Poster Abstracts

6.1

1. Zooplankton seasonal vertical migration in an optimality-based plankton ecosystem model

Markus Pahlow, GEOMAR, 6.1

Several species from various zooplankton taxa perform seasonal vertical migrations (SVM) of typically several hundred meters between the surface layer and overwintering depths, particularly in high-latitude regions. One hypothesis explains SVM as a strategy to reduce exposure to visual predators during winter. We use the 1D OPPLA (OPtimality-based PLAnkton ecosystem model) to simulate SVM behavior in zooplankton in the Labrador Sea and compare the success of the migrating and non-migrating species. A sensitivity analysis of SVM related parameters suggests that SVM traits can exert strong control on the plankton community. SVM affects the timing and extent of primary production and the seasonal cycle of inorganic nutrients. In particular, species doing SVM can persist and even dominate the summer-time zooplankton community, even in the presence of cheaters — zooplankton that have the same traits as the migrators, but avoid performing SVM. The presence of higher (visual) predators make the cheaters disappear quickly in our simulations, whereas SVM can persist in the presence of non-migrating species even without higher predators.

2. Long-term changes in the coastal Baltic Sea

Helmke Hepach, GEOMAR, 6.1

We here present assessments of the time series station Boknis Eck located in the coastal Southwerstern Baltic Sea in the Eckernförde Bay. Boknis Eck is one of the longest-sustained time series in the world with first measurements starting in April 1957. Despite recent efforts to reduce anthropogenic pressures on the Baltic Sea ecosystem, such as reducing the influx of inorganic nutrients, the Baltic Sea habitats continue to degrade. We here present data of bacterial abundance and productivitiy as well as dissolved organic matter to assess their impact on the state of the ecosystem. Furthermore, we show first analyses of phytoplankton biodiversity in the Eckernförde Bay between 2010 and 2020.

3. From Farm to Sea: Investigating the impact of Seaweed Aquaculture on species geographic distribution and seaweed population structure

Janina Brakel, HIFMB, 6.1

In the Anthropocene, human activities like aquaculture may impact marine coastal ecosystems. Intentional or unintentional introduction of organisms for aquaculture, and conscious and unconscious selection of aquaculture stock - when these interact with wild populations - affect marine species distribution, and population genetic structure and connectivity of the cultivated species, but also associated species. Currently, the fastest growing sector of aquaculture is the cultivation of seaweeds. It has become a major driver of economic activity in many coastal communities worldwide. Taking one of the largest sectors of seaweed cultivation as an example, the cultivation of carragenophytes (red algae) for carrageenan extraction, we investigated through an

international consortium genetic diversity and distribution of cultivated red algae species for carrageenan production, in wild populations as well as in seaweed farms. We also examine pattens of distribution and diversity of associated organisms, specifically of epiphytical filamentous red algae (EFAs) that are considered a pest. Here, I will present research from my past and present postdoc position, investigating species distribution and population genetic structure between farm and wild populations, and geographic locations. My research aims to understand better consequences of marine species domestication within coastal ecosystems to provide data for an improved management in support of a sustainable seaweed aquaculture sector.

4. A Line in the Ocean, 30 by 30: Ocean Borders and Carceral Limits
Alexa Obando Campos, HIFMB 6.1

There are currently calls for 30% of the seas and oceans to be zoned for protection and management by 2030. These targets rely on the establishment of designated areas of space to manage ocean health, marine biodiversity and to balance competing economic uses and environmental pressures. This type of percentage-based target for the conservation and restoration of seas and oceans, have been central to global governance efforts. In this context, we understand governance as an inherently geographical process and an exercise of power at the sea which is neither neutral nor apolitical.
The project will explore the 30x30 campaign (through some cases studies), its conservation goals and its carceral logics, with the objective of politicize conservation process and understand it as a geopolitical. These are some initial questions that arise: Who is enforcing this? Can this create a process of militarization of the sea and surveillance mechanism? How state involve new private actors to expand control? Who benefits and who losses?

5. Macroalgal biodiversity and biomass of Kongsfjorden through time and space
Luisa Düsedau, AWI 6.1/6.2

The Arctic Svalbard archipelago is one hotspot of global warming and Kongsfjorden (W- Svalbard) experiences a continuous increase in seawater temperature, glacial melt, freshwater run-off and sedimentation. In 1996/98, 2012-14 and 2021 seaweed biomass, species diversity and depth distribution of kelps were quantified at our study site in order to identify potential changes over time. We repeated the earlier studies by stratified random sampling along a sublittoral depth transect (0, 2.5, 5, 10 and 15 m; 1x1 m^2 frames; n=3) and documented the lower depth distribution of kelps at 2-20 m depth. With 21 biomass dominant species collected in 2021, the biodiversity along the depth transect remained stable. In contrast, the lower distribution limit and the relative abundance of all kelp species severely decreased. Between the 1st and 2nd study, the biomass maximum doubled and shifted upwards from 5m to 2.5m depth. Although this pattern did not change in 2021, the community structure shifted from a Laminaria digitata/Hedophyllum nigripes based community to an Alaria esculenta dominated kelp forest. In 2021, Alaria esculenta was the only kelp species present at 10m depth while the other kelps retreated to shallower waters. Comparison of kelp demography in 2013 and 2021 revealed a change in dominance relationships between age classes.

Presently, a kelp forest with a balanced age distribution is only found at 2.5m depth. Our time series reveals consequences of increasing turbidity and decreasing light availability for Arctic kelp forests in an environment in transition.

6. A comprehensive eDNA metabarcoding survey of gelatinous zooplankton biodiversity in a changing Arctic

Ayla Murray, AWI 6.1

The Arctic is warming four times faster than the global mean and the 'Atlantification of the Arctic' via Fram Strait is evident in the increasing changes to both physical and biological processes in the region. Greater understanding of how these changes are impacting local marine biodiversity is crucial for management and mitigation decisions, as well as formulating accurate predictions of future marine ecosystems. Gelatinous zooplankton (GZP) are a highly diverse group of taxa, including cnidarians, ctenophores and pelagic tunicates and can have a wide range of ecosystem impacts. Little is known about GZP diversity and distributions in the Arctic Ocean, and even less about how they are being impacted by climate-related changes. This is because they are notoriously difficult to catch in good condition and are often actively left out of zooplankton surveys, which has led to a lack of reliable and comprehensive baseline datasets, especially in the Arctic Ocean. Here we investigate GZP biodiversity across different systems in the Atlantic side of the Arctic, using eDNA metabarcoding. We compare diversity and distributions in different water masses (Atlantic vs Arctic waters), habitats (pelagic and under-ice environments), regions (coastal fjords and open water systems) and seasons (Polar Day and Polar Night). Cytochrome c oxidase I and 18S rDNA amplicons were sequenced using the Illumina NovaSeq platform and validated with net catch data from the same period and localities where possible. This data represents a valuable contribution to future research on changing GZP biodiversity and community composition, as well as biomonitoring of rare and non-indigenous species in a changing Arctic.

7. Integrative 'omics to investigate marine microbial diversity

Florian Trigodet, AWI 6.1/6.2

In a world of big data microbiology, many computational tools have emerged to enable the exploration of microorganism's lifestyle and diversity. This generation of computational tools have been the foundation of the current multi-omics era. These software tools have been used to create "workflows" that make specific analysis accessible to life scientists, but also constraining the questions that can be asked. We have introduced anvi'o (analysis and visualization of 'omics data) as an alternative solution to empower microbiologists with the freedom to address their questions from their data. With its modular infrastructure, anvi'o allows for flexibility, interactivity, reproducibility and extensibility. More than 100 interoperable programs, each performing individual tasks, can be combined to create new and unique 'omics workflow. Our group have been using anvi'o to investigate marine microbial diversity through the combination of multiple 'omics strategy. For instance, we have been able to combine microbial population genetics with protein biochemistry to characterized the population structure of a subclade of SAR11, one of the most abundant microbial populations in the ocean. This single project successfully combined metagneomics, pangenomics, phylogenomics and protein structure prediction. Generating hundreds

of millions of sequences for a single sample is now commonplace for microbiologist and with integrative, community-led software like anvi'o, the creative thinking required to make sense of this big data is no longer limited by analytical frameworks.

8. Reactivity-based analysis of network motifs reveals vulnerability hotspots in ecological food webs

Melanie Habermann, HIFMB 6.1

The representation of complex systems as dynamical networks is a useful approach to identify driving factors behind observed dynamics. The question how the network structure and specific smaller patterns (i.e., network motifs) within the network influence the system and may cause certain dynamics is especially interesting. Typical stability analyses have not yet shown clear results. Here, I introduce an approach that uses the reactivity of a system to quantify the contribution of network motifs in driving the system's behavior. Specifically, I demonstrate how this method can be applied to ecological food webs to identify vulnerable regions inside the network that are particularly susceptible to perturbations.

9. High-throughput microcosm approach reveals bacterioplankton dose-, species-, and form dependence to phytoplankton organic matter

Marjan Ghotbi, GEOMAR 6.1/6.2

The marine microbiome modulates oceanic biogeochemical cycles and is strongly influenced by microbe-to-microbe interactions, including interactions between phytoplankton (the base of the food web) and heterotrophic bacteria. These interactions range along a continuum of positive to negative impacts on the phytoplankton, affecting ecosystem function, and are difficult to discern in the complex natural environment. Controlled lab experiments offer the ability to advance understanding of the specificity, stability, and dynamics of microbe-to-microbe interactions, but are often limited in the scope and range of conditions tested. To address this, we are developing and streamlining a high-throughput 96-well microcosm approach that facilitates varying numerous important ecologically relevant factors in a single experiment. Here, we apply this approach to explore how phytoplankton bloom species, scale, and stage impact bacterioplankton response by observing wild bacterial community response to different doses and forms – as growing cells, necromass, and DOM – produced from three species of phytoplankton, Chaetoceros calcitrans, Prorocentrum minimum, Rhodomonas salina. Daily samples were taken from microcosms over 12 days for biomass and microbial community composition. We observed distinct bacterial communities in response to different treatments, for example predominance of Vibrionaceae with phytoplankton necromass, Marinomonadaceae with dilute live phytoplankton, Pseudoalteromonas with higher concentration of live phytoplankton and DOM, and Rhodobacteraceae with DOM. These results suggest different conditions select for different bacterial communities that inform the function of marine microbiomes at micro and macro scales.

6.2

10. Assessing baleen whale exposure to algal toxins in unexplored feeding grounds

Marina Arregui Gil, AWI 6.2

Harmful algal blooms (HABs) and the phycotoxins they produce negatively affect marine wildlife and public health. Moreover, many phycotoxins variants and their potential negative impacts are still unknown. Among marine organisms, most baleen whale species perform long seasonal migrations between breeding and feeding grounds. In the last ones, they ingest large quantities of prey, thus, being potentially at a high risk of phycotoxin exposure when feeding in temporal and spatial association with HABs and associated toxins. Despite this vulnerability, baleen whale phycotoxin exposure on these grounds remains largely unknown worldwide. This postdoctoral project aims to partially fill this gap by assessing baleen-whale phycotoxin exposure in various temperate and subtropical whale feeding grounds where HABs and associated phycotoxin frequently occur. Current efforts are focused on optimizing the phycotoxin extraction protocols in marine mammal (MM) samples for proper subsequent quantification. The reasoning for this is that the knowledge of the impact of phycotoxins on MMs is limited, and there is no standardized protocol for phycotoxin analysis by HPLC-FLD and LC-MS/MS for these animals. Also, working with MMs tissues and fluids is challenging and often limits sample availability. Thus, minimizing the amount of samples used and reducing the matrix effects of these complex samples is essential. It is expected that the outcome of this project will provide a baseline for future comparisons in a global warming scenario where HABs are expected to increase in frequency and duration, and thus, adverse effects on MM populations might also be aggravated.

11. A Jekyll-and-Hyde seaweed pathogen

Florian Weinberger, GEOMAR 6.2

Most - if not all - macroalgae live in symbiosis-like relationships with microorganisms and manipulation of symbionts could provide new opportunities for improved and more efficient management of seaweeds. Hence, we intended to investigate whether the sensitivity of the red alga Gracilaria vermiculophylla to bacterial pathogens can be increased by inoculation of protective microorganisms. Thallus bleaching is frequently observed in Gracilaria, and Pseudoalteromonas arctica and some other bacterial taxa are known inducers of the symptom. The virulence of these facultative pathogens was demonstrated to be controlled by an array of other bacterial taxa, among them Pseudoalteromonas sp. strain GNORD11, a species that has not yet been described. P. arctica induced disease symptoms in Gracilaria when more than 20 cells ml-1 were inoculated. Surprisingly, the supposed protector GNORD11 also induced disease symptoms when between 30 and 30 000 cells ml-1 were inoculated. However, at higher cell densities no virulence was observed and GNORD11 even prevented the virulence of P. arctica. Strain GNORD11 thus behaves according to the Jekyll-and-Hyde principle, which predicts that certain symbionts may shift between mutualistic and antagonistic behaviour toward their host. Our study highlights the complexity of seaweed-microbiome interactions and the necessity of a more complete understanding of factors that control mutualism and antagonism.

12. Single Cell Sorting to support your research
Kristina Bayer, GEOMAR 6.2

In our research unit we are running the MoFlow Astrios EQ High-Speed Single Cell Sorter from Beckman Coulter which provides us with various possibilities to sort out specific cells (or particles) of interest from your sample at a validated performance of 70,000 sort decisions/second (>100,000 events/second acquisition rate validated performance). Equipped with 4 lasers (355nm, 488nm, 561nm, 642nm) we can detect up to 18 fluorescence parameters simultaneously. We analyze your sample and sort up to six specific populations of interest simultaneously in tubes, or in diverse formats from agar-, or well plates (up to 1536 well) or directly on microscopic slides. The sorted cells (as bulk or as single cells) can be used for downstream genomic, transcriptomic or proteomic applications or to culturing purposes. If you have specific applications we would love to collaborate with you on the possibilities the sorter provides. The Pposter will also show some examples from past and current projects.

13. Decoding the timing mechanisms of maturation and reproduction
Gabriele Andreatta, AWI (Kristin Tessmar-Raible Group)

Animals exploit environmental cycles to orchestrate key events in their life-cycles. However, this fundamental synchronization is challenged by climate change and anthropogenic impact, making the understanding of the underlying mechanisms paramount for species and ecosystems survival. We use the genetically-tractable marine bristle worm Platynereis dumerilii to investigate how sexual maturation and reproduction are properly timed. This species coordinates such processes with the lunar cycle, a very widespread phenomenon in marine environments, yet poorly understood at the molecular mechanistic level. To fill this knowledge gap, we characterized a maturation delay and an altered lunar reproductive timing in a knockout strain for the light-sensitive cryptochrome (L-Cry). Surprisingly, the lack of this photoreceptor determines a delay in germline development, resulting in a significant lifespan extension. Moreover, this developmental delay seems to impact on the monthly timing of the last maturation event which precedes spawning. Interestingly, our molecular analyses and quantitative RNAseq identify the endocrine system as a major target of L-Cry signalling. Notably, we find altered expression of NR0B, the ortholog of vertebrate DAX-1/SHP, key factors for gametogenesis and steroidogenesis, and absent in other major invertebrate groups. Our study reveals remarkable changes in life-history traits associated to the loss of a photoreceptor and unveils unexpected similarities in the endocrine dynamics regulating invertebrate and vertebrate sexual maturation. Extending these analyses into an eco-evo direction, in the MSCA project MOM-OR-DAD starting next year, I plan to investigate the molecular and genomic basis underlying the evolution of reproductive strategies and reproductive timing using Platynereis worms as models.

14 Acute warming differentially affects protein and energy metabolism in polar and temperate eelpout
Nina Krebs, AWI 6.2

Ectotherm metabolism is highly dependent on ambient temperature which affects aerobic scope as an essential trait for e.g. growth performance. Here, we examined the effects of acute warming in a polar stenothermal fish, the Antarctic eelpout Pachycara brachycephalum, compared to its closely related North Sea counterpart, the eurythermal common eelpout Zoarces viviparus. At different temperatures, we examined whole-animal oxygen consumption rates and collected white muscle samples to determine protein synthesis rates, protein degradation and changes in metabolite levels.

15. Intertidal Oysters under Anthropogenic Pressure Does microplastic limit the tolerance to climate warming?

Nina Paul (AWI), 6.2

Microplastics (MP) have been identified as an emergent environmental threat, especially for filter-feeding organisms. Most studies however used unrealistic high MP concentrations, experimental setups mimicking just the subtidal habitat, or neglected the potential synergistic risk of MP under climate warming. This study focused on effects of environmentally realistic MP concentrations on the metabolism of intertidal Pacific oysters (Crassostrea gigas). Based on their natural habitat, the oysters experienced a simulated semidiurnal tidal cycle (9 h:3 h immersion:emersion) at 16 °C and were exposed to different concentrations (0 µg/L, 0.025 µg/L, 25 µg/L) of a mixture of polystyrene MP beads (4 µm, 7 µm, 10 µm, at equal weight). In vivo uptake of MP was visualised using nuclear magnetic resonance imaging (MRI). Dose- and time-dependent effects of MP were analysed in gill and digestive gland tissues along the exposure period (0d, 3d, 12d). At the end of the incubation, a group of oysters experienced rising air temperature during the final low tide simulation (3 °C/h) for investigating potential effects of MP on their susceptibility to warming. Untargeted metabolic profiling based on 1H-nuclear magnetic resonance (NMR) spectroscopy revealed dose-dependent disorders in gill metabolome. Elevated glutamate and homocysteine levels suggest affected energy metabolism and ongoing oxidative stress, respectively. Additionally, high MP concentrations induced the same changes in gill metabolome like short-term warming during simulated low tide without MP. These findings may suggest potential synergistic or antagonistic effects of combined MP exposure and warming. Further research needs to clarify potential consequences for intertidal oyster populations.

6.3

16. Can oxygen utilization rates track the long-term trend of mesopelagic respiration?

Haichao Guo, GEOMAR 6.3

The ocean is losing oxygen due to an imbalance in oxygen supply and aerobic respiration. Therefore, monitoring the temporal changes in the aerobic respiration is essential to quantitatively understand the contribution of biogeochemical processes to oceanic oxygen change. By analyzing results from simulations of an Earth system model, we investigate whether the classical OUR (oxygen utilization rate) approach can be used to reliably diagnose changes of the respiration rate in the mesopelagic zone. OUR is calculated as the ratio of the gradients of the apparent oxygen utilization (AOU, saturated oxygen concentration minus local oxygen concentration) and seawater age that can be computed from transient abiotic tracers. Results show that in intermediate waters of the North Atlantic Subtropical Gyre (200m-1000m), vertically integrated OUR shows the same trend (decrease by around 0.2 mol O2/m2/y) as the model's vertically integrated true respiration for the time period 1850 to 2100. However, in our second study region, the mesopelagic Tropical South Atlantic, integrated OUR increases by 0.2 mol O2/m2/y, while the local true respiration decreases by 0.3 mol O2/m2/y, i.e. the trend in OUR is significantly different from that of true respiration (p-value << 0.0001). We identify changes in water mass mixing over time, affecting AOU and age in different ways, as one explanation for the divergence of changes in OUR and true respiration in this region.

17. Accounting for bottom-up driver interactions and ocean acidification alters model projections of future phytoplankton communities

Miriam Seifert, AWI 6.3

Large-scale ocean biogeochemistry models usually consider nutrients, light availability, and temperature as growth-controlling factors of phytoplankton. Ocean acidification and modified responses to one driver by changes in another driver (referred to as driver interactions) are at present not taken into account in these models. Potentially, this leads to incomplete projections of future phytoplankton biomass. In the presented work, we first parameterized growth sensitivities to changes in the carbonate system. We then used the results of a meta-analysis on driver interactions (carbonate system x temperature x light) to develop model parameterizations. The parameterizations were tested in the biogeochemistry and phytoplankton functional type model REcoM under present-day and future conditions. While future phytoplankton biomass decreases by a similar amount with and without driver interactions (5-6%), interactive effects become visible on a group-specific level. Once driver interactions are considered, the biomass of diatoms and small phytoplankton decreases by -8.1% and -5.0%, respectively, and the biomass of coccolithophores increases by +33.2% from present-day to future conditions on a global scale. In comparison, the biomass of diatoms, small phytoplankton, and coccolithophores changes by 0.0%, -9.0%, and -10.8%, respectively, in

simulations without driver interactions. Hence, projections of the global future phytoplankton community shift towards a larger share of small phytoplankton and coccolithophores and a smaller share of diatoms if driver interactions are taken into account. Our studies reveal that model projections may miss out important information on the future phytoplankton community composition and group-specific direction of change if driver interactions and ocean acidification are not considered.

18. The imprint of sea ice cover on benthic carbon mineralization in the Southern Ocean

Moritz Holtappels, AWI 6.3

The Seasonal Ice Zone (SIZ) around Antarctica covers an area of 19 Mio km2 and is considered the largest biogeochemical province in the Southern Ocean. Despite a well-documented control of sea ice on primary production, its large-scale effect on the biological carbon pump, i.e. the sinking of organic carbon into deep waters and ultimately to the sediments, remains poorly constrained. Here we demonstrate that the degree of sea ice cover during the growth season is a strong predictor for carbon re-mineralization rates in underlying sediments. We compiled all available benthic rate measurements for the SIZ and found that 80% of their variability can be explained by two environmental factors, (i) the long-term occurrence of moderate sea ice cover and (ii) water depth (i.e. the Martin curve).
We constructed a simple empirical model to estimate benthic carbon re-mineralization for the entire SIZ, resulting in a rate 46 Tg C per year, of which 71% can be assigned to shelf sediments of less than 1000m water depth. Applying the empirical function of Dunne et al (2007) for the burial rate, the total organic carbon supply to the sediments was estimated to be 52 Tg C per year and the carbon export from the euphotic zone (<100m) was calculated to be ~500 Tg C per year.

19. Effects of Ocean Alkalinity Enhancement in the deep and bottom water formation regions on the 21st century CO2 uptake in low and high emission pathways.

Tanvi Nagwekar, AWI 6.3

Subduction regions are crucial for transferring and sequestering carbon in the deep ocean over multi-decadal to centennial timescales. We hypothesize that Ocean Alkalinity Enhancement (OAE), a Carbon Dioxide Removal (CDR) method based on olivine dissolution, is more effective in enhancing oceanic CO2 uptake in deep and bottom water formation regions. Using the FESOM2.1-REcoM3 ocean-only model, we quantify the response of olivine addition (alkalinity, iron, silicic acid) over 2030-2100 under SSP1-2.6 and SSP3-7.0 scenarios. We deposit 3 Pg olivine/yr globally and 0.22 Pg olivine/yr regionally, focusing on major deep and bottom water formation areas in the Southern Ocean, Labrador, and Norwegian Sea for regional application.
CO2 uptake for SSP1-2.6 (SSP3-7.0) scenarios increases by 1.2 (1.2) PgC/yr globally and 0.2 (0.2) PgC/yr regionally. Despite smaller olivine deposition area, regional case shows 2.3-fold higher CDR potential, primarily due to enhanced

biological activity in the Southern Ocean from nutrient fertilization, accounting for 80% of CDR. However, nutrient addition favors small-phytoplankton calcification for global and regional case, leading to lower surface alkalinity in the last decade of the simulations. Interestingly, CDR potential of adding alkalinity only is 4% (3.3%) higher in the subduction regions than in global OAE under the SSP1-2.6 (SSP3-7.0). Southern Ocean shows the deepest carbon penetration (upto ~4000m) than other ocean basin majorly due to nutrient effect. Overall, subduction regions demonstrate higher CDR efficiency in both cases (alkalinity+nutrients, only alkalinity addition), with a two-order magnitude larger effect when nutrients are included, due to Southern Ocean iron fertilization.

20. Modelling Biogenic Aerosol Precursors in the Arctic Ocean: Occurrence patterns and long-term trends

Moritz Zeising, AWI 6.3

Especially in remote regions such as the Arctic Ocean, cloud properties can be affected by the transfer of biogenic aerosol precursors from the upper ocean into the atmosphere. As measurements in the Arctic are still sparse in time and space, we present a setup of the coupled ocean biogeochemical model FESOM2.1-REcoM3 where we integrated dissolved carboxylic acid containing polysaccharides (PCHO) and Transparent Exopolymer Particles (TEP) to simulate these biogenic aerosol precursors. The simulation results in an estimate of 200-400 µg C L-1 TEP on the continental shelves and 10-50 µg C L-1 in the central basins (0-30 m depth range). Furthermore, the model simulates a significant positive trend of TEP of 0.5-3 µg C L-1 yr-1 during July-September in the Amerasian Basin (+3.5% yr-1), the Canadian Archipelago (+1.2% yr-1) and the Kara Sea (+0.8% yr-1), in contrast to the eastern Fram Strait (-0.4% yr-1), the Barents Sea (-0.3% yr-1), and parts of the Eurasian Basin with a significant decrease of -0.5-2 µg C L-1 yr-1. The overall model results fit to observational studies and can be used as a baseline to study the effects of local aerosol production in the Arctic realm, and as such, enhance our understanding of aerosol feedbacks contributing to Arctic Amplification.

21. Coastal sources of iron from South Georgia are differently bioavailable to phytoplankton

Jasmin Stimpfle, AWI 6.3

In vast regions of the Southern Ocean, phytoplankton productivity is limited by the micronutrient iron (Fe). Besides the amount of Fe in seawater, its bioavailability i.e., the Fe chemical species that can be acquired by phytoplankton, governs primary production and consequently biological sequestration of carbon dioxide. The sources of Fe that fuel extensive open ocean phytoplankton blooms downstream of the island South Georgia (Atlantic sector of the Southern Ocean) are poorly known. To investigate the bioavailability of five coastal Fe sources (groundwater, coastal water and glacial meltwater from 3 different locations) during the Polarstern expedition Island Impact (2022), we determined Fe uptake rates by a naturally Fe-limited phytoplankton community in presence of these five Fe sources using the

radioactive tracer 55Fe. Our preliminary results show that the selected Fe sources are not equally taken up by phytoplankton, with the coastal water being highly accessible and the groundwater being least accessible.

22. Dense water driven lateral injection into the Weddell Sea basin: Latest results from the project Southern Weddell-C-Pump
Andreas Rogge, AWI 6.3

Polar dense waters are formed as a result of brine rejection during sea ice formation and heat loss. When propagating through shelf regions those water masses can also cross lee polynyas with increased primary productivity due to enhanced light availability and nutrient supply from wind-induced mixing. Fractions of the produced carbon-rich material can thereby be entrapped in polar dense waters and carried down the continental slopes into the deep ocean basins during dense water subduction. Hence, those currents can act as lateral injection pumps and increase the retention times of carbon from the atmospheric pool whereas they also represent a food source for the deep sea community. The Filchner Trough area on the southern Weddell Sea shelf is a hotspot of both, dense water transport and outflow as well as primary production in lee polynyas but investigations on lateral carbon injection into the deep Weddell Sea basin are missing. Here we show latest results from the project Southern Weddell-C-Pump within the framework of the COSMUS campaign (PS124). Combining optical particle observations with oceanographical and chemical measurements we created a carbon budget including air-sea CO¬2 flux, POC and DIC pools as well as lateral DIC and POC outflow from the shelf. We further linked our results with numerical simulations from ocean and ecological models (FESOM/REcoM2) to visualize the fate of the injected material, to estimate the potential total annual injection, and to resolve seasonal outflow patterns.

23. The Role of Ballasting, Seawater Viscosity and Oxygen for Carbon Export and Transfer Efficiencies in the Global Ocean
Onur Karakus, AWI, 6.3

The flux of particulate organic carbon (POC) from the euphotic zone to the deep ocean plays an essential role in the global carbon cycle. The efficiency of this flux is evaluated generally by the metrics ’export efficiency’ and ’transfer efficiency.’ While export efficiency summarizes both the particulate organic carbon formation and its sinking from the euphotic zone, transfer efficiency illustrates the carbon sequestration efficiency of the system. Only limited observations of both metrics are available, and there is thus considerable interest in using biogeochemical models to analyze large-scale patterns. This study aims to assess the global spatial distribution of export and transfer efficiencies. In particular, we analyze the impact of ballast minerals, seawater viscosity, and oxygen-dependent remineralization, which are often not considered in biogeochemical models, on carbon export and transfer efficiencies. Therefore, we implemented a new particle sinking routine describing the effects of the processes mentioned above on the sinking speeds and remineralization rates of the particulate organic matter into the ocean biogeochemical model REcoM. The globally integrated POC flux across the euphotic zone varies between 4.7 and 5 Pg C yr^{-1} depending on the inclusion

of the processes in the model. Our results show that the global mean export efficiency across the euphotic depth stays similar (13.7±0.2%) whether or not the effects of seawater viscosity, mineral ballasting, and oxygen-dependent remineralization were included in the model. However, the global mean carbon transfer efficiency is more sensitive and varies between 25% and 32% in the different simulations. Our results highlight that ballast minerals increase aggregate settling velocity and were more efficient in increasing transfer efficiency than both seawater viscosity and decreased remineralization due to oxygen limitations. In the model, high export efficiency only co-occurred with high transfer efficiency when zooplankton fecal pellets had a substantial contribution to the export flux.

24. Metabarcoding of Arctic deep-sea scavengers' diet suggests a role of nekton in benthopelagic coupling

Sophie Valerie Schindler, GEOMAR 6.3/6.1

Deep-seafloor communities primarily depend on organic matter from the water column above. While the influence of small sinking particles like detritus on benthic communities is well-known, the role of medium- or large sized food falls such as fish, gelatinous fauna or cephalopods is little understood. The amphipod Eurythenes gryllus is the dominant scavenger in Arctic ecosystems and was already used as natural food fall sampler, giving insight in the external carbon input in from of dead organisms sinking to the seafloor. At two stations in the Fram Strait (AWI HAUSGARTEN), a free-fall lander was deployed equipped with four traps containing inaccessible bait to attract scavengers. Trapped benthopelagic amphipods were collected, directly stored at -80°C on board and later dissected for gut contents. The stomach content of n=101 Eurythenes specimens was prepared for COI gene metabarcoding, producing 2347 unique sequences of which 57 could be assigned to 19 possible prey taxa and one crustacean-infesting parasite. Prey sequences were found in 24 Eurythenes specimens, including six cephalopod taxa (Cirroteuthis, Gonatus, Abralia, Discoteuthis, Leachia, Onychoteuthis), ten fish taxa (Melanogrammus, Hippoglossoides, Lycodes, Liparis, Platichty, Chirolophi, Triglops, Scomber, Boreogadus, Amblyraja), one crustacean (Pasiphea tarda) and two mammals (Erignathus barbatus and Lagenorhynchus albirostris). In nine amphipods, the crustacean parasite Hematodinium sp. was detected. The findings suggest the significance of mid-sized and mid-water organisms as carbon source and expand Eurythenes' known dietary range. The Arctic Ocean's strong benthopelagic carbon coupling may face weakening due to global warming and further investigation of these results will help understanding this vulnerable ecosystem.

25. Assessing the global ocean carbon sink: Data-assimilation into an ocean biogeochemical model

Frauke Bunsen, AWI 6.3

Since the industrialization, the ocean has served as an important sink for anthropogenic CO2 emissions. However, accurately quantifying the amount of CO2 absorbed by the global ocean remains challenging due to a limited number

of direct observations. The ocean's CO2 uptake is currently estimated relying on global ocean biogeochemistry models and observation-based data products. Nevertheless, there has been an increasing discrepancy in the results obtained from both methods over the past two decades. To bridge this gap, we seek to combine our theoretical understanding of ocean dynamics and biogeochemistry with observations through data assimilation into the coupled ocean circulation and biogeochemistry model FESOM-REcoM. In a first step, we assimilate temperature and salinity observations to ensure a realistic ocean circulation, which is crucial for an accurate representation of the carbon cycle. Here, we present preliminary results for the year 2016.

6.4

26. Baleen whales in a changing Arctic Ocean: Investigating acoustic occurrence and habitat usage of endemic and seasonally migrating species

Marlene Meister, AWI 6.4

The Arctic Ocean's baleen whales face severe environmental changes due to climate change, including rising water temperatures, sea-ice retreat, and altered plankton bloom occurrences. These factors are likely to affect habitat suitability for the Arctic endemic bowhead whale (Balaena mysticetus), as well as seasonally migrating baleen whale species, such as blue (Balaenoptera musculus) and fin (B. physalus) whales, causing northward distributional range shifts and changes in migratory behaviors. Secondary effects could exacerbate stress on marine mammals through increased interspecific competition, orca (Orcinus orca) predation, and human activities in previously inaccessible Arctic Ocean areas. To investigate impacts of climate change on baleen whales, passive acoustic monitoring data collected between 2012 and 2022 in eastern and central Fram Strait are analyzed applying both manual and automatic detection methods. Preliminary results on blue whale acoustic presence suggest vocalizations to primarily occur from July to October. Notably, an unanticipated early onset of calling activity in May 2019 might suggest a potential temporal shift towards earlier calling times in recent years. However, due to data limitations, a comparison of phenological patterns across years could not be performed so far. Vocalizations on a few consecutive days in January 2017 and February 2021 suggest individual blue whales to either stay or migrate into Fram Strait during winter. The findings offer critical information on baleen whale (acoustic) occurrence and habitat usage, necessary to monitor anthropogenic and climate-change related threats to marine life and for developing effective conservation strategies in the face of the rapidly changing Arctic environment.

27. Light pollution changes the performance of marine grazers and filter feeders – results from two global projects in research-based education

Mark Lenz, GEOMAR 6.4

It is only recently that light pollution has been recognized as an anthropogenic stressor for coastal ecosystems, and its effects remain widely unknown. The disruption of natural biorhythms due to artificial light in night-time environments has the potential to alter the feeding activity and the performance of benthic invertebrate species. In two globally replicated studies, we investigated the influence of light pollution on grazers, such as sea urchins, as well as on filter feeders, i.e. mussels, in laboratory experiments. Under the influence of realistic levels of light pollution, we observed significant changes (up to 40%) in the daily food consumption rates of the grazers, while the direction of this effect varied with the study system. The feeding activity of the mussels remained unchanged by artificial light at night, while a decline in byssus production and strength occurred in some but not all experiments. This indicates that artificial light at night exerted a stress on the animals. The studies were conducted in the

framework of GAME (Global Approach by Modular Experiments), a programme that combines research in marine ecology with the training and internationalization of Master students. GAME has more than 40 science partners in 30 countries worldwide and allows the implementation of one research project with up to 20 participants per year.

28. Large-scale transport of Microplastics from the European waters to the Arctic

Fangzhu Wu, AWI 6.4

High concentrations of microplastic (MP) particles have been reported in the Arctic Ocean, but studies on the high-resolution lateral and vertical transport of MPs from the European waters to the Arctic are still scarce. The European-wide project FACTS (Fluxes and Fate of Microplastics in Northern European Waters), funded by JPI Oceans, aims to address the geographical transport of MP from temperate waters of the southern North Sea to the Arctic waters of the Barents Sea. Here, samples from different water compartments, including samples from the surface, subsurface, above and below the pycnocline, were successfully collected at 23 stations in the area of interest using an improved Neuston Catamaran, the COntinuos MicroPlastic Automatic Sampling System (COMPASS) and in situ pumps, respectively. Different types of FTIR microscopy and spectroscopy were applied to obtain information on MP abundance, polymer composition and size distribution. Preliminary results indicate that the abundance of small microplastics (SMPs, <300 µm) varies considerably within the water column, with significantly higher abundances in the surface water compared to water collected above and below the pycnocline. Furthermore, the average abundance of SMPs in surface water samples was four orders of magnitude higher than the abundance of large microplastics (>300 µm), and overall, SMPs <50 µm account for >80% of all detected MPs. A total of 19 different polymers were detected in all samples, and no significant differences in polymer diversity were found in the water compartments, implying a relatively homogeneous distribution of MP particles in the water column. However, the predominant polymer differs among different sampling transects and water compartments. Further statistical analyses and modelling stimulations are still needed to help better explain the sources, transport, occurrence, and fate of SMPs in the northern marine waters.