OS22C HC: Hall III Tuesday 1330h

Nutrient Dynamics in Coastal Ecosystems: Linking Physical and Biological Processes IV

Presiding: **I C Anderson,** Virginia Institute of Marine Science

OS22C-177 1330h POSTER

Impacts of Municipal Wastewater Effluent on Benthic Algal Assemblages in a Second Order Semi-tropical Stream

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Municipal wastewater treatment plant effluent can alter the receiving streams algal community structure and production by affecting natural hydrologic patterns and nutrient levels. Benthic algal standing biomass, colonization rate, and species diversity are currently under investigation at six sites along a sewage-impacted stream to asses the spatial and temporal impacts of the effluent on the algae. An artificial substrate consisting of PVC pipe is being used to collect samples of benthic algae. Monthly standing biomass measurements show an increased accumulation from spring (38 to 860 mg-chl m^{-2}, Apr-01 range) to summer (410 to 3400 mg-chl m^{-2}, Aug-01 range), with a decrease in fall (1.3 to 310 mg-chl m^{-2}, Oct-01 range). Spatially, maximum biomass occurs just below the sewage effluent outfall and a minimum accumulation occurs at the most downstream site. Benthic algal colonization rate follows a similar seasonal trend, with higher rates during the summer (45 mg-chl m^{-2} day^{-1}, Aug-01 average) than in the spring (21 mg-chl m^{-2} day^{-1}, Apr-01 average). Algal species composition of both standing biomass and colonization rate samples are currently being assessed to determine differences between upstream and downstream sites regarding the presence and absence of pollution tolerant and grazing resistant species. Nutrient limitation of algal growth in this stream is unlikely. Both DIN and SRP were consistently high ranging from 86 to 940 uM, and 28 to 99 uM respectively. In addition, algal standing biomass and colonization rates do not correlate with either DIN or SRP concentrations. As the only continuous source of water, the two municipal wastewater effluents produce a constant perennial stream discharge. However, high watershed runoff after precipitation creates a significant increase in stream flow. For example, after a 6.7 cm rainfall, flow increased from 19 to 2200 cfs. Scouring of all benthic algae from the sand substrate was observed after as little as 1.0 cm of rainfall. The benthic algae in this stream appear to be limited by light availability (seasonal variability in day length), periodic scouring events, and potentially, grazing pressure.

OS22C-178 1330h POSTER

Evaluation of Ground Water Input to a Tropical Coastal Lagoon Using Radium 223 and Radium 224

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Ground water discharge into coastal lagoons can be a significant source of fresh water and nutrients to these systems, influencing many factors such as salinity gradient, primary productivity, ecosystem structure, dissolved gas concentration, and exchange rate of water. However, it is often difficult to estimate ground water input due to mixing of saline and fresh water within shallow aquifers and the presence of small ground water discharge points throughout a given lagoon. We used the activities of two radium isotopes, 223-Ra (half life 11.4 days) and 224-Ra (half life 3.66 days) to calculate the residence time of water in Celestun, a tropical coastal lagoon on the Yucatan Peninsula, Mexico, and to estimate the ground water flux into this lagoon.

The northern Yucatan Peninsula is dominated by karst topography with exceptionally high permeability, resulting in rapid infiltration of precipitation and practically no surface streams. The ground water is characterized by a thin fresh water lens underline by a marine saline intrusion and the water table is relatively shallow (Perry et al., 1995). Since Celestun Lagoon receives little to no surface or riverine input of freshwater, the majority of fresh water input to this lagoon comes from seasonally variable groundwater discharge. This groundwater discharge produces a strong horizontal salinity gradient in the lagoon throughout the year, and also provides a significant source of nutrients to the lagoon. Ra isotopes activities were measured along the length of the lagoon (following the horizontal salinity gradient), at several known groundwater discharge points within the lagoon, at several wells in the area around the lagoon, and along a coastal transect at the mouth of the lagoon. Preliminary results indicate that radium activities in the saline groundwater are very high compared to the activities found in the fresh water lens, coastal ocean water, and surface run-off. Data will be used to estimate the ground water flux into the lagoon and the residence time of water in the lagoon.

OS22C-179 1330h POSTER

Modeling the Influence of Danube River Nutrients on the Northwest Black Sea Shelf Ecosystem

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We employ a three-dimensional hydrodynamic model and a one-dimensional physical and biological model to address the impact of the Danube River outflow on the ecosystem of the NW Black Sea Shelf. The study is part of the DANUBS project (NUtrient management in the DAnube basin and its impact on the Black Sea). We pay particular attention to the parameterization of river plume dynamics (Danube and neighboring major rivers) and to the air-sea interaction parameters. We address the impact of the meteorological forcing as well as of the vertical stratification on the functioning of the biological system.

The numerical simulations show that the coastal circulation is greatly influenced by river runoff and especially that of the Danube, which is dominant with monthly averaged values ranging from 5,000 to 10,000 m3/s. The transport of low-salinity waters and nutrients associated with the Danube runoff is greatly influenced by wind stress and topographic effects. We demonstrate that the seasonal cycle in the biological system is strongly controlled by the seasonal variability of mixed layer dynamics. About half of the variance in the primary production can be attributed to the spring weather conditions. Horizontal advection and basinscale/mesoscale processes contribute substantially to the physical and biogeochemical variability. It is shown that the topography of the Black Sea pycnocline presents an important physical factor governing the primary production in the biological model.

OS22C-180 1330h POSTER

Sediment Resuspension in the Pamlico and Neuse River Estuaries: A Potential Source of Nutrients

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The Neuse and Pamlico river estuaries are shallow, dynamic systems that have been plagued with symptoms of eutrophication over the past two decades. Extensive research has been conducted over the last 5-10 years to better understand the complex nutrient dynamics of these systems. However, most of these studies have concentrated on nutrient cycling in the water column. Only recently have studies focused on the benthic environment, and most sediment studies have neglected the dynamic nature of the benthos, focusing instead on diffusion as the dominant transport process delivering nutrients to the water column. Although diffusion of nutrients across the sediment/water interface may be important during quiescent periods of sediment deposition and short-term storage, wind events associated with storms throughout the year will resuspend newly deposited sediments resulting in the advective transport of sediment porewater, rich with nitrogen, phosphorus and carbon, into the water column. Sediment resuspension may increase water column nutrient concentrations, and therefore present estimates of nutrient and carbon inputs from the sediments may be too low.

An on-going project is attempting to estimate short-term sediment dynamics and flux of nutrients released to the water column from natural resuspension events in these two estuaries. Sediment cores at 9 sites in the estuaries have been collected at least bi-monthly since May 2001. The short-term rate of sediment deposition is being evaluated using naturally-occurring radionuclides (Be-7, Th-234, and Cs-137). Porewater nutrient inventories at all sites have also be determined. This technique will allow evaluation of the depth to which sediments have been disturbed and the advective flux of nutrients to the water column. Evaluating this advective flux of nutrients to the water column is crucial to understand estuarine nutrient cycling. The temporal and spatial relationships of sediment deposition and porewater concentration in both estuaries will be discussed.

OS22C-181 1330h POSTER

Coupling of Biological and Physical Processes in a Shallow, Temperate Coastal Lagoon: N-Cycling Process Rates

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The degree to which shallow coastal lagoons can retard or remove nutrients during their transport across the land margin will depend both upon the relative rates of biological and physical processes and position within the system. This relationship is especially important for biological processes enhanced by benthic pelagic coupling. We have performed a study relating nitrogen cycling process rates to tidal flushing in Hog Island Bay, a coastal lagoon located on the ocean-side of Virginias Delmarva Peninsula. Groundwater, contaminated by nutrients derived from agriculture, is a major source of nitrogen to the system. The lagoon, drained by a narrow, deep channel, is intersected by extensive intertidal areas; average depth is 1 m. The system is dominated by benthic micro- and macroalgae which temporarily sequester N entering the system during spring and early summer. Decomposition of macroalgal blooms and resulting sedimentary detrital material in late summer may release both DIN and DON to the water column. Coupling of N mineralization in the sediments and water column to processes such as nitrification denitrification, benthic microalgal or phytoplankton uptake, and immobilization, which can remove or retard export of N from the system requires that the time scales of water transport and biological process rates be similar. Using a coupled hydrodynamic and particle-tracking model Fugate et al. (see adjacent poster) determined that residence times within the lagoon were spatially variable. Biological observations indicated that storage of nitrogen in sediment organic matter was highest in sites that the model predicted to have relatively long residence times. Given a pulsed decomposition event, we will relate rates of DON release and mineralization to subsequent uptake given various transport times.

OS22C-182 1330h POSTER

Determining Residence Time in Hog Island Bay Using a 2-D Finite Element Model Allowing for Dewatering of Intertidal Flats

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Hydrodynamic modelling of shallow lagoons with extensive intertidal areas requires special attention to elemental areas which go dry during low water. A vertically averaged finite element model is used to simulate tidal flooding and dewatering of tidal flats in which a porous medium beneath the sediment water interface is used to simulate natural slow drainage in intertidal areas. The water's residence time in shallow bodies of water determines the extent to which microbial nutrient cycling or tidal flushing affects the nutrient budget for the water (Anderson et al., see adjacent poster). Results from sediment particle tracking show that residence time varies spatially within the lagoon and also show the importance of wind events in shallow lagoons.

OS22C-183 1330h POSTER

Influence of Physical Forcings Variations on the Lagoon of Venice Water Quality

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A finite element hydrodynamic model, an energetic model, and an ecological model have been internally coupled in order to test the responses of the Lagoon of Venice ecosystem to different scenario of external forcing. The transport model is a barotropic bidimensional model based on a finite element discretization of the spatial domain, which allows for very good spatial resolution of the lagoon morphology while keeping at a low level the computational demand. The energetic model computes water temperature starting from meteorological daily measurement, by using standard heat fluxes formulation. The ecological model simulates the dynamic of phytoplankton, zooplankton, nutrients (ammonia, nitrate and phosphate) organic detritus (organic nitrogen, organic phosphorous and CBOD) and dissolved oxygen. It is based on the ecological module EUTRO of WASP (Water Analysis Simulation System released by US-EPA), which has been modified in order to cope with the peculiarities of the Lagoon of Venice. The coupled model, the Venice Lagoon Finite Element Ecological Model (VELFEEM), has been verified to be coherent from both physical and ecological points of view. A reference condition has been identified by running a one year long simulation under climatologic condition. The sensitivity to physical forcings (tide, wind, and solar irradiation) and to the input of macronutrients has then been investigated, by comparing model predictions of spatial and temporal evolution of major state variables and of an aggregate index of water quality (TRIX).

OS22C-184 1330h POSTER

Towards 3-D ecosystem modelling of the Irish Sea

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The Irish Sea presents an ideal location for developing coupled physical-biological models. It is semi-enclosed, contains stratified and well-mixed regions controlled by tidal currents, has nutrient enrichment from river inputs, and a biological system not dominated by a single plankton or zooplankton species. A computationally efficient 3-dimensional modelling system (POLCOMS) has been developed which acts as 'host' to ecosystem dynamics. This system has been applied at eddy-resolving lengthscales (1.2 km) to the Irish Sea and the annual cycle of nutrients, primary and secondary production investigated. The structure of the modelling system allows different ecosystem formulations to be explored and 2 different approaches - a model with two compartments each for phytoplankton and zooplankton based on the ecosystem model of Anderson & Williams 1998 (Est. Coastal Shelf Sci., 46, 93-109) and the more complex multi-compartment European Regional Seas Ecosystem Model based on Baretta et al, 1995 (Neth. J Sea Res., 33, (3/4), 233-246). From direct comparisons of the two approaches with data we can investigate the complexity required of ecosystem models to reproduce the observed biological functioning and explore the (sometimes subtle) physical-biological interactions occurring in the Irish Sea.

URL: http://www.pol.ac.uk/home/research/polcoms/

OS22C-185 1330h POSTER

A Comparison of DOM Metabolism in an Estuarine System and a Coastal Lagoon

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Coastal systems such as Hog Island Bay (HIB) in the Virginia Coast Reserve LTER and the Plum Island Sound (PIS) LTER in Massachusetts may play important roles in retarding and removing dissolved inorganic and organic nutrients during their transport to the coastal ocean. The DOM in HIB is primarily autochthonous in origin and is produced during decomposition of macroalgal blooms during midsummer, whereas in PIS, the nitrogen source is mainly terrestrial in origin-DON from forests or DIN from residential/suburban areas. Three replicate water column samples from each of three stations along a transect from the land to the sea were taken bimonthly from February to October in HIB and from May to September in PIS. Samples were filtered using pre-combusted glass fiber filters (1.0um) in order to remove most phytoplankton and most grazers, and were then partitioned into three subsamples for determinations of net metabolism, gross nitrogen mineralization, and nitrification. Net DOM metabolism was measured using 21-day dark incubations at in situ temperature, and subsamples were analyzed for dissolved inorganic nutrients, dissolved organic carbon, and dissolved organic nitrogen concentrations. Gross nitrogen mineralization and nitrification were measured using the isotope pool dilution technique with 15NH4+ and 15NO3- additions, respectively. These data suggest that the DOC in HIB is more labile than that in PIS: 14.7% of the initial DOC was utilized within the first week at HIB and 4.9% in PIS. The lability of the DOC in HIB correlated with the initial C:N ratio of the DOM in an unexpected manner in that increasing C:N ratios corresponded with increasing DOM utilization rates (slope=3.0, r2= 70%). The DOC lability in PIS did not appear to correlate with the C:N ratio. Average net nitrogen mineralization was 45% of gross mineralization in HIB samples and 64% in PIS samples suggesting that one third to one half of the ammonium produced by mineralization was immediately consumed. Potential mechanisms for consumption include nitrification and immobilization into microbial biomass. Nitrification rates ranged from 11% to 500% of gross mineralization, suggesting that nitrification was a significant fate for ammonium in the systems, but the level of importance varied with season and sampling location.

OS22C-186 1330h POSTER

Spectral Analysis of Bulk Reflectance from Coastal Waters

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We apply routine techniques of diffuse reflectance spectroscopy to establish a systematic procedure for global analysis of the in-situ reflectance from coastal water over the 400-900 nm region of the spectrum. Starting with the critical 750-900 nm near-infrared range of the spectrum, the technique provides a sequential multi-parameter fit to bulk reflectance in the 810, 600, 400, and 676 nm regions of the spectrum. In these spectral regions bulk reflectance from coastal water can be linked to the inherent optical properties of its main constituents: pure water, inorganic suspended solids, dissolved organic matter, and phytoplankton pigment. Using the in-situ reflectance alone, we are able to estimate the volume scattering coefficient for suspended particles and determine the spectral volume absorption coefficients attributable to dissolved organic matter, inorganic particles, and phytoplankton pigment. The predicted results for the total absorption and total scattering coefficients agree to within 15 percent of the measured values for the Mississippi Sound, Lake Superior, and Great Bay, New Jersey.

OS22C-187 1330h POSTER

Carbon and Nutrient Dynamics in a Tropical and Hypertropic Lagoon

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Spatial and temporal variability of carbon and nutrients were studied in the Tapong Bay, a small semi-enclosed lagoon surrounded largely by urbanized watershed in southwestern Taiwan. Dissolved and particulate phases of carbon (DIC, DOC, POC) and nutrients (DIN, DIP, Dsi, DON, DOP, PN, PP) were investigated bimonthly from August 1999 to August 2000. There is only one tidal inlet for exchanging water between the Tapong Bay and Taiwan Strait, which results in a low water exchange rate and oxygen deficient condition in the bottom water of the inner bay during warm seasons. Water exchange time of the Tapong bay ranges from 7.1 d (summer) to 13.2 d (winter) with a mean of 10.6 days. Nutrient dynamics is largely controlled by allochthonous inputs and biological removals in the bay. Diffusion fluxes from sediments to overlying water account for only about 7.6% of annual DIN inputs and 1.0% of annual DIP inputs. Abundant nutrients support high primary productivity (1380 g C m^{-2} yr^{-1}) which primarily drives the bay into highly eutrophic condition as particulate organic matter is derived mainly from biological production. Excess of DIP appears to occur throughout the study period in the bay. Seasonal variations of primary productivity are therefore controlled by temperature, solar radiation and turbidity, rather than nutrients. Net CO_2 invasion occurred during the study period despite the calcification was pronounced in the lagoon. The net ecosystem production (NEP) derived from daily changes of DOC and POC is about 6.29 mmole C m^{-2} d^{-1} that is close to 6.65 mmole C m^{-2} d^{-1} simulated from the biogeochemical modeling. Although carbon and nitrogen budgets are temporally variable, the net annual production rate of organic carbon estimated from the biogeochemical model is 5.8 mole C m^{-2} yr^{-1}, implying that the Tapong Bay is an autotrophic system. The annual nitrogen fixation also exceeds the annual denitrification with a magnitude of 1.30 mole N m^{-2} yr^{-1}.

OS22C-188 1330h POSTER

Nutrient Dynamics in Coastal Ecosystem: Modelling Nitrogen Fluxes in the Lagoon of Venice

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A 3D model is used to investigate water quality, primary production and nitrogen cycle in the lagoon of Venice. The lagoon has buffered human impact from century, but in the last few decades the pressure of human activities has been growing greater and greater, modifying physical, chemical and ecological equilibrium of the ecosystem. Examples of sources affecting the ecosystem are discharge of polluting/eutrophicating substances, overfishing, hydrological changes due to geomorfological modifications. On account of the fact that the hydrodynamic regime of the Venice lagoon is predominantly governed by tidal movement, transport process is described by anisotrophic eddy-diffusion. The biological compartment includes dissolved oxygen, nitrate, ammonium, phosphate, phytoplankton and zooplankton biomass, plus carbon, nitrogen and phosphorous in the suspended organic matter and in the sediment. The system exchanges energy and matter through its open boundaries. Mean daily experimental meteoclimatic data have been used to estimate the

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water temperature and the average daily light intensity, which is modulate in order to simulate the night-day cycle. Nutrient are discharged from point (industrial area, rivers) and non-point sources (the sewage of the city of Venice and the major islands), estimated from monitoring program and by land-use model. Sediment burying and denitrification process are included, too. The model has been corroborated by the comparison with experimental data from a water quality monitoring program, and utilised to investigate the nitrogen cycle. Nutrient budget are computed for each month of the year, and for each one of the three sub-basin of the lagoon. Analysis of model results shows as differences in ecosystem response and water quality between the three sub-basin arise as a consequence of no-homogeneous distribution of discharge point sources along the lagoon edge and of differences in water exchanges through the different inlets induce

OS22C-189 1330h POSTER

Transport and Fate of UK Nutrient Input to the Southern North Sea.

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There is concern that nutrients discharged to the North Sea have an adverse impact on the health of the ecosystem. Much of the nutrient load enters the regional circulation through estuaries, but uncertainty about the marine transport pathways makes it difficult to arrive at a clear consensus about the fate of any particular input.

For example, it has recently been suggested that an area of high phytoplankton productivity at the Frisian Front (the so-called green curtain) might be fuelled partly by nutrients emanating from the western sector of the North Sea. It is proposed that high turbidity UK coastal waters inhibit utilisation of the nutrient load which is then available to support phytoplankton growth once sediment settles out of the water in the lower tidal energy environment off the north of Holland.

A comprehensive field program deploying a variety of instrumentation and techniques (moored current meters; sediment landers; towed undulating and CTD; continuous nutrient determinations; Lagrangian drifters; primary productivity experiments) was undertaken between January 2000 and August 2000. This program has quantified the east-west flux of water and nutrients and examined nutrient/phytoplankton dynamics in the region.

It is clear that nitrogen (NO3 and NH4) is transported from the western North Sea towards the east. However this study has shown that while the suspended load affects the light climate it does not significantly inhibit production. Results also show that following the spring bloom the ammonia turnover rate is much greater than that of nitrate. These high turnover rates coupled with the inhibitory effects of ammonium on nitrate uptake may limit the rate of nitrate depletion in nutrient rich grazing balanced ecosystems

OS22C-190 1330h POSTER

Vertical Distribution of Dissolved and Particulate Organic Phosphorus in the Western Pacific Ocean.

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Vertical profiles of dissolved and particulate organic phosphorus (DOP and POP) were investigated at one coastal and two pelagic locations near Japan Honsyu Island in the western Pacific Ocean. DOP exhibited high concentrations ($\sim$0.5 μM) in the upper ocean ($<$ 1,000 m). The DOP concentration decreased gradually with depth and reached around the minimum detection limit in deep layers. POP concentrations were extremely low ($<$ 0.1 μM) and decreased considerably within the upper 100 m depth. There was a good correlation between POP and chlorophyll *a* concentrations, indicating that planktonic biomass is a significant source of POP. However, some analytical difficulties were found in POP measurement; the estimated POP concentration increased with the filtration volume of sample waters. This was likely due to adsorption of DOP onto the matrix of a glass fiber filter (GF/F).

At depth intervals, some samples were analyzed for solvent extractable, hydrophobic fraction of organic P, namely lipid P. The highest concentration of particulate lipid P was observed at the surface, while dissolved lipid P concentrations increased with depth. Lipid P was a minor component of organic P in surface seawater, accounting for less than 3% of total organic P. The contribution of lipid P increased with depth, especially in dissolved fraction, and reached 36% of total organic P at 2,000 m depth. These results suggested that a significant proportion of organic P produced in the surface euphotic layer is composed of labile compounds and that lipid P is an important component of refractory organic P that withstands diagenetic decomposition in the water column.

OS22C-191 1330h POSTER

Exploring Nitrogen Sources in an Oligotrophic Shallow Water Carbonate Marine System Using δ^{15}N of Marine Plants, San Salvador, Bahamas

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Recently there has been increasing concern regarding the role of terrestrial anthropogenic nutrient sources in the ecology of oligotrophic marine systems. San Salvador Island, Bahamas, represents a nutrient-depleted marine system that derives much of its nitrogen from nitrogen fixing epiphytic and subsurface cyanobacteria. Because San Salvador does not have freshwater streams able to transport significant amounts of terrestrial nitrogen, riverine inputs do not contribute significantly to marine dissolved inorganic nitrogen (DIN). On the north end of the island, however, a domestic sewage outfall represents a potentially significant anthropogenic source of DIN. The δ^{15}N value of a sewage source is usually higher than organic N or DIN from N fixation. The aim of this pilot study was to assess the usefulness of δ^{15}N analysis of various marine plant species to identify and characterize the distribution of terrestrial and anthropogenic nutrient sources in the coastal region of San Salvador.

Macroalgae and seagrass are sessile, and therefore represent relatively long-term indicators of nutrient sources in the water column. Accordingly, it was hypothesized that the δ^{15}N of the marine plants growing in areas receiving relatively ^{15}N-enriched terrestrial nutrients (i.e. sewage inputs, etc.) would reflect this source of DIN. In June 2000, a pilot study was conducted to assess the usefulness of δ^{15}N for differentiating among deep marine, coastal marine, terrestrial, and anthropogenic nitrogen sources. The results of this pilot study not only demonstrated the effectiveness of δ^{15}N as a tracer for anthropogenic sewage inputs, but also revealed interesting biogeochemical patterns in the Pigeon Creek tidal estuary on the south end of the island.

Based on the pilot study's results, a second, more focused, sampling effort was conducted in June 2001. This effort incorporated previous sampling locations as well as several new sites, including the northern arm of Pigeon Creek tidal estuary and two interior mesohaline lakes. Results will be interpreted in terms of temporal intra-site variability and possible biogeochemical processes occurring with Pigeon Creek estuary. Furthermore, differences in isotopic composition of subsurface and exposed plant biomass will be explored - revealing differences in porewater vs. water column nitrogen cycling in the shallow, nutrient poor waters surrounding San Salvador.

OS22C-192 1330h POSTER

Physiological ecology and seasonality of *Ulva* mats in a temperate rocky shore

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The seasonal fluctuations in biomass, photosynthetic performance and chemical composition of the green-tide forming *Ulva* species (mostly *U. pertusa*) were investigated in a rocky intertidal zone, southern coast of Korea. Water temperature, salinity, inorganic nutrient and precipitation influencing *Ulva* dynamics were also monitored over a 15-month period. There was very pronounced seasonality not only in the biomass of *Ulva* species but also in photosynthetic performance, and in variation in tissue pigments and nutrients. In addition to a primary seasonal response, significant variation in biomass was correlated with nutrient inputs from the surrounding watershed, heavy rain events and thermal desiccation. There was a unimodal seasonal pattern in which biomass peaked in May (2.0 kg FW m^{-2}) and dropped significantly from June to September. Recovery of *Ulva* mats, as indicated by recruitment of new plant, began during fall. Photosynthetic rates, maximum photosynthesis (P_{max}) and photosynthetic efficiency (α) were highest during the growth period and were lowest when biomass peaked or declined in May and July. Tissue pigments had a less clear seasonal pattern, with maximum Chl a (3.17 mg mg^{-1} FW), Chl b (2.14 mg mg^{-1} FW) and carotenoids (1.40 mg mg^{-1} FW) observed in October. Relative amount of nitrogen and phosphorus bound in *Ulva* species also displayed an obscure seasonal trend, with lowest value (1.80% and 0.05%, respectively) in May and highest in late November (3.16% N) and in late December (0.14% P).

URL: http://altair.chonnam.ac.kr/~eses/ocean/proffesors/kykim/welcome.html

OS22C-193 1330h POSTER

Epiphytic Algae as UV-B Filters on Seagrass Leaves.

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Epiphytes are considered detrimental to seagrasses as they reduce the amount of light, i.e. photosynthetically available radiation (PAR) that reaches the plant surface. We evaluated the possibility that epiphytes can also be beneficial to seagrasses by reducing the amount of ultraviolet (UV)-B radiation that reaches seagrass leaves. Epiphytes on UV-B transparent artificial leaves transmitted a significantly lower amount of radiation in the UV-B than in the PAR range. Therefore, epiphytic layers are effective UV-B filters on seagrass leaves. This benefit is lost when PAR transmission is reduced to levels below the compensation point.

OS22C-194 1330h POSTER

Phytoplankton Nutrient Status and Variable Fluorescence Measurements in a Gulf of Mexico Estuary.

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Development of rapid techniques to determine in situ phytoplankton nutrient status could facilitate understanding of phytoplankton growth and species succession. Variable fluorescence parameters of phytoplankton communities can be easily and rapidly measured, and changes in parameters such as the maximum quantum yield of fluorescence (Fv/Fm) have been related to nutrient status in single-species cultures. To test if changes in Fv/Fm are useful in assessing nutrient status of mixed natural assemblages, variable fluorescence parameters were measured during nutrient-addition bioassays. Assays were conducted on samples collected during 2001 in Santa Rosa Sound, a component of the Pensacola Bay estuarine system, located along the northern Gulf of Mexico (Florida, USA).

During the study, nutrient additions always stimulated phytoplankton net growth. Nitrogen appeared to be the primary limiting nutrient in summer and fall, phosphorus was sometimes limiting in winter and spring. Combined N and P addition generally had a greater stimulatory effect than either nutrient alone. Trace metal or iron additions never had a stimulatory effect, either alone or in combination with other nutrients. Initial values of Fv/Fm were frequently high ($>$0.55) but generally increased after addition of the primary limiting nutrient. One might interpret increased Fv/Fm and higher growth following nutrient addition to indicate enhanced physiological condition of the entire community. However, our observations suggest that changes in Fv/Fm were related to changes in community composition. Variable fluorescence measurements on different size fractions suggest that nutrient addition had relatively little effect on large portions of the phytoplankton but promoted overgrowth of the community by large cells with high Fv/Fm values. Large increases in Fv/Fm following nutrient addition coincided with large shifts in community size structure. When size structure changed little, nutrient additions had little effect on Fv/Fm, despite increased net growth. Interpreting variable fluorescence measurements within a mixed community can be complicated by such shifts in community composition.

OS22C-195 1330h POSTER

Phytoplankton Size Structure, Nutrients, Variable Fluorescence, and Algal Phosphatase Activity in a Gulf of Mexico Estuary.

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Relationships between phytoplankton dynamics and physiology, and environmental conditions were studied in Santa Rosa Sound, Florida, USA, at near-weekly intervals during 2001. Santa Rosa Sound is a component of the Pensacola Bay estuary in the northern Gulf of Mexico. Parameters measured included temperature, salinity, inorganic nutrients, and size-fractionated chlorophyll. Phytoplankton variable fluorescence parameters were measured to evaluate their potential for assessing in situ phytoplankton nutrient status. Algal phosphatase (Pase) activities were used to examine relative phosphorus stress.

During the study, dissolved inorganic nitrogen (DIN, mostly as NH4) concentrations ranged <0.5-5.2 uM, dissolved inorganic phosphorus (DIP) concentrations ranged <0.03-0.3 uM, and dissolved silica (DSi) concentrations ranged 6-32 uM. DIN and DSi negatively correlated with salinity, suggesting that rainfall and runoff were primary sources. Chlorophyll concentrations peaked during spring (10-15 ug/L), then dropped about 50% and remained low through summer and fall. Phytoplankton size structure typically was evenly distributed between large (>5 um) and small (<5 um) size fractions, except in late summer/fall when small cells often dominated. Maximum quantum yield of chlorophyll fluorescence (Fv/Fm) for the bulk community varied from 0.54 to 0.62 with lowest values during spring. Fv/Fm was more strongly related to DIP than DIN. The high values of bulk Fv/Fm suggested a phytoplankton community in balanced growth with respect to nutrients. However, a companion study found that nutrient additions always stimulated phytoplankton growth, suggesting that at least a portion of the community was nutrient limited. The large size fraction consistently had higher Fv/Fm values, although the difference was usually small. Lower Fv/Fm in the small fractions may indicate greater nutrient stress. However, abundant cyanobacteria could have biased Fv/Fm in the small fraction towards low values. Chlorophyll-normalized Pase activity positively correlated with DIN concentration, suggesting that phytoplankton were driven towards P stress when DIN was supplied. In general, parameters related to phytoplankton physiology varied little and suggested a community acclimated to ambient conditions.

OS22C-196 1330h POSTER

Nitrogen Limitation of Primary Production and the Potential Role of Nitrogen Fixation in a Naturally Developing Salt Marsh

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Nitrogen (N) is commonly the element limiting productivity in temperate salt marshes. This limitation may be more severe in immature marshes that have low standing stocks of N. Nitrogen fixation in salt marshes is generally high in comparison to other marine ecosystems, and can be an important source of N for primary production. In this study we measured the effect of N fertilization on Spartina alterniflora and benthic microalgal chlorophyll a (chl a) in one mature (>150 yr) and two young (7 and 15 yr) naturally developing barrier island salt marshes along a chronosequence at the Virginia Coast Reserve LTER site. N fixation in the light and dark was also measured seasonally for one year in these three marshes. While S. alterniflora above ground biomass was highest in the older marsh, there was a significant increase in biomass as a result of N fertilization only in the 2 younger marshes. An increase in areal above ground N of S. alterniflora was observed only in the youngest marsh. Benthic microalgal chl a was highest in the youngest marsh. However, N fertilization led to a significant increase in chl a at the youngest and oldest sites, but not at the intermediate aged site. These results suggest that primary productivity, of both micro- and macrophytes, in these developing salt marshes may be limited by N availability. Light availability at the sediment surface did not appear to be a factor controlling benthic chl a in any of the marshes. There was not a clear pattern of N fixation relative to marsh age in fall, winter, or spring. During the summer, however, we measured the highest rates of N fixation at all sites, with young > intermediate > mature. Light rates were consistently higher than dark rates at all sites in summer and at the 2 young sites in winter, suggesting that phototrophic N fixation was important at these times of year. Annual N fixation, calculated from integrated light and dark measurements made during each season, was 2-3 fold higher in the youngest marsh (18.3 g N m-2 y-1), than in the intermediate-aged (9.0 g N m-2 y-1) or the mature marsh (6.1 g N m-2 y-1). This high rate of N fixation in the young marsh is likely to be relatively more important in supplying N to nutrient-limited primary producers than in mature marshes that have higher standing stocks of organic matter and nutrients in the sediments. N fixation appears to be important in the early establishment and success of primary producers on bare substrate, and will contribute to the further development of a mature marsh by building substrate nutrient reserves.

OS22C-197 1330h POSTER

An Analysis of Factors Effecting the Growth of Benthic Microalgae Following the Decline of a Surface Phytoplankton Bloom

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The West Florida continental shelf is an oligotrophic system for most of the year. An episodic chlorophyll plume often occurs on the northern portion of the shelf during the spring months. The fate of the plume's nutrients upon its decline in the late spring and early summer is unknown. Decreased chlorophyll levels and sustained nutrient stocks may be explained by sediment/water-column interactions, including the presence of benthic microalgae.

A one-dimensional model of 16 state variables was constructed to simulate the decline of a surface chlorophyll bloom in the northeastern Gulf of Mexico as measured during the Florida Shelf Lagrangian Experiment (FSLE). Remineralized nutrients from the declining bloom were taken up by heterotrophic bacteria in the water-column and by benthic microalgae in the sediments.

Perturbation experiments revealed that low light levels due to increased CDOM did not have significant effects on the benthic microfloral community, while increased diffusion coefficients at the sediment/water interface adversely effected the microphytobenthos.

OS22C-198 1330h POSTER

The Distribution of Phytoplankton Standing Stock and Primary Productivity in Association with Observed Nutrient and Hydrographic Conditions Prevalent in the Laguna Madre of South Texas: A Multi-year Picture.

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The Laguna Madre of Texas is part of an extensive barrier beach island and lagoon complex, extending from Corpus Christi south to the Rio Grande River. Laguna Madre is divided into upper and lower sections by sand flats, with the only connection being a dredged channel through the area called "Land Cut". Overlying extensive seagrass beds, waters of this shallow, hypersaline bay system tend to be low in nutrients and relatively clear. Strong winds, high temperatures and the lack of rainfall (mean = 25 inches per year) drive a loss of water by evaporation as high as 60 inches per year. The resulting salinities of this lagoon can be as high as 75 parts per thousand. Monthly hydrographic, nutrient and pigment measurements were collected over several years. Estimates of primary productivity were also obtained at selected stations during monthly samplings. The hydrographic distributions showed north to south gradients of salinity in Laguna Madre, with maximum values in the upper reaches of Baffin Bay. The dissolved inorganic nitrogen (DIN) concentrations also displayed maximum concentrations in Baffin Bay, with ammonium accounting for 60-95 % of the total nitrogen. The concentrations of nitrate and chlorophyll a, within the Laguna Madre correspond closely with salinity and sustain the relatively high rates of primary productivity.

OS22C-199 1330h POSTER

Alkaline Phosphatase Activity in Monterey Bay

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Phosphorus (P) is an essential nutrient utilized by all living organisms, and has been recognized as a limiting nutrient in some oceanic systems (Cotner et al., 1997; Karl et al., 1995; Michaels et al., 1996; Wu et al., 2000). However, relatively little is known about the extent of P limitation in natural environments, how P limitation varies spatially and temporally, and what determines how and when P becomes limiting (Benitez-Nelson, 2000). A more direct estimate of the degree of P limitation in a variety of oceanic systems is needed to better understand P cycling and dynamics within the ocean and how these have and will change in response to global climate and environmental perturbation. Accordingly, the objective this study is to assess the P-status of marine planktonic communities in Monterey Bay using the activity of alkaline phosphatase in the water column.

Alkaline Phosphatase (AP) is the most widely used enzyme by marine organisms to hydrolize organic P compounds to biologically available orthophosphate. Accordingly it is expected that in areas where P is a limiting nutrient organisms will produce and release more AP to seawater so they can utilize the dissolved and particulate organic P compounds. Indeed it has been suggested that the AP activity is a reliable indicator of P-availability to planktonic communities (Ammerman and Azam, 1985; Cotner and Wetzel, 1991; Hong et al., 1998). High enzyme activities indicate low Dissolved Inorganic Phosphate (DIP) availability while low levels suggest that DIP supply satisfies the community P-demand.

We will assess the utility of alkaline phosphatase activity in seawater as an indicator of the degree of P-limitation and evaluate the causes for differences in the activity as well as the degree of spatial and temporal variability in P-status. We will determine the P-hydrolyzing enzyme activities in solution and in different plankton size fractions. The study encompasses data from a three-station transect in Monterey Bay, ranging from coastal waters to open ocean depths of several thousand meters, and a coastal station in San Francisco Bay. As this study is primarily interested in AP activity within the euphotic zone, AP activity will be presented for the upper 200 meters for each station. Preliminary work has shown measurable AP activity levels that will be correlated temporally and spatially. Ancillary parameters such as nutrient concentrations, primary productivity, and species composition, will also be obtained from time series data collected by Monterey Bay Aquarium Research Institute (MBARI).

OS22C-200 1330h POSTER

Influence of CO_2, Iron, Nitrogen and Phosphate Limitation on Intracellular DMSP Concentrations in a Coastal Diatom.

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DMS (dimethylsulfide) is a significant source of sulfur to the marine atmosphere. Its atmospheric oxidation to acidic sulfur species (eg H_2SO_4) influences cloud nucleation and the planetary heat balance. DMS is derived from enzymatic cleavage of DMSP (dimethylsulfoniopropionate), which is produced in high concentrations by certain groups of phytoplankton. DMSP is thought to function in phytoplankton as an osmolyte. However several studies suggest that there may be other functions for this molecule. Sunda et al. have proposed that DMSP may also function as the first link of an antioxidant system: DMSP/DMS/DMSO. To further examine this hypothesis, we have conducted batch culture growth studies with the coastal diatom *Thalassiosira pseudonana* under different nutrient limitations that can disrupt photosynthesis and thereby increase cellular oxidative stress. We observed that limitation by CO_2, nitrogen and iron (under both nitrate and ammonium supported growth) increases intracellular DMSP concentrations by up to 30 fold. Thus, limitation by a variety of nutrients may influence DMSP dynamics in marine systems.

TUE

OS22C-201 1330h POSTER

The Effect of Nitrate and Irradiance on Natural Fluorescence

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Estimating chlorophyll biomass from remotely sensed natural fluorescence relies on empirical relationships that simplify the physiological relationship between chlorophyll biomass and the natural fluorescence quantum yield. A number of environmental factors can elicit physiological responses that change this relationship, and two such factors, nitrate availability and irradiance intensity, vary widely in the ocean both spatially and temporally. The influence of these two factors on natural fluorescence radiance was examined in continuous culture experiments. In cultures of Thallasiosira weissflogii grown under different irradiances and growth rates, fluorescence per unit ambient irradiance correlated broadly with chlorophyll biomass. However, specific combinations of irradiance intensity and growth rate demonstrated very poor correlation, particularly at high irradiances. These poor correlations can be improved in some cases by varying the time at which natural fluorescence is sampled; correlations made at or 2 hours after solar noon were less robust than those made in the forenoon. Diurnal variability in natural fluorescence appeared to be correlated to the perceived level of nitrate availability, and simple metrics that quantify this variability may have potential in remote sensing studies. Diurnal fluorescence action spectra and pigment data were examined to identify the mechanisms that dominate the observed diurnal changes natural fluorescence. Potential physiological interpretations of this variability are discussed.

OS22C-202 1330h POSTER

Light Stress and TEP Production in Phytoplankton Communities in Turbid Coastal Waters

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The effect of light stress on the production of transparent exopolymer particles (TEP) was studied in natural phytoplankton populations off the New Jersey coast during the 2001HyCODE/COMOP Coastal Predictive Skill Experiments. Nearshore waters generally are optically turbid and the resident phytoplankton populations are often low-light adapted. TEP production is generally enhanced when cells are photoinhibited. Given this, we hypothesized that coastal communities should be particularly sensitive to high light stress and thus potentially produce a great deal of TEP when they are mixed to surface waters. Secondarily, we predicted that surface light stress should be greater for inshore communities compared to offshore communities who reside in clearer waters. Discrete samples were collected from offshore and inshore stations at 8 m depth, and were incubated for 24 hours outdoors under ambient light. Ambient light levels were comparable to light levels just below the surface at both offshore and inshore sampling sites. Nearshore populations were very low light adapted as indicated by significantly lower Ik values (factor of 2) and were heavily light stressed, compared to their offshore counterparts, by surface irradiance. The TEP abundance and TEP production rates were an order of magnitude greater than the offshore community. This confirmed that light stress is positively correlated with TEP production in natural populations. In this area, topographic variations associated with ancient river deltas cause upwelled water to evolve into an alongshore line of three recurrent upwelling centers that are co-located with historical regions of low Dissolved Oxygen (DO). Upwelling results in the Ekman transport of water offshore and the transport of mid- and bottom water phytoplankton communities to the surface. Satellite and ship data confirm that significant phytoplankton blooms are associated with these upwelling events. Furthermore, SCUBA divers often observe marine snow. Given our findings of the potentially large TEP production rates in the nearshore populations, we hypothesize that TEP formation, via light-stressed populations, may strongly influence the hypoxic/anoxic zones off the coast of New Jersey.

URL: http://marine.rutgers.edu/cool/

OS22C-203 1330h POSTER

Spatial Variability of Benthic Microalgal Pigments and Hyperspectral Reflectance of Sediment Surfaces Near Lee Stocking Island, Bahamas

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The study area is characterized by optically shallow water and a mosaic of carbonate sediment types and habitats. Multiple sediment cores were collected within a 0.25 m^2 grid at 11 sites around Lee Stocking Island, Bahamas. Sampling sites included an area with high tidal flow and shoaling ooid sand, grapestone sand (clusters of cemented sand grains), sediments covered with a dense biofilm, sand in and around seagrass beds, and sand on the surface of and around a mound created by burrowing shrimp. Spectral reflectance (wavelengths 400-710 nm; approximately 0.3 nm resolution) was measured 25 mm above the surface of each core. Microalgal pigments in the top 5 mm of each core were identified and quantified by high performance liquid chromatography.

Microalgal biomass, as indicted by chlorophyll a, varied dramatically within and among sampling sites. Differences in the ratios of taxonomically significant pigments to chlorophyll a indicate diverse microalgal community structures both within and among sampling sites. The shape and magnitude of reflectance spectra were variable both within and among sampling sites. Subtle differences in shapes of reflectance spectra were enhanced by second derivative analyses and provide information about microalgal community structure. Results of these studies indicate that the types of benthic microalgae and their distributions on or near sediment surfaces affect reflectance properties of sediments in three ways. First, microalgal biomass causes a decrease in the magnitude of reflectance across the visible spectrum because of the combined absorptive properties of their photosynthetic and photoprotective pigments. Second, microalgal community structure affects the shape of reflectance spectra because different pigments that are characteristic of specific types of microalgae have unique absorptive properties. Third, extracellular polysaccharide produced by microalgae and bacteria living on and near sediment surfaces, and within which the microalgae are embedded, increases sand grain spacing and enhances the probability of photons being absorbed so that reflectance is reduced across the spectrum.

OS22C-204 1330h POSTER

Effects of UV-Radiation and Nutrient Status on Production of Mycosporine-Like Amino Acids (MAAs) in Harmful Bloom-Forming Dinoflagellates

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Mycosporine-like amino acids (MAAs) are a group of compounds that absorb strongly in the UV range (absorption maxima 310-360nm) and are present in many marine organisms including dinoflagellates. Several species of dinoflagellates form large, monospecific near-surface blooms where they are exposed to high doses of ultraviolet and visible radiation. Possession of UV-absorbing compounds like MAAs may be one factor that allows these species to form such blooms. Experiments involving two toxic bloom-forming species, *Alexandrium tamarense* and *Gymnodinium breve*, were conducted to investigate the role of nutrient status and light (UVR and PAR) on MAA production. Two nutrient regimes, nitrogen replete and nitrogen starved, were used to determine how increases in nitrogen due to coastal eutrophication might influence MAA production. Cultures from both nitrogen states were exposed to environmentally realistic levels of UVR + PAR or PAR-only and monitored for MAA content, in-vivo and extracted UV/VIS absorption, Fv/Fm, chlorophyll content, cell concentration and cell size.

The results of these experiments showed that strong UV-induced MAA synthesis occurred under both nitrogen-replete and nitrogen-starved conditions. However, the specific composition of MAAs produced differed between the two nitrogen treatments. The fact that these cells continue to produce MAAs when nitrogen is scarce may indicate that MAAs play an important functional role, such as photoprotection.

OS22C-205 1330h POSTER

Phytoplankton Deposition and Resuspension From Sandy Beds in Oscillatory Flows

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In permeable sediments such as those found on continental shelves, the interaction of near-bed currents with bottom topography creates pressure gradients that can induce interstitial flows that enhance the exchange between sediments and the water column. Previous studies conducted in steady unidirectional flows with isolated roughness elements have demonstrated that this process greatly increases the incorporation of fine-grained organic matter into the sediment. In this study we examined uptake and release of phytoplankton by rippled sand beds under simulated wave boundary layer flows–conditions that are more representative of shelf environments. Using an oscillatory water tunnel, the deposition of a cultured diatom to a well-sorted coarse sand under non-eroding flows (peak velocity = 12 cm s^{-1}) was determined for a flat bed and beds consisting of numerous small (λ = 10 cm, H = 4 cm) or large (λ = 20 cm, H = 8 cm) ripples. Deposition experiments were run overnight, and sectioned syringe cores used to quantify bed diatom distribution. For flat bed experiments, there was little horizontal variation in the depth-integrated bed diatom density, and 85 % of the cells were found in the surface layer (0-1 cm). In other treatments, ripple geometry controlled diatom depositional patterns in a manner consistent with the expected direction and magnitude of interstitial flows. Depth-integrated diatom concentrations were highest in the troughs where pressure gradients force water into the sediment and lowest on the crests where water exits the bed. Not surprisingly the depth of diatom penetration was greater in the troughs than the crests. Differences between troughs and crests also scaled with ripple size. For example, trough depth-integrated diatom density was 2.5 × higher than that occurring in crests for small ripples and increased to 3.8 × for the large ripples. Similar trends in the depth of diatom penetration were also observed. When flow speed was increased to form large ripples from a previously phytoplankton-impregnated small rippled bed, up to 65 % of the bed diatoms were resuspended in the first several minutes of sediment movement. Sampling of the newly-formed large ripples showed that sediment transport had homogenised diatom distribution in the surface layers (0-5 cm) except under ripple crests where rapid burial had protected a layer of diatoms some 2-4 cm beneath the surface. Thus, while sediment topography such as ripples clearly influences the spatial distribution and flux of organic matter into the bed, changing bed morphology ultimately controls the amount of burial or resuspension to the water column.

OS22C-206 1330h POSTER

The Effect of Clearing Size and Wave Exposure on Initiation of Alternative States in West Australian Kelp Beds

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Beds of the small kelp Ecklonia radiata are a dominant feature of temperate reefs in Western Australia. These kelp beds are best described by an alternative states model as a mosaic of kelp patches and gaps which are usually dominated by Sargassum spp. or foliose red algae. In a recent review of experimental approaches to investigating alternative states in communities Petraitis and Latham (Ecology 1999 80(2):429-442) emphasized the importance of distinguishing between processes initiating and processes maintaining alternative states. Contrary to many other kelp-dominated systems grazing does not seem to play a significant role

in structuring kelp assemblages in Western Australia. Physical disturbance in the form of winter storms and swell events is the major forcing agent, creating gaps in the dominant kelp canopy. Studies have shown that E. radiata control kelp bed assemblage structure by modifying the surrounding physical environment. It has however also been shown that physical environment and turf algae in gaps may control E. radiata distribution. Consequently, there is now good evidence for mechanisms maintaining alternative states in West Australian kelp beds. Petraitis and Latham (op. cit.) also emphasized the importance of spatial scale in alternative state initiation, i.e. the presence of disturbance size thresholds needed to change from one state to another. This idea is implicitly included in most alternative states models, but it remains largely untested experimentally. Results will be presented from an experiment where we tested the hypothesis that there is a threshold level of disturbance (gap size) above which gaps will persist and that this threshold is lower in more stressful environments (higher wave exposure). Clearings ranging in size from 0 - 200 m2, covering the range of naturally occurring gaps, were made in kelp beds on exposed and sheltered reefs and kelp recruitment monitored for 18 months including two annually occurring recruitment events.

OS22D HC: Hall III Tuesday 1330h

Transport and Transformation of Biogeochemically Important Materials in Coastal Waters I

Presiding: **B J Eadie,** NOAA - Great Lakes Environmental Research Laboratory

OS22D-207 1330h POSTER

Phytoplankton Community Structure and Seasonal Succession in Tomales Bay, CA.

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Tomales Bay, Northern California, is situated just north of Point Reyes, in the Gulf of the Farallons National Marine Sanctuary. Previous studies made as part of the Land Margin Ecosystem Research Study showed Tomales Bay to receive oceanic inputs from both the Gulf of the Farallons, and near-shore sources. Upwelling fronts in the Gulf move shoreward during relaxation events bringing planktonic larvae in contact with warmer, low salinity waters. At this interface, mixing of waters from Tomales Bay, and upwelled coastal waters, may provide phytoplankton seed for bloom events, and a food source for planktonic larvae. As part of the LMER project, the phytoplankton community structure was described for a single annual cycle in a dry year. How community structure changes with inter annual cycles and as a result of upwelling events is yet unknown. This study describes the phytoplankton community structure and seasonal succession in Tomales Bay at two sites, over an eighteen-month period, from April 2000 to October 2001. Phytoplankton were identified and counted using the Utermohl technique and inverted microscopy, along with measurements of chlorophyll a. Peaks in phytoplankton abundance occurred in summer of both years with different taxa dominating each year. Samples for hydrographic and nutrient analyses were made during these bloom times. This poster focuses on phytoplankton community structure and bay nutrient regimes, as they may compare to near-shore biologic and oceanographic conditions.

OS22D-208 1330h POSTER

Temporal and Spatial Distributions of Nutrients and Phytoplankton Productivity in a Northern California Upwelling Region Measured During CoOP-WEST

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Nutrients and phytoplankton uptake rates of nitrate and ammonium were measured in the upwelling region off Bodega Bay in Northern California as part of the NSF CoOP-WEST interdisciplinary study. Water samples were collected over the continental shelf and offshore during the upwelling season in late spring 2000 and 2001. To assess the contribution of different phytoplankton size classes to the uptake of nitrate and ammonium, samples of water incubated with either 15N-nitrate or 15N-ammonium were filtered on either GF/F filters for total phytoplankton community or on 5um silver filters to sample the larger phytoplankton cells. Upwelling areas are typically high new production ecosystems and nitrate uptake is expected to be greater than ammonium uptake. Also, the larger phytoplankton cells tend to dominate both the nitrate uptake rates and the total biomass. In both years of the present study, strong wind-driven upwelling resulted in high concentrations of surface nitrate and silicate near the coast from a source depth of 200m. During the subsequent relaxation period, nitrate uptake increased and was dominated by the larger phytoplankton cells. In contrast, the lower nutrient offshore waters contained a larger concentration of smaller cells taking up ammonium. The relationship between wind events and relaxation plays a crucial role in the realization of productivity in this upwelling ecosystem.

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OS22D-209 1330h POSTER

Inter and Intra-annual Patterns of Phytoplankton Assemblages During Upwelling Events off the Coast of Northern California (CoOP WEST Study)

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As part of a NSF funded project (Coastal Ocean Processes; Wind Events and Shelf Transport - CoOP WEST) to determine the fate of upwelled nutrients and primary productivity, the composition of the phytoplankton assemblage was examined off northern California during June, 2000 and May/June, 2001 during upwelling season. Phytoplankton were enumerated using the Utermohl technique, and biomass (as chlorophyll a) was measured for the community as a whole and for cells greater than 5um in diameter. For both years, high levels of chlorophyll and phytoplankton cells occurred following upwelling events. At the height of the blooms, total chlorophyll concentrations and phytoplankton biomass were approximately twice as high in 2000 as in 2001, as were the concentrations of available silicate and nitrate just prior to the blooms. Taxonomic observations for each year show that diatoms (especially Chaetoceros spp.) dominated when larger cells were the major contributors to total phytoplankton biomass. As nutrients were consumed during periods of relaxation, diatom cell numbers increased in populations over the shelf and closer to the coast. In 2000 the off shore population in less nutrient rich waters was dominated by smaller, flagellated phytoplankton. In 2001 the spatial shift seen in 2000 from an inshore community dominated by diatoms to an offshore community dominated by flagellates was not observed. Also different in 2001 was the appearance of picoplankton such as Synechoccocus sp. that were observed towards the end of the field study. These differences in the phytoplankton assemblages are likely attributable to different wind event patterns between the two study years.

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OS22D-210 1330h POSTER

Nitrogen cycling during winter/spring transition in southern Lake Michigan

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Nitrogen is not limiting in Lake Michigan, but it can be a "currency" to assess microbial food web processes and carbon sources. Nutrient-addition experiments were conducted in March and June 1999 and March and May 2000 to measure net direction and magnitude of NH4+ fluxes and relate the results to microbial food web composition. Lake water was fortified with four mM (final concentration) 15NH4+, or a 15N labeled amino acid mixture, and incubated for 24 h in 70-ml bottles to observe net fluxes of these dissolved nitrogen compounds under natural light and dark conditions. Microbial food web components were quantified at the same stations. Net ammonium uptake in the light occurred at most (57 to 86%) of the stations in the different cruises. Net ammonium production was observed in zero to 29% of stations in the four cruises, and no significant change in ammonium concentrations occurred in 13 to 25% of stations. The presence of natural light affected fluxes in 29-75% of the stations, but the remaining stations did not show significant differences. Addition of phosphorus had a moderate but significant effect on ammonium uptake in 43 to 63% of the stations. Amino acid concentrations in lighted bottles showed a net uptake in 13 to 42% of the stations, net production in 25-63% of the stations, and no significant change in 17 to 38% of stations. Overall, amino acid demand was negligible except for a few stations. Light affected amino acid uptake in 5 to 50% of stations. Chlorophyll levels and microbial food web abundance were higher at stations near the St. Joseph River mouth than other stations. Likewise, uptake rates of ammonium and amino acids were higher and rates differed more between light and dark bottles at the St. Joseph River mouth stations. Correlation significance between uptake rates and food web characteristics at the different stations depended on the inclusion of St. Joseph River mouth stations. We conclude that winter/spring microbial food web abundance and nitrogen cycling activity were higher in the river plume region than other regions of the southern lake.

OS22D-211 1330h POSTER

The Spatial and Temporal Distribution of Phosphorus in Western Lake Superior

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Phosphorus is the limiting nutrient for biological production in many lacustrine ecosystems, including oligotrophic Lake Superior. In the past, surveillance programs and other investigations have focused primarily on the measurement of total phosphorus (TP) at the lake surface as a measure of the trophic state of Lake Superior. Although TP concentrations are useful for this purpose, these data alone tell us nothing about the biogeochemical cycling of this important nutrient. At present, little is known about the spatial and temporal distribution of phosphorus and its speciation in Lake Superior. This lack of knowledge stems, in part, from the inability of many standard techniques to resolve low concentrations of soluble reactive phosphorus (SRP). Moreover, total dissolved phosphorus (TDP) has not been routinely measured. Over the last two years, we have sampled the water column at several stations along a transect from the shallow bay waters near Duluth-Superior Harbor to the deep coastal waters. The detailed profiles of TP, TDP, and SRP show that the distribution of phosphorus in its dissolved and particulate pools can vary significantly spatially and seasonally. The data suggest that the soluble non-reactive phosphorus (SNP) pool, which is comprised primarily of dissolved organic phosphorus and is calculated as the

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