skeletal carbonate is known to be affected by both environmental factors (e.g. insolation and temperature) and physiological factors (e.g. photosynthesis, calcification, and the statues of the symbiotic relationship between corals and zooxanthellae) it is the most promising proxy for reconstructing past bleaching events. Two high resolution (weekly to fortnightly) δ^{13}C, δ^{18}O and Sr/Ca records from 1987-1997 of coral cores recovered from depths of 2m and 12m near the island of Moorea, French Polynesia have been made. In this calibration study, we are testing whether we can detect a signal of coral bleaching and SST, which will then allow us to reconstruct past events. Temperatures calculated using common calibration curves for both δ^{18}O and Sr/Ca reveal seasonal variations matching both satellite and in-situ measured SSTs in the shallow core. In the deep core, Sr/Ca derived temperatures have a muted seasonal cycle reflective of its greater depth, while the δ^{18}O record is ambiguous and may in part reflect changes in upwelling. The δ^{13}C record from the deep coral has a clear seasonal cycle on the order of $1.2^{o}/_{oo}$, reflecting seasonal variations in cloud cover and/or changes in the extent of heterotrophic verses autotrophic feeding. The most noticeable aspects of the δ^{13}C record from the shallow core are two significant decreases of $0.8^{o}/_{oo}$ in 1991 and 1994 when large portions of the reef were bleached. A decrease in the maximum δ^{13}C values after 1994-1995 may be indicative of increased cloud cover. This increased cloud cover may have prevented bleaching of the reef in 1998 when SSTs were above the bleaching threshold. A two year record from a coral that was known to have been bleached on Pandora Reef, Great Barrier Reef, in 1998 supports these results. This core was sampled at weekly resolution, and both the Sr/Ca and δ^{18}O track even small changes in a STT record measured at a nearby island. At the onset of bleaching, the δ^{13}C decreased by $5^{o}/_{oo}$, presumably due to a decrease in photosynthesis associated with a loss of the zooxanthellae during bleaching. These calibrations studies suggest that δ^{13}C, δ^{18}O and Sr/Ca measurements can be used to reconstruct past bleaching events, if corals are sampled at high enough resolution.

OS11T HC: 323 C Monday 0830h

Zooplankton: Feeding, Growth, and Distribution I

OS11T-01 0830h

Feeding Ecology and Potential Predatory Impact of *Tortanus dextrilobatus*, an Invasive Carnivorous Copepod in the San Francisco Estuary

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Tortanus dextrilobatus (Copepoda: Calanoida) is one of at least seven copepods to have successfully invaded San Francisco Bay over the past 25 years. Although it is widespread and at times abundant ($> 10^3$ m^{-3}) in the San Francisco Estuary, the ecological impacts of this invertebrate predator are unknown. The objective of this study was to investigate the functional response of adult female *T. dextrilobatus* predation upon both native (*Acartiura sp.*) and non-native prey (*Oithona davisae* and *Acartiella sp.*). Predator and prey organisms were collected in the field and studied during two seasons (summer and autumn) at ambient temperature (19°C and 14°C) and salinity (13-19 psu) conditions. Twenty-four hour experiments were conducted with a plankton wheel (1 rpm) in a temperature and light controlled room. *T. dextrilobatus* exhibits a saturation type of functional response (characterized by an Ivlev curve) wherein maximum ingestion rates occurred within the range of natural prey densities. These experimentally derived feeding rates were applied to field observations of distribution and abundance (1997-1999) to estimate the potential predatory impact of this carnivorous copepod upon the zooplankton community in the San Francisco Estuary.

OS11T-02 0845h

Egg production, hatching and mortality of *Calanus sinicus* in the Bohai Sea, P. R. China

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Calanus sinicus is an important component of pelagic food chain in the coastal temperate waters of China. Egg production rates were measured in June, September, and December 1998 and April 1999 in the Bohai Sea. The influence of temperature on egg production rates was evaluated in June and December and hatching rates were measured December and April. Population structure was determined from field samples filtered through a 20m net. Egg production rates were maximal in April and minimal in December. The high egg production rate in April may have been due to an abundance of mature females from overwintering stock and the spring phytoplankton bloom. Temperature appears to have a significant influence on egg production rates within the optimum range. Egg production rates showed substantial spatial variation depending upon sample location and this variation was up to an order of magnitude. Egg hatching rates were 97.9% and 23.2% in April and December, respectively. These results were consistent with seasonal variations in abundance. In April, high production and high hatching rates were consistent with the seasonal pattern of high abundances that occurs in May and June. Low abundances in September and December corresponded to low egg production and low hatching rates.

OS11T-03 0900h

Onset of Dormancy in the Copepod *Calanus pacificus* in the Southern California Bight: Timing of Descent, Indicators of Preparation for Dormancy, and Environmental Conditions

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The timing of onset of dormancy in abundant, open-ocean, calanoid copepods such as *Calanus pacificus* affects their population dynamics and availability as prey items of fish and marine mammals and as grazers of phytoplankton. The mechanism of dormancy induction in open-ocean copepods is unknown, and it is therefore impossible to predict how dormancy timing might change as a result of environmental change. Onset of dormancy was examined in field-collected *C. pacificus* to identify the timing of onset of dormancy, to evaluate two potential indicators of preparation for dormancy in surface copepods, and to compare changes in environmental conditions at the surface with changes in the dormant status of copepods. Vertically stratified zooplankton samples were collected between the surface and 1100 m at San Diego Trough on twelve dates between April 2000 and January 2001. The timing of onset of dormancy was inferred from the appearance and build up of fifth copepodite stages (CVs) in deep water, which occurred from June to October 2000. Two potential indicators of preparation for dormancy at the surface, jaw development phase frequency distributions and average ecdysteroid (molting hormone) titers, were examined in deep, dormant CVs and in surface CVs and CIVs (fourth copepodites). Dormant copepods remain in the postmolt jaw development phase. Therefore the proportion of surface CVs in the postmolt phase is expected to increase when surface CVs are preparing for dormancy. Because jaw phase distributions can also change due to environmental factors, CV jaw phase distributions were compared with those of CIVs, which do not become dormant in the Southern California Bight. A higher proportion of postmolt CVs was observed when onset of dormancy was occurring than when onset was not occurring. In contrast, CIV jaw phase distributions did not differ between these dates. Ecdysteroid titer is low in CVs after molting and during dormancy. Therefore average CV ecdysteroid titer is expected to be lower when onset of dormancy is occurring than when onset of dormancy is not occurring. Onset of dormancy was spread over a wide range of dates and occurred mainly during a period of decreasing day length and increasing surface temperature. The two largest increases in deep CV abundance occurred during or shortly after peaks in subsurface chlorophyll concentration.

OS11T-04 0915h

Development Times of *Euphausia Pacifica* Larvae in the Laboratory

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We are working out the population dynamics of euphausiids in the Oregon upwelling zone with the goal of estimating growth, productivity and mortality rates *in situ*. It is first necessary to establish the variability in times to stage and in developmental pathways for a given population of animals before making assumptions that allow for use of field samples to determine these rates. In this study, gravid adult female *Euphausia pacifica* were collected 25 miles off the coast of Newport, OR. These females were transferred to the laboratory where eggs were spawned, hatched, and reared under close observation at 10.5° C. Four cohorts of larvae were monitored daily until they reached the juvenile 1 stage. They were fed to excess with a combination of *Isochrysis sp., Chaetoceros calcitrans, Rhodomonas salina*, and *Heterocapsa triquetra* cells. We plotted the cumulative percent of individuals within each developmental stage and performed arcsine transformations in order to estimate median development times using linear regression.

The first calyptopis stage and the third furcilia stage appear to be bottlenecks in the development of this species. These stages had durations nearly double that of any other stages. Individual cohorts developed at nearly the same rate until the first furcilia stage, after which one cohort began to develop significantly faster. Median time to juvenile 1 ranged from 51.9 to 60.6 days with significant differences among cohorts. Differences in development time among cohorts appear to be closely related to the degree of synchrony in development within a cohort. Our development time results matched well with those found by Ross (1981) for a population taken from Puget Sound, WA, despite other differences in their population dynamics.

OS11T-05 0930h

Velocity and Shear Stress Fields of Krill, Euphausia pacifica

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The movements of planktonic animals influence the cycling of matter and energy by altering the size distribution and abundance of particles and aggregates. In order to test whether animal-generated flow fields disrupt marine snow, we measured the structure of flows created by swimming krill. The velocity field and shear stress around a tethered krill were mapped using digital particle image velocimetry (DPIV). The velocity fields showed the position of the jet generated by the movement of the krills pleopods. Water entrained broadly around the krill is directed into a high-speed jet behind the last set of pleopods. The Reynolds number of the krill-generated jet is 500 based on an average velocity of 5 cm/sec through the central region of the jet of 1 cm width. Maps of the instantaneous flow fields show eddies at the edge of the jet and analyses of the shear stress show maxima at the jet edge. Toroidal vortex rings develop in the shear layer of the jet and propagate downstream. Snow particles entrained into the jet by the induced motion of the vortex rings are subjected to high values of shear stress, potentially capable of aggregate disruption. Detailed observations of the flow field and behavior of the macroplanktonic organism, krill, will enhance our understanding of the role of body size and movement patterns in intermediate Re realms. Studies of fluid flow and animal movements at this scale bridges the research of the biological-physical

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interactions occurring in small organisms like bacteria and copepods to these processes affecting larger organisms like crabs and lobsters.

OS11T-06 0945h

Decoding Complex Fluid Mechanical Signals: Neural Responses From the Mechanosensory Hairs on the Antennule of Gaussia princeps.

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Aquatic animals create spatially and temporally complex fluid disturbances as they move through the water. The ability of copepods to discriminate predators from prey and identify potential mates relies on their ability to decode these complex signals. Behavioral studies have shown that copepods do distinguish different qualities of the fluid signals and respond in an ecologically appropriate manner. Furthermore, not only do they show spatially accurate behaviors but they also respond with extraordinarily short latency. Physiological studies, in conjunction with analysis of behavior, have shown that individual mechanosensory hairs (setae) on the antennule of copepods produce neural signals that, at least partially, mediate these responses. However, despite our growing knowledge surrounding the behavioral responses of copepods, it is still unclear what characteristics of the setal bend elicit either the neurophysiological or behavioral response. Neither is it understood how the mechanosensory system in copepods codes for the different fluid mechanical signals. To address these issues, we examined the physiological thresholds for mechanical stimulation of specific seta on the antennule of Gaussia princeps. In addition, by using an extra-cellular recording technique that measures the response of numerous neurons along the antennule, we also examined the relative timing between firing rates of adjacent seta. Setal motion in response to a calibrated water jet was digitally recorded at speeds of 2000 Hz while simultaneously measuring neural activity (42,000 Hz). Our initial results suggest that the rate of change in setal motion is an important parameter controlling the neural response. The frequency of discharge showed a positive graded response to increased signal strength and hence setal motion. This supports the hypothesis that intensity is coded in part, by discharge frequency. We also found very rapid interspike frequencies (maximum frequency of 5 kHz) that permit the rapid comparison of intensity between closely spaced seta. Such spatial comparisons among seta may function to interpret signal direction. The implications of these results are discussed in light of the number of neural spikes received prior to initiating a rapid, accurate behavioral response, and of the ability of the animal to respond appropriately to ephemeral environmental signals.

OS11T-07 1020h

Behavioral Adaptations of the Cubozoan Medusae Tripedalia cystophora for Feeding on Copepod Swarms

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The copepod Dioithona oculata forms dense swarms in mangrove prop-root habitats, mainly in light shafts that penetrate the mangrove canopy. These swarms reach peak densities exceeding 50 copepods per ml. Surprisingly, these high density swarms rarely attract visual predators such as small fish. Planktivorous fish may be reluctant to enter the prop root habitat to feed because of numerous ambush predators (barracuda, snapper) that position themselves along the mangrove fringe. However there is a non-visual invertebrate predator, the cubozoan medusae Tripedalia cystophora, that has evolved behavioral adaptations to locate and exploit these copepod swarms. Tripedalia possess both lensed and pigment cup eyes that make them capable of sophisticated photobehavior which allows them to locate and remain within light shafts to exploit high density swarms of copepods. Using phototactic behavior Tripedalia swim laterally to enter areas of higher light intensity. Once these light shafts are located, the medusae exhibit klinokinetic responses, reversing direction when they pass out of an area of higher light intensity; this behavior guides them immediately back to the light shaft. Tripedalia feed by ensnaring copepods on nematocyst-laden tentacles, and then drawing the tentacle up to the mouth. A simple one-to-one correspondence between feeding motions and copepods ingested allows for measurement of feeding rates in the field or laboratory based on visual or videotaped observations. Feeding rates increase rapidly with copepod density, and maximum rates are not achieved until the high densities associated with swarms are reached. Feeding motions are rarely observed at lower copepod densities that exist between swarms. It seems doubtful that this small medusae could survive without its ability to locate and exploit these high density copepod swarms.

URL: http://www.utmsi.utexas.edu/staff/buskey

OS11T-08 1035h

Relationships Between Copepod Lipids and Seston Characteristics in the North Water Polynya (Baffin Bay)

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A central objective of the International North Water Polynya Study is to characterize the food web in this ecosystem and to quantify the transfer of biogenic carbon among populations. We are interested in describing patterns of copepod omnivory in the polynya, understanding how omnivory varies both between species and spatially, and assessing its importance to energy flow. We compared the *in situ* lipid composition of *Calanus hyperboreus* (CV), *C. glacialis* (CV) and *Metridia longa* (CVIF) collected at 16 stations during fall 1999, over *ca.* 4 degrees latitude. Using the percent contribution of bacterial fatty acids (BFA; odd-chained and/or branched) to total fatty acids in copepod neutral lipids as a proxy for the ingestion and assimilation of marine snow (containing bacteria) and/or bacterivorous protists, we show that copepods in the polynya feed omnivorously, to varying degrees, depending on the species and *in situ* conditions. Over all sampling stations, percent BFA in *C. hyperboreus* ranged from 0.5 to 1.8 %, in *C. glacialis* from 0.7 to 3.9 % and in *M. longa* from 1.1 to 5.8 %. We calculated unsaturation coefficients (UC; proportion of total copepod wax ester that is polyunsaturated), which also varied spatially and between species. Across all sampling stations, UC in *C. hyperboreus* ranged from 0.3 to 0.7; for *C. glacialis* and *M. longa* the ranges were 0.2 to 0.6 and 0.03 to 0.3, respectively (the lower the number, the more omnivorous the organism). We are currently investigating relationships between seston characteristics and copepod lipid composition to find a metric (*e.g.*, integrated chlorophyll, bacterial biomass, particulate organic carbon, seston lipid composition) that may allow us to predict the degree of copepod omnivory from characteristics of the prey community. We expect that spatial variability in copepod lipid composition will be related to changes in the prey community within the polynya.

OS11T-09 1050h

Mesoscale Distributions of Lipids in the Copepods of the California Current

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Quantitative measurements of lipid class composition were taken from the most abundant copepods (primarily *Calanus* sp.) collected during the US GLOBEC California Current broadscale cruise of July 2000. Storage and metabolically active lipids (wax esters and triacylglycerols respectively) were generally positively correlated with *in situ* phytoplankton biomass (as measured by extracted chl-*a* concentration), but not strongly so. Inshore waters were characterized by cooler temperatures, higher nitrate and chl-*a* concentrations, while offshore waters were the opposite: warmer, and with lower nitrate and chl-*a* concentrations . Correspondingly, the highest lipid concentrations occurred over the shelf, and the lowest beyond the shelf edge. Over the shelf, triacylglycerol concentrations were highest in areas with low nitrate while wax ester concentrations were independent of nitrate, suggesting that short-term lipid accumulation had occurred over time scales longer than that of upwelling and primary productivity. Examination of the spatial structure of lipid concentrations with Mantel correlograms indicates that the greatest differences occurred at scales on order of 25 km. The greatest differences in temperature and phytoplankton biomass occurred at scales considerably smaller than that (less than 10 km). These results suggest that lipid accumulation is driven by smaller scale processes, rather than regional ones.

OS11T-10 1105h

Copepod-dilution grazing experiments: what can they tell us?

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The realization that many "herbivorous" copepods can often be omnivorous, has forced a rethinking of how we approach trophic interactions. Estimating in-situ secondary or tertiary production requires a way to quantify the grazing rates of the secondary-tertiary consumer on an assemblage of prey items, including both heterotrophs and autotrophs. These measurements are especially critical for studies of net carbon export from copepod fecal pellet production and understanding the mitigation of deleterious egg production and hatching success from diatom consumption by copepods. Here, we examine the feasibility of conducting a "copepod-dilution" experiment to estimate copepod grazing rates on multiple prey items. We did this by conducting a sensitivity analysis of a computer simulation of this experiment, using different concentrations of copepods the "dilution factor" simultaneously feeding on microzooplankton and diatoms, where the microzooplankton could also grow as they ate the diatoms. We included stochastic variability in the grazing rates of both the copepods and the microzooplankton to assess the relative number of replicates and treatment levels necessary to make meaningful conclusions. This experimental setup appears very sensitive to the absolute initial concentration of phytoplankton and microzooplankton, and the microzooplankton grazing rate. In many cases, it was not possible to accurately determine relative grazing rates without also conducting a separate, classical microzooplankton dilution experiment to explicitly calculate the phytoplankton growth and microzooplankton grazing rates. At sea, it is unlikely that it would be possible to estimate the critical parameters before setting up such an experiment. Thus, it may always be necessary to conduct a microzooplankton dilution series at the same time as the copepod incubations.

URL: http://star-scream.ocean.washington.edu

OS11T-11 1120h

The Grazing Impact of Appendicularians on Picoplankton in the Coastal Subtropical Pacific

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The grazing impact of *Oikopleura fusiformis* and *O. longicauda* on picoplankton was investigated in the coastal waters of O'ahu, Hawaii during the summer and fall of 2001. *O. fusiformis* and *O. longicauda* are the dominant species of appendicularian in this area year-round. Field and laboratory experiments were conducted to determine their clearance rates on *Synechococcus* spp., *Prochlorococcus* spp., autotrophic eukaryotes and heterotrophic bacteria. At each of the field experimental sites, individual appendicularians were gently captured *in situ* in 264-ml polycarbonate bottles approximately 20-m offshore. Controls consisted of ambient seawater without appendicularians collected at the same site as appendicularian capture. Incubations were conducted onshore in seawater at ambient temperatures for a period ranging from 30 min to 3 h, until the animal no longer maintained a constant feeding current. During each experiment, aliquots were taken approximately every 30 min, preserved in paraformaldehyde and frozen in liquid nitrogen. Clearance rates were determined by measuring the rate of cell decline over the incubation period using flow cytometry. Experimental animals were measured and identified to species in the laboratory. In addition to field experiments, laboratory work was performed to develop the use of a natural tracer to directly determine the clearance rate of these animals on picoplankton. The average abundances of *Synechococcus* spp., *Prochlorococcus* spp., autotrophic eukaryotes and heterotrophic bacteria during the experiments were 4 x 10^3 cells ml^{-1}, 2 x 10^4 cells ml^{-1}, 2 x 10^3 cells ml^{-1} and 1 x 10^6 cells ml^{-1}, respectively. The average clearance rate of *O. fusiformis* was 1.4 l $animal^{-1}d^{-1}$, ranging from 0.5 - 2.7 l $animal^{-1}d^{-1}$, and was related to size of the organism. *O. longicauda* exhibited much lower rates, with an average of 0.5 l $animal^{-1}d^{-1}$. Given the high clearance rates of *Oikopleura* spp. and local abundances that often exceed 1 animal l^{-1}, these organisms are capable of clearing the entire water column of picoplankton daily. These results suggest that *Oikopleura* spp. may play a significant role in the transfer of energy from picoplankton to higher consumers in the coastal subtropical ocean.

OS11T-12 1135h

How Much of the Ocean Primary Production is Grazed by Mesozooplankton?

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A comparative analysis of the importance of mesozooplankton as grazers of the phytoplanktonic primary production (PP) across a wide spectrum of marine ecosystems revealed mesozooplankton ingestion rates to increase non-linearly with increasing PP. The slope of the log-log relationship between ingestion rates and PP was significantly < 1, indicating a decline of relative importance of mesozooplankton grazing with increasing PP. The impact of mesozooplankton on PP (as the percentage PP consumed per day) is moderate in most of the studies (mode 6%, mean 22.6%), and decreases exponentially with increasing productivity. Contrary to the common assumption, the size barrier imposed by dominant picoautotrophs does not always result in a lower grazing pressure in unproductive communities (we consider here those with PP $<$ 250 mg C/m/d). Yet, the amount of phytoplanktonic carbon ingested per unit of mesozooplankton biomass is lower in unproductive communities than in moderate (250 to 1000 mg C/m/d) and highly productive ones ($>$ 1000 mg C/m/d). This observation, together with the generally low values of daily biomass-specific ingestions, suggests that alternative food sources (e.g., protozoans), must represent an important component of mesozooplankton diet in unproductive ecosystems. The relationships obtained in the study yield an estimate of 5.5 Gt phytoplanktonic C consumed per year in the global ocean, which represents 12% of the oceanic PP.

OS11U HC: 318 B Monday 0830h

Algal Blooms, Red Tides, Brown Tides, and Pfiesteria I

Presiding: **J T Turner,** School for Marine Science and Technology, University of Massachusetts Dartmouth**; D G Redalje,** The University of Southern Mississippi

OS11U-01 0830h

Blooms of the Red Tide Dinoflagellate, *Alexandrium* spp. in the Gulf of Maine, Summer 2001.

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Blooms of the toxic dinoflagellate, *Alexandrium* spp., are common in the Gulf of Maine, and often result in the closure of shellfishing in near shore waters because of paralytic shellfish poisoning. We participated in a regional study of the dynamics of *Alexandrium* in the Gulf of Maine as part of the U.S. ECOHAB Program, and have conducted field work in 1998, 2000 and 2001. Our ship-board surveys conducted in 1998 and 2000 indicated: (1) the densest blooms were mostly offshore phenomena; (2) there were two broad but distinct offshore populations, one in the central Gulf of Maine, and another at the mouth of the Bay of Fundy; (3) *Alexandrium* cell densities were correlated with a nondimensional ratio of light and nutrients (Townsend et al., Cont. Shelf Res. 21: 347-369; 2001). The light-nutrient ratio assumes that growth of this large dinoflagellate is best in both high light and high nutrient environments. Pronounced offshore blooms of *Alexandrium* were observed in summer of 1998, during surveys conducted in June, July and August; cell densities were much lower during the late spring surveys conducted in 2000 (April-May and June), suggesting to us that *Alexandrium* follows the spring diatom bloom. We emphasize here results from our survey conducted in July 2001, which was intended to test the light-nutrient ratio hypothesis against other hypotheses that might explain summertime offshore blooms (advection from an upstream source, competitive interactions between dinoflagellates and diatoms). The hydrographic structure of the Gulf of Maine in July 2001 was different from that observed in July 1998. There were fewer wind events (storms) in 2001 resulting in warmer surface water temperatures and a shallower pycnocline than we observed in July of 1998; we argue that this provided optimum growth conditions, as indicated by the light-nutrient ratio, and indeed, offshore cell densities of *Alexandrium* were greater in July 2001 than in July 1998. We include preliminary analyses of the physical connections between the two offshore patches of cells seen in both 1998 and 2001 (in the Bay of Fundy and central Gulf of Maine) by way of advection of cells within the Eastern Maine Coastal Current. In addition to proposing the light-nutrient ratio hypothesis, we also examine the potential role of different ratios of dissolved inorganic nitrogen and silicate in controlling diatom and *Alexandrium* populations. Coastal waters of the Gulf of Maine are rich in silicate from freshwater sources, and hence support high cell densities of diatoms, but not *Alexandrium*. On the other hand, offshore waters have N/Si ratios of 1.3-1.5, and support high cell densities of *Alexandrium*, but (usually) not diatoms.

OS11U-02 0845h

Planktonic *Alexandrium* spp. Hypnozygote Cysts in the Gulf of Maine: A Shallow Water Trap?

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Hypnozygote cysts are a known part of the life cycle of *Alexandrium* spp. Negatively buoyant cysts purportedly fall to the benthos where they undergo mandatory quiescence. If oxygen is present an endogenous clock initiates germination, after which the newly germinated cells divide and swim, or are advected, to the photic zone, establishing the spring vegetative population. Offshore in the Gulf of Maine (GoM), where blooms are well documented, this paradigm is not entirely adequate. Benthic cyst studies have shown wide distribution of cysts, but the largest concentrations are below 100 m and at the downstream end of the Eastern Maine Coastal Current (EMCC) in which *Alexandrium* spp. typically bloom. Additionally, stratification effectively isolates near bottom water in all but shallow areas and the Bay of Fundy (BoF).

To investigate the occurrence of planktonic cysts, water samples were collected during three cruises in the Gulf of Maine in February, April, and June of 2000. 30 L samples were taken from three depths: 2 m below the surface, 5 m above the bottom, and, in all months but June, the top of the bottom nepheloid layer (BNL). Samples were sonified, stained, and examined for cysts using an epifluorescence microscope. Cysts were widely distributed, although not ubiquitous, in bottom and top of BNL samples throughout the GoM, especially over known benthic cyst beds in the BoF and offshore from Penobscot Bay. Highest densities occurred in February (10^3 m^{-3}); June and April had densities of 10-10^2 m^{-3}. Surface samples only contained cysts in February (10^2 m^{-3}). There was no obvious relationship between hydrography and cyst distribution.

Evaluating the role of suspended cysts in bloom initiation necessitates rough growth calculations. With an average speed of 15 km/d, the EMCC transports a given water mass from the mouth of the BoF to Penobscot Bay in roughly 12 days. Assuming a growth rate of 0.3 divisions d^{-1}, a population could double 3-4 times during that passage. To account for cell densities of 300 cells/L as seen in April of 2000 off Penobscot Bay, for example, 20 cells/L, or 20 cysts/L are necessary in the BoF where the EMCC originates. Observed planktonic cyst densities are 10-10^3. This may not mean that planktonic cysts are unimportant, but rather that some physical mechanism exits allowing vegetative cells to accumulate. The presence of the cyclonic gyre at the mouth of the BoF may be one such mechanism, eddies in the EMCC another.

What is the ecological significance of benthic cysts? Benthic cysts appear to establish annually recurring populations of vegetative cells in shallow water where conditions are favorable. In some areas, benthic cysts likely indicate more about where previous blooms terminated than about where new ones might begin. Benthic cysts are, however, implicated in coastal bloom initiation. The global proliferation of *Alexandrium* and other dinoflagellates in recent decades has been explained by transportation of cysts in ship ballast water. Inherent in this explanation is the assumption that natural populations (including the cyst stage) are inadequate for natural transoceanic movement of *Alexandrium* populations (although this possibility has not been eliminated). These ideas, and observations in the GoM, suggest that the ability of benthic cysts to initiate blooms is trapped by water depth and vertical mixing strength. What remains undetermined is the depth to which benthic cysts are viable as a means of vegetative population initiation. A simple experiment to determine how long a newly germinated cell can survive in darkness could constrain this depth.

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Trophic Accumulation of PSP Toxins in Zooplankton Size Fractions During Alexandrium Blooms in Casco Bay, Gulf of Maine, April-June, 1998

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As part of the ECOHAB Gulf of Maine regional program, paralytic shellfish poisoning (PSP) toxins were measured in various zooplankton size fractions from Casco Bay throughout the April - June, 1998 red tide period. Toxins in the 20-64 micrometer fraction represented toxic Alexandrium cells, whereas toxins in larger size fractions were associated with various microzooplankters (64-100, and 100-200 micrometers) or mesozooplankters (200-500 micrometers and $>$ 500 micrometers). Toxin levels across all zooplankton size fractions generally increased from low levels in April and early May (3-108 nmol STX equiv/g wet wt), to high levels (19-126 nmol STX equiv/g wet wt) in late May, with declining but in some cases still high levels (undetectable - 446, mean = 2.4 nmol STX equiv/g wet wt) in June. Distributions of toxins in size fractions suggest that Alexandrium was grazed by a variety of zooplankters, including microzooplankters such as tintinnids and copepod nauplii, and mesozooplankters such as copepodites, adult copepods and marine cladocerans. Zooplankton represent an intermediate through which PSP toxins can be vectored to upper-trophic-level consumers such as fish, marine mammals and seabirds.

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A Multiyear Perspective of Pseudo-nitzschia Populations and Toxin Transfer Events in Food Webs of Central California, USA

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Since mid-1999, our group has been tracking the populations of toxic species in the diatom genus Pseudo-nitzschia in Monterey Bay, California. During this time, there have been multiple blooms of P. australis and P. multiseries, with the former being more common. On several occasions during the blooms we found that domoic acid, the neurotoxin produced by these two species, broadly contaminated pelagic food webs, including krill, fish, and even filter-feeding whales. Furthermore, the diatoms coagulated into flocculent aggregates, which settled to the seabed, where they presumably were available to benthic consumers. Here we show the pattern of occurrence of toxic species and domoic acid over the 2 year time interval, and provide several examples of toxin contamination in regional animal populations.

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Growth Dynamics of Harmful Algal Blooms off the Gulf of Mexico Coast of Florida

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The dynamics of blooms of the red tide forming dinoflagellate *Karenia brevis* was studied during research cruises conducted off Panama City, Florida in October 2000 and off St. Petersburg, Florida in October