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Phenology of macrophytes and phytoplankton in the Grabow – a shallow coastal lagoon of the Baltic Sea

Abstract

Macrophyte cover and species richness influence structure and functioning of shallow water ecosystems. Macrophytes can reduce phytoplankton blooms and stabilize a clear water state by storing nutrients and providing refuge for zooplankton. In the shallow coastal lagoon “Grabow” (southern Baltic Sea) eutrophication led to a turbid, phytoplankton dominated state and a loss of macrophytes. In the past years, however, macrophyte biomass increased again, though the water is still turbid.

In this study, seasonality of macrophyte and phytoplankton biomass in the Grabow in 2013 were analyzed. It was found that macrophyte cover and production are confined to spring and summer months, loss of biomass started already in September. In spring, macrophytes appear after the phytoplankton bloom; a second phytoplankton bloom developed in parallel to macrophyte senescence in autumn. The lowest phytoplankton biomass co-occurred with the highest macrophyte biomass in July and August. In conclusion, macrophyte cover in the Grabow developed too late to prevent the spring phytoplankton bloom but may reduce phytoplankton biomass during summer months and consequently have a positive effect on water quality.

Keywords: Macrophyte, phytoplankton, biomass, primary production, shallow coastal bay, photosynthesis

1 Introduction

Abundance of submerged macrophytes essentially determines the structure and function of shallow waters. In particular, macrophytes have a pronounced positive effect on water clarity: they take up nutrients and store them long term in their biomass, thus reducing phytoplankton growth and the probability of blooms. Dense submerged vegetation provides refuge for filtering zooplankton, which enhances grazing on algae. In addition, shading effects of submerged macrophytes reduce production of phytoplankton (SCHEFFER 1999). Such effects have been described for freshwater ecosystems, but also for shallow coastal waters (DAHLGREN & KAUTSKY 2004; MCGLATHERY et al. 2007; ROSQVIST et al. 2010).

In the shallow coastal lagoons (“Bodden”) of the Darß-Zingst peninsula (southern Baltic Sea) eutrophication has led to a strong reduction of underwater vegetation cover

and loss of plant species or communities in the 1970s (LINDNER 1972; BEHRENS 1982; TEUBNER 1989). This resulted in phytoplankton-dominated waters with high turbidity. At the same time phytoplankton biomass increased (SCHIEWER 2008). Since 1990 nutrient input into the system has been reduced (LUNG 2013) and macrophyte biomass increased again (YOUSEF & SCHUBERT 2001). Nevertheless, turbidity is still high indicating that macrophytes are not able to diminish the effects of eutrophication.

Yet, not only macrophyte occurrence and biomass are important for the effects of eutrophication on the system as has been described by SAYER et al. (2010) in a study of 39 shallow lakes from areas with a temperate Atlantic climate. Also, the duration of macrophyte cover and species richness influence the concentration and timing of phytoplankton peaks. Since there are few phenological data on macrophyte occurrence in the Darß-Zingst Bodden Chain (DZBC), not much is known about the variation of biomass cover in the course of the year.

In this study, the seasonality in biomass of the dominant macrophyte species (*Potamogeton pectinatus*, *Ruppia* sp. and *Chara baltica*) was analyzed in the Grabow, the easternmost lagoon of the DZBC, to determine the duration of macrophyte cover. Additionally, primary production and thereby the potential biomass of *C. baltica* were calculated and used to determine biomass losses of *C. baltica*. Seasonality of macrophytes was then compared with the development of phytoplankton biomass to discuss possible interactions between the two primary producers. We hypothesize that – although macrophyte biomass may be high during summer - macrophytes are scarce at the beginning of the year when phytoplankton biomass increases. Macrophytes in the Grabow might not be able to reduce phytoplankton growth in spring, because they occur later in the year, when phytoplankton abundance is already high. However, due to high turnover rates of phytoplankton, nutrient competition can still occur later in the year when established macrophytes might reduce growth rates of phytoplankton. Therefore, detailed phenological studies about the seasonal development of macrophytobenthos are needed to estimate their potential impact on phytoplankton. The understanding of mechanisms that determine turbidity in the DZBC are of great interest in connection with the EU Water Framework Directive (WFD). Up to now, measures, such as reducing nutrient input into the DZBC, have not resulted in the establishment of the “good ecological status”.

2 Material and methods

2.1 Study area

The DZBC is located at the Baltic coast of Germany. It is a series of four consecutive lagoons between the mouth of the river Recknitz in the West and the connection to the Baltic Sea in the East. There is a strong gradient in salinity, nutrient concentration and turbidity from the westernmost to the easternmost lagoon, the Grabow. The Grabow comprises 41.5 km² with an average depth of 2.3 m (SCHLUNGBAUM & VOIGT 2001). The salinity in the Grabow is influenced by occasional seawater influx and averages between 7 and 10 PSU (SCHLUNGBAUM & BAUDLER 2001). In the year 2013 Secchi depth ranged from 30 – 80 cm and mean total phosphorus (TP) concentration was 2.2 µM (measured by the Biological Station Zingst), indicating the eutrophic state of the Grabow.

2.2 Biomass

Samples of *Potamogeton (Stuckenia) pectinatus*, *Ruppia* sp. and *Chara baltica* were collected during the vegetation period (May – November) in 2013 from an area north of Dabitz harbor from a water depth of approximately 40 cm. Biomass was measured by collecting all plants on 3-5 randomly chosen areas of defined size and determining fresh mass (FM). FM was converted into dry mass (DM) using a conversion factor determined from independent samples from the respective area: Water content was 70 % for *C. baltica* and 23 % for *P. pectinatus* and *Ruppia* sp. Units of carbon per square meter were attained by multiplying biomass in DM by a carbon content of 0.26 g C*g DM⁻¹ in the case of *C. baltica* and 0.4 g C*g DM⁻¹ in the case of *P. pectinatus* and *Ruppia* sp. (VOLKMANN, unpublished data).

Biomass of phytoplankton was kindly provided by the Biological Station Zingst in the form of chlorophyll *a* (chl *a*). Samples were taken monthly (except February and March due to ice cover) from the center of the Grabow. Chl *a* was extracted using 96 % Ethanol and concentration was measured photometrically.

2.3 Attenuation coefficient (k_{par})

Photosynthetic active radiation (PAR in $\mu\text{mol photons} \cdot \text{m}^{-2} \text{s}^{-1}$) was measured at 0.1 m intervals throughout the water column at each sampling date using a LI-COR data logger (LI-1000) equipped with a spherical quantum sensor (LI-193). The attenuation coefficient (k_{par}) was calculated by fitting a linear regression to the logarithmized PAR plotted against water depth.

In addition, k_{par} was calculated using the formula by LUFT (2012), which includes the parameters colored dissolved organic matter (cDOM), seston concentration, chl *a* concentration, turbidity and secchi depth (parameters measured and provided by the Biological Station Zingst):

$$k_{par} = 0.178 * cDOM + 0.005 * seston + 0.013 * chl\ a - 0.104 * turbidity - 0.324 * secchi\ depth + 0.986$$

Eq. 1: Calculation of the attenuation coefficient (k_{par}) using colored dissolved organic matter (cDOM), seston concentration, chlorophyll *a* concentration, turbidity and secchi depth (LUFT 2012).

2.4 Primary production

Primary production of *C. baltica* was measured using the O₂-evolution method. Samples were stored in the dark in water from the field and photosynthesis parameters were measured in the laboratory not later than one day after sampling. To measure photosynthesis-irradiance (PI) curves, the photosynthetic light dispensation system (WOLFSTEIN & HARTIG 1998) was used. 3-5 replicates were measured per sampling date using nine light intensities ranging from 14 to 2000 $\mu\text{mol photons m}^{-2} \text{s}^{-1}$. 3 ml of dimethylformamide (DMF) were used to extract chl *a* from each analyzed plant. Chl *a* extraction was done overnight; the samples were stored in the dark at 7°C. Then chl *a* content was measured photometrically (PORRA et al. 1989). PI-curves were used to determine the photosynthetic parameters maximum photosynthesis (P_{max}), dark

respiration (R_d), slope of the curve where irradiance is limited (α) and negative slope in case of photoinhibition (β), which were based on chl *a* (WALSBY 1997). In addition, further parameters were calculated: $P_{\max(\text{net})}$ is the net maximum photosynthesis ($P_{\max} - R_d$); L_{cp} the light compensation point, i.e. the light intensity where oxygen production by photosynthesis compensates oxygen consumption by respiration ($R_d * \alpha^{-1}$) and I_k the light saturation point, i.e. the light intensity where maximum photosynthesis is reached ($P_{\max(\text{net})} * \alpha^{-1}$).

To estimate photosynthetic performance in the field, light intensity at sampling depth (40 cm) was calculated using the Lambert-Beer law:

$$E_d = E_{\text{global}} * e^{-k_{\text{PAR}} * d}$$

Eq. 2: Lambert-Beer Law. E_d : Light intensity in depth d ; E_{global} : global irradiance; k_{PAR} : light attenuation coefficient.

Global irradiance was provided by the Biological Station in Zingst. The calculated irradiance at 40 cm depth and the photosynthetic parameters were then used to determine primary production in units of $\text{O}_2 * \text{g chl a}^{-1}$ using the equation of WALSBY (1997):

$$P = P_{\max} * \left[1 - e^{\frac{-\alpha * I}{P_{\max}}} \right] + \beta * I + R_d$$

Eq. 3: P : Photosynthetic performance; P_{\max} : maximum photosynthesis; α : slope of the curve where irradiance is limited; I : light intensity at sampling depth; β : negative slope in case of photoinhibition; R_d : dark respiration.

To receive primary production in units of carbon per area ($\text{C} * \text{m}^{-2}$), the biomass in FM per area ($\text{FM} * \text{m}^{-2}$) and the chl *a* content ($\text{Chl a} * \text{FM}^{-1}$) was used to convert biomass into chl *a* per area ($\text{chl a} * \text{m}^{-2}$). Thus we obtained primary production in units of oxygen production per area ($\text{O}_2 * \text{m}^{-2}$). Oxygen production was then converted into carbon production using a photosynthetic quotient of 1.2 (WOLFSTEIN & HARTIG 1998).

2.5 Statistics

Patchiness at the study site resulted in large data scatter and thus data were not normally distributed. Therefore, differences of photosynthetic parameters and biomass between months were analyzed using Kruskal-Wallis and Dunn's test. Medians, 25th- and 75th percentiles as well as boxplots were used to describe the data.

For the calculation of primary production, all individual results of photosynthetic parameters for one month were combined with all measured biomasses. For example in September, nine individual plants were measured to determine photosynthetic parameters. In the same month, five areas were analyzed to estimate biomass per square meter. Thus, there are 45 (9*5) individual results for primary production in September. Medians and 25th- and 75th percentiles were calculated for each month.

2.6 Plant biomass losses

To assess biomass losses of *C. baltica* total biomass production was estimated by accumulating primary production of each month. For example, biomass in June was estimated as primary production in May plus primary production in June. Medians of each month as well as 25th and 75th percentiles were summed. Estimated biomass was then compared with the actual biomass in the field (cf. MADSEN & ADAMS 1988). The difference between the estimated and the actual biomass shows the losses in plant biomass.

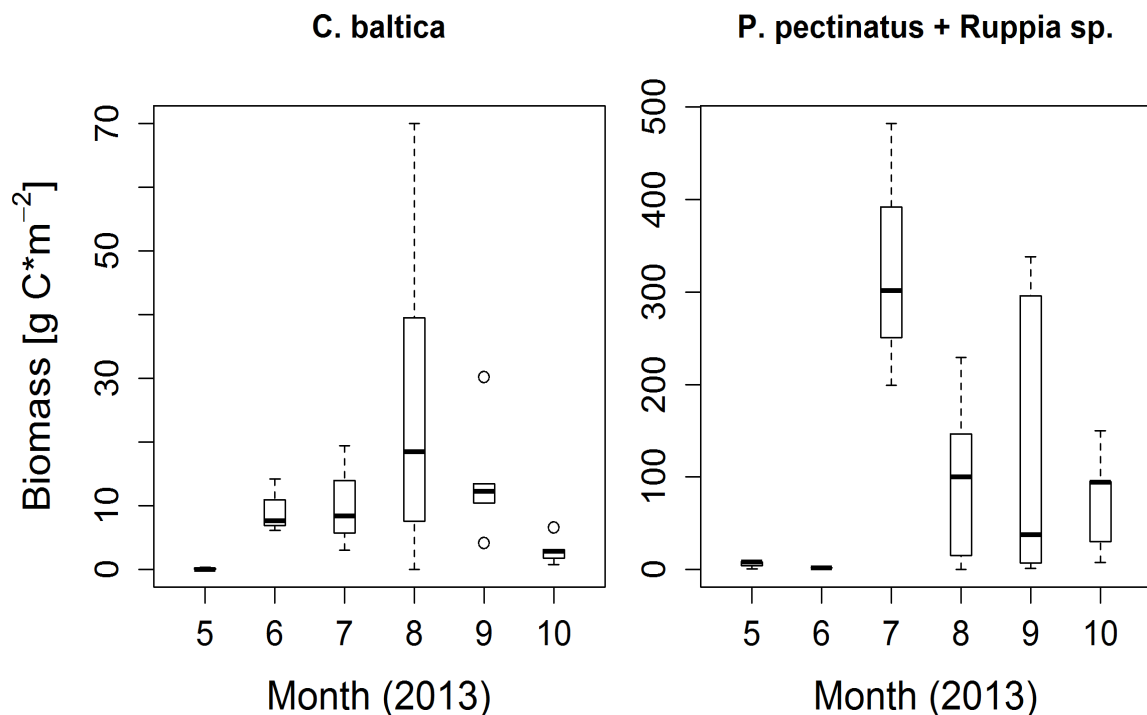


Fig. 1: Boxplots of biomasses of *C. baltica* and *P. pectinatus* + *Ruppia* sp. in 2013 (n = 3-10).

3 Results

Seasonal variation of biomasses of the dominant macrophytes in the Grabow are shown in figure 1. No plants were found before May and after October. Biomass maxima were reached in July and August, though the large scatter of the data did not reveal significant differences between months. However, biomass of *P. pectinatus* + *Ruppia* sp. was significantly lower in May and June than in July 2013 ($p < 0.05$). The vascular plants *P. pectinatus* and *Ruppia* sp. constituted the most part of the vegetation, reaching a combined maximum biomass of 328 g C*m⁻² on average. Maximum biomass of *C. baltica* averaged 26 g C*m⁻². Patchiness at the study area is responsible for the large scatter of the data.

Chl *a* was used as an indicator of phytoplankton biomass (Fig. 2). In the winter months chl *a* concentrations in the Grabow were very high; in January values exceeded 30 $\mu\text{g}\cdot\text{l}^{-1}$. In February and March no chl *a* data were available due to ice cover.

Phytoplankton biomass development was still ongoing in April and reached values of $75 \mu\text{g} \cdot \text{l}^{-1}$. The lowest chl a concentration ($10 \mu\text{g} \cdot \text{l}^{-1}$) was observed in July, co-occurring with the macrophyte biomass maximum. The phytoplankton autumn bloom reached chl a values of $77 \mu\text{g} \cdot \text{l}^{-1}$ in September.

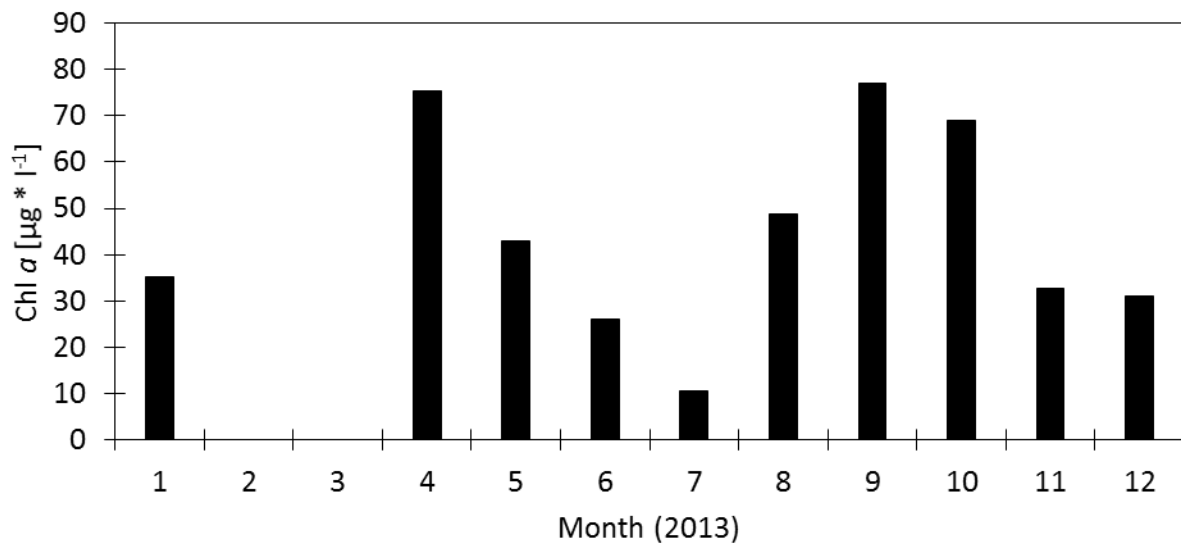


Fig. 2: Phytoplankton biomass in $\mu\text{g Chl a} \cdot \text{l}^{-1}$ ($n = 1$).

The attenuation coefficient (k_{par}) in the Grabow averaged $1.9 \cdot \text{m}^{-1}$ during the year 2013 when measured with the LI-COR data logger and $1.4 \cdot \text{m}^{-1}$ when calculated using the formula by LUFT (2012). For the estimation of primary production in the field the measured k_{par} of $1.9 \cdot \text{m}^{-1}$ was used.

There is a pronounced seasonality in the photosynthetic parameters P_{max} , R_d , I_k , L_{cp} and $P_{\text{max}(\text{net})}$ in *C. baltica* (Table 1). Net maximum photosynthesis was highest in July and August, reaching values of 90.3 and $67.9 \text{ mmol O}_2 \cdot \text{h}^{-1} \text{ g chl a}^{-1}$, respectively. $P_{\text{max}(\text{net})}$ in these two months was significantly higher than in May, June and November ($p < 0.05$), whereas there was no difference in $P_{\text{max}(\text{net})}$ between spring values (19.5 and $27.0 \text{ mmol O}_2 \cdot \text{h}^{-1} \text{ g chl a}^{-1}$ in May and June, respectively) and autumn values ($27.8 \text{ mmol O}_2 \cdot \text{h}^{-1} \text{ g chl a}^{-1}$ in November). R_d was $21.9 \text{ mmol O}_2 \cdot \text{h}^{-1} \text{ g chl a}^{-1}$ in July and thus significantly higher than in the other months ($7.6 - 12.0 \text{ mmol O}_2 \cdot \text{h}^{-1} \text{ g chl a}^{-1}$; $p < 0.05$) except September. In May maximum photosynthesis was reached at very low light intensities (I_k : $35.4 \mu\text{mol photons} \cdot \text{m}^{-2} \text{ s}^{-1}$) compared to I_k values in July and August ($178.9 - 323.1 \mu\text{mol photons} \cdot \text{m}^{-2} \text{ s}^{-1}$; $p < 0.001$). The light compensation point was reached at significantly lower light intensities in May and November (20.8 and $19.5 \mu\text{mol photons} \cdot \text{m}^{-2} \text{ s}^{-1}$, respectively) compared to July and August (57.1 and $56.8 \mu\text{mol photons} \cdot \text{m}^{-2} \text{ s}^{-1}$, respectively; $p < 0.05$). The initial slope of the PI-curve α tended to be lower in summer since the August value (0.2) was significantly lower than values in May (0.5) and September (0.6 ; $p < 0.05$).

Global irradiance, k_{par} and the photosynthetic parameters were used to calculate monthly primary production in units of carbon per square meter. The accumulated primary production (i.e. primary production in May plus primary production in June etc.) represents the estimated biomass of *C. baltica* in the Grabow. Differences between the estimated biomass and the actual measured biomass indicate plant biomass losses (Fig. 3). During the first half of the vegetation period, estimated and actual

biomass did not differ significantly. After reaching the highest biomass in August, losses of plant biomass occurred in September and October. Annual maximum biomass production of *C. baltica* approximates 20 g C*m⁻². This value is reached in August. In September and October very low production rates and senescence of the plants result in a decline in biomass and total die back of *C. baltica*.

Table 1: Medians of photosynthetic parameters of *C. baltica*. 25th- and 75th-percentiles in brackets (n = 4-17). Units: P_{max}, R_d, P_{max(net)} [mmol O₂*h⁻¹ g Chl a⁻¹]; L_{cp}, I_k [μmol photons * m⁻² s⁻¹]. No measurements were performed in October.

	P_{max}	α	β	R_d	P_{max (net)}	L_{cp}	I_k
May	33.5 (28.2; 37.2)	0.5 (0.4; 0.6)	0.0 (0.0; 0.0)	9.9 (8.7; 13.0)	19.5 (16.3; 24.0)	20.8 (15.8; 23.0)	35.4 (32.9; 46.6)
June	43.9 (33.2; 55.9)	0.5 (0.3; 0.6)	0.0 (0.0; 0.0)	11.7 (11.7; 13.5)	31.3 (21.8; 41.1)	29.7 (20.4; 34.5)	78.0 (73.6; 113.5)
July	109.0 (100.9; 117.8)	0.4 (0.3; 0.7)	0.0 (0.0; 0.0)	21.9 (18.2; 23.7)	90.3 (78.2; 97.2)	57.1 (26.1; 81.4)	178.9 (121.3; 362.7)
August	79.1 (70.0; 90.6)	0.2 (0.1; 0.3)	0.0 (0.0; 0.0)	12.0 (11.1; 13.1)	67.9 (58.4; 77.1)	56.8 (43.8; 80.9)	323.1 (276.0; 399.2)
September	49.0 (41.0; 69.3)	0.6 (0.5; 1.0)	0.0 (0.0; 0.0)	12.2 (9.1; 27.9)	35.7 (32.8; 39.5)	23.3 (20.2; 27.4)	56.3 (52.1; 77.2)
November	35.4 (32.2; 39.3)	0.4 (0.3; 0.4)	0.0 (0.0; 0.0)	7.6 (6.0; 8.8)	27.8 (26.0; 30.6)	19.5 (18.3; 20.3)	74.3 (72.0; 84.2)

4 Discussion

Seasonal analysis of the macrophytes and phytoplankton in the Grabow in 2013 show that biomass peaks of the two groups of primary producers alternated during the year. Biomass of macrophytes showed a distinct seasonality, increasing from May until August, while phytoplankton biomass reached its minimum in July. Thus, macrophyte production might promote the reduction of phytoplankton abundance during summer, presumably by reducing nutrient availability in the water column or providing refuge for filtering zooplankton. However, the growing season of macrophytes was restricted to four months (May to August) and, in *C. baltica*, large biomass losses were observed as early as September. A decline in primary production rates in *C. baltica* was observed at the same time. Phytoplankton blooms were observed in April before macrophyte appearance, and again during macrophyte senescence in September and October. Growing season of macrophytes thus seems to be too short to establish a permanent macrophyte dominated state in the Grabow. Data of photosynthetic parameters and biomasses of macrophytes were not normally distributed, indicating that the dataset is not sufficient to describe absolute values of photosynthesis and biomass of macrophytes. However, seasonal changes over the year can be described using non-parametric tests. Data presented in this paper are from 2013 only. The long-term dataset of the Biological Station Zingst suggests high interannual variability in the seasonal development of phytoplankton in the Grabow. However, since there are few

data on macrophyte phenology, this is a first attempt to compare and discuss the interactions between both groups of primary producers.

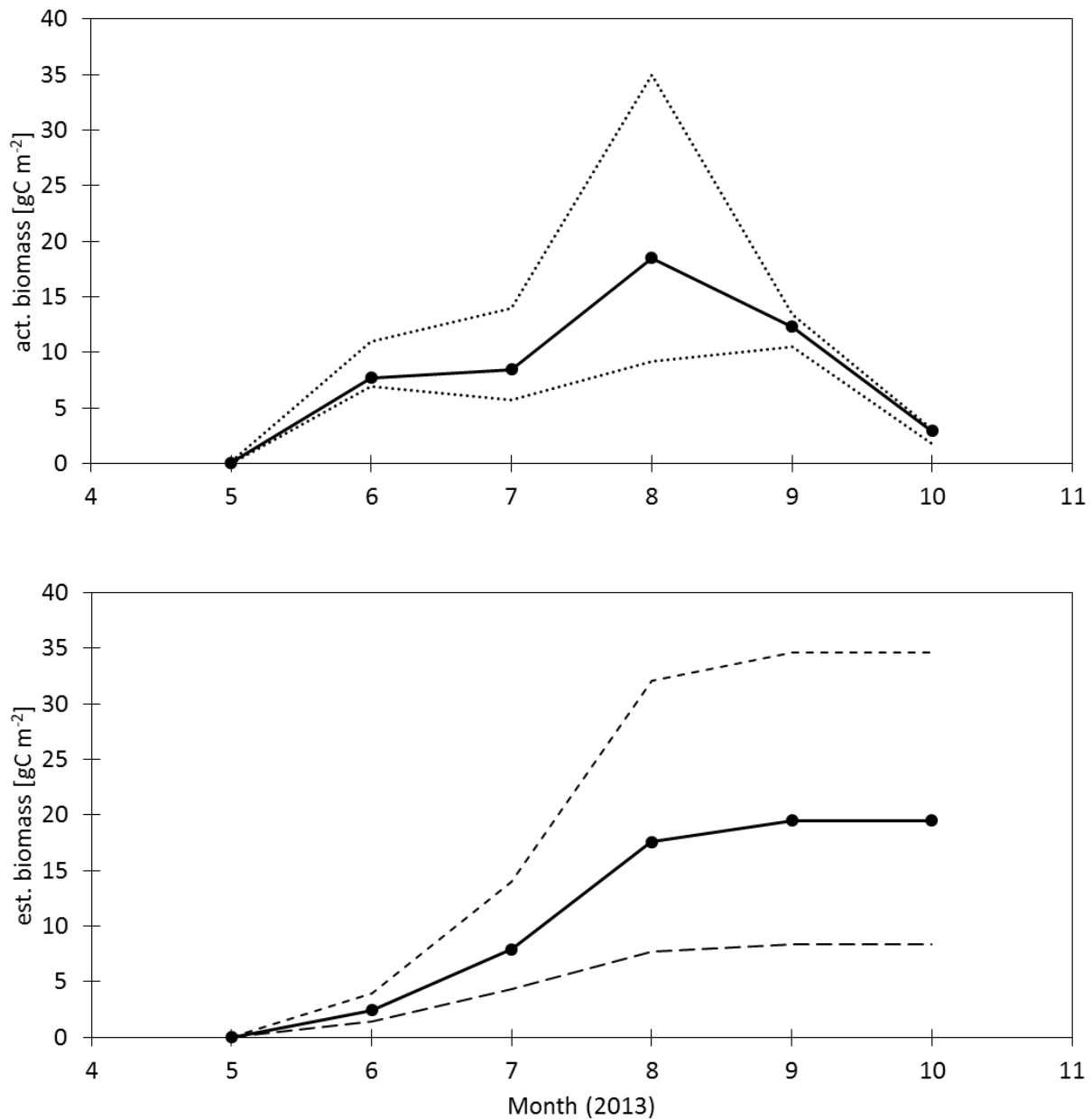


Fig. 3: Medians of actual measured biomass from the field (upper panel) and accumulated primary production representing estimated biomass of *C. baltica* (lower panel). Dotted and dashed lines represent 25th and 75th percentiles of measured and estimated biomass, respectively (n = 20-100). Differences between the curves indicate biomass losses.

According to the theory of two alternative stable states (SCHEFFER et al. 2001) a shift from the macrophyte to the phytoplankton-dominated state happens abruptly as soon as a threshold phosphorus concentration is exceeded. The theory states that a return to the macrophyte dominated state, is only possible by reducing nutrient concentration far below the concentration that caused the original shift. In the Grabow, nutrient concentrations and turbidity are still high in spite of a reduction of nutrient input since 1990 (LUNG 2013). However, macrophyte biomass increased in the past years

(YOUSEF & SCHUBERT 2001), indicating that the theory of two alternative stable states does not apply here and that other factors, for example light conditions and herbivory by water birds or fish influence macrophyte abundance. Our findings confirm the concept of SAYER et al. (2010), who stated that plant loss during eutrophication is a gradual process and that the effect of macrophytes on phytoplankton depends on the length of the growing season and diversity of macrophytes. In the Grabow diversity of the macrophyte community is confined to three annual species, which results in a very short growing season.

SAYER et al. (2010) state that evergreen species result in a long seasonal period of macrophyte production and less fluctuation in macrophyte biomass. Under such circumstances, nutrients might be stored in macrophyte biomass over the whole year, thus preventing phytoplankton growth and reducing turbidity (SAYER et al. 2010). *C. baltica* is generally known to occur both as annual and perennial form (BLÜMEL 2003). At the study site in the Grabow no overwintering green plants were detected. This might be due to the cold winter 2012/13. However, biomass loss was observed already in September and thus cannot be attributed to low temperatures or ice cover. Presumably, waterbird and fish herbivory (SCHMIEDER et al. 2006) as well as increased wave action due to storms caused the die off. In addition to biomass, photosynthetic performance per unit chl *a* ($P_{\max (net)}$) of *C. baltica* decreased in September to November compared to summer values. This indicates that production of new biomass is low in autumn and biomass losses cannot be regenerated. In addition to *C. baltica*, *P. pectinatus* and *Ruppia* sp. were dominant species at the study site. All three species showed a similar seasonality in their biomass with a maximum in July or August. Accordingly, growing season of macrophytes is very short in the Grabow; significant production rates are observed only from May to August. Thus, nutrients cannot be stored in macrophyte biomass over the whole year in the Grabow.

A higher species diversity, with species alternating in the timing of their biomass maximum, can lead to a much longer period of vegetation cover (SAYER et al. 2010). In brackish waters, such as the Grabow, species diversity is generally low due to salinity conditions (REMANE 1934). However, herbaria and publications from the 19th century prove the historical abundance of several species in the Grabow (SCHUBERT et al. 2003), which strongly decreased in abundance or were lost during eutrophication. According to these findings, without eutrophication, a larger diversity of charophytes, with e.g. *Chara aspera*, *C. canescens*, *C. liljebladii*, as well as vascular plants, such as *Ceratophyllum* and *Myriophyllum*, can be expected in the Grabow (SCHUBERT et al. 2003). Under the present eutrophic conditions *P. pectinatus* might be a better competitor for light than the charophytes (VANDEN BERG et al. 1999) In lakes recovering from eutrophication it was observed that turbidity was high during a time of *P. pectinatus*-dominance but low during dominance of *Chara* (HARGEBY et al. 1994; VANDEN BERG et al. 1999). In Lake Müggelsee *P. pectinatus* was the first species to re-establish during re-oligotrophication (HILT et al. 2013). In this lake, waterfowl and fish herbivory as well as slow vegetative recolonization of deeper plant stands hampered macrophyte re-establishment. 20 years after nutrient load reduction, macrophyte species diversity and maximum colonization depth increase again. In the Grabow, a further reduction of nutrient concentration and turbidity could induce a shift to a *Chara*-dominated vegetation, which then in turn can stabilize the low turbidity state, e.g. via a higher species diversity and a longer period of vegetation cover. As stated by HILT et al. (2013) for Lake Müggelsee, patience rather than biomanipulation or sediment removal might be the best way to allow species re-establishment in the Grabow.

The theories of SCHEFFER et al. (2001) and SAYER et al. (2010) both were established based on freshwater lakes. However, there are also studies that describe effects of macrophytes on the structure and function of shallow coastal bays (e.g. MCGLATHERY et al. 2007), indicating that the theories made for freshwater are applicable also to coastal waters. ROSQVIST et al. (2010) found that the stabilizing effect of macrophytes in Baltic Sea coastal lagoons strongly depends on habitat isolation from the open sea. In their study, vegetation in less isolated lagoons was not able to reduce phytoplankton biomass. For the Grabow, having a rather restricted connection to the open Baltic, one may assume that internal interactions (e.g. between macrophytes and phytoplankton) are more pronounced and therefore comparisons with shallow lakes are justified. On the other hand, brackish waters tend to be more turbid than freshwater systems, even at high macrophyte abundance (JEPPESEN et al. 2007; SCHEFFER 1999). This is due to a salinity-mediated shift in zooplankton community from a high abundance of the effective filter feeder *Daphnia* in freshwater to a dominance of small or selective filter feeders such as rotifers, *Bosmina*, *Eurytemora* and *Acartia* (JEPPESEN et al. 2007). In addition, fish and invertebrate predation pressure on zooplankton can be higher in eutrophic brackish lagoons, resulting in low zooplankton:phytoplankton ratios and thus a low grazing pressure on phytoplankton (JEPPESEN et al. 2007). Consequently, a clear water state comparable to freshwater lakes cannot be expected to occur in the Grabow. However, this study shows that phytoplankton biomass is lowest during summer 2013, when macrophyte production and biomass are highest. A higher diversity and extended macrophyte growing season might therefore have a positive effect on water quality in the shallow coastal bay.

Zusammenfassung

Die Struktur und Funktion flacher Gewässerökosysteme wird stark durch das Vorhandensein ausgedehnten Makrophytenbewuchses beeinflusst. Makrophyten können Phytoplanktonblüten reduzieren und einen Makrophyten-dominierten Zustand mit klarem Wasser stabilisieren, indem sie z.B. Nährstoffe langfristig speichern und ein Refugium für filtrierendes Zooplankton bieten. Im Grabow, einem flachen Boddengewässer in der südlichen Ostsee, führte Eutrophierung zu einem trüben, Phytoplankton-dominierten Zustand und dem Verlust von Makrophyten. In den letzten Jahren hat die Makrophyten-Biomasse aber wieder zugenommen, während das Wasser weiterhin trübe ist.

Diese Arbeit beschäftigt sich mit der Saisonalität von Makrophyten und Phytoplankton im Grabow im Jahr 2013. Es zeigte sich, dass ausgedehnte Makrophytenrasen und deren Produktion auf die Frühjahrs- und Sommermonate beschränkt sind und es bereits im September zu Biomasseverlusten kommt. Die Makrophyten erscheinen erst nach der Frühjahrsblüte des Phytoplanktons; eine zweite Phytoplanktonblüte konnte während des Absterbens der Makrophyten im Herbst beobachtet werden. Die geringste Phytoplanktonbiomasse trat gleichzeitig mit der höchsten Makrophytenbiomasse im Juli und August auf. Insgesamt scheint die Makrophytenbiomasse im Grabow nicht ausreichend, um Massenentwicklungen des Phytoplanktons zu verhindern. Im Sommer, während des Maximums der Makrophytenbiomasse, lässt sich aber ein positiver Effekt der Makrophyten auf die Wasserqualität des Boddens vermuten.

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