Mycosporine-like amino acid (MAA) distributions associated with phytoplankton communities in temperate and subtropical environments were studied in the eastern Pacific Ocean. One winter cruise (Navo 1, February 1997) and two summer cruises (Navo 10, September 1997 and GRZ, September 1998) were conducted along a transect that originated in Monterey Bay, California. Two cruises extended 280 km offshore (NAVO 1 and NAVO 10) and the other extended 3800 km offshore (GRZ). The relationship between particulate ultraviolet (UV) light absorption and MAA concentrations was examined, and physical and biological data were correlated with the MAAs to assess what factors may determine MAA distribution and abundance. Results showed that MAAs accounted for approximately 67% of the variability in particulate UV absorption in the upper mixed layer, where detrital particles were low relative to phytoplankton biomass. The relationship between MAA and UV absorption deteriorated below the mixed layer, where UV absorbance by detrital material increased. There was a high conservation in MAA content, both in the occurrence of individual MAAs and in their proportions. Mycosporine-glycine, shinorine and porphyra 334 comprised 75% of the total MAA standing crop at 20 of 26 sites. Mycosporine glycine was consistently the most abundant MAA, constituting at least 50% of the total MAAs at 75% of the sites sampled. MAA concentrations were highest within the upper mixed layer at all stations and decreased below the limit of detection below the mixed layer. The lowest MAA concentrations were observed during the winter cruise, where reduced irradiance and deepened mixed layers presumably reduced MAA synthesis. At most sites (19 of 26 stations) MAA distributions revealed vertical concentration gradients through the mixed layer even though chlorophyll was vertically homogenous and temperature was isothermal. Thus, the field data suggest that MAA synthesis and/or degradation rates potentially meet or exceed the vertical mixing rate. The results support the notion that MAAs provide a protective function for phytoplankton in the upper ocean.

OS42H-187 1330h POSTER

The Dynamic Green Ocean Model, Phase 1: Coccolithophorids in an Ocean Global Circulation Model.

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The recently started Dynamic Green Ocean Project aims at representing the complexity of biogeochemical fluxes from 5 major phytoplankton groups into a General Circulation Model. This project is analogous to the inclusion of plant functional types in models of land biology. The Dynamic Green Ocean Model is developed in collaboration with a group of scientists worldwide (http://www.bgc-jena.mpg.de/bgc_prentice/projects/green_ocean/start.html). The basis for this project is the PISCES ocean biogeochemistry model (Aumont et al. in preparation), which includes the potentially limiting nutrients PO_4^{3-}, Fe and SiO_3^-, in colimitation with light. Current plankton groups are diatoms, nanophytoplankton, micro- and mesozooplankton. Here, we report on preliminary results of introducing coccolithophorids as a third phytoplankton group. We present results of coccolithophorid specific behaviour, and a sensitivity analysis of those factors that are generally considered to favour coccolithophorids. We compare our results to observations of the mean, and of the seasonal and interannual variability of coccolithophorid abundance, and to open ocean alkalinity budgets.

OS42H-188 1330h POSTER

Si Cycle in the North Eastern Atlantic During the POMME Experiment (March-April 2001), Evidences of Co-Limitation of Phytoplankton Growth by the Availibility of Silicon, Iron and Other Nutrients.

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Phytoplankton Si uptake rates have been measured in March and April 2001 in the northeastern Atlantic as part of the POMME (Progamme Océean Multidisciplinaire Méso Echelle) project which addressed the mesoscale phytoplankton dynamics between the Azores Islands and Portugal (39-44°N, 17-21°W) during two cruises conducted in March and April 2001. At 4 long-term stations, Si uptake rates (ρSi) were measured by *in situ* ^{32}Si incubations and kinetic parameters (potential maximum specific uptake rate (V_{max})and half-saturation constant (K_S)) were estimated from on-deck ^{32}Si incubations. The impacts of Fe, Si, N, P and Saharan dust addition on Si uptake rates and siliceous biomass evolution were also assessed by differentially enriched microcosm experiments. At each study site, two kinetic experiments were realized with samples collected at 20 and 40 m depth. 3 kinetics out of 16 could not be fitted by using a Michaelis-Menten relation and exhibited a linear increase of the specific Si uptake rates (VSi) with increasing $Si(OH)_4$ concentrations. V_{max} were always higher at 20 m than at 40 m and ranged between 0.14-0.65 d^{-1} which corresponded to doubling times ranging between 0.2-0.7 doubl.d^{-1}. During the March cruise, under pre-bloom conditions, K_S ranged between 1.8-5.9 μM. In April, during the onset of the spring bloom, K_S were lower, ranging between 0.6 to 1.5 μM. Although falling within the usual range of values found in the literature, K_S were often higher than ambient $Si(OH)_4$ concentrations which is indicative of a potential Si limitation. The potential role of iron availability on Si kinetics was investigated at the southern site. Seawater samples were incubated under clean conditions during 6 days in large volume tanks treated with different iron additions (control, +0.15 nM Fe, +2.5 nM Fe). Addition of iron alone did not significantly modify the K_S values although a slight increase in V_{max} was observed after 4 days under pre-bloom conditions (March cruise). The apparent lack of relationship between iron availability and Si kinetics could however have resulted from the limitation by another essential nutrient. In the second enrichment experiment, large volume samples were incubated for 6 days and received various treatments: addition of iron alone (+Fe), macronutrients (nitrate, phosphate, silicic acid: +N+P+Si), iron and macronutrients (+Fe+N+P+Si), Saharan dust, or deferoxamine mesylate (+DFOB, iron-complexing molecule). We observed different patterns between the study sites but +Fe or +N+P+Si treatments usually resulted in lowered VSi as well as lowered biogenic silica crops as compared to +Fe+N+P+Si or Saharan dust treatments. At one site, addition of Saharan dust resulted in a 16-fold increase of VSi as compared to the control whereas the +Fe+N+P+Si treatment only resulted in a 9-fold increase. Results are indicative of the co-limitation of siliceous phytoplankton by the availability of iron and major nutrients, including silicic acid. Results also confirm the role of Saharan dust events and their potential impact on the phytoplanktonic community structure via fertilization of surface waters with iron and also possibly with other nutrients.

OS42I HC: 323 A Thursday 1330h

Mediation of Benthic-Pelagic Coupling by Life-Cycle Patterns and Vertical Migration

Presiding: **N H Marcus,** Florida State University**; M H Bundy,** Academy of Natural Sciences Estuarine Research Center

OS42I-01 1330h INVITED

Multi-Channel Benthic-Pelagic Coupling in Rocky Intertidal Habitats: Consequences and Generality

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Rocky intertidal communities have long served as "model" ecological communities, generating numerous insights and concepts that have enjoyed wide applicability to other aquatic and terrestrial communities. In recent years, our ideas on how such systems are structured has shifted from a predominantly "top-down" perspective, where consumer-prey interactions were emphasized as the primary determinants of structure, to a coupled "top-down/bottom-up" perspective, where top-down effects are considered a consequence of variation in processes operating at the base of the food chain, such as nutrients, production, and the supply of propagules. This shift in perspective was a response to efforts to examine the dynamics of rocky intertidal communities at larger spatial scales, and to the realization that significant "meso-scale" (10's to 100's of km) variation in oceanographic conditions in the inner shelf was likely to have major ecological consequences. Oceanographic processes impact coastal communities through several "channels," by delivering: nutrients for primary producers, particulates (phytoplankton, zooplankton, detritus) for filter-feeding invertebrates, and propagules ("recruitment") for macrophyte, invertebrate, and fish populations. Earlier research highlighted the potentially important effects of larval transport on populations and communities, and work in the past decade has begun to reveal that nutrient and particulate transport can have striking impacts as well, leading to a "multi-channel model of benthic-pelagic coupling" for shallow hard-bottom marine ecosystems. Current research occurs mostly in upwelling-dominated marine ecosystems and is focused on several issues: determination of the relevant oceanographic transport mechanisms and the differential responses of propagules, particulates and nutrients; evaluation of the relative impacts on community structure of the different channels; identification of the scales of dispersal and the degree of connectedness among communities; determination of the generality of the multichannel model of benthic-pelagic coupling in space and time; and the application of new insights to issues of human concern, such as the consequences of global climate change, conservation of marine resources, mitigation of habitat destruction, and restoration of exploited marine populations. Future issues include evaluation of the applicability of this model to other marine habitats, such as soft-sediment and subtidal communities; and to non-upwelling ecosystems.

OS42I-02 1400h

Sequential Resuspension of Protists by Accelerating Tidal Flow; Implications for Community Structure in the Benthic Boundary Layer

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In-situ flumes and near-bed sampling during tidal flow were used to determine resuspension thresholds of protists and bacteria at a silty, subtidal coastal site. Heterotrophic nanoflagellates, oligotrich ciliates, the diatom Navicula distans, and bacteria resuspended in weak flow (friction velocity $<$ 0.6 cm/s), likely associated with a surficial fluff layer of sediment. Hypotrich ciliates and scuticociliates resuspended in moderate flow (0.8 cm/s), independent of sediment erosion thresholds. Furthermore, cultures of a hypotrich and two scuticociliates isolated from the site displayed species-specific resuspension thresholds in the field. Pigmented nanoflagellates and several other diatoms had the strongest thesholds (0.9-1.6 cm/s), with the diatoms mostly coinciding with bulk sediment erosion. Taxon-specificity of resuspension thresholds may be due to cell size/density, cell behavior, and/or association with sedimentary particles. During acceleration from slack tide to a peak flow of friction velocity 1.3 cm/s, near-bottom cell concentrations were enhanced by factors ranging from 2 to 16, differing among taxa and therefore influencing community structure. During acceleration, the total oligotrichs, hypotrichs, and scuticociliates changed from 75 to 96% of individuals in the ciliate community, and the resuspending diatom taxa changed from 37 to 63% of the pennate cells. Cells deposited again at slack tide, and the zone of this cyclical exchange was approximately from 0.2 cm below to 100 cm above the sediment-water interface. Sequential resuspension suggests that the species makeup of the assemblage exchanging with the water column depends on the maximal bed shear stress occurring during a resuspension event, and thus it should vary with the spring-neap cycle as well as with atmospheric forcing and geographic differences in hydrography.

OS42I-03 1415h

Influence of Turbulence on Settlement of Bivalve Larvae

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Transport and deposition of planktonic bivalve larvae are likely to be largely controlled by hydrodynamic factors as current velocities exceed swimming capabilities of larvae. At small scales the probability to hit the sediment may be determined by local turbulence structure, dependent on roughness elements on the bottom and larval behaviour. The role of larval behaviour in settlement processes, although observed in some still-water studies, is debatable in field situations or in a flume tank.

Flume tanks, designed to produce and manipulate boundary layer flow, have become important tools in biological research on particle dynamics. Flume tanks are generally constructed in such a way that turbulence levels are minimised in order to produce a nicely predictable laminar flow, so that any effects of either bottom structures or activity of benthic fauna on the flow can be accurately visualised and quantified.

Settlement and resuspension processes are influenced by two types of processes: random, turbulent motion and directional or advective motion. The random motion is caused by turbulent diffusion, advection is determined by the sinking velocity of inert particles and by the combination of sinking and swimming behaviour for settling larvae. The ratio between random mixing and advection is expressed in a dimensionless parameter, the Péclet number. Particularly in biological flume experiments this scaling parameter is often not taken in consideration. Since in most flume tanks the levels of turbulence are "ironed out" by the use of collimators and turning vanes, settling processes in flumes may become rather biased towards the advective component, in comparison to the field situation. Preliminary calculations based on modelled levels of turbulence indicate that neither turbulent nor advective motion is dominant in the field.

In a large 10 m^3 race-track flume we evaluated settlement of larval mimics at different flow velocities and different levels of turbulence. These experiments clearly illustrated the importance of accurately scaling turbulence levels on particle dynamics. Particularly the erosion of the viscous sublayer by increased levels of turbulence may be an important factor in settlement.

URL: http://www.nioo.knaw.nl/cemo.htm

OS42I-04 1430h

Small-Scale Spatial Variability in Harpacticoid Emergence on a Continental Shelf

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Some species of harpacticoid copepods leave the sediment, enter the water column, and return to the sediment on a diel cycle. This phenomenon, known as emergence, has potentially important impacts on both the pelagic and benthic environments. Variations in emergence have been studied at between-habitat scales, but few investigations have examined small-scale spatial variability. On continental shelves, sediment crests and troughs are conspicuous within-habitat heterogeneity. Hogue and Miller (1981) found sediment crests to have greater meiofaunal abundance than sediment troughs. Because high harpacticoid abundance has been found to increase emergence (Service and Bell 1987, Walters 1988), harpacticoid emergence could vary between sediment crests and troughs. The purpose of our study was to test for differences in percent emergence between sediment crests and troughs. We worked at a sandy, 20-m site on Florida's continental shelf. Inverted-funnel traps were deployed for 24 hours to collect emergers. At the end of a run, we cored below each trap to assess harpacticoid abundance in the sediment. Of the 12 emergent species found, the percent emergence of only one species was significantly greater from crests, and the percent emergence of no species was greater from troughs. These findings suggest that the environmental differences between sediment crests and troughs have relatively little influence on emergent behavior. We also investigated the variations in percent emergence as a function of the abundance of conspecific and of total harpacticoids. The percent emergence of no species depended on total copepod density, but we found a significant negative intraspecific dependence on percent emergence for six of the species. We conclude that intraspecific interactions in the sediment are important for many emergent species. Our results suggest that the intraspecific interactions influencing emergence do not arise from intraspecific competition but might arise from the need to locate mates.

OS42I-05 1505h

When Coastal Macrofauna Rise and Go to Bed: Mediation of Vertical Migration by Light and Tides

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We have used a combination of acoustics and emergence traps in coastal Maine and Puget Sound, Washington, to study timing of migrations up from the seabed and back down. The acoustic device that we use is the TAPS-6 (Tracor Acoustic Profiling System, with six frequencies from 265 kHz to 3 MHz). We moor the instrument on the bottom and have aimed it at various angles from directly uplooking to horizontal. The traps resolve species composition, whereas acoustic methods provide high spatial and temporal resolution. Nocturnal emergence is ubiquitous and dominated by mysids at most of our locations and times. The effect is sometimes subdued on brightly moonlit nights, as expected from published work. The added resolution of acoustics reveals a "Dracula effect" that is also evident in catches between normal and inverted emergence traps. There apparently is a much stronger selective premium on getting back to the bed before dawn than on coming up at a particular time. Where tidal currents are strong, tidal modulation is also evident. Greater emergence on incoming tides frequently is observed, consistent with published work on mysid catches in the plankton. A puzzling, weaker "echo" of the nocturnal migration is often seen, however, at the same phase of the tide as the nocturnal migration but during daylight. Whereas predation by visual predators and retention in embayments and estuaries are consistent explanations for some of these features, there appear to be some interesting trophic interactions within the migrations themselves, copepods being eaten by mysids, which are themselves eaten by decapod shrimp.

URL: http://www.ume.maine.edu/~marine/jumars/research.html

OS42I-06 1520h

Crustacean Zooplankton and Dreissenid Mussel Veligers and Adults–Algae Consumption Versus N and P Excretion in Western Lake Erie

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Invasion of the Great Lakes by zebra mussels has initiated concern that consumption of algae by veligers and adults will disrupt important food chain linkages to sport fish juveniles and adults by competing directly with crustacean zooplankton. We performed direct measurements of clearance rates for crustacean zooplankton, and dreissenid veligers and adults as a function of body size from sites in western Lake Erie in 1991-1993. We determined crustacean zooplankton and veliger abundance from a series of vertical tow samples collected from 20-40 stations from May-October in 1995-2000. We determined adult dreissenid abundance and biomass by a combination of SCUBA and side-scan sonar surveys. Combining these data with literature values of ammonia and phosphate excretion rates, we were able to compare changes in ingestion and excretion by crustacean zooplankton, veligers, and adult dreissenids. Zooplankton clearance rates exceeded those of veligers or adult dreissenids due to the small individual ingestion rates of veligers and the spotty distribution of adult dreissenids, but excretion of N and P by dreissenid adults exceeds that of zooplankton by a factor of 10, and is increasing. The indirect impacts of nutrient regeneration by benthic dreissenids (and their pelagic larvae) may thus be greater than the direct impact of their grazing.

OS42I-07 1535h

Vertical transport of N and P: zebra mussel excretion and impacts on the algal community relative to crustacean biomass

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Invasion of the Great Lakes by zebra mussels has initiated concern that consumption of algae by veligers and adults will disrupt important food chain linkages to sport fish juveniles and adults by competing directly with crustacean zooplankton. However, the larger problem may be caused by nutrient excretion. We determined crustacean zooplankton and veliger abundance from a series of vertical tow samples collected from 20-40 stations from May-October in 1995-2000. We determined adult dreissenid abundance and biomass by a combination of SCUBA and side-scan sonar surveys. Combining these data with literature values of ammonia and phosphate excretion rates, we were able to compare changes in ingestion and excretion by crustacean zooplankton, veligers, and adult dreissenids. We then estimated vertical nutrient transport by combining temperature gradient microstructure measurements (SCAMP-Precision Measurements Engineering) with benthic and pelagic nutrient excretion and phytoplankton uptake rates. Excretion of N and P by dreissenid adults exceeds that of zooplankton by a factor of 10, and is increasing. The transport model indicates that mussel excretion has created previously absent vertical structure in NH4-N and PO4-P, which may have large impacts on the algal community structure and primary production. The indirect impacts of nutrient regeneration by benthic dreissenids (and their pelagic larvae) may thus be greater than the direct impact of their grazing.

OS42I-08 1550h INVITED

Space and Time Considerations: Ecological Interactions in Planktonic Communities and Rapid Evolutionary Responses

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Is the great diversity of planktonic organisms maintained by 1) dominance of abiotic over biotic controls and weak interspecific interactions, or by 2) strong interspecific interactions (competition, predation) and highly tailored evolutionary adjustments? Are disagreements between limnologists and oceanographers merely a question of scale, of one-dimensional versus multi-dimensional, expanding and mixing environments? We address the problem by developing a general model for planktonic species interactions, incorporate trade-offs between competitive ability and resistance to predation, and solve for stability characteristics. For lake and coastal species that rely on recruitment from resting eggs, dispersal of individuals and resting eggs is an important additional consideration, as well as refuges in time (seed bank "storage effects"). The evolutionary perspective is explored by retrieving resting eggs from sediment cores for genetic studies and experiments. Genetic changes are examined at mega-(DNA sequencing), meso-(allozyme), and micro-evolutionary (common garden) levels.

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