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California and the World Ocean '02

October 28, 2002
Fess Parker's Doubletree Resort
Santa Barbara, CA

Sea Grant Graduate Researcher Symposium and Poster Presentation

Program and Abstracts

Sea Grant
California

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Sea Grant is a unique partnership of public and private sectors, combining research, education, and outreach for public service. It is a national network of universities meeting changing environmental and economic needs of people in our coastal, ocean, and Great Lakes regions.

Sea Grant Graduate Researcher Symposium and Poster Presentation

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A remarkable pool of talented graduate researchers, who are supported by California Sea Grant, conduct research to provide the science-based foundation so important to the wise use and management of our coastal and marine resources. Under the guidance of expert scientists at colleges and universities throughout California, these trainees work to find answers and solutions to many of the complex problems facing our oceans and estuaries today. More than 900 students have been involved in the Sea Grant Trainee Programs in California since its inception in 1968. After completing either masters or doctoral degrees, these trainees often become California's next generation of scientists, engineers, and resources managers. California and the World Ocean '02 Conference will provide an excellent opportunity for these young researchers to network and share their scientific discoveries with a broad spectrum of people interested in our oceans.

To accomplish this, the California Sea Grant College Program and the University of Southern California Sea Grant Program are hosting a special Sea Grant Graduate Researcher Symposium and Poster Presentation at the California and the World Ocean '02 Conference. The Sea Grant Symposium is scheduled for Monday, October 28, 2002 from 2:00 to 6:15 p.m. This will be followed by a poster reception from 6:30 to 8:30 p.m. and conclude with judging and awards for the three best presentations and posters.

Symposium Organizers

Shauna Oh
California Sea Grant College Program

Paul Olin
California Sea Grant Extension Program

Judith Doino Lemus
University of Southern California Sea Grant Program

Sea Grant
California

Sea Grant Graduate Researcher Symposium Program

Monday, October 28, 2002 (2:00-6:15pm)

Co-chairs: Paul Olin, Shauna Oh, and Judith Doino Lemus

2:00-2:15 **Welcome**
RUSSELL MOLL, DIRECTOR, CALIFORNIA SEA GRANT COLLEGE PROGRAM

2:15-2:30 **Temporal Variability of Radium Isotopes in the Coastal Ocean: Shoreline Observations and Estimates of Cross-Shelf Transport**
S.L. COLBERT* AND D.E. HAMMOND

2:30-2:45 **Bacterial Contamination at Huntington State Beach: Investigating Potential Nearshore Pathways**
JEAN T. ELLIS*, BURTON H. JONES, AND DOUGLAS J. SHERMAN

2:45-3:00 **Patterns of Morphological Variation, Reproduction and Recruitment in Lower Intertidal Populations of the Kelp *Egregia menziesii* (Turner) Areschoung**
SARAH K. HENKEL

3:00-3:15 **The Effects of Armoring the Coastline on Intertidal Flora and Fauna**
DAWN ALEXANDRA OSBORN

3:15-3:30 **Recovery of Trophic Function in a Restored Pacific Wetland: Effect of Shading on Microalgal and Infaunal Communities**
CHRISTINE WHITCRAFT* AND LISA LEVIN

3:30-3:45 **From Host to Host: Interaction of Behavior and Environment on Parasite Transmission**
JONATHAN T. FINGERUT*, CHERYL ANN ZIMMER, AND RICHARD K. ZIMMER

3:45-4:00 **What Can Comparative Physiology Tell Us about the Nature of Marine Species Invasions?**
CAREN E. BRABY

4:00-4:15 **BREAK**

4:15-4:30 **The Diversity and Availability of *Caulerpa* Species Found in Retail Aquarium Outlets in Southern California**
SUSAN M. FRISCH* AND STEVE N. MURRAY

4:30-4:45 **Locating Marine Reserves Based on Coastal Features: Coupling Ocean Circulation and Larval Settlement around a Headland**
AMBER J. MACE

4:45-5:00 **Observation and Analysis of the Fine Scale Spatial Pattern of Pacific Sardine and Northern Anchovy Eggs**
K. ALEXANDRA CURTIS* AND DAVID M. CHECKLEY, JR.

5:00-5:15 **Radiocarbon in Otoliths of Yelloweye Rockfish *(Sebastes ruberrimus)*. A Unique Chronometer for the Waters of Southeast Alaska**
LISA A. KERR*, ALLEN H. ANDREWS, BRIAN R. FRANTZ, KENNETH H. COALE, THOMAS A. BROWN, AND GREGOR M. CAILLIET

5:15-5:30 **Habitat Structure and Recruitment Success of Two Near Shore Reef Fishes**
KELLY ANDREWS

5:30-5:45 **Toxicokinetics and Biotransformation of *p*-nitrophenol in Red Abalone (*Haliotis rufescens*)**
PATTI L. TENBROOK*, S.M. KENDALL, M.R. VIANT, AND R.S. TJEERDEMA

5:45-6:00 **Plicatamide: A Novel Antimicrobial Agent Isolated from the Blood Cells of the Ascidian *Styela plicata***
J. ANDY TINCU*, STEVEN W. TAYLOR, AND ROBERT I. LEHRER

6:00-6:15 **Dynamic Mechanical Properties of Whelk Egg Capsules (Genus *BUSYCON*)**
H. SCOTT RAPOPORT* AND ROBERT E. SHADWICK

* PRESENTING AUTHOR

Sea Grant Graduate Researcher Poster Presentation

Monday, October 28, 2002 (6:30-8:30pm)

SG.P1 **Flux Observations at the Golden Gate**
JONATHAN FRAM* and MAUREEN MARTIN*

SG.P2 **Linking Connectivity Pathways to Chemical Markers in Pelagic Juvenile Rockfish Otoliths**
MARY M. NISHIMOTO*, MILTON LOVE, ROBERT WARNER, AND LIBE WASHBURN

SG.P3 **Environmental Estrogens and Estrogen Mimics Adversely Effect the Normal Development of the Sea Urchin Embryo**
TROY A. ROEPKE*, MARK J. SNYDER, AND GARY N. CHERR

SG.P4 **Morphologic and Histologic Changes in Red Abalone (*Haliotis rufescens*) Subjected to Eight Different Treatment Combinations of Water Temperature, Food Availability and Infection with "*Candidatus* Xenohaliotis californiensis"**
BEVERLY A. BRAID*, JAMES D. MOORE, RONALD P. HEDRICK, RONALD S. TJEERDEMA, AND CAROLYN S. FRIEDMAN

SG.P5 **Early Embryonic Apoptosis in the Sea Urchin, *Strongylocentrotus purpuratus*: Developmental Timing, Control, and Responses to Environmental Disturbance**
REBECCA LISETTE VEGA

SG.P6 **Phytoplankton Community Structure and Seasonal Succession in Tomales Bay, CA**
LINDA RIGHETTI JUDAH*, G.N. CHERR, F.J. GRIFFIN, B.A. BRAID, C. LANGDON, F.P. WILKERSON, A. MARCHI, AND C.S. FRIEDMAN

SG.P7 **Deep-Water Habitat Characterization of Seafloor Imagery: A Tool for California Demersal Fisheries Management**
MERCEDES D. ERDEY* AND H. GARY GREENE

SG.P8 **Novel Approaches for Investigating Spicule Biosynthesis in Living Demosponges**
JAMES C. WEAVER*, KATSUHIKO SHIMIZU, JENNIFER N. CHA, PAUL K. HANSMA, GALEN D. STUCKY, AND DANIEL E. MORSE

SG.P9 **Reactivity of Vanadium Bromoperoxidase from Marine Algae: Enzyme Induced Cyclization Reactions**
JAYME N. CARTER* AND ALISON BUTLER

ABSTRACTS: Symposium Presentations

Temporal Variability of Radium Isotopes in the Coastal Ocean: Shoreline Observations and Estimates of Cross-Shelf Transport

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Evaluating the impact and fate of surface water runoff and associated contaminants requires knowledge of the rates of mixing and transport in the coastal zone. The distribution of naturally-occurring radium isotopes, 223Ra (t1/2=11 days), 224Ra (t1/2=4 days), and 228Ra (t1/2=6 years) are being explored as a tracer to evaluate these rates. These isotopes are added to the oceans at the shoreline. As they mix into the open ocean, their decay rate provides a convenient clock to calibrate models that describe mixing and transport of coastal waters across the shelf. Two types of sampling have been utilized to study these processes: shore-based sampling in the surf zone and offshore sampling on transects from 0.5 to 15 km from the coast. These studies have been carried out at several locations between Huntington Beach and Santa Monica, California.

Shoreline samples were collected every other hour for 10-12 hours at 6 beaches between Santa Monica and Huntington Beach, California, during a range of seasons and tidal amplitudes. The short-lived isotope concentrations (223Ra and 224Ra) are related to the tides, with higher concentrations during low tide and lower concentrations at high tide. As the tidal range while sampling increased, the average isotope concentration decreased, as a result of increased offshore mixing. During the largest tidal ranges while sampling, the variability of the isotope concentrations was greatest, but the 224Ra/223Ra ratio remains relatively constant. This indicates that the two isotopes co-vary and probably have a coherent source.

Four offshore transects have been obtained in the Huntington Beach area.
Vertical profiles indicate the short-lived Ra isotopes are primarily concentrated in the mixed layer. Results show that on the time scale of a few days, the system appears to be in steady state. Higher concentrations offshore were observed during Spring. This difference appears to result from confinement of the input to a shallower mixed layer because inventories are remarkably consistent and suggest that the input does not vary greatly with time. Fits to a one-dimensional exponential function indicate that the two short-lived isotopes have quite similar horizontal scale distances. This is unexpected because a 1-D diffusion-reaction formulation predicts that scale distances should differ by a factor of 1.6. We interpret the similarity of the scale distance as perhaps due to the importance of vertical mixing, causing a relatively rapid dilution of both isotopes. Efforts are underway to fit the data from these transects with a 2-D model to calculate both offshore and vertical mixing rates.

Bacterial Contamination at Huntington State Beach: Investigating Potential Nearshore Pathways

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Bacterial contamination of nearshore waters is a major environmental and public issue facing managers and users of southern California beaches. Beach closure is the common response to contamination. Huntington State Beach, CA, has been the location of numerous closures during the past four summers, resulting in a significant impact to the local economy. Previous studies have not clearly identified the nearshore pathways of the persistent bacterial contamination problem. Studies were conducted in July 2001 and August 2002. The goal of the 2001 study was to detect and understand interactions between nearshore circulation and the transport of bacteria from potential sources to the surf zone and the beach. Three field experiments were designed to measure the dynamics of dye transport, as a surrogate for bacterial transport, in the nearshore using current meters, pressure sensors, and fluorometers. Data collection occurred July 19-21, 2001. Rhodamine, used as a surrogate for bacterial contaminants, was injected into the surf zone, offshore of the surf zone, and through the local power plant as a means of tracking pathways of dispersion. Dye movement was mapped using fluorometers in the surf zone, a movable fluorometer offshore that captured the vertical dye distribution, aerial photography using a Digital Multi-Spectral Video sensor, and with water samples collected at 15 minute intervals at 5 stations along the beach.

Results indicate that under each scenario a portion of the dye plume was in the surf zone and was advected rapidly alongshore, predominately north toward the Huntington Beach pier. During the power plant injection, dye reached the surf zone within one hour of injection. Within two hours the dye was present along one-third, or 1.5 kilometers, of Huntington State Beach. The results suggest that most of the State Beach could be contaminated from a point source offshore within about a six hour period, under nearshore conditions that are not unusual during the summer season. The goals of the 2002 study were to establish interactions between the local power plant outfall and the nearshore, to characterize the longshore current, to investigate the presence of a long-period internal wave, and to better recognize the dispersion and persistence of dye (hence contaminant) in the nearshore.

Patterns of Morphological Variation, Reproduction and Recruitment in Lower Intertidal Populations of the Kelp *Egregia menziesii* (Turner) Areschoug

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Egregia menziesii is an important habitat-structuring component of shallow water, benthic communities throughout California. Morphological variation in this species is high, particularly in the lateral blades. Fertile sporophylls are believed to be produced throughout the year; however, spatial and temporal patterns of thallus morphology and sporophyte reproduction have not been fully investigated in southern California. We studied lower intertidal populations of *E. menziesii* at three sites. Growing axes (n = 9) were collected monthly to quantify sporophyll production and the frequencies of different lateral types. Band transects were surveyed quarterly to determine temporal patterns of sporophyte recruitment. Sporophylls were found in low numbers throughout the year, but showed a strong peak in winter, suggesting this may be a cold-water adapted species. Intense sporophyte recruitment began in March and lasted though July, indicating a gametophyte period of less than 6 months. Lateral morphology varied in a consistent pattern related to axis length; most thalli initially developed spatulate blades and then produced filiform laterals as axis length increased. Thalli subjected to intense grazing pressure had shorter axes dominated by spatulate blades, while those growing under low grazing pressure exhibited longer branches, densely covered with filiform laterals. These differing lateral morphologies have differing ecological implications. Filiform laterals had higher levels of productivity on a per gram dry weight basis. Spatulate laterals were heavily preferred over filiform laterals by the rasping grazer *Norrisia norrisi*, while *Stronglyocentrotus purpuratus* exhibited a preference for the filiform laterals. Observed changes in the frequencies of morphologically variable lateral blades along *E. menziesii* axes hypothetically affect thallus drag as well.

The Effects of Armoring the Coastline on Intertidal Flora and Fauna

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The extensive anthropogenic armoring of the shoreline along the California coast provides an unusual opportunity to determine the effects of variation in substrate type on settlement and post-settlement processes of sessile intertidal flora and fauna. Armoring is a disturbance, covering up native rocks and associated organisms, adding hard substrate, boulders or seawalls, to a zone where ephemeral rocks and sand once existed. Substrate characteristics have been shown to attract or repel invertebrate larvae and algal spores. The interactions between intertidal organisms and substrate type might play a significant role in structuring benthic communities influencing not only initial settlement, but also subsequent species assemblages. Much work has been done examining the mechanisms that determine intertidal zonation patterns, but the differences in these patterns with respect to substrate type have been largely neglected. It is important to understand how rock types affect settlement and post-settlement processes in sessile intertidal organisms to determine if it influences intertidal zonation patterns, explaining differences between shores.

Behavioral and physical adaptations to the environment influence the abundance and distribution patterns of intertidal species. The rocky substrate available to settling larvae likely influences the patterns of zonation and community structure on rocky shores. Substrate characteristics have been shown to attract or repel invertebrate larvae and algal spores. A species assemblage that is more attracted to a particular substrate type could affect succession by its subsequent interaction with later assemblages. Settlement and post-settlement mortality are affected by specific local physical conditions such as coastal morphology, currents, available space, wave action, and by the abundance of predators. In a pilot study at 2 spatially separated sites, I performed a series of clearings on basalt, sandstone and mudstone rocks and counted all invertebrates and weighed dried algae from the cleared substrates. Canonical discriminant analysis led to a high degree of classification (MANOVA, $p<0.001$ site 1 and $p<0.01$ site 2) for different rock types with respect to community structure. Through a series of transplantation experiments, I am examining settlement and post-settlement processes on plates of different rock types with natural rugosity in the field and subsequently, testing for effects of rugosity with molds. I am testing thermal effects on community structure by deploying settlement and post-settlement plates with temperature loggers in the mid-high intertidal zone. The goals of this project are to:
1) determine if there is a difference in community assemblages relating to different rock types and if so, as seems likely, 2) demonstrate the mechanism responsible for these differences, and 3) link those patterns to life history characteristics.

Recovery of Trophic Function in a Restored Pacific Wetland: Effect of Shading on Microalgal and Infaunal Communities

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Wetland systems are accessible, delicate, and historically-undervalued ecosystems in need of additional research to manage them in the face of ever-increasing pressure of development. Wetlands function as sources and sinks for chemical, biological, and genetic materials as well as unique habitats for important fauna and flora. Many anthropogenic influences on wetlands such as development pressure, habitat alteration, and species invasion, have significantly reduced the area of wetlands across the country. In California, less than ten percent of the original coastal wetlands remain. Thus, research concerning how to manage existing wetlands, restore degraded wetlands, or mitigate for lost habitat has become critical.

This project is designed to identify key factors controlling trophic functions in Mission Bay wetlands and to develop methods to evaluate recovery of trophic function in a created salt marsh. Here I describe an experiment in which we manipulate light and plant cover to determine how vascular plants interact with the benthic microalgae and invertebrate communities. Isotope tracer experiments and the literature suggest that the microalgae are the primary food source for many consumers in salt marshes. Thus, it is hypothesized that vascular plant-mediated changes in the abundance and composition of the microalgal assemblage will significantly affect the abundance and composition of the infaunal community. Alteration of light available to the benthic microalgae should cause significant change in the microalgal community. Clipping and shading manipulations, designed to mimic the effects of vascular plant presence and absence, reveal the influence of plants on abiotic environmental factors that might mediate changes in the biotic community: porosity, salinity, dissolved oxygen, and temperature at the soil surface.

Data are being generated for associated epifauna and macrofauna. This experiment, in combination with other methods of studying trophic interactions, such as natural abundance stable isotopic analyses, HPLC analyses of algal pigments, gut content analysis, and in situ tracer experiments, will help understand the trophic ecology of animal communities in salt marshes. The data generated will help us understand the implications of changing plant and algae cover associated with marsh restoration or plant invasion, and thus further our ability to restore function to wetland communities.

From Host to Host: Interaction of Behavior and Environment on Parasite Transmission

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The estuarine trematode *Himasthla rhigedana* uses three hosts in its complex lifecycle: a primary avian host, where sexual reproduction takes place, and two intermediary hosts in which the parasites reproduce through asexual reproduction. Short-lived (~4hr) free-swimming cercarial larvae transmit infection between the first (snails) and second (snails or crabs) intermediary hosts. We have quantified interactions between cercariae and their environment throughout the entire transmission process: emergence from the first host (production), transport in the water column, and subsequent recognition and infection of the second host (settlement). Laboratory experiments and real-time *in-situ* studies of all three stages have defined cues (light and temperature) and behaviors (diurnal emergence, negative phototaxis and substrate choice) that maximize the chances of cercariae encountering and infecting a suitable host. Additionally, we determined that swimming behaviors which produced vertical distributions skewed towards their benthic hosts were successful in still-water and slow-flow conditions ($u_* = 0.2$ cm/s). Such conditions ($u_* \leq 0.2$ cm/s) occur ~70% of the time that cercariae are in the water column. In faster flow ($u_* = 0.8$ cm/s), turbulent mixing distributed larvae like passive particles throughout the water column, neutralizing behavioral effects. The transmission of parasite infection between hosts through planktonic larvae is similar to the dispersal and settlement of free-living invertebrate larvae. Thus the relevance of these results extends well beyond parasitology, providing transport mechanisms underlying concepts such as supply-side ecology.

What Can Comparative Physiology Tell Us about the Nature of Marine Species Invasions?

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Species invasions are not a new phenomenon in marine communities but they have gained infamy in the past few decades because of the increased rate of invasions world-wide and because of the massive population explosions of some invaders. Despite the fact that we are more aware of species invasions and the anthropogenic vectors that facilitate them, we know little about why certain species are able to succeed in a novel habitat. While it is likely that there are many biological and ecological factors involved in invasion success, we are interested in the role ecological physiology plays in determining which populations succeed. We are using bay mussels, in the genus *Mytilus*, to address this question. *Mytilus trossulus* and *M. galloprovincialis* co-occur from Monterey to Cape Mendocino, in a patchy hybrid zone – a distribution thought to be evidence of differential adaptation to microhabitat variation. Native to the Mediterranean, *Mytilus galloprovincialis* invaded Southern California some time between 1900 and 1950 and is currently the only bay mussel south of Monterey. It has been suggested that, within the hybrid zone, the two species are distributed based on salinity and temperature gradients. We have surveyed the adult population at 8 subtidal sites (floating docks) in Monterey Bay (MBay) and San Francisco Bay (SFBay), monitored temperature and salinity at each site from December 2000 to the present and are currently testing physiological limits of adults to temperature and salinity stress. Scoring individuals using multiple gene loci, we genetically identified adult populations and found that adult *M. trossulus* increase in abundance as one moves up the estuarine gradient (towards higher temperature variability and lower salinity). Water temperature at these sites varies daily and seasonally, with a maximum daily change of 11°C and a maximum annual range of 25°C (winter minimum of 7°C and summer maximum of 32°C). High-resolution salinity measurements within MBay show that salinity excursions are correlated with rainfall and tidal fluctuations and have a maximum daily change of 7 psu per 24, hours during summer months. Seasonal ranges are yet to be determined. To quantify the differential thermal tolerance of each species, we have measured a characteristic break in heart activity during thermal stress. We have found that *M. trossulus* has a lower heat tolerance than *M. galloprovincialis*, with the breaks in heart rate occurring at 27.0±0.6°C and 29.1±0.6°C, respectively and that neither is statistically distinguishable from the hybrids (27.8±0.5°C). Our preliminary results suggest that environmental temperature is not contributing to the distribution of the two species, given their upper thermal limits and the observed upper habitat temperatures. We are currently testing salinity tolerances of the two species to determine the likelihood that this environmental parameter is limiting species distribution. Finally, our results suggest that future changes in watershed manipulation and coastal temperature (such as caused by global warming) have the potential to affect marine community composition and may play a role in facilitating some marine invasions.

The Diversity and Availability of *Caulerpa* Species Found in Retail Aquarium Outlets in Southern California

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Biological invasions are recognized as a serious threat to marine biodiversity. Within the last two years, invasive populations of *Caulerpa taxifolia* were found in southern California's coastal waters as well as in New South Wales, Australia. In addition, two other seaweeds (*Undaria pinnatifida and Caulacanthus ustulatus*) also appear to have recently invaded southern California's warm temperate waters. The introduction of *C. taxifolia* has attracted much attention because this exotic seaweed is thought to have significantly altered the structure of Mediterranean marine ecosystems following its 1984 invasion. The southern California inoculation of *C. taxifolia* is believed to have resulted from the release of aquarium specimens. Besides *C. taxifolia*, other species of *Caulerpa* being sold for aquarium use also may have the potential to invade temperate waters. As a first step towards making this determination, the availability (% frequency) of *Caulerpa* species being sold in southern California for aquarium use was ascertained. Fifty retail saltwater aquarium stores were visited in three southern California counties between November 2000 and August 2001. Sixteen *Caulerpa* taxa were identified from the retail aquarium outlets. *Caulerpa* species were sold in 52% of these stores. *Caulerpa taxifolia*, "Mediterranean form", was offered for sale in 10% of the visited stores; *C. serrulata* var. *hummii* (18%), C. racemosa (14%), and *C. racemosa* var. *lamourouxii* (14%) were the most commonly sold species. These data indicate that the aquarium industry is bringing into the region other species of *Caulerpa* besides *C. taxifolia*. Some of these species may also have the potential to invade temperate waters.

Locating Marine Reserves Based on Coastal Features: Coupling Ocean Circulation and Larval Settlement Around a Headland

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I am investigating patterns of ocean circulation and larval settlement of marine invertebrates in order to provide data critical to marine managers for developing effective resource management programs. My research as a Sea Grant Trainee expands on an ongoing California Sea Grant project to develop an integrated bio-economic metapopulation model that analyzes spatial management policies such as marine reserves. I am examining how small-scale topographic features such as headlands (4-10km) affect the delivery of twenty species of marine invertebrate larvae to nearshore habitats. This comparative approach will enable me to investigate whether diverse species recruit via different mechanisms along the shore. During the peak settlement season of March through August 2000-2002, I monitored settlement of marine invertebrate larvae using three replicate moorings with artificial substrate settlement collectors at various locations. Each mooring had collectors at two depths (surface and bottom) and consisted of a mesh bag containing 3 Tuffy scrub pads, and a barnacle plate. I sampled these collectors every 2-15d and I collected continuous salinity, temperature, and wind stress data and weekly site-based CTD data. In 2000, I monitored a long-term site (9 yr) adjacent to the Bodega Marine Laboratory. In 2001, I expanded the monitoring to include 7 sites around Bodega Head to identify spatial patterns of settlement around a headland. I have found a strong pattern of larval settlement where larvae consistently settled in higher densities in the lee of the headland than along the windward side, indicating the presence of a retention zone. My preliminary results also indicated that species richness and abundance of settlers differed between the surface and the bottom suggesting that larvae are transported in wind-driven surface water and upwelled bottom water. In 2002, I increased the sampling frequency at 4 sites to investigate temporal patterns of settlement and mechanisms of larval transport. I am correlating physical and settlement data to determine if upwelling/relaxation events and internal waves may deliver larvae to shore. Increasing our scientific understanding of these processes adds to a basic understanding of marine community ecology and will contribute to determining the most effective location, size, and spacing of marine reserves.

Observation and Analysis of the Fine Scale Spatial Pattern of Pacific Sardine and Northern Anchovy Eggs

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Pacific sardine (*Sardinops sagax*) and northern anchovy (*Engraulis mordax*) eggs were sampled on the scale of 0.5 to 5 km. For each species, a small area within an egg patch was marked with a drifter and sampled repeatedly using 4-minute samples from the Continuous Underway Fish Egg Sampler (CUFES). Variograms calculated for staged sardine egg samples have a low nugget effect on the order of 10% (sample values are strongly correlated on the smallest scales). In contrast, the nugget effect in variograms for anchovy eggs ranges from 50% to 100%, so the majority of the total variance is random noise at the scales sampled. These differences in the spatial pattern of the eggs are interpreted as differences between the organization and behavior of the spawning schools. When compared with other literature on sardine (*Sardinops sagax*) and anchovy (*Engraulis spp.*), both in California and in other upwelling systems, a picture begins to emerge of spatial pattern controlled by the interaction between species, population size, seasonality, and physical spawning habitat characteristics. Further sampling on a broad range of spatial and temporal scales is necessary to address this hypothesis. The resolution of sampling will be increased valuably by the development of the Real-time Flow Imaging and Classification System (REFLICS) for automated counting of fish eggs in the CUFES flow.

Radiocarbon in Otoliths of Yelloweye Rockfish *(Sebastes ruberrimus)*. A Unique Chronometer for the Waters of Southeast Alaska

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Atmospheric testing of thermonuclear devices during the 1950s and 1960s created a global radiocarbon (^{14}C) signal in the ocean environment that scientists have identified as a useful tracer and chronological marker in natural systems. Researchers have monitored radiocarbon change through time in seawater both directly and by proxy, such as annually banded hermatypic corals. In addition, the bomb-generated radiocarbon signal retained in fish otoliths can be used as a permanent, time-specific marker of the radiocarbon present in ambient seawater, making it a useful tool in age validation of fishes. The goal of this study was to determine radiocarbon levels in otoliths of the age-validated yelloweye rockfish (*Sebastes ruberrimus*) to establish a chronological benchmark for the waters of southeast Alaska. Radiocarbon values from the core material, or first years growth, of 43 yelloweye rockfish otoliths were plotted against estimated birth year to produce a radiocarbon time series for southeast Alaskan waters from 1940 to 1990. This record reflected the atmospheric rise in radiocarbon during the 1950s and 1960s, and is similar to the records created from other fish otoliths throughout the world's oceans.

Habitat Structure and Recruitment Success of Two Near Shore Reef Fishes

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State and federal agencies are charged with identifying and protecting "essential fish habitat" for vulnerable fish species. Consequently, evaluating particular habitats that may differ in the recruitment and subsequent survival of young-of-year reef fishes is crucial to this mandate. In this study, I use a large-scale experimental reef to identify habitat characteristics of two rocky reef fishes, the California sheephead (*Semicossyphus pulcher*) and the blackeye goby (*Rhinogobiops nicholsii)* at three spatial scales. These species serve as models to examine how differences in habitat coverage may influence the recruitment success of coastal fishes.

The experimental system covered a 2.5 km section of coastline and consists of seven blocks of eight reef modules, each module covering an area of 1600 m^2. I examined three treatments of habitat, consisting of nominal coverages of rocky substrate (17%, 34%, and 67% area of modules covered with quarry rock). Each module was surveyed twice in 2001 (October and December) for newly recruited California sheephead and blackeye goby. At the largest spatial scale, recruitment of each species showed similar results in that densities were generally higher on modules of 34% coverage. For the California sheephead, recruitment was significantly higher on modules of 34% coverage than other coverages, while the blackeye goby showed higher recruitment to 34% coverage than to 17% coverage but not 67% coverage. At the scale of reef modules, perimeter (ecotone) habitat had significantly lower recruitment than "inside" the reef modules. At the smallest scale of within modules, several measures of habitat structure were quantified within 1-m^2 quadrats to identify potentially important microhabitat characteristics. Quadrats at randomly selected locations within each module were compared with quadrats containing newly recruited individuals. Vertical relief accounted for variation in the distribution of the California sheephead, while rugosity contributed to explaining the distribution of recruits of the blackeye goby.

The information obtained thus far with these species may point to some intermediate level of habitat coverage as advantageous for enhancing recruitment of at least some near shore fishes. This is especially relevant to the California sheephead, targeted as a near shore fishery. Moreover, further research to examine the survival of these and other species among different habitat treatments may provide a better understanding of how early recruitment and post-recruitment survival may be influenced by habitat structure.

Toxicokinetics and Biotransformation of *p*-nitrophenol in Red Abalone (*Haliotis rufescens*)

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Red abalone (*Haliotis rufescens*) were exposed to 3.6 µM (0.5 ppm) ^{14}C-labelled *p*-nitrophenol (PNP) for 24 h, then were allowed to depurate in clean seawater for another 24 h. Absorption, conditional uptake clearance and elimination rate constants were 0.12 ± 0.04 h^{-1}, 3.2 ± 1.1 mL g^{-1} h^{-1} and 0.05 ± 0.02 h^{-1}, respectively. The sigmoidal shape of the PNP uptake curve suggests a biphasic process. A whole-organism total concentration factor (TCF) of 2.37 ± 0.07 was determined from equilibrium tissue and water concentrations, with the highest concentration of PNP plus metabolites found in gill tissue (11.8 ± 0.2 nmol g^{-1}, wet weight). Digestive gland, foot muscle and remaining body tissues accumulated 8.8 ± 0.9, 7.7 ± 0.6 and 7.5 ± 0.6 nmol g^{-1} radiolabelled residues, respectively. Abalone depurated 87% of absorbed PNP within 24 h, of which 87.5 ± 3.1% was unmetabolized parent compound, 13.1 ± 3.1% was *p*-nitrophenylsulfate, 0.32 ± 0.09% was *p*-nitroanisole, and 0.14 ± 0.07% was *p*-acetamidophenol.

Plicatamide: A Novel Antimicrobial Agent Isolated from the Blood Cells of the ascidian *Styela plicata*

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In our search for antimicrobial peptides in the innate immune systems of marine invertebrates we have isolated some novel oligopeptides from hemocytes of the ascidian *Styela plicata*. The peptides are related to the low molecular weight tunichrome and halocyamine class of compounds which contain DOPA residues and which are also oxidatively decarboxylated. However the *S. plicata* peptides are larger and have provided the first opportunity to investigate the biosynthetic origins of this class of compounds by molecular biological techniques. Plicatamide (FFHLHFH-dcDDOPA (where dcDDOPA = decarboxy-*(E)*-a,b-dehydro-3,4-dihydroxyphenylalanine), an octapeptide from the blood cells of *S. plicata*, displayed potent, broad-spectrum antimicrobial activity and was especially active against *Staphylococcus aureus*. Plicatamide exposure triggered a massive efflux of potassium that began within seconds. Within 2 minutes, the treated bacteria had dramatically decreased their oxygen consumption and most became nonviable. Native plicatamide formed cation-selective channels in model lipid bilayers composed of bacterial lipids. Both its induction of potassium efflux and the formation of membrane channels suggest that plicatamide targets the membranes of susceptible organisms. Methicillin resistant *S. aureus* treated with plicatamide for 5 minutes manifested multiple, small dome-shaped surface protrusions and contained prominent mesosomes. These surface bulges suggest that osmotic forces also contribute to its antimicrobial effects. We synthesized and tested several oligopeptide analogues of plicatamide. One of these peptides, PI-101 (FFHLHFHY-amide) closely resembled native plicatamide in its antimicrobial activity and its ability to induce potassium efflux. Although plicatamide was potently hemolytic for human red blood cells, it did not lyse ovine erythrocytes. The small size, rapid action, and potent antistaphylococcal activity of plicatamide makes it an intriguing lead compound for future antimicrobial peptide design.

Dynamic Mechanical Properties of Whelk Egg Capsules (Genus *BUSYCON*)

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Whelks (marine snails) create elaborate egg capsules made from a rubbery proteinaceous material. Prior quasi-static testing of this material by these authors has shown mechanical behavior commensurate with molecular long-chain hierarchical materials such as keratin. Specifically, a bimodal stress/strain curve with an initial linear high-stiffness behavior that gives way to a fairly linear low-stiffness behavior was demonstrated. The transition from these two states (high-stiffness/ low-stiffness) is fully repeatable and recoverable even though it would normally suggest a state of failure in most materials.

To fully ascertain the mechanical properties of a viscoelastic material, dynamic characterization is required. Here we consider the characteristics of the formation process responsible for the mechanics of the fully-formed egg capsule. Furthermore, we quantify the dynamic mechanical properties over a range of strains responsible for the bimodal stress/strain curve seen in quasi-static testing. Our results indicate a surprising feature where parameters for viscoelastic quantification (e.g. phase difference) are consistent over the high-stiffness/low-stiffness regions of the stress strain curve indicating that some type of material recovery is occurring. Repeating these experiments while applying a ramp strain superimposed on the excitation frequency yields results expected for the two regions indicated in the stress/strain curve. This suggests that the recovery phenomenon is delayed during constant strain of the material. These observations are consistent with a transient stabilizing crosslink that is disrupted by strain. Chemical disruption of this transient crosslink with formic acid effects the disappearance of the initial high-stiffness portion of the stress/strain curve and allows comparison of the dynamic mechanical properties for the low-stiffness region between the initial test which required an applied ramp to ascertain the dynamic properties of the low-stiffness region. The chemical treatment was fully reversible further supporting the transient nature of the crosslinks whose contribution is speculated upon further.

ABSTRACTS: Poster Presentations

Flux Observations at the Golden Gate

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Fluxes of water, salinity, sediment, and chlorophyll are being measured in the Golden Gate Channel in an effort to understand and quantify exchange between San Francisco Bay and the Pacific Ocean. The Golden Gate Channel is much deeper than the waters adjacent to it. This uniquely deep bathymetric contraction affects mixing and exchange between the bay and the coastal ocean.

Fluxes at the Golden Gate vary dramatically in space and time. Transects across the channel will be taken every 10 minutes for 24 hours, once during the neap tide and once during the spring tide of each season. This poster is a display of data from the first field campaign of this project, which includes three 12-hour days of velocity data and two 12-hour days of scalar data. Future campaigns, the next of which will commence this October, will include full 24-hour data sets. The velocity data are collected by a boat-mounted ADCP. Scalar data includes temperature, salinity, turbidity, chlorophyll, and photosynthetically active radiation. Instruments attached to a tow-yoed SeaSciences Acrobat collect the scalar data.

The first data set was taken during a period of high flow from the Sacramento-San Joaquin Delta. High freshwater inflow creates relatively strong stratification, resulting in baroclinic circulation. Although there are not two distinct density layers, during maximum ebb tide, surface currents flow out of the bay and bottom currents flow into the bay. Stratification magnitude and phasing differ dramatically from the north side to the south side of the channel. Details of the velocity circulation patterns and how they affect scalar transport are discussed.

Linking Connectivity Pathways to Chemical Markers in Pelagic Juvenile Rockfish Otoliths

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An estimate of the degree of connectivity among local populations through larval dispersal can help to define the appropriate geographic scale of resource management (e.g., spatial extent of fishery closures, placement of marine reserves). The objective of our study is to reconstruct larval transport pathways in relation to dynamic coastal circulation and mesoscale features such as fronts and eddies that limit dispersal. We use a novel approach incorporating microchemistry data from time-keeping otoliths and remotely-sensed sea surface current mapping to link larval transport to coastal circulation. In 1998, we linked late-larval stage and pelagic juvenile fish abundance patterns to cyclonic eddy circulation in the channel (Nishimoto and Washburn, in press). In the present study, laser-ablation inductively coupled plasma mass spectrometry (LA-ICPMS) data was collected from otoliths of shortbelly rockfish (*Sebastes jordani*) sampled within the eddy feature and outlying areas. LA-ICPMS measures the concentration of selected elements at discrete locations within the calcium carbonate structure of an otolith (e.g., its edge and core). Our ongoing work indicates that pelagic juveniles collected from geographic areas with distinguishable water mass properties possess unique trace element signatures in their otoliths.

Environmental Estrogens and Estrogen Mimics Adversely Effect the Normal Development of the Sea Urchin Embryo

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Environmental estrogens and estrogen mimics acting as endocrine disruptors exert effects either directly or indirectly on endocrine systems generally through a receptor mediated process. These estrogenics mimic the natural endogenous hormones and/or inhibit normal hormone activities. Little is known about the effects of environmental estrogens on invertebrate physiology and reproduction. This study is one of the first to study the effects of estrogenics on invertebrate reproduction and development at environmentally relevant concentrations. Experiments exposing developing sea urchin embryos to two known estrogenic compounds (4-Octylphenol, Bisphenol A) and two non-estrogenic endocrine disruptor compounds or EDCs (TBT, *o,p*-DDD) plus natural and synthetic reproductive hormones (17β-estradiol (E_2), estrone (E1), estriol (E_3), progesterone (P_4) and 17α-ethynylestradiol (EE2)). Normal development of sea urchin embryos was assessed following 96-hour exposures in order to obtain dose response relationships and to determine overall embryo sensitivity. EE_2 and E_2 were both effective at high physiological concentrations for vertebrates endocrine systems. The order of embryo sensitivity measured in percent of control normal development was as follows: 4-Oct >> DDD > EE_2 > E_2 >> BisA > P_4 > E_1 >> E_3. TBT, though quite effective at concentrations much lower than those reported at polluted sites, did not respond in a dose-dependent manner but expressed a 'biphasic' response. Concentrations lower than $1x10^{-5}$ ppb were more effective than concentrations 1 to 2 orders of magnitude higher. Stage specific exposure experiments were conducted to determine the most sensitive developmental periods – early embryo/blastula, during gastrulation and post-gastrulation. In experiments with TBT, E_2, DDD and 4-Oct, the most sensitive stage was the early embryo/blastula (pre-hatching) exposures with little overall sensitivity in the gastrulation stage regardless of concentration. This sensitivity coincides with the expression of an orphan non-specific steroid receptor, SpSHR2 (Kontrogianni-Konstantopoulos et al., 1998). ER modulators, ICI 182,780 and tamoxifen, were added to the development bioassays with the estrogenic compounds and mimics to interfere with their actions. Tamoxifen, a partial ER agonist, alone inhibited development in the low nanomolar range and was effective at lowering the sensitivities of the embryos to the estrogenic compounds. ICI 182,780, a complete antagonist, also inhibited development in the low nanomolar range but, increased embryo sensitivities to the treatments. In conclusion, the evidence suggests a critical role for endogenous estrogens in the development of the sea urchin mediated through an ER-like receptor and reveals a possible receptor pathway for toxicity due to environmental estrogen exposure.

Morphologic and Histologic Changes in Red Abalone (*Haliotis rufescens*) Subjected to Eight Different Treatment Combinations of Water Temperature, Food Availability and Infection with "*Candidatus* Xenohaliotis californiensis"

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Withering Syndrome (WS) is a progressive, fatal disease affecting several species of abalone (*Haliotis* spp.) in California and Mexico. The causative agent, "*Candidatus* Xenohaliotis californiensis" is an intracellular Rickettsiales-like prokaryote (RLP) that infects epithelial cells of the post-esophagus, digestive gland and intestine of abalones. Affected abalones become weak, anorexic, lose weight and ultimately die. Microscopically, the myofibers of the foot muscle atrophy and are replaced by connective tissue. Metaplastic changes in the digestive gland (DG) result in replacement of secretory and absorptive cells by connective tissue and absorptive/transport ducts. To examine the relationship between temperature, food availability and RLP infection in the development of gross and microscopic signs of WS, six replicates of 30 abalones each were assigned one of the following eight treatments: 1) Unexposed/Fed/18∞ C water temperature; 2) Unexposed/Fed/Ambient water temperature; 3) Unexposed/Starved/18∞ C; 4) Unexposed/Starved/Ambient; 5) Exposed/Fed/Ambient; 6) Exposed/Fed/18∞ C; 7) Exposed/Starved/Ambient; 8) Exposed/Starved/18∞ C. At selected time points 18 animals per treatment were weighed, measured, rated for degree of withering, and sacrificed. Tissue samples excised for histological examination were evaluated for DG metaplasia, foot degeneration, and RLP infection intensity in the post-esophagus and DG. By day 351, RLP infection and metaplasia was confined almost exclusively to groups 6 and 8. Animals in treatment 6 had significantly greater metaplastic changes ($p<.001$) and significantly greater RLP infection intensities in the DG and post-esophagus than animals in all other groups ($p<.001$). This suggests that the metaplastic changes are pathognomic for WS. Group 8 had significantly more pedal degeneration ($p<.001$) than group 3, suggesting that infected animals are catabolizing more foot muscle for energy. The percentage of withered animals also illustrates this point: By day 351, 13% of group 8 animals were withered, compared to 4% of group 3 animals. These data illustrate key differences and similarities in disease progression between red and black abalones based on our data herein and previous studies by Kismohandaka et al. (1993) and Friedman et al. (1997).

Early Embryonic Apoptosis in the Sea Urchin, *Strongylocentrotus purpuratus*: Developmental Timing, Control, and Responses to Environmental Disturbance

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Embryonic cells have a paucity of stress defense systems in comparison to adult cells. Heat shock, cell cycle checkpoints, and DNA repair mechanisms are reduced or absent in many of the earliest stages of metazoan development. Apoptosis may be a key event in embryogenesis to ensure proper removal of damaged cells. We here demonstrate that sea urchin blastomeres can and do undergo classical apoptosis naturally and in response to chemical exposure prior to the putative mid-blastula transition. Cell permeability changes are the first of the apoptotic signals to be recorded followed by caspase activation, and finally DNA fragmentation. Although a small basal amount of apoptosis occurs naturally, increases in apoptotic signals occur upon exposure to cell toxins. The signals necessary to promote the apoptotic program are currently unknown in sea urchin development. We hope to elucidate why apoptosis occurs at this time in embryogenesis rather than around the mid-blastula transition as seen in lower vertebrate models. Additionally, the sudden appearance and accumulation of apoptotic cells at a defined period in development may provide a unique and quantitative measurement for embryonic toxicity and health.

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. The bay hydrodynamics have been well studied through the Land Margin Ecosystem Research (LMER) project of the 1980s. However, the biological properties of the water column are less well understood. The focus of this research, funded by Sea Grant project # R/A-115TR to study the causes of spring oyster mortality, describes the near-surface phytoplankton community structure and seasonal succession in Tomales Bay (TB). Special attention was given to whether spring blooms of phytoplankton contained harmful species (HABs) contributing to historic spring mortality events of cultured Pacific oysters, *Crassostrea gigas*, and whether oyster mortalities might coincide with these events. Phytoplankton samples were analyzed from three sites, over an 18 month period, from April 2000 to October 2001. Near surface samples were also collected in near-by Bodega Harbor (BH) for comparison. Phytoplankton were identified and counted using the Utermohl technique and inverted microscopy; hydrographic and nutrient analyses were also made in the central portion of TB during 2001 to examine their effect on the phytoplankton community. During the study period inter-annual variation in phytoplankton community structure was more pronounced than spatial variation within the bay. Distinct seasonal patterns of community structure also emerged and were typical of temperate estuarine communities. Three oyster families were out-planted at two time periods (fall 1999, 2000 and spring 2000, 2001) to examine differential performance between family lines and planting period. Fall plants survived significantly more than did oysters planted in the spring ($p<0.05$). In addition, two families (one commercial strain and Molluscan Broodstock Program, MBP, family 10-115) outperformed MBP family 10-116 ($p<0.001$). The 2000 mortality in June coincided with a *Gymnodinium sanguinium* bloom, while the June 2001 mortality was not associated with any phytoplankton bloom.

While suspected harmful algal species were present throughout the study period, phytoplankton did not appear to be directly involved in oyster mortalities. Oyster mortalities were repeatedly associated with extreme temperature fluctuations, which may play a direct role in oyster mortalities.

Deep-Water Habitat Characterization of Seafloor Imagery: A Tool for California Demersal Fisheries Management

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The recent collapse of many marine demersal fish stocks has drawn attention to the need to review standard fishery management plans. Demersal fishes are often associated with structural features of benthic habitats. Therefore the understanding of physical habitat features associated with each demersal species is critical to management. In 1996, this concern led to the reauthorization of the Magnuson-Stevens Fishery Conservation and Management Act. The act requires regional fishery councils and the National Marine Fishery Service to identify and designate Essential Fish Habitat (EFH) for each managed species. EFH includes specific significant habitats within the whole living range of a species. To understand and represent these habitat associations, the focus of our work, supported by Sea Grant, was in the preparation of deep-water marine benthic habitat maps along the California Continental Margin. The objectives of this project were to create digital marine benthic habitat maps from available data and to incorporate all digital habitat maps into a queriable GIS database. These maps form a base upon which available chemical, physical and biological information of the region can be included and queried in the GIS database. Newly collected multibeam data as well as expansive industry sidescan and other marine geological data (sidescan sonar mosaics, high resolution seismic reflection profiles and sediment data) were used to map habitat types. Analogue sidescan sonar data revealed information on seafloor sedimentary properties while multibeam bathymetry images showed the slope and morphology of geologic features. As an example of this mapping effort we illustrate seafloor images (industry sidescan and newly collected multibeam and backscatter data) and an interpreted habitat map for the Bodega Basin nearshore region, Central California. Results of this work can be used by fishery biologists, management agencies and conservation groups to construct sustainable management strategies and for establishing Marine Protected Areas (MPA).

Novel Approaches for Investigating Spicule Biosynthesis in Living Demosponges

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With a precision of nanoscale fabrication that in many cases exceeds modern human engineering capabilities, biomineralized materials have attracted a great deal of attention in recent years as model systems for the analysis and *in vitro* synthesis of high-performance hierarchically-ordered organic/inorganic nanocomposites. The supporting skeletal elements of the marine demosponge, *Tethya aurantia* are excellent examples of these intricately architectured materials and comprise approximately 75% of the dry weight of this species. Each fiberglass-like siliceous spicule (measuring approximately 2mm in length and 30μm in diameter) contains a central proteinaceous axial filament that extends its entire length. These filaments are more than simple, passive templates; they actively catalyze and spatially direct hydrolysis and polycondensation to form silica, (as well as the phenyl- and methyl-silsesquioxane) from the corresponding silicon alkoxides at neutral pH and low temperature. Catalytic activity also is exhibited by the constituent subunits obtained by disaggregation of the protein filaments and those produced from recombinant DNA templates cloned in bacteria. Site-directed mutagenesis and predictive synthesis of biomimetics has provided support for the mechanism of catalysis deduced from homology with other enzymes.

In addition to the macroscopic skeletal elements (megascleres) described above, *T. aurantia* also synthesizes a small percentage of aster-like spicules (microscleres) of two distinct morphologies and size classes, providing microscale skeletal support in the outer sponge cortex. Studies of spicule formation in regenerating cellular aggregates isolated from *T. aurantia* reveal that the synthesis of these two major spicule types (megascleres and microscleres) may be independently regulated, presumably at the genetic level.

In a first step to visualize the real-time synthesis of these intricate skeletal elements in living sponges, we discovered and used a novel silica-specific fluorescent tracer to localize the actively mineralizing sclerocytes. The fluorescent probe is rapidly assimilated by the sclerocytes and incorporated into the newly synthesized silica, providing a powerful tool for monitoring both biosynthetic rates and the detailed mechanisms of spicule formation *in vivo*.

Reactivity of Vanadium Bromoperoxidase from Marine Algae: Enzyme Induced Cyclization Reactions

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Vanadium bromoperoxidase enzymes (V-BrPO) have been primarily isolated from marine algae. V-BrPO catalyzes the oxidation of bromide and iodide by hydrogen peroxide using vanadium as the cofactor. The oxidized halogen intermediate can act to halogenate an appropriate organic substrate or oxidize a second equivalent of hydrogen peroxide to produce dioxygen in the singlet excited state.

In addition, the production of halogenated natural products is also widespread in marine algae. These compounds range from halogenated indoles, terpenes, acetogenins, phenols etc., to volatile hydrocarbons. In many cases the halogenated natural products have important biological activities, such anti-microbial properties, anti-fungal, feeding deterrent properties, and anti-infammatory properties.

V-BrPO has been cloned from the marine red algae *Corallina officinalis, Laurencia pacifica, Plocamium cartilagineum,* and *Delisea pulchra.* Kinetic characterization of V-BrPO from the algae *C. officinalis* and *P. cartilagineum* has been performed. Active-site mutagenesis of V-BrPO has also been examined. In addition, V-BrPO has been used to examine the probable biosynthetic routes to halogenated terpenes and acetogenin natural products by enzymatic bromonium ion induced cyclizations.

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