University of Connecticut

J. Evan Ward, Professor
University of Connecticut
Department of Marine Sciences
1080 Shennecossett Road, Groton, CT 06340
voice: (860) 405-9073; fax: (860) 405-9153
e-mail: evan.ward@uconn.edu
web page: http://web.uconn.edu/jevanward

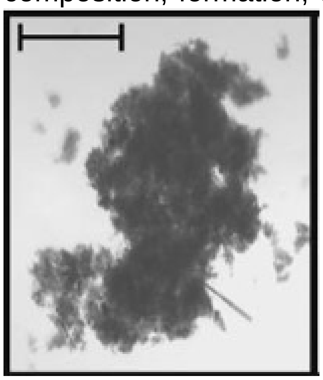
RESEARCH PROJECTS AND INTERESTS

I am an experimental biologist whose research interests are directed toward an understanding of the dynamic interactions between marine animals and their environment. In particular, my work focuses on the endogenous and exogenous factors that mediate the behavior and physiology of benthic, particle-feeding invertebrates. I take an integrative approach in my research program by studying processes ranging from the organism to ecosystem level. Much of my research focuses on commercially important species, or shellfish (e.g., clams, oysters, mussels, scallops). These animals exert great control over the particle supply and distribution in many coastal ecosystems, and can influence the biology and ecology of other organisms. Additionally, they provide vital ecosystem services, and are an important link between the oceans and human health. Because suspension feeders play such a key role in near-shore ecosystems, it is important to understand how they obtain and process food and non-food particles, what factors control feeding processes, and the effects of environmental perturbations on their overall health. My work is funded by grants from the National Science Foundation (Integrative Organismal Biology, Ecology of Infectious Disease Programs), and the National Oceanographic & Atmospheric Administration (Oceans and Human Health Initiative & CT Sea Grant).

I. Interactions Between Marine Aggregates and Benthic Suspension Feeders: Living and non-living particulate matter is ubiquitous in aquatic systems. Through physical, chemical and biological interactions, this particulate matter aggregates into larger particle masses (marine snow, flocs). During certain times of the year, >70% of suspended particles can be in an aggregate form, ranging in size from a few microns to more than a centimeter. Aggregation of particles has been recognized as an important mechanism for the transport of carbon, nutrients, and other materials to the benthos. Aggregates are abundant in coastal environments where large populations of benthic, suspension feeders thrive, and this rapidly sinking material carries particles of various sizes at concentrations 10–10,000 times higher than that freely suspended in the seston. Our work on the interaction of aggregates and suspension feeders can be divided into three areas of focus.

a. ***Aggregates, TEP and benthic pelagic coupling -*** The traditional concept of benthic-pelagic coupling by suspension feeders involves the removal of phytoplankton and other particles from the water column, deposition of feces and pseudofeces to the bottom, and conversion of food material for animal production. This traditional paradigm, however, may not be the only mechanism by which suspension-feeders accomplish coupling. Recently, we have described another possible mechanism by which suspension feeders can couple the benthic and pelagic realms. Through laboratory and field work, my students and I have demonstrated several key points regarding this proposed mechanism: 1) the pumping of water over feeding structures releases large quantities of transparent exopolymer particles (TEP); 2) the released TEP enhances particle aggregation and, consequently, deposition of material to the benthos; and 3) the aggregates and their constituent particles can be ingested. This cascade of events may represent an important but under-studied process that impacts water column processes and the fate of organic matter in near-shore waters. Currently, we are working to better define the importance of our newly described mechanism and to determine the importance of aggregates as a food resource.

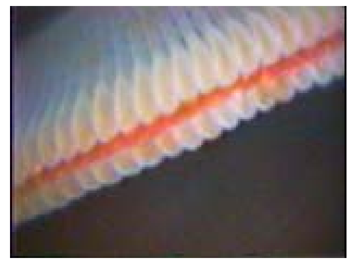
b. ***The ecological role of marine aggregates in linking pathogens to molluscan shellfish (an Oceans and Human Health Linkage*****) -** In this study we are focusing on the role of aggregates as a link between pathogens (e.g., protistan & prokaryote) and bivalve shelllfish. Because aggregates are ubiquitous in the marine environment, benthic organisms (e.g., bivalves) are exposed to a steady supply of aggregated material and the various microorganisms contained within. Although many recent studies have focused on the composition, formation, distribution, and fate of marine aggregates none have addressed the role of aggregates in the ecology of marine pathogens. We hypothesize that marine aggregates enhance the transmission of shellfish diseases by at least two mechanisms: 1) as reservoirs when they serve to concentrate marine pathogens within their matrix; and 2) as vectors when they serve to enhance the capture efficiency of smaller pathogens (e.g., bacteria, zoospores) by the gills, thus increasing exposure to the bivalve host. Results from our studies over the past few years support these hypotheses. This research is being conducted in collaboration with scientists at Old Dominion University, VA (F. Dobbs, M. Lyons), University of Minnesota (R. Hicks), and University of Georgia (J. Drake).



c. ***The aggregate pathway and enhanced uptake of nanomaterials (an Oceans and Human Health Linkage*****) -** Manufactured nanoparticles and nanotubes are at the forefront of nanotechnology and are being used in a variety of applications including cosmetics, electronics, drug delivery, manufacturing technologies, molecular biology, and paints. Several types of nanoparticles have been shown to have toxic effects on cells in vitro, causing mitochondrial and DNA damage, and cell death. Recent studies on a few species of fish and invertebrates have provided data which demonstrate that harmful effects on these organisms are also possible. The way in which nanoparticles are taken up by aquatic organisms, however, has been little studied. In this project, we are considering how feeding limitations of several bivalve species affect their uptake of nanoparticles, and determining how the form of delivery (freely suspended or incorporated in aggregates) mediates bioavailability, retention, and thus internal exposure. These results will provide for the first time more realistic estimates of body burdens allowing us to probe the effects of nanoparticles on whole animal and cellular processes, and to develop biokinetic models of rates and processes for bivalves in the environment. This work is being conducted in collaboration with Rob Mason (Department of Marine Sciences) and Bryan Huey (Department of Chemical, Materials, & Biomolecular Engineering).

II. Feeding Behavior and Physiology of Bivalve Molluscs: In this line of research, my students and I are addressing fundamental questions regarding suspension feeding mechanisms. We are studying bivalve species that possess different gill architectures, which translate to differences in the way in which particles are handled by the pallial organs. This research direction can be divided into two areas of focus.

a. *Elucidating particle selection mechanisms in bivalves* - In this project, we are applying previously developed techniques of feeding physiology and biochemistry to examine the bases of selection at the cell and organ level. The work addresses long-standing questions regarding the mechanism(s) by which bivalves and other suspension feeders accomplish particle selection. At the core of this research are two fundamental questions:1) Is particle selection an active process, i.e., based on chemically mediated behavior, or a passive process, i.e., based on interactions between particles and mucus-coated feeding structures?; and 2) Do different groups of suspension-feeding molluscs employ the same or different mechanisms for particle discrimination? Our work focuses on the most plausible mechanisms involved in the selection process, and includes: a) manipulating particle surfaces to determine if selection is a function of surface properties (charge, wettability, stickiness); and b) investigating whether lectins in gill and labial-palp mucus bind to carbohydrate residues of the extracellular matrix of phytoplankton to mediate selection. Results from this research are providing a better understanding of feeding processes in different species of bivalves, the potential impact of bivalves on coastal environments, and how environmental perturbations (e.g., pollution) might affect particle feeding. This study is being conducted in collaboration with Sandra Shumway, another faculty member in the Department of Marine Sciences, and scientists at Stony Brook University, NY (E. Pales Espinosa, B. Allam).



b. *Functional mechanisms of control in the bivalve pump* - Using our recently developed Pressure-Gape System, Video Endoscopy, and Particle Image Velocimetry (PIV) we are investigating the physiological bases of water pumping and particle feeding in bivalve molluscs. Experiments are designed to determine relationships between valve gape and pumping rate (volume flux), investigate mechanisms by which bivalves alter pumping activity, test the hypothesis that bivalve pumping activity is mediated by exogenous factors, and examine the variation in pumping behavior and performance among several bivalve species. Our research has the potential to resolve some of the long standing controversies regarding the physiological basis of water processing in bivalves, and will provide back-ground data for future studies on the performance of bivalves in the natural environment. This study is being conducted in collaboration with Sandra Shumway, another faculty member in the Department of Marine Sciences, and scientists at the University of Louisiana (L. Deaton).

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