The research magazine of *Florida Institute of Technology*

DISCOVERY

VOL. 13, ISSUE 2

Winter 2017

SPECIAL REPORT:

Indian River Lagoon

Florida Tech Scientists and Engineers Tackle a Murky Problem Harming the Biodiverse Estuary.

revitalize
research
realize
resolve

MESSAGE FROM THE PRESIDENT

Research to benefit all mankind.

A short sentence, but a deep commitment. A commitment we strive to uphold and embody every day here at Florida Tech.

As this latest edition of the university's research magazine makes clear, our faculty and students are driven by their desire to find answers. Whether in the depths of our beloved Indian River Lagoon or along the tracks of a model train set, whether in engineering or human-centered design, the quest for illumination and truth guides all of these journeys.

As you will read, these bright people achieve revelations large and small in their classrooms and labs. And as they progress beyond our Melbourne campus, they achieve something, else, too: carrying on our proud tradition of being global citizens seeking, and finding, a lifetime of success.

T. Dwayne McCay, Ph.D.,
President

MESSAGE FROM THE SENIOR VICE PRESIDENT FOR RESEARCH

No matter the topic, research often shares the same traits: a clear goal, well-defined methods and, maybe most importantly, a nearly insatiable curiosity fueling the researchers themselves.

The hope is that those traits converge into something powerful and revelatory. Though the scope of the results may vary, thankfully that is very often the end result.

Revelations will also await the fortunate readers of this winter edition of Discovery. It is exciting to me how the articles here, from a look at our extraordinary efforts to help understand why the Indian River Lagoon is unwell and how best to cure it, to a fascinating glimpse into efforts to get machines to communicate with one another, perfectly capture the variety of research under way at Florida Tech.

Please enjoy this glimpse into our labs and classrooms and quite possibly into the very future itself.

S. Ann Becker, Ph.D.,
Senior Vice President for Research

DISCOVERY
http://newsroom.fit.edu/discovery-florida-tech
Florida Institute of Technology
PRESIDENT T. Dwayne McCay, Ph.D.
SENIOR VICE PRESIDENT FOR RESEARCH S. Ann Becker, Ph.D.
VICE PRESIDENT FOR MARKETING AND COMMUNICATIONS Wes Sumner

DISCOVERY is published twice a year by Florida Tech's Office of Marketing and Communications and is distributed to over 50,000 readers.
EDITOR Adam Lowenstein, *adam@fit.edu*
ASSOCIATE EDITOR Shelley Preston, *spreston@fit.edu*
ART DIRECTOR/DESIGNER Judi Tintera, *jtintera@fit.edu*
COPY EDITOR Christena Callahan, *ccallaha@fit.edu*
CONTRIBUTING WRITERS Adam Lowenstein, Shelley Preston, Shelby Langner
PRODUCTION Kristie Kwong
WEB LAYOUT David Smith
PHOTOGRAPHY Dominic Agostini, Ning Liu, Shelley Preston, Jon Shenker, Robert van Woesik
HOW TO KEEP IN TOUCH
Florida Tech, Office of Marketing and Communications, 150 W. University Blvd., Melbourne, FL 32901-6975, 321-674-8548, Fax 321-674-8598, *wsumner@fit.edu*
CHANGING ADDRESSES?
Don't leave copies of your *Discovery* magazine behind. Send your new address to Florida Tech, Office of Development Services, 150 W. University Blvd., Melbourne, FL 32901-6975, *advs@fit.edu*

Florida Institute of Technology
High Tech with a Human Touch®
www.fit.edu

Cover: The Indian River Lagoon is a grouping of three lagoons: Mosquito Lagoon, Banana River and the Indian River, on the Atlantic Coast of Florida. But the most biodiverse lagoon ecosystem in the Northern Hemisphere, home to more than 2,000 species of plants and animals, is ailing. Florida Tech researchers are looking for answers.

14

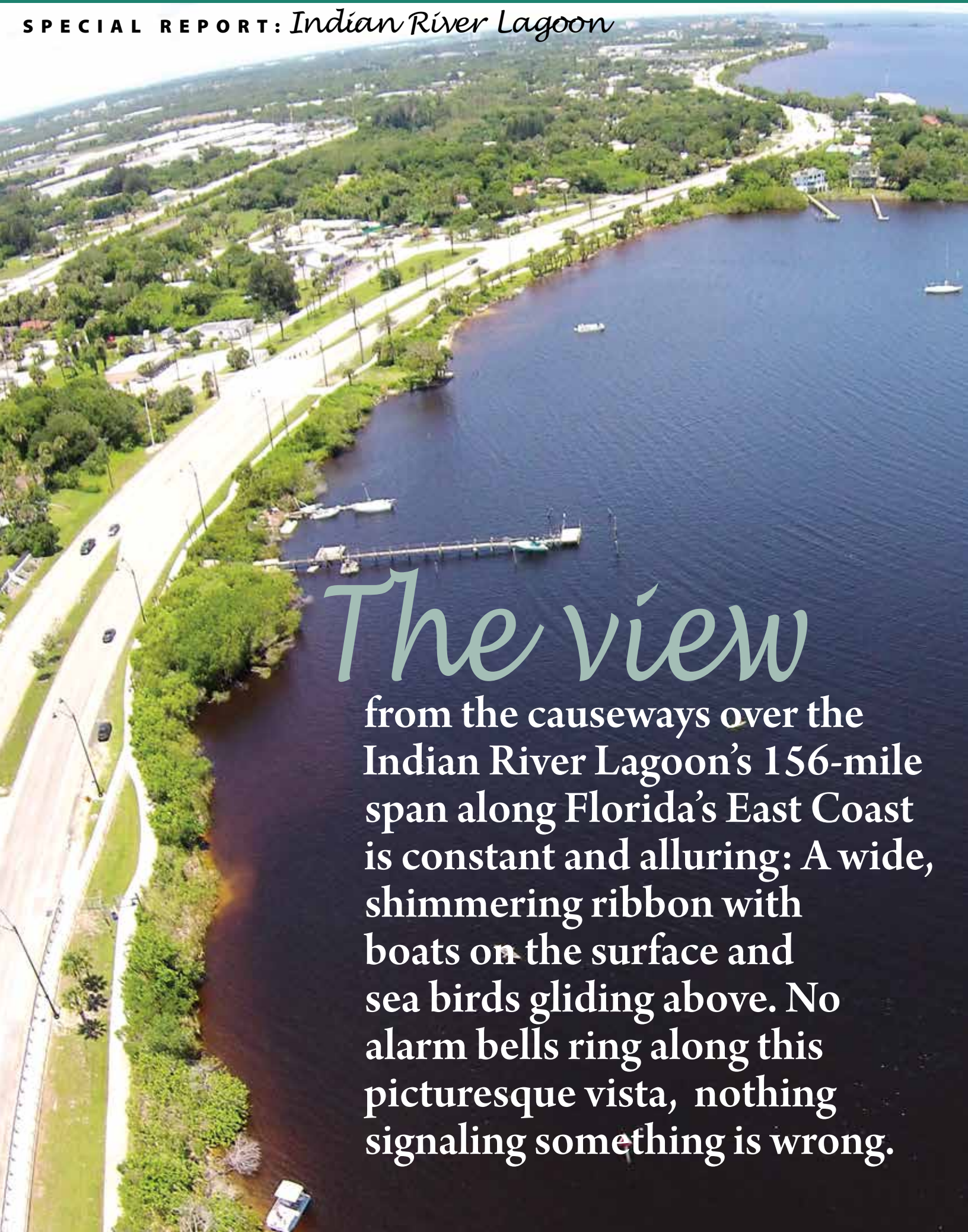
Teaching Trains to Talk

How model locomotives are allowing researchers to seek breakthroughs in machine learning and human-machine interaction.

WINTER 2017 ISSUE

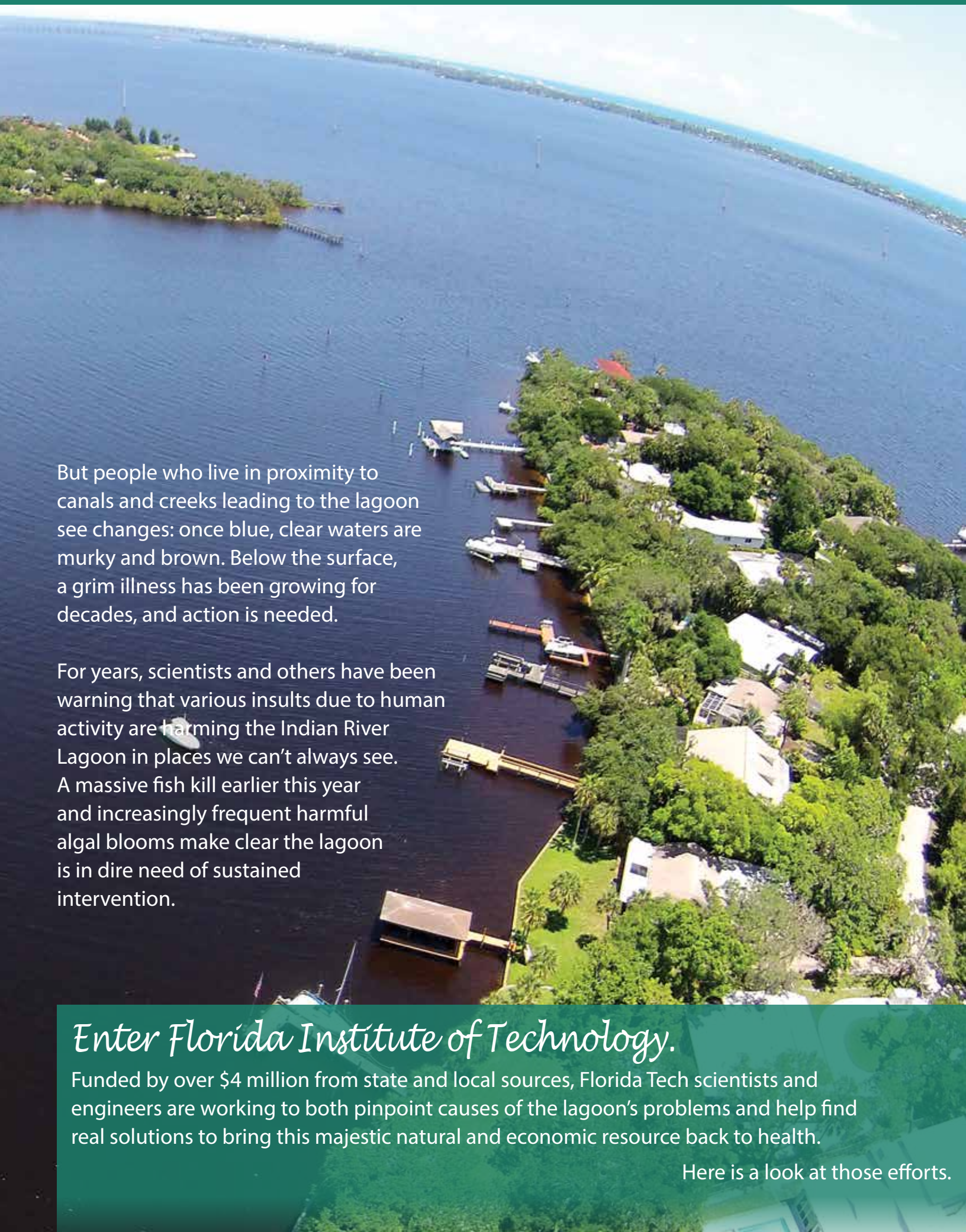
View past issues of *Discovery* at:
newsroom.fit.edu/discovery-florida-tech

WE'RE LISTENING. *Please send comments or suggestions to Adam Lowenstein at adam@fit.edu.*



The view

from the causeways over the Indian River Lagoon's 156-mile span along Florida's East Coast is constant and alluring: A wide, shimmering ribbon with boats on the surface and sea birds gliding above. No alarm bells ring along this picturesque vista, nothing signaling something is wrong.



But people who live in proximity to canals and creeks leading to the lagoon see changes: once blue, clear waters are murky and brown. Below the surface, a grim illness has been growing for decades, and action is needed.

For years, scientists and others have been warning that various insults due to human activity are harming the Indian River Lagoon in places we can't always see. A massive fish kill earlier this year and increasingly frequent harmful algal blooms make clear the lagoon is in dire need of sustained intervention.

Enter Florida Institute of Technology.

Funded by over $4 million from state and local sources, Florida Tech scientists and engineers are working to both pinpoint causes of the lagoon's problems and help find real solutions to bring this majestic natural and economic resource back to health.

Here is a look at those efforts.

The hand of John Trefry, professor of chemical oceanography, is covered in muck, the colloquial term for the viscous organic goo below the surface of the Indian River Lagoon.

A Murky Challenge, Beneath the Surface

Florida Tech Scientists and Engineers Seeks Answers to Muck in the Indian River Lagoon

John Trefry gives the signal, and the pontoon boat is slowly guided into Turkey Creek from a dock not far from U.S. 1 in Palm Bay, Florida. Amid sterilized plastic bottles, depth readers and other equipment, Trefry, a professor of chemical oceanography at Florida Institute of Technology, is headed out with a couple of researchers to collect water samples on this early summer day. The morning is ideal, with a light breeze and a temperature that isn't yet to the point of roasting. It's the kind of weather that lured many to this part of east-central Florida, seeking homes near the banks of the Indian River Lagoon and nearby beaches.

A National Public Radio reporter is among the passengers, and after motoring along for a few minutes, Trefry stops the boat to show her something. He drops a scooper attached to rope into the water and pulls it up a moment later, filled with a viscous, black slime that gives off the stink of rotten eggs.

This, in colloquial terms, is muck. And it is creating a very complicated challenge.

A Growing Problem

The consistency of mayonnaise, muck is widely considered a major culprit in the ongoing health woes of the Indian River Lagoon, the 156-mile long estuary that, with its 2,000 species of plants, 600 species of fish and 300 species of birds, is considered among the most biologically diverse waterways in North America.

The muck is mostly water combined with clay, silt, sand and shell, but it also contains up to 25 percent organic matter. By comparison, natural sediment in the Indian River Lagoon is less than one percent organic matter.

This fine-grained, organic-rich sediment (a more scientifically accurate name for muck) is the product of decades of, in essence, growth in the five counties the Indian River Lagoon borders. Grass clippings

and yard waste in greater and greater quantity from the growing number of homes have made their way to the lagoon. Since 1950, for example, Brevard County's population, which is situated along a majority of the lagoon's banks, has grown from 23,000 to 550,000. The majority of that growth has been west of Interstate 95.

That development's impact on the natural Central Florida landscape has made it easier for storm water to carry this organic debris, practically unimpeded, into the lagoon.

Paved surfaces do not absorb rainwater, so nearly every drop runs across the surface and into the lagoon, carrying whatever it picks up along the way—from mowed weeds to dog droppings to cigarette butts. After time, the organic part of this waste is munched on by bacteria in the water, turning the matter into the black ooze that collects in piles, some several yards high, on the bottom of the lagoon.

No seagrass can grow where these piles sit, and the muck is inhospitable for creatures used to living on the once purely sandy bottom.

Why so Damaging?

According to Trefry, muck damages the lagoon in the following ways:

- increases turbidity and inhibits seagrass growth;
- depletes oxygen in sediment and water;
- covers the natural bottom and destroys natural biological habitats;
- accumulates potential pollutants;
- stores and releases nutrients in ways contrary to their natural ebb and flow.

Muck and other organic waste accrued over decades, such as sewage, animal waste and lawn fertilizer, have increased the nitrogen in the water, which serves as food for extreme algae blooms that lead to fish kills when oxygen is depleted as the algae die and decay. Florida Tech studies found about three tons of nitrogen are released from muck in Turkey Creek alone every year.

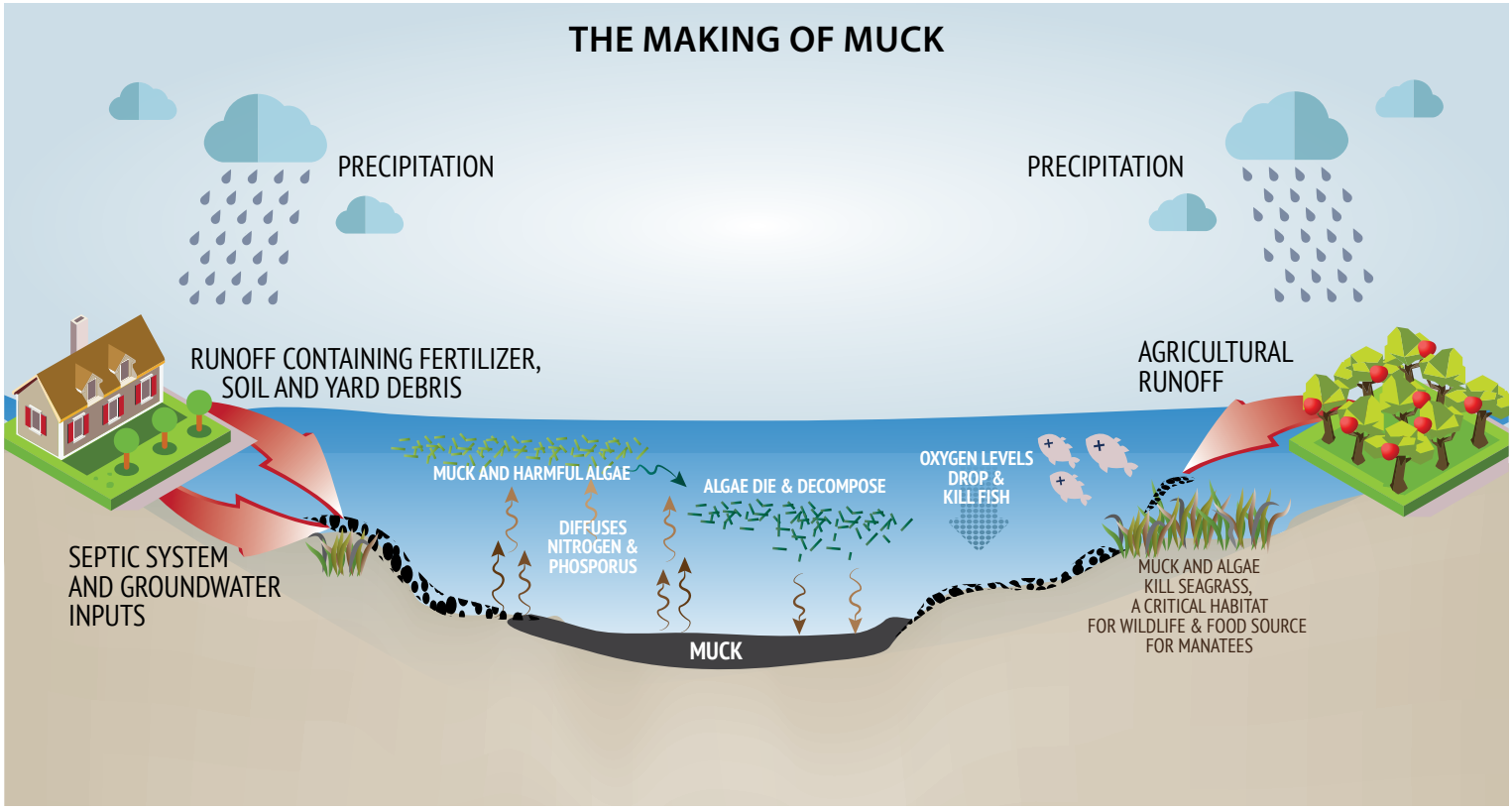
Too much nitrogen is killing the lagoon.

And no, it can't be seen from a causeway.

Looking for Answers

Trefry's research is about investigating the best way to remove the muck and restore the lagoon's natural sediment. It's not an easy task, in part because there is just so much of the stuff.

Continued on page 9



Indian River Lagoon: An Economic Force of Nature

Beyond its status as one of North America's great natural amenities, the Indian River Lagoon has a powerful economic impact on the Central Florida region.

According to a 2016 economic valuation study by the East Central Florida Regional Planning Council and the Treasure Coast Regional Planning Council, the total overall annual economic out, or value received, from the Indian River Lagoon in 2014 was **$7.6 billion**, when the IRL region attracted more than **7.4 million** visitors. The figure does not include nearly **$1 billion** in annualized real estate value for property located on or near the IRL.

The study also found that for every dollar spent on achieving a sustainable IRL, the lagoon returns $33 in total economic value.

"Over the years, as the IRL improves in health and productivity, annual Return on Investment in the future can be expected to increase," the study found.

Angelica Zamora-Duran, a biological oceanography masters student under the guidance of associate professor Kevin Johnson in the Department of Ocean Engineering and Sciences, collects a surface sediment sample to identify and score the microscopic creatures living there.

Continued from page 7

Just in the Indian River between Melbourne and Titusville is an estimated 5 million cubic yards of muck, which is enough to make a wall of muck five feet tall across six lanes of highway that would run for 70 miles.

Whether a half-inch deep or several yards high, sitting in depressions on the floor of the lagoon, muck creates a dead zone lacking the lagoon's native and critical flora and fauna as it spews out more nitrogen and phosphorous.

After Trefry shows the muck to the reporter, he points to a platform in the middle of Turkey Creek, the thing many hope will play a key role in remediating the mess on the lagoon floor: a huge dredging operation funded with state and federal dollars and overseen by Brevard County.

The platform holds a hydraulic pump that dips into the lagoon and essentially vacuums up the muck. It is siphoned through a pipeline to a spoil site on the riverbank where the offending muck particles can settle, and then the clean water left over can be pumped back in to the lagoon.

Based on Trefry's calculations, the "legacy load" of muck—the amount accumulated over years of unmanaged runoff—releases at least as much nitrogen from inside the lagoon as what is currently going into the lagoon. Trefry, who first discussed muck in the early 1980s, thinks dredging will help restore a proper chemical balance to the waters.

But there is no quick fix.

Current estimates from Brevard County's Save the Lagoon plan to pump out enough muck to make a difference will cost the county at least $200 million over a decade. Setting up a dredge in the lagoon also requires clearing many bureaucratic hurdles, which can add months, if not years, to starting an operation any place in water. The hope is through assistance of legislators and agencies the process will eventually become more streamlined.

Dredging Turkey Creek. The platform holds a hydraulic pump that dips into the lagoon and essentially vacuums up the muck. It is siphoned through a pipeline to a spoil site on the riverbank where the offending muck particles can settle, and then the clean water left over can be pumped back in to the lagoon.

In fact, the Turkey Creek operation is actually a test to prove dredging works: Trefry and his Florida Tech team are monitoring the water quality in this area before, during and after muck removal.

Though it is among the more high-profile endeavors, dredging is only one prong of a multifaceted effort to restore the IRL. "Once we dredge the muck, it's going to come right back in," Trefry said. "We need to figure out more ways of preventing the muck from entering the lagoon in the first place."

Mangrove forests and natural wetlands along the banks of the Indian River Lagoon historically acted as a buffer to stop the flow of organic matter into the water, but these natural features have largely been replaced by sprawling suburban lawns and seawalls that don't stop clippings and fertilizer as they flow into the water.

A University at Work

With millions of dollars in funding from the Florida Legislature and Brevard County over the next several years, Florida Tech researchers are involved in multiple muck-related efforts to monitor and improve the health of the Indian River Lagoon beyond studying the dredging process and the impact it may have on seagrass and various organisms living in the lagoon.

As data are collected and answers determined, this foundation of scientific information will be used, in part, to help policy makers and the community at large find effective ways to address the lagoon's woes. The work could also have an impact on lagoon science around the world in places where other estuaries face similar threats.

Here's a look at some of the muck-related work under way by university faculty members:

Kevin Johnson, program chair of ocean sciences, monitors the health of flora and fauna such as seagrass and plankton near the muck dredging area. He also studies what is living—or

Continued on page 10

Continued from page 9

not living—in the muck, such as clams and worms. "We want to know if the quality of mud or muck affects what can live there," he said. "What is the effect on infaunal communities if you dredge the muck out?"

Jon Shenker, associate professor of biological sciences, says juvenile tarpon, snook, redfish, seatrout and many other fish species rely on habitats within the Indian River Lagoon to survive. Shenker's laboratory continues its years-long study of these lagoon populations and how to effectively manage and restore habitats to increase their nursery value. Shenker is also investigating how the removal of muck may affect the habitat for these fishes.

Gary Zarillo, professor of ocean engineering, is modeling the effect of muck removal and what the removal process means for water quality when the muck has been disturbed. The process of muck removal may release more nitrogen and toxins than muck that has settled. Zarillo's research weighs the possible immediate problems of removing muck versus the long-term benefits of having the muck removed.

Charles Bostater, associate professor of ocean sciences, focuses his research on muck movement at the bottom of the lagoon. He developed collection devices, or sondes, that captures and measures the directional movement of muck before, during and after dredging. The research is designed to gauge the effectiveness of dredging and to help determine if dredging has succeeded in reducing the amount of fluid muck.

Steven Lazarus, professor of meteorology, is modeling the effect of weather patterns on the condition of the lagoon. Wind, rain and storms agitate the lagoon's water and can change its salinity. Severe weather can also churn the muck up at the bottom of the lagoon, transplanting it to other locations and altering its concentration. Lazarus measures these changes and their implications on the IRL's health.

Students from Jon Shenker's laboratory study the lagoon's fish populations and how to effectively manage and restore their habitats to increase their nursery value.

Engineering Solutions

Beyond science research, part of the $4 million in Florida Tech's awarded grant money goes to studying and developing engineering solutions to the lagoon's problems.

"Florida Tech is in an excellent position to make a difference," says **Thomas Waite**, professor of ocean engineering. "Not only are we looking at the lagoon's problems as scientists, but we have the academic resources to come up with engineering solutions."

Human development has altered the way rainwater enters the lagoon. Paved roads, sidewalks and causeways act as sluices when it rains, funneling storm water and everything it picks up along with it and dumps straight into the lagoon. Waite and **Robert Weaver**, an associate professor of ocean engineering and director of Florida Tech's Indian River Lagoon Research Institute, are teaming up to investigate ways to counter these man-made problems.

One of the projects involves trying to prevent sediments that form muck from reaching the lagoon floor in the first place. Their pilot study in Turkey Creek is aimed at removing sediment as it enters the canals and creeks leading to the lagoon.

Weaver is developing a suction head with a variable flow rate that can remove just the fine sediments and leave the sand and shell in place. The finer particles will get pumped to a mobile trailer where they will be removed with a ferrate treatment system, and the clean water will be dumped back into the creek.

Weaver and Waite recently took their system to the field. "Once we get that dialed in," Weaver said, "the idea is to follow up with a barge-based system. If we can develop a low-cost system—a few barges slowly moving around the canals sucking up the muck and spitting out clean water—then slowly but surely we can deal with muck in places that can't be reached by traditional dredges."

No Fast Fix

In order to be successful, the Indian River lagoon cleanup must be a multipronged effort, said **John Windsor**, professor emeritus of oceanography and environmental science who helps oversee Florida Tech's research efforts.

Windsor believes taking out the muck is important but said the root causes of the lagoon's ills are more complicated.

"We must fix the problems that exist by going to the source," he said. "We need to figure out where it's coming from and do what we can to stop it."

Brevard County this summer released its Save Our Lagoon Plan for the IRL cleanup that seem to take such a multipronged approach. It included reducing pollution and nutrient inputs, continuing muck removal through dredging and restoring natural ecosystems that act as filter feeders to slow down water entering the lagoon. Two of the best species for doing that, oysters and mangroves, are in serious decline.

"We need to restore the native plants and animals, reduce what we are putting into the lagoon and remove what we've been putting in for the last 50 years," Weaver said, "and that is no small task."

But for the sake of the lagoon, the creatures that live there and the humans who reside nearby, Florida Tech researchers are united in putting science and engineering to work.

Shelley Preston

(Top) Daniel Hope, a biological oceanography student under associate professor Kevin Johnson, deploys a grab to collect sediment and possible organisms from the bottom of the lagoon.

(Bottom) A collection instrument dropped into the bottom of the lagoon in Turkey Creek pulls up the mucky sediment below.

Listening to the Lagoon

Barnacles, Other Marine Animals Serve as Estuary's Sentinels

Kody Lieberman pulled a set of framed PVC panels from beneath the Indian River Lagoon. On this spring day, they were heavy with tangles of sponges and plant life.

Lieberman is a research assistant at the Center for Corrosion and Biofouling Control at Florida Institute of Technology. Run by professor **Geoffrey Swain**, the center is funded by the Office of Naval Research and Industry to develop environmentally friendly coatings and methods to prevent barnacles and other unwanted marine organisms from developing on ship hulls and other structures.

"Historically, we get a lot of barnacles at this site," Lieberman said. "But recently, their numbers have fluctuated and this appears to be associated with the changing health of the lagoon."

The researchers have seen a marked decline in the amount of marine life at the test site. It seems Mother Nature, fueled by man-made development and other impacts, has lost her vigor, leaving a wounded lagoon.

Although the full impact on the summer-breeding barnacle population is still unfolding, decline in barnacles and other filter-feeding organisms is not good for the lagoon, Lieberman said.

They and other marine animals in the Indian River Lagoon are sentinels of the ecosystem's health, a unique and important indicator of how the community is doing as custodians of this valuable body of water.

The data gathered by Lieberman at the test site compliments the technology and research of others at Florida Tech to help lead to better understand and management of the lagoon.

Jon Shenker, a Florida Tech biologist, has seen the estuary's troubles affect the number and diversity of the fish that have called the lagoon home and that he studies. Algal blooms deplete the water of oxygen, causing fish to suffocate and die.

And just one event like a fish kill has implications for all living organisms in the lagoon. "Those fish won't produce new fish to replace them, and that has an impact," Shenker said. Dolphins rely on fish for food and are territorial in their habitat, without enough fish the dolphin population will likely decline, too.

But as is often the case with the natural world, its denizens can help repair the damage in addition to falling victim to it.

(Opposite page: clockwise from top left) Oysters, valued for their filtering properties, are encouraged to grow near man-made structures in the lagoon through Florida Tech's Living Docks program. Native plants used for the Living Shoreline project, spearheaded by Robert Weaver, can prevent shore erosion. Kody Lieberman, a graduate student of Geoffrey Swain, shows some of the creatures clinging to laboratory panels submerged in the Indian River Lagoon.

Years ago, for example, the Indian River Lagoon teemed with oysters. But scientists say that over the years pollution and coastal construction such as bridges and seawalls have wiped out huge numbers of them. One important step to stemming the lagoon's decline, said **Robert Weaver**, an ocean engineer at Florida Tech, is to restore the oyster population in the lagoon.

Oysters are considered to be important to the lagoon's health for a number of reasons: other species depend on them for food and habitat; large clumps of them create natural reefs that help block wave energy, which prevents shoreline erosion; and they filter impurities from the water.

Weaver and **Kelli Hunsucke**r, a research assistant professor in the Department of Ocean Engineering and Sciences, started Living Docks, a program aimed at enlisting the community's help to turn docks and seawalls along the shores of the lagoon into a home for oysters. The program enables non-scientists and community members to create inexpensive but effective habitats that encourage oysters and other organisms such as sponges and barnacles to collect near man-made structures in the lagoon.

Mesh bags filled with oyster shells are hung from the sides of these structures and submerged into the water. The presence of the shells attract oyster larva and other filter-feeding organisms.

"One dock with 37 pilings with an average of 32 oysters per piling can potentially filter about 21 million gallons of water per year," Hunsucker said, not including the filtering impact of other organisms, such as barnacles and sea squirts.

Weaver is also working with volunteers, including students and faculty at Florida Tech, on a Living Shoreline project funded by Brevard County. This initiative will call for the use of oyster beds near the shoreline to act as a breakwater and the planting of native grasses and mangroves on the banks to buffer erosion. Improved shorelines with nooks and crannies to hide in would also attract fish.

Earlier this year, Weaver and his team had started surveying a section of the Indian River Lagoon on the north side of the Melbourne Causeway. The plan is to model the breakwater in the lab using a wave machine and then implement it into the lagoon.

"We are trying to give people real ways to help the lagoon, something to feel good about—something they can do on their own property," Weaver said. "Whether you have a seawall, revetment or natural shoreline, there are ways to contribute."

Back at the bio-fouling research lab a few month later, summer barnacle breeding is under way. Lieberman wasn't overjoyed at what he was seeing, but he was encouraged. The lagoon is resilient, even in its delicate state.

"We have had fewer barnacles than 2015 so far," he said. "However, we still had more barnacle recruitment than the years right after the algal superbloom and the season is not over. I am staying optimistic."

Shelley Preston

Indian River Lagoon Research Institute

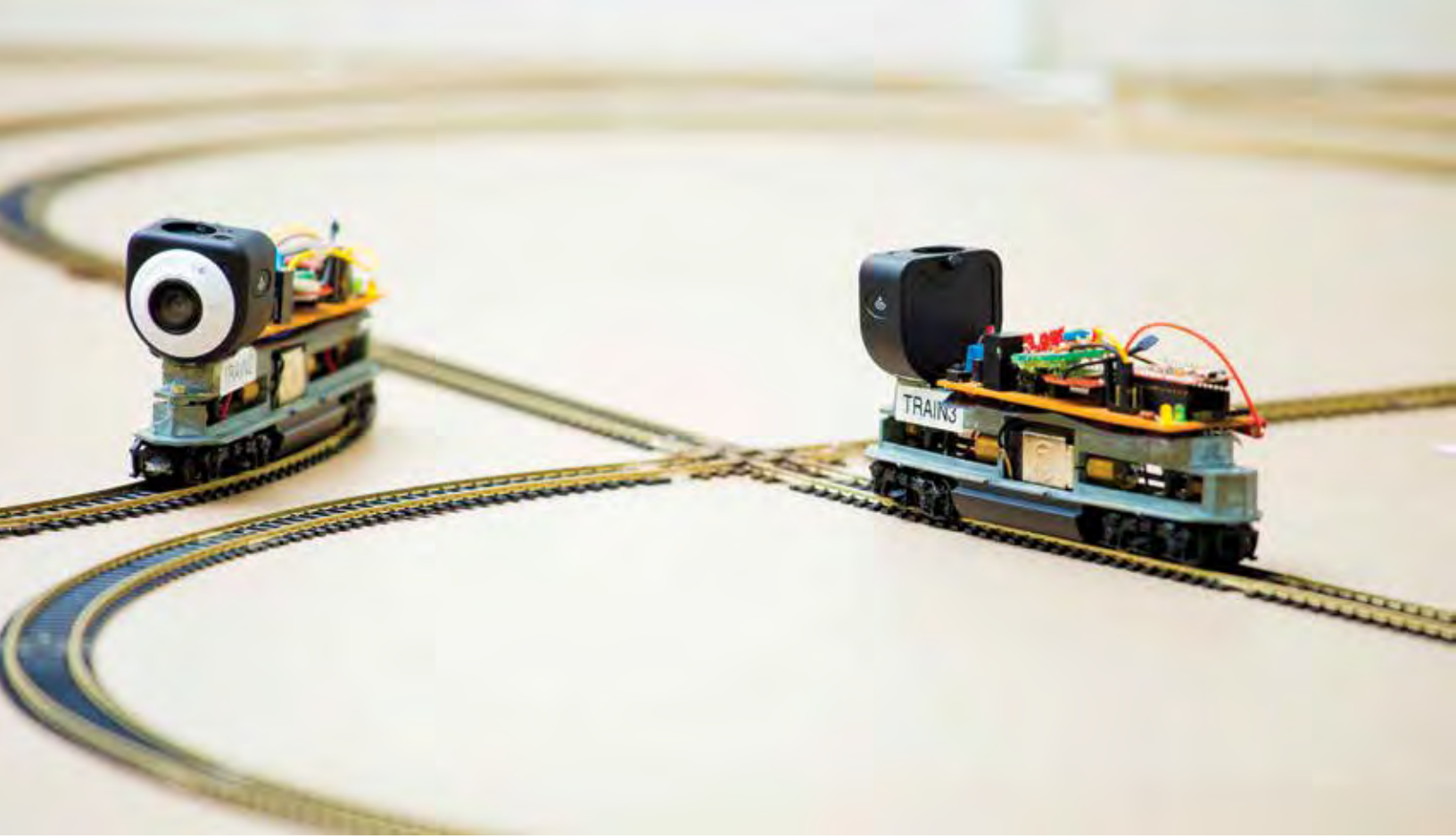
More than 20 Florida Institute of Technology faculty members come together at the Indian River Lagoon Research Institute. The group works with government and public leaders to help develop sustainable solutions for the revitalization and care of the Indian River Lagoon.

Established at the university in 2013, the institute works to develop actionable plans based on research to improve costal water quality. Its members focus on communicating the need to reduce human input into the lagoon and promote restoration efforts that include removing the legacy load of muck, restoring natural shorelines and encouraging the propagation of natural filter feeders such as oysters and clams back to the estuary.

The institute also organizes and hosts an annual technical conference that brings leading engineers, scientists, county officials and community members together. The 2016 event on coastal water quality, "From Science to Solutions," focused on adapting and applying science to guide management decisions and develop solutions aimed at improving coastal water quality.

The institute's broader mission is to take proven methods developed and tested at Florida Tech to other estuary communities in need to offer ideas and advice proven by research.

Learn more at **research.fit.edu/irlri** and on Twitter at **@IRLRI_FIT.**



Teaching Trains to Talk

How Model Locomotives are Allowing Researchers to Seek Breakthroughs in Machine Learning and Human-Machine Interaction

As three electric train cars navigate their tracks, the clicks and whirs coming from what could be a hobbyist's set are audible. The locomotives rattle over miniature trestles and motor through potentially perilous junctions.

But it is what cannot be heard that ultimately makes this tableaux more appropriate for a laboratory than a play room:

Negotiations.

As two of the cars head toward the same crossing, collision avoidance algorithms in a nearby server run the calculations and send information to hand-made circuit boards affixed to the top of each car. These processors take in the information, calculate other factors such as location and speed, and then determine how the train cars proceed.

At the junction, one car stops, allowing the other to safely pass.

"Humans can negotiate. We can understand when context changes, or problems arise," said **Marco Carvalho**, acting dean of the School of Computing and executive director of the Harris Institute for Assured Information at Florida Institute of Technology. "But computers can't do that."

Yet.

As Carvalho and his team of faculty and students continue their work, the concepts on display, in fact, end up influencing some of society's key technologies in years to come, from cybersecurity to autonomous vehicles to robot-filled factories.

"We want to get a computer to think more like a person," said **Tom Eskridge**, an associate professor at the Harris Institute who specializes in artificial intelligence and cognitive modeling. "We want them to have their own view of the world, to predict what they would do."

Rather than a Terminator-style dystopia, such advances could lead to improvements in safety, efficiency, transportation and more.

And the train set, which is almost like a virtual network manifested, is the perfect place to experiment.

Factory Applications

The train set-up was inspired by highly mechanized factories where robots on a track move from station to station to complete tasks. The train stopping for a set period of time is akin to the factory robot completing one job before it moves to the next one.

The train system allows researchers to develop optimization algorithms that can return the favor by helping robots do their jobs in the most efficient way, said **Adrian Granados**, a research associate at the Harris Institute.

"To be efficient, we must avoid collisions," he added.

Automobile Autonomy

The train car experiments could also help improve self-driving vehicles.

Existing systems such as Tesla's Autopilot use a host of different technologies to provide a high level of driver assistance, including cameras, ultrasonic sensors, forward-facing radar and a powerful computer to process all of this data.

Despite the amazing advances illustrated by these systems and their beyond-human capabilities, the train car experiments suggest a realm of machine interactions yet to be achieved.

What if collision avoidance algorithms can keep crowded roads accident-free? Can autonomous vehicles be equipped to offer and accept communications with other autonomous vehicles? What about sensing and communicating with their environment?

The work researchers and students do with the train set will help answer those questions.

Better Cybersecurity

Because the train set uses an ad hoc Wi-Fi network allowing for free communications between the locomotives, it can also allow for research into cybersecurity.

"Consider each train car as a company, defending its system," Carvalho said.

Cyber threats developed by students can be unleashed in the system, allowing others to work on methods of securing the ad hoc networks.

This work is often combined with a network security class that has students creating fully operational virtual companies and then protecting them from cyber-attacks.

"Because students use these tools and they see activity on the network that has specific signatures, they recognize that and can respond," Carvalho said in an earlier interview. "Through this attack and defend process, they start to learn the traces that are only gained through experience."

Adam Lowenstein

Marco Carvalho, acting dean of Florida Tech's School of Computing and executive director of the Harris Institute for Assured Information.

Designing the Space Tourism Experience

The School of Human-Centered Design, Innovation & Art puts people first when thinking about the future needs of space flight.

Ladies and Gentlemen, this is your captain speaking. An attendant will be around shortly to ensure your helmets are tightly secured and that all loose objects have been removed from the cabin and stowed. Now sit back, relax and enjoy your sub-orbital flight. We will be leaving Earth shortly.

Fantasy? Not for long. And when space tourism finally gets off the ground, research from Florida Institute of Technology will likely be on board in several critical ways. From the space suit you wear to the design of the flight deck to the rules for safety, Florida Tech's School of Human-Centered Design, Innovation & Art, known as HCDi, is working to make safety, efficiency and comfort integral to the space flight experience.

Guy André Boy, HCDi's dean, says the aim of the school is to foster a human-centered approach to engineering and design with ideas such as usability, tangibility, sustainability and feasibility in mind in the creation process, not afterward.

"Human-systems integration in the space environment has to consider and mitigate the challenge of many environmental extremes that are lethal to humans," he said. "That means that systems that we design must perform at maximum efficiency, sustainability and autonomy and have very low mass and high durability."

HCDi continues to develop and orchestrate various kinds of disciplines that are necessary to the design of space systems.

"Among them, the most important ones are modeling and simulation, advanced interaction media, cognitive engineering, complexity analysis, organization design and management, and life-critical systems," Boy said.

Suitable Outfit

This spring, Florida Tech acquired a functional space suit from Final Frontier Designs of Brooklyn, NY,

Ondrej Doule wears a suit designed specifically for space tourism.

for use in developing a universal cockpit specifically for space tourism. Florida Tech is one of just three universities nationwide to have a space suit of this type.

To test the functionality of the simulated spacecraft environment, **Ondrej Doule**, an assistant professor at HCDi, needs to know what the pilots and passengers will be wearing when they blast off and later make the journey back to Earth.

"The suit provides pilots and spaceflight participants with another level of safety, and we believe it maybe as common in future space tourism as gloves and helmets are for motorcycle road trips," Doule said. "The human body, and human activities in space, has to be understood in much higher detail than in any other environment."

Furthermore, he added, researchers must have a deep understanding of what it's like to wear a space suit before they begin to improve spaceship flight deck and cabin design.

"For any area of spaceship flight deck research, design or engineering, understanding one's dexterity, perception and work constraints imposed by a suit are extremely important," he said.

The garment Doule will be working with is called an intra-vehicular activity, or IVA, suit, and it would be worn inside the vehicle during mission-critical events such as launch, re-entry and landing. The IVA suit provides a contained, head-to-toe pressurized environment that protects the body from any loss of cabin pressure. Unlike space suits used by NASA astronauts, Florida Tech's new suit is more utilitarian than bespoke. The suit is made using advanced techniques such as 3-D printed components and is much lighter than usual suits. It is also adjustable and can be worn more than once and by more than one person.

Doule and research subjects will wear the suit while performing tests on the multidirectional-motion cockpit simulator he is designing to ensure the user experience is as realistic as possible. He agreed to collaborate with Final Frontier on the suit's technology as well as external technology including wearables and displays.

"For us, it's still a learning process, and Florida Tech's research plays an important role," said Ted Southern, Final Frontier Designs' president and designer.

Safety First

Before citizens take their first joy ride into space, however, a set of safety regulations needs to be in place. Set by Federal Aviation Administration, the rules will likely incorporate commercial jet-type specifications along with requirements specific to human space flight.

Boy, the HCDi dean, received a grant from the FAA to craft rules and regulations that would keep passengers and crew safe from the ground to zero G. With previous experience on the certification of commercial aircraft, and with his position as a NASA scientist who worked during the space shuttle era, Boy considers factors such as safety, efficiency and comfort for passengers.

"Nobody has done this before," he said. "We have a chance to provide recommendations and criteria for certification for commercial/tourist spacecraft at the ground floor."

Boy and his team are working with FAA Commercial Space Transportation to consider a person's place within the commercial spacecraft's framework, such as:

- The design and organization of flight decks so they make sense to a pilot wearing protective gear in zero gravity.
- Allocating work between humans and machines.
- Best practices for restraining individuals and objects inside the vehicle.
- Physiological factors: acceptance of vibrations, noise and reassuring passengers that the vehicle provides acceptable constraints.
- Physical requirements of passengers. What will be the fitness baseline?

"Because we are humans and not machines, we need human-centered design methods to discover optimal ways to develop technologies, systems or societies that will be purposeful, safe and efficient," Boy said.

Doule added, "Commercial human space flight has to embrace professional human-systems integration at the very beginning of concept creation to successfully send people to space, and we at HCDi are excited to help make that happen."

Shelley Preston

The Eyes Have It

Understanding the Amazing Transformation of Tarpon Retinas Could Lead to Human Applications

With their spectacular aerobatic displays and massive size, tarpon have been one of the most sought-after gamefish in Florida and around the world for over 100 years.

Today, scientists are finding these spectacular fish to be just as alluring.

A team of researchers led by **Michael Grace**, a biologist and senior associate dean of science at Florida Institute of Technology, has discovered evidence that tarpon have an amazing ability to reorganize the architecture and function of their retinas as the fish age in order to optimize vision in different light environments.

"We are trying to understand color vision and how it changes in tarpon over the course of life, because these fish migrate through radically different habitats as they mature, including ones with very different light colors and intensities," Grace said. "We are trying to understand the mechanisms of dramatic change in their eyes, something that doesn't happen in people."

Understanding how and why this happens could have major ramifications for treating and even curing blindness and other health-related ocular issues in people because the human nervous system doesn't exhibit the capacity for radical reorganization or recovery from damage that fish nervous systems do.

Tarpons begin life in dark, deep ocean incubators where little light penetrates. Correspondingly, the light-detecting cells in their retinas at that stage are all rods, the cells used to detect dim light. As with many aspects of the tarpon eye, this rod-only arrangement is exceedingly rare among fish species.

Then, as tarpon move into the reddish-colored inshore waters as juveniles, and ultimately to shallower, brighter coastal waters as adults, something extraordinary happens: their retinas develop cone cells, which detect color and are better suited for bright light. These changes in retinal structure and function help the fish hunt prey and avoid predators in each new light habitat encountered over the course of development. And tarpon develop not just one type of cone cell, not two cone cells as many mammals have, or even three as humans have: tarpon eyes develop at least five different kinds of cone cells by the time they are adults.

This extraordinary accomplishment has important implications. While humans can discriminate perhaps a million different colors using their three types of color-sensing cone cells, tarpon may be able to discriminate 100 million colors, or even more. In other words, color vision in adult tarpon is far better than human color vision.

"Animals with three cones are already unusual, four is almost unheard of, and five is truly amazing," Grace said.

Grace and his team published articles on tarpon retinal development in the scientific journals *Visual Neuroscience*, *Environmental Biology of Fishes*, and *Contributions in Marine Science*. Their latest work provides a detailed analysis of the closest relatives of tarpon—bonefish,

"While humans can discriminate perhaps a million different colors using their three types of color-sensing cone cells, tarpon may be able to discriminate 100 million colors, or even more."

ladyfish and eels. This research was published in the journal *Visual Neuroscience* last year in an article authored by Grace, his former student, Scott Taylor, now at the University of Michigan, and Cornell University researcher Ellis Loew. The article is entitled, "Ontogenic retinal changes in three ecologically distinct elopomorph fishes (Elopomorpha: Teleostei) correlate with light environment and behavior."

Armed with the knowledge that tarpon eyes change in concert with change in their surrounding light environment, Grace and his team are now delving into the how and why.

"That's the final piece of this puzzle," Grace said, "Are tarpon simply genetically programmed to go through these changes, or is there something about the environment that drives change to their eyes?"

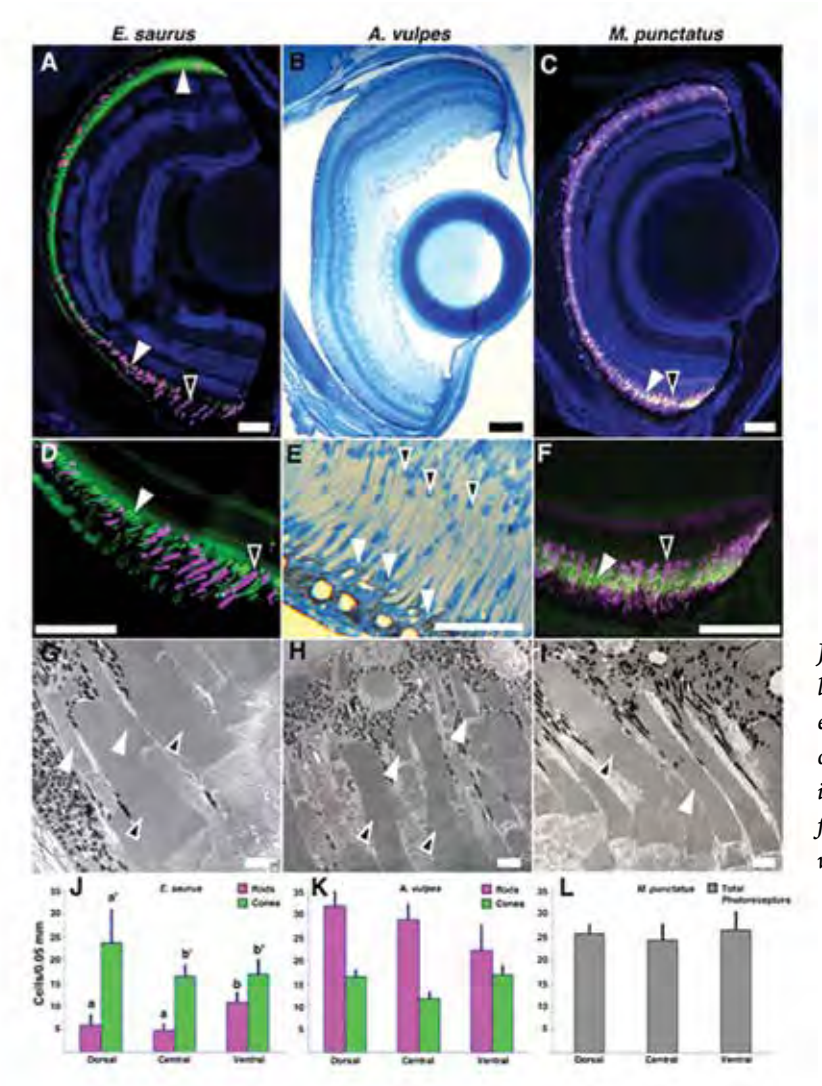
Grace and his doctoral students **Lorian Schweikert** and **Kristin Kopperud** developed electroretinography techniques to gauge sensitivity and how the eyes respond to colors. Based on this new research, environment appears to be a trigger.

"The progressive change over their course of life suggests they have the capacity to modulate—and fairly quickly, too," he said.

What makes this discovery important beyond tarpon is that science is eager to mimic the ways tarpon generate different cells to become super-seers.

"Humans and fish are made from the same stuff. We're like Legos; blocks of the same stuff put together in different ways," Grace said. "If we can figure out how tarpon eyes reinvent themselves throughout their life, we can apply the mechanisms to the treatment of retinal disease or other neurological diseases."

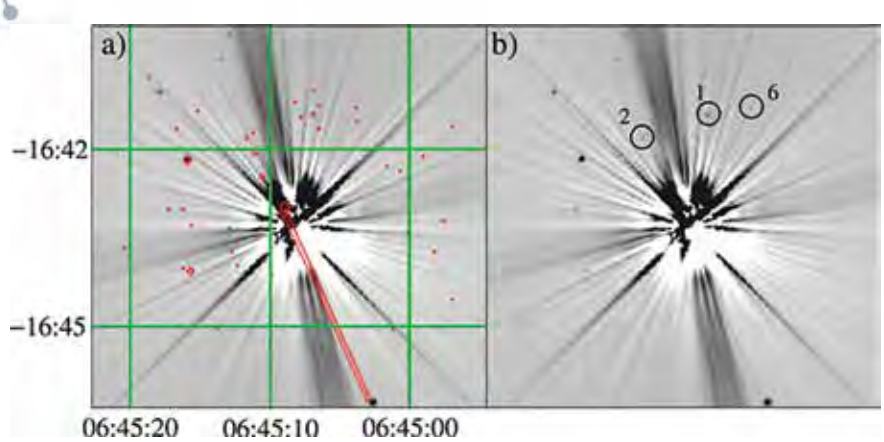
Shelley Preston



Juvenile retinas of tarpon, ladyfish and bonefish exhibit an explosion of cone cell genesis and increasing specializations for light environments in which they are active.

Research in Brief

A LOOK AT RECENT SCIENCE AND ENGINEERING HIGHLIGHTS FROM FLORIDA TECH FACULTY AND STAFF



CID May Help Find Earth-Like Exoplanets Around Other Stars

Daniel Batcheldor, astrophysicist and head of the department of physics and space sciences, led a study demonstrating that the use of charge injection devices could help spot faint celestial objects such as planets around other stars. The device could help solve the problem of very bright stars drowning out the comparatively faint light of a nearby planet and making them hard to detect. "The CID is able to look at a very bright source next to a very faint source and not experience much of the image degradation you would normally experience with a typical camera," Batcheldor said. These devices can be used on ground-based and space-based telescopes. A CID prototype is scheduled to be tested for the International Space Station.

Integrating Mental Health into Primary Care

A million-dollar grant awarded to psychologist **Kristi Van Sickle** will benefit poor and underserved populations of Brevard County by providing greater access to mental health services. Florida Tech School of Psychology's Integrated Healthcare Training, directed by Van Sickle, offers doctoral students a stipend to pursue the practicum portion of their training at Brevard Health Alliance clinics. She says bringing more psychologists to an integrated health environment will provide patients with a one-stop shop for helping to heal the whole body, including mental health. Issues such as depression, anxiety and drug dependence can all be addressed at the patient's primary care center and covered by insurance.

RESEARCH GRANT ROUNDUP *2016*

More than two-dozen researchers at Florida Tech received new grants of $100,000 or more through October 2016. Here's a look at who got how much and for what. Grants are arranged by name of the recipient, name of the project, funding amount and awarding agency.

Kristi Van Sickle, Associate Professor Psychology
Graduate Psychology Education Programs
$1,042,313 from Department of Health and Human Services (on behalf of Health Resources & Services Administration)

Marco Carvalho, Dean School of Computing
Adaptive Resource Management Enabling Deception
$733,588 from Raytheon BBN (on behalf of Defense Advanced Research Projects Agency)

Mark Bush, Professor Biological Sciences
Pollen Enterprise Database Phase IV
$476,357 from MITRE (on behalf of Department of Homeland Security)

Hamid Rassoul, Dean College of Science and Ningyu Liu (former) Professor Physics and Space Sciences
Cedar: High Speed Spectroscopic Studies of Lightning Bolts: Starters, Jets, And Gigantic Jets
$456,363 from National Science Foundation

Mark Bush, Professor Biological Sciences
Collaborative Research Belmont Forum: Vulnerability of Populations Under Extreme Scenarios
$449,824 from National Science Foundation

Véronique Petit, Assistant Professor Physics and Space Sciences
Time Resolved Studies of Outflows from Massive Stars Using the Observatory of the Southeastern Association for Research in Astronomy
$417,399 from National Science Foundation

Amazonian Natives Had Little Impact on Land

An emerging theory from some archeologists and anthropologists suggests that native peoples heavily modified the Amazonian rainforests prior to European contact, leading to the idea that the rainforest could recover quickly from modern deforestation. But research by **Mark Bush**, professor of biological sciences, refutes the theory that the ancient Amazonians had a substantial impact on the land. A paper Bush co-authored titled, "Anthropogenic influence on Amazonian forests in prehistory: An ecological perspective" in the *Journal of Biogeography*, strongly affirms that the Amazonian ecosystem is fragile in the face of logging and mining enterprises that could cause irreversible harm to the forest.

SPOTLIGHT ON TOP RESEARCHERS

John Trefry

Professor of Chemical Oceanography
Department of Ocean Engineering and Sciences, College of Engineering

General research focus:
Trace metal and nutrient geochemistry; marine pollution

Current research funding: $2,225,041

What has you excited about your current research?

I have had the good fortune to carry out research in such diverse ocean environments as 400˚C, deep-sea hydrothermal vents and the frozen Arctic. My present efforts are focused on eutrophication that plagues our local Indian River Lagoon. Although dismayed by our neglect of this amazing habitat, I am excited that our lab is an integral part of the challenge to determine what sparks rampant algal blooms and how best to restore and preserve our lagoon and others like it around the world.

Why is it important to conduct research?

Research, in its many forms, provides us with the information needed to make decisions, understand how the universe works and develop technological breakthroughs that truly change the Earth. The frequency and creativity of new discoveries and answers to really tough questions confirm the importance of promoting and conducting research. Indeed, our quest for knowledge and innovative tools gives us all a feeling of excitement and a sense of pride that moves the human spirit.

John Trefry, Professor of Chemical Oceanography
Brevard County Muck Dredging Project Determining the Effectiveness of Muck Removal and the Impact of Upland Runoff on Water Quality in the Indian River Lagoon
$406,350 from Brevard County

Yi Liao, Associate Professor of Chemistry and Clayton Baum, Professor of Chemistry
Reversible Metastable-state Photoacids
$400,000 from National Science Foundation

Marco Carvalho, Dean School of Computing
Behavior-extracting Autonomous Resiliency Toolkit
$399,000 from Raytheon BBN (Air Force Research Laboratory)

Georgios Anagnostopoulos, Associate Professor Electrical and Computer Engineering and Anthony Smith, Assistant Professor of Electrical and Computer Engineering
REU Site: Advances of Machine Learning in Theory and Applications
$359,998 from National Science Foundation

Pallav Ray, Assistant Professor Ocean Engineering and Sciences
Exploring the Role of Topography and Land-Sea Contrast on the Propagation of the MJO Across the Maritime Continent
$351,841 from Office of Naval Research

Jean Perez, Assistant Professor Physics and Space Sciences
Connecting Theory and Simulations of Turbulence in the Inner Heliosphere With Singlepoint Measurements by Solar Probe Plus and Solar Orbiter
$312,161 from NASA

Csaba Palotai, Assistant Professor Physics and Space Sciences
A New Tool For Studying Jupiter's Clouds, Storms And Vortices
$306,428 from NASA

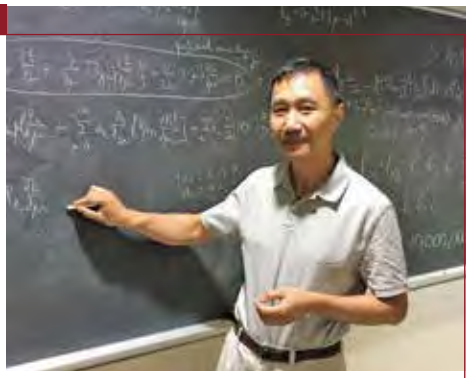
Robert Weaver, Associate Professor Ocean Engineering and Sciences and Thomas Waite, Professor Ocean Engineering and Sciences
Brevard County Muck Dredging Project: Feasibility of Muck Removal at Fixed Locations in the IRL Watershed and Subsequent Ferrate Treatment to Remove
$299,500 from Brevard County

Continued on page 22

Lightning Research Captures Global Media Attention

Physicist **Ningyu Liu** and **Hamid Rassoul**, dean of Florida Tech's College of Science, used a high-speed camera to capture lighting flashes from a storm near the university's Melbourne campus this spring. The video circulated around the world in major media outlets such as *Time* magazine, the BBC and *Newsweek*. The flash was recorded at 7,000 frames per second (FPS), and the playback speed seen in the video is 700 FPS. The video was made possible with new high-speed camera purchased with a $456,000 grant from the National Science Foundation.

SPOTLIGHT ON TOP RESEARCHERS



Ming Zhang

Professor of Physics and Space Sciences
Department of Physics and Space Sciences, College of Science

General research focus:
Space weather, high-energy space radiation, interstellar medium, heliosphere, Earth magnetosphere

Current research funding: $1,436,519

What has you excited about your current research?

In order to know the environment that surrounds the Earth, we need to know how the Earth interacts with the sun and how the sun interacts with the galaxy. NASA and space agencies of other countries are sending many space missions to explore the space environment that consists of particles and electromagnetic fields. Working with scientists on missions such as Voyager, IBEX and STEREO, my research is a part of efforts to gain understanding of the fundamental physics hidden inside spacecraft measurements.

Why is it important to conduct research?

Our society is becoming more and more reliant on space technology. The operation of space missions, as well as commercial airlines, wireless communication and even electricity distribution grid systems can be adversely affected by space weather events originating from the sun. My research will eventually lead to reliable tools for forecasting space weather and effective methods for mitigating its hazards.

RESEARCH GRANT ROUNDUP *2016* continued

Continued from page 21

Brian Kaplinger, Assistant Professor Mechanical Aerospace Engineering and Beshoy Morkos, Assistant Professor Mechanical Aerospace Engineering
Development of a STEM Education Program in Support of Naval Flight Test Engineering
$252,628 from Office of Naval Research

Robert Van Woesik, Professor Biological Sciences
Identifying Coral Refuges in the Florida Reef Tract
$203,796 from Florida Fish and Wildlife Commission

Kegang Wang, Professor Mechanical Aerospace Engineering and Martin Glicksman, Dean College of Engineering
Testing Analytical and Numerical Models in Phase Coarsening Using NASA Physical Sciences Informatics System
$199,661 from NASA

Robert Weaver, Associate Professor Ocean Engineering and Sciences
Restoring Natural Filtration Systems in the Indian River Lagoon— "Living Shoreline"
$176,580 from East Coast Zoological Society of Florida

Fareena Saqib, Assistant Professor Electrical and Computer Engineering
CRII: SaTC: Hardware-Based Authentication and Trusted Platform Module Functions for IoTs
$175,000 from National Science Foundation

Kevin Johnson, Associate Professor Ocean Engineering and Sciences
Brevard County Muck Dredging Project: Biological Responses to Muck Dredging in the Indian River Lagoon, Part I Seagrass Monitoring and Infaunal Surveys
$168,200 from Brevard County

Psychologists Consult U.S. Navy on Efficient Teamwork

Industrial organizational psychologists **Patrick Converse**, **Jessica Wildman** and **Erin Richard** were recently awarded a grant by the Office of Naval Research to assist the Navy with communication among multiteam systems on carrier strike groups. The researchers will conduct in-depth interviews with team members and compile the data to determine the best training techniques for these teams. "Our goal is to understand at a systematic level how teamwork occurs in multiteam systems so that we can provide better training on how to communicate and coordinate effectively during complex, mission-critical situations," Wildman said.

Science Helps Florida Corals Flourish

Biologist **Robert Van Woesik** recently received a grant from the Florida Fish and Wildlife Commission to find very precise locations along the natural Florida reef that are optimal for coral survival. He and his team will be looking at factors such as correct temperature and water flow conditions. Once locations have been pinpointed, the hope is that the corals grown at coral nurseries in Florida waters ranging from Broward County to the Dry Tortugas maintained by the Florida Reef Resilience Program will have better survival rates when relocated to these strategic areas.

Shelby Langner and Shelley Preston

Marco Carvalho, Dean School of Computing
Integrated Decision Engine for Evolving Defenses
$150,000 from Raytheon BBN (Air Force Research Laboratory)

George Rybicki, Research Associate Professor Physics and Space Sciences
Carbon-14 Elevations as an Indicator of Underground Weapons Testing
$132,497 Department of State

Gary Zarillo, Professor Ocean Engineering and Sciences
Brevard County Muck Dredging Project: Hydrologic and Water Quality Model for Management and Forecasting Within Brevard County Waters
$130,000 from Brevard County

Gary Zarillo, Professor Ocean Engineering and Sciences
State of the Inlet Analysis 2016-2017
$110,250 from Sebastian Inlet Tax District Commission

Philip Chan, Associate Professor Computer Sciences and Cybersecurity
Accent Analytics: Opportunity Timeline
$104,000 from Accent Technologies

Jean-Paul Pinelli, Professor Civil Engineering-Construction Management
Characterization and Modeling of the Damage Caused by Hurricane Induced Water Penetration in Coastal Buildings and Subsequent Risk Evaluation
$100,000 from Florida Sea Grant (NOAA)

Fareena Saqib, Assistant Professor Electrical and Computer Engineering
EDU: Collaborative: HACE Lab: An Online Hardware Security Attach and Countermeasure Evaluation Lab
$100,000 from National Science Foundation

Leesa Souto, Visiting Professor Ocean Engineering and Sciences
Brevard County Muck Dredging Project: Source to Slime Study in the Indian River Lagoon
$100,000 from Brevard County

Florida Institute of Technology
High Tech with a Human Touch®
Office of Marketing and Communications
150 W. University Blvd.
Melbourne, Florida 32901-6975

DISCOVERY

This hollow stainless-steel chamber, which is about the size of a boxcar and insulated with foam, is called a **Mars Environment Chamber**. It can be pressurized and cooled to mimic the atmospheres of Mars or even the moon. NASA planned to use it for research, but funding wasn't available to continue the project and it was donated to Florida Tech. **Daniel Batcheldor,** department head of physics and space sciences at Florida Tech's College of Science, helped deliver the enormous chamber from Kennedy Space Center to campus and is in the process of getting it in working order for future experiments.

DISCOVERY is printed on Sustainable Forestry Initiative (SFI)® certified paper.

MK-268-416