DFG Deutsche Forschungsgemeinschaft

2019

Annual Meeting Program

Priority Program 1704 DynaTrait

Annual Meeting

16.09.2019 - 20.09.2019

University of Potsdam, Germany

We meet at "Obere Mensa" at Campus Neues Palais, House 12, 1st floor, University of Potsdam

Color code: Yellow: Common activities in plenary room; BLUE: Group work; Green: Seminar room at Maulbeerallee 2; Gray: Breaks and free time activities.

Monday	Program	Where*
ca. 12:30	Self-organized lunch at Mensa (pay yourself, no catering!)	Mensa
ca. 14:00	**Coffee & cake is served at Obere Mensa (plenary room). Please help yourself.**	Obere Mensa
	Plenary	
14:00	Welcome note: **Ursula Gaedke** (DynaTrait chair, U Potsdam, GER)	Obere Mensa *
14:05	**Keynote by Thomas Kiørboe (DTU)** Defense in protistan plankton: mechanisms and trade-offs	Obere Mensa
14:35	**All participants please introduce yourself** • State your name, affiliation & co-workers, and what your current research focus is about • Optional: Point out your poster/s	Obere Mensa
15:45	Coffee break (15min, catering)	Obere Mensa
16:00	**Poster session I**	Obere Mensa
17:30	• Synthesis groups: chairs introduce their topics & goals	Obere Mensa
18:00	• Synthesis groups form and discuss their work plan for the following days	Obere Mensa / Seminar rooms
ca. 19:00	Catering from Café Kieselstein / Get together with drinks	Obere Mensa
21:45	End of day / Rooms are closed	Obere Mensa

Tuesday	Program	Where
	Plenary	
09:00	**Keynote by Sebastian Diehl (U Umeå, SE)** Evolution of resource specialization in competitive metacommunities	Obere Mensa
09:30	**Selina Våge (U Bergen, NO)** Trade-offs between competitive and defensive abilities shape pelagic microbial food webs	Obere Mensa
09:45	**Kasia Kenitz (Scripps, US)** What does autonomous underwater imaging tell us about plankton ecology?	Obere Mensa
10:00	Coffee break (15min, catering)	Obere Mensa
10:15	**Synthesis groups**	Obere Mensa & Seminar rooms
12:15	**Gregor Fussmann, McGill, CN** Experimental disease dynamics: the role of individual and population level traits	Obere Mensa
12:30	**Maria Stockenreiter, LMU, DE** Trait-related feedback dynamics in natural plankton communities	Obere Mensa
12:45	**Stefanie Moorthi, U Oldenburg, DE** Competitive interactions between heterotrophic and mixotrophic ciliates depend on resource fluctuation regime and feeding traits	Obere Mensa
13:00	**Lynn Govaert (EAWAG, CH)** Contributions of plasticity and evolution to trait change in two competing protist species under salt stress: does the community context matter?	Obere Mensa
13:15	Lunch break (pay yourself at Mensa)	Mensa
14:30	**Dr. Claudia Neusüß** *Workshop "Uncertainty in Science" (part 1)*	Obere Mensa
16:00	Coffee break (30min)	Obere Mensa
16:30-18:00	**Dr. Claudia Neusüß** *Workshop "Uncertainty in Science" (part 2)*	Obere Mensa
ca. 18:00	Dinner at Indian Villa (group dinner paid by DynaTrait)	Inner city location*

*Indian Villa restaurant is at Hegelallee 5, 14467 Potsdam (see details under "Locations" at the end of the document).

Wednesday	Program	Where
9:00	**Keynote by Elena Litchman (MSU, USA)** Experimental approaches to trait-based ecology	Obere Mensa
9:30	**Kai Wirtz (HZG, DE)** A trait-based framework for explaining non-additive effects of multiple stressors on plankton communities	Obere Mensa
9:45	**Anita Narwani (EAWAG, CH)** Phyt to compete: evolutionary responses to competition and resource limitation in phytoplankton	Obere Mensa
10:00	**Carlo Albert (EAWAG, CH)** A universal phase transition in plankton trait dynamics	Obere Mensa
10:15	**Thomas Lorimer (EAWAG, CH)** Revealing and exploiting the non-convexity of trait space	Obere Mensa
10:30	**Lutz Becks (U Constance, DE)** Can we predict when evo drives eco?	Obere Mensa
10:45	Coffee break (30min)	Obere Mensa
11:15	**Poster session II**	Obere Mensa
12:30	Lunch break (120min) Optional walk through Park Sanssouci & Frisbee or visit the nearby palace "Neues Palais"	Obere Mensa
14:30	Synthesis groups	Obere Mensa / Seminar rooms
17:00	**Poster session III**	Obere Mensa
18:00	PI meeting	Obere Mensa
18:00	Juniors meeting	Seminar room
Ca. 18.30	Optional: join the group going to a nearby restaurant ** or self-organized evening	Diverse locations**

** The optional dinner location is a restaurant located about a 20-min walk through Park Sanssouci or 10-15min away by bus. If you prefer to organize your evening yourself, please ask Potsdam staff for recommendations of suitable restaurants.

Thursday	Program	Where
9:00	**Keynote by Chris Klausmeier (MSU, USA)** Trait-based approaches in temporally and spatially varying environments	Obere Mensa
09:30	Synthesis groups decisions & next steps	All rooms
10:45	Coffee break (15min)	Obere Mensa
11:00	**Toni Klauschies (University of Potsdam, DE)** Ecological and evolutionary causes of intermittent predator-prey cycles	Obere Mensa
11:15	**Ellen van Velzen (U Potsdam, DE)** New answers to old questions: prey adaptation and the emergence of predator coexistence	Obere Mensa
11:30	Wrap-up session | Report from synthesis groups (chairs)	Obere Mensa
ca. 12:30	Meeting ends & farewell (all except PhD students)	
12:30	Lunch (pay yourself at Mensa)	Mensa
14:15	PhD students visit botanical garden	Botanical garden
15:00	**Introduction to literature seminar on Theory of trait variation and eco-evolutionary dynamics** **Sabine Wollrab**	Maulbeerallee 2
Ca. 18.00	Optional: join the group going to a nearby restaurant or self-organized evening	Diverse locations

On Friday, we conduct the literature seminar for PhD students and young scientists only!

Friday	Program	Where
9:00	Literature seminar (led by Sabine Wollrab from IGB Berlin)	Maulbeerallee 2
12:00	Lunch (pay yourself at Mensa)	Mensa
13:30	Literature seminar continues	Maulbeerallee 2
15:00	End of seminar / farewell	Maulbeerallee 2

Presentations (Monday-Thursday)

Monday, Sep 16

Thomas Kiørboe, Centre for Ocean Life (Denmark Technical University), DK

Thomas Kiørboe

Defense in protistan plankton: mechanisms and trade-offs

The evolution and ecology of protistan plankton are typically interpreted mainly in the context of resource acquisition and competition but are equally shaped by factors governing mortality, e.g. due to grazing. Protistan plankton have evolved many different defense mechanisms. These range from 'active' defenses, such as chemical or behavioral defenses, to 'passive' defenses, such as stealth behavior. The details of these are often poorly understood. I will describe the mechanism of these three types of grazer defenses in dinoflagellates, diatoms, and heterotrophic flagellates as well as our attempts to estimate the costs and benefits (trade-offs) or the various mechanisms. I will speculate on the evolution of defenses, and on the implications of defense for the composition and function of microbial communities.

Tuesday, Sep 17

Sebastian Diehl, Umeå University, SE

Sebastian Diehl, Jonas Wickman

Evolution of resource specialization in competitive metacommunities

Ecological models predict that spatial heterogeneity in the supply of different resources can promote regional consumer diversity through e.g. source-sink dynamics or species sorting. But are such - purely ecological - scenarios evolutionarily plausible? When traits are subject to adaptive evolution, will the antagonistic interplay of spatially variable local selection and homogenizing dispersal facilitate or impede regional diversification? We explored this question with a focus on trade-offs in resource-acquisition traits and the degree of resource substitutability. Using a model of competition for two discrete resources, we studied the evolution of resource-uptake specialization as a function of resource type (substitutable to essential) and the shape of the trade-off in resource uptake affinities (generalist- to specialist-favoring). In homogeneous environments, evolutionarily stable coexistence of consumers is only possible for substitutable resources and specialist-favoring trade-offs, yielding one extreme specialist on each resource at the evolutionary endpoint. Under these conditions, spatial heterogeneity cannot promote further evolutionary diversification, because the same two specialists preempt the available niche space everywhere also in a heterogeneous landscape. Instead, in heterogeneous environments, consumer diversity is maximized for intermediate trade-offs and either clearly substitutable or clearly essential resources. Importantly, a regime shift in how niche space can be partitioned occurs at the transition from substitutable to essential resources. When resources are substitutable, different phenotypes are locally most abundant where the supply of their preferred resource is highest. In contrast, when resources are strictly essential, phenotypes are locally most abundant where the supply of their preferred resource is most scarce. As a consequence, a diversity minimum arises at the switch point between these two opposite selection regimes (i.e. when resources are weakly interactively essential). Here, local selection becomes independent of the local resource supply ratio, and a single generalist frequently outcompetes all other strategies.

Selina Våge, University of Bergen, NO

Selina Våge

Trade-offs between competitive and defensive abilities shape pelagic microbial food webs

I have over the last 10 years worked with models and theory for marine microbial food webs. In particular, I have studied how individual interactions and resulting food web functioning are dictated by trade-offs between life strategies such as competing well for limiting resources and defending successfully against predation or parasitism. My work has shown that many aspects of the pelagic microbial food web may be traced back to these fundamental trade-offs, which act across various scales. For instance, resolving virus-host interaction models to the level of strain-specificity provided a possible answer to the debate on whether the utterly successful bacterial clade SAR11 may be a competition or defense specialist, and whether this could be reconciled with findings of highly abundant SAR11 viruses. Also, including strain-specific virus-host interactions in a microbial food web model gave a framework to potentially understand what dictates virus:host ratios in marine environments. I will summarize the importance of trade-offs regulating simple ecological mechanisms and how they may underlie different aspects of the pelagic ecosystem.

Kasia Kenitz, Scripps Institution of Ocenography (UC San Diego), US

Kasia M. Kenitz, Eric C. Orenstein, Paul L.D. Roberts, Peter J.S. Franks, Jules S. Jaffe, Melissa L. Carter, Andrew D. Barton

What does autonomous underwater imaging tell us about plankton ecology?

Automated imaging technologies provide powerful tools for high-resolution, in situ monitoring of plankton communities. Digital imaging systems collect vast numbers of images of aquatic organisms and suspended particles, and automated methods, such as supervised machine learning techniques, are now used to deal with this onslaught of biological data. Still, the challenge is how to translate this "big data" into ecologically meaningful information that improves our understanding of the dynamics of plankton communities. Here, I will discuss how we used underwater imaging and computer vision to investigate the controls of population variability in colony-forming marine diatoms at Scripps Pier, a coastal location in the Southern California Bight. I will discuss a second example, where we leveraged crowd-sourced taxonomic expertise to identify and enumerate the population dynamics of greater than thirty groups of protists at Scripps Pier.

Gregor Fussmann, McGill University, CN

Gregor Fussmann, Christina Tadiri, Marilyn Scott

Experimental disease dynamics: the role of individual and population level traits

Understanding infectious disease dynamics is of fundamental concern to human health and conservation, particularly in the context of globalization, habitat fragmentation and climate change. Here we use the well-studied model system of guppies and their ectoparasite, Gyrodactylus turnbulli, to investigate how heterogeneity at the individual and population levels can influence host-parasite dynamics. Laboratory experiments, backed by mathematical modelling, demonstrated the relatively higher impact of infection duration vs. infection intensity on parasite spread in metapopulations. This result highlights the potential role of tolerance as an overlooked individual trait with community level consequences. At the (inter-)population level we detected interactive effects between population connectivity and parasite load, which indicates an importance of considering parasite distribution when determining disease mitigation and conservation strategies.

Maria Stockenreiter, Ludwig-Maximilians-University Munich, DE

Maria Stockenreiter, Patrick Fink, Herwig Stibor

Trait-related feedback dynamics in natural plankton communities

Biodiversity loss is often accompanied by a loss of traits related to resource use and growth, which are important for food web dynamics and trophic transfer efficiencies. Such a decrease in functional diversity affects its consumers via e.g. food quality effect (bottom-up), but also its ability in responding to the altered top-down effects. In our field mesocosm experiments, we focus on the feedback loop from reduced phytoplankton trait diversity to phytoplankton dynamics via diversity-mediated shifts in zooplankton performance. We addressed this general objective with field experiments with natural plankton communities to estimate the direction and strength of total feedback effects. We carried out two field mesocosm experiments with, were we estimated how altered grazing, due to shifts in phytoplankton diversity result in multiple (and partially interdependent) feedback effects. In these field experiments we were able to analyze the total feedback effects under natural conditions. Nutrient assays clearly showed the variations in nutrient limitation patterns caused by the feedback between phytoplankton diversity and zooplankton grazing. Differences in diversity and evenness of phytoplankton in response to altered nutrient availability were clear feedback mechanisms resulting from zooplankton grazing on different diverse phytoplankton. We will further present first data about feedback mechanisms from this year experiment were we further manipulated the cladoceran to copepod ratio to alter the grazing behavior of zooplankton responding to a gradient of phytoplankton diversity.

Stefanie Moorthi, University of Oldenburg, CN

Sabine Flöder, Moritz Klaassen, Toni Klauschies und Stefanie Moorthi

Competitive interactions between heterotrophic and mixotrophic ciliates depend on resource fluctuation regime and feeding traits

The structure and stability of food webs essentially depends on the feeding interactions between species of adjacent trophic levels that are determined by corresponding resource use, defense and offense traits of the organisms. Such functional traits and associated trade-offs play a key role for ecosystem functioning. In our project we evaluate the importance of consumer trait variation for biomass and trait dynamics in a freshwater ciliate consumer - microalgal prey system, focusing specifically on the consumer trade-off between starvation resistance and maximum grazing rate. In the present study we investigated the role of mixotrophy as a mechanism of starvation resistance, i.e. the ability of photosynthetic carbon fixation in addition to phagotrophy, for the trait and biomass dynamics under constant and fluctuating resource supply conditions. We conducted a 48-day chemostat experiment and studied the interactions of two combinations of different heterotrophic and mixotrophic ciliates under different regimes of resource (prey and light) supply, i.e. resources were provided either continuously or in pulses, entailing periods of resource depletion. Prey and light regimes interactively affected the proportions of mixotrophs and heterotrophs; however the effects strongly depended on species composition. While continuous prey supply promoted mixotrophs in one species combination in under both constant and fluctuating light regime, heterotrophs were promoted in the other combination. The contribution of mixotrophs increased with prey pulses in one species combination, but only under continuous light supply when photosynthetic carbon fixation, i.e. the relevant trait to enhance starvation resistance in mixotrophs, was ensured. Fluctuations of both resources promoted consumer coexistence. These experimental findings are supported by corresponding simulation results of a mathematical model that was designed to reflect the experimental conditions. In the second half of the experiment, however, when consumer densities increased and per capita algal prey supply decreased, the outcome of competition seemed to be more strongly determined by the ability of the consumers to utilize bacteria in addition to algal prey than by their nutritional mode (mixotrophy versus heterotrophy). This finding emphasizes that the relevance of different traits and trade-offs for food web dynamics and community composition may change over time, even though environmental forcing remains the same.

Lynn Govaert, Swiss Federal Institute of Aquatic Science and Technology, Switzerland

Lynn Govaert, Luis J. Gilarranz, Florian Altermatt

Contributions of plasticity and evolution to trait change in two competing protist species under salt stress: does the community context matter?

Attempts to bridge evolutionary biology and community ecology have been mainly conceptual. Hence, experiments often lack such an integration: evolutionary experiments often ignore the community context, while community ecological experiments ignore the possibility of evolution to occur. We performed an experiment that takes both aspects into account. Specifically, we evaluate the evolutionary response of two competing protist species - *Paramecium aurelia* and *Spirostomum teres* - to an increased salinity gradient when the species occur in monoculture, or when they co-occur across 5 different salinity concentrations during 3 months. At the end of the selection experiment, we performed a common garden experiment of both monocultures and mixed cultures to evaluate the evolutionary response of both protist species to each of the five salt concentrations. To that extent, we used a recently developed method, the reaction norm approach, to calculate contributions of plasticity, mean trait evolution and evolution of plasticity to observed changes in population mean trait values, but also in higher moments of their trait distribution, and of the community reaction norm. This approach allows connecting plasticity responses with evolution in response to novel environments and determines how these contributions change depending on the presence of a competing species.

Wednesday, Sep 18

Elena Litchman, Michigan State University, US

Elena Litchman

Experimental approaches to trait-based ecology

Trait-based framework is becoming the mainstay of ecology, as it reduces complexity while including functional diversity. It also helps identify the mechanisms of community assembly. Observational studies of trait distributions and trait-based models have advanced the trait-based framework in recent years. However, the experimental testing of explicitly trait-focused community assembly mechanisms is still lacking. Here I present experimental tests of the novel theory on species and trait abundance distributions (SADs and TADs). Our experiments support the theory that combines niche-based processes with immigration and show that species abundances correlated with the degree of trait-environment matching. The results demonstrate that the niche-based processes and immigration can produce realistic SADs and that experimental phytoplankton communities provide an effective way to test new theories of trait-based community assembly.

Kai Wirtz, Helmholtzzentrum für Ozeanforschung Geesthacht, DE

Kai W. Wirtz, Niousha Taherzadeh, Michael Bengfort

A trait-based framework for explaining non-additive effects of multiple stressors on plankton communities

Phytoplankton communities are increasingly subject to multiple stressors of natural or anthropogenic origin. The cumulative effect of these stressors, however, may vary considerably from the sum of impacts from individual stressors. Nonlinear effects such as changes in community traits can either boost up (synergistic) or weaken (antagonistic) single stressors. Despite previous empirical studies and meta analyses on the interaction types of various multiple stressors, a more fundamental understanding of cumulative effects is lacking. To fill this gap, we here propose a new theoretical framework that is centered on the concept of interaction traits and their trade-offs. The framework is applied to a novel size-based plankton model resolving multi-species phytoplankton-nutrients-detritus-zooplankton dynamics within the upper mixed layer. The model is validated using data from a series of outdoor mesocosm experiments. In the direct aftermath of single perturbations that increase net growth rate, here nutrient enrichment and grazer removal, the simulated phytoplankton community undergoes structural changes as visible in altered community traits. These temporal variations explain why the multiple stressor interaction switches from antagonistic to synergistic as compensatory trait variations reduce over time of the experiment. This finding can be generalized within our trait-based explanatory framework to mechanistically assess and predict effects of other stressor combinations and for other organism groups.

Anita Narwani, Swiss Federal Institute of Aquatic Science and Technology, CH

Anita Narwani

Phyt to compete: evolutionary responses to competition and resource limitation in phytoplankton

Resource limitation is a major driver of ecological and evolutionary dynamics of all organisms, including phytoplankton. Short-term responses to resource limitation include plastic re-wiring of the molecular and metabolic phenotypes of cells. Yet little is known about the evolution of resource requirements and the molecular phenotype after longer-term selection by resource limitation. Can competitive abilities adapt to limiting resources? Do requirements for different resources evolve independently or are trade-offs intrinsic? What is the metabolic basis of this evolutionary adaptation? To answer these questions we combined experimental evolution of the green alga *Chlamydomonas reinhardtii* under multiple different types of resource limitation, with estimates of change in population-level resource requirements and protein expression. Through common garden experiments on the descendants of the evolution experiments, we found that resource limitation resulted in convergent changes in the expression of core metabolic proteins. These protein expression changes suggest upregulation in anabolic metabolic pathways (photosynthesis and ribosome synthesis), and downregulation of catabolic pathways (respiration). This occurred concurrently with an increase in the C:N:P stoichiometric molar ratios of many of the descendant lineages. We also found that minimum resource requirements (Tilman’s R*) for light, nitrogen and phosphorus evolved, generally declining under long-term low-resource selection. There was evidence of positively correlated adaptive evolution of R*s, and little evidence for the evolution of trade-offs. Such evolutionary change in traits related to competition for limiting resources may impact the outcome of competitive community assembly. Future work will investigate the potential for eco-evolutionary feedbacks of resource competition in phytoplankton.

Carlo Albert, Swiss Federal Institute of Aquatic Science and Technology, CH

Carlo Albert, Jenny Held, Francesco Pomati

A universal phase transition in plankton trait dynamics

Scaling laws are ubiquitous in ecology. In particular, fundamental ecological traits, like cell size, often follow scale-free or self-similar distributions. This hints at the possibility that these systems operate near a critical transition point where the system undergoes a qualitative change in behaviour (self-organized criticality paradigm). Near a critical point, systems exhibit macroscopic behaviour that is largely independent of their microscopic details. This means that the macroscale behaviour of such complex systems can be accurately and robustly described by simple mathematical models. However, it has generally not been shown that scaling in ecological trait distributions arises from criticality. Here we show that a generic class of cell growth and division models exhibits a critical phase transition, and provide new experimental evidence for this transition in the population and biomass dynamics of two aquatic unicellular species. This new type of phase transition separates a phase dominated by cell-biomass accumulation from a phase dominated by cell division. As resources were depleted in vitro, we observed this phase transition in both population dynamics, and in moment scaling of cell-biomass, for both prokaryotic and eukaryotic cells grown under different light intensities. Our theory also explains previously observed self-similarity of size distributions of aquatic species, and predicts new testable scaling laws for the response of individual-level trait distributions to perturbations. Our results provide the first explicit support for the criticality hypothesis in trait-based ecology, which paves the way for more general applications of the theory of critical phenomena. Immediate generalizations would include the response of multiple traits (e.g. C, N or P content) to multiple environmental drivers (e.g. temperature, pH). Together with the inherent robustness of scaling laws under the criticality hypothesis, this holds great promise for predictions relating to global nutrient cycles in a changing environment.

Tom Lorimer, Swiss Federal Institute of Aquatic Science and Technology, CH

Tom Lorimer, Francesco Pomati, Carlo Albert, Stuart Dennis, Marta Reyes, Christian Ebi

Revealing and exploiting the non-convexity of trait space

Trait distributions in multiple dimensions are used to make inferences about species niches or interactions over environmental gradients. These distributions are often assumed to be convex, but in more than one dimension, the underlying nonlinear processes may break this assumption. Moreover, restricting analysis to one dimension (or treating dimensions as independent) can obscure potentially important higher-dimensional differences, thereby increasing the apparent "noise" in the system behaviour. To better understand and overcome these potential problems, we have developed novel graph-based measures for trait distribution non-convexity, and trait distribution proximity. These measures do not make assumptions about the intrinsic dimensionality or shape of the data. We will present these measures, as well as some results of their application to in situ plankton imaging data from a new dual-magnification automatic underwater microscope in a lake in Switzerland.

Lutz Becks, University of Constance, DE

Lutz Becks

Can we predict when evo drives eco?

Species interactions and abiotic stress can affect eco-evolutionary dynamics in a variety of ways, by altering for example the strength of selection, the response to selection for ecologically relevant traits and/or by directly altering the population dynamics, which in turn feeds back onto trait evolution. An increased understanding of the effects of different abiotic and biotic stressors on eco-evolutionary dynamics will be important for our ability to preserve species, communities and ecosystem functions. I will present results from experiments to highlight potential ecological and genetic conditions that favour or disfavour, or change the qualitative outcome of eco-evolutionary dynamics.

Thursday, Sep 19

Christopher Klausmeier, Michigan State University, USA

Christopher Klausmeier

Trait-based approaches in temporally and spatially varying environments

Aquatic ecosystems vary in time and space. This heterogeneity provides potentially strong mechanisms of species coexistence, but can complicate trait-based modeling efforts. In this talk I will discuss how to capture temporal and spatial variation in trait-based models and give a few examples of how temporal and spatial heterogeneity structure plankton communities. Finally I will discuss how the shape of the fitness function has an overlooked effect on the evolutionary capacity of species to respond to directionally changing environments.

Toni Klauschies, University of Potsdam, DE

Toni Klauschies, Ursula Gaedke and Ellen van Velzen

Ecological and evolutionary causes of intermittent predator-prey cycles

Previous studies have shown that adding trait variation to a population substantially affects the stability of predator-prey dynamics and the phase difference between their oscillations. In these predator-prey models, however, the amplitudes often remained constant over time. This strongly contrasts with predator-prey dynamics observed in long-term chemostat experiments and recent theoretical work, showing that several mechanisms may lead to intermittent predator-prey cycles with temporal variation in the amplitudes of the predator-prey dynamics. For instance, differences in the shape of the functional responses of two different predators may provoke temporal fluctuations in the amplitudes of the predator-prey cycles due to recurrent changes in their relative abundances: a dominance of the predator with a linear functional response stabilizes the dynamics whereas the predator with a non-linear functional response destabilizes the dynamics when becoming abundant. We analysed various mathematical models that incorporate trait variation within one or two trophic levels, in order to reveal general conditions that may give rise to intermittent cycles in predator and prey biomasses. Our results suggest that three conditions are necessary for intermittent cycles to occur. First, the predator-prey system should comprise at least two subsystems that exhibit substantial differences in their dynamic stability. Second, these subsystems should recurrently alternate their dominance in the predator-prey system, leading to a second “trait” cycle superimposed on the biomass dynamics. Finally, the time scale of the trait dynamics must be significantly slower than the biomass dynamics; hence, the change in the dominance of one subsystem to another one has to occur with some time lag. When all three conditions co-occur, trait variation may cause intermittent cycles by inducing temporal variation in the dominance of various phenotypes that differ in their ability to promote stable or unstable population dynamics. For instance, co-evolution may promote intermittent cycles in the predator-prey dynamics by inducing a lag in the predators' trait adjustment in response to altered trait values of the prey. The resulting temporal variation in the interaction strength between predator and prey is associated with temporal changes in the stability of the population dynamics: a dominance of defended prey promotes stability whereas a high abundance of undefended prey induces predator-prey oscillations. Our results highlight that intermittent cycles may frequently occur in simple predator-prey systems that account for trait variation at one or two trophic levels.

Ellen van Velzen, University of Potsdam, DE

Ellen van Velzen

New answers to old questions: prey adaptation and the emergence of predator coexistence

Ecological theory has long been invaluable for generating insights into the mechanisms underlying important system features such as stability and coexistence. However, the vast majority of long-standing theory was derived before the ubiquity of contemporary adaptation became recognized, and thus views these important questions from a purely ecological perspective. From this viewpoint, traits either do not change, or change so slowly that this can be neglected. When traits can change rapidly, such theories may need to be adjusted – or they may be blown out of the water entirely. Here I use one of the oldest theories in ecology, extinction via competitive exclusion, as an example. In the absence of other stabilizing mechanisms, two predators cannot coexist on a single prey; this would require them to suppress prey biomass to exactly the same level (i.e. they need to have the same R*), which is held to be self-evidently impossible. I show how adding defense adaptation in the prey destroys this prediction by causing an eco-evolutionary feedback loop between prey defense and predator biomass dynamics. Equalization of the predators' R*-values arises as an emergent property of this feedback loop, thus enabling their stable coexistence. This result showcases the importance of regarding long-standing questions, as well as their long-standing answers, from an eco-evolutionary perspective.

Posters

Poster abstracts (when available) are listed below the table.

No.	Authors	Affiliation	Poster title
01	Mridul K. Thomas	DTU	Inferring functional traits from ecological time series
02	Ewa Merz, Thea Kozakiewicz, Peter Isles, Marta Reyes, Stuart Dennis, Thomas Lorimer, Carlo Albert, Nelson Stevens and Francesco Pomati	Eawag	Extracting plankton morphological features based on automated underwater imaging
03	Francesco Pomati, Ewa Merz, Tom Lorimer, Carlo Albert	Eawag	Understanding plankton trait dynamics and community change using in-situ automated monitoring
04	Markus Pahlow, Chia-Te Chien	GEOMAR	Optimality-Based Plankton in the UVic Earth System Model
05	Bei Su*, Markus Schartau and Friederike Prowe	GEOMAR / *U Liverpool	Can mesocosm observations inform model trophic structure?
06	Giannina Hattich, Jorin Hamer, Sivia Pulina*, Birte Matthiessen	GEOMAR / *University of Sassari (Italy)	Eco-evolutionary dynamics and phytoplankton community functioning in different nutrient regimes
07	Onur Kerimoglu	HZG	A generalized plankton model
08	Patrick Thomas, Esteban Acevedo-Trejos, Agostino Merico, Helmut Hillebrand, Maren Striebel	ICBM / U Oldenburg, ZMT	The interplay between phytoplankton cell size variation and ecosystem function
09	Maren Striebel, Miriam Gerhard, Apostolos M. Koussoroplis, Helmut Hillebrand	ICBM / U Oldenburg	Phytoplankton community responses to temperature fluctuations under different nutrient concentrations and stoichiometry
10	Sabine Flöder, Joanne Yong, Lara Bromann, Rebecca Schröter, Lukas Ross, Laura Hennigs, Jorrit van der Sluis, Julia Schmidt, Thorsten Brinkhoff, Toni Klauschies and Stefanie Moorthi	ICBM / U Oldenburg, U Potsdam	The Relevance of Consumer Competition and Feeding Traits, as well as their Trade-offs, in Determining Multispecies Trophic Interactions – State of the Art
11	Alexey Ryabov	ICBM	Competition-induced starvation drives large-scale population cycles in Antarctic krill
12	Patch Thongthaisong, Minoru Kasada, Hans-Peter Grossart, Sabine Wollrab	IGB	The influence of zooplankton feeding preference for the zoospores of parasitic fungi on competition between edible versus inedible algae in aquatic plankton communities
13	Jessica Titocci, Maria Stockenreiter, Herwig Stibor, Patrick Fink	LMU, UFZ, U Cologne	Loss of functional traits in phytoplankton-zooplankton dynamics from a lake mesocosm experiment
14	Patrick Fink, Maja Ilic, Jessica Titocci, Luna Benitez-Requena, Sara Hammerstein, Maria Stockenreiter, Herwig Stibor	LMU, UFZ, U Cologne	Effects of natural phytoplankton trait diversity on Daphnia spp.
15	Christian Laumen, Linda C. Weiss, Kathrin P. Lampert, Ralph Tollrian	RUB	The influence of environmental changes and individual trait

			variability (phenotypic plasticity) on biodiversity and ecosystem stability
16	Tom Réveillon	U Constance	Buffering of external perturbation through Indirect Evolutionary Facilitation (IEF)
17	Ruben Hermann	U Constance	Indirect evolutionary rescue
18	Dietmar Straile, Reiner Kümmerlin, Nathalie Wagner, Frank Peeters	U Constance	Long-term changes in the mean traits of the phytoplankton community in Lake Constance
19	Nadja Kath, Ellen van Velzen, Ursula Gaedke	U Potsdam	Phenotypic plasticity affects coexistence in a small food web
20	Ruben Ceulemans, Ursula Gaedke, Christian Guill	U Potsdam	Generalizing the effects of trait variation on tritrophic food webs
21	Valerie Wentzky, Christoph Jäger, Jörg Tittel, Karsten Rinke	UFZ	Functional trait dynamics in phytoplankton communities during oligotrophication

Poster abstracts

1. Inferring functional traits from ecological time series

Mridul K. Thomas (DTU)

In phytoplankton, traits relating to resource acquisition, predation resistance and temperature tolerance are believed to determine the outcomes of competition. Unfortunately, these traits are time-consuming to measure and a lack of data has limited our ability to model ecosystem processes in complex natural systems. I will discuss how applying machine learning tools to ecological time series can partly address these problems. Using datasets from lakes and oceans, I show that we can quantify the traits that govern population dynamics for many of the members of a community simultaneously. Furthermore, we can use this approach to uncover how interactions between environmental dimensions influence phytoplankton growth, and the trade-offs that shape competitive interactions. I hope to convince you that this approach can help us understand the mechanisms underlying complex ecological dynamics in natural systems.

2. Extracting plankton morphological features based on automated underwater imaging

Ewa Merz, Thea Kozakiewicz, Peter Isles, Marta Reyes, Stuart Dennis, Thomas Lorimer, Carlo Albert, Nelson Stevens and Francesco Pomati (Eawag)

Body size is one of the key determinants of plankton community structure and food-web dynamics, offering a promising approach to explain and predict changes in species composition and diversity along environmental gradients. Conventional techniques to measure plankton body size are costly and time consuming, reducing the frequency accuracy and integrity of plankton size distribution datasets. Here we present a novel method to estimate zoo- and phytoplankton size distributions with high-frequency using in situ automated underwater imaging (Eawag plankton camera) and benchmarking it with traditional microscopy.

3. Understanding plankton trait dynamics and community change using in-situ automated monitoring

Francesco Pomati, Ewa Merz, Tom Lorimer, Carlo Albert, Peter Isles (Eawag)

Plankton community dynamics and trait distributions emerge from a complex interplay between a highly variable environment and a nested set of feedbacks, from individuals to population, community and food-web interactions. Such interactions occur in nature at the scale of minutes to hours, and µm to mm. Traditional monitoring data are not sufficient to fully characterise plankton dynamics. In this poster we will present underwater automated imaging, as produced by the dualmagnification Eawag plankton camera, as a new tool to phenotype and study plankton species dynamics in lakes across three levels of the food-web in situ, with high frequency and high spatial resolution.

4. Optimality-Based Plankton in the UVic Earth System Model

Markus Pahlow, Chia-Te Chien (GEOMAR)

Optimality-based formulations offer a more realistic description of plankton-organism behaviour and flexible phytoplankton stoichiometry than the simplistic, fixed-stoichiometry representations in most current Earth-system models. We have implemented an optimality-based plankton ecosystem model (OPEM) in the UVic Earth System model with alternative formulations of diazotroph temperature dependence. We have run the model into steady state for an ensemble of 400 parameter sets, generated by latin-hypercube sampling of 13 parameters. The ensemble simulations can be used to analyse the model's sensitivity to its parameters and select reference simulations based on the ability to reproduce observed tracer distributions (inorganic nutrients, oxygen, and chlorophyll) and global net primary production (NPP) and nitrogen fixation. Performance in terms of tracer distribution is quantified by a cost function considering the RMS differences as well as correlations and covariances between tracers. Model-data discrepancies reveal promising avenues for further model improvement. (1) Improved distribution of NPP with a less-restrictive temperature dependence of facultative diazotrophs indicates the importance of temperature relations but also the need for a better resolution of phytoplankton community composition. (2) The wrong sign in the vertical gradient of particulate C:P points to the necessity of including preferential P (and possibly also N) remineralisation. (3) The strong sensitivity of the nitrogen, oxygen, and carbon inventories to the minimum (subsistence) phytoplankton N quota points to the importance of understanding the controls on plankton physiology and its effects on global biogeochemistry.

5. Can mesocosm observations inform model trophic structure?

Bei Su*, Markus Schartau and Friederike Prowe (GEOMAR, *now at U Liverpool)

Traits controlling plankton trophic interaction structure the lower trophic levels of the food web, with consequences for both higher trophic levels and the element cycling of carbon, nitrogen and phosphorus. Observing feeding traits in a complex food web is challenging. Controlled laboratory conditions facilitate the observation of traits, but are typically restricted to specific species. A variety of species and the variability of natural plankton communities can be investigated in mesocosms. Here we investigate whether a model-based analysis of mesocosm observations of food webs can inform about the underlying trophic pathways. We base our study on the existing model of Larsen et al. (Limnol. Oceanogr. 60, 2015, 360-374) that describes the shift from a diatom- to a bacteria-dominated community by adding a trophic link between ciliates and diatoms. An alternative model includes a pathway where ciliates and diatoms are targeted separately by copepods with passive and active feeding traits. For both model configurations we perform parameter identification analyses, including maximum likelihood estimation of the models' parameter values. We compare the optimised solutions of these models and evaluate whether the available observational data suffice to identify and constrain either of the potential trophic pathways. We discuss the explanatory power of observed changes in community structure, which may guide the development of trait-based models for large scale biogeochemical applications.

6. Eco-evolutionary dynamics and phytoplankton community functioning in different nutrient regimes

Giannina Hattich, Jorin Hamer, Sivia Pulina*, Birte Matthiessen (GEOMAR, *also at University of Sassari, Italy)

This Project aims to use genotype trait variation in nutrient uptake related traits of phytoplankton to understand (i) competitive dynamics and potential eco-evolutionary coupling and (ii) their consequences and relative importance for changing community properties in response to changing nutrient scenarios in the world's oceans. Our model system consists of nine genotypes each of two functionally different and stably coexisting marine phytoplankton species, the diatom *Chaetoceros affinis* and the coccolithophore *Emiliania huxleyi*. Here we present preliminary results of the community dynamics and changing community properties in different nutrient regimes (Redfield, P-limited and N-limited) of a still ongoing long-term experiment. We also present first measurements of genotype's trait variability in maximum uptake rates (V_{max}) and half saturation constants for nitrate uptake (K_n), and first estimates of the relative importance of species vs genotypes compositional shifts to explain differences in community properties among nutrient regimes. By involving potential eco-evolutionary dynamics the results will be important to better predict phytoplankton change in the light of altering nutrient conditions currently ongoing in many oceanic regions.

7. A generalized plankton model

Onur Kerimoglu (HZG)

Representation of physiological plasticities and functional diversity of plankton in coupled physical-biogeochemical models vary greatly. Degree of such details should be determined according to the exact question at hand, and the availability of computational resources. Typically, rigidity of model frameworks restrict such adjustments. This results in models that usually vary in multidue of aspects in addition to those in the representation of plankton, which in turn limit their comparability. Here I present a novel model platform called the generalized plankton model, which facilitates adjusting the detail at which the physiological processes and trophic interactions are described. The ease at which the model complexity can be adjusted not only allows optimizing the model complexity for the question and resources at hand, but also allows performing isolated structurual sensitivity analyses. I present example configurations for simulating micro/mesocosm employing idealized 0-D or 1-D setups, or entire ecosystems employing a realistic 3-D setup of the southern North Sea. I would like to discuss how the generality of the model can be further improved by inclusion of more mechanistic or consistent descriptions and additional physiological or behavioral plankton traits through collaborative efforts.

8. The interplay between phytoplankton cell size variation and ecosystem function

Patrick Thomas, Esteban Acevedo-Trejos, Agostino Merico, Helmut Hillebrand, Maren Striebel (ICBM / U Oldenburg, ZMT)

Phytoplankton cell size is a key trait in marine ecosystems, yet we have a relatively poor predictive understanding of how cell size variation, both within and across species, affects ecosystem functioning. In this project, we use a unique combination of experimental and modeling approaches to assess the feedbacks between cell size variation and the functioning of marine phytoplankton communities. First, we conducted two replicated microcosm experiments using natural phytoplankton communities from the North Sea, with both spring and summer communities, to test how environmental changes drive trait changes in phytoplankton. We manipulated temperature, nutrients, and grazing over a two-week incubation period and have thus far made cell size measurements for a representative subset of the 144 experimental units used. Preliminary analysis of cell biovolumes suggests that presence of copepod grazers, increased temperatures, and increased nutrients all led to greater variation (i.e., CV) in community cell sizes. Furthermore, grazing and temperature both decrease overall mean cell size, which is mostly driven by increases in the small colonial haptophyte Phaeocystis. Conversely, preliminary data suggest that within certain diatom species (e.g., Asterionellopsis glacialis), grazing caused slight increases in mean cell size. Overall, these data suggest that environmental change can alter multiple aspects of trait distributions both within and across species. Next, we will conduct a further experiment to explicitly test the role of intra- vs. inter-specific trait variation in ecosystem functioning under environmental change; we will then combine these empirical data with an individual-based modeling approach to extend our inferences beyond those possible with controlled laboratory experiments.

9. Phytoplankton community responses to temperature fluctuations under different nutrient concentrations and stoichiometry

Maren Striebel, Miriam Gerhard, Apostolos M. Koussoroplis, Helmut Hillebrand (ICBM / U Oldenburg)
Nutrient availability and temperature are important drivers of phytoplankton growth and stoichiometry. However, the effect of temperature fluctuations on phytoplankton communities and its interactions with nutrient supply is unclear. Using a natural phytoplankton community, we conducted a laboratory experiment under two temperature regimes, fluctuating and constant, across 25 different combinations of N and P supply. In comparison with constant conditions, fluctuating temperatures decreased phytoplankton growth rate (rmax) supporting Jensen´s inequality prediction. In addition, the thermal performance curve shape was altered by nutrient conditions. Stoichiometric responses to temperature treatments supported the idea that phytoplankton cellular nutrient allocation can be adjusted according to the temperature regime. However, the responses shown by the phytoplankton communities to the temperature conditions were not highly explained by differences in the species diversity and composition. Our results suggested that temperature fluctuations interacting with nutrient conditions strongly affect the phytoplankton physiology and stoichiometry at the community level.

10. The Relevance of Consumer Competition and Feeding Traits, as well as their Trade-offs, in determining Multispecies Trophic Interactions – State of the Art

Sabine Flöder, Joanne Yong, Lara Bromann, Rebecca Schröter, Lukas Ross, Laura Hennigs, Jorrit van der Sluis, Julia Schmidt, Thorsten Brinkhoff, Toni Klauschies and Stefanie Moorthi (ICBM / U Oldenburg)
Consumer diversity effects on food web dynamics are context-dependent, and determined by species-specific traits and associated trade-offs. Our project investigates the role of trait variation on two interacting trophic levels, freshwater ciliate consumers and microalgal prey. We use a combination of experimental approaches (batch, semi-continuous and chemostat-experiments), life observations, molecular techniques and mathematical modelling to understand the consequences of consumer diversity loss for trophic dynamics and ecosystem functioning. This poster gives an overview of our research project that, so far, has focused on:

1. The interaction of inducible offences and defenses among ciliate consumers. The ciliate *Stylonychia sp.* exhibits an inducible offense by forming giant cells that are able to feed on other ciliates, such as *Coleps hirtus and Euplotes octocarinatus,* as well as on small morphotypes of its own population. *Euplotes octocarinatus* responded with an inducible defence that prevented predation by the intraguild predator. We performed life observations and a short-term (8 days) experiment using monocultures, two- and three-species combinations with and without microalgal prey to study the extent and the temporal development of this phenotypic plasticity, also via FlowCam analysis. Long-term (31 days) community dynamics of the three species combination were investigated in a chemostat-run.

2. The role of intraspecific trait diversity and competitive ability. Three *Coleps hirtus* strains were selected differing in growth and feeding traits. We developed a molecular method to distinguish these morphologically similar *C. hirtus* strains based on their rRNA internal transcribed spacer (ITS) regions. A 33-day chemostat experiment was conducted to study trait and biomass dynamics of the monoclonal *Euplotes octocarinatus* and the different *C. hirtus* strains in mono- and polyclonal combinations, feeding on two algal prey species. In a further short-term (5 days) experiment potential differences in the edibility of the three different *C. hirtus* strains for the intraguild predator *Stylonychia* sp. were tested and could be confirmed.

3. *Competitive interactions of heterotrophic and mixotrophic ciliates in response to altered resource supply.* A short term (9 days) experiment was conducted to investigate the effects of light intensities and prey concentrations on different mixtures of heterotrophic and mixotrophic *Euplotes sp*. and *Coleps sp*. strains. The results suggested that performance and competitive ability of heterotrophic and mixotrophic ciliates depend on functional traits of the competing species. Despite the higher metabolic costs for mixotrophic ciliates, both heterotrophs and mixotrophs may successfully compete for resources.

11. Functional trait dynamics in phytoplankton communities during oligotrophication

Alexey Ryabov (ICBM / U Oldenburg)

Age structured models allow us to analyze the influence of asymmetries in the traits between different developmental stages on the age structure and stability of a population.Here we show how changes in starvation mortality with krill age can lead to large-scale population cycles. Antarctic krill exhibits a five to six year population cycle, with oscillations in biomass exceeding one order of magnitude.Using data analysis complemented with modelling of krill ontogeny and population dynamics, we identify intraspecific competition for food as the main driver of the krill cycle, while external climatological factors possibly modulate its phase and synchronization over large scales. Our model indicates that the cycle amplitude increases with reduction of krill loss rates. Thus, a decline of apex predators is likely to increase the oscillation amplitude, potentially destabilizing the marine food web, with drastic consequences for the entire Antarctic ecosystem.

12. The influence of zooplankton feeding preference for the zoospores of parasitic fungi on competition between edible versus inedible algae in aquatic plankton communities

Patch Thongthaisong, Minoru Kasada, Hans-Peter Grossart, Sabine Wollrab (IGB)

Parasitic fungi are ubiquitous in aquatic systems and often closely adapted to a certain host phytoplankton species. The life cycle of parasitic fungi involves an infectious stage, the zoospore, which swims and attaches to a host phytoplankton cell where it produces new zoospores, which after lysis of the host cell can infect new host cells. Therefore the abundance of parasitic fungi is closely related to its host population density and can play a crucial role in the control of algal blooms, besides zooplankton grazing. Furthermore parasitic fungi can create an additional feeding link from otherwise inedible phytoplankton species, e.g. because of large size or toxicity, to the zooplankton via consumption of zoospores. It has been shown that zoospores can form a highly nutritional food source for zooplankton, being rich in poly-unsaturated fatty acids. Despite the prevalence of parasitic infections in aquatic food webs, the dynamic consequences of this additional feeding link and its influence on plankton community composition is understudied. In this project, we investigate how the preference of zooplankton for zoospores influences the community composition and dynamics along an enrichment gradient by analyzing a corresponding mathematical model. Model dynamics are more stable for low enrichment and get oscillatory for higher enrichment levels. The preference of zooplankton for fungi versus small phytoplankton affects average biomass levels as well as the variance of biomasses when showing periodic oscillations. A strong preference for fungi leads to an increase of zooplankton density and stabilizes the system dynamics. On the contrary a preference for small edible phytoplankton leads to increasingly strong oscillations, which could potentially lead to extinction.

13. Loss of functional traits in phytoplankton-zooplankton dynamics from a lake mesocosm experiment

Jessica Titocci, Maria Stockenreiter, Herwig Stibor, Patrick Fink (U Cologne, LMU, UFZ)

As biodiversity has rapidly been declining, it becomes crucial to understand the effects of functional trait diversity loss and community responses in a changing world. Although numerous small-scale laboratory experiments have provided considerable insights on the importance of certain traits in plankton communities in the recent years, they still not allow for a deep understanding of the complex interaction and feedback dynamics in nature. In this context, broader and more complex approaches on a larger and more nature-like scale are needed. Here, we investigate how loss of functional traits alter food web dynamics, affecting trophic transfer efficiency and specific ecosystem functions in a natural plankton community performing a within-lake mesocosm experiment. By manipulating natural phytoplankton trait diversity we hypothesize to get feedback responses to phytoplankton dynamics via diversity-mediated shifts in zooplankton community. We assume that differences in terms of phytoplankton community composition and structure (i.e. changes in pigments composition and photosynthetic activity, size distribution, essential fatty acids production and nutrient uptake rates) due to changes in nutrient availability, resource use, recycling patterns and feeding behaviors of altered zooplankton communities will occur. Overall, this will help us to assess how loss of specific traits could impact on plankton communities and to infer how the altered dynamics in turn could influence the maintenance of biodiversity itself.

14. Effects of natural phytoplankton trait diversity on Daphnia spp.

Patrick Fink, Maja Ilic, Jessica Titocci, Luna Benitez-Requena, Sara Hammerstein, Maria Stockenreiter, Herwig Stibor (UFZ, U Cologne, LMU)

While the impact of biodiversity loss on ecosystem functioning has been studied extensively, it is still not much known about the underlying mechanisms. The loss of functional traits has been shown to alter key processes of ecosystems, such as productivity and sustainability. In aquatic ecosystems, biodiversity loss on producer level is believed to have cascading effects on multiple trophic levels. In particular the phytoplankton-zooplankton interface is of high interest, as the phytoplankton content of dietary polyunsaturated fatty acids (PUFAs) was found to be crucial for the fitness of the herbivorous grazer *Daphnia*, which is not capable of de novo synthesis of such PUFAs. Essential PUFAs are thus assumed to be a functional phytoplankton trait that affects the trophic transfer efficiency and dynamics between the primary producers and consumers. We here tested the hypothesis that an altered phytoplankton community composition will result in an altered composition of dietary fatty acids. This in turn will affect the intraspecific competition in *Daphnia sp*.. We tested this hypothesis through a combination of controlled laboratory and large-scale field enclosure experiments. Our results demonstrate that the phytoplankton diversity is correlated with the composition of PUFAs, and that single PUFAs directly affect competitive interactions between the tested *D. longispina* genotypes. Our study hence provides evidence for a potential link between phytoplankton trait diversity and zooplankton population dynamics.

15. The influence of environmental changes and individual trait variability (phenotypic plasticity) on biodiversity and ecosystem stability

Christian Laumen, Linda C. Weiss, Kathrin P. Lampert, Ralph Tollrian (RUB)

Biodiversity at all levels (genetic, species, habitats) is crucial for ecosystem function and stability. Higher biodiversity means redundancy and thus single genotype extinctions may be replaced by others. Similarly, phenotypic plasticity and individual trait variability has the potential to stabilize populations. Recently however, biodiversity is declining while environmental disturbances and large-scale changes are increasing in frequency and severity. We are therefore interested in the effects of individual trait variation on the genetic diversity of a population in response to natural and anthropogenic stressors. We here investigate how trait variation and phenotypic plasticity affect biodiversity within several artificial Daphnia populations. These populations will be composed of different degrees of phenotypic plasticity to assure trait variability. We will stress these populations using natural (predation) and/ or anthropogenic stressors (elevated levels of pCO_2) and monitor the population structure including demography and genotype distribution over time (12 weeks). With this we aim to determine whether phenotypic plasticity and trait variability increase biodiversity. In contrast, phenotypic plasticity and trait variability could decrease biodiversity as it enables the plastic organism to exploit several niches rather than allowing genotype specialization.

16. Buffering of external perturbation through Indirect Evolutionary Facilitation (IEF)

Tom Réveillon (U Constance)

Eco-evolutionary feedbacks are central for ecological and evolutionary processes driving population dynamics and ecosystem functioning. Importantly, these feedbacks have been suggested to allow natural systems to buffer environmental perturbations and evidences showed that they are strongly linked to trait variation. However, little is known about how trait variation (or polymorphism) can buffer these perturbations. This concern led to the recent theory of Indirect Evolutionary Rescue (IER, Yamamichi & Miner) but empirical evidences are still lacking. Here, we focus on a predator-prey system coupling the rotifer Brachionus calyciflorus and the green algae Chlamydomonas reinhardtii to investigate the potential effects of trait variation on the persistence of natural populations in disturbed environments. In particular, we explore a trade-off pattern between anti-consumer (defence against the predator) and competitiveness traits (growth) in the prey population. We use different algae clones that differ in their position on the trade-off gradient and microplastic beads as an external perturbation that will affect the predator resource acquisition (e.g. functional response) and thus its persistence. As the environmental perturbation directly affects the predator food consumption but not its mortality (Ruben Hermann's PhD project), we define the underlying mechanism in our concept as Indirect Evolutionary Facilitation (IEF). We thus question how the reduction in resource acquisition in the predator population due to the environmental perturbation can be buffered by trait variation in the prey population. Overall, the recognition of indirect evolutionary processes will provide knowledge to help researchers predicting ecological state after a disturbance and future responses to environmental changes.

17. Indirect evolutionary Rescue

Ruben Hermann (U Constance)

High trait variation within or across species is often associated with resilience to external perturbations. The underlying mechanisms that lead promote or prevent resilience of systems are however not understood. Indirect evolutionary rescue has recently been proposed (Yamamichi & Miner) but experimental tests are missing. I use the predator-prey system of the rotifer *Brachionus calyciflorus* and the algae *Chlamydomonas reinhardtii* to investigate the possible resilience and its connection to trait variation. The algae variate in their defense traits. The different algae clones used in the experiment differ as well in the cost of their defense investment, which might influence the dynamics. Salt is used as the stressor as it increases the mortality of the predator and shows no negative impact on the prey growth rate.

18. Long-term changes in the mean traits of the phytoplankton community in Lake Constance

Dietmar Straile, Reiner Kümmerlin, Nathalie Wagner, Frank Peeters (U Constance)

The main questions addressed in our study are, how mean traits of the phytoplankton community change with eutrophication and oligotrophication and whether changes in the values of mean community traits are related to the community dynamics. The study is based on the long-term data set on phytoplankton in Lake Constance covering the period 1965 – 2007 (43 study years) with 1040 sampling dates. Each phytoplankton species was associated with trait values for the traits cell volume, maximum growth rate, grazing resistance, phosphate affinity and alpha, i.e. the initial slope of the growth-irradiance curve based on published trait compilations (Bruggeman 2011, Schwaderer *et al.* (2011). In cases in which trait values were not available they were estimated based on phylogenetic relationships. Annual averages of mean community trait values were calculated from the species traits and the biovolumes of the species at a given time. These mean community traits are sensitive to the trophic state of the lake. The long-term changes in the trait values are mainly due to changes in the relative abundance of the major phytoplankton groups rather than to changes of the species composition within these groups.

19. Phenotypic plasticity affects coexistence in a small food web

Nadja Kath, Ellen van Velzen, Ursula Gaedke (U Potsdam)

Traits such as defence or growth rate are crucial for the coexistence of species. Phenotypic plasticity allows the species' traits to change and might thus alter the species that can coexist. We used an ODE model to investigate the influence of phenotypic plasticity (inducible defence) on coexistence in a small food web containing a consumer and two autotroph species, each with two phenotypes. The autotrophs faced a trade-off between defence and maximum growth rate. In different scenarios, the reaction norm defining the maximum defence of the defended phenotypes, the costs of plasticity leading to lowered maximum growth rates for undefended phenotypes, and the trade-off slope were varied. Phenotypic plasticity is implemented via a switching function linking the amount of defence to the consumer abundance. We define coexistence as two species coexisting, i.e. at least one phenotype from each species. In both the non-plastic and the plastic version, there is coexistence, albeit the pattern of how many and which phenotypes could coexist changes. This coexistence pattern might indicate how coexistence acts in larger food webs.

20. Generalizing the effects of trait variation on tritrophic food webs

Ruben Ceulemans, Ursula Gaedke, Christian Guill (U Potsdam)

Diverse communities can adjust their trait composition to altered environmental conditions, which may strongly influence their dynamics. Previous studies of trait-based models mainly considered only one or two trophic levels, whereas most natural systems are at least tritrophic. In order to gain understanding of how trait variation can affect tritrophic communities, we investigated several different food web configurations. In each of these, the trophic levels on which there is trait variation are different. Additionally, the amount of trait variation on each of the levels is varied independently. This allows us to investigate the effect of both the location and the amount of trait variation on certain relevant metrics, namely, biomass production, temporal variation, and likelihood of coexistence. In order to capture a wide range of possible dynamical outcomes, each of the different configurations was investigated over a large range of parameter values and initial conditions. From this data, we are able to identify several general trends. Most importantly, our results show that a high amount of trait variation on all trophic levels simultaneously is crucial for a high biomass production at the top level, and strongly reduces temporal variability. Hence, our study suggests that in highly complex natural systems, loss of functional diversity anywhere in the food web may have far-reaching effects on the functioning of the whole community.

21. Functional trait dynamics in phytoplankton communities during oligotrophication

Valerie Wentzky, Christoph Jäger, Jörg Tittel, Karsten Rinke (UFZ)

Understanding and explaining the local phytoplankton communities in the pelagic water column is a central goal in aquatic biology. The preferences of phytoplankton functional groups to seasonal and vertical variations in nutrients, light, temperature and grazers are well known and have been verbally described by the Plankton Ecology Group (PEG model by Sommer et al., 1986). Using a quantitative approach, our study investigates phytoplankton functional traits along environmental gradients. We took advantage of a 50-year long, vertically-resolved data-set from a German reservoir, which underwent a strong shift in trophic conditions in the nineties. This data-set allowed us to quantitatively analyze seasonal and vertical developments in phytoplankton traits (e.g. phosphate affinity, ability to fix nitrogen) and to compare these patterns during eutrophic and oligotrophic conditions. We found that seasonal trait developments in our data-set provide not only a quantitative description but also a functional template for trait-based succession patterns in temperate lake ecosystems. The seasonal succession of traits differed depending on trophic status, with higher differences between seasons during the eutrophic period. The development of vertical niches in phytoplankton traits was highest during periods with strong thermal stratification and this pattern did not change with oligotrophication.

Synthesis groups (Monday – Thursday)

Overview of who wants to join which of the four groups:

https://dudle.inf.tu-dresden.de/dynatrait2019/

Synthesis group 1: "Vertical upscaling: Moving from two to three to multitrophic experiments and models of more complex food webs"

Chairs: Friederike Prowe (GEOMAR), Ellen van Velzen (University of Potsdam)

For PDFs of papers relevant to this topic, see https://boxup.uni-potsdam.de/index.php/s/rbCZWPryd0lmjIu

password: dynatrait

Abstract

Small-scale chemostat experiments and simple ecological models offer a powerful way to study species interactions given the small number of species / phenotypes, and hence observable dynamics. This has resulted in particular in insights into trophic interactions, like the effect of defense adaptation on predator-prey dynamics. Such species-based interactions are assumed to also underlie more complex natural food webs where tracking individual species is often not possible. Trait-based ecology is a promising concept to scale up from individual species to community level in both experiments and modelling. However, this upscaling is currently hindered by different foci of studies at the different scales, resulting in a discrepancy of properties and variables measured and analysed. In this synthesis group, we want to identify current obstacles in trophic upscaling, and develop a roadmap to overcome these obstacles and move the field forward. We start by collecting common properties of food webs of different complexity – e.g. trophic transfer efficiency, exploitation of inorganic nutrients, or distribution of biomass across different trophic levels – and develop foci addressable across different scales and types of studies. We focus in particular on trophic interactions and food web structure, as they are relevant for understanding natural systems in a changing climate and may influence largescale ecosystem functioning from local to global scales. We aim for writing a perspectives / conceptual paper with a group of co-authors, starting by getting this group together at the DynaTrait meeting in September. An outline and plan for dividing writing tasks will be developed at this meeting,; we aim for having a draft ready for submission in Spring 2020.

Synthesis group 2: "Horizontal upscaling: The effect of intraspecific trait variation on species coexistence"

Chairs: Toni Klauschies (U Potsdam) and Lynn Govaert (Eawag)

For PDFs of papers relevant to this topic, see
https://boxup.uni-potsdam.de/index.php/s/GmmO1nWK2CK6VGG

password: dynatrait

Abstract

Populations exhibit substantial intraspecific standing trait variation that may strongly influence species coexistence. However, a clear mechanistic understanding is still lacking. This may partly arise from the fact that different (and contrasting) hypotheses exist on how standing trait variation may influence species coexistence. For instance, if species can adjust their trait composition in response to selection, this can on the one hand reduce niche overlap promoting species coexistence (e.g. Abrams 2006; Klauschies et al. 2016), but on the other hand it may increase niche overlap if species become more similar potentially reducing coexistence (MacArthur and Levins 1967). Moreover, because individuals vary in their demographic and competitive rates which non-linearly determines population dynamics, the average species effects may differ from the additive effects of individuals (e.g. Hart et al. 2016). This non-linear averaging effect can also be changed by trait adaptation, which may alter the mean trait value and standing trait variation of a population. Hence, standing trait variation and adaptation may strongly interact to promote or hamper coexistence (e.g. Schreiber et al. 2011; Barabás et al. 2016). Given the tremendous loss of biodiversity over the last decade in both terrestrial and aquatic ecosystems, it is necessary to identify general conditions under which standing trait variation and trait adaptation may positively or negatively influence species coexistence. Hence, in this working group, our aim is to synthesize current theoretical knowledge and empirical evidence on the separate and joint influence of intraspecific trait variation (ITV), in both standing trait variation (trait variance) as well as mean trait adaptation (via e.g. mutation) on the potential for species coexistence. Since changes in the community composition may feedback on the maintenance of intraspecific trait variation, we want to complement our study by a general discussion about the ecological conditions and mechanisms that may contribute to the maintenance or loss of intraspecific trait variation. This will allow us to develop a general theory about the relationship of ITV and species coexistence as a main synthesis output.

Synthesis group 3: "Upscaling in space: Moving from single adaptive systems to spatially distributed adaptive metacommunities"

Chairs: Alexey Ryabov (ICBM / U Oldenburg), Maren Striebel (ICBM / U Oldenburg)

For PDFs of papers relevant to this topic, see
https://cloudstorage.uni-oldenburg.de/s/oaynisfQ5bPH5tM

Abstract

Spatial distributions of species traits are shaped by adaptation and competition which are typically local processes affected by environment and exchange of traits between communities. Migration and dispersal can generate a strong local species turnover. Although new immigrants might initially replace only a part of the local trait spectrum, their introduction can ultimately affect the entire community. Thus, changes in the trait distribution of one community caused either by a local environmental change or by demographic stochasticity can cascade to adjacent patches causing there, either replacement of resident species or

adaptive/maladaptive changes of resident species traits. Spatial heterogeneity plays an important role in community dynamics. The agreement between local and regional relationships might be full, partial or non-existent at all. For instance, losses of species richness at the global scale not necessarily lead to a decrease of species richness at regional and local scales, as well as any changes in richness at local scales will not necessarily be reflected in regional and global trends. Thus, it is important to consider space as a crucial factor affecting species adaptation and dynamics of adaptive meta-communities. In adaptive meta-communities some local parts can serve as a rescue for rare genes, which might currently not be suitable for most habitats but which might later compensate for losses in species fitness caused by abrupt environmental changes. Local adaptation can be fast in isolated communities under stable environmental conditions. In connected communities, adaptation might either be speeded up by dispersal of suitably adapted genes, but can be also suppressed, when local disturbances are common and environmental variability is large. Models predict a strong effect of dispersal and evolution on biodiversity trends across environmental gradients. Furthermore, a change in environmental conditions might create extinction and evolutionary debts, causing delayed cascading changes in trait distributions. In addition to abiotic factors, the rates and boundaries of species adaptation are subject to some biotic constraints, such as stoichiometry, allometric scaling, and resource use efficiency. Thus, to quantify biodiversity changes and to predict future trends, it is important to understand how the spatial scaling of species adaptation affects resilience, turnover rates, biodiversity and functioning of adaptive metacommunities.

Synthesis group 4: "Combining empirical studies: Insights from small-scale experiments to mesocosms and field studies"

Chairs: Maria Stockenreiter and Herwig Stibor (LMU)

For PDFs of papers relevant to this topic, see
https://boxup.uni-potsdam.de/index.php/s/V3UwPtPwcga1Wem

Password: dynatrait

Abstract

There is a substantial body of studies investigating responses of food webs to altered environments in well-controlled and highly replicated small scale microcosm experiments. However, their realism is limited and a variety of theoretical and empirical studies indicate that their abilities to predict responses to large-scale perturbations vary. Scale transition theory shows that dynamics on larger spatial scales differ from predictions based on the local dynamics alone. Aquatic ecologists often use mesocosm experiments to upscale microcosm analyses to larger scales and higher environmental complexity. For example, mesocosm studies can be used to investigate whether traits, which are responsible for biodiversity - ecosystem function relationships in laboratory plankton communities are also relevant for natural plankton populations. If that is the case, the consequences of losing important ecophysiological traits cannot easily be predicted from laboratory studies alone, in particular, if complex interactions and feedback loops occur. However, increasing complexity often entails a loss of experimental control and replicability, often being nonexistent in comparative field studies. Costs and benefits of different experimental scales are well known, but seldom are advantages of different scales considered in complementary ways. We will compare results from microcosm and mesocosm/ field experiments investigating food web dynamics and discuss how scale and complexity interfere with experimental outcomes and conclusions. Additionally, we will discuss strategies how different experimental scales could be used complementarily to derive more robust and general insights into ecological dynamics.

Abbreviations of affiliations

AWI – Alfred-Wegener-Institute - Helmholtz-Centre for Polar and Marine Research, Bremerhaven / Helgoland, Germany
DTU– National Institute of Aquatic Resources. Centre for Ocean Life. Technical University of Denmark, Denmark
EAWAG – Swiss Federal Institute of Aquatic Science and Technology, Dübendorf, Switzerland
GEOMAR – Helmholtz-Zentrum für Ozeanforschung, Kiel, Germany
HZG – Helmholtz-Zentrum für Material- und Küstenforschung Geesthacht, Geesthacht, Germany
ICBM – Institute of the Chemistry and Biology of the Marine Environment, Oldenburg, Germany
IGB – Leibniz-Institute of Freshwater Ecology and Inland Fisheries, Berlin, Germany
LMU – Ludwig-Maximilians University of Munich, Munich, Germany
McGill – McGill University, Montreal, Canada
MSU - Michigan State University, USA
RUB – Ruhr University Bochum, Bochum, Germany
Scripps – Scripps Institution of Oceanography, UC San Diego, USA
UFZ – Helmholtz-Zentrum für Umweltforschung, Leipzig / Magdeburg, Germany
U Bergen – University of Bergen, Bergen, Norway
U Umeå = Umeå University, Umeå, Sweden
U Cologne – University of Cologne, Cologne, Germany
U Constance – University of Konstanz, Konstanz, Germany
U Potsdam – University of Potsdam, Potsdam, Germany
ZMT – Leibniz Center for Tropical Marine Ecology, Bremen, Germany

Locations

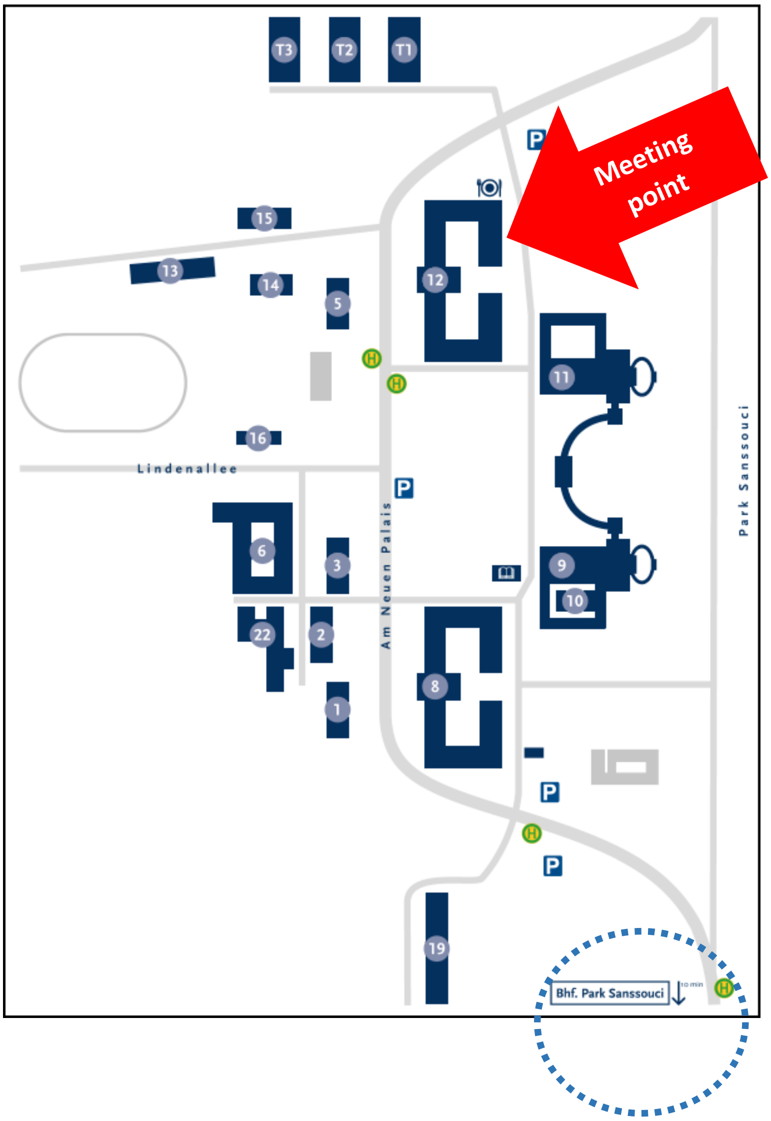
If you need assistance: call Alice: +49 177 88 99 329

The fastest way to get to the Campus Am Neuen Palais of the University of Potsdam is to take the regional train RE1 or RE21 to the station “Park Sanssouci Bahnhof”. You can walk from here in 15min to the University campus or take the bus (2 stops).

Bus numbers 605, 606, and 695 leave from there – the bus stop is 50m away when you exit the trait station. Take the bus in direction towards the city center (695 “Hauptbahnhof”) or “Wissenschaftspark Golm” (605, 606). Exit at the bus stop “Campus Universität / Lindenallee” (2 stops from the station Potsdam Sansscouci, see map below). The bus station “Campus Unversität / Neues Palais” can also be reached from Potsdam Hauptbahnhof in 25min by the same buses (coming from the other direction). Buses leave about every 20min from Bus stop “Campus Universität / Lindenallee” in both directions until midnight.

The one-way ticket prices in Potsdam are 1.50 EUR for 4 consecutive stations (“Kurzstrecken-Ticket”) and 2.10 EUR for longer trips (“Potsdam AB Ticket”) independent of the mode of transport (bus, tram, regional train). There is also a “4-Fahrten-Karte” at a reduced price (instead of buying 4 tickets for 4 trips). If you go to Berlin, all tickets are more expensive and the fare system is more complex. Please check out prices at https://www.vbb.de/en/tickets (and www.bvg.de).

In Potsdam, you need to present your ticket to the driver or buy a ticket at the vending machine inside of the bus. The drivers do NOT sell tickets. In Berlin, you also have to show your ticket to the bus driver who sometimes sell tickets, but there are also plenty of vending machines at larger stations (buy in advance: often the easier option!).



Left: Campus map of Am Neuen Palais, University of Potsdam. **The plenary room "Obere Mensa" is located in house no. 12, first floor, at the Campus Am Neuen Palais (red arrow).** The closest bus stop is called "Campus Universität / Lindenallee" served by lines 695, 606, and 605. You can also walk from the trait station at "Bahnhof Park Sanssouci" (see blue circle at the bottom right) in about 10min. We will put up signs to help you find the room.

In addition to the plenary room, there are two seminar rooms at the ground floor in house 12.

The **dinner location on Tuesday** (paid by DynaTrait) is the Indian Villa at Hegelallee 5 in Potsdam close to the city center. You can get there by walking with us through Park Sansscouci (35min, but nice walk!) or taking bus 695 from Neues Palais in direction of the city centre. Get out after about 20 min at bus stop "Jägertor/Justizzentrum".

Directions to Indian Villa from Neues Palais:
https://www.google.com/maps/dir/Am+Neuen+Palais,+Potsdam/Restaurant+%E2%80%9EINDIAN+VILLA%E2%80%9C,+Hegelallee+5,+14467+Potsdam/@52.3980725,13.0247435,15z/data=!3m1!4b1!4m14!4m13!1m5!1m1!1s0x47a8f43dab478cc5:0x2505323c369cee33!2m2!1d13.0124867!2d52.4001224!1m5!1m1!1s0x47a8f5d0ae824055:0x8dace34ecc798923!2m2!1d13.0559984!2d52.403594!3e3

The **dinner location on Wednesday** (optional) will be a restaurant in 20-30min walking distance from the meeting place. We will ask you on Monday where you want to go and how many people want to join the group. Options are Sala Thai €-€€, a Thai restaurant close to the citiy center, Dortusstrasse with plenty of vegetarian and some vegan options. Or the casual "fusion-cuisine" restaurant Alex within the mall at Platz der Einheit which also has a broad variety of veggie / vegan meals.

List of participants

We expect about 60 participants. In alphabetical order of last names:

Title	First name(s)	Last name	Affiliation	Country
Dr	Esteban	Acevedo-Trejos	ZMT	Germany
Dr	Carlo	Albert	Eawag	Switzerland
Ms	Verena	Bamberger	RUB	Germany
Dr	Alice	Boit	U Potsdam	Germany
Mr	Ruben	Ceulemans	U Potsdam	Germany
Dr	Subhendu	Chakraborty	U Copenhagen	Denmark
Dr	Evangelia	Charalampous	GEOMAR	Germany
Prof	Sebastian	Diehl	Umeå University	Sweden
Dr	Straile	Dietmar	U Constance	Germany
Dr	Elias	Ehrlich	U Potsdam	Germany
Dr	Patrick	Fink	UFZ	Germany
Dr	Sabine	Flöder	U Oldenburg / ICBM	Germany
Prof	Gregor	Fussmann	McGill University	Canada
Prof	Ursula	Gaedke	U Potsdam	Germany
Mr	Ovidio	García Oliva	HZG	Germany
Dr	Lynn	Govaert	Eawag	Switzerland
Prof	Hans-Peter	Grossart	IGB	Germany
Dr	Michal	Grossowicz	GEOMAR	Germany
Mr	Jorin	Hamer	GEOMAR	Germany
Dr	Giannina	Hattich	GEOMAR	Germany
Prof	Hillebrand	Helmut	ICBM	Germany
Mr	Ruben	Herman	U Constance	Germany
Prof	Helmut	Hillebrand	ICBM	Germany
Dr	Teppo	Hiltunen	U Helsinki	Finland
Dr	Peter	Isles	Eawag	Switzerland
Ms	Nadja	Kath	U Potsdam	Germany
Dr	Kasia	Kenitz	UC San Diego / Scripps	USA
Dr	Onur	Kerimoglu	HZG	Germany
Prof	Thomas	Kiørboe	DTU	Denmark
Dr	Toni	Klauschies	U Potsdam	Germany
Prof	Christopher	Klausmeier	Michigan State University	USA
Mrs	Helena	Klip	AWI	Germany
Dr	Kathrin	Lampert	U Cologne	Germany
Mr	Christian	Laumen	RUB	Germany
Ms	Xiaoxiao	Li	U Potsdam	Germany
Prof	Elena	Litchman	Michigan State University	USA
Dr	Kai	Lohbeck	U Constance	Germany
Dr	Tom	Lorimer	Eawag	Switzerland
Dr	Birte	Matthiessen	GEOMAR	Germany
Mrs	Ewa	Merz	Eawag	Switzerland
Dr	Grossowicz	Michal	GEOMAR	Germany
Dr	Stefanie	Moorthi	U Oldenburg / ICBM	Germany
Dr	Thomas	Mridul	DTU	Denmark

Mrs	Anita	Narwani	Eawag	Switzerland
Dr	Markus	Pahlow	GEOMAR	Germany
Prof	Frank	Peeters	U Constance	Germany
Dr	Friederike	Prowe	GEOMAR	Germany
Dr	Silvia	Pulina	GEOMAR	Germany
Mr	Tom	Réveillon	U Constance	Germany
Mr	Tobias	Romankiewicz	U Cologne	Germany
Dr	Alexey	Ryabov	U Oldenburg / ICBM	Germany
Dr	Våge	Selina	U Bergen	Norway
Dr.	Tom	Shatwell	UFZ	Germany
Dr	Maria	Stockenreiter	LMU	Germany
Dr	Dietmar	Straile	U Constance	Germany
Dr	Maren	Striebel	U Oldenburg / ICBM	Germany
Dr	Mridul	Thomas	DTU	Denmark
Mr	Patrick	Thomas	U Oldenburg / ICBM	Germany
Ms	Patch	Thongthaisong	IGB	Germany
Ms	Jessica	Titocci	U Cologne	Germany
Dr	Wojciech	Uszko	Swedish University of Agricultural Sciences	Sweden
Dr	Linda	Weiss	RUB	Germany
Prof	Markus	Weitere	UFZ	Germany
Prof	Kai	Wirtz	HZG	Germany