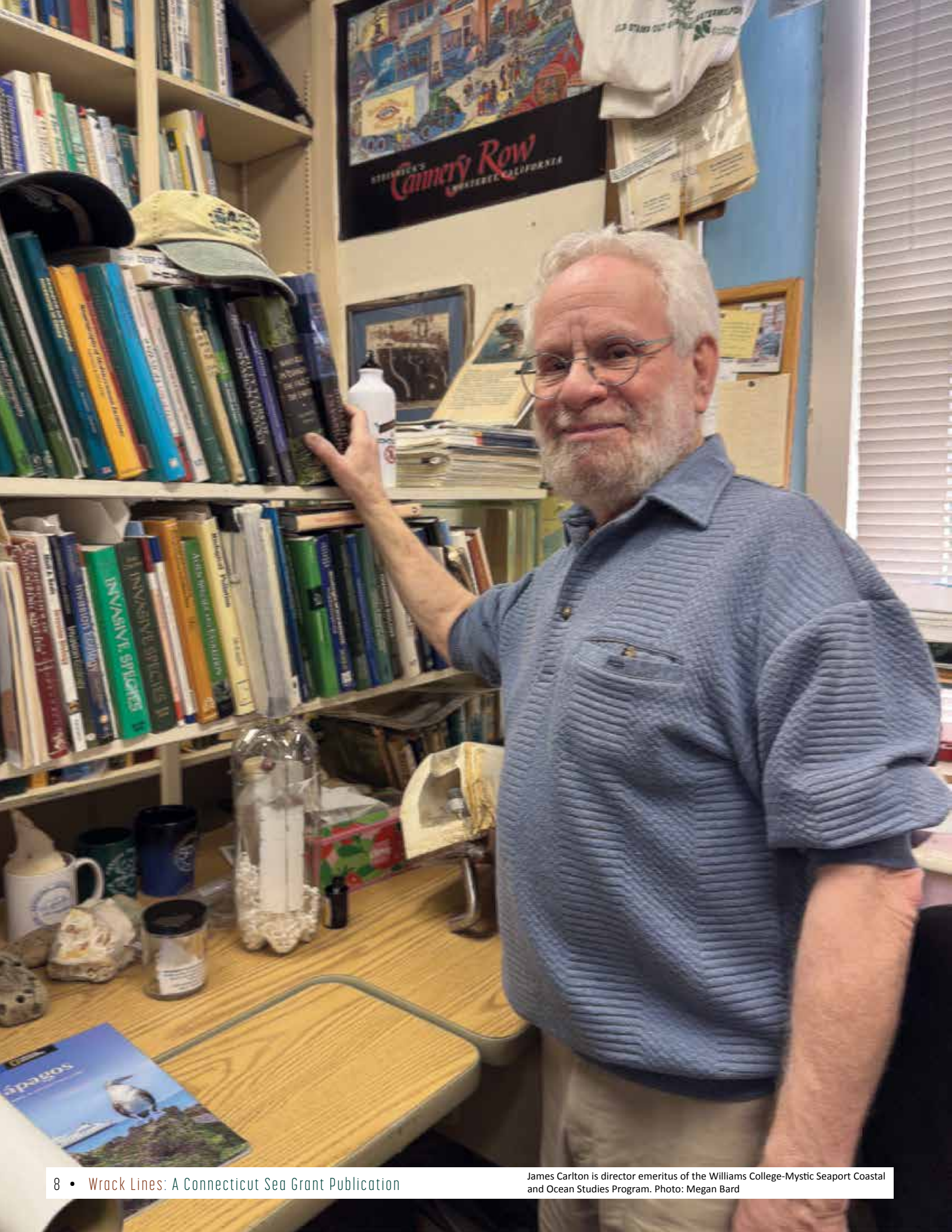

James Carlton is director emeritus of the Williams College-Mystic Seaport Coastal and Ocean Studies Program. Photo: Megan Bard

He's a passionate scientist, 'wizard of bioinvasions' and mentor to many worldwide

By Megan Bard

James Carlton couldn't help himself, even on this crisp February afternoon.

He had to explore the crevices of the stone walls at a small beach within the Mystic Seaport Museum. The visit was intended to be a brief stop for a photo. Instead, Carlton crouched at the edge of the Mystic River, searched between the stones and collected ribbed marsh mussels and Atlantic oyster shells from the beach.

"It's a great time to be a barnacle when the river hardens," he said, referring to sediment accumulation on the riverbed while rolling the shells around in his hands and looking out over the water.

Carlton, 77, professor of marine sciences emeritus at Williams College and director emeritus of the Williams College-Mystic Seaport Coastal and Ocean Studies Program, has been researching marine bioinvasions in some capacity—from hobby to leading global projects as a principal investigator—since he was 14 years old. Today, emerging marine scientists and established colleagues consider him the father of marine bioinvasions.

"Through his training and mentorship, he's essentially raised generations of marine scientists," said Laura Meyerson, professor of habitat restoration ecology at the University of Rhode Island and co-editor-in-chief of *Biological Invasions*. "When you work with him on a project, he makes you feel like you're discovering it right there with him."

In the years since he accidentally stepped on a tube worm in Lake Merritt, a small brackish lagoon within the San Francisco Bay estuary, and learned that it likely came from the South Seas, Carlton has become one of the world's premier researchers of marine invasive species.

"I still have his dissertation, a two-volume tome, on my desk. It's a resource for understanding Pacific Northwest marine invasions," said Marjorie Wonham, associate teaching professor at the University of Washington School of Aquatic and Fishery Sciences and the marine biology department at the Friday Harbor Laboratories.

Since the mid-1970s, Carlton's work has appeared in nearly 300 scientific journals and publications, and he helped author eight books. He has also embarked on hundreds of trips to various ports worldwide, collected more non-native species and marine debris than can be housed in his office and collections area, and boosted the careers of dozens upon dozens of up-and-coming marine biologists.

An advocate for marine biodiversity and conservation, Carlton has testified before Congress nine times, helped draft national policy on ballast water, and confirmed that marine invasive species can survive the journey across the high seas if attached to an appropriate vector, such as plastic. A few years later, Carlton and his colleagues' research on marine debris released after the March 2011 tsunami that devastated the eastern coast of Japan sparked a new understanding of how species can travel. He now organizes teams of novice and expert researchers each summer for a week of intensive collection and analysis of invasive species in coastal waterways.

Claire Goodwin of Hunts Marine Science Center in New Brunswick, Canada, one of 20 researchers who joined Carlton on a rapid bioassessment survey for marine invasives in Long Island Sound last summer, tries to determine whether a sponge she had just found was an invasive or native species. Photo: Judy Benson

Since his initial tube worm discovery, Carlton's focus has evolved to include projects on coastal areas from Alaska to Mexico, Maine to the Chesapeake Bay, the Hawaiian Islands, Chile, Argentina, the Galapagos Islands, South Africa and Europe.

"He will travel anywhere. He's passionate about his work and knowledgeable about so many things," said Evangelina Schwindt,

principal researcher at BIOMAR-CONICET in Argentina and co-editor-in-chief of *Biological Invasions*, the journal Carlton founded.

"We don't have a replacement for Jim. That worries me," she said. "So we worked on the manual where he shares 50 to 60 years of knowledge stored in his head and gives researchers the steps to create accurate lists of species and determine which are native and non-native."

BALLAST WATER

Carlton's early research focused on ballast water—fresh or salt water held in tanks and cargo holds of ships to provide the stability needed while traversing rough seas or weigh them down to pass under a bridge. For centuries, Carlton noted, humans unknowingly transported non-native, invasive species as they crossed the oceans on large ships. Little concern was given to these invasive creatures in the United States until the late 1980s.

Zebra mussels, native to Eastern Europe, were discovered after ships traveling down the St. Lawrence Seaway released their ballast water into the Great Lakes. Beachgoers' feet were sliced on their razor-sharp shells. They clogged pipes, disrupting water flow to thousands of people in Michigan for three days. Congress suddenly noticed.

After testifying before Congressional committees, Carlton helped draft policy requiring ships to release ballast water before entering their ports-of-call to reduce the chances of introducing bioinvaders into coastal ecosystems. The resulting legislation now requires ship captains to inform a division within the Smithsonian Environmental Research Center (SERC) how they treat and release the ballast water to minimize the potential for introducing non-native species.

Carlton said any invasive species introduced to an ecosystem could become the dominant organism, replacing and displacing native species. From an economic and human health perspective, this can limit biodiversity and disrupt local industries, from factories and fisheries to tourism.

"It's a challenge," he said. "In an area like Long Island Sound, where we have a major oyster industry, one parasite, one pathogen, one disease could wipe it out."

Ballast water isn't the only way marine invasive species cross oceans, however.

MARINE RAFTING

Historically, when ships traveling from the open ocean entered freshwater harbors, most experts assumed that any invasive

Aly Putnam, left, doctoral student at UMass Amherst, examines an invasive orange striped anemone from Japan that she an another researcher found during the rapid bioassessment survey last summer. Photo: Judy Benson

species accumulated at sea and affixed to the side of a ship, a process called biofouling, would not survive the change in salinity or water temperature.

Then came the March 2011 earthquake and subsequent tsunami that ravaged Japan's East Coast to challenge that earlier presumption.

Marine models suggested that Japanese tsunami debris would reach North America in the spring of 2013. So, in late spring 2012 marine researchers were surprised to see remnants of a large dock floating just off the coast of Oregon. As luck would have it for the researchers, it was spotted just a few miles from a marine biology lab staffed by Carlton's colleague, John Chapman.

"We knew it was from the tsunami because four very large docks had been lost, and the piece we recovered had the name still legible on the side," Carlton said.

More surprisingly, roughly 100 organisms were alive on the dock section, surviving despite being cast out into the high seas with little food, ultraviolet rays, cold water and predators. Then, more debris arrived, including boats, buoys, large pieces of metal and Styrofoam. All carried non-native species that survived–a phenomenon called marine rafting–with some being at sea for nearly a decade. Today, Carlton said thousands of non-native species are likely to have survived the passage, with a fair number "getting off the train" somewhere in the open ocean. Curious to see what else could be offshore, Carlton and colleagues took a boat out to look. That quest revealed that some species continued to thrive on vast amounts of floating plastic, creating a novel habitat.

"We've hardened the surface of the ocean with millions of pieces of non-biodegradable plastic that has given them a substrate to live on," Carlton said. "It's really one of the last untouched places on Earth, the high seas and the vast ocean. This was a profound modification."

Carlton continues to work with colleagues, collecting data and searching for new non-native species. He intends to publish an update soon to a 2017 paper he co-authored with eight colleagues on "transoceanic species dispersal and implications for marine biogeography." The original paper appeared on the cover of the journal *Science.*

RAPID ASSESSMENT SURVEY

Marine rafting, ballast water and warming oceans have all contributed to the changing ecosystem along the coastlines, particularly within Long Island Sound. Carlton now leads teams of novice and experienced researchers on an intense week-long survey of the Sound during the summer to understand better how it is changing, including one last summer funded by Connecticut Sea Grant.

Called Rapid Bioassessment Surveys, the initiative requires the team to collect samples of native and non-native species

Botrylloides violaceus, commonly called "chain tunicate" or "orange sheath tunicate" is a species from Japan that was found during the rapid bioassessment survey. Photo: Judy Benson

on a defined stretch of coastline from Maine to New York. Researchers spend an hour at each site, usually at marinas and along floating docks known for their rich biofouling communities.

"Long Island Sound is a model system for understanding historic change in coastal environments," Carlton said. "It's a great spot because it includes some iconic places…and has large human and fisheries populations along the shore."

Because of warming waters, he notes, "the invasive species are thriving."

He said the Sound is an ideal place for the assessment because data on the species of fish, molluscs, crustaceans, invertebrates and seaweed have been well documented over the past century.

Through the assessment and by talking with local fishers and residents, the team can track the steadily shifting populations of species migrating north from the Chesapeake Bay that normally would not survive.

THE WIZARD OF INVASIONS

Throughout his 40 years of teaching and 26 years as the director of the Williams-Mystic program, Carlton worked with or sponsored thesis research for more than 100 undergraduate, graduate and postdoctoral students worldwide. They have joined him in his laboratories, for bioassessment summer research programs and in remote locations collecting and logging new native and non-native marine species.

When colleagues and current and former students are asked about Carlton by someone unfamiliar with his work, they certainly talk about his research, but they share a common theme of admiration about who he is as a person.

"He's an amazing teacher who is passionate about his research and in love with life," said Diamela De Veer Pueyo, a postdoctoral researcher at SERC.

He's been called the godfather or father of marine invasion biology. Aria Lupo, a biological technician at SERC, prefers the title of "Wizard of Bioinvasions."

"He's been everywhere, knows everyone and he just seems to make things happen," said Lupo, who worked with him over college summer breaks. "My exposure to marine science and the realities of field work were through him."

His colleagues and students appreciate the support he gives them to develop their own projects and follow their instincts.

Katie Brandler, a sophomore marine science and conservation major at Duke University, first worked with Carlton as a sophomore in high school. Searching for a mentor, she emailed Carlton out of the blue. He responded immediately.

"He spoke to me for an hour about the research, job openings in the field and about his studies," she said. When they hung up, Brandler had secured a chance to work with Carlton on his new research in Long Island Sound.

WHY CARE?

Across the street from the James T. Carlton Marine Science Center of the Williams College—Mystic Seaport Maritime Studies Program building, on the museum's main campus, new educational boards are displayed for the public about marine invasive species. Carlton believes in educating the public about what's in their waterways to help them understand why they should care.

"I can answer that question in a scientific way, but so much of it is cultural, social and philosophical," he said. "The appreciation of the diversity and beauty of nature, can I teach that? Or does that come from within?"

In the last four or five decades, there have been significant changes in American fisheries, yet most people are unaware.

"When they go to Legal Seafood and look at the menu they wouldn't notice," he said. Replacement species and a global supply chain can mask the scale of the change.

When the public, politicians and well-meaning environmental groups seek to restore an area, the issues that arise can be tricky, Carlton said.

"It's a shifting baseline, but you tend to lament the world you knew as a child," he said.

In his office, hundreds of books line multiple bookcases, desktops, and windowsills. Species samples are stacked on shelves, and "the largest collection of invasive species T-shirts" hang on the wall near his desk.

"I don't consider myself a hoarder, but as a collector. That's a fine line," he said.

James Carlton has an extensive collection of invasive species in his office from over 40 years of teaching and research. Photo: Megan Bard

'He's been everywhere, knows everyone and he just seems to make things happen.'