FALL 2006

St. Anthony Falls Laboratory

Channel

University of Minnesota

From Microbes to Macrophytes and everything in between: Faculty research spans the gamut

fall 2006

SAFL CHANNEL

departments

Cover: Associate Professor Miki Hondzo and Post-Doctoral Associate Cailin Huyck Orr in the Main Channel facility at SAFL. Photo courtesy of Brad Stauffer.

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THE DIRECTOR'S PERSPECTIVE

I am very excited to introduce to you the very first issue of our new and improved publication. *The Alumni Channel* that served us well as the means to communicate with our alumni and friends for many years is being revamped this fall as *The SAFL Channel*. Our new publication is designed to more effectively communicate the depth and breadth of our ongoing interdisciplinary research. With more space for articles and graphics we will strive to give you a comprehensive overview of one of our research themes in every issue. The focus of this first issue is on biological fluid mechanics research, which in recent years has emerged as a major thrust of our research portfolio. I hope you will enjoy reading about Miki Hondzo's exciting research on how turbulence affects biochemical processes in lakes, rivers, and the coastal ocean, as well as our work on computational biofluid dynamics. Appropriately, this issue also includes an interview with the latest addition to our faculty roster, Claudia Neuhauser, professor and head of the Department of Ecology, Evolution, and Behavior.

But *The SAFL Channel* is just the second major recent change in the way we communicate with the outside world. As of a few weeks ago SAFL wears a brand new outfit. Two sets of banners are now hanging on the north and south sides of SAFL to introduce us to our neighbors and identify who we are and what we do. Earth, Water, and Life are the three words we chose to describe our research profile in the broadest terms. We borrowed these words from NCED's logo to mark the dramatic transformation SAFL has undergone in the last decade, from a traditional hydraulics laboratory to a leading, interdisciplinary institution for environmental research. So the next time you visit us, do take the time to walk across the stone-arch bridge and take a look at the new addition to the Minneapolis river front: SAFL's banners!

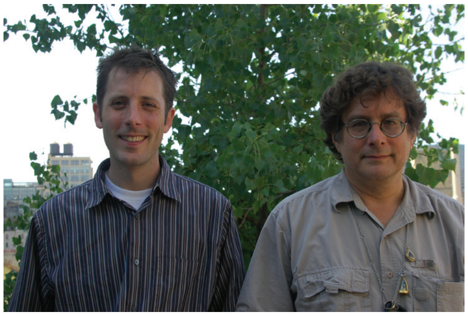
I have been fortunate to assume the directorship of SAFL at a time when the laboratory is arguably at the best point of its nearly 70-year old history. The visionary leadership of past directors and the creativity and innovative spirit of our faculty and research staff have created opportunities that were simply not there a few years ago. For that, I am convinced that even better days lie ahead for this extraordinary place. A major challenge we are now facing is to raise the resources to renovate our aging building and expand our research infrastructure. Our vision is to modernize SAFL to make it a more functional working environment while we remain respectful of its heritage and unique location in the center of the Minneapolis river front. This fall we will be starting an organized effort to raise the resources that will allow us to do just that and I am optimistic that with your help we will be able to transform our vision into a reality of which we can all be proud.

—Fotis Sotiropoulos
Professor and Director, SAFL

Editor: Maia Homstad (homst004@umn.edu)
The Alumni Channel is published biannually by
St. Anthony Falls Laboratory
University of Minnesota
Minneapolis, MN 55414
(612) 624-4363
www.safl.umn.edu
SAFL is a research unit of the Institute of Technology.

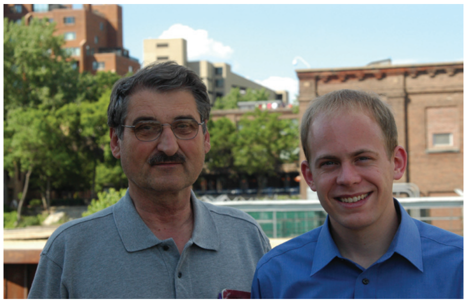
announcements

congrats grads



Wes Lauer (PhD ‘06)
Advisor: Gary Parker

Nikki Strong (PhD ‘06)
Advisors: Lesley Perg & Chris Paola



Ben Janke (MS ‘06)
Advisor: Heinz Stefan

Nikos Theodoratos (MS ‘06)
Advisor: Efi Foufoula-Georgiou
(In back: Post doc Ion Iorgulescu)

Ben O’Connor (PhD ‘06)
Advisor: Miki Hondzo

Luca Sittoni (MS ‘06)
(Advisors, not pictured: Chris Paola & Vaughan Voller)

honors & awards

Fotis Sotiropoulos recently received an NSF grant to support an interdisciplinary research project to develop models of freely swimming planktonic micro-organisms. These models will shed new light into the response of plankton to small-scale biological-physical-chemical signals in the sea, and answer questions pertaining to the hydrodynamics of plankton swimming

Miki Hondzo, in collaboration with William Arnold, Paige Novak, Raymond Hozalski, and Nihar Jindal, recently received an NSF grant to support an interdisciplinary research project on “Wireless technologies and embedded sensor network sensing: Application to integrated urban water quality management.”

Rob Stoll (PhD ‘07) was awarded Best Student Poster for *Surface heterogeneity effects on regional-scale fluxes in stable boundary layers: an LES study* at the American Meteorological Society’s 17th Symposium on Boundary Layers and Turbulence in San Diego, CA on May 23rd.

Ben Janke (PhD ‘09) has been awarded a 3 year U.S. EPA Fellowship to further his graduate education at SAFL.

ANNOUNCEMENTS CONTINUED ON P. 4

SAFL faculty members honored at Scholars Walk


Heinz Stefan


Efi Foufoula-Georgiou


Gary Parker


Chris Paola

Heinz Stefan is acknowledged as a recipient of the 1998 ASCE Hunter Rouse Award, and a Morse-Alumni Distinguished Teacher Award.

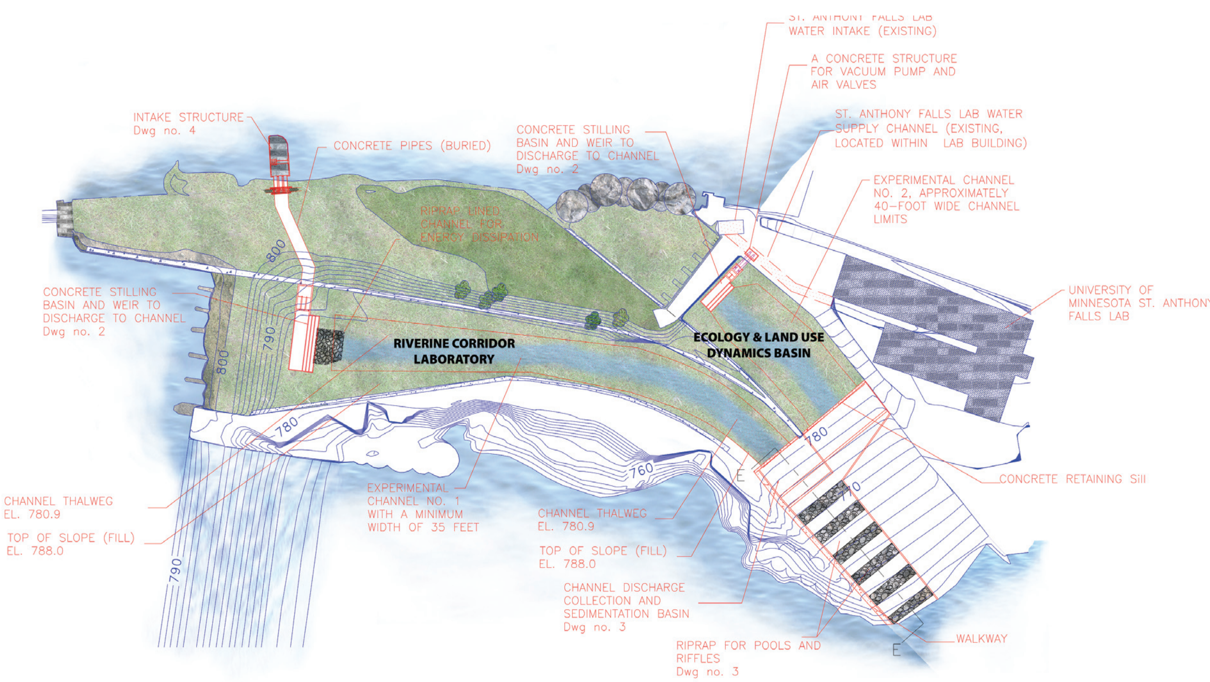
Efi Foufoula-Georgiou is recognized for being a recipient of the 2003 Dalton Medal, and for her membership in the European Academy of Sciences.

Chris Paola is recognized as a recipient of a Morse-Alumni Distinguished Teacher Award.

Gary Parker is noted as being the 2002 G.K. Warren Award winner.

news

- SAFL is proud to welcome professors Robert Street (Oct. 18) and Robert Dalrymple (Nov. 1) as the inaugural speakers in our new Distinguished Lecture Series.
- Provost Thomas Sullivan visited SAFL this summer to tour the lab and meet with faculty.
- Construction on the Outdoor StreamLab is scheduled to begin Spring 2007.



from microbes TO MACROPHYTES

Miki Hondzo walks the walk of interdisciplinary research

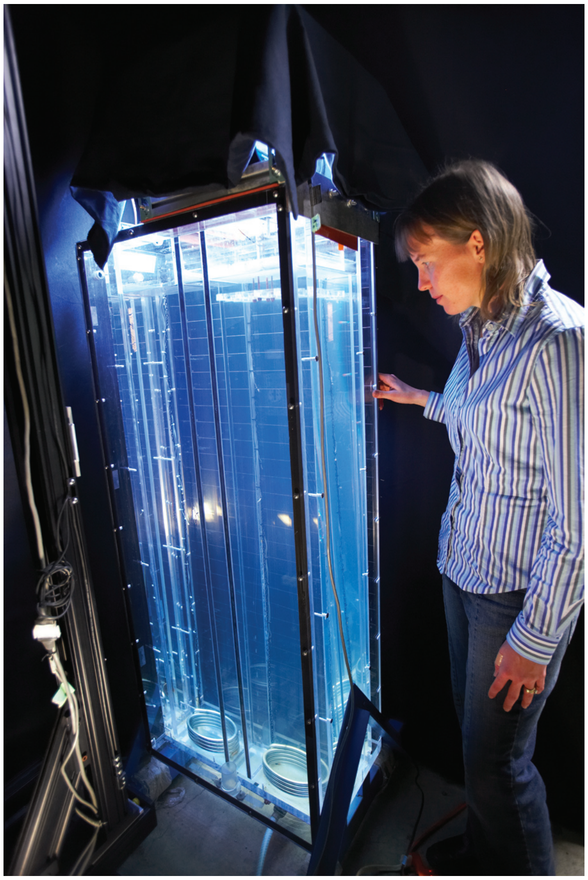
Civil engineering associate professor Miki Hondzo has a knack for being in two places at once. Or three or four. Not only does he hold an appointment in the department of Civil Engineering, but he is also a dedicated researcher at the St. Anthony Falls Laboratory, a principal investigator for the National Center for Earth-surface Dynamics, a co-PI on the Integrative Graduate Education and Research Traineeship (IGERT) program, a major collaborator with the Ecology, Evolution, and Behavior department at the University of Minnesota, and now, PI of the NSF-funded initiative on Collaborative Large-scale Engineering Assessment Network for Environmental Research (CLEANER). In addition, he advises half a dozen graduate students who conduct research experiments at SAFL and at various field sites. His involvement across so many prestigious centers is reflected in his own research, which is an amalgam of disciplines. Hondzo's research interests have evolved more specifically into studying how environmental fluid dynamics affect the biochemical processes in lakes, rivers, and watersheds. He begins at the microscopic level and works his way up from there.

Hondzo says the reason to conduct experiments at microscopic levels is to explore possible universal scaling relationship between living organisms and moving fluid. Lab-based experiments, such as those in SAFL's Main Channel (see cover photo), focus on simplified conditions, in order to provide a basis for fine-scale heterogeneity in the physical processes which drive small-scale responses. Controlled field scales will be developed through the Outdoor StreamLab, to open in spring 2007. Field heterogeneities can then be verified with field measurements in order to bridge the gap from microscopic to field scales.

Currently, Hondzo's major focus is on leading the Ecological Fluid Dynamics research group, which studies the interactions among fundamental fluid mechanics, microbiological processes, and chemical reactions that are mediated by biological organisms. The group's purpose is to understand the base interactions of the food web, and quantify how biological processes can affect water quality in aquatic and engineered ecosystems.

From local to global

One current environmental issue related to Hondzo's research is nitrogen loading in the Gulf of Mexico. Fertilizers used in the agricultural fields of Minnesota, Iowa, and Illinois, traveling through runoff down the Mississippi, contribute to the significant excess of nutrients (namely nitrogen) in the Gulf. These nutrients provide an increase in the biological and microbiological growth, whose respiratory activity in the shallow water of the ocean is resulting in zero oxygen (hypoxia) conditions. One of Hondzo's graduate students, Ben O'Connor (PhD '06), has succeeded in providing a scaling relation between geomorphology and fluid mechanics with the microbial respiratory activity in the field. "What we are trying to understand is how nitrogen gas is converted to a biologically available form (or vice versa) at the bottom of that food chain," says Hondzo. Once nitrogen is converted (by microbes) in the biologically available forms, it is used by algae, then plants, and so on up the food chain.



Maria Spitael conducts research in the Plankton Tower.

How could one go about minimizing transport of nitrogen to the Gulf? "It turns out that pools with slow velocities and high settling of fine organic particles in streams provide so-called 'hot spots' of denitrification. With that mechanistic understanding, we should be able to design a stream [that feeds into the Mississippi River] that will be a combination of pools and riffles that will maximize denitrification in the environment," says Hondzo.

Clear waters ahead?

Zooplankton, also a key element at the base of the food web, are another topic of study. Graduate student Maria Spitael (MS '06) has been analyzing how zooplankton aggregation in thin layers is affected by the temperature structure and turbulence conditions in stratified bodies of water. Although this research is focused on

Hondzo continued on p. 11

Mean Green Math Machine

Claudia Neuhauser, professor and head of Ecology, Evolution, and Behavior, joined SAFL as its newest faculty member last Spring, shortly after receiving the IGERT (Integrative Graduate Education and Research Traineeship) grant with professors Miki Hondzo and Chris Paola. To introduce her to the greater SAFL community, we asked her a few questions about her work then and now.

What is the goal of the IGERT program?

The goal of the IGERT is to enable us to understand the effects of biological and physical processes on ecosystems. I am hoping that over the years, we will develop collaborations among the IGERT faculty that will allow us to combine our expertise across the fields of ecology, civil engineering, geology, and computer science to develop a framework that allows us to understand these interactions.

Your role with the IGERT group is somewhat different from the PIs whose research takes place in a laboratory. How do you approach a typical research project?

My research is purely theoretical. Pencil and paper are my main tools. I increasingly use computer simulations to gain a better understanding of the models I work on before formulating and proving theorems. Much of my research concerns understanding dynamics of ecological communities, in particular, the effects of local and stochastic interactions. For instance, I have developed spatial models to study how plants compete for space or how pathogens or mutualists interact with their hosts and under what circumstances these species can coexist or exclude each other. My research is either motivated by concrete problems, for instance, determining the effects of habitat fragmentation on the genetic diversity of plants living in this habitat, or they follow more traditional theoretical ecology research, for instance I study the effects of introducing a spatial component in traditional ecological models that lack a spatial component. An example of this latter situation is a project I did a few years ago where we investigated a standard competition model where the non-spatial version had been around for many decades. The model we developed enabled us to show mathematically rigorously that space may impede coexistence, a result that showed that a commonly held belief, namely that space facilitates coexistence, is wrong.

How are you currently involved with the IGERT students?

I currently do not advise an IGERT student but I am quite heavily involved in the IGERT program as the PI on this training grant. Aside from the administrative tasks that come with leading a training grant, I see my primary role as facilitating interactions among participants and developing the quantitative aspects of this training grant. I meet weekly with all the students we currently have in the program. All the first-year students are participating in a year-long course that is co-taught by a large number of participating faculty and that has a concurrent journal club, which I go to. I meet with the second year students in a seminar where we are developing an outreach project that will likely focus on developing a sensor network that can be used to assess water quality in streams. These training programs come with additional components to provide training that goes beyond preparing them for research careers. These include career development opportunities for careers in either academia or industry. This will start next year. I am also responsible for the assessment program and I work with Tom Dohm from the Office of Measurement on developing a general framework for assessing training grants that can be used by other training grants as well.

PHOTO COURTESY OF TIM RUMMELHOFF

You've spoken about the importance of making material relevant to students and its effect on learning motivation. How did this affect you as a professor?

When I came to the University of Minnesota in 1996, I taught a calculus course for students who were not in IT. Many of these students were interested in becoming biology majors. I found it quite difficult to motivate the students with the material that was in the textbook and that I was supposed to cover. There was also quite a bit in the textbook that I knew they would never need. They

NEUHAUSER CONTINUED ON P. 12

the flow of the copepods

Computational Biofluids Research at SAFL

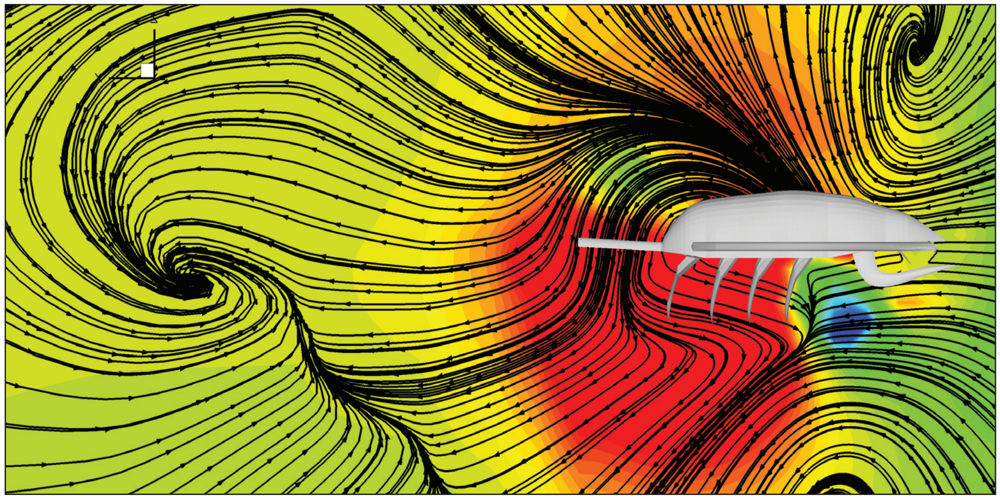


Fig. 1: Simulated flow patterns generated by a planktonic copepod attempting to escape a predator.

Most living systems—from single cells, to organs, to entire animals or human beings—are surrounded by and filled with fluids, such as air, water, blood, etc. Biologists are becoming increasingly cognizant of the fact that living systems respond to stimuli imposed by ambient fluid flow. There is mounting evidence that certain complex blood flow patterns can trigger biochemical responses at the cellular level that could lead to the onset of diseases, such us atherosclerosis and aortic heart valve disease. In an entirely different setting, tiny organisms (such as zooplankton) have been shown to have a complex response to turbulence in the water column, organizing in distinct thin layers in stratified lakes and deltas (see cover article).

The apparent coupling between fluid mechanics and biology has led to the emergence of a new, cross-disciplinary scientific area known as biological fluid mechanics or *biofluids*. The area of biofluids brings together researchers from biology and engineering disciplines where fluid mechanics is a core focus to study problems ranging from the hydrodynamics of fish and plankton swimming, to the aerodynamics of bird and insect flight, to the hemodynamics of the human cardiovascular system. The study of such problems is not only important from a fundamental scientific standpoint, but could also lead to exciting technological and ecological innovations. These include: virtual surgery; biomedical devices such as artificial organs and drag delivery systems; bio-mimetically inspired robots, sensors, and propulsive systems; the effective restoration of natural rivers to create ecologically sound aquatic habitats; and the design of environmentally friendly renewable energy systems.

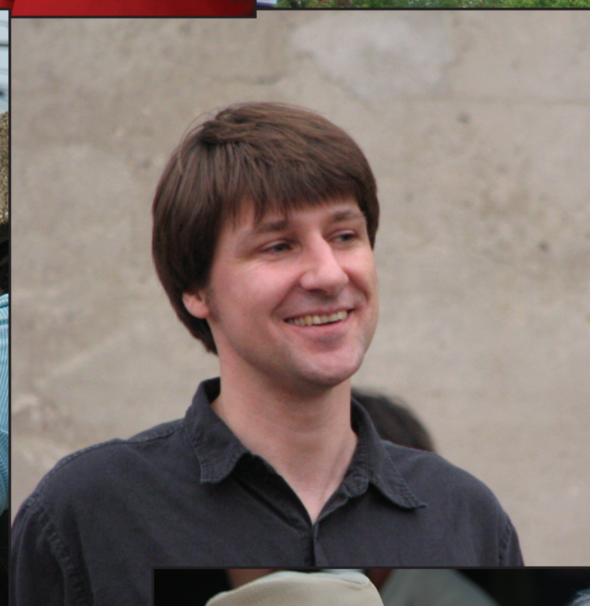
"As an institution with a long history of leadership in interdisciplinary fluid mechanics, SAFL is naturally at the leading edge of biofluids research."

As an institution with a long history of leadership in interdisciplinary fluid mechanics, SAFL is naturally at the leading edge of biofluids research. Associate professor Miki Hondzo's work is an example of how state-of-the-art experimental techniques can help make major strides in the research of biofluids problems involving ecosystem restoration. Biofluids research can also greatly benefit from the development and application of advanced computational fluid dynamics (CFD) techniques. Numerically simulating biological flows is inherently challenging as they are multi-scale and often multi-phase. They also occur over a broad range of Reynolds numbers and flow regimes, and involve arbitrarily complex, flexible immersed boundaries interacting in a strongly coupled manner with the flow. SAFL's Computational Hydrodynamics and Biofluids (CHB) group is developing computational techniques that can address these complexities at the spatial and temporal resolution required for elucidating the link between fluid mechanics and biology. Our ongoing research includes: the simulation of plankton and fish-like swimming; the study of pulsatile blood flow in mechanical and bioprosthetic heart valves; and the development of an imaging-based CFD framework for patient-specific surgical planning.

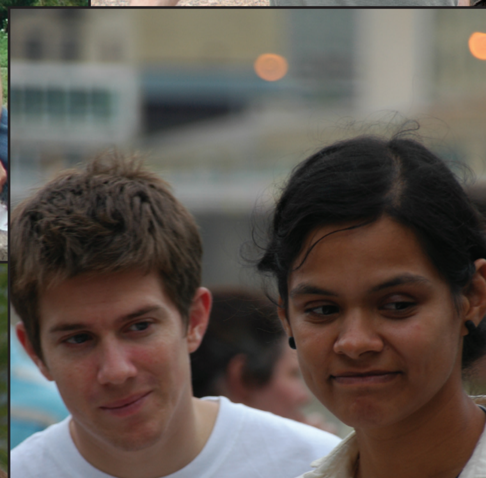
An example of the advanced computational techniques being developed by the CHB group is given in Fig. 1, which shows calculated flow patterns generated by a swimming planktonic copepod. Copepods are micro-crustaceans (approximately 1 *mm* long) and are among the most abundant animals on the planet. They constitute a major source of food for fish, and their feeding habits play an important role in controlling

Biofluids continued on p. 13

SAFL Fa



ll Picnic



Alumni Spotlight: Praveen Kumar

Praveen Kumar, Professor in the Department of Civil & Environmental Engineering and Director of the Institute for Sustainability of Intensively Managed Landscapes at the University of Illinois at Urbana-Champaign, received his PhD from SAFL in 1993. He has since gone on to become one of our distinguished alumni, receiving numerous honors and awards in his field of hydroclimatology and terrestrial hydrology. Among the many students he has advised was Patricia Saco, recipient of the 2003 Straub Award.

What was your biggest challenge coming to Minnesota as a graduate student?
Definitely dealing with the winters. Minneapolis was perceptibly colder even though I spent a winter in Ames, Iowa, but the real challenge was commuting between SAFL for research and the campus for the classes. Fortunately I had rented a place midway so I'd leave my car at the apartment and then walk to campus, and drive to SAFL. It got easier with time as I got used to it and I started enjoying the winters.

Who were your mentors while you were at SAFL?
Professor Efi Foufoula-Georgiou as my PhD advisor and Professor Gary Parker. I also enjoyed my interactions with Professor Randal Barnes.

How did your time at SAFL affect how you work as an academic?
SAFL provided an ideal atmosphere for research, to think independently and creatively. I spent a lot time in the Straub Library during the weekends – it provided the openness of a large room with lots of light, as well the quiet needed to think and work.

What are your fondest memories of your time at SAFL?
Spending quiet time in the Straub Library, and looking out over the water fall on a cold day! I also liked the Ice Castle in St. Paul constructed during winter.

How do you feel the field of hydrology has changed since you received your PhD?
Hydrology has become more inter-disciplinary during the last 10 years or so. Also, since the problems we deal with are very complex, "natural laboratory" is now recognized as a more suited environment for research. From a data sparse field, hydrology is becoming a data rich field although the need for more comprehensive data to address today's complex problems continues to grow. New advances in information technology are enabling faster delivery of these data to the users. There is significantly more exploration of the link between climate, anthropogenic influences, and terrestrial hydrologic processes.

What types of projects are you working on at UIUC currently?
My current research may be described through four thematic elements. First, I continue to look at issues pertaining to multiscale variability of hydrologic processes that I started during my PhD at SAFL. Second, my research in hydrogeomorphology involves understanding the interaction between streamflow and geomorphology at a range of time scales. For example, we are trying to understand how evolutionary processes give rise to observed self-similarity and tree organization in stream networks. Third, my research focus is in the area of hydroclimatology which involves developing a mechanistic understanding of the interaction between land and atmosphere, developing tools for inferring the dynamical characteristics from data, and developing assimilation techniques for using satellite data in models. Fourth, my research involves developing new informatics based methods (such as data mining) for unraveling hidden relationships from large volumes of remote sensing and time-series data to understand and model interactions between ecological and hydrologic processes.

"SAFL provided an ideal atmosphere for research, to think independently and creatively."

Do you have any words of advice for current or future students?
Interdisciplinary research is becoming more important. Today's problems are very complex and require expertise and perspectives from many disciplines. While the disciplinary training is essential, inter-disciplinary exposure is a must. I would strongly recommend that current and future students carefully think how their training reflects inter-disciplinary strength. ■

Hondzo continued from p. 5

lakes, similar conditions operate at the deltas of large rivers, and understanding zooplankton aggregation could be instrumental in post-Katrina restoration efforts in the Mississippi Delta's channels and wetlands.

In an experimental tank called the "plankton tower," Spitael is able to investigate the effects of physical variables on vertical distributions of zooplankton in the water column. She controls the light, temperature, and mixing in the tank and then measures the position and swimming speed of the zooplankton in relation to the other variables. "The hope is to understand which conditions are most favorable to encouraging zooplankton to thrive in lakes, because they are an important food source for fish, and they also consume algae, so they are associated with clearer water," she says.

Nature's little filters

Recent graduate Tanya Warnaars (PhD '05) focused her thesis on periphyton growth under different geomorphological and physical conditions in streams. Periphyton (algae attached to rocks in streams) acts like a filter for water by trapping passing bacteria, and provides a food source for zooplankton, which then are a nutrient source for fish, plants, trees, and so on, propagating throughout the food web.

A related project is that of PhD students Amy Hansen and Becky Stark, who are researching how macrophytes (larger, floating plants) accumulate heavy metals under different fluid flow conditions. Heavy metal contamination in streams is a major environmental issue for many areas, and our understanding of how turbulence mediates heavy metal uptake by macrophytes may help lead to better water quality.

Amer Al Homoud (PhD '07) is examining microbial fluid flow interactions, specifically, biochemical oxygen demand (BOD) in a moving fluid. Hondzo argues that BOD tests, which are enforced by the EPA for effluent discharge limits, do not provide reliable data because the standards were based on studies done in stagnant fluid. Yet there is much more microbiological activity in a turbulent flow in contrast to a stagnant flow, and since real-life bodies of water are mostly turbulent, new laboratory analyses methods need to be created that better reflect actual field conditions.

With the advent of the Integrative Graduate Education and Research Trainee (IGERT) grant, Hondzo has been able to broaden his collaborations to include working with Claudia Neuhauser, Head of EEB (see p. 5), an aspect that he is particularly excited about. "We were not meant to have boundaries, so I think it's good that it's getting harder to make them," he says. ■

"We were not meant to have boundaries."

—Miki Hondzo

thanks to our donors

The St. Anthony Falls Laboratory gratefully acknowledges the following donors who have generously provided support during 2005 and 2006. Every gift makes a difference.

Anadarko Petroleum Corp.
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Nels Nelson
Joseph Orlins
Aeek Paintal
Christopher Paola
Gary Parker
Michael Riley
Idell & Edward Silberman
Fotis Sotiropoulos
Frank Tsai
Vaughan Voller
Venugopal Vuruputur
Catherine Wetzel

If you would like to make a future contribution to the lab, please contact Ken Schaefer, Associate Development Officer, at schaef@umn.edu or (612) 626-7637.

Neuhauser continued from p. 6

of course would ultimately benefit from becoming familiar with mathematical thinking but I would have felt a whole lot better about the material if I could have told them where they would need it. This dissatisfaction with the material got me thinking about why we require calculus in the first place to students outside of IT and what they will need it for. I spent a year developing a calculus course for biology students to see whether a biology-oriented calculus course would be better received by students. When I taught this new course a year later, it was clear that it was much easier to teach mathematics to students if I also told them where it was used and translated the mathematics into the language of biology. The problem of computing the slope of a tangent line, which, not surprisingly, is not on the top of the list for biology students, became a problem about determining how populations grew, to which they could relate much more easily. Making the material relevant to the students will make them think about it more and so the material will stick much better.

Your textbook "Calculus for Biology and Medicine" (now in its second edition) has been very successful. Do you have any plans for integrating current SAFL research examples into future editions?

I am always looking for good examples from current research projects that I can integrate into either this book or into the mathematical modeling course I teach. I currently have a project that is funded by the Howard Hughes Medical Institute that allows me to do just that, namely find good examples and integrate them into either the courses I teach or into other biology courses. Current research examples are great ways to show our undergraduate students that what we teach is relevant and used in current research.

"Current research examples are great ways to show our undergraduate students that what we teach is relevant."

You use "spatial stochastic processes" (an area of probability) to create models that address questions in biodiversity and population genetics. Can you provide an example of how this might be applied to a specific environmental concern?

Over the past six years I was PI on a National Science Foundation Biocomplexity research grant that involved quite a few faculty from the College of Biological Sciences and what is now CFANS. We tried to understand community dynamics where both ecological and evolutionary forces were important. One of the projects dealt with the evolution of resistance of the European corn borer, a major pest of corn, to genetically modified corn that is supposed to kill this pest. We looked at how the spatial planting patterns of corn or how predation of the corn borer can affect the rate of evolution of resistance. Another project within this grant was concerned with understanding the effects of prairie fragmentation on genetic diversity of prairie plants. This was a combination of empirical and theoretical work. Most of the prairie land has been converted to other land uses, like agriculture. The fragments are typically quite small. We showed that genetic diversity decreases as fragments get smaller and used models to predict the fate of these fragments.

The results my colleagues and I prove are useful in understanding the complex simulation models that are needed to address environmental problems. The models we investigate are abstractions of reality and they allow us to isolate mechanisms and study their consequences. Models that are built to address environmental problems often combine many mechanisms and have large numbers of parameters, which makes it often difficult to understand their behavior.

Are you currently working on developing any new mathematical tools? If so, are you collaborating with anyone else?

I currently have a post-doc, who is also a mathematician. We are working on understanding how pathogens and mutualists affect the diversity of their hosts. The goal of another project, which we are now starting, is to develop a statistical tool for studying the genetic diversity of host populations that are associated with pathogens or mutualists. This project also involves a mathematician who is currently in the School of Mathematics.

Two other stories in this issue feature the research of Miki Hondzo and Fotis Sotiropoulos. How would you explain the connection between the work that the three of you do?

Both Fotis and Miki work on fluid dynamics and much of their work addresses flow problems. My work is on ecological communities. Since there is feedback between ecological communities and transport of chemicals in the water where these organisms live, we will need to develop models that better integrate these two aspects. I am hoping that within the IGERT training program, we will find opportunities to develop this interface.

At SAFL we have both computational and model-based approaches to our research. Which group would you rather have lunch with?

Much of my work is model-based, so the model-based folks might be a better fit. But I am also quite interested in expanding my research into the computational realm since I think that this is really needed if we want to take advantage of the new technologies that are coming out in the environmental sciences. So, I might end up having lunch with the computational folks. ■

—Maia Homstad
Science Writer

Biofluids continued from p. 7

phytoplankton population growth. Plankton biologists have long hypothesized that copepods are able to discern an attractive mate from a lunging predator by sensing their respective hydrodynamic signatures in the form of coherent vortical structures. As revealed by our numerical simulations, copepods can indeed generate very complex hydrodynamic signatures due to their intricate anatomy and the deployment of multiple moving appendages (antennules, legs, tail, etc.). The computational technique we have developed accounts for all major anatomical intricacies using a sharp-interface, immersed boundary methodology, and is uniquely able to simulate copepod flowfields from first principles and at fine numerical resolution. That is, our method can predict the full three-dimensional details of the flow created by a self-propelling copepod by using data for describing the entire body geometry in conjunction with data for prescribing the motion of each individual appendage.

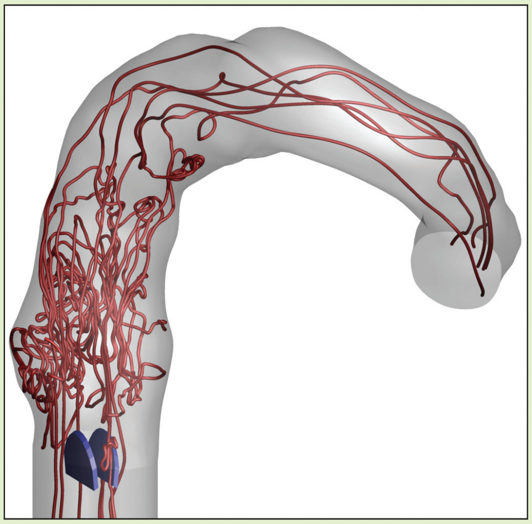


Figure 2: Simulated blood flow patterns though a bileaflet mechanical heart valve implanted in an actual aorta anatomy at an instant in time just prior to the start of the diastolic phase.

The computational biofluids techniques we are developing provide biologists, bioengineers, and medical practitioners with unprecedented opportunities. Our ability to simulate animals as complex as copepods will help biologists gain novel insights into the hydrodynamics of aquatic propulsion and also provide the fundamental understanding required for developing biomimetically inspired robotic platforms. Our work in the area of cardiovascular fluid mechanics has already yielded the first-ever insights into the complex flow patterns in mechanical heart valves (see Fig. 2). Such level of detail is essential for optimizing the design of prosthetic cardiovascular devices and for exploring the presumed links between fluid mechanics and cardiovascular disease. A critical prerequisite for the success of our computational work is the close synergy between computational scientists and biologists, and the integration of experimental and computational work. The diverse areas of expertise and the interdisciplinary focus of SAFL researchers, along with our outside collaborations, facilitate this integration and ensure that our computational work remains firmly grounded in the biological reality we are striving to simulate. ■

—Fotis Sotiropoulos
Professor and Director, SAFL

In other news...

~ **Chris Paola** was interviewed on Minnesota Public Radio's Midmorning show this August. Paola spoke about Hurricane Katrina and the geology of New Orleans in the program entitled *The Mountains Beneath Us*. The discussion was continued that evening during "Cafe Scientifique," a public science forum sponsored by the Bell Museum. To listen to the broadcast, please visit: **www.safl.umn.edu**.

~ The field work of **John Gulliver's** research team made the local headlines in the August 10th *Duluth News Tribune*. Graduate students Brooke Asleson (MS '07) and Rebecca Nestingen (MS '08), and undergraduates Tom Natwick and Geoffrie Kramer, were measuring soil moisture content in the UMD rain gardens as part of a research project on stormwater runoff. To read the full article, please visit **www.safl.umn.edu**.

~ An article on SAFL is scheduled to appear in a future issue of *The Rake* magazine. Insiders report the feature-length story will run this winter.

Graduate student Brooke Asleson and undergraduate research assistant Tom Natwick use a soil moisture probe to determine how saturated the soil is in the UMD rain garden. Photo courtesy of Bob King/Duluth News Tribune.

Summer Interns Shine at SAFL

This summer SAFL hosted 17 undergraduate interns from universities across the country to do research with SAFL faculty. Students were part of intern programs with the Minnesota Supercomputer Institute, the Department of Geology and Geophysics, the Department of Civil Engineering, and with the National Center for Earth-surface Dynamics' Undergraduate Summer Internship Program. Students spent 10 weeks at SAFL working on projects that spanned the gamut from cataloging invertebrates for StreamLab06, to creating an artificial forest in the wind tunnel, to finding ways to create K-12 curriculum from research being done at SAFL.

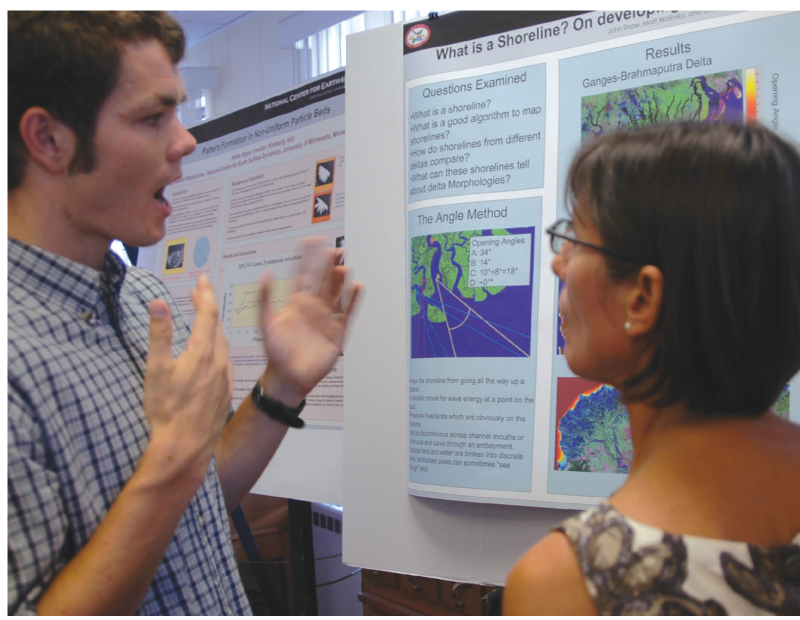
Weekly research meetings and an all-SAFL undergraduate poster session at the end of the summer provided students with the opportunity to interact and learn about one another's research.

Summer intern Jordan Theissen with his advisor Jeff Clark, both of whom came from Lawrence University to conduct research at SAFL. Theissen presented the results of his study in a poster entitled *Surface-wave Effects on Hyporheic Exchange with a Stationary Gravel Bed.*

The undergraduate summer interns also had the chance to see Minnesota on field trips to the Vermillion River, Taylor's Falls, and the Cedar Creek Natural History Center. High-school students working in the Big Back Yard at the Science Museum of Minnesota joined our summer interns for these field trips, led by interns of NCED's ESTREAM program. The ESTREAM program offers undergraduates who are studying to be science teachers a chance to do hands-on research at SAFL.

All of our summer interns had a chance to discover whether they have the desire and potential to become research scientists. The 10 weeks of summer flew by as students attempted to design and carry out a research project and then deliver their results through posters and papers. ■

—Diana Dalbotten
NCED Director of Diversity



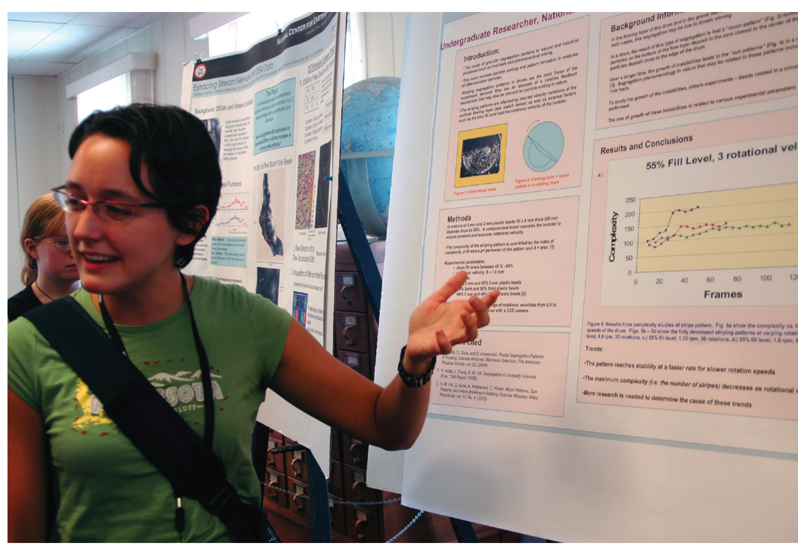
John Shaw, a summer intern funded by the National Science Foundation through the Department of Geology and Geophysics, describes his research project on shoreline boundaries to Efi Foufoula-Georgiou.

Emily Horth, ESTREAM intern, teaches the Youth Science Center Park Crew from the Science Museum about river dynamics at the Vermillion River.

Holly Perryman (top right) was advised by Heinz Stefan on her project *Analysis of Ground Water Input from Stream Temperature Data.* Here she is shown with two Science Museum interns on a field trip to the Vermillion River.

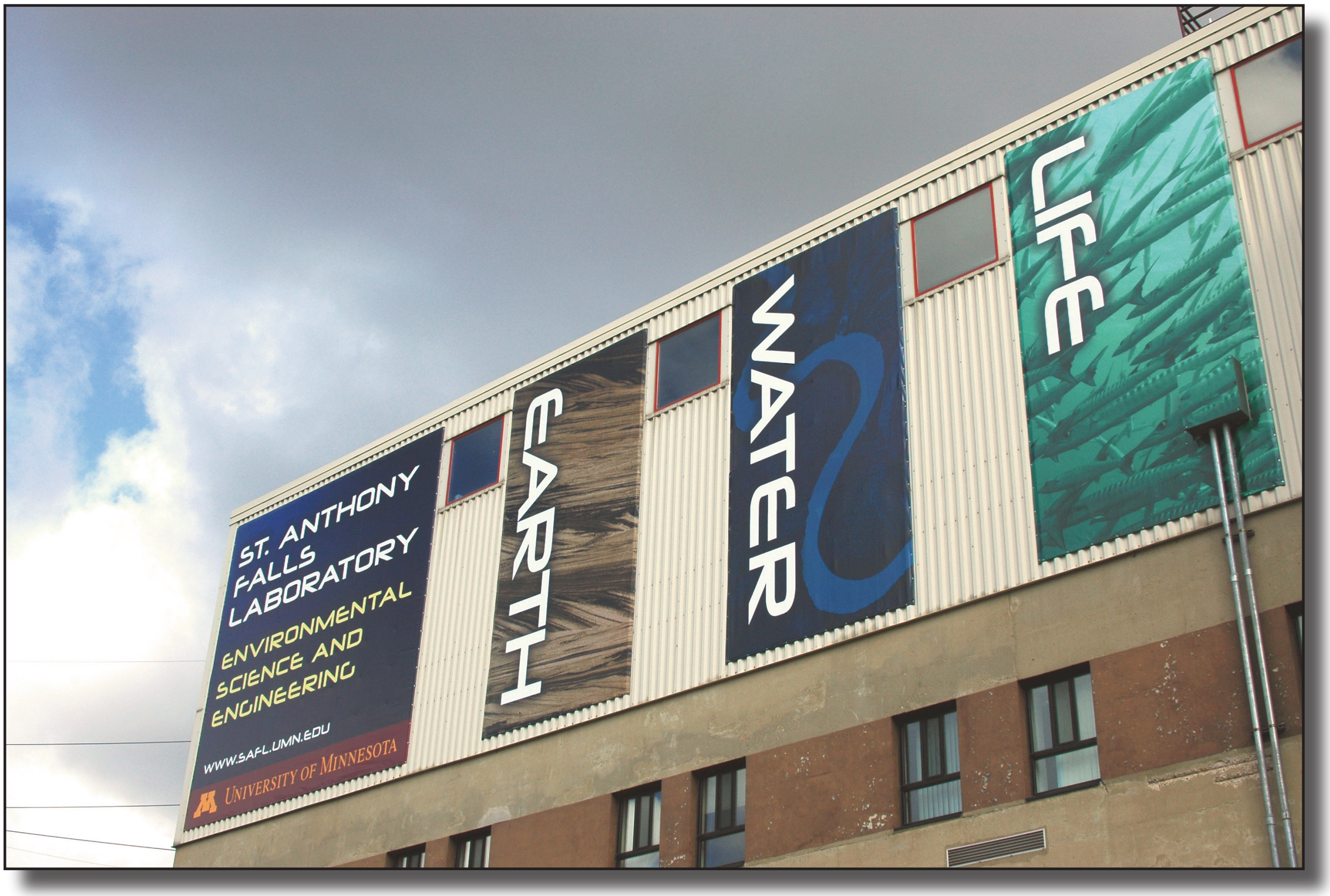
Learning about biodiversity at the Cedar Creek Long Term Ecological Research Station in Isanti, MN.

Alyxis Feltus (right), an intern from the Fond du Lac Tribal and Community College, spent most of her time in the Main Channel conducting research for her project on *Invertebrate Benthic Communities and Drift within an Indoor Test Channel Along the Mississippi River*



Hallie Boyer, pictured here explaining her poster, was mentored by Kimberly Hill (and Hill's graduate student Leslie DellAngelo) on a research project entitled *Pattern Formation in Non-Uniform Particle Beds*

LOOK WHAT'S NEW AT SAFL!



ST. ANTHONY FALLS LABORATORY
UNIVERSITY OF MINNESOTA
2 THIRD AVENUE SOUTH
MINNEAPOLIS, MN 55406
WWW.SAFL.UMN.EDU

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