Maryland Sea Grant Research Fellows Summer Symposium 2003

Chesapeake Biological Laboratory
June 27, 2003

Program Summary

Edited by
Annette Meredith
and
Fredrika Moser

Sponsored by
Maryland Sea Grant College

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Introduction: Maryland Sea Grant Research Fellows Program

Maryland Sea Grant (MDSG) provides support to a limited number of graduate students whose research is directly linked to projects funded through the biennial Omnibus award from National Oceanic and Atmospheric Administration (NOAA).

Maryland Sea Grant Research Fellows receive support for salary, benefits and tuition. Fellowships usually are awarded for two years but Maryland Sea Grant stresses the importance of a full year's commitment by a student and PI with the intent of funding a single student per PI for the entire two-year fellowship period.

The fellowship program generally receives more requests for fellowships than the program can support. Successful fellowship applicants are usually supported by projects that link a strong research effort to a clearly defined role for the graduate student and a commitment from the PI to foster the "research-to-outreach" process at this early stage of the student's development.

Applicants are selected by a panel comprised of MDSG staff, several outside faculty members who are not part of the current competition and members of the MDSG Academic Advisory Committee.

Towards the end of the first year of the award, the PI and student provide a brief progress report before a fellow will be renewed for the second year of the project.

Program Activities

The central goal of the fellowship program is to provide support to facilitate a strong academic interaction between a PI and graduate student within the context of the degree granting program of the host institution and the Sea Grant funded research project. MDSG is committed to maintaining the primacy of this relationship. Hence, fellows are not required to teach or perform other functions for their departments or laboratories. However, we do feel it is essential that students are exposed to concepts and activities that foster an appreciation of the research-to-outreach process that is essential to a Sea Grant project. Toward that end, MDSG requires students to participate in certain activities over the course of their fellowship period. The activities are:

Welcome Luncheon for Fellows at Maryland Sea Grant. This informal event provides an opportunity for the fellows to learn about Sea Grant and their respective projects. It is also a time to discuss the concept of outreach associated with an academic research effort.

Mid-Year Symposium. The summer symposium provides a more formal opportunity to assemble the fellows to discuss their research progress. The

audience includes staff, students and scientists from the two University of Maryland Center for Environmental Sciences marine labs: Chesapeake Biological Laboratory and Horn Point Laboratory. The symposium audience also includes Maryland Sea Grant fellows from our summer Research Experience for Undergraduates (REUs).

Mentoring and Undergraduate Interaction. The Symposium provides a forum for the MDSG Fellows and REUs to meet and discuss Chesapeake Bay research and graduate studies in marine science. The interaction of MDSG Fellows with REUs provides the Fellows with a mentoring opportunity and a chance to explain their research to undergraduates, many of whom may not be familiar with the MDSG Fellow's research area. This interaction helps to train the MDSG Fellows in teaching and mentoring. This opportunity to interact with a REU student can extend to more direct instruction and guidance, as REUs are sometimes placed in laboratories where a MDSG Fellow is also working. Although the REUs are mentored by faculty members, often the MDSG Fellows have the opportunity to work closely with the REUs on laboratory and field techniques. Maryland Sea Grant believes that the Symposium and further summer interaction with the REU program greatly enriches the education and outreach experience of the MDSG Fellows.

Other Activities. Maryland Sea Grant research fellow's program continues to provide (when possible) support for specialized training, attendance at meetings and other relevant activities that will enhance the fellowship experience. The program works with students and advisors to facilitate further interactions with members of the scientific and management communities.

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Microbulbifer degradans: ***An extraordinarily versatile recycler of organic matter in the Chesapeake Bay***

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The marine bacterium, *Microbulbifer degradans* strain 2-40 (2-40) was isolated from decaying marsh cord grass, *Spartina alterniflora,* in the Chesapeake Bay. Previous studies have shown that 2-40 synthesizes at least 10 different enzyme systems which allow growth on complex polysaccharides (CP) from various algal, invertebrate and plant sources. These CP include agar, alginate, chitin, carboxymethylcellulose (CMC), □-glucan, laminarin, pectin, pullulan, starch and xylan. The draft genome sequence of 2-40 has recently been obtained in conjunction with the Department of Energy's Joint Genome Initiative (JGI). 25 open reading frames have been identified in the genome as likely endocellulases, cellodextrinases, or cellobiases, and at least 9 identified as xylanases. Additionally, there are as many as 15 likely pectin lyases in the draft sequence. In this study, the enzymatic activity of cell pellets and culture supernatants were monitored during growth on sole carbon source xylan and Avicel. Zymograms reveal eight bands active against CMC, with MW from 30-150kDa, when grown on Avicel. Five xylanolytic bands are seen in xylan-grown cultures (MW 29 to 125kDa). Growth on either Avicel or xylan yields enzymatic activity against both substrates, suggesting co-induction of the cellulase and xylanase systems. This study provides the first report of 2-40 utilization of crystalline cellulose, as well as a preliminary description and characterization of extensive cellulase and xylanase systems in 2-40. To our knowledge, *M. degradans* 2-40 is the first marine bacterium shown to have enzymatic systems capable of degrading all three of the major components of plant cell walls as well as systems acting against algal and invertebrate CP. Studies are underway to definitively determine the complement of enzymes expressed during growth on xylan and avicel and to better understand their regulation. Based upon the number of its degradative enzyme systems, 2-40 appears to be a versatile saprophyte and a significant participant in the marine carbon cycle.

Ecological consequences of the phylogenetic diversity of phytoplankton

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Unlike terrestrial primary producers, which are all essentially chlorophytes, phytoplankton contain representatives of several distinct classes of organisms. Understanding the ecological consequences of this diversity is an important aspect of understanding the role of phytoplankton in aquatic ecosystems. In this presentation I will draw on two areas of research in which I have been involved to illustrate this point. Mixotrophic nutrition is the combination of autotrophy and heterotrophy within a single organism. I examined the balance of autotrophy and heterotrophy in the mixotrophic dinoflagellate, *Karlodinium micrum*. Although previously established as an obligate autotroph, my research showed that growth stimulation during feeding on prey was fueled primarily by heterotrophic metabolism. More recently, I have been involved in a project examining relationships between Chesapeake Bay primary production and the abundance of different phytoplankton groups determined through photopigment analysis. We have found that freshwater input to the bay from the Susquehanna River is associated with predominance by diatoms. Further, the presence of diatoms is associated with ecologically meaningful differences in primary production. Both of the lines of research mentioned above support the idea that phylogenetic diversity is an important contributor to the variability we observe among phytoplankton populations in nature.

Distributions and feeding ecology of larval fishes in an estuarine transition zone

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In Chesapeake Bay, several anadromous fishes (e.g., shads and river herrings [alosids], striped bass and white perch [moronids]) have overlapping spawning periods. It was hypothesized that survival of their young is influenced by overlaps in taxa distributions and diets. Ichthyoplankton surveys were conducted in fresh and oligohaline portions of the Patuxent River, Chesapeake Bay, during spring-summer 2000 and 2001 to determine abundances, distributions, and diets of constituent taxa with respect to environmental conditions. Small alosines occurred >10 kilometers above the salt front, a feature that shifted location with changing environmental conditions and served to segregate distributions of larval taxa. Larval moronid and gizzard shad distributions were more closely associated with the salt front and overlapped consistently with large alosid larvae. Diversity was greatest above the front, where 48% of the larvae were moronids, while naked goby larvae contributed 90% to the catch below the salt front. Analysis of stomach contents indicated moderate to high dietary overlap for larvae of similar sizes, independent of taxonomic status.

Influence of hypoxia on trophic interactions between the ctenophores, ichthyoplankton, and zooplankton in Chesapeake Bay

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Low dissolved oxygen (DO) in aquatic ecosystems limits the habitat available to organisms, altering encounter rates and subsequent predator/prey interactions. We investigated the influences of hypoxia among lobate ctenophores (*Mnemiopsis leidyi*), ichthyoplankton, and zooplankton as part of an intraguild predation food web in Chesapeake Bay using field, laboratory, and simulation modeling methods. Hypoxic conditions may favor ctenophores over their prey because of greater tolerance to low DO. Field surveys show that vertical overlap between predator and prey varies with bottom DO and time of day, with a general increase in habitat overlap as bottom DO increases, and slightly lower overlap at night. Laboratory experiments indicate that predation rates by ctenophores on *Gobiosoma bosc* larvae and *Anchoa mitchilli* eggs and yolk sac larvae were unaffected by hypoxia, but swimming speeds and behavior could change, potentially affecting encounter rates. Observations of encounters between individual ctenophores and larvae (n=96) revealed that ingestion success was low after the first encounter (10%) but rose to 56% when subsequent escape and re-capture were taken into consideration. The age and size of ichthyoplankton prey may also contribute to the outcome of a predation interaction. Logistic regression yielded significant differences in ctenophore ingestion success due to DO, larval age, and their interaction. An individual-based model using these field and laboratory results predicts that larval survival was sometimes higher when the bottom layer was hypoxic than when DO was high throughout the water column. Hypoxia shifts the vertical distribution of ctenophores and ichthyoplankton according to bottom DO and water column depth, altering predation rates. We will expand this model to examine if predation by ctenophores has less impact on fish populations than does competition, and whether environmental conditions, such as seasonality or hypoxia, shift the relative importance of interactions between these species, allowing persistence of food web structure.

Changes in sediment nutrient cycling and biogeochemistry associated with the development and spatial distribution of estuarine seagrass beds

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Many studies have shown that the presence of submersed aquatic vegetation (SAV) can significantly alter habitat quality and sediment biogeochemical cycling. Although considerable information exists on how plant density, plot size and sediment nutrients affect transplanting success, there is little quantitative information on how reciprocal plant-sediment interactions affect development and long-term survival of natural and transplanted meadows. The purpose of this study is to provide a clear and quantitative understanding of how sediment quality and associated biogeochemical processes change with development and spatial distribution of estuarine seagrass beds. We propose to generate this information using comparative measurements of plant characteristics and sediment nutrient cycling in natural and transplanted *Ruppia maritima* and *Zostera marina* beds of different age, size and spatial distribution. Study sites will include approximately 10 *R. maritima* beds within the Choptank River estuary and 6 *Z. marina* beds within the York River estuary. Bed age and development for study sites will be estimated using an existing annual time-series of aerial photographs. Bed age of transplanted SAV sites has been previously recorded. Within each site, we will measure plant characteristics, sediment pore-water and sulfide pools, and sediment nutrient cycling activities. Sediment quality in these seagrass beds will be assessed using mixed species transplants in the field and growth assays in controlled greenhouse conditions, and by relating these results to observed bed characteristics and nutrient biogeochemistry. We will also measure ambient rates of denitrification, nitrogen-fixation, sediment respiration, and nutrient (N and P) recycling fluxes in selected experimental sites with natural and transplanted *Ruppia maritima* and *Zostera marina* beds. This project will provide information to improve restoration protocols for plant density, bed size, and species combinations that will generate healthy sediments required for self-sustaining estuarine SAV communities.

Eastern oyster biodeposition and sediment nutrient dynamics in La Trappe Creek (Choptank River Estuary, Chesapeake Bay, USA)

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Prior to the ~100-fold decline in stocks of the eastern oyster, *Crassostrea virginica*, in Chesapeake Bay, this suspension-feeding bivalve may have exerted top-down control on phytoplankton biomass and promoted enhanced denitrification in Bay sediments. To quantify nitrogen and phosphorus removal associated with oyster biodeposition, I anchored ~1,100 oysters in aquaculture floats in a shallow, mesohaline cove of La Trappe Creek, a tributary to the Choptank River estuary. Reference sites were selected outside the predetermined zone of oyster biodeposition, and sediment cores were incubated under fluorescent lamps (~70 to 80 □mol m^{-2} s^{-1}) to simulate a diel cycle. I compared sedimentation rates, nutrient fluxes (N_2, O_2, NH_4^+, NO_2^- + NO_3^-, and PO_4^{3-}), pore water nutrient concentrations, C and N concentrations in surface sediments, and sediment chlorophyll *a* (Chl *a*) from the sites. At all sites, there were only minimal fluxes of N and P species up into the water column and down into the sediment. Nutrient fluxes and pore water concentrations did not significantly differ between treatments (P = 0.05). The float site possessed significantly greater Chl *a* in surface sediments than cores taken at the reference site. Although sedimentation was significantly greater beneath the floats than at the reference site, differences in surface sediment C and N were not statistically significant (P = 0.05). I conclude that microphytobenthos (MPB) intercepted regenerated nutrient species prior to their release to the water column and also reduced the availability of NO_3^- to denitrifying bacteria in the underlying anaerobic sediments, thereby precluding denitrification. It is possible that without this active MPB community and with a greater concentration of oyster biodeposition settling directly beneath the aquaculture floats (e.g., less dispersion) that there would have been a considerable flux of nutrients from the sediments into the water column at the site with oyster biodeposition. Current research focuses on the effect of eastern oyster biodeposition on sediment nutrient dynamics under light conditions insufficient to support primary production at the sediment surface.

The spatial ecology of blue crab winter mortality in the Chesapeake Bay

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The blue crab *Callinectes sapidus* supports the most lucrative remaining fishery in the Chesapeake Bay and is an important benthic predator in the Bay ecosystem. Modeling the population dynamics of blue crabs is an important component in assessing the status of the blue crab stock. Currently, stock assessments assume that crab mortality is constant over the winter months, but varying degrees of winter severity may induce inter-annual variability in overwintering mortality. My master's research will build from laboratory experiments, funded by Maryland Sea Grant, to quantify the impacts of acute and chronic levels of low temperature on blue crab survival. The first objective is to model the probability of mortality of crabs as a function of their size and exposure history to temperature and salinity. The survival model will then be combined with observed crab abundance and environmental data from the Winter Dredge Survey and EPA Chesapeake Bay Program to predict winter mortality of crabs in the field. Specifically I will test the hypothesis that blue crab mortality does not vary temporally or spatially. I have begun to assemble and analyze the historical environmental data and the preliminary results indicate that the lower bay has a shorter, less severe winter than the upper bay. The resulting geostatistical models will be used to estimate changes in estimates of the initial number of crabs available to the fishery and the fishing mortality in the year subsequent to winter mortality.

Spatial ecology of blue crab (Callinectes sapidus) *in Chesapeake Bay*

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The spatial distribution of blue crab and the fishery that exploits it are often ignored in modeling and management of this species in the Chesapeake Bay. However, spatial patterns at various scales are a striking feature of blue crab life history and of the different components of the fishery. Knowledge of the spatial ecology of blue crabs could lead to more effective and equitable management. Using data from the annual winter dredge survey and a variety of modeling techniques, we have:

1) Developed a novel approach to geostatistical interpolation that is based on distance through the water rather than a straight-line metric.

2) Used this technique to describe and map (using GIS) the spatial patterns of blue crab winter abundance, and to estimate the size of the blue crab stock in Chesapeake Bay.

3) Described the relationship between patterns of abundance and the distribution of environmental parameters such as temperature, salinity, depth, and bottom type using a two-stage Generalized Additive Model (GAM).

Results are discussed in relation to blue crab management strategies (e.g. the lower Bay spawning sanctuary) and theories of habitat use.

List of Maryland Sea Grant Funded Projects with Fellows[1]

MDSG Fellows	Abstract Titles	Fellow Funded	MDSG Funded Projects (MDSG Project Number)	Principal Investigators	Project Dates
Jason Adolf	Ecological consequences of the phylogenetic diversity of phytoplankton	Feb 96 - Jan 00	Assimilation modeling of planktonic processes in Chesapeake Bay with aircraft and satellite ocean color data (R/P-44)	L.W. Harding R.R. Hood	Feb 98 - Jan 00
			Satellite remote sensing with SeaWiFS to detect seasonal and interannual variability in phytoplankton abundance in the Chesapeake Bay and adjacent coastal waters (R/P-37)	L.W. Harding W.E. Esaias	Feb 96 - Jan 98
Laurie Bauer	The spatial ecology of blue crab winter mortality in the Chesapeake Bay	Sep 02 - Sep 04	Winter mortality of Chesapeake blue crabs, *Callinectes sapidus* (R/F-93)	A.H. Hines V.S. Kennedy W.F. Van Heukelem T.J. Miller G.R. Davis	Feb 02 - Jan 04
Patrick Campfield	Distributions and feeding ecology of larval fishes in an estuarine transition zone	Feb 00 - Jan 03	Evaluating and improving larval stocking as a method to restore American shad in Chesapeake Bay (R/F-90)	E.D. Houde S.P. Minkkinen	Feb 00 - Jan 03
Jessica Davis	Changes in sediment nutrient cycling and biogeochemistry associated with the development and spatial distribution of estuarine seagrass beds	Feb 03 - Jan 05	Sediment biogeochemistry and seagrass bed development: implications for restoration and sustainability (R/P-56)	W.M. Kemp L. Murray J.C. Cornwell	Feb 03 - Jan 05
Rebecca Holyoke	Eastern oyster biodeposition and sediment nutrient dynamics in La Trappe Creek (Choptank River Estuary, Chesapeake Bay)	May 02 - May 04	Quantifying the magnitude of nitrogen and phosphorus removal associated with restoration of oysters in the Chesapeake Bay (R/P-51)	R.I.E. Newell J.C. Cornwell D.W. Meritt	Feb 02 - Jan 04
Olaf Jensen	Spatial ecology of blue crab (*Callinectes sapidus*) in Chesapeake Bay	Jan 01 - Sep 02	The spatial dynamics of blue crab in Chesapeake Bay (R/F-89)	T.J. Miller	Feb 00 - Jan 02
Sarah Kolesar	Influence of hypoxia on trophic interactions between the ctenophores, ichthyoplankton, and zooplankton in Chesapeake Bay	Feb 01 - Sep 03	Does low dissolved oxygen favor dominance of gelatinous zooplankton in Chesapeake Bay? (R/P-50)	D.L. Breitburg J.E. Purcell	Feb 00 - Jan 02
		Jan 99 - Jan 00	The importance of understanding ecological complexity to predicting effects of multiple stressors on coastal systems (R/PT-05)	D.L. Breitburg	Jan 99 - Dec 02
Larry Taylor	*Microbulbifer degradans*: An extraordinarily versatile recycler of organic matter in the Chesapeake Bay	Jul 01 - Jan 04	Chitinosomes in *Microbulbifer degradans*: A new paradigm for the degradation of complex polysaccharides of marine origin (R/BT-10)	R.M. Weiner S.W. Hutchinson	Feb 02 - Jan 05
		Sep 99 - Dec 00	Bioremediation of recalcitrant complex carbohydrate biopolymers by a novel marine bacterium (R/BT-07)	R.M. Weiner	Feb 99 - Jan 02

[1]Students funded by Maryland Sea Grant Fellowship