RHODE ISLAND'S OCEAN AND COASTAL MAGAZINE • VOL 10 NO 2 WINTER 2018

41°N

GEOLOGY

A PUBLICATION OF RHODE ISLAND SEA GRANT & THE COASTAL INSTITUTE AT THE UNIVERSITY OF RHODE ISLAND • A SEA GRANT INSTITUTION

41° N

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41° N is published twice per year by the Rhode Island Sea Grant College Program and the Coastal Institute at the University of Rhode Island (URI). The name refers to the latitude at which Rhode Island lies.

Rhode Island Sea Grant is a part of the National Oceanic and Atmospheric Administration and was established to promote the conservation and sustainable development of marine resources for the public benefit through research, outreach, and education.

The URI Coastal Institute works in partnerships to provide a neutral setting where knowledge is advanced, issues discussed, information synthesized, and solutions developed for the sustainable use and management of coastal ecosystems. The Coastal Institute works across and beyond traditional structures to encourage new approaches to problem solving.

Change of address, subscription information, or editorial correspondence: 41° N, Rhode Island Sea Grant, University of Rhode Island, Narragansett Bay Campus, Narragansett, RI 02882-1197. Telephone: (401) 874-6800. E-mail: 41N@gso.uri.edu

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UNDERLYING EVERY WAVE THAT CRASHES ON RHODE ISLAND'S shore are millions of years of geologic history. In this issue, we examine the many surprising (to me, at least) ways that geology shapes life along our coast.

41°N: Rhode Island's Ocean and Coastal Magazine is dedicated to bringing you stories and images that reveal interesting and unexpected details of scientific discoveries, the ocean economy, Rhode Island history, and the lives of people who work on and around the water.

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Thank you for your support!

—MONICA ALLARD COX
Editor

RHODE ISLAND SEA GRANT NOTECARDS

Contents

Laying Low

GEOGRAPHICAL VULNERABILITIES OF COASTAL LIVING

by **Meredith Haas**

AN OLD CHURCH CONVERTED INTO TWO TOWN-homes sits 60 feet above Newport Harbor, safely away from the encroaching sea.

It is here that long-time Newport residents Hilary and David Stookey moved nearly five years ago, leaving their previous home along Almy Pond, a stone's throw from Bailey's Beach. They sought refuge, in part, from flooding, a rising sea, and the erosion that is consuming Rhode Island shorelines—which are also sinking.

"Did climate change play a part in this? Oh, yes. Major time," says Hilary about their decision to move. She describes watching the water from the pond rise up on their former property during previous storms. On a few of these occasions, they received phone calls from the police department telling them to evacuate their home. "There were several reasons for wanting to leave, but we'd seen that image," she says of the damage caused by storm surge and heavy rains. "And we weren't very keen [on staying]."

Although the Stookeys had lived in and traveled to over a dozen cities and countries before settling in Newport 16 years ago, their latest move was the first to be influenced by changes in the local landscape–many of which are the result of the area's geological and geographical features.

Part of the problem for Rhode Island is that the majority of its coastal zone is at sea level or only 10 to 30 feet above. These low-lying areas encompass not only residential homes, but also historic buildings, businesses, and important infrastructure (such as roads, bridges, hospitals, fire stations, and wastewater treatment facilities), as well as salt marshes that are vital habitats and buffers against wave energy and storm surge. The Stookeys' former property reached roughly 10 feet above sea level at its highest point, making it highly vulnerable to an influx of rain or stormwater pouring from the 13 drains that filter into Almy Pond.

"It comes down to low-lying areas where you're going to see huge areas inundated during storms and sea level rise," says Bryan Oakley, a geoscientist at Eastern Connecticut State University investigating shoreline change in Rhode Island. He explains that some places—like Island Park on Aquidneck Island and Oakland Beach and Brushneck Cove in Warwick, as well as areas in Barrington, Warren, and Bristol—are especially vulnerable due to a combination of development and low elevation.

"They're all sitting on glacial deltas, or stratified deposits of sand, gravel, and mud ... if you look at deltas, wherever they are around the world, they tend to be flat, gently sloping land forms susceptible to inundation and sea level rise."

Vulnerability is tied to elevation and erosion.

Once the water rises a little, Oakley says, "It can go inland a pretty good distance."

While some areas may be more vulnerable than others due to the extent they are developed, all of Rhode Island's 21 coastal communities along the 400-mile stretch of coastline are vulnerable to inundation and wind-driven storm surge—even more so as sea levels continue to climb.

A 2017 report by the National Oceanic and Atmospheric Administration (NOAA) projects a greater increase in global sea levels than previously expected—up to 8 feet by the end of the century. The Northeast, however, is anticipated to experience an additional 1 to 3 feet on top of that projection.

In Wickford, 2 to 3 feet of sea level rise—expected by 2050—would put the town dock underwater and threaten over 100 properties collectively valued at $68 million to $95 million. Statewide, 3 to 5 feet of sea level rise would compromise almost 100 miles of roadway, an amount that doubles at 7 feet of rise. At that level, much of downtown Providence and the ports of Galilee, Quonset, and Providence would be underwater, and nearly 7,000 people living within the flood zone would be at risk, according to a recent Rhode Island Division of Planning report.

Add in storm surges and the problems get worse. During Superstorm Sandy, Rhode Island's south coast was hit with storm surges reaching nearly 5 feet above normal high tide. In Providence, the storm surge height was 9.4 feet above sea level and 4.6 feet above normal high tide. Researchers are beginning to see the degree in which the shape of Narragansett Bay may be contributing to greater surge heights in specific areas.

In a recent pilot project by the Coastal Resources Management Council (CRMC) and the University of Rhode Island, researchers compared the state's exposed southern shore with more protected areas in the upper bay region to assess differences in coastal vulnerabilities. They found that the narrowing of the bay northward toward Providence intensifies wind-driven storm surge, concentrating damage in isolated pockets, whereas surge would spread out more evenly over a greater geographic area along Rhode Island's southern shoreline.

"It turns out there's a 40 percent amplification from the mouth of the bay to the head of the bay ... and almost no amplification as you go along the [southeastern] coast," said Malcolm Spaulding, a professor emeritus of ocean engineering at URI, as reported by the *Providence Journal,* during a public meeting last summer. "I didn't quite believe that until I started taking a look at the numbers, but sure enough."

As storm surges are magnified with every foot gained in sea level rise, their effects will ripple throughout all coastal areas for the entire state.

"If NOAA is anywhere near right on this, it's an order of magnitude faster than we've seen over the last century, and we're already … seeing flooding in areas [like Newport] that have never flooded before," says Oakley.

"To put it in perspective, we've had 10 inches [of sea level rise] during the last 90 years," said Grover Fugate, executive director of Rhode Island's CRMC, during a meeting with state energy and environment officials in February, according to a report by ecoRI news. "We're potentially about to have 10 feet in the next 80 years."

This added boost in local sea level is attributed to a combination of factors, according to Oakley. A warming climate is melting the Greenland and Arctic ice sheets, as well as weakening the Gulf Stream, which is drawing less water away from the East Coast.

And some places around the world, including Rhode Island, are sinking.

Although it has been over 20,000 years since Rhode Island was covered by ice, its effects remain present as the land slowly subsides.

The Laurentide Ice Sheet—a massive, mile-thick sheet of ice about the size of Antarctica—covered much of North America from Canada to Block Island and Long Island at its peak nearly 26,000 years ago. Its weight forced the Earth's crust to sink into the underlying, more pliable mantle below, much in the same way a cargo ship would when loaded. The more fluid mantle material then flowed outward, underneath the Earth's crust, toward the edge of the ice sheet, forming a peripheral bulge, elevating the surrounding landscape. But as the ice retreated, removing the load from the Earth's surface, the mantle material that had flowed outward began flowing back, causing those areas that were once elevated to drop back down.

"That's what's happening now for Rhode Island. We're on that peripheral bulge," says Simon Engelhart, a geoscientist at URI investigating past changes in sea levels and concurring land subsidence.

He explains that while the peak of the bulge is in New Jersey, Delaware, and Maryland, where the land is sinking at a greater rate of 1.5 millimeters per year, Rhode Island is still losing about one millimeter annually based on measurements from a GPS installed on the URI campus. This subtle sinking, which could continue for tens of thousands of years before leveling out, may seem minimal compared to projected sea levels, but is still a significant contributor to sea level rise at present.

"[Land subsidence] is going to be important in the short term even though it's small because it's still a component of what we're seeing," he says, referring to "nuisance flooding." These events, which are expected to increase with sea level rise, can cause road closures, overwhelm storm drains, and damage surrounding infrastructure. "The Newport tide gauge [measures] about 2.7 millimeters per year of relative sea level rise since it was started in 1930. A little more than a third of that is coming from land subsidence."

Not only is the land sinking, it is also retreating landward. Coastal environments are naturally in a constant state of change as breaking waves, wind, tides, and currents move sediment from one place to another. Both salt marshes and beaches have the tendency to move toward the land behind them due to storm direction and sea level rise. But when the land is developed, this process is blocked, leading to a loss of shoreline and of the salt marshes that protect inland areas from storm surges and absorb floodwaters from heavy rain.

Rhode Island has already lost more than half of its salt marshes due to development since the Industrial Revolution, and this loss is continuing at alarming rates. Sediment is crucial to maintaining their elevation, says Engelhart, noting that salt marshes have been able to keep pace with land subsidence rates but not accelerated sea levels.

"Wetlands can't produce organic matter, or wetland peat, quick enough to allow them to maintain their position," he says.

But Oakley stresses that it's more of an issue of space. "If you give [salt marshes] the space, the hope is that they can keep up with sea level rise and migrate because they like to be at that certain elevation of water," he says. "The challenge is [when there is] developed property, sea walls, or roads [behind them], and so they don't have the space to continue to migrate."

Oakley argues the same is true for barrier beaches, pointing to Napatree Point as a good example of a naturally evolving beach barrier. This 1.5-mile sandy spit along Rhode Island's southern shore in Westerly that separates Little Narragansett Bay from the Atlantic Ocean has been pushed about 250 feet landward (toward Little Narragansett Bay) since 1939 via storm surge overwash and deposition of washover fans during hurricanes.

"Barriers are resilient landforms and are formed by the same processes that modify them. The things that are problems for people on barriers—storm surge and overwash—are the same things that form these land forms," he says. "If you allow them to operate, barriers will be OK. They'll move, they'll migrate, and faster with sea level rise, but they'll probably still exist as long as we leave them alone."

Unfortunately, coastal communities draw hard lines in shifting sand.

"In terms of erosion, the most vulnerable spots are the south shore. It's a combination of geology and

The barrier beach that is Napatree Point in Westerly has moved 250 feet landward since 1939.

where it's developed," says Oakley, citing Matunuck and Misquamicut as two of the most vulnerable areas in the state due to a combination of infrastructure, low elevation, and high erosion rates.

"Both are eroding glacial headlands—land that can erode relatively easily," he says, noting how they behave more like barriers and experience higher erosion rates than other areas along the south shore.

"[Matunuck] is subject to a lot of erosion for reasons we don't have the definitive answers for. We have some speculation and some ideas, but it's certainly a combination of the right elevation, the right wave focus, and the right conditions to have a high rate of shoreline change—approaching 5 feet per year at South Kingstown Town Beach."

Although the lowest points are still going to be the most vulnerable due to inundation and overwash, the bluffs on Block Island are made of similar material and just as vulnerable to erosion.

"The bluffs will continue to erode no matter what we do with sea level rise because waves can reach the base of the bluff and undercut and cause erosion," Oakley says. "But there isn't a ton of development right on those places where you'd see massive loss of infrastructure from the bluffs eroding. And the benefit of the bluffs eroding is providing a source of sediment for the beaches. Even though it's high wave energy, the east side of Block Island and parts of the south side have low erosion rates comparatively because they're getting fed by the sediment coming from the bluffs."

Then there are headlands, such as Weekapaug Point, Green Hill Point, and Point Judith, that are made out of more resistant material called till—a mixture of clay and boulders left by the glacier. "They're the ones that are more resistant and erode a little bit slower than the other headland and barriers," he says.

But they, too, will erode. And the changes to the coastal landscape at large will challenge coastal communities to act.

"We've got to be able to adapt to this because all of these areas are going to see impacts faster," says Oakley. "That's a scary proposition, but it's one we can deal with if we start to act and think about it now rather than [if we] keep dragging our feet."

Since their move, David Stookey utilized his background in finance and spent three years writing the self-published book *Climate-Proof Your Personal Finances* as a way to help people start thinking about the costs associated with changes in the climate. "It's looking for a moment to [act] even if you don't have to because things aren't that bad yet," he says.

Stookey describes the ocean view from the bedroom window of their former home, joking that with one good storm, Bailey's Beach, between Almy Pond and Narragansett Bay, would be gone, allowing them to sail directly out to sea. "Maybe we could've stayed there another 10 years," he says with a shrug.

"We could see the ocean side of Bailey's Beach from the upstairs of the house," he says. "I would visualize a hurricane and think 'this is not a good place to be.'"

The Landscape of the Sea

SAILORS MAY BE SHAPED BY THE WATER, BUT IT'S CLEAR THE LAND INFLUENCES THEM, TOO

by **Elaine Lembo** Photographs by **Onne van der Wal**

HAVE YOU EVER STOPPED TO CONSIDER THAT IN the pantheon of historic milestones of Rhode Island, there is one event that rises above all others? Moreover, that it underscores the significance of the natural attributes of the Ocean State and its renowned estuary, Narragansett Bay, as well as how they are intertwined with the people who over the centuries have thrived here?

Notoriously, the 1772 grounding and burning of the British revenue schooner *Gaspee*—an act whose ramifications were transatlantic in scope—involved sailboats and their crews. It also showed how local knowledge of depths, shoals, and shallows helped one crew to partake in a bold act of defiance, while lack of it led the other to disaster.

In another sense, this famous event illustrates just how much the configuration of the state's shores, islands, and bay—both sandy terminal moraine remnants and the hard granite of the deep ancient river valleys left by glacial episodes of the Pleistocene period—influenced sailors and sailing, does so today, and will continue to do so tomorrow.

A Time of Transformation

Also called the "Prelude to a Tea Party" and the "first blow for freedom," the *Gaspee* incident is an event that, particularly for Rhode Islanders, supersedes those in Boston and Philadelphia for status as the first significant act of colonial revolt.

One thing is certain: the lore of the *Gaspee*, the packet sloop *Hannah* that it chased to its peril onto a shoal off Namquit Point, as well as the Pawtuxet Village holiday that commemorates the act, took hold in the hefty imagination of a young Rhode Islander, Christopher Pastore. And as he matured into a keen sailor, writer, and college professor, Pastore thought of the *Gaspee*, the contours of his home state in southeastern New England, and the waters he'd often taken to with gusto, in a new light.

The result, *Between Land and Sea: The Atlantic Coast and the Transformation of New England*, is Pastore's examination of the Narragansett Bay watershed from first European settlement through the early 19th century. Published in 2014, its chapters present the symbiotic relationship of land and sea with people along many lines, from cultural and historic to economic and political. In so doing, his treatment of the influence of the area's topography on water-based trade, transportation, and recreation is a constant thread.

Pastore holds specific views about the bay and shores—not just how people use their features, but how, he suggests, they should think about them. "Much more than a geologic formation or passive recipient of human action, Narragansett Bay is a cultural construct, created and recreated by the people who live near and work on its waters," he says. "We need to think of how the estuary has changed over time materially and imaginatively. The way people imagine things shapes the way they interact with their world."

That the bay looms large in the minds of its citizens is hard to dispute, from the existence of organizations committed to protecting its longevity to its renown as a premier locale for world-class sailing and racing.

"In many ways, the bay is the soul of Rhode Island," Pastore says. "Through our cuisine, our recreation, there's an awareness of the bay and the ocean. Even people who know nothing about sailing—they know it's there, they understand the America's Cup, even if only a little bit. The fact that the belly of Rhode Island is Narragansett Bay, I believe, is clear indication that geography affects awareness."

Facts and Attributes

Some indisputable facts put the water around us front and center:

• Narragansett Bay bisects Rhode Island, extending 28 miles inland, up to 12 miles across, and includes 36 large and small islands.

• It covers 10 percent of the state's area and reaches two-thirds of the way into its borders.

"The water's just a short hop from virtually every Rhode Island community," observes Ocean State native and longtime cruising sailor Lynda Morris Childress. Her *Narragansett Bay and the South Coast of Massachusetts* guide to sailing the region remains the go-to source for boating here. Published in 1996 and relevant today, it includes detailed directions and descriptions from local knowledge, research, and onsite exploration of hundreds of accessible anchorages.

Childress organizes the area into four regions: upper, middle, lower (including Block Island), and the Sakonnet River. The inclusion of the southern Massachusetts coast, as well as Buzzards Bay, Nantucket, and Martha's Vineyard makes sense, as sailors, by nature, have for centuries explored these nearby regions along with Rhode Island waters as one body—another fact that underscores just how uniquely situated we are.

Indeed, interpretations of the bay's exact boundaries have varied throughout history. According to Pastore, although some Rhode Islanders imagined the bay as extending from Gay Head to Montauk, a 1741 boundary dispute between Rhode Island and Massachusetts defined Narragansett Bay as extending from Point Judith to Sakonnet Point, a geographic designation that still exists today.

The alluring natural attributes of this piece of geography that juts into the Atlantic Ocean are many. As Childress and countless others know well, advantages include accessibility from myriad launch sites, an average water depth of 26 feet, and reliable southwest winds in summer popularly named the "smokey southwester." And, the bay generally tends to freeze up less in winter than ports farther north.

But there's much more, and it's best to let sailors themselves describe it.

According to Robert Morton, marine geologist, longtime competitive ocean sailor, and managing partner of Newport Biodiesel, what he most appreciates about the area for water-based recreation is directly linked to its past.

While beachgoers enjoy the result of what happened at the lower boundary of glacial ice movement —the sandy terminal moraine deposits reaching from Long Island through to Block Island, Cape Cod, Martha's Vineyard, and Nantucket—what Morton values most are the river valleys it cut out underneath.

"I really like New England because you have glacial estuaries," he says. "There are so many harbors and so many places to go. It's a varied place to sail. You go to Florida, it's all the same. You go to California, there are two harbors you can go to. I really think that the geology of New England is unique. You get the glacial effect here."

Besides being responsible for the creation of so many anchorages, the "glacial effect" sets the stage for thrilling racing. "The currents created by all the islands and channels add a whole other challenge to racing," Morton says. "It makes it fun."

It's also no coincidence that the New York Yacht Club, which held its first cruise to Newport in the summer of 1844—the year it formally organized as a club—also chose Newport as its summer base and site of yacht racing for the America's Cup, the oldest trophy in international sport, from 1930 to 1983.

"They liked coming to Newport because of its good, deep natural harbor," says Sheila McCurdy. Among hefty credentials, McCurdy is a trustee of Mystic Seaport Museum, a licensed captain, and has skippered and crewed in countless ocean and inshore races and cruising events, with more than 100,000 miles in her wake. She holds a master's degree in marine affairs from the University of Rhode Island.

A resident of Newport's next-door town of Middletown, she fully appreciates the conditions that account for the celebrated historic and modern-day appeal of the bay and Southeastern New England racing and cruising grounds overall.

Besides oppressive summertime heat in New York, she says, to get out to a place to race, urban crews must head out past Brooklyn and Sandy Hook Bay. As any Rhode Islander can attest, everything rests on convenience and ease of access. "Here, you are in the ocean in three miles," she says.

Sailboat racing is a popular pastime in Newport, known to some as the "sailing capital of the world," thanks to glaciers of long ago.

Or, as sailor, retired marina manager, longtime bay advocate, and Newport resident Michael Keyworth succinctly puts it: "It's a wonderful story that other coastal states can't tell."

The Pearl of Rhode Island, Today and Tomorrow

But with all this appeal comes responsibility, a daunting prospect for a Yankee society that over the centuries grew accustomed to developing, as well as polluting, the waterfront.

"By creating something with a clearly defined edge, we've made the coast less resilient, less able to absorb the blows of human initiative and natural variation," Pastore asserts.

Today, the far-ranging impacts of that human initiative are unavoidable and require attention, according to a variety of stakeholders and officials.

Licensed captain and maritime instructor Kent Dresser is among them. Dresser's background includes salvage and rescue; he also heads up Clean Bays, a group specializing in shoreline debris mitigation.

"Various interests have left decades of industrial waste in the bay," he says. "It's not just that people throw garbage on the beach. We have built and abandoned our shoreline, generation after generation, up and down the pearl of Rhode Island, Narragansett Bay."

Clean Bays' efforts include removing more than 100 camels—10- to 12-ton wood-and-steel objects used as fenders between naval ships—from bay waters, Dresser says.

"Essentially, these are railroad ties soaked in creosote," he says. "Debris such as this has a deleterious effect on sailing and boating. Anyone who has ever struck a submerged object or worried about striking a submerged object understands the negative impacts of marine debris.

"If you want to come home from the Bermuda race and sail into Newport late at night, or have the boats in the Volvo Ocean Race barrel up the East Passage, you want to make sure they're not going to hit a 12-ton camel when they sail past Castle Hill. That would have a negative effect on everybody. Do we want boats and a coastline, or do we want garbage? I choose boats," Dresser says.

Beyond immediate, ongoing concerns about pollution are those regarding climate change.

According to Grover Fugate, executive director of the Rhode Island Coastal Resources Management Council, marina owners and other waterfront developers will need to adapt to big changes by the middle of the century. Updated projections of sea level rise of, at the high end, up to nearly 10 feet by 2100 will "take out potential infrastructure for sailing and boating by mid century," Fugate says. "There's very little that will be left."

While mitigation efforts will determine actual sea level rise and "the boating world isn't going to go away, it will have to change how it uses these areas," he adds.

Predictions like those are a concern for naval architect and engineer Andy Tyska, who's the president of Bristol Marine. As a small business owner, he's active in civic and industry groups such as the Rhode Island Marine Trades Association, where he's served as president and chairman of several committees.

His perspective on how economic interests have contributed to Pastore's "defined edge," and what may lie ahead, is tied in part to his involvement in waterfront enterprise.

"In business, you can't always resign yourself to the hand that Mother Nature deals you, and do nothing, nor can you disregard coastal features and develop the waterfront solely around your needs," he says. "A balanced, environmentally responsible approach is most appropriate."

"To stay economically viable, a balanced way is, in my view, the best way," he adds. "You get to it through adaptation of the shoreline that's thoughtful, with responsible zoning and protected uses to minimize impact. It allows for predictability of operations in shipping, trade, and recreation while remaining sensitive to the environment."

Regarding potential shoreline changes as a result of climate change, he says: "Culturally and economically, we are very much dependent on our proximity to and access to the water, and as we adapt, we'll continue to find innovative ways to access the water for trade and for recreation in a manner that keeps that part of the fabric of our existence alive."

Those sentiments aren't lost on Curt Spalding, former regional administrator for the Environmental Protection Agency and former longtime executive director of Save The Bay. Spalding, a lifelong sailor and experienced ocean racer, treasures memories of his father bringing him to the bay to watch the America's Cup. It set the stage for an adulthood of bay stewardship and efforts to improve its water quality.

"Chris Pastore's argument is that we've made the challenge more difficult because of our European pattern of dominating the ecosystem to our economic benefit," he says. "Creating a hard, much less dynamic edge is part of that development. We have to figure out how to work to secure the bay's resilience and health in the face of climate change and sea level rise.

"Essentially, we're depending on systems and supporting infrastructure that have to get wet. We've never thought of that. Could we live with it? The bigger problem will be how we reset our understanding of that edge. The water will come over it. You can raise areas and protect them, channel the water to places, but you're not going to hold water out. That's a completely different idea than what's existed from 1600 to today. Building ever higher walls simply won't work."

Yet sailors, so shaped by the sea, can be part of the solution, Spalding believes.

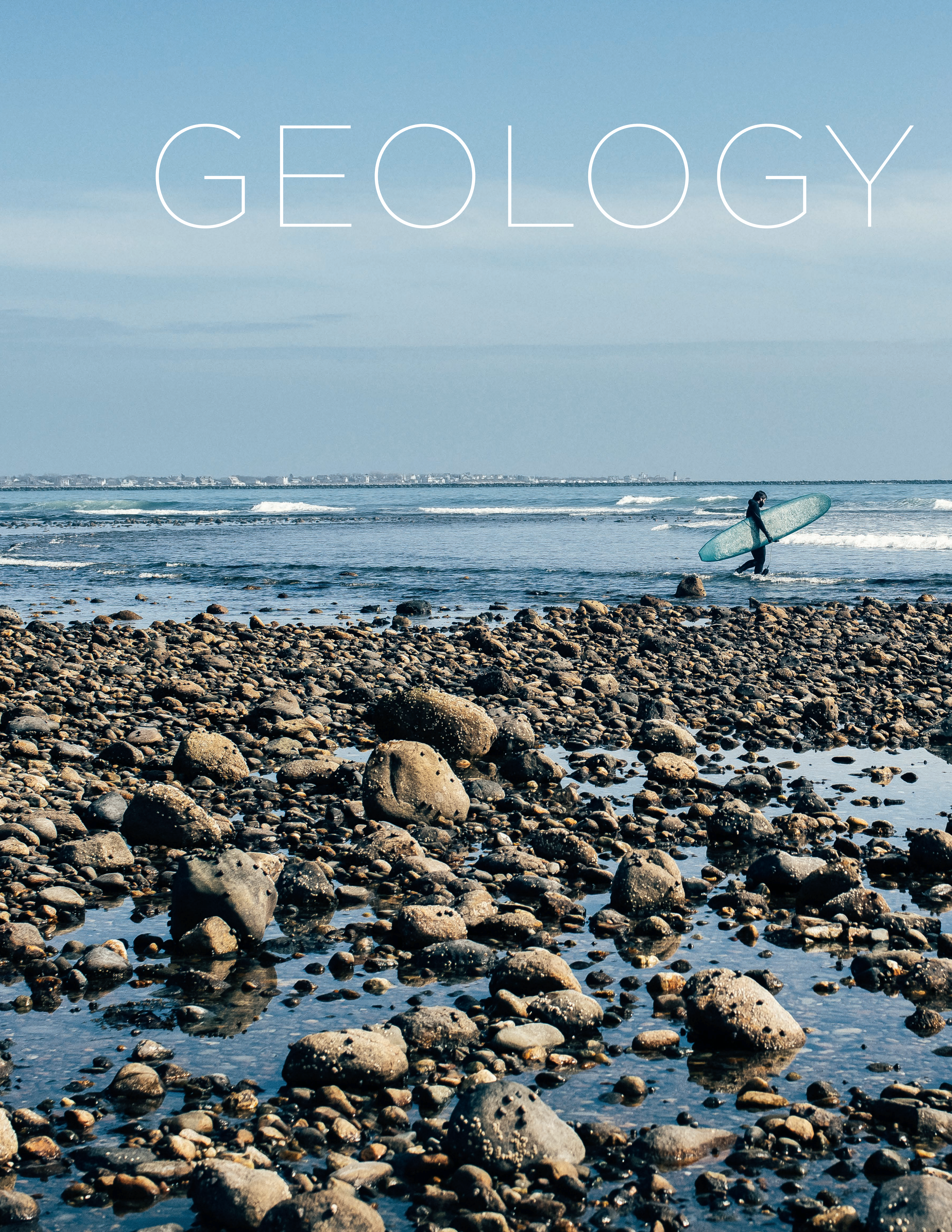
"Sailors can be thoughtful contributors to a new approach of redefining the hard edge of our coastal and island communities," he says. "Why? Capable sailors understand the need to change before change happens. Sails have to come down before the wind is out of control. Precautions need to be taken to avoid a catastrophic outcome. In a similar way, we need a much more proactive mindset to adapt to our rapidly changing coastal areas. The fundamental mindset of a sailor fits this line of thinking pretty well."

That mindset can extend to the larger citizenry here.

"There's something very deep in Rhode Islanders' sense of place and geography," Spalding says. "The opportunity to connect with our marine environment is extraordinary. As Pastore points out, the way we live here includes wide access to fishing and coastal activities. Whether we sail, fish, comb beaches, or simply observe, we have an especially intimate relationship with these resources. If we can engage in a conversation about resilience, accepting the need to change, and how, as sailors and fishermen, we already know our coast is dynamic, it gives me optimism that we'll figure it out."

Or, as Pastore so eloquently puts it: "Perhaps it is time to forge a new definition of progress, one that accepts the necessity of hybridity and impermanence by embracing the sea. For if the push of progress is to define Rhode Island's future relationship with the bay, it will no doubt be met with the pull of the sea's powerful tides."

GEOLOGY



IN MOTION

THE FOUNDATION OF SURFING

by **Meredith Haas**

Photographs by **Jesse Burke**

SURFING IN NEW ENGLAND OFTEN MEANS DONNING thick, hooded wetsuits, navigating the occasional snow-covered beach, and avoiding rocks—conditions that explain why surfing here was slow to catch on when the sport first took hold in the warmer waters and sandy beaches of California and Hawaii before gaining broader popularity in the 1960s. It was hard to believe, then, that there was even surf in Rhode Island, or anywhere along New England's rocky coast.

Now, several decades later, on any given day of the year, whether conditions promise ankle-biter waves or overhead sets, you can usually find suited-up surfers making their way out to popular surf spots, including a south-facing reef that extends several hundred yards between the Ocean Mist and Matunuck Point in South Kingstown. Known for its consistent left or right breaks of either soft peeling waves or heavier, faster sets when big south or southeast swells roll in, this cobblestone reef is an extension of the Matunuck headland and the remnant of a glacier that retreated over 18,000 years ago, says Bryan Oakley, a geoscientist at Eastern Connecticut State University.

As surfers wade out to these breaks, each careful step over the various contours and sizes of cobblestones and boulders speaks to the geological history from which all surfers, including windsurfers and kite boarders, benefit.

Long before surfing came to Rhode Island, and long before the first wave was ever ridden nearly 3,000 years ago in Western Polynesia, waves have been crashing along shorelines that have contracted, expanded, and migrated from glaciers advancing and retreating, sea levels falling and rising, and plates within the Earth's crust converging and diverging to form the landmasses of today. In short, surfers have been benefiting from millions of years of weathering and tectonic activity that have subsequently shaped coastlines and their respective breaks. And while Rhode Island may not boast large, powerful waves like those found at Mavericks on Northern California's coast or the tubes of the Banzai Pipeline on the North Shore of Oahu, Hawaii—where waves can crest over 25 feet—its surfing community, like all others worldwide, is tied to the local geology—specifically, the topography of the seafloor.

"There's a direct correlation between geology and surfing," says Jim Turenne, a soil scientist with the Rhode Island Natural Resources Conservation Service and an avid local surfer, pointing to various surf spots in Rhode Island on an interactive soil map that identifies coastal composition as sandy, cobblestone—rocks that vary in size from four inches to a foot—or larger boulders. "The bottom tells you what kind of break it will be."

Waves are the result of a domino effect of energy generated, mainly, by wind. The greater the speed of the wind, the longer it blows, and the greater the distance over which it blows (also known as fetch), the bigger the waves. As individual waves organize into sets traveling at the same speed, their quality is determined by the amount of time two successive wave crests pass through a fixed point, known as the swell period.

"As a general rule, the longer the swell period, the further the swell has traveled, allowing the swell to become more organized," says Brian Caccioppoli, a local surfer and marine geology research assistant at the University of Rhode Island Graduate School of Oceanography (GSO). "In addition, the higher the swell period, the faster and more energetic the breaking waves will be at the shore."

Local factors, such as the direction of the swell, winds, and tides are also factors for creating quality surf, but it's not until the swell interacts with the seafloor that it turns into breaking waves. As a swell approaches the coastline and moves into shallow water, friction slows down the bottom of the wave as it meets the seafloor, while the top continues at the same speed, causing the wave to stand up—creating the wave face sought after by surfers—and spill over. This happens when the approaching wave reaches a water depth 1.3 times its height (the distance from trough to crest), which can happen abruptly or gradually, depending on the slope of the seafloor—the rate of the change in depth from the shore to the open ocean.

Areas along the West Coast or along volcanic archipelagos like Hawaii, for example, are associated with large, barrel-shaped waves that are achieved from prevailing winds traveling longer distances across the Pacific Ocean that quickly rise on steep slopes. Because of the rapid change in depth, waves in these locations tend to break with more height and power. Breaks along the East Coast, on the other hand, do not generate as much energy—with the exception of hurricane-generated swells—because storms tend to travel west to east, traveling out to sea, and do not cover as great a distance across the Atlantic as they do in the Pacific. In addition, the East Coast sits on a broad, gently sloping continental shelf that slows swell energy by dragging the wave over a greater distance of the seafloor. Rhode Island's coast sits several hundred miles from the edge of the continental shelf with a slope that varies widely, making some areas unsurfable, such as the shoreline between Monahan's Dock to Black Point in Narragansett that has a quick drop off to roughly 80 feet, making it too deep to produce any surf at that location, according to Turenne.

Joe Klinger


Brian Caccioppoli

Jim Turenne

Swells that hit Block Island tend to be larger both because the island catches swells earlier, as it lies 13 miles south from the mainland, but also because its slope rises more quickly from 200 to 10 feet within several hundred yards. “Tack two feet on to what we’re getting at Point Judith and that’s what they’re getting at Block Island,” Turenne says. The Ruggles break, however, which is located at the eastern end of Ruggles Avenue in Newport and behind the famous mansions of Bellevue Avenue, can hold 20-foot waves on a big swell, largely because of the underlying bedrock.

“When you get into Ruggles, you’re surfing on slabs of bedrock,” says Turenne. “It’s deeper water so it needs a bigger swell.”

Depth and Character

How a wave breaks is just as important as its size and is dependent upon the shape and type of bottom, or features of the seafloor.

“This is why Point Judith has [some of] the best waves,” Turenne says, pointing to the classic point break that juts out like a canine incisor at the intersection between Narragansett Bay and Block Island Sound, explaining that while it might not hold as heavy of a wave as Ruggles, it is more consistent. “If you look at the shoal, [waves are hitting that] and causing them to peel off, versus Narragansett Beach where it’s flat; there’s no structure at all to it, so it just dumps over and doesn’t peel.”

What Turenne is referring to is how wave energy refracts, or is directed over different depths created by these bottom features. Sandy beach breaks, like Narragansett Town Beach, or First and Second beaches at the edges of Newport and Middletown, behave differently from cobblestone reefs and rocky point breaks, as well as breaks over exposed bedrock like Ruggles or in Jamestown, because the bottom is more fluid and susceptible to change. Storms and wave action shift and alter the depth at different points, making these types of breaks disappear and reappear with sand movement, especially along Rhode Island’s southern shore, which is more exposed to storms and higher wave energy. Depending on how the sand bar builds and shifts, the break will change accordingly. A flat beach break, for example, is not ideal for surfers because the wave would crest and spill across the whole line at the same time (referred to as dumping or closing out), which often happens at Narragansett Town Beach.

“Sand bars are always changing,” says Turenne. “Sometimes Narragansett Beach is good, and other times it dumps over with no shape.”

Surfers generally look for peeling waves that break gradually to the left or to the right along the wave crest. This is achieved when one side of the wave is forced to break before another. It’s like a car hitting the brakes on only one side, forcing the car to veer in the direction of its slower half, according to Tony Butt and Paula Russell in their book *Surf Science*. Waves will veer, or bend towards the slower section, creating a wave that’s surfable. Although this can be achieved by sandbars, rocky points and cobblestone reefs offer more consistent breaks with often bigger and longer rides depending on the direction of the swell—one of the main features that sets Rhode Island apart for New England surfing. Due to its largely south-facing coastline, including Block Island, Rhode Island can catch most southern swells (Long Island tends to block

Joe Klinger

southwest swells) that would otherwise bypass most of New England's primarily east-facing coastline.

"The beauty of Rhode Island is that we can surf on just about every direction" of wind and swell, says Turenne.

Thousands of Years in the Making

Many of the 30-some-odd surf spots scattered between Westerly and Little Compton have been thousands of years in the making. While beach breaks are largely the result of more modern processes such as everyday erosion of bluffs and headlands, the processes that create cobblestone and rocky breaks take a bit more time. Much of the underwater geology is glacial till—a mixture of gravel, clay, silt, and sand—that extends out onto the continental shelf, which turns into boulder and cobblestone fields as you get closer to shore. This is a result of the advance and retreat of the Laurentide Ice Sheet, which formed during the most recent ice age in North America. This mile-thick expanse of ice extended from Canada and covered New England more than 20,000 years ago. As the ice sheet advanced, it picked up, crushed, and dragged layers of rock and soil underneath, moving boulders and other material like a conveyor belt toward the coast just beyond Block Island, where sea level was 300 feet lower than it is today. The furthest reach of the glacier is marked by "terminal" moraines where debris of rocks and sediment collected by the glacier as it advanced was dumped at the outer edge of the ice. This is how Block Island formed, along with Long Island, Nantucket, and Martha's Vineyard, which all lie along the same terminal line. Additional recessional end moraines formed at locations where the glacier paused its retreat and deposited a large amount of till in one location (like the Charlestown Moraine along Route 1).

"Glaciers, in addition to eroding and clearing out everything that was here prior to the last glaciation, deposit material directly from the ice or from meltwater in front of the glacier. When a glacier gets to its southern limit, or as it's receding back north as the climate warms, it will form moraines at stillstands [where] the ice just sits at a place and even though it isn't advancing forward, the ice within the glacier is still flowing forward and depositing lots of sediment directly from the ice at that location," says Joe Klinger, another local surfer who is also a coastal geologist and environmental scientist with the consulting firm Ecotones Inc. Point Judith was formed in a similar way, he adds.

"Point Judith is interesting because it's an end moraine in a complicated area where two sub-lobes of ice may have come together. One within Narragansett Bay/Buzzards Bay, and then another lobe of ice to the west. Point Judith is in the middle as well as at that glacial stillstand location," he says. "That's why Point Judith is what it is."

As glaciers advance and retreat, they do so in lobes, or sections that move at different speeds and directions. As climate started to warm and the glacier moved back, the lobe to the west of Point Judith formed what is called the Charlestown moraine and other moraines associated with it, says Klinger. "Out in front of that, all the water that was melting from the glacier was pouring towards the ocean as we know it today. Again, sea level was so low it was on the other side of Block Island, but all that meltwater was


Brian Caccioppoli

carrying glacial fluvial deposits, also termed outwash, and that's what Matunuck is—sand, gravel, and cobble from meltwater outwash," he says. "It's very different from Point Judith, and [it's] what gives Matunuck its specific surfing setup because you have an outwash plain generally sloping south into the ocean. So, when the waves come, they're coming up that cobble bottom and [they] make the beautiful wave that is Matunuck."

"It's mostly rounded rock fragments, which is why Trestles is such a great wave," says Turenne, commenting on one of the three breaks off Matunuck that resembles its famous Californian namesake. "It juts out at the right spot, making it peel right off."

As the glacier continued to retreat up through Narragansett Bay, it exposed channels in the old sedimentary basin that had been scoured and carved from the weight and pulsing of the ice sheet as it advanced south and receded back north, which formed the East and West passages around Conanicut Island.

"In general, the whole state was covered by ice, but the ice falls into two general categories—'clean' and 'dirty' ice. Areas with lots of boulders and till (glacial sediment of very mixed grain sizes) were in the dirty ice zone, and areas in the clean ice zone tend to not have boulders and till deposited as the ice melts," says John King, professor of geological oceanography at GSO, explaining why some of the bottom features differ between the eastern and western half of the state. "In the eastern part of the state, the dirty ice zone of comparable age to the Charlestown moraine was well south of Jamestown and Newport, and those areas were being eroded by clean ice scouring bedrock. There are different things happening near the terminus of a glacier than there are further back beneath the ice sheet. Further back is mostly erosion, whereas there is a lot of deposition at the ice margin."

But the bedrock between Jamestown and Aquidneck Island are different from each other, according to Turenne. The breaks at Jamestown, for example, are over flat slabs of shale, similar to the break at Bonnet Point, he says, that formed roughly 300 million years ago when the wetland, which is now Narragansett Bay and referred to as the Narragansett Basin, was buried, compacted under tremendous pressure, and transformed into rock. "If you've ever driven through [Route] 138 getting into Jamestown, you go right through the outcrop and notice all the rocks are stratified, and they're black," he says, noting the difference between that and the bedrock that lies beneath the Ruggles break, which is a combination of the Narragansett Basin shale and granite rock over 500 million years old that formed when all of the continents were locked into one super continent near the South Pole.

The underlying bedrock of Rhode Island was formed during this period when it was a volcanic island arc like Japan is today. "Rodini was the first supercontinent that split apart. Laurentia, which is North America, went north, and Gondwana, which was Africa and South America, went south about 1.2 billion to 500 million years ago," explains Turenne. "We were part of Africa as a volcanic island arc called Avalonia. All of eastern New England was part of this series of island arcs."

Future of Surfing in Rhode Island

While processes from the last glaciation took thousands of years, and plate tectonics took several millions or billions of years, to shape Rhode Island's surf to what it is today, rapid changes in sea levels may change breaks further within a few decades. Sea level rise is expected to climb up to 8.2 feet over the next century, according to a recent report by the National Oceanic and Atmospheric Administration, due to the rapid melting of the ice cover in Greenland and Antarctica.

Unfortunately, Rhode Island and the rest of New England will experience an additional 1 to 3 feet of sea level rise above the global projection, according to Rhode Island's Coastal Resources Management Council, due to a variety of factors from increased surface temperatures to changes in the Gulf Stream. This is a significant change in a state that has only experienced 10 inches of sea level rise over the last century.

The consequences of sea level rise are far reaching, and one area likely affected will be current surf spots.

"Some surf spots change entirely in character over a three-foot tide cycle," says Caccioppoli, explaining that it's not uncommon to see surfers leave the water at high tide, especially at Matunuck, where an incoming tide can make the waves deeper and slower.

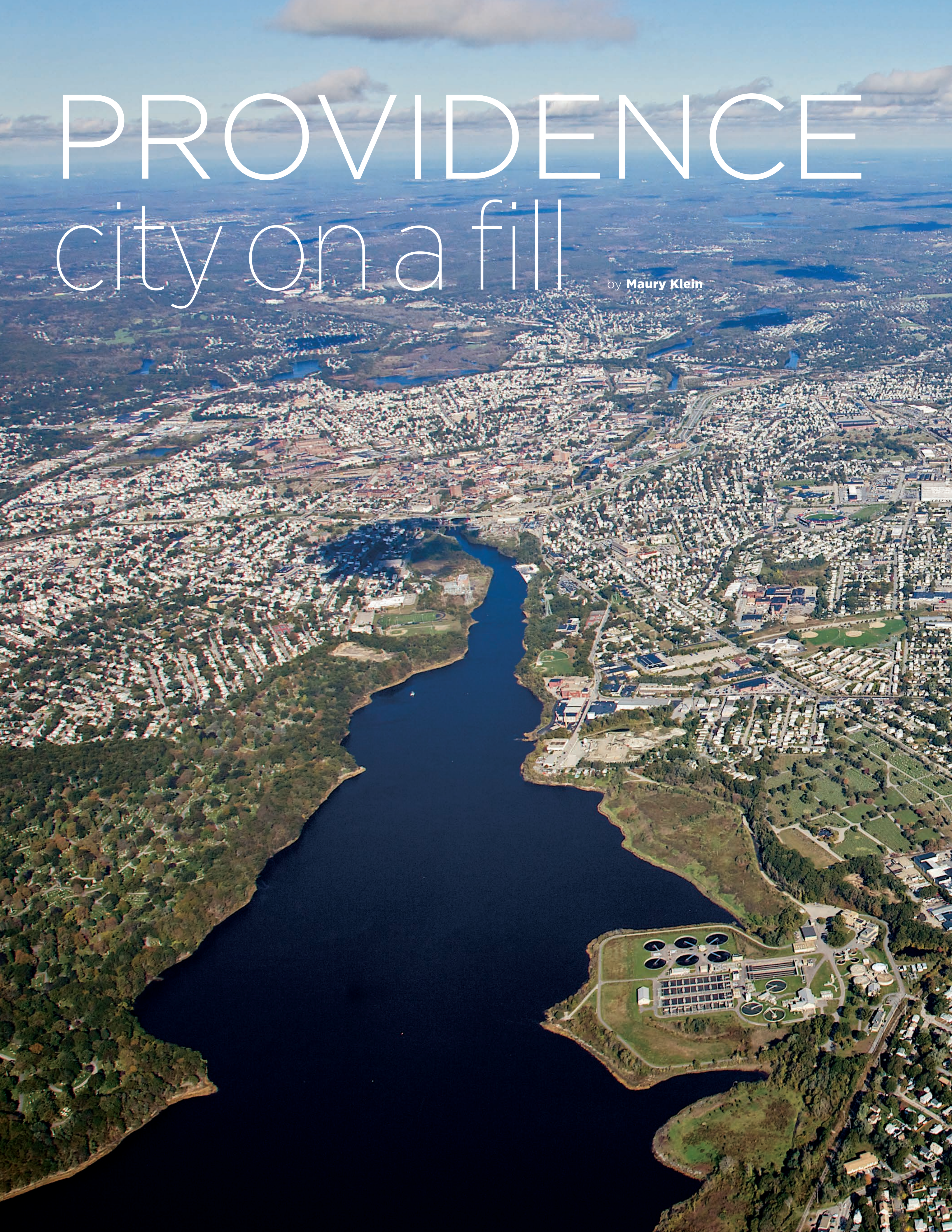
"Over the long term, [sea level rise] is going to completely change surfing in Rhode Island and everywhere else," says Klinger. "As the water gets deeper, the waves are going to break differently and closer to shore, and the places we typically line up now won't be there because the water will be too deep—particularly on those steep bluffs and point breaks."

Klinger adds that beaches will tend to migrate landward and upward (a process called transgression), if they're allowed to, changing how those breaks work, and that surfing spots, like wetlands, will drown if the beaches can't migrate.

"What happens at bluffs like Point Judith and Matunuck is going to be interesting because then it's an interplay between the rate of sea level rise, the amount of erosion, and what we as people do to prevent that or let it happen," he says, adding that these processes don't bode well for surfing in existing spots but may create new breaks in the future. "There's probably areas we don't surf today that might be good spots in 100 years."

PROVIDENCE
city on a fill

by **Maury Klein**



WATER WAS THE LIFELINE FOR EVERY SETTLEMENT in early America. However, as villages grew into towns and then cities, some found themselves squeezed into a space that led them to expand by pushing back the sea through a process that archaeologists call "landmaking." In New England, Boston offered the most conspicuous example. When founded in 1630, it occupied a small peninsula connected to the mainland by a narrow neck. Over time, this 487-acre strip was more than doubled in size by filling in tidal flats and marshes, creating what historian Nancy S. Seasholes calls "an enormous amount of made land." And the size of neighboring Charlestown, now a part of Boston, was nearly doubled by fill.

Providence underwent this same process on a more modest scale. The land purchased by Roger Williams between 1636 and 1638 led to an early settlement at the foot of College Hill near a natural spring. Although scarcely half the size of Newport during the 1700s, the town gradually emerged as a major shipbuilding center with one of its larger facilities located in what is now the center of Kennedy Plaza. Providence sat on an estuary known as the Great Salt Cove, which was formed by the confluence of the Moshassuck and Woonasquatucket rivers into the Great Salt (now Providence) River. A shallow tidewater area, it was bounded by College Hill to the east and Jefferson Plain and Smith Hill to the north. To the west, the Woonasquatucket River meandered through a broad valley of salt marshes. South of the cove lay the Weybosset peninsula that evolved into downtown Providence.

The cove covered several hundred acres and was deep enough to accommodate sailing ships. A drawbridge connected the East Side to Weybosset Point. By the 1790s, Market Square, located at the south edge of the cove, emerged as the town center of Providence. Shipping and seafaring interests spurred the town's growth, along with the coming of textile manufacturing, bleacheries, printworks, foundries, ironworks, and machine firms. The development spurred by increased prosperity soon found itself blocked by the so-called "Seven Hills of Providence," especially Smith Hill and College Hill. One obvious solution was to create more land by filling in parts of Great Salt Cove, which began as early as 1780, for the construction of new wharves. Twelve years later, part of the cove's east side was filled, creating a new street called North Water (later Canal).

In 1782, a committee created to define a limit on encroachments into the cove drew up the city's first harbor line; 15 years later, harbor lines were extended all the way around the cove. "Harbor lines imposed

Aerial photograph by Dave Cleaveland

The rise of railroads marked the end of Providence's Great Salt Cove.
Photo courtesy of Rhode Island State Archives

planned order on waterfront development," explains Michael Holleran, who formerly taught in the architectural studies department at the Rhode Island School of Design, in a 1990 article, "and—most important in the comparatively shallow cove—defined an area meant to be kept as open water." Another waterfront innovation, the frontage street, also blocked excess filling by increasing access to the shore. However, in July 1815, the town extended harbor lines to the lower harbor and in the process fixed the head of navigation at Weybosset, south of the cove. As Holleran observes, "Land interests had triumphed over water interests."

The plan was to build a fixed bridge at Market Square, which meant that ships could no longer reach the warehouses on North Main Street. In September, the timetable moved unexpectedly forward when the Great Gale of 1815 destroyed the existing drawbridge and pitched ships into waterfront structures. Once the new span was completed, the cove ceased to be a navigable outlet to the sea and became instead a tidal lake. The Blackstone Canal, which opened July 1, 1828, added to this transformation by damming the cove's northeast corner to create its tidewater terminal. Later dismissed as "the greatest fiasco in Providence business history," the canal lost money steadily and ceased operations in 1849, but its presence affected the cove's evolution.

To thrive economically, Providence needed efficient overland transportation. Existing roads fell far short of meeting this need, as did the Blackstone Canal. By 1840, the apparent solution emerged in the form of railroads, which the city soon viewed as a primary weapon in its efforts to compete with Boston. Already, in 1835, the Boston and Providence Railroad had opened its line between the two cities. Two years later another railroad, the New York, Providence and Boston (known as the Stonington line), connected New York with Providence. Both lines reached the city at the southern end of the harbor, well below the cove and the center of town. However, in 1844, a third project, the Providence and Worcester Railroad (P&W), proposed replacing the Blackstone Canal with a railroad that of necessity would enter downtown from the north. For this to happen, the road's promoters wanted to construct a terminal and yards on land created by filling part of the cove.

A bitter debate ensued in the city council as the other two railroads, seeing the virtue of a central interchange, asked to join the P&W in a joint terminal. In 1846, the council agreed to let the P&W reduce the cove to an elliptical basin, provided it built a promenade park around it. The cove was, as Holleran observes, "'available space,' quite a lot of it, at the center of a growing city where space was increasingly in demand." It was also "an ornament to the city, to be adorned and protected"—and a smelly nuisance, especially at low tide, from refuse, sewage, and industrial waste that grew viler over the years.

Most of the basin and promenade were completed by 1849. Three years later, the council granted another railroad cove land in the marshes west of the basin if the company agreed to complete the basin wall and promenade. By 1857, the basin entered what Holleran calls its "golden years" when the city landscaped the completed park and decked it out with cast-iron railings and seats. The handsome railroad depot, designed by Thomas A. Tefft, also pleased strolling sightseers. But the stench from human and industrial waste worsened as both the population and number of factories grew. A clash between the rural-dominated General Assembly and the city over control of the cove led to the city buying the state's interest for $200,000 in 1870 and gaining full authority over the lands.

As other railroads sought entry to the cove lands, pressure increased to fill more of the cove. "If it is necessary for us to cut down the beautiful trees in our most spacious gardens, public and private, for the sake of our children and the future of the city," declared former governor William W. Hoppin in 1881, "let us give the railroads these facilities."

Many opposed this attitude. A newly formed group, the Public Parks Association, fought the railroads' effort to acquire the rest of the cove lands but conceded that pollution justified filling the cove. The two sides disagreed only over whether the land should be used for a park or railroad facilities. A commission appointed in 1881 produced a plan favoring the railroads that aroused a storm of controversy; it resigned in 1886 after five years of frustrating effort. The railroads put forward another plan that, slightly modified, finally won city council approval in 1889. The council sold the remaining cove lands to the railroads, and filling of the basin began in 1891.

The city sold about 41 acres to the newly consolidated New York, New Haven & Hartford Railroad. Large segments of the rivers were covered and retaining walls completed in 1892, creating channels for the two converging rivers. The promenade was eliminated and its three river bridges removed. The railroad chose the cheaper plan of elevating tracks rather than streets and placed the new depot and approach tracks on an embankment with street and highway traffic underneath, creating a barrier between the city's center and lands to the north that became known as the "Chinese Wall." New streets, including Francis, Gaspee, and Promenade, were built to provide north-south access, and two freight yards were constructed.

The Rhode Island Company was one of a number of railroads that changed the Providence landscape.
Photo courtesy of Rhode Island State Archives

The cove had ceased to exist, buried beneath rail facilities even as the state decided in 1893 to build its capitol on Smith Hill. Within a few years, the rail facilities lost their importance, and pollution of the rivers grew steadily worse. Downtown Providence, dismissed as "the world's widest bridge," remained partitioned by the Chinese Wall until the advent of the Northeast Railroad Corridor project in 1981 set in motion its complete transformation. The freight yards were removed, the tracks relocated, and a new train station built. A new development district, the Capital Center, utilized the vacated cove lands stretching from the capitol to Kennedy Plaza. The three rivers were uncovered, a dozen new bridges constructed, and traffic rerouted. Eleven acres of new pedestrian parks went up along the Providence River, connecting downtown to the East Side for the first time since the days of the Great Salt Cove.

Like the city's railroad age, the Providence Renaissance arose atop the cove that had once been the lifeline of the city's earliest days.

BEACH BIRDS

GEOLOGY'S LINK TO AVIAN ABUNDANCE

by **Todd McLeish**

ONE OF THE RAREST BREEDING BIRDS IN THE Northeast finds the beaches of Rhode Island particularly appealing in summer—not for swimming and sunbathing, of course, but for nesting and feeding. Piping plovers, sparrow-sized pale shorebirds classified as threatened on the U.S. endangered species list, breed more densely in Rhode Island than anywhere else in their Atlantic coastal range.

About 90 pairs of the birds—up from just 10 in the 1980s—can be found laying eggs and raising their chicks on a half dozen beaches in the state, from Goosewing Beach in Little Compton to Moonstone Beach in South Kingstown and Napatree Point in Westerly. They choose those particular beaches for reasons of geology as much as for any other characteristic. According to ornithologist Peter Paton, they seek ocean-facing beaches where crashing waves create a sizable wrack line of seaweed and other debris for feeding, wide unvegetated beaches that give them plenty of visibility to watch for approaching predators, and sand that frequently blows over the dunes to create washover fans for nesting habitat.

"Piping plovers are particularly adapted to open beach areas created by storms," says Paton, a professor of natural resources science at the University of Rhode Island. "When Hurricane Sandy came through and pushed sand back into the dunes behind the beaches and created big sand fans, that provided them with prime nesting habitat.

"But if the storms and sea level rise push beaches farther and farther into vegetated upland areas," he adds, "or if there's no place for the beaches to move, it could be a serious issue for them."

The plover/geology connection doesn't stop there, however. The plumage of the birds is sand colored, allowing them to more easily blend in with their

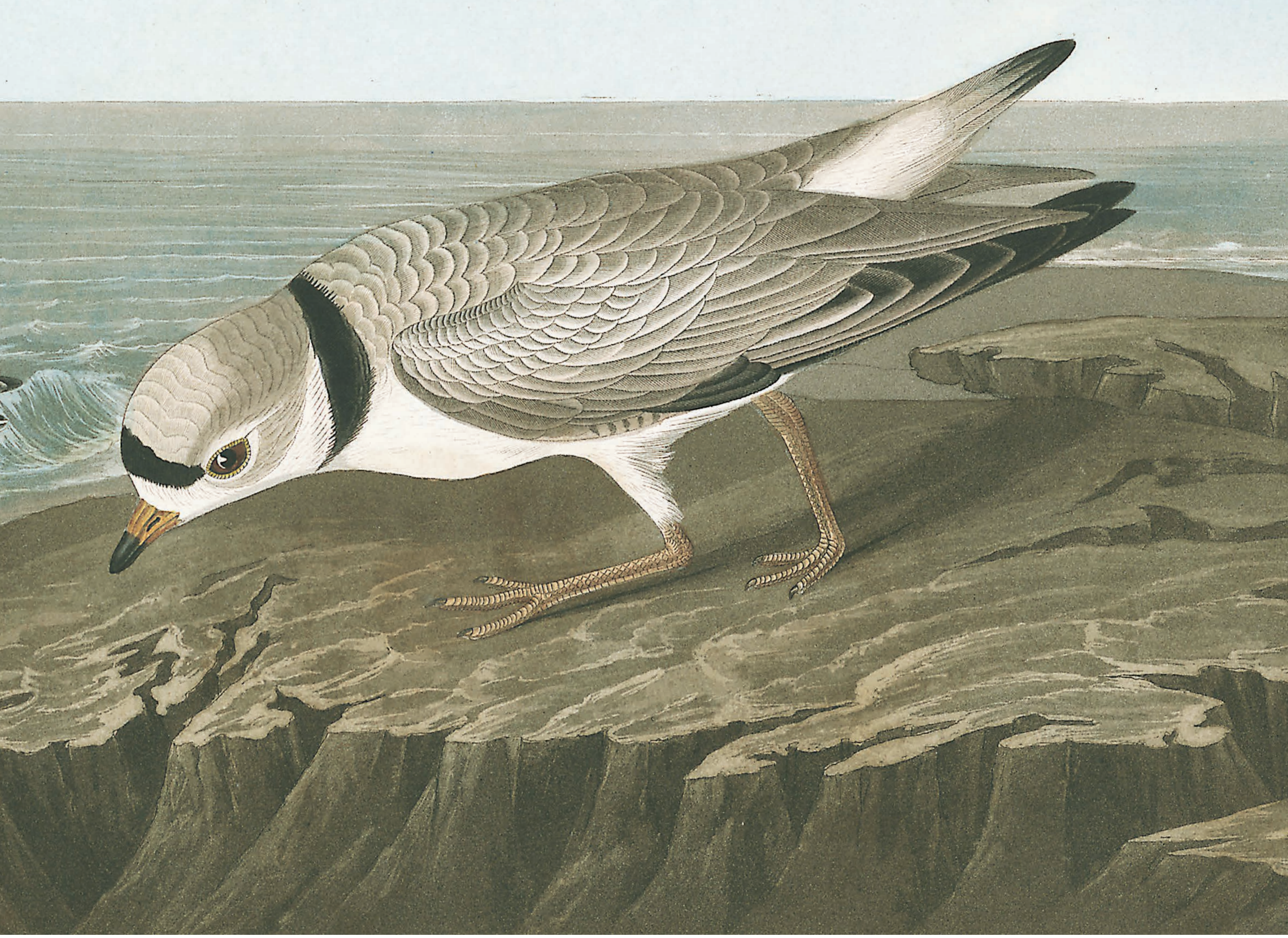


Image courtesy of National Audubon Society

environment when they are wandering the beach looking for food or when incubating their eggs. And their nest is generally placed in an area of sand with scattered small cobblestones, because the eggs are camouflaged to look like the stones.

Least terns, gull-like birds that are also on the endangered list, choose the same beaches as the plovers for nesting, and for similar reasons. American oystercatchers do, too, though their preferred nesting habitat isn't nearly as narrowly defined. The large black-and-white shorebird with a bright orange beak seeks open, undisturbed, sandy beaches near shellfish beds for feeding. Several other bird species, like spotted sandpipers and savannah sparrows, raise their young in the vegetated dunes adjacent to beaches, and even more birds prefer nearby salt marshes.

The link between birds and geology isn't one that many birders or geologists spend much time thinking about, but the link exists nonetheless. What the birds seek in the geology of their preferred beach varies from species to species. The grain size of the sand matters to some birds, as does the slope of the beach, whether it has an adjacent coastal pond, and how protected it is from waves and storm surge.

Luckily, Rhode Island's beaches are highly variable, providing many of the elements required by a wide variety of birds for feeding and nesting. Unlike the shoreline of New Jersey or the Outer Banks of North Carolina, where the beaches are much the same for hundreds of miles, a short walk on an Ocean State beach often turns up considerable geologic diversity. And that diversity is the result of the region's glacial history.

"One characteristic of our glacial shorelines is the heterogeneous sediment types and land forms that intersect the shoreline," says Bryan Oakley, a coastal geologist and assistant professor at Eastern Connecticut State University, who has studied the Rhode Island coastline for nearly a decade. He noted that the region is dominated by two types of sediment: till, which consists of what he calls "a poorly sorted mixture of everything from clay to gravel deposited directly by the ice sheet," and stratified deposits of sand, gravel, and silt from the rivers and lakes formed by the melting glacier.

"Till produced things like Green Hill and Quonochontaug and Point Judith, boulders without a lot of sand in front of them," Oakley explains. "The Matunuck Headlands from Cards Pond to East Matunuck is comprised of stratified deposits. The beaches themselves might not look too different—you've got a pile of sand with a dune behind it—but what you find further down differs from place to place. There are differences in grain size that relate to the underlying glacial geology."

Considerable variability exists among the beaches in Narragansett Bay as well. According to Janet Freedman, a geologist with the Rhode Island Coastal Resources Management Council, the sand and sediment in bay-facing beaches are often a bit muddier than those on the south shore due to a division in the glacial ice sheet that deposited finer grain sediment, mica schists, and sandstone on beaches in the bay. "Along the south shore the glacial material is more granitic, and that is more of a coarser grain size," she says.

"A beach is just a pile of sediment," adds Oakley. "If you have a source of sand and gravel suitable for the wave and tidal energy at the site, you'll have a beach. The difference in the bay is that there are lots of shoreline protection structures, so the beaches are armored to some degree, more so than we see on the south shore."

From a bird's perspective, all that geologic variability means a wide variety of food is likely hidden in the sediments, waiting to be eaten. While just a handful of bird species nest on the state's beaches, dozens more visit throughout the year—especially during migration—to bulk up on the tiny invertebrates that fill nearly every nook and cranny of the coastline.

Although few research studies have been conducted about the creatures that live in the sand on New England beaches, Tim Simmons has become a local expert on the topic. A retired biologist who worked for many years for the Massachusetts Natural Heritage and Endangered Species Program, he has spent much of his career studying beach tiger beetles and other associated species in Massachusetts. He calls beach sand "an incredible ecological niche" for tiny amphipods, beetles, flies, and other invertebrates.

"People don't see how alive a beach is," he says. "They compare it to a desert, but that's far from what it is."

Simmons says that some amphipods and beetles choose to live in the fine sands because that's where they find it easiest to burrow beneath the surface. Others choose coarser sands where there are larger spaces between the grains, while still others prefer the saturated sand closest to the waterline.

"There are a whole lot of things in there that you can't really even see unless you're wearing polarized sunglasses," he says. "I remember watching shorebirds feasting on something, but I couldn't see what. Every time a wave came up and went back down, the birds ran in to grab something. Turns out it was the larvae of a polychaeta worm. The birds could see them, but I couldn't until I put on my sunglasses."

Because the composition of the sand on many beaches changes from season to season and storm to storm, many of the invertebrates that live in the sand must be prepared to move when the conditions change or when their food supply shifts.

"Some beaches that are perfect habitat for some species in the summer are rocky and full of boulders in winter with nowhere for the creatures to hide," Simmons says. "In the mud at inlets to coastal ponds, you get a different suite of species than in the sand. But then when washover fans carry beach sand over the mud, the mud creatures have to pack up and move."

Those that can't move fast enough get washed away or become food for something else. The predatory tiger beetle that Simmons studies is capable of rapid movements and can often detect vibrations caused by the eroding beach in time to emerge from its burrow and escape to a safer location. They move from season to season, too, traveling to the dunes in winter and back to the sand near the wrack line in summer.

"There's also a grasshopper that's almost completely bound to dune blow-outs, where a storm has blown out the vegetated face of a dune and created a bowl-shaped depression," he says. "As juveniles, they're flightless and hop around, and birds often forage there for them in the early morning."

The wrack line is another beach ecosystem that changes daily and where another unique suite of creatures can be found. A 2004 study by a URI graduate student recorded an abundance of species that spend at least part of their lives in the wrack line. Some eat the decomposing seaweed or use it as cover from predators and extreme temperatures, others lay their eggs there, and wolf spiders make daily migrations from the dune grass to the wrack to prey upon amphipods.

Shorebirds of many varieties—from piping plovers and ruddy turnstones to whimbrels and semipalmated sandpipers—eat anything and everything they can find in the wrack.

A visit to Napatree Point further illustrates this link between birds and geology. The mile-long sandy peninsula extending southwest from Watch Hill in Westerly has experienced dramatic changes in the last 100 years—from being the site of 39 homes prior

Photo courtesy of Janice Sassi

to the 1938 hurricane to a somewhat pristine barrier beach today that shifts with almost every storm.

Riding down the peninsula on an all-terrain vehicle, Janice Sassi, manager of the Napatree Point Conservation Area, points out the wide sandy beach on the ocean-facing side, where piping plovers are often observed feeding on flies and amphipods in the wrack line during the breeding season. It's here that wintering and migrating sanderlings adroitly chase the receding waves to quickly grab larval crabs that briefly expose themselves to filter feed, then the birds dash shoreward to avoid getting their ankles wet as the next wave approaches. Closer to the point, where seaweed-covered boulders divide the shrubby dunes from the sea, purple sandpipers forage for arthropods and mollusks amid the plant material on the waist-high rocks.

On the opposite side of the dunes, just 75 yards away, a narrow beach faces the quiet Little Narragansett Bay, where thousands of migrating shorebirds feed on horseshoe crab eggs deposited beneath the sand at the high tide line in May and June, where the region's highest concentration of oystercatchers forage in the adjacent mussel beds, and where about 40 other species regularly search for a meal among the rocks, seaweed, and sand during migration, including northern harriers that hunt for mice and voles in the dunes in winter and nesting osprey that hunt for fish wherever they can find them in summer.

"There are so many birds here in the summer and during migration that it's like you're at the mall during the holidays," says Sassi, noting that she and her volunteers work hard to ensure that the hordes of boaters and beach-goers that also visit Napatree in summer do not disturb the birds.

Bryan Oakley says that while the sand is not likely much different on one side of the peninsula or the other, the wave energy is certainly lower on the bay side, making for better habitat for many species of birds and their prey. The calmer water on the bay side is also home to abundant minnows of several varieties, the perfect meal for the terns that nest nearby.

"As often as I'm here, it's different every single time," Sassi says. "The light is different, I see something different, and yet the birds are always here.

Where else can you go where you have bay on one side, ocean on the other, you have a lagoon, the dunes are allowed to migrate as they're supposed to, and you have shrublands and all kinds of wildlife. To realize that the geology plays such a role in attracting the birds is amazing."

A Military History of Narragansett Bay

by **Brian L. Wallin**

NARRAGANSETT BAY IS A GIFT OF THE GLACIERS, which over millions of years left behind a 30-mile long, 102 square-mile navigable waterway, one of the finest deep-water ports on the East Coast.

John King, University of Rhode Island oceanography professor, notes that "you tend to get a pattern of muds in the upper reaches of the bay and in coves, and progressively more sand and gravels as you move toward the mouth of the bay."

Those sandbars and mud flats played a key role in a landmark event leading up to the American Revolution. On June 9, 1774, the British revenue schooner *Gaspee* was pursuing a colonial vessel, the *Hannah*, suspected of smuggling tea. The *Hannah*'s captain knew the waters like the back of his hand and led the British into the shallows off Warwick. The *Gaspee* ran firmly aground. A group of Providence men, alerted to the stranding, rowed from the city, captured the crew, and burned the English ship the next day.

In 1636, seeking religious freedom from the Massachusetts colony, Roger Williams established a permanent settlement on the upper bay, and later settlers began to move down along the west bay. Meanwhile, another religious leader, Anne Hutchinson, led her followers from Massachusetts to Aquidneck Island. Soon, fishing, agriculture, and eventually commercial trading flourished around the bay. By the early 18th century, Rhode Island was well settled. Although Providence did not emerge as a significant port city until later, Newport, because of its proximity to the mouth of the bay, quickly established its position as a major trading port rivaling Boston, New York, and Philadelphia.

Rhode Island's military importance was not lost on the colonists or the British Crown. Narragansett Bay was easily accessed from Block Island and Rhode Island Sounds. If an enemy could run the gauntlet guarded by Brenton Point and Point Judith, then Newport, Providence, Fall River, and all points between would be vulnerable.

To address this vulnerability, in the late 1600s, Newport merchants set up a gun battery near what is now the corner of Thames and Pelham streets. Later, the British Crown built the first permanent fortification on Goat Island at the request of the city of Newport. During the Revolution, that fortification eventually reverted to colonial forces and finally came under control of the new federal government.

When the Revolution broke out in earnest, the Royal Navy was ordered to quell Newport's independent (and tax-evading) populace. During the war, Britain's powerful land forces occupied the city while its ships controlled the lower bay and the New England coast. Needless to say, this dealt a disastrous blow to Newport's mercantile trade. Newport's role as a center of trade never fully recovered after the war.

America's alliance with France in 1778 signaled the beginning of the end of the British presence. To deter the French fleet, the British scuttled a number of ships around Newport harbor (the remains of these vessels have been discovered and explored in recent years). When the British pulled out of Newport in October 1779, they left behind a devastated economy and a determination on the part of the new American government to forcefully protect the bay.

Aided by the French, the U.S. established a series of coastal fortifications. Protection of the East Passage was paramount. Under famed French military engineer Major Stephen Rochefontaine, forts were erected on Conanicut Island on a rocky promontory known as The Dumplings, in Newport Harbor on Goat Island, and at Brenton Point. It was from the latter site that local colonials had fired their first shots against the British. On July 4, 1779, the U.S. Army also commissioned what was to become Fort Adams.

These defenses served until the War of 1812 while the threat of a British seaborne attack loomed large. In 1816, recognizing its initial efforts were obsolete, the U.S. Government Fortifications Board authorized a series of stronger installations and established the

FROM THE *GASPEE*
TO UNMANNED
UNDERWATER VEHICLES,
THE BAY
HAS PLAYED AN
IMPORTANT ROLE
IN U.S. NAVAL DEFENSE

Army Coast Artillery Corps. Narragansett Bay became a keystone. If the bay could be invaded, all of New England and even New York could be attacked. Fort Adams served as a principal defensive position into the early 20th century.

The Civil War marked the next important phase of the military's commitment. More powerful gun batteries were installed around the bay's entrances. The U.S. Naval Academy was also temporarily relocated to Newport, and the Navy steadily increased its presence thereafter. In 1884, the Navy further cemented its relationship with the creation of the Naval War College in what was formerly the Newport Poor Asylum.

As warships evolved from wood and sail to steam and steel, Admiral David Dixon Porter recognized the potential of underwater warfare using torpedoes and mines. Porter's vision encouraged Secretary of War Edwin Stanton in 1869 to authorize an experimental torpedo station on Goat Island to

develop, build, and test underwater weaponry, including explosives, electrical devices, mines, and torpedoes.

From the torpedo station, a testing range was laid out northwards up the bay about 6 miles to a point near Prudence Island. The length and contour of the bay's seabed was particularly conducive to the layout of the range and recovery of test weapons. The Navy then centered its torpedo design, manufacturing, and testing at Newport until 1951, with underwater weapon research continuing in Newport to the present. The torpedo station steadily expanded during both world wars, eventually occupying all of Goat Island. In 1919, Gould Island, off the northeast shore of Jamestown, was acquired for underwater weapons storage and testing. In 1942, a firing station was built at the northern tip of Gould, replacing a firing barge that had been located just north of Goat Island.

A stereoscopic view of Fort Adams

Thousands of torpedoes were tested from Gould's firing pier during World War II, monitored from the air and by underwater sensors along the testing range. Aircraft from Quonset Point and PT boats from Melville also used the range to practice torpedo drops.

Although recovery boats were used to bring test torpedoes back to the firing pier, more than a few times during World War II, the "tin fish" went awry. Some sank to the seabed never to be seen again. A torpedo traveled across Newport Harbor and ran aground in Brenton Cove. In 1944, one wound up on the beach at Jamestown at summer resident Mary Miner's home. Yet another came ashore on Prudence Island. On April 9, 1942, traveling down the bay from the Motor Torpedo Boat Squadrons Training Center in Melville, PT-59 accidentally launched a live torpedo that struck the stern of an Army transport ship inside the mouth of the bay off Jamestown. The PT skipper used his powerful engines to nudge the damaged ship to shore to be salvaged and returned to service.

Poor performance of Newport's torpedoes early in the war was eventually traced to outdated manufacturing techniques and lack of appropriate testing. Dummy test warheads were lighter than explosive warheads, and the fact that the latter would run deeper when fired by submarines against an enemy was never taken into consideration. Also, the top-secret magnetic exploder developed at Newport was never tested under combat conditions and thus failed to perform as intended (apparently, it was not taken into consideration that the earth's magnetic field in the Pacific Ocean area was different from that of the northern hemisphere off America's east coast). Even when the magnetic device was deactivated, the older contact trigger did not work because the poorly engineered firing pin regularly malfunctioned and failed to detonate the warhead.

It took nearly 18 months for these issues to be addressed, but by 1943, the problems were solved, and Newport's torpedoes became a major factor in the Pacific theater of operations. In 1951, when torpedo production was turned over to private industry, the Navy continued to center its underwater weapons research and development program at Newport. Under the auspices of the Naval Undersea Warfare Center located at Naval Base Newport, that mission continues today.

Before and during both world wars, Newport was home to squadrons of destroyers and was also regularly visited by naval vessels of all types, including battleships, cruisers, and aircraft carriers. Sixty-five thousand enlisted personnel received training at Newport in World War I, forcing the Navy to significantly expand its base facilities from Coasters Harbor Island (location of the Naval War College) to the adjacent Coddington Point.

In 1922, Rear Admiral Hugh Rodman led a review board that emphasized the need to further expand the Navy's presence on Narragansett Bay. A coaling station established at the turn of the century at Melville in Portsmouth was converted to fuel oil storage as the navy's propulsion systems evolved. An adjacent site became home to the PT boat training center and the Navy's mine and net repair depot. Bay area residents became accustomed to seeing some of the Navy's largest ships calling at Newport well into the 20th century.

Onshore defense facilities also evolved. In 1885, Secretary of War William C. Endicott chaired a congressional panel to recommend improved coast defenses. In the 1890s, several so-called Endicott forts were approved for the bay's entrances, and Fort Adams'

A seafloor map created using 3D printing technology

Photo by Yasmin Tadjeh
for National Defense Magazine

The bay's topography consists of three glacier-created valleys: the East and West passages and the Sakonnet River. The majority of marine traffic—commercial and recreational—utilizes the East Passage. A 35-foot dredged channel leads to North Kingstown's Quonset Point; lighter draft vessels use the West Passage. A once-40-foot deep channel continues north to Providence. However, river silting has reduced that depth to about 35 feet. Since 1971, to protect the overall water quality in the upper bay, there has been an embargo placed on additional dredging near Providence.

Jamestown resident Mary Miner poses with a test torpedo that inadvertently landed on her property.

Photo courtesy of the U.S. Naval War College Museum Photograph Archive

armaments were enhanced. By 1906, facilities were operational on the east side of Conanicut at Fort Wetherill, on the west bay at Fort Getty, Fort Kearny in Saunderstown, and Fort Greble on Dutch Island. All were equipped with heavy caliber weapons capable of reaching well out to sea.

Endicott batteries were open, with reinforced concrete walls as much as 15 to 20 feet thick, underground ammunition bunkers, and support facilities. Artillery up to 12-inch disappearing guns rose up on their mountings to fire and then dropped down for reloading. After the end of World War I, many forts saw staffing and functions reduced, and provided only seasonal training for some military units. Fort Adams remained the bay's only active Army facility. However, as the winds of war began to blow in the late 1930s, the government's focus once again returned to the bay.

In 1940, thanks in large part to the efforts of Rhode Island's congressional delegation, the decision was made to construct one of the nation's largest naval air bases at Quonset Point in North Kingstown. Simultaneously, the Navy established the neighboring Seabee

Base at Davisville. Thousands of pilots trained at Quonset and the nearby Charlestown Naval Air Station during the war. Some 100,000 enlisted men trained at Davisville. Massive expansion also went on at new or existing Navy facilities in and around Newport for training of officers and enlisted personnel, both men and women. More than 200,000 were eventually trained at Newport, utilizing a complex of Quonset huts that covered Coddington Point.

In 1939, the Army acquired land at Point Judith (Fort Greene) and Sakonnet Point in Little Compton (Fort Church), where a pair of massive 16-inch gun emplacements were installed and became operational early in World War II. Specially built railroad flatcars carried the huge naval weapons from the arsenal in Watertown, Massachusetts, where they had been stored following reductions in warship construction after World War I. Each 20-ton gun required heavy-duty, multi-axle trailer trucks to move them by road from rail sidings to their final destinations on each side of Narragansett Bay. The weapons, well protected by reinforced concrete, could fire a 2,000-pound projectile 25 miles out to sea. Their field of fire ranged from beyond Martha's Vineyard down to Long Island. Army records indicate that whenever the guns were test-fired, numerous noise and vibration complaints were received from neighbors.

A flight of torpedo bombers passes over Quonset Naval Air Station control tower during World War II training.

Photo courtesy of the U.S. Navy

New forts—Varnum in Narragansett and Burnside on Beavertail in Jamestown—augmented existing gun batteries at forts Adams, Wetherill, Getty, and Kearny. The military also blocked off the entire southern end of Beavertail for a sophisticated joint Army-Navy harbor entrance defense and command post and radar installation. Sensitive electronic equipment controlled a minefield protecting the bay entrances. Anti-submarine nets were also placed: a permanent barrier across the West Passage between forts Kearny and Getty and a gated net between forts Wetherill and Adams on the East Passage.

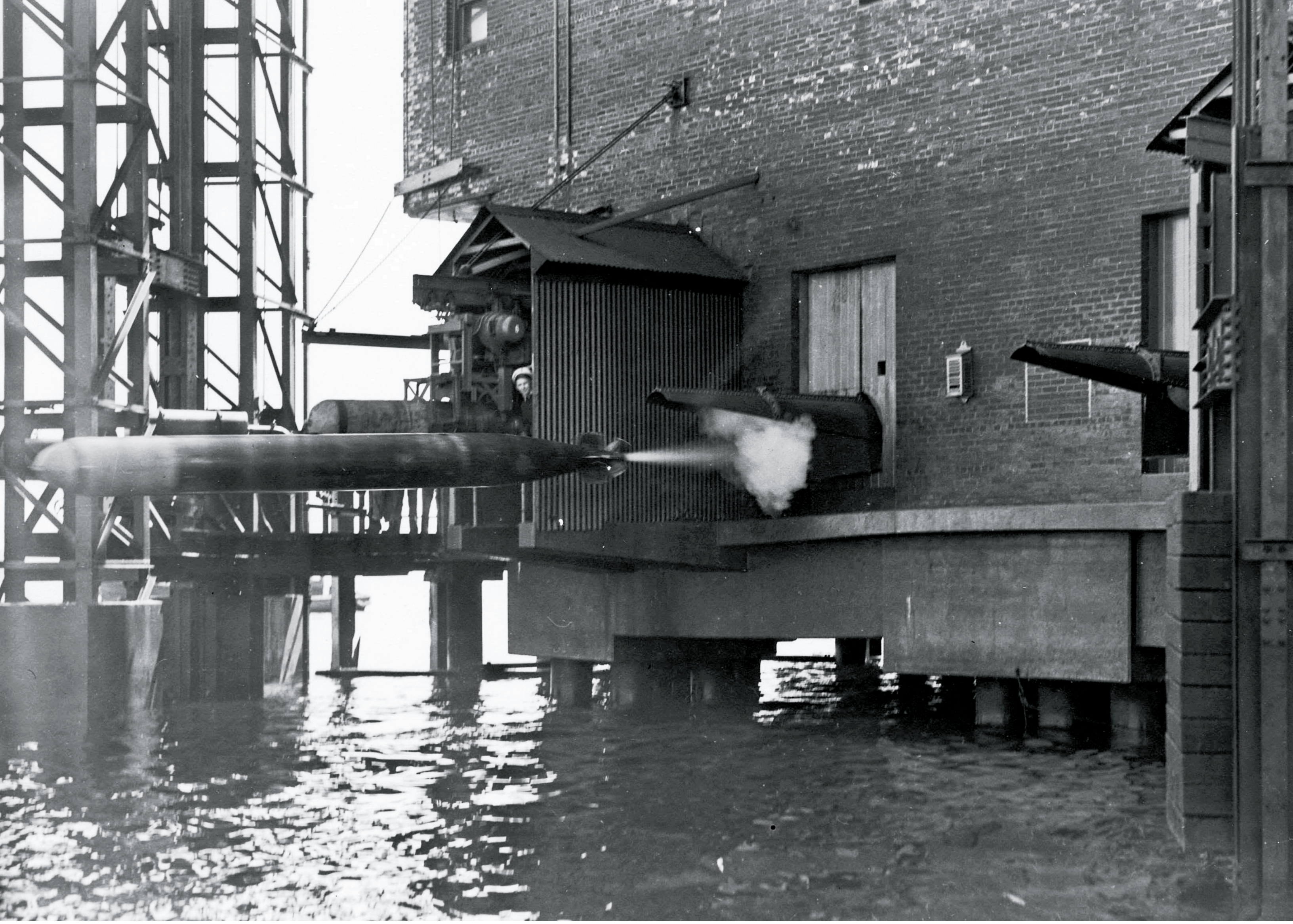
Rhode Island National Guardsmen of the 243rd Coast Artillery were called up to federal duty in 1940 and were supported by troops from other New England units, manning the coastal forts for the duration of World War II. Rhode Island's coast defenses were controlled from Fort Adams. Observation and fire control stations, disguised as summer cottages or farm silos, dotted the coastline and Block Island. By late 1943, the threat of surface attacks had diminished, but concern for airborne and underwater enemies remained. Smaller anti-boat, anti-aircraft weapon batteries including mobile 155-mm guns replaced most heavy caliber defenses around Narragansett Bay. No Rhode Island artillery was ever fired in anger during the war.

In 1973, a major nationwide realignment of military forces saw the Navy transfer a number of ships from Newport (and the closure of Quonset Point and Davisville). By 1994, the last warships had been reassigned from Newport. However, on October 1, 1998, the Navy cemented its presence on Narragansett Bay, with Naval Station Newport assuming oversight of officer training and other education services, the Naval War College, and the Naval Undersea Warfare Center.

The warfare center develops and tests underwater military technologies, including unmanned underwater vehicles (UUVs). Spokesman John Woodhouse calls the center's location on the bay ideal. "We can literally walk a drone from the lab to the water, test it on our instrumented range running from the mouth of the bay up toward Prudence Island, and recover it using one of our small boats or even … staff who have trained to become Navy-certified divers."

Christopher Egan, a warfare center program manager, says testing in an area accessible to the public can be interesting. "We've had to deter some boat operators on occasion from trying to snap up a cool device."

The Navy and its civilian partners hope to see



underwater drones eventually duplicate the capabilities of airborne systems. Engineers believe advances in propulsion and guidance could enable an undersea drone to conduct missions as long as 70 days. One drone recently plotted its own course from the Woods Hole Oceanographic Institute to Newport without reliance on surface GPS or other communications, using features on the sea floor and avoiding obstacles in its path.

In 2015, the Navy established the Annual Naval Technology Exercise (ANTX) hosted by the warfare center to unite industry, warfare centers, and universities in showcasing capabilities and technologies. In 2016, some 30 organizations, including URI, demonstrated unmanned systems and their command and control and communication methods. URI professor Harold Vincent, partnering with DBV Technology, Inc. of North Kingstown, tested a portable underwater GPS that utilized seafloor-anchored beacons activated by a UUV, allowing it to navigate to its desired destination while remaining below the surface. ANTX 2017 was expected to bring together an even larger number of participants.

The Gould Island torpedo test station launches a "tin fish," one of some 75,000 such tests of these weapons conducted by the Newport Naval Torpedo Station factory during Word War II.

Photo courtesy of the U.S. Naval War College Museum Photograph Archive

Currently, some 33,000 people are employed in the state's defense industry, and some $750 million in federal defense contracts flow into Rhode Island, the clear majority coming from the Navy.

Those numbers may grow. In 2016, the privately funded Undersea Technology Innovation Center was created to assist local companies seeking defense work. According to acting Executive Director Molly Donohue Magee, "there's commercial technology that may be suitable for defense, and defense technology that may have commercial applications." And URI recently partnered with the warfare center to develop partnerships and collaborative research and development initiatives between the Navy and private businesses.

Thanks to these new efforts, Narragansett Bay will likely have a role in military history for years to come.

We are the landscape

AN INTERVIEW WITH LORÉN SPEARS

by **Hugh Markey**

Photographs by **Michael Cevoli**

"**WE'RE INTERRELATED WITH THE LANDSCAPE**; the name 'Nahiganseck' (later corrupted to Narragansett by Europeans) means 'the people of the small points,' which is describing the topography that we're on that is adjacent to the ocean," says Lorén Spears, executive director of the Tomaquag Museum, as she sits at a table in the crowded office she shares with two other museum employees and reflects on her tribe's relationship to the geology of what is now Rhode Island.

"According to our creation legends, we came up out of the marshy areas and were created from that soil. We are the landscape. We're intrinsically connected to each other. Today we're still here, and we're still interconnected to the land."

The natural world and the changing seasons have long been the hub of Narragansett life. "We have stories that revolve around the collection of sap, the buckeyes we would fish for, using the river systems for transportation. You can get pretty much anywhere in the state by using the rivers that are right outside this building."

"In summer, we'd have our village near the salt water for fishing, shellfishing, hunting, and gathering, along with the crops that we would grow." Spears refers to "lifeways," which are "everything about who we are as a people and the influence of what we do in our lives. All those things that are part of living our life as an indigenous person. In that time period, the lifeways were composed of doing all the things that were needed to survive: making spear points, arrow points, nets, clothing. And you'd use all the resources. In the case of deer, for example, we would eat the venison, but we would also use the brain to tan the hide, the muscle sinews for sewing, the skin for blankets, and bones and teeth for adornment or tools. We would utilize the whole thing. We'd place the villages close to fresh water, but also nearby the salt water. We would harvest the edible mushrooms, wild berries and nuts, fiddlehead ferns. Each season had its foods to be harvested. That's why we celebrate 13 Thanksgivings: they're based on the landscape and the resources found on that landscape."

In addition to Thanksgiving, Spears says that the famous New England clambake is another food-oriented celebration that was appropriated from the indigenous people by the Europeans. "Centuries ago, a native village may have had thousands of people in it, and the clambake evolved as a way of feeding all those people. We made it with clear broth, as opposed to one with milk in it, and the activities that were going on in creating it were part of the lifeways: you were making the tools, the baskets for gathering, the pottery for cooking, the weirs (a fence-like structure used to direct the fish to a confined area where they could be harvested) for fishing." Spears also blames the Europeans for misappropriating an item that is perhaps one of the best known local treasures—wampum.

"In the history books, wampum has been locked into this tiny Eurocentric window of maybe 50 years when it was used as a kind of money. It was used between Europeans and indigenous people as a monetary unit because they (Europeans) had the need to come up with a monetary system. That was not how we were using wampum. We were fine with bartering.

"Wampum was very sacred. It was used to honor people, in ceremonies, and to call people to council, to name just a few. You'd send a runner with a strand of wampum with a message that each leader was to meet at a certain place, at a location known as the council rock. Wampum was used to record history, to document major events. The way that they were woven created a picture that documented history. This tradition was going on for thousands and thousands of years before the Europeans arrived. Yes, we were trading and gifting wampum, but a gift was very much an honor and very much a part of our culture. It was a sign of respect. It was used as a form of congratulations on achieving something.

"My aunt tells the story of when she was up in the mesas of New Mexico. As an indigenous person, she was invited to come to a ceremony. While she was up there, some of the elders pulled her aside. They told her that they had been waiting for someone to come from our community. They had wampum that had been passed down for hundreds of years that had come from a native of the northeast coastal area. They were waiting for someone to return to this remote place, and that person happened to be my aunt. When we travel, we often carry wampum, whether as the shell or as a prepared, adorned piece. It's an example of the idea that we traveled to distant places and still had this interconnectedness between tribal communities."

Even as Narragansetts were forced into other areas as a result of King Philip's War in 1675, they maintained their ties to the land. "Our people were kidnapped and sold into slavery in the Caribbean. The story goes that our people escaped the sugar plantations down there and set up in an area known as St. David's Island, the last island in the archipelago. They made their own community there over the years. The residents were originally from all these places along the East Coast, right up to New England. In the last 15 to 20 years, we've had a chance to reconnect with a tribe in Bermuda, and genetic testing ties them to tribes of the coastal Northeast. We made our connection and now we travel back and forth and stay with each other. Those are powerful things, and they also speak to our connection to the land, because even though they were all those miles away, for example, instead of making corn husk dolls, they made banana

leaf dolls. They are now a mix of the indigenous people of the Caribbean, the indigenous people of North America, and those of Africa."

Narragansetts were conservation minded as well. Spears tells the story of a local tribe member who was quahogging. He was using two buckets: in one he would put quahogs that were the right size, and in the other he would put those that were too small. Once he finished, he would walk to a separate area and dump the bucket of smaller shellfish. "So eventually, you would basically manipulate the ones that weren't big enough to an area that would, in a year or so, become your primary area for shellfishing."

"Changes that were made by the Native Americans were much more in harmony with the environment than those made by the Europeans. Even in the case of our middens (trash piles), the materials there were left behind, but they were materials that would eventually return to the earth. The reason why you can't find a 3,000-year-old basket from our people is because it was made from the earth, and eventually it returns to the earth. We burned the forest to produce gardens and to make traversing the area easier. It's not like Providence Place Mall, where you filled in the swamp and built a mall on top of burial grounds and on top of estuaries and completely manipulated that. Our ancestors worked with nature versus using excessive manipulation of nature."

Conflicts between native and non-native culture continue today: "When I was younger, my husband and I were crabbing on a salt pond in Charlestown. A guy who had a house on the pond came over in a boat and started screaming at us about taking 'all the crab from the pond.' I said, 'Your water? Your crabs?' I gave him a few choice words of my opinion on that. He motor boated back to his house. Then later, he sent his son out to us with an offering of bluefish to make up for what had happened. That's an example of the mindset people have that if you own the house, you own all the water and all the resources around it."

Despite the inevitable encroachment of modern society on traditional ways, Spears says that the central notion of working with the land is a value still being practiced. "I think our interrelationship with the land helped us to survive, even right up into the 21st century. I often refer to us as having subsistence-supported diets. Yes, we go to the grocery store and buy lots of things, but I often tell children that if you were to come to my house and open my refrigerator you would see things like frozen cranberries (and not the ones from Ocean Spray!), you would see frozen mushrooms, fish, venison. We're using modern technology to freeze it, but we're still partaking in these local harvests.

"I don't feel that we were impacting the land so much as the land was impacting us. We were very respectful of the land and the ebb and flow of the seasons and ebb and flow of the landscape. Yes, we had places that were favored areas, but we were less likely to manipulate the landscape as we were more likely to be in tune with utilizing the land.

"You only took what you needed from the land."

ICE AND OYSTERS

From Glaciers to the Raw Bar

"Every oyster is a tide pool in miniature, a poem built of salt water and phytoplankton that nods to whatever motes of meaning shaped it. It is the sea made solid. The bay gone sentient."

— ROWAN JACOBSEN, famed oyster aficionado, in his latest book *The Essential Oyster*

Story and photographs by **Kate Masury**

An oyster may seem like a simple food; plucked straight from the water, it can be enjoyed on the spot, without any extra ingredients or cooking necessary. While its preparation may seem simple, its consumption reveals a complex story of glaciers and environment. The layers of flavor conveyed through an oyster divulge the ultimate connection to place. Oysters taste like the sea but not just any generic oceanic flavor; they taste of the exact body of water they were raised in and tell the story of the geologic history and biology of the area.

The unique characteristics of the place an oyster was grown are what gives each oyster its distinctive flavor. This is referred to as meroir, the ocean equivalent to terroir in wine, and a term coined by Bob Rheault, executive director of the East Coast Shellfish Growers Association, in 1991. Rheault credits his mother, a French teacher, for his conception of the term. The French word terre means land, and terroir is the characteristic flavor given to a wine by the land in which its grapes were grown. Soil, climate, and topography of the vineyards all contribute to making each wine unique. In French, the word for sea is mer, thus meroir was born. Rheault says that for oysters, "meroir is a combination of the algae, the sediment, the salinity, the ionic composition of the water, and really whatever gives the oyster flavor—we are still figuring it out."

Rhode Island Meroir

Rhode Island is home to about 50 different aquaculture businesses, most of which are dedicated to growing oysters. Not only does the state produce a lot of oysters, but it also produces incredibly delicious oysters. In his book, *A Geography of Oysters*, Rowan Jacobsen describes Rhode Island's oysters as "jewels—oysters that rival any in the world."

To understand Rhode Island's unique meroir, we need to take a closer look at the environment in which the oysters are grown. "Rhode Island has a unique geology in that the adjacency of the salt ponds to each other creates a compact, really good area for producing oysters … we have the coastal ponds all aligned and then Narragansett Bay," says Perry Raso, Rhode Island shellfisherman, oyster grower, and owner of the Matunuck Oyster Bar.

Most of Rhode Island's landscape and much of its meroir is a product of ice, as glaciers have been the dominant shaping force of the past 80,000 years. During this time, glaciers repeatedly covered Canada, much of the northeastern United States, Europe, and Asia. The glaciers formed lobes of incredibly thick, heavy layers of ice over a mile high, which flowed under their own weight. As they moved, the force and weight of the ice bulldozed the bedrock. The glaciers carried layers of rock and sediment with them for hundreds of miles, with each lobe carrying a different mineral composition along its path.

The glaciers eventually reached the Narragansett Bay area, which at the time was a large freshwater lake within a sedimentary basin. As the glaciers flowed through the basin they carved channels through the sediments, exposed very old bedrock, and turned the mud and cobble into metamorphic rock.

The glaciers continued to flow past what is our present-day coastline, then paused, and slowly retreated as temperatures warmed. In the place where they paused, they left behind mounds of soil, rock, and gravel. These mounds formed what are now Long Island, Block Island, Martha's Vineyard, and Nantucket. The glaciers grew and paused again, depositing rocks, soils, and gravel between Westerly, Charlestown, and Narragansett, and forming what is called the Charlestown Moraine.

Rhode Island's famous salt ponds were also a result of the glaciers. According to Mark Stolt, an environmental soil scientist in the College of the Environment and Life Sciences at the University of Rhode Island, "if you get below the marine materials [in the salt ponds], you would find remains of fresh water deposits of cedar swamps." The locations of the salt ponds mark the place where large glacial ice blocks once sat. As temperatures warmed, meltwaters flowed from the glaciers carrying and deposit-

Perry Raso, owner of the Matunuck Oyster Bar, grows oysters in Potter Pond.

ing stratified materials, building up the land around the ice blocks. When the ice blocks melted, the depression left from the ice filled with fresh water and formed the beginning of the salt ponds. The meltwater also deposited rocks, sand, and sediment into the ponds, stratifying the layers of the pond's floor. The largest and heaviest rocks and sediments sank to the bottom and the smallest sediments—clay and silt—settled on top, later adding an important flavor component to Rhode Island's salt pond oysters.

Sea level rose after the glaciers retreated, causing salt water to flow into the ocean basin, filling Block Island Sound and Narragansett Bay. According to Janet Freedman, a coastal geologist at the Rhode Island Coastal Resources Management Council, "sea levels did not rise at a constant rate. Initially, when the glaciers first collapsed, there was rapid sea level rise. However, about 5,000 years ago, the rate of sea level rise slowed, which allowed barrier spits to form." During extreme weather events, the waves broke open inlets, allowing salt water and marine materials to mix with the fresh water and nutrients in the ponds, creating brackish water and ideal oyster-growing conditions.

The same glacial influence that produced each pond also created variations among the ponds. "What we have here in southern Rhode Island is a unique situation with pond, after pond, after pond, at different depths," says Perry Raso. He added that among and within the ponds there are also differences—salinity, mineral composition, sediment type, nutrient levels, and plankton composition all vary on different scales. Therefore, each oyster farm, even if it is located within the same pond as others, has its own environmental conditions, and these unique differences can be experienced through the flavors of the oysters that grow in them.

Stages of Flavor

When you eat an oyster, there are three stages of flavor. The first stage is salt. "Salinity is what hits you immediately when you tilt an oyster into your mouth. It can be overwhelming, unnoticeable, or anywhere in-between," writes Rowan Jacobsen. How salty or briny your oyster tastes is a function of the salinity of the body of water it was grown in. This is communicated to you by the oyster, through the liquor, the liquid the oyster sits in within the shell. An oyster's blood is primarily sea water, and it takes on the salinity of its surroundings. Additionally, an oyster can hold seawater within its

shell, allowing it to survive out of water for extended periods of time.

The bodies of water in Rhode Island and throughout most of New England are highly saline, thus New England oysters are typically salty. Despite this, even slight differences in salinity can be tasted. “Your tongue is so primed for salt, you can detect about 2 ppt [parts per thousand] pretty easily,” says Bob Rheault. Within Rhode Island, the two major oyster growing regions are the salt ponds and Narragansett Bay. The bay typically has very salty oysters, while oysters grown in the salt ponds are typically less salty due to fact that many ponds have freshwater inputs such as streams or groundwater sources that lower that salinity.

However, there are exceptions. “A Quonnie Rock, grown in Quonochontaug (“Quonnie”) Pond, is a very salty oyster. The pond flushes unbelievable amounts of water through it,” explains Max Sherman, general manager at the Ocean State Shellfish Cooperative, referring to a large inlet that allows a lot of salt water to enter Quonnie. “You might taste it and think it was a bay oyster, but it’s not. It’s just grown in a salt pond that has unbelievable flow.”

The second stage of flavor comes from the body of the oyster. Body, in this sense, is not referring to the literal body of the animal, though it is a key component. It is another term borrowed from the wine world and refers to the way a flavor fills your mouth. Something that is “full-bodied” is bold and complex in flavor, while something that is “light-bodied” tends to quickly dissipate or vaporize in your mouth. To really taste the body of an oyster, you must chew the actual body to release the oyster’s sweetness, texture, and other distinctive flavors.

Russ Blank, owner of Rome Point Oysters, motors out to his farm.

“Much of the body of an oyster comes from what the oyster is eating,” says Graham Brawley, director of sales and marketing at the Ocean State Shellfish Cooperative. A large part of an oyster’s diet consists of phytoplankton, and many oyster farmers believe that the type of phytoplankton their oyster is eating impacts the flavor of their oysters. At different times of year, you will see different combinations and amounts of phytoplankton in the ponds, and they often differ from the types of phytoplankton that grow in the bay.

David Borkman, an environmental scientist for the Rhode Island Department of Environmental Management, says, "in terms of plankton, quantity is more important than either quality or composition." The salt ponds and estuaries can accumulate larger quantities of phytoplankton because they are enclosed spaces and don't get flushed out as easily as the open ocean. More phytoplankton equals more food for the oyster. And more food means the oyster can produce more glycogen—a polysaccharide, or starch—that gives an oyster its sweetness.

Phytoplankton is not the only thing an oyster eats. "A big part of an oyster's diet is actually detritus," says Rheault. "It's pieces of eelgrass that are rotting and being decomposed, or different parts of organic matter that might be floating around in the pond or bay. As much as 50 percent of what they eat is not phytoplankton, but other types of organic carbon." These other food sources can create unique and interesting flavors that link an oyster to the body of water in which it had been feeding.

The third stage of flavor in an oyster is the finish. The finish is the aftertaste, the lasting impression the oyster leaves after you have chewed and swallowed. In oysters grown on the East Coast, the finishes are often mineral flavors but can also be buttery, nutty, or metallic, and taste of seaweed, citrus, cucumber, tea, melon, and a wide range of other possibilities. What the oyster is eating, the bottom sediment, mineral composition, and other environmental characteristics all impact both the body and finish of an oyster.

The actual experience of eating an oyster only lasts a moment. In that short period of time, the three stages of flavor come together to reveal the oyster's story and its connection to place. For example, eating a Salt Pond oyster, grown in Point Judith pond by Dave Roebuck, is an intense oyster experience. They are grown at a salinity of 32 ppt in bottom culture, meaning they are planted directly on the mud versus sitting in oyster cages above the bottom, as is common with many Rhode Island oysters. This creates a briny oyster with a complex, full body and lots of mineral flavors. Roebuck says you can taste iron and petrol in his oysters. (While petrol may not be a term you typically associate with something you plan to consume, it is a common descriptor for wines and is often associated with sought-after Rieslings.)

Eating an East Beach Blonde oyster, grown in Ninigret Pond, is a completely different experience. Ninigret has a narrow saltwater inlet and also several freshwater streams, creating a mild salinity oyster with a smooth buttery sweetness. Oysters coming out of Ninigret Pond are also sometimes said to have a cucumber finish that is attributed to a type of phytoplankton that grows there.

Rheault says that he has noticed a "distinctive aftertaste" associated with all shellfish that come out of southern New England salt ponds—an aftertaste that bay and oceanic shellfish lack. It's a "rich, full-bodied flavor" that he attributes to the clay left by the glaciers.

In contrast, "A bay oyster is a wonderfully clean, salty, and bright oyster that I liken mostly to the oysters that I taste from Maine," Rheault says. This is certainly true of a Fox Island oyster, grown by Wickford Oyster Company; however, bay oysters can also have complex finishes. For example, Rome Point oysters, grown by Russ Blank in Narragansett Bay, are high salinity, briny oysters with a strong minerality and slight metallic finish. "Our oysters have a very distinct mineral aftertaste. It's from all the weeds and algae that grow on the cages. It's a totally different weed than what they get in the ponds," says Russ.

Whatever your preference, Rhode Island has an oyster for you. Rhode Island's geologic history and glacial influence have produced excellent oyster-growing waters and, as a result, a diverse portfolio of delectable oysters. Each oyster has its own unique meroir. So, on your next trip to the raw bar, order a selection of local oysters, and as they are served to you on a bed of crushed ice, take a second to acknowledge the glaciers that made your meal possible.

Between Land and Sea

THE ATLANTIC COAST AND THE TRANSFORMATION OF NEW ENGLAND

by Christopher L. Pastore

Reviewed by **Hugh Markey**

A 1777 MAP OF NARRAGANSETT BAY described the area as home to "one of the finest Harbours in the World … fish of all kinds … in the greatest plenty and perfection. Horses are boney and strong, the Meat Cattle and sheep are much the largest in America, (and) the butter and cheese are excellent." In short, the map avowed, Narragansett Bay offered "every necessary of Life in Abundance."

In *Between Land and Sea: The Atlantic Coast and the Transformation of New England*, author Christopher L. Pastore traces the ways in which the belief that the natural world was there for the benefit of mankind literally shaped the landscape of New England from the rugged days of Roger Williams through the Gilded Age and the "summer cottages" along Ocean Drive in Newport. His extensive use of primary sources provides a lively narrative by those who made their fortunes hunting beaver, cartographers creating the first coastal maps, and merchants fighting to establish their towns as the most trade friendly. All the while, coastal regions were being transformed into something quite different from what had existed before Europeans arrived in the New World.

The first real changes made to the environment came with the interaction of two seemingly humble resources: quahogs and beavers. Long a staple in the Native American diet, quahogs were also the source of wampum. Elsewhere in this issue, Narragansett Tribal member Lorén Spears points out that wampum, contrary to popular belief, was not a form of money to First Peoples. Rather, it was a largely ceremonial decoration, used to honor accomplishments and special occasions. However, Pastore notes that Europeans quickly became fascinated with it and began a brisk trade in beaver pelts for it: "Wampum turned a largely localized, small-scale trade in furs into a region-wide mad dash for pelts. But the removal of so many beavers and the subsequent disintegration of their dams fundamentally changed the way water rolled downhill."

Overhunting of beaver caused a chain reaction. Pastore says that Roger Williams referred to beavers as "'beasts of wonder' that could 'draw of great pieces of trees with his teeth, with which, and sticks and earth I have often seen, faire streames and rivers damm'd and stopt up by them.'"

However, when the beavers were killed, their dams eventually washed away. The ponds that had been formed by the dams broke free, and the benthic layer dried out. Meadows grew from the newly dried soil, which in turn drew settlers to the grassy land, which would not require the work involved in clearing trees.

Pastore traces the ways in which the coast of New England shaped history, along with some of the paradigms through which humans viewed the coast. Some regarded uncultivated (or "unimproved," in the human-centric parlance of the day) regions as a source of ill health and felt that humans had a duty to manipulate the coastal locale. Pastore quotes Scottish historian William Robertson, who wrote, "When any region lies neglected and destitute of cultivation, the air stagnates in the woods, putrid exhalations arise from the waters; the surface of the earth, loaded with rank vegetation, feels not the purifying influence of the sun or of the wind; the malignity of the distempers natural to the climate increases, and the new maladies no less noxious are engendered."

I had always considered the unfolding of New England history as a series of human accomplishments. *Between Land and Sea* introduces the idea of the coast as an active player in shaping the evolution of this part of America. Much of Pastore's book specifically documents centuries of change that occurred along the shores of the bay, in Rhode Island cities and towns from Newport and Bristol to Warwick and Providence that were home to traders, farmers, merchants, and even pirates. His observations and quotations from writers of the period create a history that provides a feel for the people who chose to manipulate the coastal environment, whether motivated by religion, politics, or greed.

Martin Johnson Heade
(United States, 1819-1904)

***Rhode Island Shore*, 1858**

**Los Angeles County Museum of Art,
Gift of Charles C. and Elma Ralphs Shoemaker**

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