Diversität auf die Produktionsleistung der Gemeinschaften war stärker ausgeprägt, nachdem die Gemeinschaften die kurzen Temperatur-Peaks erfahren hatten. Als Mechanismus hinter der gesteigerten Gemeinschaftsleistung bei höherer Diversität konnte „Complementarity" identifiziert werden: sich ergänzende, unter den vorherrschenden Bedingungen vorteilhafte Eigenschaften mehrerer Arten. Temperatur-Peaks führten jedoch andererseits zu einer merklichen Verringerung der Diversität. Höhere Temperaturen stellten sich außerdem als vorteilhaft für Cyanobakterien heraus, im Vergleich zu Grün- und Kieselalgen die hitzebeständigste jener drei Algengruppen, die in diesem Experiment getestet wurden. Diese Verminderung der Diversität und die damit einhergehende Verschiebung der Artenzusammensetzung war in jenen Gemeinschaften, welche an kühlere Temperaturen angepasst waren, am stärksten ausgeprägt. Durch diese Ergebnisse konnte diese Studie somit einen wichtigen, zweifach negativen Effekt erhöhter Wassertemperaturen auf Phytoplanktongemeinschaften aufzeigen: die Verringerung der Diversität und Artenanzahl einerseits, sowie andererseits bzw. als Folge davon, die Verringerung des Potentials höher diverser Gemeinschaften, extreme Hitzeereignisse in sensiblen aquatischen Systemen wirkungsvoll abzupuffern.

Data collection

Table A1 Particulate Organic Carbon (POC) of monocultures (3 replicates) measured by infrared spectrometry (C-Mat 500, Ströhlein) at the experimental temperatures of 12°C, 18°C, and 24°C at the start of the experiment (t_0), after two weeks of constant temperatures (t_1), and after an additional week of daily temperature peaks (t_2). Chlorophyceae: Chl=*Chlamydomonas reinhardtii*, Ped=*Pediastrum simplex*, Sce=*Scenedesmus obliquus*, Spi=*Spirogyra* sp., Sta=*Staurastrum tetracerum*; Cyanophyceae: Ana=*Anabaena cylindrica*, Aph=*Aphanizomenon gracile*, Chr=*Chroococcus minutus*, Lep=*Leptolyngbya fragilis*, Osc=*Oscillatoria limosa*; Bacillariophyceae: Ast=*Asterionella formosa*, Fra=Fragilaria crotonensis, Nav=*Navicula pelliculosa*, Ske=*Skeletonema subsalsum*, Ste=*Stephanodiscus minutulus*.

Taxon	Replicate	Temp. [°C]	POC t_0 [mg L^{-1}]	POC t_1 [mg L^{-1}]	POC t_2 [mg L^{-1}]
Chl	1	12	0.669	4.921	8.186
Chl	2	12	0.669	5.235	8.408
Chl	3	12	0.669	4.786	8.707
Ped	1	12	0.609	4.717	2.680
Ped	2	12	0.609	5.200	2.312
Ped	3	12	0.609	5.521	2.458
Sce	1	12	0.501	4.898	8.859
Sce	2	12	0.501	5.211	8.262
Sce	3	12	0.501	4.958	8.417
Spi	1	12	0.280	1.813	0.546
Spi	2	12	0.280	1.475	0.600
Spi	3	12	0.280	1.749	0.686
Sta	1	12	0.475	2.099	1.792
Sta	2	12	0.475	2.809	1.679
Sta	3	12	0.475	3.578	2.002
Ana	1	12	0.190	3.767	4.133
Ana	2	12	0.190	4.500	3.963
Ana	3	12	0.190	6.053	3.399
Aph	1	12	1.967	6.313	7.446
Aph	2	12	1.967	6.580	7.404
Aph	3	12	1.967	6.464	6.927
Chr	1	12	0.475	1.954	1.864
Chr	2	12	0.475	2.148	1.512
Chr	3	12	0.475	2.562	2.030
Lep	1	12	0.531	3.461	2.114
Lep	2	12	0.531	2.939	2.483
Lep	3	12	0.531	2.586	2.301
Osc	1	12	0.284	2.312	2.992
Osc	2	12	0.284	2.907	2.635
Osc	3	12	0.284	3.525	3.031
Ast	1	12	0.899	3.530	1.719
Ast	2	12	0.899	2.807	1.661
Ast	3	12	0.899	2.911	1.822
Fra	1	12	0.321	2.161	4.862

Table A1 cont.

Taxon	Replicate	Temp. [°C]	POC t_0 [mg L^{-1}]	POC t_1 [mg L^{-1}]	POC t_2 [mg L^{-1}]
Fra	2	12	0.321	1.892	4.564
Fra	3	12	0.321	1.973	4.657
Nav	1	12	1.926	2.213	2.219
Nav	2	12	1.926	2.511	2.122
Nav	3	12	1.926	2.610	2.313
Ske	1	12	0.435	1.707	4.419
Ske	2	12	0.435	1.492	3.294
Ske	3	12	0.435	1.599	7.164
Ste	1	12	0.295	1.840	1.763
Ste	2	12	0.295	2.078	2.057
Ste	3	12	0.295	1.964	1.844
Chl	1	18	0.669	7.219	14.224
Chl	2	18	0.669	6.941	14.628
Chl	3	18	0.669	5.723	14.083
Ped	1	18	0.609	5.106	2.806
Ped	2	18	0.609	5.372	2.575
Ped	3	18	0.609	5.787	2.658
Sce	1	18	0.501	5.917	11.153
Sce	2	18	0.501	5.408	10.999
Sce	3	18	0.501	5.540	11.540
Spi	1	18	0.280	1.237	3.965
Spi	2	18	0.280	0.978	0.819
Spi	3	18	0.280	1.099	0.589
Sta	1	18	0.475	2.716	2.344
Sta	2	18	0.475	3.849	2.503
Sta	3	18	0.475	4.017	2.458
Ana	1	18	0.190	3.538	8.076
Ana	2	18	0.190	4.218	8.530
Ana	3	18	0.190	3.716	6.888
Aph	1	18	1.967	8.648	9.136
Aph	2	18	1.967	8.030	8.480
Aph	3	18	1.967	8.004	7.952
Chr	1	18	0.475	2.608	2.834
Chr	2	18	0.475	2.645	3.011
Chr	3	18	0.475	2.450	2.760
Lep	1	18	0.531	3.382	3.570
Lep	2	18	0.531	3.729	3.685
Lep	3	18	0.531	3.528	3.738
Osc	1	18	0.284	2.825	5.103
Osc	2	18	0.284	3.206	3.129
Osc	3	18	0.284	3.034	5.228
Ast	1	18	0.899	3.515	3.574
Ast	2	18	0.899	3.328	2.842
Ast	3	18	0.899	3.390	3.133
Fra	1	18	0.321	1.898	8.932
Fra	2	18	0.321	2.515	8.373
Fra	3	18	0.321	3.291	8.405
Nav	1	18	1.926	2.875	3.915
Nav	2	18	1.926	2.958	4.531
Nav	3	18	1.926	3.018	4.094

Table A1 cont.

Taxon	Replicate	Temp. [°C]	POC t_0 [mg L^{-1}]	POC t_1 [mg L^{-1}]	POC t_2 [mg L^{-1}]
Ske	1	18	0.435	2.534	6.885
Ske	2	18	0.435	3.042	4.894
Ske	3	18	0.435	3.149	5.166
Ste	1	18	0.295	1.498	1.098
Ste	2	18	0.295	1.765	1.509
Ste	3	18	0.295	1.642	1.400
Chl	1	24	0.669	6.022	15.549
Chl	2	24	0.669	5.295	12.795
Chl	3	24	0.669	4.684	12.818
Ped	1	24	0.609	3.812	2.441
Ped	2	24	0.609	3.297	2.549
Ped	3	24	0.609	3.496	2.503
Sce	1	24	0.501	4.711	9.657
Sce	2	24	0.501	5.549	8.098
Sce	3	24	0.501	5.823	9.581
Spi	1	24	0.280	0.927	0.476
Spi	2	24	0.280	0.111	0.408
Spi	3	24	0.280	1.020	0.575
Sta	1	24	0.475	2.288	1.842
Sta	2	24	0.475	2.190	2.268
Sta	3	24	0.475	3.113	2.619
Ana	1	24	0.190	4.490	5.072
Ana	2	24	0.190	3.494	7.458
Ana	3	24	0.190	4.142	6.969
Aph	1	24	1.967	5.159	5.436
Aph	2	24	1.967	5.571	5.600
Aph	3	24	1.967	5.964	5.702
Chr	1	24	0.475	1.492	6.790
Chr	2	24	0.475	1.401	4.958
Chr	3	24	0.475	2.454	3.871
Lep	1	24	0.531	2.746	2.168
Lep	2	24	0.531	3.579	2.102
Lep	3	24	0.531	3.070	2.151
Osc	1	24	0.284	4.100	2.607
Osc	2	24	0.284	3.108	1.968
Osc	3	24	0.284	3.340	2.180
Ast	1	24	0.899	2.440	1.381
Ast	2	24	0.899	2.729	1.584
Ast	3	24	0.899	2.635	1.566
Fra	1	24	0.321	4.116	8.853
Fra	2	24	0.321	4.615	9.971
Fra	3	24	0.321	5.732	8.373
Nav	1	24	1.926	3.629	5.026
Nav	2	24	1.926	4.032	4.612
Nav	3	24	1.926	4.312	4.909
Ske	1	24	0.435	2.121	4.795
Ske	2	24	0.435	2.262	5.073
Ske	3	24	0.435	2.433	5.323
Ste	1	24	0.295	1.252	1.071
Ste	2	24	0.295	2.331	1.425
Ste	3	24	0.295	1.976	1.315

Table A2 Particulate Organic Phosphorous (POP) of monocultures (3 replicates) measured by CFA (Continuous Flow Analysis; molybdate reaction after sulfuric acid digestion) at the experimental temperatures of 12°C, 18°C, and 24°C at the start of the experiment (t_0), after two weeks of constant temperatures (t_1), and after an additional week of daily temperature peaks (t_2). Taxa name abbreviations see Table A1.

Taxon	Replicate	Temp. [°C]	POP t_0 [μg L^{-1}]	POP t_1 [μg L^{-1}]	POP t_2 [μg L^{-1}]
Chl	1	12	81.3	218.7	383.4
Chl	2	12	81.3	233.4	438.9
Chl	3	12	81.3	219.6	371.1
Ped	1	12	62.8	224.4	193.5
Ped	2	12	62.8	229.5	196.2
Ped	3	12	62.8	251.1	200.7
Sce	1	12	68.1	229.2	258.3
Sce	2	12	68.1	237.6	258.3
Sce	3	12	68.1	309.3	261.0
Spi	1	12	58.6	97.6	112.3
Spi	2	12	58.6	71.5	195.3
Spi	3	12	58.6	83.0	213.6
Sta	1	12	60.1	84.6	149.8
Sta	2	12	60.1	119.2	155.5
Sta	3	12	60.1	125.0	128.4
Ana	1	12	57.2	266.4	160.5
Ana	2	12	57.2	131.1	189.3
Ana	3	12	57.2	216.9	148.8
Aph	1	12	83.9	183.3	201.3
Aph	2	12	83.9	185.4	192.3
Aph	3	12	83.9	203.7	180.6
Chr	1	12	70.9	124.3	248.1
Chr	2	12	70.9	116.8	265.8
Chr	3	12	70.9	127.7	256.8
Lep	1	12	64.0	80.0	190.8
Lep	2	12	64.0	56.4	211.2
Lep	3	12	64.0	76.2	124.5
Osc	1	12	49.8	127.2	159.0
Osc	2	12	49.8	151.2	119.4
Osc	3	12	49.8	163.2	145.2
Ast	1	12	57.1	107.6	141.6
Ast	2	12	57.1	118.9	106.9
Ast	3	12	57.1	120.6	117.1
Fra	1	12	97.6	108.5	137.1
Fra	2	12	97.6	109.0	132.0
Fra	3	12	97.6	118.1	141.9
Nav	1	12	61.7	79.9	341.7
Nav	2	12	61.7	64.4	375.9
Nav	3	12	61.7	76.6	472.8
Ske	1	12	71.6	129.0	296.1
Ske	2	12	71.6	121.5	318.9
Ske	3	12	71.6	125.7	250.8
Ste	1	12	58.4	631.2	312.6
Ste	2	12	58.4	704.4	307.8
Ste	3	12	58.4	796.2	382.5

Table A2 cont.

Taxon	Replicate	Temp. [°C]	POP t_0 [μg L^{-1}]	POP t_1 [μg L^{-1}]	POP t_2 [μg L^{-1}]
Chl	1	18	81.3	365.1	851.4
Chl	2	18	81.3	341.4	825.0
Chl	3	18	81.3	251.4	998.4
Ped	1	18	62.8	243.3	181.8
Ped	2	18	62.8	226.2	182.4
Ped	3	18	62.8	270.9	253.8
Sce	1	18	68.1	249.6	267.3
Sce	2	18	68.1	237.9	311.4
Sce	3	18	68.1	262.2	309.6
Spi	1	18	58.6	73.4	195.3
Spi	2	18	58.6	76.0	174.9
Spi	3	18	58.6	59.9	215.3
Sta	1	18	60.1	103.3	154.7
Sta	2	18	60.1	142.3	190.0
Sta	3	18	60.1	153.5	187.6
Ana	1	18	57.2	179.1	322.5
Ana	2	18	57.2	219.6	316.8
Ana	3	18	57.2	195.3	313.2
Aph	1	18	83.9	175.5	196.8
Aph	2	18	83.9	180.0	200.7
Aph	3	18	83.9	192.3	189.3
Chr	1	18	70.9	133.0	282.0
Chr	2	18	70.9	132.4	295.8
Chr	3	18	70.9	115.8	121.8
Lep	1	18	64.0	64.1	330.9
Lep	2	18	64.0	84.7	301.2
Lep	3	18	64.0	123.6	315.6
Osc	1	18	49.8	200.4	130.2
Osc	2	18	49.8	113.7	102.3
Osc	3	18	49.8	138.6	99.6
Ast	1	18	57.1	91.3	142.2
Ast	2	18	57.1	96.7	262.8
Ast	3	18	57.1	97.9	288.9
Fra	1	18	97.6	119.2	168.0
Fra	2	18	97.6	110.3	164.4
Fra	3	18	97.6	110.8	164.1
Nav	1	18	61.7	100.3	313.2
Nav	2	18	61.7	141.5	368.4
Nav	3	18	61.7	125.0	357.9
Ske	1	18	71.6	140.7	307.5
Ske	2	18	71.6	159.6	325.5
Ske	3	18	71.6	150.6	325.5
Ste	1	18	58.4	448.8	298.8
Ste	2	18	58.4	375.0	271.2
Ste	3	18	58.4	276.0	272.1
Chl	1	24	81.3	375.0	807.6
Chl	2	24	81.3	304.5	762.0
Chl	3	24	81.3	309.9	775.2
Ped	1	24	62.8	402.9	184.2
Ped	2	24	62.8	148.8	165.3

Table A2 cont.

Taxon	Replicate	Temp. [°C]	POP t_0 [μg L^{-1}]	POP t_1 [μg L^{-1}]	POP t_2 [μg L^{-1}]
Ped	3	24	62.8	158.7	149.7
Sce	1	24	68.1	214.8	257.1
Sce	2	24	68.1	268.5	253.8
Sce	3	24	68.1	208.2	253.2
Spi	1	24	58.6	50.3	164.7
Spi	2	24	58.6	67.9	171.8
Spi	3	24	58.6	75.8	203.5
Sta	1	24	60.1	122.4	146.5
Sta	2	24	60.1	96.5	135.2
Sta	3	24	60.1	148.9	169.1
Ana	1	24	57.2	234.6	275.1
Ana	2	24	57.2	207.9	293.4
Ana	3	24	57.2	158.7	452.1
Aph	1	24	83.9	159.0	148.2
Aph	2	24	83.9	159.6	169.8
Aph	3	24	83.9	162.3	148.5
Lep	1	24	64.0	134.8	237.0
Lep	2	24	64.0	103.3	319.8
Lep	3	24	64.0	188.8	204.9
Osc	1	24	49.8	189.0	103.8
Osc	2	24	49.8	138.6	97.2
Osc	3	24	49.8	137.1	81.6
Chr	1	24	70.9	60.6	195.9
Chr	2	24	70.9	50.3	206.4
Chr	3	24	70.9	154.8	133.5
Ast	1	24	57.1	70.7	252.0
Ast	2	24	57.1	115.0	233.4
Ast	3	24	57.1	87.8	137.8
Fra	1	24	97.6	118.7	167.4
Fra	2	24	97.6	135.7	163.8
Fra	3	24	97.6	134.9	189.9
Nav	1	24	61.7	75.5	354.9
Nav	2	24	61.7	89.5	276.0
Nav	3	24	61.7	98.0	339.9
Ske	1	24	71.6	213.9	292.8
Ske	2	24	71.6	186.9	306.3
Ske	3	24	71.6	180.6	125.7
Ste	1	24	58.4	328.2	254.4
Ste	2	24	58.4	290.4	265.5
Ste	3	24	58.4	339.0	328.2

Table A3 Molar carbon-to-phosphorous (C:P) ratios of monocultures calculated based on POC (in mg L^{-1}) and POP (in mg L^{-1}) at the experimental temperatures of 12°C, 18°C, and 24°C at the start of the experiment (t_0), after two weeks of constant temperatures (t_1), and after an additional week of daily temperature peaks (t_2). Taxa name abbreviations see Table A1.

Taxon	Replicate	Temp. [°C]	C:P t_0	C:P t_1	C:P t_2
Chl	1	12	21.21	58.02	55.06
Chl	2	12	21.21	57.84	49.40
Chl	3	12	21.21	56.20	60.50
Ped	1	12	25.02	54.20	35.72
Ped	2	12	25.02	58.43	30.39
Ped	3	12	25.02	56.70	31.58
Sce	1	12	18.98	55.10	88.44
Sce	2	12	18.98	56.55	82.48
Sce	3	12	18.98	41.34	83.16
Spi	1	12	12.33	47.93	12.55
Spi	2	12	12.33	53.18	7.93
Spi	3	12	12.33	54.31	8.28
Sta	1	12	20.37	63.97	30.85
Sta	2	12	20.37	60.78	27.84
Sta	3	12	20.37	73.79	40.21
Ana	1	12	8.57	36.46	66.40
Ana	2	12	8.57	88.51	53.99
Ana	3	12	8.57	71.96	58.90
Aph	1	12	60.47	88.81	95.38
Aph	2	12	60.47	91.52	99.29
Aph	3	12	60.47	81.83	98.91
Chr	1	12	17.28	40.54	19.37
Chr	2	12	17.28	47.43	14.67
Chr	3	12	17.28	51.75	20.38
Lep	1	12	21.41	111.51	28.58
Lep	2	12	21.41	134.39	30.32
Lep	3	12	21.41	87.51	47.66
Osc	1	12	14.71	46.86	48.52
Osc	2	12	14.71	49.58	56.91
Osc	3	12	14.71	55.69	53.82
Ast	1	12	40.61	84.57	31.31
Ast	2	12	40.61	60.86	40.07
Ast	3	12	40.61	62.24	40.11
Fra	1	12	8.49	51.38	91.44
Fra	2	12	8.49	44.77	89.17
Fra	3	12	8.49	43.10	84.62
Nav	1	12	80.43	71.39	16.74
Nav	2	12	80.43	100.49	14.56
Nav	3	12	80.43	87.90	12.61
Ske	1	12	15.67	34.12	38.48
Ske	2	12	15.67	31.66	26.63
Ske	3	12	15.67	32.80	73.66
Ste	1	12	13.00	7.52	14.55
Ste	2	12	13.00	7.61	17.23
Ste	3	12	13.00	6.36	12.43
Chl	1	18	21.21	50.98	43.08
Chl	2	18	21.21	52.43	45.72

Table A3 cont.

Taxon	Replicate	Temp. [°C]	C:P t_0	C:P t_1	C:P t_2
Chl	3	18	21.21	58.71	36.37
Ped	1	18	25.02	54.12	39.80
Ped	2	18	25.02	61.24	36.40
Ped	3	18	25.02	55.09	27.01
Sce	1	18	18.98	61.13	107.60
Sce	2	18	18.98	58.62	91.08
Sce	3	18	18.98	54.49	96.12
Spi	1	18	12.33	43.45	52.36
Spi	2	18	12.33	33.20	12.09
Spi	3	18	12.33	47.34	7.06
Sta	1	18	20.37	67.80	39.08
Sta	2	18	20.37	69.75	33.98
Sta	3	18	20.37	67.50	33.79
Ana	1	18	8.57	50.94	64.58
Ana	2	18	8.57	49.53	69.43
Ana	3	18	8.57	49.07	56.71
Aph	1	18	60.47	127.06	119.71
Aph	2	18	60.47	115.04	108.95
Aph	3	18	60.47	107.32	108.33
Chr	1	18	17.28	50.58	25.92
Chr	2	18	17.28	51.53	26.25
Chr	3	18	17.28	54.56	58.43
Lep	1	18	21.41	136.11	27.82
Lep	2	18	21.41	113.51	31.54
Lep	3	18	21.41	73.60	30.54
Osc	1	18	14.71	36.34	101.06
Osc	2	18	14.71	72.71	78.88
Osc	3	18	14.71	56.46	135.36
Ast	1	18	40.61	99.26	64.82
Ast	2	18	40.61	88.72	27.89
Ast	3	18	40.61	89.27	27.96
Fra	1	18	8.49	41.06	137.09
Fra	2	18	8.49	58.82	131.33
Fra	3	18	8.49	76.63	132.08
Nav	1	18	80.43	73.89	32.23
Nav	2	18	80.43	53.91	31.72
Nav	3	18	80.43	62.25	29.50
Ske	1	18	15.67	46.45	57.74
Ske	2	18	15.67	49.15	38.77
Ske	3	18	15.67	53.91	40.93
Ste	1	18	13.00	8.61	9.48
Ste	2	18	13.00	12.13	14.35
Ste	3	18	13.00	15.34	13.27
Chl	1	24	21.21	41.41	49.65
Chl	2	24	21.21	44.84	43.30
Chl	3	24	21.21	38.98	42.64
Ped	1	24	25.02	24.40	34.17
Ped	2	24	25.02	57.13	39.77
Ped	3	24	25.02	56.81	43.12
Sce	1	24	18.98	56.56	96.85

Table A3 cont.

Taxon	Replicate	Temp. [°C]	C:P t_0	C:P t_1	C:P t_2
Sce	2	24	18.98	53.29	82.28
Sce	3	24	18.98	72.12	97.58
Spi	1	24	12.33	47.55	7.46
Spi	2	24	12.33	4.23	6.12
Spi	3	24	12.33	34.68	7.29
Sta	1	24	20.37	48.20	32.42
Sta	2	24	20.37	58.52	43.24
Sta	3	24	20.37	53.90	39.94
Ana	1	24	8.57	49.36	47.55
Ana	2	24	8.57	43.33	65.55
Ana	3	24	8.57	67.30	39.75
Aph	1	24	60.47	83.68	94.59
Aph	2	24	60.47	90.01	85.04
Aph	3	24	60.47	94.75	99.02
Chr	1	24	17.28	63.47	89.37
Chr	2	24	17.28	71.84	61.94
Chr	3	24	17.28	40.87	74.77
Lep	1	24	21.41	52.55	23.59
Lep	2	24	21.41	89.32	16.95
Lep	3	24	21.41	41.94	27.08
Osc	1	24	14.71	55.94	64.76
Osc	2	24	14.71	57.82	52.21
Osc	3	24	14.71	62.83	68.89
Ast	1	24	40.61	89.02	14.13
Ast	2	24	40.61	61.22	17.50
Ast	3	24	40.61	77.34	29.31
Fra	1	24	8.49	89.44	136.38
Fra	2	24	8.49	87.69	156.97
Fra	3	24	8.49	109.59	113.69
Nav	1	24	80.43	123.98	36.52
Nav	2	24	80.43	116.14	43.09
Nav	3	24	80.43	113.42	37.24
Ske	1	24	15.67	25.57	42.23
Ske	2	24	15.67	31.21	42.71
Ske	3	24	15.67	34.75	109.20
Ste	1	24	13.00	9.84	10.86
Ste	2	24	13.00	20.70	13.84
Ste	3	24	13.00	15.03	10.33

Table A4 Mean daily growth rates (n=3) of monocultures after two weeks of constant temperatures (t_1) and after an additional week of daily temperature peaks (t_2) including standard errors (SE). Daily growth rates (r) of monocultures were calculated based on POC as the difference between the natural logarithm of the POC mean end value (t_{end} at t_1 or t_2, respectively) of a taxon and the natural logarithm of the respective mean POC start value (at t_0) divided by days of incubation (t=14 at t_1, t=21 at t_2): $r = (LN(POC_{t_{end}}) - LN(POC_{t_0}))/t$. Taxa name abbreviations see Table A1.

Taxon	Temp. [°C]	r t_1 [d^{-1}]	SE t_1	r t_2 [d^{-1}]	SE t_2
Chl	12	0.1434	0.0019	0.1537	0.0009
Ped	12	0.1523	0.0033	0.0999	0.0020
Sce	12	0.1646	0.0014	0.1678	0.0010
Spi	12	0.1276	0.0045	0.0699	0.0031
Sta	12	0.1258	0.0110	0.0970	0.0024
Ana	12	0.2289	0.0099	0.1759	0.0028
Aph	12	0.0848	0.0009	0.0952	0.0011
Chr	12	0.1097	0.0057	0.0961	0.0042
Lep	12	0.1230	0.0060	0.1027	0.0022
Osc	12	0.1652	0.0087	0.1433	0.0021
Ast	12	0.0877	0.0051	0.0643	0.0013
Fra	12	0.1309	0.0028	0.1607	0.0009
Nav	12	0.0169	0.0036	0.0397	0.0012
Ske	12	0.0929	0.0028	0.1464	0.0108
Ste	12	0.1353	0.0025	0.1214	0.0022
Chl	18	0.1635	0.0051	0.1789	0.0005
Ped	18	0.1561	0.0026	0.1035	0.0012
Sce	18	0.1726	0.0019	0.1811	0.0007
Spi	18	0.0977	0.0049	0.1039	0.0280
Sta	18	0.1422	0.0089	0.1108	0.0009
Ana	18	0.2142	0.0037	0.2099	0.0031
Aph	18	0.1022	0.0018	0.1027	0.0019
Chr	18	0.1205	0.0017	0.1186	0.0012
Lep	18	0.1355	0.0020	0.1249	0.0006
Osc	18	0.1688	0.0026	0.1632	0.0080
Ast	18	0.0953	0.0011	0.0930	0.0032
Fra	18	0.1467	0.0114	0.1894	0.0010
Nav	18	0.0305	0.0010	0.0698	0.0021
Ske	18	0.1354	0.0048	0.1545	0.0050
Ste	18	0.1222	0.0034	0.1045	0.0046
Chl	24	0.1479	0.0052	0.1767	0.0031
Ped	24	0.1255	0.0030	0.1002	0.0006
Sce	24	0.1690	0.0046	0.1710	0.0027
Spi	24	0.0889	0.0020	0.0588	0.0047
Sta	24	0.1186	0.0079	0.1064	0.0049
Ana	24	0.2180	0.0053	0.2006	0.0057
Aph	24	0.0742	0.0030	0.0826	0.0007
Chr	24	0.0921	0.0127	0.1458	0.0077
Lep	24	0.1263	0.0055	0.0994	0.0004

Tabel A4 cont.

Taxon	Temp. [°C]	r t_1 [d^{-1}]	SE t_1	r t_2 [d^{-1}]	SE t_2
Osc	24	0.1792	0.0059	0.1312	0.0039
Ast	24	0.0758	0.0024	0.0576	0.0021
Fra	24	0.1928	0.0069	0.1920	0.0025
Nav	24	0.0519	0.0036	0.0769	0.0012
Ske	24	0.1180	0.0028	0.1499	0.0014
Ste	24	0.1290	0.0133	0.1022	0.0040

Table A5 Particulate Organic Carbon (POC) of communities (see Table 2) measured by infrared spectrometry (C-Mat 500, Ströhlein) at the experimental temperatures of 12°C, 18°C, and 24°C at the start of the experiment (t_0), after two weeks of constant temperatures (t_1), and after an additional week of daily temperature peaks (t_2).

Species richness	Mixture	Replicate	Temp. [°C]	POC t_0 [mg L^{-1}]	POC t_1 [mg L^{-1}]	POC t_2 [mg L^{-1}]
2	1		12	0.591	4.102	28.150
2	2		12	0.413	4.502	8.406
2	3		12	0.705	3.092	7.075
2	4		12	0.557	3.500	9.700
2	5	1	12	0.783	1.505	1.087
2	5	2	12	0.783	1.440	1.152
2	5	3	12	0.783	1.472	1.130
3	1		12	0.526	4.112	8.397
3	2		12	0.508	2.403	3.165
3	3		12	0.425	3.272	23.554
3	4		12	0.444	5.621	7.738
3	5	1	12	0.854	4.476	8.464
3	5	2	12	0.854	4.297	8.605
3	5	3	12	0.854	4.374	8.523
6	1		12	0.947	6.236	9.769
6	2		12	1.181	8.102	20.915
6	3		12	0.577	6.038	20.669
6	4		12	1.183	5.003	10.068
6	5	1	12	1.024	5.978	22.086
6	5	2	12	1.024	5.741	20.400
6	5	3	12	1.024	5.828	20.692
9	1		12	0.810	6.172	18.626
9	2		12	0.928	6.514	19.334
9	3		12	0.950	6.538	18.749
9	4		12	0.951	6.886	19.990
9	5	1	12	0.911	4.611	19.837
9	5	2	12	0.911	5.022	19.748
9	5	3	12	0.911	4.807	20.636
12	1		12	0.719	5.641	18.599
12	2		12	0.995	5.550	18.636
12	3		12	1.026	5.212	18.251
12	4		12	1.043	5.317	18.717
12	5	1	12	0.787	4.788	17.963
12	5	2	12	0.787	5.191	17.924
12	5	3	12	0.787	4.924	18.127
2	1		18	0.591	6.546	12.792
2	2		18	0.413	5.733	12.972
2	3		18	0.705	5.515	11.570
2	4		18	0.557	4.023	12.592
2	5	1	18	0.783	2.085	3.183
2	5	2	18	0.783	2.237	2.809
2	5	3	18	0.783	2.101	3.008
3	1		18	0.526	13.095	11.758
3	2		18	0.508	9.248	9.767
3	3		18	0.425	23.424	25.805

Table A5 cont.

Species richness	Mixture	Replicate	Temp. [°C]	POC t_0 [mg L^{-1}]	POC t_1 [mg L^{-1}]	POC t_2 [mg L^{-1}]
3	4		18	0.444	12.705	9.613
3	5	1	18	0.854	6.715	10.481
3	5	2	18	0.854	6.718	9.790
3	5	3	18	0.854	6.839	9.826
6	1		18	0.947	7.313	9.870
6	2		18	1.181	10.157	22.775
6	3		18	0.577	10.027	22.502
6	4		18	1.183	7.630	21.729
6	5	1	18	1.024	10.876	22.623
6	5	2	18	1.024	10.015	20.619
6	5	3	18	1.024	10.321	20.971
9	1		18	0.810	7.806	19.600
9	2		18	0.928	9.188	18.503
9	3		18	0.950	10.209	20.905
9	4		18	0.951	9.566	22.081
9	5	1	18	0.911	11.085	23.660
9	5	2	18	0.911	10.775	21.517
9	5	3	18	0.911	5.813	22.940
12	1		18	0.719	9.254	20.588
12	2		18	0.995	9.125	22.276
12	3		18	1.026	9.954	21.589
12	4		18	1.043	9.745	22.766
12	5	1	18	0.787	8.305	19.923
12	5	2	18	0.787	7.904	22.133
12	5	3	18	0.787	7.734	22.790
2	1		24	0.591	7.256	11.066
2	2		24	0.413	6.920	8.550
2	3		24	0.705	5.708	11.057
2	4		24	0.557	5.389	10.759
2	5	1	24	0.783	2.902	2.743
2	5	2	24	0.783	2.793	2.348
2	5	3	24	0.783	2.541	2.340
3	1		24	0.526	7.314	11.680
3	2		24	0.508	5.357	11.292
3	3		24	0.425	18.401	23.682
3	4		24	0.444	6.890	19.444
3	5	1	24	0.854	8.525	13.449
3	5	2	24	0.854	8.710	12.839
3	5	3	24	0.854	8.587	12.463
6	1		24	0.947	7.667	20.533
6	2		24	1.181	9.707	19.893
6	3		24	0.577	11.398	18.285
6	4		24	1.183	8.004	16.357
6	5	1	24	1.024	12.278	20.311
6	5	2	24	1.024	11.507	20.757
6	5	3	24	1.024	12.002	18.687
9	1		24	0.810	6.434	14.722
9	2		24	0.928	6.253	15.064
9	3		24	0.950	6.669	14.478
9	4		24	0.951	6.523	13.936

Table A5 cont.

Species richness	Mixture	Replicate	Temp. [°C]	POC t_0 [mg L^{-1}]	POC t_1 [mg L^{-1}]	POC t_2 [mg L^{-1}]
9	5	1	24	0.911	7.247	15.802
9	5	2	24	0.911	6.508	16.709
9	5	3	24	0.911	6.695	15.460
12	1		24	0.719	7.629	9.523
12	2		24	0.995	7.202	9.747
12	3		24	1.026	7.726	18.163
12	4		24	1.043	8.257	17.501
12	5	1	24	0.787	6.390	14.381
12	5	2	24	0.787	6.905	14.393
12	5	3	24	0.787	7.252	16.700

Table A6 Particulate Organic Phosphorous (POP) of communities (see Table 2) measured by CFA (Continuous Flow Analysis; molybdate reaction after sulfuric acid digestion) at the experimental temperatures of 12°C, 18°C, and 24°C at the start of the experiment (t_0), after two weeks of constant temperatures (t_1), and after an additional week of daily temperature peaks (t_2).

Species richness	Mixture	Replicate	Temp. [°C]	POP t_0 [μg L^{-1}]	POP t_1 [μg L^{-1}]	POP t_2 [μg L^{-1}]
2	1		12	125.6	322.4	765.6
2	2		12	180.6	336.0	352.0
2	3		12	196.3	338.8	306.8
2	4		12	219.7	228.4	613.6
2	5	1	12	276.3	307.2	222.2
2	5	2	12	276.3	310.0	227.0
2	5	3	12	276.3	276.8	224.0
3	1		12	225.6	382.8	424.4
3	2		12	234.7	286.4	297.6
3	3		12	247.5	348.0	698.2
3	4		12	202.1	409.6	394.8
3	5	1	12	625.1	317.2	442.0
3	5	2	12	625.1	330.0	484.8
3	5	3	12	625.1	314.8	470.8
6	1		12	470.4	349.6	470.0
6	2		12	480.0	203.2	677.6
6	3		12	371.7	554.0	635.2
6	4		12	392.6	300.0	383.2
6	5	1	12	449.8	413.6	825.6
6	5	2	12	449.8	402.8	672.8
6	5	3	12	449.8	421.2	754.4
9	1		12	472.8	394.0	599.2
9	2		12	500.6	484.8	593.6
9	3		12	443.3	406.8	640.8
9	4		12	472.8	360.4	687.2
9	5	1	12	476.9	448.0	712.0
9	5	2	12	476.9	455.6	763.2
9	5	3	12	476.9	348.0	691.2
12	1		12	2342.0	323.6	681.6
12	2		12	2778.0	410.0	727.2
12	3		12	3052.0	636.4	700.0
12	4		12	3090.0	302.8	698.4
12	5	1	12	3206.0	511.6	656.0
12	5	2	12	3206.0	453.2	726.4
12	5	3	12	3206.0	500.4	671.2
2	1		18	125.6	563.2	1074.4
2	2		18	180.6	563.6	522.4
2	3		18	196.3	788.8	412.8
2	4		18	219.7	528.4	530.4
2	5	1	18	276.3	442.4	249.2
2	5	2	18	276.3	429.2	263.2
2	5	3	18	276.3	452.4	233.2
3	1		18	225.6	275.6	429.6

Table A6 cont.

Species richness	Mixture	Replicate	Temp. [°C]	POP t_0 [μg L^{-1}]	POP t_1 [μg L^{-1}]	POP t_2 [μg L^{-1}]
3	2		18	234.7	275.0	275.6
3	3		18	247.5	290.8	878.4
3	4		18	202.1	305.6	352.8
3	5	1	18	625.1	336.8	451.6
3	5	2	18	625.1	405.6	492.4
3	5	3	18	625.1	355.6	475.2
6	1		18	470.4	324.4	352.8
6	2		18	480.0	448.4	810.4
6	3		18	371.7	443.6	675.2
6	4		18	392.6	367.2	345.6
6	5	1	18	449.8	434.4	677.6
6	5	2	18	449.8	482.0	663.2
6	5	3	18	449.8	453.6	720.0
9	1		18	472.8	507.6	676.0
9	2		18	500.6	376.0	523.2
9	3		18	443.3	332.8	692.0
9	4		18	472.8	301.2	764.0
9	5	1	18	476.9	233.6	860.8
9	5	2	18	476.9	259.2	804.0
9	5	3	18	476.9	244.0	871.2
12	1		18	2342.0	332.0	676.8
12	2		18	2778.0	207.2	816.0
12	3		18	3052.0	343.6	763.2
12	4		18	3090.0	454.0	706.4
12	5	1	18	3206.0	318.0	640.0
12	5	2	18	3206.0	455.6	703.2
12	5	3	18	3206.0	413.2	737.6
2	1		24	125.6	366.8	631.2
2	2		24	180.6	337.6	313.6
2	3		24	196.3	400.8	345.6
2	4		24	219.7	352.8	377.6
2	5	1	24	276.3	349.6	232.0
2	5	2	24	276.3	403.2	243.2
2	5	3	24	276.3	318.4	249.6
3	1		24	225.6	319.6	332.8
3	2		24	234.7	262.4	282.4
3	3		24	247.5	218.8	821.6
3	4		24	202.1	306.0	356.8
3	5	1	24	625.1	243.2	361.6
3	5	2	24	625.1	214.6	354.4
3	5	3	24	625.1	223.0	346.4
6	1		24	470.4	181.2	340.8
6	2		24	480.0	296.2	666.4
6	3		24	371.7	444.4	540.8
6	4		24	392.6	424.8	284.8
6	5	1	24	449.8	540.0	598.4
6	5	2	24	449.8	562.0	601.6
6	5	3	24	449.8	426.4	579.2
9	1		24	472.8	387.6	488.8
9	2		24	500.6	252.4	519.2

Table A6 cont.

Species richness	Mixture	Replicate	Temp. [°C]	POP t_0 [μg L^{-1}]	POP t_1 [μg L^{-1}]	POP t_2 [μg L^{-1}]
9	3		24	443.3	637.2	521.6
9	4		24	472.8	315.6	444.8
9	5	1	24	476.9	500.4	709.6
9	5	2	24	476.9	496.0	506.4
9	5	3	24	476.9	443.2	493.6
12	1		24	2342.0	350.8	299.2
12	2		24	2778.0	459.6	538.4
12	3		24	3052.0	352.0	352.0
12	4		24	3090.0	274.0	661.6
12	5	1	24	3206.0	350.8	534.4
12	5	2	24	3206.0	344.0	460.8
12	5	3	24	3206.0	435.6	648.0

Table A7 Molar carbon-to-phosphorous (C:P) ratios of communities (see Table 2) calculated based on POC (in mg L^{-1}) and POP (in mg L^{-1}) at the experimental temperatures of 12°C, 18°C, and 24°C at the start of the experiment (t_0), after two weeks of constant temperature treatment (t_1), and after an additional week of daily temperature peaks (t_2).

Species richness	Mixture	Replicate	Temp. [°C]	C:P t_0	C:P t_1	C:P t_2
2	1		12	12.13	32.81	94.81
2	2		12	5.90	34.55	61.58
2	3		12	9.26	23.53	59.47
2	4		12	6.54	39.51	40.77
2	5	1	12	7.31	12.63	12.61
2	5	2	12	7.31	11.98	13.09
2	5	3	12	7.31	13.71	13.01
3	1		12	6.02	27.70	51.02
3	2		12	5.58	21.64	27.43
3	3		12	4.43	24.25	86.99
3	4		12	5.67	35.39	50.54
3	5	1	12	3.52	36.39	49.38
3	5	2	12	3.52	33.58	45.77
3	5	3	12	3.52	35.83	46.68
6	1		12	5.19	45.99	53.60
6	2		12	6.35	102.82	79.59
6	3		12	4.00	28.10	83.91
6	4		12	7.77	43.01	67.75
6	5	1	12	5.87	37.27	68.98
6	5	2	12	5.87	36.75	78.19
6	5	3	12	5.87	35.68	70.73
9	1		12	4.42	40.39	80.16
9	2		12	4.78	34.65	83.99
9	3		12	5.53	41.45	75.45
9	4		12	5.19	49.27	75.01
9	5	1	12	4.93	26.54	71.84
9	5	2	12	4.93	28.42	66.72
9	5	3	12	4.93	35.62	76.99
12	1		12	0.79	44.96	70.36
12	2		12	0.92	34.90	66.08
12	3		12	0.87	21.12	67.23
12	4		12	0.87	45.28	69.11
12	5	1	12	0.63	24.14	70.61
12	5	2	12	0.63	29.54	63.63
12	5	3	12	0.63	25.37	69.64
2	1		18	12.13	29.97	30.70
2	2		18	5.90	26.23	64.03
2	3		18	9.26	18.03	72.28
2	4		18	6.54	19.63	61.22
2	5	1	18	7.31	12.15	32.94
2	5	2	18	7.31	13.44	27.52
2	5	3	18	7.31	11.98	33.27
3	1		18	6.02	122.53	70.58
3	2		18	5.58	86.72	91.39
3	3		18	4.43	207.72	75.76

Table A7 cont.

Species richness	Mixture	Replicate	Temp. [°C]	C:P t_0	C:P t_1	C:P t_2
3	4		18	5.67	107.21	70.26
3	5	1	18	3.52	51.42	59.85
3	5	2	18	3.52	42.71	51.27
3	5	3	18	3.52	49.59	53.32
6	1		18	5.19	58.13	72.14
6	2		18	6.35	58.41	72.47
6	3		18	4.00	58.29	85.94
6	4		18	7.77	53.59	162.13
6	5	1	18	5.87	64.56	86.10
6	5	2	18	5.87	53.58	80.17
6	5	3	18	5.87	58.68	75.11
9	1		18	4.42	39.66	74.77
9	2		18	4.78	63.01	91.20
9	3		18	5.53	79.11	77.90
9	4		18	5.19	81.90	74.53
9	5	1	18	4.93	122.36	70.88
9	5	2	18	4.93	107.20	69.01
9	5	3	18	4.93	61.44	67.90
12	1		18	0.79	71.88	78.44
12	2		18	0.92	113.57	70.40
12	3		18	0.87	74.71	72.95
12	4		18	0.87	55.35	83.10
12	5	1	18	0.63	67.34	80.28
12	5	2	18	0.63	44.74	81.16
12	5	3	18	0.63	48.27	79.68
2	1		24	12.13	51.01	45.21
2	2		24	5.90	52.86	70.30
2	3		24	9.26	36.73	82.50
2	4		24	6.54	39.39	73.48
2	5	1	24	7.31	21.40	30.49
2	5	2	24	7.31	17.86	24.90
2	5	3	24	7.31	20.58	24.17
3	1		24	6.02	59.01	90.50
3	2		24	5.58	52.65	103.11
3	3		24	4.43	216.87	74.33
3	4		24	5.67	58.06	140.52
3	5	1	24	3.52	90.39	95.91
3	5	2	24	3.52	104.66	93.42
3	5	3	24	3.52	99.29	92.77
6	1		24	5.19	109.12	155.37
6	2		24	6.35	84.51	76.98
6	3		24	4.00	66.14	87.19
6	4		24	7.77	48.59	148.11
6	5	1	24	5.87	58.63	87.53
6	5	2	24	5.87	52.80	88.97
6	5	3	24	5.87	72.58	83.20
9	1		24	4.42	42.80	77.66
9	2		24	4.78	63.88	74.82
9	3		24	5.53	26.99	71.58
9	4		24	5.19	53.30	80.79

Table A7 cont.

Species richness	Mixture	Replicate	Temp. [°C]	C:P t_0	C:P t_1	C:P t_2
9	5	1	24	4.93	37.35	57.42
9	5	2	24	4.93	33.83	85.09
9	5	3	24	4.93	38.95	80.77
12	1		24	0.79	56.08	82.07
12	2		24	0.92	40.41	46.68
12	3		24	0.87	56.60	133.06
12	4		24	0.87	77.71	68.21
12	5	1	24	0.63	46.97	69.39
12	5	2	24	0.63	51.76	80.55
12	5	3	24	0.63	42.93	66.46

Table A8 Daily growth rates of communities (see Table 2) at the experimental temperatures of 12°C, 18°C, and 24°C after two weeks of constant temperatures (t_1) and after an additional week of daily temperature peaks (t_2). Daily growth rates (r) of communities were calculated based on POC as the difference between the natural logarithm of the POC mean end value (t_{end} at t_1 or t_2, respectively) of a community and the natural logarithm of the respective mean POC start value (at t_0) divided by days of incubation (t=14 at t_1, t=21 at t_2):
$r = (LN(POC_{t_{end}}) - LN(POC_{t_0}))/t$.

Species richness	Mixture	Replicate	Temp. [°C]	r t_1 [d^{-1}]	r t_2 [d^{-1}]
2	1		12	0.1384	0.2170
2	2		12	0.1705	0.1764
2	3		12	0.1056	0.1428
2	4		12	0.1313	0.1691
2	5	1	12	0.0466	0.0486
2	5	2	12	0.0435	0.0514
2	5	3	12	0.0451	0.0504
3	1		12	0.1468	0.1649
3	2		12	0.1111	0.1202
3	3		12	0.1458	0.2242
3	4		12	0.1813	0.1691
3	5	1	12	0.1183	0.1422
3	5	2	12	0.1154	0.1430
3	5	3	12	0.1166	0.1425
6	1		12	0.1346	0.1441
6	2		12	0.1375	0.1699
6	3		12	0.1678	0.2034
6	4		12	0.1030	0.1350
6	5	1	12	0.1260	0.1792
6	5	2	12	0.1231	0.1755
6	5	3	12	0.1242	0.1761
9	1		12	0.1450	0.1823
9	2		12	0.1392	0.1776
9	3		12	0.1378	0.1750
9	4		12	0.1414	0.1780
9	5	1	12	0.1158	0.1797
9	5	2	12	0.1219	0.1795
9	5	3	12	0.1188	0.1816
12	1		12	0.1471	0.1879
12	2		12	0.1228	0.1725
12	3		12	0.1161	0.1701
12	4		12	0.1163	0.1705
12	5	1	12	0.1290	0.1819
12	5	2	12	0.1347	0.1818
12	5	3	12	0.1310	0.1824
2	1		18	0.1718	0.1794
2	2		18	0.1878	0.1971
2	3		18	0.1469	0.1663
2	4		18	0.1413	0.1815
2	5	1	18	0.0699	0.0998

Table A8 cont.

Species richness	Mixture	Replicate	Temp. [°C]	r t_1 [d^{-1}]	r t_2 [d^{-1}]
2	5	2	18	0.0750	0.0938
2	5	3	18	0.0705	0.0971
3	1		18	0.2296	0.1809
3	2		18	0.2073	0.1738
3	3		18	0.2864	0.2285
3	4		18	0.2395	0.1794
3	5	1	18	0.1473	0.1524
3	5	2	18	0.1473	0.1491
3	5	3	18	0.1486	0.1493
6	1		18	0.1460	0.1446
6	2		18	0.1537	0.1739
6	3		18	0.2040	0.2075
6	4		18	0.1331	0.1716
6	5	1	18	0.1687	0.1804
6	5	2	18	0.1629	0.1760
6	5	3	18	0.1650	0.1768
9	1		18	0.1618	0.1847
9	2		18	0.1638	0.1755
9	3		18	0.1696	0.1802
9	4		18	0.1649	0.1827
9	5	1	18	0.1785	0.1881
9	5	2	18	0.1765	0.1836
9	5	3	18	0.1324	0.1866
12	1		18	0.1825	0.1927
12	2		18	0.1583	0.1810
12	3		18	0.1623	0.1781
12	4		18	0.1596	0.1798
12	5	1	18	0.1683	0.1869
12	5	2	18	0.1648	0.1919
12	5	3	18	0.1632	0.1933
2	1		24	0.1791	0.1725
2	2		24	0.2013	0.1772
2	3		24	0.1494	0.1641
2	4		24	0.1621	0.1740
2	5	1	24	0.0935	0.0927
2	5	2	24	0.0908	0.0853
2	5	3	24	0.0841	0.0851
3	1		24	0.1880	0.1806
3	2		24	0.1683	0.1807
3	3		24	0.2692	0.2245
3	4		24	0.1958	0.2130
3	5	1	24	0.1643	0.1643
3	5	2	24	0.1658	0.1620
3	5	3	24	0.1648	0.1606
6	1		24	0.1494	0.1795
6	2		24	0.1505	0.1675
6	3		24	0.2131	0.1976
6	4		24	0.1365	0.1581
6	5	1	24	0.1774	0.1752
6	5	2	24	0.1728	0.1763

Table A8 cont.

Species richness	Mixture	Replicate	Temp. [°C]	r t_1 [d^{-1}]	r t_2 [d^{-1}]
6	5	3	24	0.1758	0.1713
9	1		24	0.1480	0.1711
9	2		24	0.1363	0.1657
9	3		24	0.1392	0.1627
9	4		24	0.1375	0.1608
9	5	1	24	0.1481	0.1689
9	5	2	24	0.1404	0.1715
9	5	3	24	0.1425	0.1678
12	1		24	0.1687	0.1560
12	2		24	0.1414	0.1417
12	3		24	0.1442	0.1698
12	4		24	0.1478	0.1673
12	5	1	24	0.1496	0.1714
12	5	2	24	0.1551	0.1714
12	5	3	24	0.1586	0.1785

Table A9 Resource Use Efficiency (RUE) of monocultures (mean values, n=3) and communities (see Table 2) at the experimental temperatures of 12°C, 18°C, and 24°C after two weeks of constant temperatures (t_1) and after an additional week of daily temperature peaks (t_2). Resource Use Efficiency was calculated by relating biomass [as μg POC L^{-1} d^{-1}] to total P concentration [0.2 μg TP L^{-1} d^{-1}] per sample (Ptacnik *et al*. 2008). Of the three replicates per mixture no. 5, replicate no. 1 had randomly been chosen before RUE calculation. Taxa name abbreviations see Table A1.

Taxon / species richness	Mixture	Temp. [°C]	RUE t_1	RUE t_2
Chl		12	23.72	40.16
Ped		12	8.00	2.91
Sce		12	23.92	40.54
Spi		12	13.47	8.69
Sta		12	24.51	11.83
Ana		12	13.88	13.74
Aph		12	22.73	18.25
Chr		12	10.58	8.58
Lep		12	30.73	34.57
Osc		12	14.27	10.95
Ast		12	9.57	22.36
Fra		12	14.68	8.26
Nav		12	11.64	10.56
Ske		12	9.34	8.99
Ste		12	7.62	23.62
2	1	12	19.54	134.06
2	2	12	21.44	40.03
2	3	12	14.72	33.70
2	4	12	16.67	46.20
2	5	12	7.17	5.18
3	1	12	19.58	39.99
3	2	12	11.44	15.07
3	3	12	15.58	112.17
3	4	12	26.77	36.85
3	5	12	21.32	40.31
6	1	12	29.70	46.52
6	2	12	38.58	99.60
6	3	12	28.75	98.43
6	4	12	23.83	47.95
6	5	12	28.47	105.18
9	1	12	29.39	88.70
9	2	12	31.02	92.07
9	3	12	31.14	89.29
9	4	12	32.79	95.20
9	5	12	21.96	94.47
12	1	12	26.87	88.57
12	2	12	26.43	88.75
12	3	12	24.82	86.92
12	4	12	25.32	89.14
12	5	12	22.80	85.55

Table A9 cont.

Taxon / species richness	Mixture	Temp. [°C]	RUE t_1	RUE t_2
Chl		18	31.56	68.16
Ped		18	5.26	8.53
Sce		18	26.77	53.49
Spi		18	16.80	11.60
Sta		18	25.82	12.76
Ana		18	14.39	21.37
Aph		18	18.21	37.29
Chr		18	12.23	13.66
Lep		18	39.18	40.59
Osc		18	16.89	17.45
Ast		18	12.23	40.81
Fra		18	16.24	15.16
Nav		18	14.05	19.91
Ske		18	7.79	6.36
Ste		18	13.85	26.90
2	1	18	31.17	60.92
2	2	18	27.30	61.77
2	3	18	26.26	55.10
2	4	18	19.16	59.97
2	5	18	9.93	15.16
3	1	18	62.36	56.00
3	2	18	44.04	46.51
3	3	18	111.55	122.89
3	4	18	60.51	45.78
3	5	18	31.98	49.92
6	1	18	34.83	47.01
6	2	18	48.37	108.46
6	3	18	47.75	107.16
6	4	18	36.34	103.48
6	5	18	51.80	107.74
9	1	18	37.18	93.34
9	2	18	43.76	88.12
9	3	18	48.62	99.56
9	4	18	45.56	105.16
9	5	18	52.79	112.68
12	1	18	44.07	98.05
12	2	18	43.46	106.09
12	3	18	47.41	102.82
12	4	18	46.41	108.42
12	5	18	39.55	94.88
Chl		24	25.40	65.34
Ped		24	4.64	2.32
Sce		24	25.53	43.39
Spi		24	12.05	10.68
Sta		24	16.84	11.90
Ana		24	16.74	10.72
Aph		24	19.25	30.95
Chr		24	8.49	24.79
Lep		24	26.50	26.57
Osc		24	14.91	10.19

Table A9 cont.

Taxon / species richness	Mixture	Temp. [°C]	RUE t_1	RUE t_2
Ast		24	22.96	43.17
Fra		24	12.39	7.19
Nav		24	19.01	23.09
Ske		24	8.83	6.05
Ste		24	10.82	24.11
2	1	24	34.55	52.70
2	2	24	32.96	40.72
2	3	24	27.18	52.66
2	4	24	25.66	51.24
2	5	24	13.82	13.07
3	1	24	34.83	55.62
3	2	24	25.51	53.78
3	3	24	87.63	112.78
3	4	24	32.81	92.60
3	5	24	40.60	64.05
6	1	24	36.52	97.79
6	2	24	46.23	94.74
6	3	24	54.28	87.08
6	4	24	38.12	77.90
6	5	24	58.47	96.73
9	1	24	30.64	70.11
9	2	24	29.78	71.74
9	3	24	31.76	68.95
9	4	24	31.06	66.37
9	5	24	34.51	75.26
12	1	24	36.33	45.35
12	2	24	34.30	46.42
12	3	24	36.79	86.50
12	4	24	39.32	83.35
12	5	24	30.43	68.49

Table A10 Community diversity (*H*) calculated as the Shannon Index: $H = -\sum_{i=1}^{n} p_i * \ln p_i$, with n being species richness and p_i being one species' fraction of biovolume of the community biovolume, for the three experimental temperatures of 12°C, 18°C, and 24°C at the start of the experiment (t_0), after two weeks of constant temperatures (t_1), and after an additional week of daily temperature peaks (t_2). Of the three replicates per mixture no. 5, replicate no. 1 (see Table 2) had randomly been chosen before diversity calculation.

Species richness	Temp. [°C]	H t_0	H t_1	H t_2
2	12	0.32	0.17	0.05
2	12	0.62	0.38	0.36
2	12	0.35	0.66	0.02
2	12	0.62	0.41	0.55
2	12	0.50	0.31	0.04
3	12	0.22	0.65	0.67
3	12	0.63	0.22	0.11
3	12	0.74	0.18	0.07
3	12	0.14	0.91	0.87
3	12	0.50	0.69	0.22
6	12	0.59	1.25	0.22
6	12	1.24	1.11	0.92
6	12	1.04	0.55	0.50
6	12	0.78	1.56	0.64
6	12	0.95	0.68	0.41
9	12	1.44	1.15	0.96
9	12	1.37	1.60	0.91
9	12	1.39	1.64	0.88
9	12	0.84	0.81	0.68
9	12	1.53	1.25	0.81
12	12	1.51	1.30	1.30
12	12	1.83	1.83	0.76
12	12	2.05	1.70	0.94
12	12	2.14	1.70	0.91
12	12	2.11	1.42	0.85
2	18	0.32	0.39	0.29
2	18	0.62	0.69	0.62
2	18	0.35	0.62	0.57
2	18	0.62	0.67	0.61
2	18	0.50	0.14	0.04
3	18	0.22	1.08	0.90
3	18	0.63	0.40	0.11
3	18	0.74	0.10	0.48
3	18	0.14	1.06	0.84
3	18	0.50	0.77	0.78
6	18	0.59	0.99	0.34
6	18	1.24	1.09	0.74
6	18	1.04	1.06	0.70
6	18	0.78	1.09	0.88
6	18	0.95	0.31	0.84

Table A10 cont.

Species richness	Temp. [°C]	H t_0	H t_1	H t_2
9	18	1.44	1.06	0.77
9	18	1.37	1.48	1.12
9	18	1.39	1.42	1.13
9	18	0.84	1.17	0.96
9	18	1.53	1.33	1.05
12	18	1.51	1.46	1.10
12	18	1.83	1.52	0.91
12	18	2.05	1.46	1.07
12	18	2.14	1.66	0.94
12	18	2.11	1.72	1.19
2	24	0.32	0.51	0.13
2	24	0.62	0.66	0.36
2	24	0.35	0.69	0.42
2	24	0.62	0.41	0.52
2	24	0.50	0.06	0.02
3	24	0.22	0.78	0.64
3	24	0.63	0.30	0.04
3	24	0.74	0.59	0.56
3	24	0.14	0.79	0.77
3	24	0.50	0.91	0.66
6	24	0.59	1.01	0.52
6	24	1.24	1.08	0.95
6	24	1.04	0.95	0.77
6	24	0.78	1.58	1.51
6	24	0.95	0.57	0.64
9	24	1.44	1.53	1.18
9	24	1.37	1.43	1.22
9	24	1.39	1.29	1.38
9	24	0.84	1.16	0.95
9	24	1.53	1.17	1.12
12	24	1.51	1.57	1.39
12	24	1.83	1.36	1.12
12	24	2.05	1.52	1.55
12	24	2.14	1.31	1.26
12	24	2.11	0.81	1.08

Table A11 Net biodiversity effect, complementarity effect, and selection effect of communities (see Table 2) calculated after Loreau & Hector 2001 for the three experimental temperatures of 12°C, 18°C, and 24°C after two weeks of constant temperatures (t_1) and after an additional week of daily temperature peaks (t_2).

			Net effect		Complementarity effect		Selection effect	
Species richness	**Mixture**	**Temp. [°C]**	t_1	t_2	t_1	t_2	t_1	t_2
2	1	12	-0.59	46.44	-0.34	28.00	-0.25	18.44
2	2	12	1.27	8.01	0.63	5.37	0.64	2.64
2	3	12	-0.33	10.47	4.71	28.35	-5.03	-17.88
2	4	12	-6.14	-1.23	-4.08	-0.15	-2.07	-1.08
3	5	12	-2.21	-9.30	-2.42	-7.34	0.21	-1.96
3	1	12	1.15	8.92	2.50	14.23	-1.35	-5.31
3	2	12	0.17	-3.52	0.96	6.57	-0.79	-10.09
3	3	12	0.58	41.70	0.13	18.96	0.45	22.74
3	4	12	4.12	12.76	8.90	28.21	-4.78	-15.44
3	5	12	-2.10	2.80	-2.69	-4.53	0.59	7.33
6	1	12	0.90	3.11	0.64	-5.70	0.26	8.81
6	2	12	0.11	22.89	1.76	21.20	-1.66	1.69
6	3	12	2.28	11.12	3.08	21.03	-0.80	-9.91
6	4	12	-1.95	29.23	1.08	31.63	-3.04	-2.40
6	5	12	-3.10	21.17	-2.41	18.68	-0.69	2.49
9	1	12	1.84	26.32	3.20	18.87	-1.36	7.45
9	2	12	-2.29	20.22	7.42	17.87	-9.71	2.35
9	3	12	0.78	23.09	1.18	24.82	-0.40	-1.74
9	4	12	0.92	22.75	-0.85	18.85	1.77	3.90
9	5	12	-2.28	22.18	-2.43	15.59	0.15	6.58
12	1	12	0.43	25.43	-0.83	17.15	1.26	8.28
12	2	12	-2.12	18.96	-1.91	48.86	-0.21	-29.91
12	3	12	-2.60	18.65	-2.28	8.74	-0.32	9.90
12	4	12	-2.64	19.37	-2.83	6.45	0.19	12.92
12	5	12	-0.92	23.06	-1.54	8.85	0.62	14.21
2	1	18	1.00	10.34	0.77	5.22	0.23	5.12
2	2	18	2.04	13.83	2.45	31.17	-0.41	-17.33
2	3	18	1.84	18.51	4.34	25.91	-2.50	-7.40
2	4	18	-4.68	-10.13	-4.60	-10.92	-0.08	0.79
3	5	18	-3.39	-7.70	-3.48	-2.96	0.09	-4.75
3	1	18	9.69	12.48	18.27	19.79	-8.58	-7.31
3	2	18	6.09	4.70	10.00	50.22	-3.91	-45.52
3	3	18	20.53	42.34	13.47	27.34	7.06	15.00
3	4	18	10.87	15.26	13.47	18.66	-2.60	-3.40
3	5	18	-0.55	2.26	-1.15	10.59	0.60	-8.33
6	1	18	1.13	-4.48	0.95	-12.31	0.18	7.83
6	2	18	1.40	17.64	11.38	6.38	-9.97	11.26
6	3	18	5.67	30.22	4.91	36.23	0.76	-6.01
6	4	18	0.36	21.87	2.47	19.36	-2.11	2.51
6	5	18	1.91	9.47	1.29	4.25	0.62	5.22
9	1	18	2.85	21.90	2.79	7.17	0.06	14.73
9	2	18	1.14	7.53	2.57	-2.73	-1.43	10.26
9	3	18	3.75	19.11	5.25	21.99	-1.50	-2.88
9	4	18	2.56	19.23	0.99	11.20	1.56	8.04
9	5	18	3.81	18.54	1.40	6.40	2.41	12.14
12	1	18	3.65	22.27	4.36	7.56	-0.71	14.71

Table A11 cont.

			Net effect		Complementarity effect		Selection effect	
Species richness	**Mixture**	**Temp. [°C]**	**t_1**	**t_2**	**t_1**	**t_2**	**t_1**	**t_2**
12	2	18	0.94	16.86	-0.30	3.97	1.24	12.88
12	3	18	1.68	14.45	1.08	3.28	0.59	11.16
12	4	18	1.28	16.64	-0.35	-0.32	1.63	16.96
12	5	18	2.17	19.16	1.37	25.09	0.80	-5.94
2	1	24	3.20	7.64	2.71	0.35	0.49	7.29
2	2	24	3.51	7.94	4.72	33.57	-1.22	-25.63
2	3	24	2.94	17.45	4.50	22.78	-1.57	-5.33
2	4	24	-3.46	-7.35	-4.23	-9.27	0.77	1.92
3	5	24	-1.20	-7.29	-1.21	-3.22	0.01	-4.06
3	1	24	4.05	14.71	5.06	32.12	-1.00	-17.41
3	2	24	1.48	8.16	10.05	98.25	-8.57	-90.09
3	3	24	15.96	39.95	12.19	33.55	3.77	6.40
3	4	24	5.30	36.11	4.28	31.66	1.02	4.45
3	5	24	2.81	8.16	2.31	5.08	0.50	3.08
6	1	24	1.25	17.98	3.01	8.76	-1.76	9.22
6	2	24	1.50	18.01	2.86	7.35	-1.35	10.65
6	3	24	6.71	23.67	7.40	46.67	-0.70	-23.00
6	4	24	1.12	15.47	3.74	33.38	-2.62	-17.92
6	5	24	2.70	9.58	6.85	6.85	-4.15	2.73
9	1	24	1.61	13.10	2.49	6.09	-0.89	7.01
9	2	24	-2.31	4.86	-0.52	-4.51	-1.80	9.37
9	3	24	-0.04	9.15	4.92	14.43	-4.96	-5.29
9	4	24	-0.73	6.94	-0.61	3.58	-0.12	3.36
9	5	24	-0.25	6.67	-1.77	-1.92	1.53	8.59
12	1	24	2.31	1.95	3.28	0.88	-0.97	1.07
12	2	24	-0.87	-3.69	-1.64	-11.92	0.77	8.23
12	3	24	-0.46	11.39	0.45	2.49	-0.92	8.90
12	4	24	-0.19	9.47	-1.47	-2.29	1.28	11.76
12	5	24	0.57	10.05	-0.45	-4.02	1.02	14.08

Table A12 Biovolumes (in $\mu m^3 L^{-1}$) of each taxon contained in the communities (see Table 2) at the three experimental temperatures 12°C, 18°C, and 24°C at the start of the experiment (t_0), after two weeks of constant temperature treatment (t_1) and after an additional week of daily temperature peaks (t_2). Biovolumes were only determined for replicate no. 1 randomly chosen from the total of three replicates per mixture no. 5. Taxa name abbreviations see Table A1.

Species richness	Mixture	Temp. [°C]	Taxon	Biovolume [$\mu m^3 L^{-1}$] t_0	Biovolume [$\mu m^3 L^{-1}$] t_1	Biovolume [$\mu m^3 L^{-1}$] t_2
2	1	12	Chl	2.697E+08	4.788E+10	1.033E+11
2	1	12	Ped	2.454E+09	2.074E+09	8.198E+08
2	2	12	Sce	5.282E+08	1.277E+10	1.835E+10
2	2	12	Lep	2.458E+08	1.840E+09	2.442E+09
2	3	12	Ped	2.676E+09	4.979E+09	6.762E+07
2	3	12	Nav	3.310E+08	8.502E+09	2.227E+10
2	4	12	Sce	5.928E+08	2.750E+10	1.813E+10
2	4	12	Ana	1.316E+09	4.633E+09	5.730E+09
2	5	12	Sta	2.414E+09	5.026E+09	4.418E+09
2	5	12	Ske	5.934E+08	5.086E+08	3.263E+07
3	1	12	Sce	3.583E+08	1.115E+10	2.513E+10
3	1	12	Lep	1.728E+08	5.751E+08	2.847E+09
3	1	12	Nav	2.271E+08	2.808E+09	4.018E+09
3	2	12	Aph	3.890E+08	2.036E+09	4.563E+09
3	2	12	Fra	3.453E+07	1.438E+07	7.188E+06
3	2	12	Ske	7.439E+08	9.582E+07	9.496E+07
3	3	12	Chl	4.964E+08	3.057E+10	7.949E+10
3	3	12	Spi	7.587E+08	1.098E+08	0.000E+00
3	3	12	Lep	1.449E+08	1.139E+09	1.029E+09
3	4	12	Aph	8.473E+07	5.010E+09	2.248E+09
3	4	12	Lep	2.008E+07	9.748E+08	3.802E+09
3	4	12	Nav	3.100E+07	6.489E+09	1.152E+10
3	5	12	Sce	2.352E+08	6.848E+09	1.973E+10
3	5	12	Ped	2.965E+09	1.245E+09	2.788E+08
3	5	12	Chr	7.365E+08	7.855E+08	7.171E+08
6	1	12	Sce	1.470E+08	4.278E+09	2.313E+10
6	1	12	Spi	8.646E+08	1.094E+09	0.000E+00
6	1	12	Aph	3.262E+08	1.889E+09	7.637E+08
6	1	12	Chr	4.713E+08	6.326E+08	3.058E+08
6	1	12	Fra	7.929E+06	1.016E+07	6.098E+06
6	1	12	Ske	2.651E+08	1.894E+08	2.695E+07
6	2	12	Chl	1.175E+08	1.292E+10	5.044E+10
6	2	12	Sce	1.005E+08	3.814E+09	1.258E+10
6	2	12	Spi	0.000E+00	0.000E+00	0.000E+00
6	2	12	Sta	9.184E+08	7.467E+08	2.554E+09
6	2	12	Osc	1.073E+09	1.946E+09	1.360E+09
6	2	12	Nav	7.539E+07	1.132E+09	4.991E+09
6	3	12	Chl	1.492E+08	1.862E+10	6.086E+10
6	3	12	Ped	1.390E+09	0.000E+00	6.223E+07
6	3	12	Lep	8.118E+07	3.691E+08	1.497E+09

Table A12 cont.

Species richness	Mixture	Temp. [°C]	Taxon	Biovolume [$\mu m^3 L^{-1}$] t_0	Biovolume [$\mu m^3 L^{-1}$] t_1	Biovolume [$\mu m^3 L^{-1}$] t_2
6	3	12	Fra	1.797E+06	0.000E+00	5.881E+07
6	3	12	Nav	1.523E+08	3.705E+09	9.303E+09
6	3	12	Ske	6.495E+08	1.002E+08	5.376E+07
6	4	12	Sce	1.374E+08	2.225E+09	4.228E+11
6	4	12	Spi	0.000E+00	0.000E+00	0.000E+00
6	4	12	Aph	5.131E+08	9.911E+08	4.185E+10
6	4	12	Chr	4.227E+08	6.901E+08	2.665E+09
6	4	12	Osc	1.746E+09	2.873E+09	2.869E+09
6	4	12	Nav	2.236E+08	1.271E+09	6.226E+10
6	5	12	Chl	3.550E+08	2.224E+10	9.072E+10
6	5	12	Spi	7.587E+08	1.094E+09	0.000E+00
6	5	12	Ana	7.753E+08	1.947E+09	8.801E+09
6	5	12	Aph	4.710E+08	1.360E+09	3.001E+08
6	5	12	Lep	7.262E+07	3.100E+08	1.930E+09
6	5	12	Fra	3.172E+07	0.000E+00	0.000E+00
9	1	12	Chl	9.190E+07	9.048E+09	4.973E+10
9	1	12	Sce	1.639E+08	3.874E+08	1.339E+10
9	1	12	Spi	5.468E+08	1.060E+08	0.000E+00
9	1	12	Sta	2.919E+09	9.800E+08	1.904E+08
9	1	12	Aph	3.512E+08	9.176E+08	2.184E+09
9	1	12	Chr	3.479E+08	2.244E+08	1.964E+08
9	1	12	Ast	2.879E+07	0.000E+00	0.000E+00
9	1	12	Fra	9.066E+06	5.881E+07	9.978E+08
9	1	12	Nav	5.181E+07	1.911E+09	5.555E+09
9	2	12	Chl	7.856E+07	1.904E+10	4.933E+10
9	2	12	Sce	8.605E+07	2.988E+09	1.123E+10
9	2	12	Sta	2.895E+08	6.020E+08	7.840E+07
9	2	12	Ana	1.823E+08	1.982E+10	1.048E+09
9	2	12	Aph	1.242E+08	1.214E+10	4.381E+08
9	2	12	Osc	6.736E+08	3.708E+09	2.107E+09
9	2	12	Fra	3.267E+06	2.205E+08	0.000E+00
9	2	12	Nav	3.903E+07	4.111E+09	3.895E+09
9	2	12	Ste	0.000E+00	1.000E+03	2.000E+03
9	3	12	Chl	8.485E+07	7.760E+09	4.769E+10
9	3	12	Sce	2.273E+08	5.084E+09	1.850E+10
9	3	12	Spi	1.367E+09	1.367E+09	0.000E+00
9	3	12	Aph	2.125E+08	6.098E+08	3.620E+08
9	3	12	Chr	1.262E+08	1.964E+08	5.611E+07
9	3	12	Lep	4.175E+07	4.507E+08	6.045E+08
9	3	12	Osc	6.454E+08	2.842E+09	1.765E+09
9	3	12	Fra	3.251E+06	1.797E+06	0.000E+00
9	3	12	Nav	2.770E+07	2.127E+09	1.966E+09
9	4	12	Chl	9.982E+07	1.238E+10	5.559E+10
9	4	12	Sce	1.216E+07	2.224E+09	1.464E+10
9	4	12	Aph	2.384E+07	3.362E+08	2.026E+08
9	4	12	Lep	4.421E+06	3.085E+08	3.946E+08
9	4	12	Osc	7.851E+08	8.133E+08	2.146E+09
9	4	12	Ast	0.000E+00	1.000E+03	2.000E+03
9	4	12	Fra	2.254E+06	0.000E+00	0.000E+00
9	4	12	Ske	1.069E+08	8.535E+07	2.117E+07

Table A12 cont.

Species richness	Mixture	Temp. [°C]	Taxon	Biovolume [$\mu m^3 L^{-1}$] t_0	Biovolume [$\mu m^3 L^{-1}$] t_1	Biovolume [$\mu m^3 L^{-1}$] t_2
9	4	12	Ste	0.000E+00	1.000E+03	2.000E+03
9	5	12	Chl	1.026E+08	2.086E+10	6.965E+10
9	5	12	Sce	1.688E+08	2.940E+09	2.153E+10
9	5	12	Spi	3.179E+09	5.468E+08	1.094E+09
9	5	12	Ana	5.270E+08	2.089E+09	8.793E+08
9	5	12	Aph	5.168E+08	1.479E+09	2.110E+08
9	5	12	Lep	8.475E+07	8.277E+08	5.522E+08
9	5	12	Fra	6.643E+06	1.797E+07	0.000E+00
9	5	12	Nav	5.647E+07	4.483E+09	2.844E+09
9	5	12	Ske	3.465E+08	0.000E+00	9.322E+06
12	1	12	Chl	9.079E+07	1.891E+10	5.398E+10
12	1	12	Ped	8.842E+08	1.535E+10	1.660E+08
12	1	12	Sce	4.715E+07	3.126E+11	1.525E+10
12	1	12	Spi	2.649E+09	2.649E+09	3.196E+09
12	1	12	Sta	5.860E+08	1.017E+10	2.240E+09
12	1	12	Ana	1.297E+08	2.919E+10	3.608E+09
12	1	12	Aph	8.967E+07	1.042E+10	1.100E+09
12	1	12	Chr	2.602E+08	5.420E+10	8.416E+07
12	1	12	Lep	1.741E+07	9.179E+09	2.340E+09
12	1	12	Fra	4.737E+06	1.615E+07	0.000E+00
12	1	12	Nav	4.670E+07	9.729E+09	5.306E+09
12	1	12	Ske	1.546E+08	9.977E+08	1.625E+08
12	2	12	Chl	4.886E+07	9.698E+09	5.722E+10
12	2	12	Ped	5.815E+08	6.915E+08	4.779E+07
12	2	12	Sce	6.544E+07	1.845E+09	1.195E+10
12	2	12	Spi	0.000E+00	0.000E+00	0.000E+00
12	2	12	Sta	3.808E+08	1.027E+09	6.720E+07
12	2	12	Ana	1.310E+08	3.661E+09	1.012E+09
12	2	12	Aph	1.774E+08	1.892E+09	1.011E+08
12	2	12	Lep	2.523E+07	3.671E+08	7.465E+08
12	2	12	Osc	8.645E+08	2.992E+09	2.356E+09
12	2	12	Fra	2.823E+06	0.000E+00	0.000E+00
12	2	12	Nav	3.309E+07	2.770E+09	4.092E+08
12	2	12	Ske	2.385E+08	2.374E+07	0.000E+00
12	3	12	Chl	7.933E+07	1.225E+10	6.390E+10
12	3	12	Ped	3.941E+08	1.014E+08	8.298E+07
12	3	12	Sce	9.442E+07	1.722E+09	1.652E+10
12	3	12	Spi	5.298E+08	1.367E+09	0.000E+00
12	3	12	Ana	1.483E+08	4.450E+09	1.647E+09
12	3	12	Aph	3.958E+08	6.840E+08	1.959E+08
12	3	12	Chr	2.504E+08	2.431E+08	1.122E+08
12	3	12	Lep	2.831E+07	2.193E+09	5.977E+09
12	3	12	Osc	8.837E+08	2.704E+09	1.048E+09
12	3	12	Fra	4.989E+06	0.000E+00	0.000E+00
12	3	12	Nav	3.674E+07	8.818E+08	1.029E+09
12	3	12	Ske	3.280E+08	1.899E+07	9.322E+06
12	4	12	Chl	1.004E+08	6.488E+09	5.303E+10
12	4	12	Ped	4.859E+08	2.766E+08	8.298E+07
12	4	12	Sce	6.415E+07	1.107E+09	1.053E+10
12	4	12	Spi	2.119E+08	2.649E+08	0.000E+00

Table A12 cont.

Species richness	Mixture	Temp. [°C]	Taxon	Biovolume [$\mu m^3 L^{-1}$] t_0	Biovolume [$\mu m^3 L^{-1}$] t_1	Biovolume [$\mu m^3 L^{-1}$] t_2
12	4	12	Sta	4.005E+08	2.333E+08	1.400E+08
12	4	12	Ana	1.222E+08	1.674E+09	2.631E+09
12	4	12	Aph	3.342E+08	3.615E+08	1.956E+08
12	4	12	Chr	1.567E+08	2.946E+08	4.696E+08
12	4	12	Osc	6.078E+08	2.826E+09	1.147E+09
12	4	12	Fra	1.220E+06	0.000E+00	0.000E+00
12	4	12	Nav	2.794E+07	9.332E+08	3.461E+09
12	4	12	Ske	2.212E+08	3.323E+07	0.000E+00
12	5	12	Chl	8.247E+07	1.263E+10	5.687E+10
12	5	12	Ped	3.941E+08	2.489E+08	4.979E+07
12	5	12	Sce	5.611E+07	2.103E+09	1.379E+10
12	5	12	Spi	1.060E+08	1.907E+06	0.000E+00
12	5	12	Sta	3.570E+08	6.720E+08	1.400E+08
12	5	12	Ana	1.841E+08	2.451E+09	1.568E+09
12	5	12	Aph	5.422E+07	9.409E+08	4.701E+08
12	5	12	Chr	2.300E+08	2.946E+08	1.403E+08
12	5	12	Lep	4.126E+07	2.561E+08	6.520E+08
12	5	12	Fra	0.000E+00	0.000E+00	0.000E+00
12	5	12	Nav	6.136E+07	1.903E+09	3.417E+09
12	5	12	Ske	8.530E+07	2.848E+07	0.000E+00
2	1	18	Chl	2.697E+08	8.509E+10	1.617E+11
2	1	18	Ped	2.454E+09	1.297E+10	1.494E+10
2	2	18	Sce	5.282E+08	1.224E+10	1.198E+10
2	2	18	Lep	2.458E+08	1.247E+10	2.662E+10
2	3	18	Ped	2.676E+09	2.868E+10	1.991E+10
2	3	18	Nav	3.310E+08	1.274E+10	5.851E+10
2	4	18	Sce	5.928E+08	6.561E+09	3.456E+10
2	4	18	Ana	1.316E+09	1.022E+10	7.907E+10
2	5	18	Sta	2.414E+09	1.887E+10	4.011E+10
2	5	18	Ske	5.934E+08	6.123E+08	2.369E+08
3	1	18	Sce	3.583E+08	2.576E+09	1.126E+10
3	1	18	Lep	1.728E+08	2.654E+09	1.356E+10
3	1	18	Nav	2.271E+08	1.789E+09	1.881E+09
3	2	18	Aph	3.890E+08	4.313E+09	7.619E+09
3	2	18	Fra	3.453E+07	1.106E+08	7.895E+07
3	2	18	Ske	7.439E+08	4.225E+08	6.737E+07
3	3	18	Chl	4.964E+08	1.212E+12	1.361E+11
3	3	18	Spi	7.587E+08	6.603E+08	0.000E+00
3	3	18	Lep	1.449E+08	2.478E+10	3.114E+10
3	4	18	Aph	8.473E+07	3.456E+09	1.130E+09
3	4	18	Lep	2.008E+07	5.115E+09	1.194E+10
3	4	18	Nav	3.100E+07	2.517E+09	7.348E+09
3	5	18	Sce	2.352E+08	9.547E+09	6.137E+10
3	5	18	Ped	2.965E+09	1.776E+10	5.018E+10
3	5	18	Chr	7.365E+08	9.482E+08	2.397E+09
6	1	18	Sce	8.646E+08	0.000E+00	1.109E+07
6	1	18	Spi	1.470E+08	6.414E+09	4.057E+10
6	1	18	Aph	4.713E+08	1.272E+09	1.222E+09
6	1	18	Chr	3.262E+08	3.798E+09	2.242E+09

Table A12 cont.

Species richness	Mixture	Temp. [°C]	Taxon	Biovolume [$\mu m^3 L^{-1}$] t_0	Biovolume [$\mu m^3 L^{-1}$] t_1	Biovolume [$\mu m^3 L^{-1}$] t_2
6	1	18	Fra	7.929E+06	7.701E+06	0.000E+00
6	1	18	Ske	2.651E+08	1.316E+08	6.847E+07
6	2	18	Chl	1.175E+08	4.116E+10	7.474E+10
6	2	18	Sce	0.000E+00	4.767E+06	4.767E+06
6	2	18	Spi	1.005E+08	8.142E+09	1.240E+10
6	2	18	Sta	9.184E+08	8.000E+08	1.067E+09
6	2	18	Osc	1.073E+09	3.473E+10	3.959E+09
6	2	18	Nav	7.539E+07	2.619E+09	2.960E+09
6	3	18	Chl	1.492E+08	3.336E+10	6.980E+10
6	3	18	Ped	1.390E+09	6.742E+09	2.276E+09
6	3	18	Lep	8.118E+07	8.243E+09	1.193E+10
6	3	18	Fra	1.797E+06	0.000E+00	7.701E+07
6	3	18	Nav	1.523E+08	4.303E+09	4.105E+09
6	3	18	Ske	6.495E+08	1.467E+08	5.697E+06
6	4	18	Sce	0.000E+00	4.767E+06	0.000E+00
6	4	18	Spi	1.374E+08	6.033E+09	2.467E+10
6	4	18	Aph	1.746E+09	2.299E+10	2.369E+09
6	4	18	Chr	4.227E+08	6.329E+08	1.122E+08
6	4	18	Osc	5.131E+08	4.017E+09	3.500E+09
6	4	18	Nav	2.236E+08	2.483E+09	3.321E+09
6	5	18	Chl	3.550E+08	2.056E+11	4.147E+10
6	5	18	Spi	7.587E+08	1.907E+06	2.119E+08
6	5	18	Ana	7.753E+08	7.911E+09	1.556E+10
6	5	18	Aph	4.710E+08	4.220E+09	4.063E+08
6	5	18	Lep	7.262E+07	2.353E+09	4.015E+09
6	5	18	Fra	3.172E+07	0.000E+00	0.000E+00
9	1	18	Chl	9.190E+07	2.397E+10	6.527E+10
9	1	18	Sce	5.468E+08	6.160E+08	0.000E+00
9	1	18	Spi	1.639E+08	3.874E+08	1.339E+10
9	1	18	Sta	2.919E+09	2.707E+09	0.000E+00
9	1	18	Aph	3.479E+08	1.019E+09	1.616E+08
9	1	18	Chr	3.512E+08	4.132E+09	1.440E+09
9	1	18	Ast	9.066E+06	0.000E+00	0.000E+00
9	1	18	Fra	2.879E+07	0.000E+00	0.000E+00
9	1	18	Nav	5.181E+07	1.391E+09	6.307E+09
9	2	18	Chl	7.856E+07	2.024E+10	5.382E+10
9	2	18	Sce	8.605E+07	1.466E+09	9.172E+09
9	2	18	Sta	2.895E+08	1.680E+09	2.800E+08
9	2	18	Ana	6.736E+08	2.280E+10	1.450E+09
9	2	18	Aph	1.823E+08	5.217E+09	1.864E+10
9	2	18	Osc	1.242E+08	6.408E+09	2.478E+09
9	2	18	Fra	3.267E+06	0.000E+00	0.000E+00
9	2	18	Nav	3.903E+07	1.536E+09	1.558E+09
9	2	18	Ste	0.000E+00	1.000E+03	2.000E+03
9	3	18	Chl	8.485E+07	2.436E+10	8.593E+10
9	3	18	Sce	1.367E+09	9.533E+06	1.907E+06
9	3	18	Spi	2.273E+08	5.755E+09	2.041E+10
9	3	18	Aph	6.454E+08	3.019E+10	1.581E+09
9	3	18	Chr	1.262E+08	6.312E+08	2.104E+08
9	3	18	Lep	2.125E+08	4.610E+09	9.677E+09

Table A12 cont.

Species richness	Mixture	Temp. [°C]	Taxon	Biovolume [$\mu m^3 L^{-1}$] t_0	Biovolume [$\mu m^3 L^{-1}$] t_1	Biovolume [$\mu m^3 L^{-1}$] t_2
9	3	18	Osc	4.175E+07	4.772E+09	1.460E+10
9	3	18	Fra	3.251E+06	8.985E+06	0.000E+00
9	3	18	Nav	2.770E+07	1.791E+09	1.929E+09
9	4	18	Chl	9.982E+07	1.871E+10	5.618E+10
9	4	18	Sce	1.216E+07	2.068E+09	7.902E+09
9	4	18	Aph	7.851E+08	3.980E+09	1.697E+09
9	4	18	Lep	2.384E+07	1.918E+09	4.509E+08
9	4	18	Osc	4.421E+06	2.369E+09	2.020E+10
9	4	18	Ast	2.254E+06	1.470E+08	0.000E+00
9	4	18	Fra	0.000E+00	1.000E+03	2.000E+03
9	4	18	Ske	0.000E+00	1.000E+03	2.000E+03
9	4	18	Ste	1.069E+08	8.161E+07	1.684E+08
9	5	18	Chl	1.026E+08	3.156E+10	6.370E+10
9	5	18	Sce	3.179E+09	5.720E+06	7.606E+08
9	5	18	Spi	1.688E+08	5.029E+09	1.231E+10
9	5	18	Ana	5.270E+08	1.823E+10	2.703E+09
9	5	18	Aph	5.168E+08	3.078E+09	7.110E+08
9	5	18	Lep	8.475E+07	4.061E+09	1.298E+10
9	5	18	Fra	6.643E+06	0.000E+00	0.000E+00
9	5	18	Nav	5.647E+07	1.492E+09	1.121E+09
9	5	18	Ske	3.465E+08	8.545E+07	1.684E+08
12	1	18	Chl	9.079E+07	3.299E+10	4.220E+10
12	1	18	Ped	2.649E+09	2.651E+09	2.649E+09
12	1	18	Sce	4.715E+07	1.764E+09	8.324E+09
12	1	18	Spi	5.860E+08	1.260E+09	8.556E+07
12	1	18	Sta	8.842E+08	8.298E+08	0.000E+00
12	1	18	Ana	1.297E+08	8.132E+09	1.940E+09
12	1	18	Aph	2.602E+08	1.094E+09	1.870E+08
12	1	18	Chr	8.967E+07	2.656E+09	1.195E+08
12	1	18	Lep	1.741E+07	2.886E+09	5.659E+09
12	1	18	Fra	4.737E+06	0.000E+00	0.000E+00
12	1	18	Nav	4.670E+07	1.444E+09	9.430E+08
12	1	18	Ske	1.546E+08	0.000E+00	0.000E+00
12	2	18	Chl	4.886E+07	2.986E+10	6.545E+10
12	2	18	Ped	0.000E+00	0.000E+00	0.000E+00
12	2	18	Sce	6.544E+07	1.888E+09	5.877E+09
12	2	18	Spi	3.808E+08	8.400E+08	1.344E+09
12	2	18	Sta	5.815E+08	1.660E+09	0.000E+00
12	2	18	Ana	8.645E+08	2.382E+10	1.540E+09
12	2	18	Aph	1.310E+08	3.215E+09	1.368E+09
12	2	18	Lep	1.774E+08	4.317E+09	4.614E+08
12	2	18	Osc	2.523E+07	3.630E+09	9.821E+09
12	2	18	Fra	2.823E+06	0.000E+00	0.000E+00
12	2	18	Nav	3.309E+07	1.617E+09	6.525E+08
12	2	18	Ske	2.385E+08	2.848E+07	0.000E+00
12	3	18	Chl	7.933E+07	1.873E+10	4.477E+10
12	3	18	Ped	5.298E+08	0.000E+00	0.000E+00
12	3	18	Sce	9.442E+07	1.259E+09	8.623E+09
12	3	18	Spi	3.941E+08	1.268E+08	1.268E+08
12	3	18	Ana	8.837E+08	1.720E+09	1.401E+09

Table A12 cont.

Species richness	Mixture	Temp. [°C]	Taxon	Biovolume [$\mu m^3 L^{-1}$] t_0	Biovolume [$\mu m^3 L^{-1}$] t_1	Biovolume [$\mu m^3 L^{-1}$] t_2
12	3	18	Aph	1.483E+08	4.450E+09	1.647E+09
12	3	18	Chr	2.504E+08	5.611E+08	1.403E+08
12	3	18	Lep	3.958E+08	2.903E+09	8.871E+08
12	3	18	Osc	2.831E+07	2.193E+09	5.977E+09
12	3	18	Fra	4.989E+06	0.000E+00	0.000E+00
12	3	18	Nav	3.674E+07	8.818E+08	1.029E+09
12	3	18	Ske	3.280E+08	4.273E+07	0.000E+00
12	4	18	Chl	1.004E+08	1.862E+10	5.946E+10
12	4	18	Ped	2.119E+08	0.000E+00	0.000E+00
12	4	18	Sce	6.415E+07	2.800E+09	1.494E+10
12	4	18	Spi	4.005E+08	1.344E+09	0.000E+00
12	4	18	Sta	4.859E+08	5.974E+09	0.000E+00
12	4	18	Ana	6.078E+08	2.756E+10	1.745E+09
12	4	18	Aph	1.222E+08	4.753E+09	2.840E+09
12	4	18	Chr	1.567E+08	1.167E+09	7.013E+07
12	4	18	Osc	3.342E+08	1.982E+09	9.039E+08
12	4	18	Fra	1.220E+06	0.000E+00	0.000E+00
12	4	18	Nav	2.794E+07	3.110E+09	3.582E+09
12	4	18	Ske	2.212E+08	7.121E+07	0.000E+00
12	5	18	Chl	8.247E+07	2.455E+10	4.879E+10
12	5	18	Ped	1.060E+08	1.907E+06	1.907E+06
12	5	18	Sce	5.611E+07	3.431E+09	1.066E+10
12	5	18	Spi	3.570E+08	1.680E+09	0.000E+00
12	5	18	Sta	3.941E+08	3.319E+09	0.000E+00
12	5	18	Ana	1.841E+08	1.602E+10	6.847E+10
12	5	18	Aph	2.300E+08	1.613E+09	2.020E+08
12	5	18	Chr	5.422E+07	6.709E+09	1.878E+09
12	5	18	Lep	4.126E+07	3.108E+09	7.956E+09
12	5	18	Fra	0.000E+00	0.000E+00	0.000E+00
12	5	18	Nav	6.136E+07	1.980E+09	1.199E+09
12	5	18	Ske	8.530E+07	1.424E+07	0.000E+00
2	1	24	Chl	2.697E+08	2.985E+10	1.822E+11
2	1	24	Ped	2.454E+09	7.883E+09	5.532E+09
2	2	24	Sce	5.282E+08	8.832E+08	2.926E+09
2	2	24	Lep	2.458E+08	1.517E+09	2.207E+10
2	3	24	Ped	2.676E+09	2.305E+10	4.149E+09
2	3	24	Nav	3.310E+08	2.191E+10	2.427E+10
2	4	24	Sce	5.928E+08	5.188E+09	1.408E+10
2	4	24	Ana	1.316E+09	3.120E+10	5.155E+10
2	5	24	Sta	2.414E+09	1.666E+10	3.360E+10
2	5	24	Ske	5.934E+08	1.785E+08	1.165E+08
3	1	24	Sce	3.583E+08	6.952E+09	5.357E+09
3	1	24	Lep	1.728E+08	2.513E+10	1.949E+10
3	1	24	Nav	2.271E+08	3.160E+09	7.653E+08
3	2	24	Aph	3.890E+08	1.753E+11	1.233E+10
3	2	24	Fra	3.453E+07	4.705E+08	1.938E+07
3	2	24	Ske	7.439E+08	1.537E+10	4.689E+07
3	3	24	Chl	4.964E+08	5.439E+10	5.306E+10
3	3	24	Spi	7.587E+08	3.813E+07	0.000E+00

Table A12 cont.

Species richness	Mixture	Temp. [°C]	Taxon	Biovolume [$\mu m^3 L^{-1}$] t_0	Biovolume [$\mu m^3 L^{-1}$] t_1	Biovolume [$\mu m^3 L^{-1}$] t_2
3	3	24	Lep	1.449E+08	2.014E+10	1.786E+10
3	4	24	Aph	8.473E+07	3.848E+09	3.357E+09
3	4	24	Lep	2.008E+07	1.100E+10	9.482E+09
3	4	24	Nav	3.100E+07	1.193E+09	8.673E+08
3	5	24	Sce	2.352E+08	1.455E+10	3.519E+10
3	5	24	Ped	2.965E+09	1.195E+10	5.178E+09
3	5	24	Chr	7.365E+08	2.225E+09	4.282E+09
6	1	24	Sce	8.646E+08	0.000E+00	0.000E+00
6	1	24	Spi	1.470E+08	8.806E+09	3.202E+10
6	1	24	Aph	4.713E+08	4.180E+09	2.420E+09
6	1	24	Chr	3.262E+08	2.180E+09	3.094E+09
6	1	24	Fra	4.989E+06	0.000E+00	0.000E+00
6	1	24	Ske	2.651E+08	2.211E+08	2.136E+07
6	2	24	Chl	1.175E+08	1.799E+10	5.924E+10
6	2	24	Sce	0.000E+00	0.000E+00	0.000E+00
6	2	24	Spi	1.005E+08	2.141E+09	1.141E+10
6	2	24	Sta	9.184E+08	1.190E+09	6.350E+09
6	2	24	Osc	1.073E+09	6.079E+09	4.209E+09
6	2	24	Nav	7.539E+07	1.209E+09	1.873E+09
6	3	24	Chl	1.492E+08	2.080E+10	7.515E+10
6	3	24	Ped	1.390E+09	3.585E+09	1.660E+09
6	3	24	Lep	8.118E+07	6.831E+09	3.209E+10
6	3	24	Fra	1.797E+06	7.895E+07	0.000E+00
6	3	24	Nav	1.523E+08	4.162E+08	2.469E+09
6	3	24	Ske	6.495E+08	1.305E+08	2.060E+07
6	4	24	Sce	0.000E+00	5.298E+08	2.734E+09
6	4	24	Spi	1.374E+08	8.086E+09	1.147E+10
6	4	24	Aph	1.746E+09	5.236E+09	3.108E+09
6	4	24	Chr	4.227E+08	2.083E+09	6.598E+08
6	4	24	Osc	5.131E+08	9.411E+09	1.546E+10
6	4	24	Nav	2.236E+08	2.609E+09	5.033E+09
6	5	24	Chl	3.550E+08	1.026E+11	5.467E+10
6	5	24	Spi	7.587E+08	4.767E+06	0.000E+00
6	5	24	Ana	7.753E+08	4.798E+09	4.425E+08
6	5	24	Aph	4.710E+08	2.001E+09	8.830E+08
6	5	24	Lep	7.262E+07	1.221E+10	1.676E+10
6	5	24	Fra	3.172E+07	0.000E+00	0.000E+00
9	1	24	Chl	9.190E+07	7.917E+09	5.244E+10
9	1	24	Sce	5.468E+08	2.697E+08	3.813E+06
9	1	24	Spi	1.639E+08	3.113E+09	1.797E+10
9	1	24	Sta	2.919E+09	7.000E+08	8.400E+08
9	1	24	Aph	3.479E+08	6.032E+08	3.395E+09
9	1	24	Chr	3.512E+08	4.959E+09	4.893E+09
9	1	24	Ast	9.066E+06	0.000E+00	0.000E+00
9	1	24	Fra	2.879E+07	0.000E+00	0.000E+00
9	1	24	Nav	5.181E+07	2.091E+09	7.495E+09
9	2	24	Chl	7.856E+07	1.195E+10	4.189E+10
9	2	24	Sce	8.605E+07	4.427E+08	4.834E+09
9	2	24	Sta	2.895E+08	7.000E+08	5.376E+08
9	2	24	Ana	6.736E+08	7.621E+09	2.044E+09

Table A12 cont.

Species richness	Mixture	Temp. [°C]	Taxon	Biovolume [$\mu m^3 L^{-1}$] t_0	Biovolume [$\mu m^3 L^{-1}$] t_1	Biovolume [$\mu m^3 L^{-1}$] t_2
9	2	24	Aph	1.823E+08	7.424E+09	2.245E+10
9	2	24	Osc	1.242E+08	2.014E+09	3.070E+09
9	2	24	Fra	3.267E+06	0.000E+00	0.000E+00
9	2	24	Nav	3.903E+07	3.050E+08	2.130E+09
9	2	24	Ste	0.000E+00	1.000E+03	2.000E+03
9	3	24	Chl	8.485E+07	2.436E+10	2.356E+10
9	3	24	Sce	1.367E+09	9.533E+06	0.000E+00
9	3	24	Spi	2.273E+08	5.755E+09	8.190E+09
9	3	24	Aph	6.454E+08	3.019E+10	9.671E+08
9	3	24	Chr	1.262E+08	6.312E+08	3.928E+08
9	3	24	Lep	2.125E+08	4.610E+09	2.958E+09
9	3	24	Osc	4.175E+07	3.530E+08	1.305E+10
9	3	24	Fra	3.251E+06	8.985E+06	0.000E+00
9	3	24	Nav	2.770E+07	1.791E+09	1.411E+09
9	4	24	Chl	9.982E+07	1.492E+10	3.104E+10
9	4	24	Sce	1.216E+07	1.096E+09	1.567E+09
9	4	24	Aph	7.851E+08	4.598E+09	1.420E+09
9	4	24	Lep	2.384E+07	1.468E+08	7.785E+08
9	4	24	Osc	4.421E+06	9.340E+09	2.477E+10
9	4	24	Ast	2.254E+06	0.000E+00	0.000E+00
9	4	24	Fra	0.000E+00	1.000E+03	2.000E+03
9	4	24	Ske	0.000E+00	1.000E+03	2.000E+03
9	4	24	Ste	1.069E+08	6.217E+07	0.000E+00
9	5	24	Chl	1.026E+08	2.162E+10	3.125E+10
9	5	24	Sce	3.179E+09	0.000E+00	5.468E+08
9	5	24	Spi	1.688E+08	1.749E+09	3.294E+09
9	5	24	Ana	5.270E+08	8.466E+09	2.642E+09
9	5	24	Aph	5.168E+08	2.503E+08	2.305E+08
9	5	24	Lep	8.475E+07	7.056E+09	2.360E+10
9	5	24	Fra	6.643E+06	8.281E+06	0.000E+00
9	5	24	Nav	5.647E+07	1.270E+08	7.830E+08
9	5	24	Ske	3.465E+08	5.250E+07	2.848E+07
12	1	24	Chl	9.079E+07	1.681E+10	3.098E+10
12	1	24	Ped	2.649E+09	2.649E+09	2.649E+09
12	1	24	Sce	4.715E+07	1.525E+09	4.396E+09
12	1	24	Spi	5.860E+08	5.600E+08	8.064E+08
12	1	24	Sta	8.842E+08	1.245E+09	0.000E+00
12	1	24	Ana	1.297E+08	1.385E+10	2.350E+10
12	1	24	Aph	2.602E+08	8.556E+08	7.541E+08
12	1	24	Chr	8.967E+07	6.002E+07	7.510E+08
12	1	24	Lep	1.741E+07	5.411E+09	1.867E+09
12	1	24	Fra	4.737E+06	0.000E+00	0.000E+00
12	1	24	Nav	4.670E+07	3.252E+08	2.236E+09
12	1	24	Ske	1.546E+08	4.533E+07	0.000E+00
12	2	24	Chl	4.886E+07	3.746E+10	2.838E+10
12	2	24	Ped	0.000E+00	0.000E+00	0.000E+00
12	2	24	Sce	6.544E+07	2.577E+09	1.727E+09
12	2	24	Spi	3.808E+08	1.075E+09	1.711E+07
12	2	24	Sta	5.815E+08	3.186E+09	5.071E+07
12	2	24	Ana	8.645E+08	2.424E+09	8.523E+08

Table A12 cont.

Species richness	Mixture	Temp. [°C]	Taxon	Biovolume [$\mu m^3 L^{-1}$] t_0	Biovolume [$\mu m^3 L^{-1}$] t_1	Biovolume [$\mu m^3 L^{-1}$] t_2
12	2	24	Aph	1.310E+08	8.791E+09	2.536E+09
12	2	24	Lep	1.774E+08	0.000E+00	2.305E+08
12	2	24	Osc	2.523E+07	9.795E+09	1.770E+10
12	2	24	Fra	2.823E+06	0.000E+00	0.000E+00
12	2	24	Nav	3.309E+07	2.892E+08	8.042E+08
12	2	24	Ske	2.385E+08	0.000E+00	0.000E+00
12	3	24	Chl	7.933E+07	7.691E+09	2.479E+10
12	3	24	Ped	5.298E+08	0.000E+00	0.000E+00
12	3	24	Sce	9.442E+07	1.096E+09	6.640E+09
12	3	24	Spi	3.941E+08	4.674E+07	8.298E+08
12	3	24	Ana	8.837E+08	2.086E+09	1.394E+09
12	3	24	Aph	1.483E+08	2.929E+09	8.090E+09
12	3	24	Chr	2.504E+08	3.905E+08	4.769E+08
12	3	24	Lep	3.958E+08	0.000E+00	0.000E+00
12	3	24	Osc	2.831E+07	1.684E+09	9.460E+09
12	3	24	Fra	4.989E+06	0.000E+00	0.000E+00
12	3	24	Nav	3.674E+07	2.434E+08	2.351E+09
12	3	24	Ske	3.280E+08	1.313E+07	5.697E+07
12	4	24	Chl	1.004E+08	2.468E+10	5.221E+10
12	4	24	Ped	2.119E+08	0.000E+00	0.000E+00
12	4	24	Sce	6.415E+07	4.842E+08	7.225E+09
12	4	24	Spi	4.005E+08	5.600E+08	0.000E+00
12	4	24	Sta	4.859E+08	8.298E+08	0.000E+00
12	4	24	Ana	6.078E+08	2.723E+09	2.016E+09
12	4	24	Aph	1.222E+08	1.042E+10	1.342E+10
12	4	24	Chr	1.567E+08	1.164E+09	8.888E+08
12	4	24	Osc	3.342E+08	9.677E+08	2.550E+09
12	4	24	Fra	1.220E+06	0.000E+00	0.000E+00
12	4	24	Nav	2.794E+07	1.205E+09	7.753E+09
12	4	24	Ske	2.212E+08	1.424E+07	6.737E+07
12	5	24	Chl	8.247E+07	1.890E+10	2.865E+10
12	5	24	Ped	1.060E+08	4.767E+06	4.767E+06
12	5	24	Sce	5.611E+07	9.637E+08	2.601E+09
12	5	24	Spi	3.570E+08	1.814E+08	1.711E+07
12	5	24	Sta	3.941E+08	8.961E+07	0.000E+00
12	5	24	Ana	1.841E+08	9.185E+08	1.703E+09
12	5	24	Aph	2.300E+08	7.423E+08	6.452E+08
12	5	24	Chr	5.422E+07	0.000E+00	0.000E+00
12	5	24	Lep	4.126E+07	7.499E+08	1.672E+10
12	5	24	Fra	0.000E+00	0.000E+00	0.000E+00
12	5	24	Nav	6.136E+07	6.190E+08	7.422E+08
12	5	24	Ske	8.530E+07	0.000E+00	0.000E+00

Table A13 Response factor calculated on a functional group level (Sarnelle 1992) as the biovolume fraction of one functional group of the community (see Table 2) after two weeks of constant temperatures (t_1) and after an additional week of daily temperature peaks (t_2), respectively, divided by the group's initial share of biovolume at t_0. n.a.=data not available (uncalculable due to LN(0)).

			Chlorophyceae		Cyanophyceae		Bacillariophyceae	
Species richness	**Mixture**	**Temp. [°C]**	**Response factor t_1**	**Response factor t_2**	**Response factor t_1**	**Response factor t_2**	**Response factor t_1**	**Response factor t_2**
2	1	12	0.00	0.00	-	-	-	-
2	2	12	0.25	0.26	-0.93	-0.07	-	-
2	3	12	-0.88	-5.68	-	-	1.75	2.20
2	4	12	1.01	0.89	-1.56	0.51	-	-
2	5	12	0.12	0.21	-	-	-0.76	-3.29
3	1	12	0.48	0.51	-1.75	-0.94	-0.44	-0.87
3	2	12	-	-	1.05	1.08	-2.56	-3.42
3	3	12	0.07	0.10	-1.06	-2.09	-	-
3	4	12	-	-	-0.48	-0.81	0.82	1.06
3	5	12	0.11	0.17	-0.75	-1.69	-	-
6	1	12	0.31	0.68	-0.21	-2.16	-1.67	-4.57
6	2	12	0.54	0.61	-1.60	-3.21	0.51	0.74
6	3	12	0.25	0.29	-0.73	-0.47	-0.69	-0.93
6	4	12	1.81	2.87	-0.44	-2.29	0.76	0.46
6	5	12	0.65	0.68	-1.38	-1.60	n.a.	n.a.
9	1	12	-0.07	0.06	-0.62	-1.55	1.98	1.52
9	2	12	0.16	1.06	-0.15	-2.53	0.88	0.69
9	3	12	0.12	0.42	-0.63	-2.26	2.22	0.90
9	4	12	2.12	2.18	-2.16	-3.04	-2.99	-5.90
9	5	12	0.06	0.32	-0.54	-2.59	0.50	-1.02
12	1	12	-0.12	0.00	0.78	-0.21	-0.60	0.41
12	2	12	0.23	0.80	-0.28	-2.11	0.04	-2.97
12	3	12	0.52	0.94	-0.33	-1.69	-1.24	-2.32
12	4	12	0.22	0.66	-0.23	-1.97	-0.32	-0.64
12	5	12	0.19	0.42	-0.52	-2.13	0.01	-0.69
2	1	18	0.00	0.00	-	-	-	-
2	2	18	-0.32	-0.79	0.46	0.31	-	-
2	3	18	-0.25	-1.25	-	-	1.03	1.91
2	4	18	0.23	-0.02	-0.12	0.13	-	-
2	5	18	0.19	0.21	-	-	-1.84	-3.51
3	1	18	-0.25	-0.11	0.51	0.80	-0.16	-1.45
3	2	18	-	-	0.98	1.08	-1.80	-3.57
3	3	18	0.09	-0.10	-1.64	0.59	-	-
3	4	18	-	-	0.00	-0.19	-0.01	0.46
3	5	18	0.17	0.19	-1.72	-2.19	-	-
6	1	18	0.13	0.64	0.13	-1.58	-2.39	-4.44
6	2	18	0.14	0.62	-0.17	-2.42	-0.10	-0.06
6	3	18	0.18	0.25	1.54	1.40	-1.37	-1.94
6	4	18	1.31	2.78	-0.14	-1.61	-0.07	0.29
6	5	18	0.73	0.40	-2.10	-0.50	n.a.	n.a.
9	1	18	-0.02	0.10	-0.03	-2.13	0.72	1.30
9	2	18	0.25	0.86	-0.13	-0.94	-0.10	-0.47
9	3	18	-0.38	0.25	0.40	-0.66	0.79	0.24

Table A13 cont.

			Chlorophyceae		Cyanophyceae		Bacillariophyceae	
Species richness	**Mixture**	**Temp. [°C]**	**Response factor t_1**	**Response factor t_2**	**Response factor t_1**	**Response factor t_2**	**Response factor t_1**	**Response factor t_2**
9	4	18	1.88	1.92	-1.02	-1.11	-2.60	-3.99
9	5	18	-0.18	0.16	0.57	-0.26	-1.20	-1.79
12	1	18	-0.19	0.00	0.97	0.24	-0.47	-1.01
12	2	18	0.13	0.69	0.05	-1.13	-1.53	-2.66
12	3	18	0.57	0.87	-0.40	-1.24	-1.42	-1.99
12	4	18	-0.08	0.66	0.16	-1.90	-0.66	-0.76
12	5	18	-0.13	-0.34	0.35	0.60	-1.02	-2.33
2	1	24	0.00	0.00	-	-	-	-
2	2	24	-0.62	-1.76	0.69	0.33	-	-
2	3	24	-0.55	-1.81	-	-	1.49	2.05
2	4	24	-0.78	-0.37	0.22	-0.09	-	-
2	5	24	0.21	0.22	-	-	-2.92	-4.04
3	1	24	-0.87	-0.81	1.14	1.21	-1.21	-2.30
3	2	24	-	-	1.01	1.09	-2.09	-4.83
3	3	24	-0.21	-0.18	0.96	0.89	-	-
3	4	24	-	-	0.18	0.19	-1.12	-1.28
3	5	24	0.13	0.11	-0.88	-0.67	-	-
6	1	24	0.16	0.56	0.07	-0.96	-2.20	-5.43
6	2	24	0.40	0.62	-0.79	-2.23	0.25	-0.38
6	3	24	0.19	0.08	1.86	2.15	-2.83	-2.70
6	4	24	1.92	2.10	-0.39	-0.57	0.24	0.58
6	5	24	0.62	0.51	-1.23	-0.77	n.a.	n.a.
9	1	24	-0.30	-0.01	0.60	-0.49	1.68	1.47
9	2	24	0.33	0.69	-0.17	-0.62	-1.05	-0.03
9	3	24	-0.32	0.02	0.34	-0.09	0.85	0.90
9	4	24	1.59	1.62	-0.52	-0.55	-3.94	-14.27
9	5	24	-0.15	-0.21	0.57	0.63	-2.84	-1.84
12	1	24	-0.49	-0.41	1.54	1.37	-1.58	-0.23
12	2	24	0.47	0.31	-0.38	-0.14	-3.20	-1.95
12	3	24	0.46	0.54	-0.20	-0.40	-1.99	-0.96
12	4	24	0.29	0.40	-0.23	-0.71	-1.17	-0.01
12	5	24	0.37	0.02	-1.09	0.19	-1.20	-1.81

Curriculum vitae

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Striebel M, Schabhüttl S, Weigelhofer G, Hein T, Weigert A (2011) "Biodiversity and ecosystem functioning in floodplain systems". Poster presentation at the International Conference on the Status and Future of the World's Large Rivers. April 11-14, 2011, Vienna, Austria.

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Schabhüttl S, Weigelhofer G, Hein T, Striebel M (submitted) Combined effects of temperature and biodiversity on phytoplankton communities.

Striebel M, Schabhüttl S, Hein T, Weigelhofer G, Weigert A (to be submitted) Biodiversity and ecosystem functioning in floodplain systems.

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