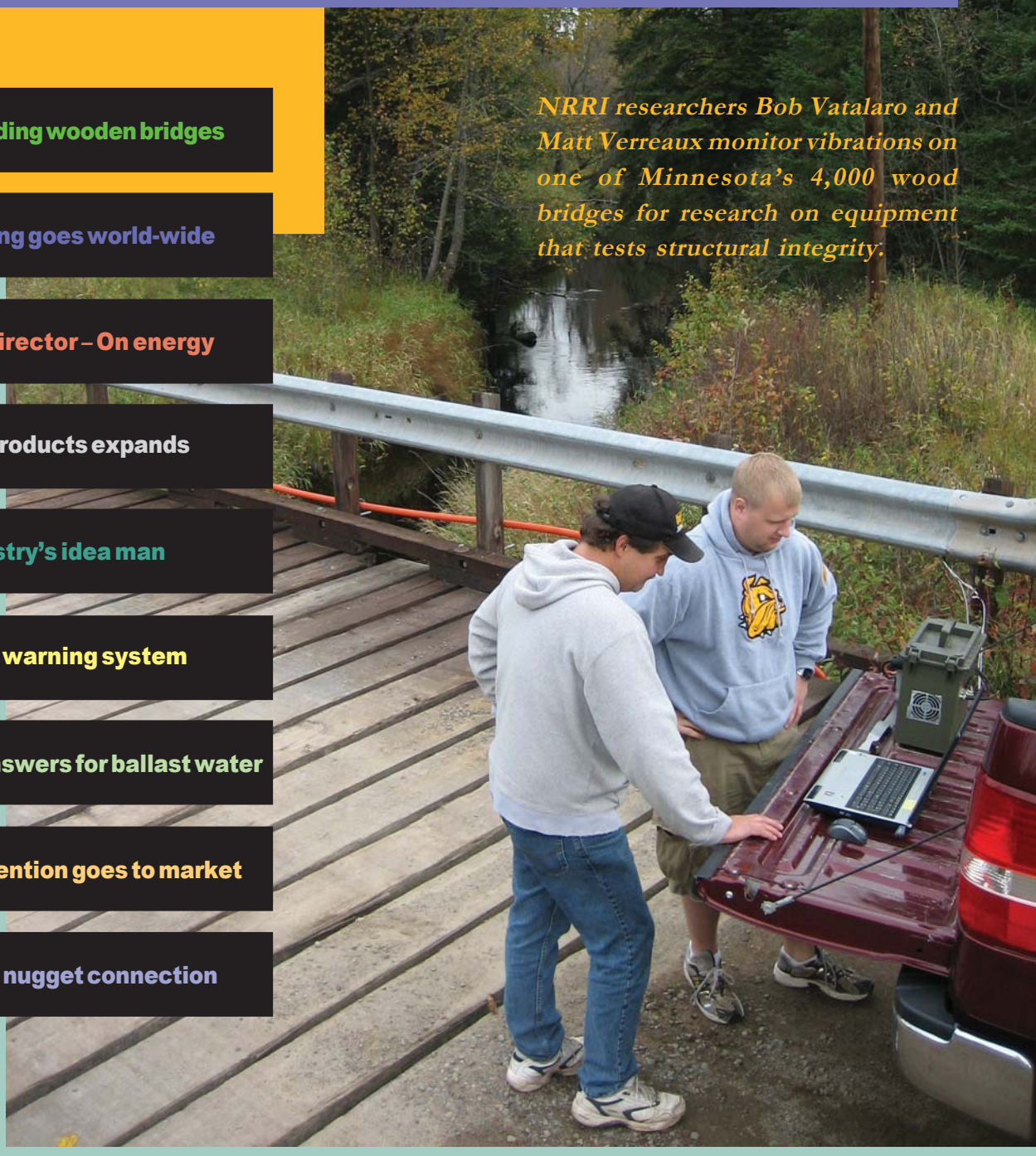
Natural Resources Research Institute
University of Minnesota Duluth

NRRI Now

Autumn 2007



NRRI researchers Bob Vatalaro and Matt Verreaux monitor vibrations on one of Minnesota's 4,000 wood bridges for research on equipment that tests structural integrity.

Growing Strong Industries ~ Developing New Ideas ~ Nurturing Natural Resources

Understanding bad bridge vibrations

NRRI develops new testing techniques for timber bridges

The importance of maintaining the structural integrity of bridges has never been more painfully clear. The collapse of the Minneapolis I-35W bridge this summer was a horrific event that puts all bridges under close scrutiny.

NRRI wood experts have been researching technologies to test timber bridges for the past six years with the Forest Products Laboratory in Madison, Wisc., and Michigan Technological University in Houghton, Mich. A newly constructed pilot scale bridge in NRRI's backyard will keep moving that research forward.

While rural timber bridges don't carry the intense traffic of steel and concrete bridges in metro areas, they do carry steady loads of heavy equipment and trucks. Over the past six years the cooperative research team worked at developing short courses on timber bridge inspection for Minnesota bridge inspectors. The course encourages the use of advanced inspection techniques such as stress wave timing and resistance micro-drilling techniques (see right) that focus on individual, structural portions of the bridge. Recent research is focusing on new techniques that test the soundness of the whole bridge using vibration technologies.

Project leader Brian Brashaw explained that changes in vibration patterns over time can signal a change—unseen rot, failed connectors, or burrowing insects—in the bridge's integrity. To understand the vibration patterns, NRRI's pilot scale bridge has been fitted with a motor that vibrates the bridge and an accelerometer that gathers the vibration signal. This data, gathered at each step of the construction process, helps the researchers understand how a bridge's size and design affect the vibration pattern.

"Once we have the new construction data, we can take it apart and replace the bridge support beams with deteriorated beams and find out how it responds," Brashaw said. "This is a very controlled situation so we can understand how each change affects the vibration characteristics of the bridge."

Basically, the researchers want a clear understanding of the signals of bridge stress and what those signals mean. This fundamental research will improve the instrumentation, testing techniques and reliability of the data, leading to future utilization of the technologies.

In addition to NRRI's bridge, a vibration testing system has also been installed on an actual rural timber bridge in Meadowlands, Minn., to demonstrate the technique and assess changes in vibration based on seasonal temperature changes and to test the repeatability of the system. The

researchers watch carefully for changes by measuring the frequency in hertz (a measurement of intervals) per second. The faster the bridge is vibrating, the more hertz. They're working on correlating the vibration characteristics of the bridge with the structural condition to identify changes or problems.

"If a bridge has a baseline vibration of 21 hertz per second, then overtime, as we monitor it, it goes down to 18 hertz, something has happened to change the vibration," said Brashaw. "Then we can do a more thorough inspection to determine the exact cause of the problem before it creates an even bigger problem and appropriate repairs can be made."The research team will be working with St. Louis County as their primary research cooperator with funding from the Minnesota Local Road Research Board. In addition to NRRI's test bridge, 15 rural timber bridges will be tested over the next nine months in St. Louis County.

Advanced Bridge Inspection Technologies

STRESS WAVE TIMING

This technology is based on the fact that the movement of stress waves is sensitive to the presence of degradation in wood. The stress wave will travel faster through sound and high quality wood than it does through wood that is deteriorated or of low quality. The transmission time is used as a predictor of the wood's physical condition.

MICRO-RESISTANCE DRILLING

Also called the Resistograph test, this technology uses a mechanical drill system that measures the relative resistance (drilling torque) of the material as a rotating drill bit is driven into the wood at a constant speed. It produces a chart showing the relative resistance profile for each drill path, diagnosing the internal condition of structural timbers.

Wood testing techniques get world wide attention

NRRI hosts the 15th International Symposium on Nondestructive Testing of Wood

It's a topic that is drawing more and more interest from around the world: nondestructive techniques for testing wood. Think about it. Wood construction—still the most often used structural material, compared to steel and concrete—is susceptible to water and insect damage, but visual inspections can miss problems under the surface. The value in a stand of trees can also be affected by decay fungi, insects and forest management practices, like thinning.

This fall, 73 people from 18 countries came to Duluth, Minn., to share and learn about the latest techniques in wood testing. NRRI wood experts include Brian Brashaw, Xiping Wang, and Bob Vatalaro. About 45 scientific presentations and poster sessions were presented on topics such as stress wave timing, transverse vibration, near-infrared nondestructive wood testing techniques and the importance of technology transfer.

A post-conference workshop on inspection techniques for historic wood structures was held at UMD's Limnology Laboratory, built in 1886 and listed on the U.S. National Register of Historic Places. The workshop provided 30 participants with opportunities for hands-on experience with visual inspection techniques, stress wave timing and resistance microdrilling.

From the Director

Michael J. Lalich

Those of you who have watched the evolution of NRRI over the past 20+ years may recall that, as part of the early vision for the Institute, an Energy Division was established. The premise in the mid-1980s was that Minnesota would rely, in part, on burning peat and forest residues for a substantial amount of energy going into the future. For environmental and economic reasons, however, this interest quickly waned and NRRI's Energy Division actually became a political liability for our fledgling Institute. Consequently, NRRI disbanded its energy program.

Fast-forward 20 years and the prospect of renewable energy has once again become a priority, given the recent run-up of gasoline prices and international concern about the greenhouse gas carbon dioxide (CO_2). The University of Minnesota is attempting to organize a coordinated effort on renewable energy and the environment. The state of Minnesota has imposed ambitious alternative energy mandates on power plants. Closer to home, NRRI is finding opportunities to contribute to renewable energy and to weigh in on related environmental and resource management issues.

A recent Blandin Foundation sponsored conference, "Seizing Opportunity: Forestry and the BioEconomy," has helped put this new priority in perspective

NRRI's renewed emphasis: Renewable energy and the environment

for me. Just a few of my "take homes" from the conference include:

- The United States has been asleep at the switch for the past 30 years and alternative energy development is a matter of national security.
- From a purely economic point of view, coal-based energy has a large advantage, but suffers from the fact that it is a major contributor to greenhouse gases.
- Solar and wind energy, not to mention nuclear power, make up a surprisingly small amount of projected energy for the future.

- Bio-energy (energy from biomass), including agricultural crops and forest by-products, has significant potential and may be carbon neutral or potentially carbon-negative since trees and crops take in CO_2 as they grow.
- Bio-energy has potential to supplant a large percentage of the nation's gasoline requirements.

Clearly the nation's developmental effort on energy going into the future will be massive. Does NRRI have a role to play? My colleagues and I think so. We realize, however, that we need to establish our niche(s) within both the University of Minnesota and the greater national research community. Fortunately we have a good base on which to grow our program.

Several speakers at the Blandin conference talked about bio-energy from a model that included two pathways and, from their viewpoint, concurrent production of value-added products and materials as a key component for making bio-energy economical. One pathway was from feedstocks converted to bio-energy and by-products using biochemical processing. The other pathway would substitute thermo-chemical processing for the biochemical processing step. There are proponents and advantages for both biochemical processing and bio-thermal processing. Likely, both will be used going into the future.

With this model in mind, let's take a quick look at NRRI's current line-up, starting with feedstocks. Fortunately, NRRI's hybrid poplar consortium with industry and agencies has been alive and well over the past 20 years due to the forestry industry's interest in wood fiber. The program is nationally prominent and made much more important by recent technological breakthroughs in the ability to produce cellulosic ethanol (in contrast to corn-based ethanol). Proprietary clones developed at NRRI are on the horizon. While hybrid poplars are essentially an agricultural crop, forest residues are also an important part of the bio-energy picture. NRRI is currently figuring prominently as the Institute is being called on by utilities and industry to assist with studies to evaluate availability and suitability of forest resources for feedstocks.

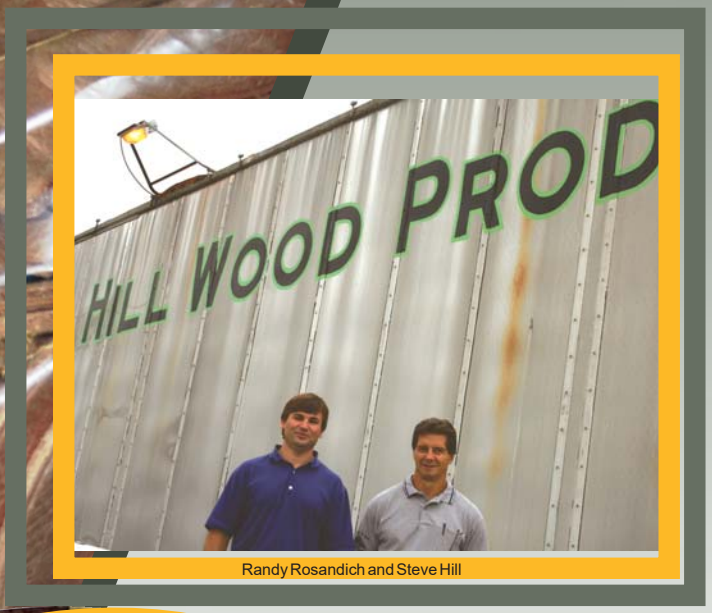
Looking next at bio-chemical processing, it is interesting to note that NRRI is uniquely positioned with a chemical extractives laboratory, focusing on chemical processing of natural products rather than the traditional approach of chemicals from oil-based fossil fuels. An early contribution from this laboratory is a proprietary process that the University is patenting. If successfully employed on a commercial scale by corn-based ethanol producers, the result will be significant energy savings, odor reduction, production of extra energy as bio-diesel, and a higher-valued, high protein animal feedstock as a by-product.

In the thermo-chemical area, NRRI has been able to nicely position itself for future research, particularly at the pilot scale, at its Coleraine laboratory. We've recently installed a state-of-the-art 25 Kilowatt Biomax™ pilot scale gasifier. Teaming with the Gas Technology Institute in Chicago, NRRI just completed an initial Excel Energy research contract to gasify woody biomass and efficiently use a metallic membrane to produce pure hydrogen that could be used in fuel cells. This is a first with great potential, but more research will be needed. Development of catalysts is an area where NRRI, with its knowledge of minerals and minerals processing, may be able to make key contributions.

Whether the bio-chemical or thermo-chemical processing route is used to produce energy, the model emphasizes the need to maximize the value of the by-product streams in terms of the materials that can be developed. Here again, NRRI is well-positioned to either mechanically or chemically develop value added by-products.

Further, there are environmental and resource management issues associated with each step of the model. And environment is at the forefront of the new national renewable energy initiative. NRRI is positioned to couple the expertise of its Center for Water and the Environment with its renewable energy development efforts going forward. Land management for crop production while ensuring proper habitat for birds and animals is critical as conservation lands are converted to bio-energy production.

So... NRRI has it all covered with expertise in feedstocks, thermo-chemical and biochemical processing, and in by-product materials and environmental expertise. Not so fast. Actually, we have our niches, but we are limited in personnel and resources. Further, the task facing our nation, state and industrial clients is momentous, complex and multi-faceted. However, please stay tuned. NRRI will do its best to refocus, grow its programs, and continue its tradition of partnering with key clients and collaborators to make meaningful, cutting-edge contributions.



Randy Rosandich and Steve Hill

Hill Wood Products expands and grows in rural Minnesota

NRRI's Market-Oriented Wood Program is industry angel

When the new, cutting edge technology in veneer saws arrived from Austria to the small northern town of Cook, Minnesota, the first thing Steve Hill did is take it apart piece-by-piece and rebuild it. Three times.

"Why did you do that?" questioned NRRI's Pat Donahue. "It's brand new!"

"Well, I don't see any Austrian technicians around to help me fix it when it breaks down, so I better know how it's put together," said Hill.

Today, Hill Wood Products has that frame saw cutting veneers from hardwoods that their competitors can't match. And with the help of NRRI, their product line is now expanding from veneers and cabinet joinery biscuits to custom, engineered flooring. The company is doubling their sales annually—phenomenal enough, but especially in the wood products industry which is generally down by 20 percent and more.

It was a web of connections, industry know-how and good timing, with NRRI's Donahue at the hub, that moved Hill Wood

Products from a third generation wooden dowel manufacturer to an example of rural business success in a competitive, global market.

The story of the Austrian frame saw starts with Donahue, director of NRRI's market-oriented wood technologies program, who was impressed with what he saw at an international trade show. He introduced the technology to Randy Rosandich who planned to start his own business with a used frame saw. Meanwhile, Steve Hill was taking over the family business and saw the need for changes in what they manufactured—dowels were one of the first wood products to go overseas for manufacturing.

Rosandich and Hill were introduced through a connection at Iron Range Resources, and the successful partnership began with ordering the new Austrian veneer frame saw, optimized for Minnesota's hardwoods by Hill.

Today, Hill Wood Products exports about two-thirds of their veneer internationally, which is a pleasant surprise for the owners.

"You don't expect to be exporting so much in this industry, but that's where we're at," said Rosandich. "In fact, our veneer business is growing by about 30 percent each year."

Still, adding value to the veneer product here in Minnesota became another goal, and the men turned back to NRRI to help them develop engineered hardwood flooring, which they launched in 2005 and now ship across the country. NRRI's research funding came from the state through Minnesota Technology, Inc., Iron Range Resources and the U.S. Forest Service.

"The key to the success of the flooring product was using NRRI's expertise and technologies for the preliminary baseline work that created the engineered floors," said Rosandich.

Product testing and prototyping took place in NRRI's lab under the supervision of technician Scott Johnson, who helped them understand the technicalities of adhesive performance, dimensional stability and the effects of moisture on the product.

"We didn't have the technology here to make the floor boards," Rosandich explained. "So we made them at NRRI and learned from their expertise to help us have a product ready for market. When we were ready to make the jump into flooring, we were really ready."

For more information about Hill Wood Products, visit www.hillwoodproducts.com.

Wood industry's idea man

Mark Joel, president of Allwood Machine, thinks Pat Donahue is brilliant when it comes to innovative thinking for Minnesota's wood-related industries.

"Someone should just follow him around with a notepad to keep track of all the viable ideas that come from his conversations," said Joel. "If you can pin him down for an hour you'll get eight viable business plans from him."

Joel credits Donahue's future-forward thinking. "He was one of the first to introduce profile laminating machines for exterior grade components and now it's an industry standard. His ideas are ahead of themselves and often come to fruition 10 – 20 years down the road."

Allwood Machinery imports and distributes a variety of niche-market equipment for wood and plastic fabrication companies.

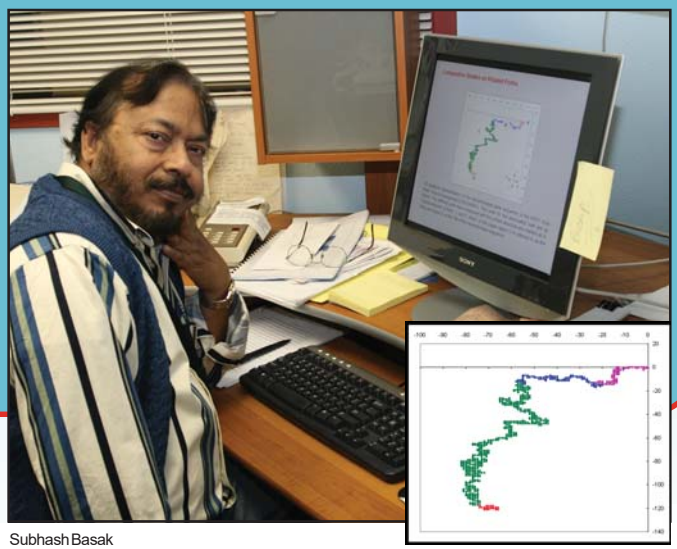
Mike Miller appreciates Donahue's connections in the industry. As director of building automation for Stiles Manufacturing he and Donahue share a "synergy for technologies that are on the cutting edge," he said.

Miller sells Weinmann products from Germany, highly automated machinery for the construction industry, so Miller and Donahue travel in the same circles, referring clients to each other and sharing knowledge.

"There are maybe three or four significant touch points over the last four to five years where Pat and I keep coming together," said Miller. "As part of his job I'll see him at trade shows and touring Weinmann factories. There are multiple avenues where he's been a resource for me."

Early warning system

Genetic modeling can help predict the spread of virus



Subhash Basak

For now, it looks like H5N1—a highly pathogenic influenza a virus associated with birds and other animals—is still rarely found in humans and is isolated to Asian countries. But nervousness about its spread into a possible pandemic has authorities watching it closely.

NRRI scientists are applying their skills in molecular informatics to help predict whether future mutations of this strain will transfer from birds to humans. Modeling the virus' genetic DNA sequence is leading to path-breaking mathematical characterization of H5N1's RNA. Early evolution processes relied on RNA molecules to serve as catalysts of both synthesis and information storage (similar to DNA).

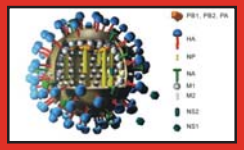
Basically, characterizing the RNA molecules is providing a new method of deriving gene function and identification. This method is being used to classify disease-causing and benign strains of avian flu so that the harmful strains can be isolated and kept from spreading.

Subhash Basak, NRRI program director for the computational/mathematical chemistry group, says using computers and mathematics to unravel the complicated jungle of information in genetic modeling makes that information easily accessible to the human mind.

"This research is focused on developing a general methodology that can be applied to many other areas," Basak explained. "Predicting what the avian flu virus might do is just one application for this new tool."

This research was funded in part by the Consortium for Bioinformatics and Computational Biology at the University of Minnesota.

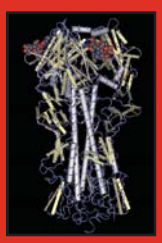
Terms:



Molecular Informatics: gathering, manipulating, storing, retrieving and classifying information recorded in molecules.

DNA: deoxyribonucleic acid

RNA: ribonucleic acid, a close cousin of DNA



NRRI joins the fight against the tiniest invaders

New ballast water testing facility seeks answers to invasive species problem

Ships need ballast water for stability, but the tiny life forms that stow away in the water can make their home in another region, often creating problems.

Invasive water species are a well-known problem in the Great Lakes, as well as for ports around the world.

Known invaders to the lakes include the round goby and the zebra mussel. But troublesome foreign single-celled algae like *Didymosphenia* (sometimes called "rock-snot") are causing problems worldwide, and now's the time to check the entrance of such species to the Great Lakes. NRRI is lending its research expertise to finding a solution to these escalating invasions.

The world's first freshwater ballast test facility was unveiled in Superior, Wisc., this summer as a collaborative project coordinated by the Great Ships Initiative. The facility is part of a cooperative effort among the Great Lakes maritime industry, federal agencies and other regional stakeholders to stop the introduction of aquatic invasive species in the Great Lakes.

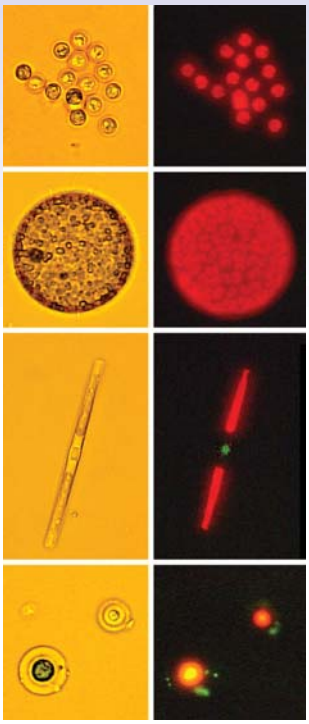
NRRI's algae specialist, Euan Reavie, will be leading up research on how to effectively kill off microscopic organisms in the ballast water so it's free of invasive species before entering a new port. Killing off algae is a new twist on his 16 years studying these microscopic life forms as indicators of water quality. But the cause is just. New regulations requiring ballast water treatment equipment on ships are being pushed through congress.

What equipment will be needed, and what treatments are effective? That's what the testing facility will determine. There are many promising technologies available, but they need to be tested for their effectiveness at killing water borne organisms and possible residual effects of any treatment needs to be identified. Chemical treatments, de-oxygenation and electronic technologies, like ultraviolet light, are some examples of technologies that may be evaluated.

Reavie is part of a team of scientists studying small freshwater animals, bacteria and viruses.

"We are benefiting so much by having Euan on our team," said Allegra Cangelosi, project leader from the Northeast-Midwest Institute in Washington, D.C. "His scientific input and deep knowledge of algae research and skills in scientific design add huge value to our research." A 20-member Executive Committee provides project oversight.

The world will be watching the progress of the ballast water technologies because all countries suffer from invasive species in their ports—though various regulations are tried to stem their spread. The House Transportation and Infrastructure Committee approved regulations that will phase in water treatment equipment on salt water ships beginning in 2009. Ships on the Great Lakes will also be required to install equipment but no timeline has been established.

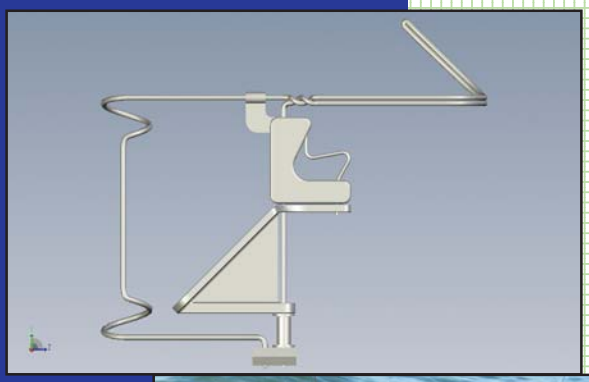


Killing algae comes with a special problem—it's hard to tell whether or not they're dead. Unlike microscopic animals which show clear movement when they are alive, algae (phytoplankton) are mostly passive and rely on the water current to move them. So Reavie developed a way to confirm the algae are dead from the various treatments using a florescent stain. The special stain can only pass through dead cell membranes causing them to glow bright green so that dead algae can be easily identified.

The photos (above, right) show four algae specimens under brightfield (left column) and fluorescence (right column) microscopy. The red glow comes from the natural fluorescence of chlorophyll and the green fluorescence (in the bottom two specimens) indicates that the stain has penetrated the cell membrane and attached to the proteins in the nuclei, indicating that those cells are dead or dying.

NRRI helps fishing buddies get invention to market

Northern Lights Technology Center makes CAD drawing and prototype



"Fish on!"

"Fish off."

To catch fish, anglers want to minimize the "off" which means setting the hook and keeping the line tight. This is especially challenging when trolling on deep lakes with a downrigger or a planer board because once a fish strikes there's a lot of extra line to reel in. Given enough lag line and time, a fish will do its best to shake off the hook.

John Ehlers and Randy Lasky got tired of losing fish because of lag on their lines. So, with the help of NRRI's rapid prototype center, they invented a solution they call the Strike Saver.

"The first thing you learn when you start fishing is 'keep your line tight,'" said Ehlers. "That's what this will do. It sets your hook and keeps your line tight."

First, they came up with a Strike Saver release system for the planer board—a system that allows multiple lines to be fished off the boat at one time. Their patent-pending "hook" release system keeps the line tight on the fish while moving the release and line toward the boat. It worked so well that another system was developed for downrigger fishing. It's a bit more complicated, but does exactly what it's designed to do—set the hook and keep the line tight.

A downrigger is a heavy cable attached to the boat on one end with a 10-pound "cannonball" weight on the other end. The angler's fishing line is attached to the cable with a release, then lowered to a desired depth and trolled along by the boat. When the fish bites, the line is released and angler reels in the fish. The Strike Saver release system moves the fishing line down the downrigger cable with a unique diving and re-surfacing plate. When the fish takes the hook the plate rotates and the current carries it back up the cable to the water surface waiting to be reattached and lowered again. One of the best features is that the heavy cannonball doesn't have to be raised and lowered after a strike.

Ehlers asked Lasky to join him in building a business around the Strike Saver and handle the "business end of things," said Ehlers. "It's been a lot of headaches getting this thing going. It's really eaten into my fishing time!"

But going it is. Their Strike Saver products—the planer board release and the downrigger release—are now on the shelves at Marine General in Duluth and sales are brisk.

"Everyone I show this to buys one," said store owner Russ Francisco. "They tell me it works exactly like they're told it will. It's amazing!"

Ehlers and Lasky credit NRRI's prototype lab director Steve Kossett with helping them make a CAD drawing of their concept and making the first couple of prototypes. Once they had a successful design, Kossett directed the men to Five Star Plastics in Eau Claire, Wisc., to make the mold for their product.

"We both have full-time jobs and developing, making and marketing this product has been very time consuming," said Lasky. "We were grateful for the help we got from NRRI to help us get our idea to market."

Ehlers works at UMD as Facilities Plumbing Supervisor and Lasky is president of Northspan Group, Inc.

Information about NRRI's Northern Lights Technology Center at www.northernlightsrp.com or Strike Saver can be found at www.strikesaver.com.

Lasky and Ehlers with store owner Russ Francisco

NRRI's upfront activity contributes to bringing iron nuggets to Minnesota

NRRI has long recognized the need for value-added, market-expanding products from Minnesota's Iron Range. And when mini-mill technologies took the lead in steel production over blast furnaces—which use the Range's taconite pellets—discussion led to action.

NRRI launched a series of meetings to evaluate emerging iron producing technologies, with a focus on converting iron ore to forms of iron that could be used by mini-mills. Collaborators from local industry, state and regional agencies were invited, including presenters and scientists from Germany, Australia and Japan who were immersed in the development of value-added irons.

Presentations by Kobe and Kawasaki Steel promoted iron nuggets that could be made from Minnesota taconite concentrates—and shipped like taconite pellets.

This connection with Kobe Steel led to an invitation to see a demonstration of their pilot scale rotary hearth furnace in Japan. NRRI's Iwao Iwasaki organized the trip for himself, key NRRI staff, as well as local industry and agency representatives. Larry Lehtinen, consultant to Iron Range Resources, asked if he could join the NRRI delegation. He came back from Japan convinced of the merits of iron nugget production.

Iwao Iwasaki

An intensive effort by the state, with industry partners, followed and led to a commercialization effort that started with pilot scale tests on a rotary hearth furnace in Silver Bay. After a restructuring of ownership interest, this has now led to the planned $235 million Mesabi Nugget Delaware LLC plant on the Iron Range. The project is a partnership between Steel Dynamics, Inc. and Kobe Steel.

Value-added iron is vitally important to the long-term future of the Iron Range, and NRRI wishes Mesabi Nugget well in its promising new endeavor.

Check us out: *www.nrri.umn.edu*

The Natural Resources Research Institute was established by the Minnesota Legislature in 1983 to foster economic development of Minnesota's natural resources in an environmentally sound manner to promote private sector employment.

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