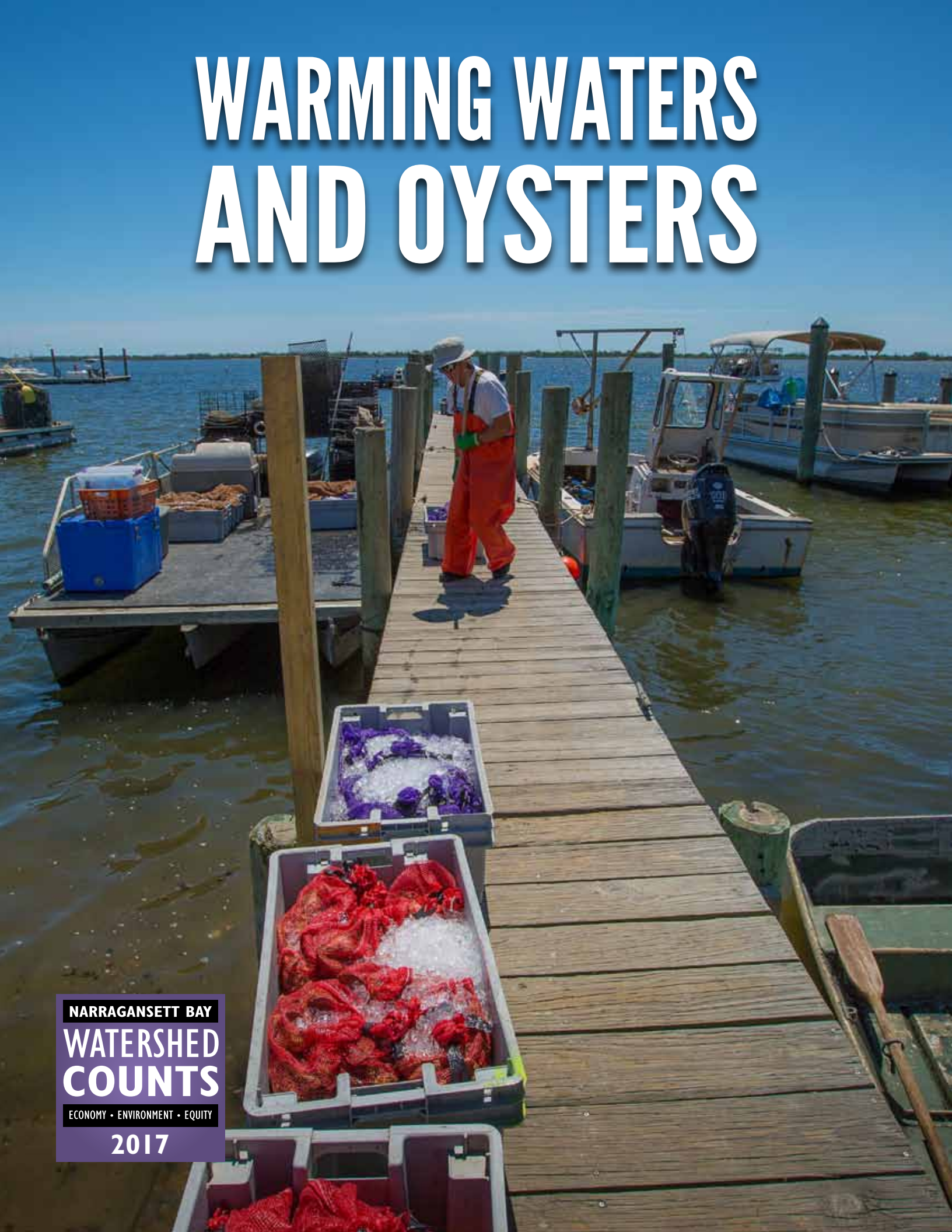
WARMING WATERS AND OYSTERS



NARRAGANSETT BAY
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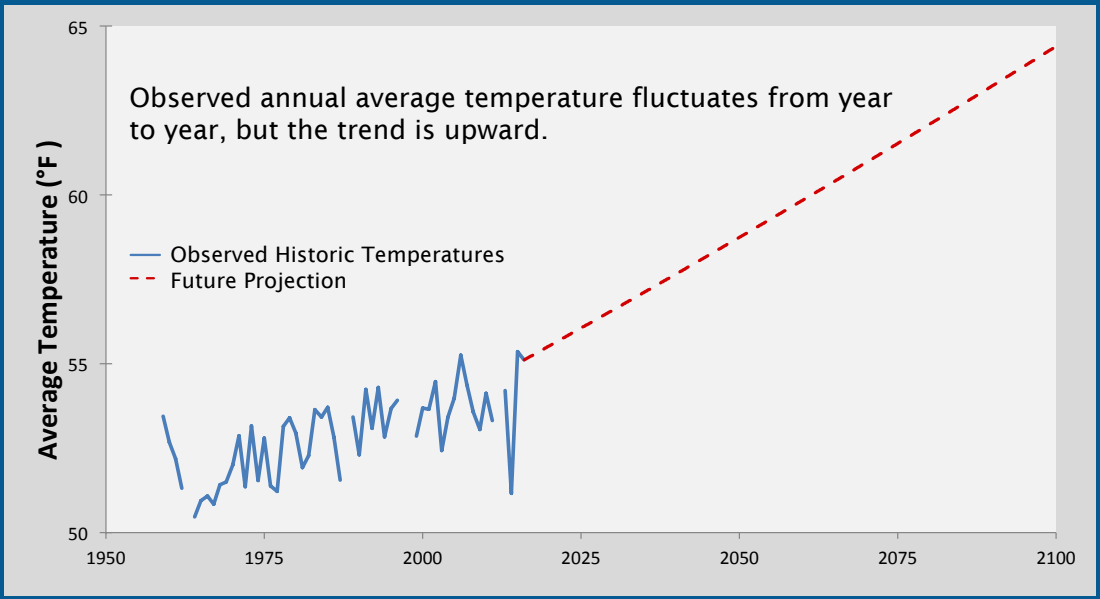


The average annual surface water temperature of Narragansett Bay has increased since the early 1950s (solid line), and is projected to increase even more by 2100 (dotted line). Data provided by The Phytoplankton of Narragansett Bay Laboratory, Graduate School of Oceanography at the University of Rhode Island. http://www.gso.uri.edu/phytoplankton/#Home

Temperatures have risen in Narragansett Bay.

- 2.5 to 2.9 ˚F (1.4 to 1.6 ˚C) in the surface waters over the past 50 years.
- 2.9 to 3.6 ˚F (1.6 to 2.0 ˚C) in the winter surface water temperatures, more than that of any other season.

Temperatures will continue to increase.

- 5 to 6 ˚F (2.7 to 3.2 ˚C) over the next 100 years when averaged over all seasons
- 5.7 to 7.2 ˚F (3.2 to 4.0 ˚C) in the winter surface water temperatures.
- Increases could be even higher than currently projected if greenhouse gas emissions are not significantly curtailed.

Warming Waters and Oysters

"The time has come," the Walrus said,
"To talk of many things:
Of shoes—and ships—and sealing-wax—
Of cabbages—and kings—
And why the sea is boiling hot—
And whether pigs have wings."

Four other Oysters followed them,
And yet another four;
And thick and fast they came at last,
And more, and more, and more—
All hopping through the frothy waves,
And scrambling to the shore.

—*Through the Looking-Glass and What Alice Found There,* Lewis Carroll

The waters of Narragansett Bay are warming. Here, we will primarily focus on the impact of warming waters on oysters, particularly oyster aquaculture, but first it is helpful to understand how much waters are warming and the impact on the ecosystem as a whole. For example, not only does this change the fragile chronology of seasonal interactions among the plants and animals that call the bay home, but the temperature of the water also impacts the water itself by causing it to expand and contribute to sea level rise.

Home is where the hot is, let's keep it cool

Warming waters will impact a range of plants and animals, as well as people who live on the coast. Let's examine this a step at a time: water expands as it gets warmer, which contributes to sea level rise, and is added to by melting glaciers. The water has to go someplace as it expands and sea levels rise, so it spills over our barrier beaches, into our salt marshes, and through our human-made structures. We normalize this by calling it flooding, but it is sea level rise and some areas will be permanently underwater in the not-so-distant future.

Another factor that's in play is that warmer waters fuel more frequent, high-intensity storms. This means that a future Superstorm Sandy—fueled by warmer waters—may make landfall as a more intense hurricane. Nor'easters and hurricanes are inevitable events that will add dramatically to the impacts of warmer waters.

The impact on plants and animals is less straightforward and scientists continuously research these complex interactions. Many plants and animals rely on water temperature cues for growth and reproduction, and, in general, they grow more quickly and are more active when water temperatures are warmer. With temperatures getting warmer, we have changing seasonal patterns, scientifically known as phenological changes, which can impact the entire ecosystem by altering food web dynamics.

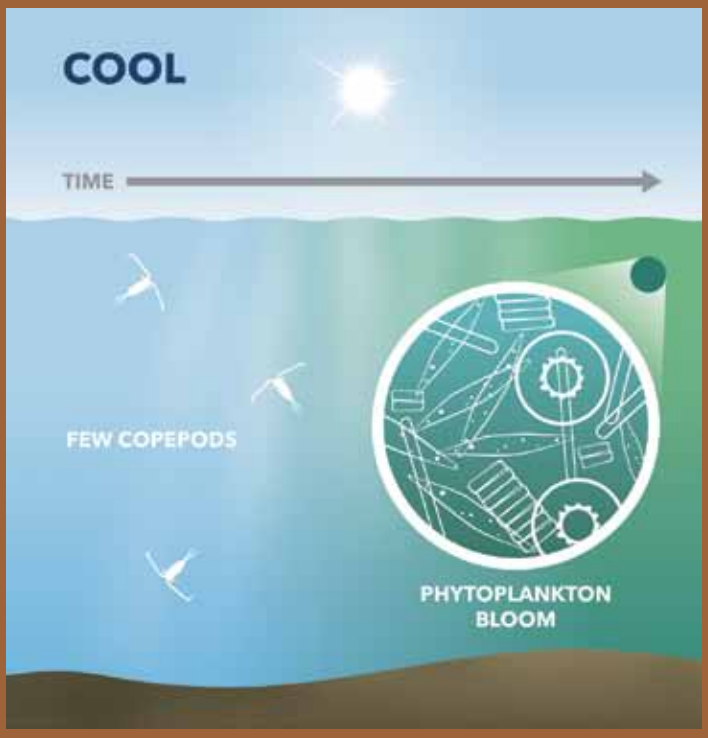
Consider this: the Semipalmated Sandpiper, a long-distance migratory shorebird, travels all the way from wintering grounds in South America to nest in the tundra of northern Canada. Napatree Point in Watch Hill, Rhode Island, is a key stopover site, and the migrating bird expects horseshoe crab eggs to replenish its energy after 6000 miles of flight. If warmer waters cued the horseshoe crabs to mate earlier, those eggs would not be there to nourish the starving Semipalmated Sandpipers. These phenological interactions are a fragile and intricate part of the web of life.

Warming waters also impact invasive species. From time to time, we hear reports of lionfish that make their way to Narragansett Bay from the Caribbean, or the increase of blue crabs that are more common in the mid-Atlantic region. But occasional visitors to our coasts are not of as much concern as the interlopers that make Narragansett Bay their permanent home. These invasive species can disrupt the bay ecosystem, and introduce new parasites and diseases, some of which are already impacting our oysters.

These are but a few examples of the impacts of warming waters on the coastal environment and the species that depend on it.

Ships passing in the night

One prominent—and potent—phenological change in Narragansett Bay is the intensity of spring phytoplankton blooms. These rapid increases of small, single-celled algae are critical to supporting life in the bay, but are impacted by copepods, microscopic crustaceans related to lobsters and crabs.



When winter water temperatures are cooler, copepods mature later, allowing phytoplankton the opportunity to multiply rapidly before the copepods start feeding. This increase in phytoplankton is known as the spring phytoplankton bloom and forms the base of the food chain, consumed by shellfish you eat and by fish you catch.

When winter water temperatures are warmer, copepods mature earlier, feeding on phytoplankton before it has the opportunity to multiply rapidly. This early grazing pressure results in a smaller—and sometimes absent—spring phytoplankton bloom, which means less food available for shellfish and fish, as well as other animals that also rely on the phytoplankton.

The world is your oyster — aquacultured in RI

Aquaculture—or cultivating marine plants and animals in a specific area—has become increasingly popular around the world, and Rhode Island is no exception to this trend. Aquaculture products range from Maine kelp to Panamanian tuna grown in small onshore aquaculture facilities to vast open-water cages. Oysters largely contribute to the Rhode Island shellfish industry, primarily through aquaculture that gets this tasty treat from salt pond to plate.

As of 2016, 70 aquaculture farms on nearly 275 acres operated in the Narragansett Bay region, producing oysters, quahogs, and mussels. Much of the oyster aquaculture is concentrated in the South Shore coastal ponds because they are easy to access and are protected from the elements.

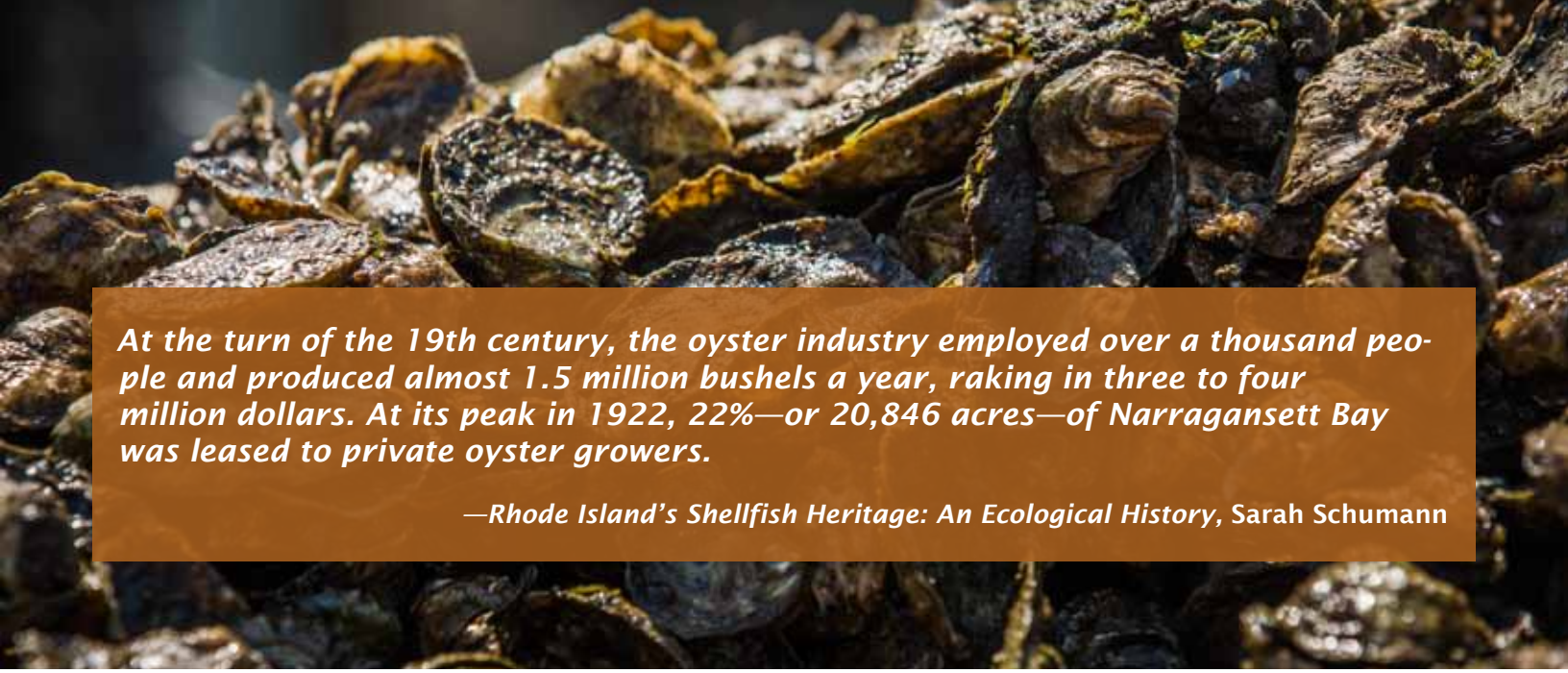
The presence of aquaculture in Rhode Island has steadily increased since 1995, when five farms occupied fewer than 10 acres.

Show your pearly whites for oyster values

On the mid-Atlantic coast and in the Gulf of Mexico, oysters can form large reefs that protect adjacent shorelines by serving as speed bumps for waves heading for the coast.

They also serve as habitat for fish and invertebrates, including other juvenile oysters that need hard surfaces to settle and grow.

Oysters are filter feeders and remove particles—including algae and organic particles—from the water as they filter for food. This improves water quality, which in turn improves oyster habitat.



At the turn of the 19th century, the oyster industry employed over a thousand people and produced almost 1.5 million bushels a year, raking in three to four million dollars. At its peak in 1922, 22%—or 20,846 acres—of Narragansett Bay was leased to private oyster growers.

***—Rhode Island's Shellfish Heritage: An Ecological History,* Sarah Schumann**

Oysters shell out money. Fishermen rake it in.

In 2016, over 7.8 million aquacultured shellfish valued at over $5.3 million were sold for consumption. Oysters made up 99% of the industry. And this value only includes the farmer's profits, but there are many more contributions to Rhode Island's economy, including truckers and shuckers, restaurateurs, or valet at your favorite oyster restaurants, making you feel like a Rockefeller.

The aquaculture industry has exploded in recent years with value more than tripling since 2010. Additional growth is expected: nine new farms will start harvesting in the next several years and kelp has been added to the list of harvested products. Also, organizations like the Rhode Island Seafood Marketing Collaborative and the Ocean State Shellfish Cooperative have expanded marketing efforts both locally and regionally.

RI's got a supermodel in aquaculture oversight

Warming waters could impact oyster aquaculture in a number of ways such as production and human health. One of aquaculture industry's biggest concerns related to warming waters is disease. While we already have evidence that oyster disease increases as waters warm, Rhode Island regulators and aquaculturists work together to uphold a comprehensive system to monitor for disease and protect public health—as advanced by the Rhode Island Shellfish Management Plan.

The Rhode Island Coastal Resources Management Council is the lead agency for leasing aquaculture operations in the state, working closely with the Rhode Island Departments of Environmental Management and Health. Those interested in establishing an aquaculture farm must submit an application for a submerged lands lease. These leases can be up to 15 years and all leases combined can total no more than 5% of each coastal pond. State agencies primarily ensure that oysters brought in for aquaculture are disease-free by monitoring the oysters and waters to protect public health as part of the National Shellfish Sanitation Program.

Today, only about 5% of the oyster landings in Rhode Island are from wild oysters. The remaining 95% is from aquaculture.

Other shellfish mussel in on the deal

Other shellfish are wild harvested and aquacultured in Narragansett Bay, and are not to be discounted.

Quahogs—the future home of the Rhody stuffie—support a beloved pastime that tourists and locals alike dig as well as a commercial fishery. Mussels and steamers are recreationally harvested, and the conch commercial fishery is growing.

Oysters: healthy, wealthy and prize

Rhode Island oyster farmers and regulatory agencies already take steps to protect oyster and human health, and have protocols in place to combat the higher occurrence of disease likely to accompany warming waters. Of current concern are MSX and Dermo, which impact oyster health (but pose no threat to human health), and Vibrio, which can impact human health if proper harvesting protocols are not followed or oysters are harvested from waters not approved for shellfishing.

In response, oyster farmers currently use MSX-resistant oysters that significantly reduce susceptibility to the disease. While there are not currently Dermo- or Vibrio-resistant oysters, research continues on their development and industry is exploring other solutions.

Rhode Island also has extensive oyster import and water quality monitoring programs. Like most aquaculture states, Rhode Island requires oysters coming into the state to have a clean bill of health from a licensed pathologist. Unlike most other states, Rhode Island takes this a step further and rigorously requires testing of oysters that are shipped intrastate among six zones. Regular water quality testing is also done in all areas available for aquaculture leases. This monitoring for pathogens and bacteria can indicate when farmers could face outbreaks and preemptive steps can be taken to protect human health.

Little Rhody waters equal big taste

Warm-water oysters grow more quickly than cold-water oysters. Oysters raised in warmer waters off Virginia and further south grow to market size in a year or less, while Rhode Island oysters may take up to two years.

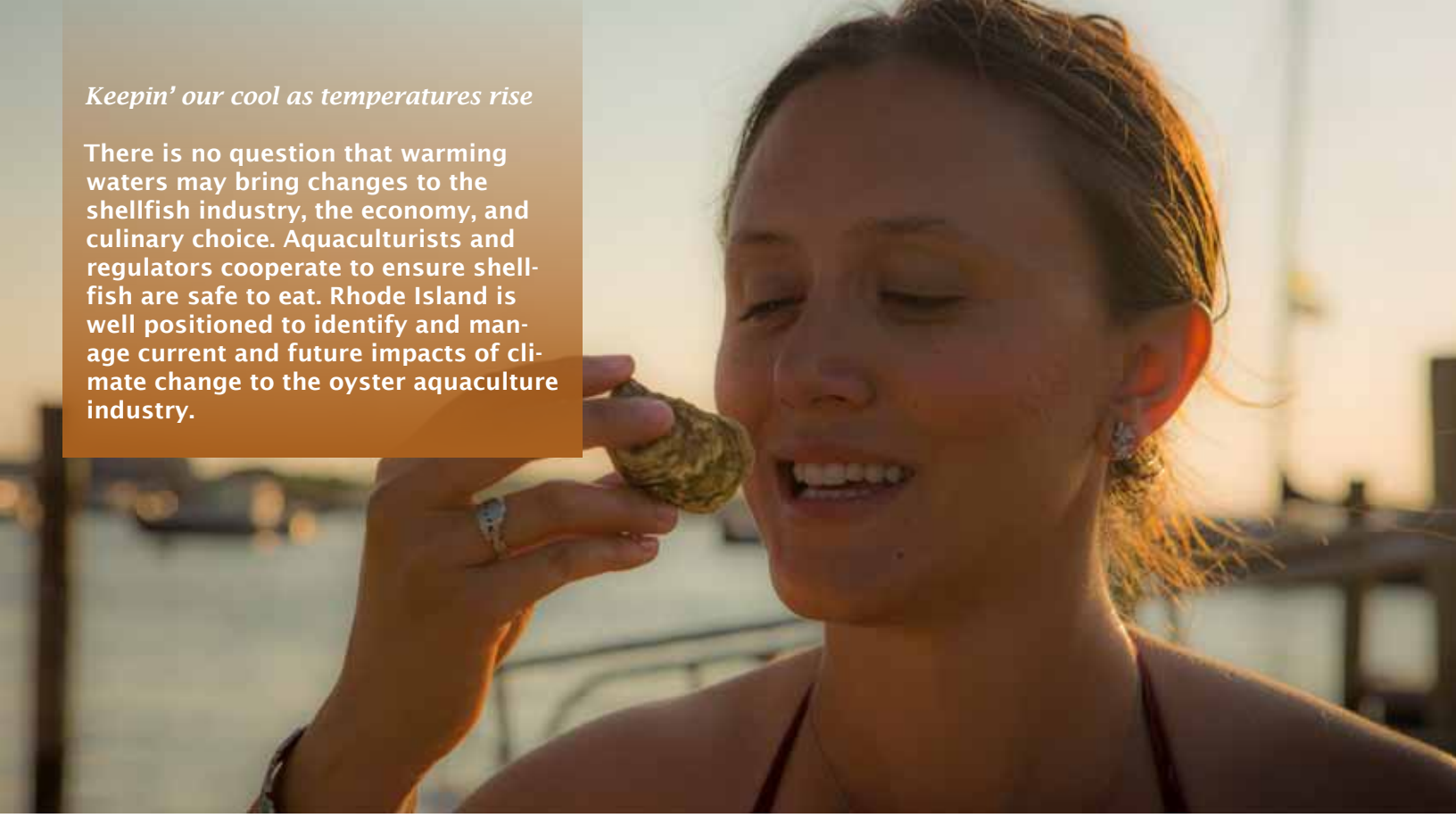
Faster growing oysters mean more to sell and eat, right? But hold the fork: warmer waters impact oyster taste. When water temperatures are lower than 50˚F, oysters stop feeding and rely on stored food called glycogen. Just like squirrels that store nuts in preparation for winter, oysters build up large glycogen reserves. Glycogen is what gives oysters their "sweetness." And Rhode Island oysters live off glycogen reserves roughly November through May. As water temperatures warm, local oysters will produce less glycogen thereby changing their taste.

Love to eat or eat to love

Warmer water temperatures also impact the number of times oysters spawn each year, and the more often they spawn the less tasty the treat. Currently, Rhode Island oysters spawn only once a year, while oysters to the south spawn three or more. But farmers to the south combat this problem by using oysters that are incapable of reproducing. Currently, most New England farmers do not use these oysters—the exception being in Ninigret Pond—but may have to switch in the future

Vigilant practices for robust oyster and human health

On the East Coast, parasites cause two common oyster diseases: MSX and Dermo, which both impact oyster health, but not human health. These two oyster diseases thrive in warm water, and cold winters in Rhode Island have historically kept them under control. Vibro is a bacteria that does cause human illness when infected oysters are consumed. Vibrio can be virulent, but Rhode Island has had very few cases of human illness due to the strict post-harvest handling requirements such as required time limits from harvest to ice. With winter water temperatures already increasing—and expected to rise even higher—a higher incidence of these diseases is anticipated in the future.



Keepin' our cool as temperatures rise

There is no question that warming waters may bring changes to the shellfish industry, the economy, and culinary choice. Aquaculturists and regulators cooperate to ensure shellfish are safe to eat. Rhode Island is well positioned to identify and manage current and future impacts of climate change to the oyster aquaculture industry.

Early warning system: oysters and HABs

2016 saw the first toxic Pseudo-nitzschia—a phytoplankton—bloom in Rhode Island. This harmful algal bloom, or HAB, prompted regulators to close areas of Narraganset Bay to shellfishing, including for oysters. All shellfish that tested positive for toxins were well below the threshold that triggers a mandatory closure, but out of an abundance of caution state regulators instituted closures to protect public health.

Pseudo-nitzschia is typically present in Rhode Island waters without causing threats to shellfish or human health; however, when the phytoplankton becomes stressed, it produces a toxin that accumulates in shellfish meat through filter feeding, and could cause human health impacts when these shellfish are eaten. Currently, it is not known why the Pseudo-nitzschia become stressed in Rhode Island, but warming waters play a role in other areas and some hypothesize that nitrogen and iron levels may factor into the equation. A complex interaction of multiple factors is also a possibility. Until scientists unravel this knot, regulators will continue to monitor it for safety.

Interestingly, oysters have a natural protection against Pseudo-nitzschia that other shellfish like mussels and clams do not. Oysters have advanced gills that can detect Pseudo-nitzschia and reject this potential food source. If Pseudo-nitzschia blooms become more frequent, this could inform management decisions on when to close oyster industries.

Other climate change concerns

Warming waters are just one climate-related concern. In addition, sea level rise is impacting working waterfronts, the home base of aquaculture operations and wild shellfishers. Increasing frequency of intense storms results in more significant rainfall events. Sudden downpours of rain can flood coastal areas, resulting in more bacteria and nutrients entering coastal waters from fertilized lawns, septic systems, and sewage overflows. State agencies and the aquaculture industry recognize that it is critical to continue taking steps to prepare for future climate change concerns.

Climate change is also causing ocean acidification (lower pH), and you may have heard reports of its impacting oysters in the Pacific Northwest. Ocean acidification is not an immediate concern in Narragansett Bay. The bay—like many estuaries—has widely-fluctuating pH and the bay's organisms are capable of dealing with low pHs. We continue to learn more about the impacts of lower pH, but, for now, the oyster industry is focused on more pressing climate change matters.

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Editorial Staff:

Nicole E. Rohr, PhD, Editor
Amber Neville
Judith Swift
Charles T. Roman, PhD

Design: Brian Jones, brianjonesdesign.com

Science Writer: Nicole E. Rohr, PhD, Coastal Institute at URI

Photos: Shed Light Productions, LLC, except where noted

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NARRAGANSETT BAY ESTUARY PROGRAM

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Selected Resources:

Aquaculture, Rhode Island Coastal Resources Management Council. http://www.crmc.ri.gov/aquaculture.html

Shellfishing, Rhode Island Department of Environmental Management. http://www.dem.ri.gov/programs/water/shellfish/

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