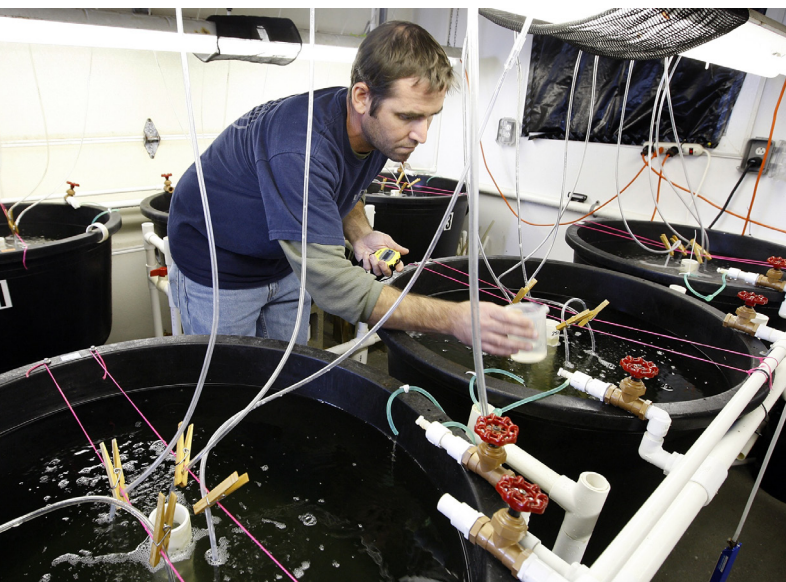




Jumpstarting North Carolina's Blue Economy: Opportunities in Ecosystem Technologies

Jess Wilkinson, Adams Bailey, and Sara Lawrence



Introduction

To jumpstart growth in the Blue Economy, North Carolina needs a statewide strategic plan for that purpose, following states like Hawaii, Massachusetts, and Mississippi. The plan needs to coordinate and support research and development of new technologies, update regulations that constrain aquaculture investment, and support pilot projects that apply new technologies.

In recent years, regions and states in the United States have sought to strategically grow and protect their economies and natural assets through investing in the Blue Economy.¹⁻³ The Blue Economy encompasses a wide range of economic activities connected to oceans,

Key Findings

- Ecosystem technologies, or ecotech, is an emerging branch of applied science that combines what we know from living ecological systems with technological advances to create and enhance products and processes. Ecotech presents a growth opportunity for North Carolina through the integration of new technologies into established Blue Economy sectors.
- North Carolina's strengths in aquaculture and coastal resilience provide a strategic opportunity for economic growth. By supporting the adoption of advanced technologies, the state could develop into a leader in these industries.
- In 2023, the US seafood trade deficit reached \$20.3 billion, with imports accounting for approximately 80 percent of total seafood consumption. Expanding North Carolina's aquaculture production could reduce import reliance and further diversify the state's economy.

coasts, and other marine ecosystems. Over the past decade, efforts to jumpstart and grow North Carolina's Blue Economy have steadily gained momentum.⁴⁻⁷ Today, North Carolina is home to numerous marine-focused research centers; businesses that are developing new technologies to modernize and streamline established Blue Economy industries; a nascent marine-focused venture capital ecosystem; and a robust set of nonprofits that protect the state's natural assets, conduct outreach, and connect the many entities in the state that are working to protect coastal areas and grow the Blue Economy.

In the past 2 years, federal investments have added to this progress by coordinating existing resources and identifying opportunities for Blue Economy expansion in North Carolina. One initiative, NC EcoTech™, was launched in 2023 with federal support and is based at the University of North Carolina Wilmington (UNCW). RTI is a member of NC EcoTech. This multiorganization initiative focuses on combining “understanding of living ecological systems with technological advances to ensure safe and sustainable solutions.”⁸ They work to leverage “ecosystem technologies” (i.e., ecotech) to help businesses tap into latent market opportunities in the region’s Blue Economy. NC EcoTech prioritized aquaculture and coastal resilience—two key Blue Economy sectors in North Carolina—because of the state’s existing successful businesses, growing industry presence, emerging technological potential, nationally recognized research centers, and economic and cultural roots in these industries.

This policy brief draws from research on North Carolina’s Blue Economy, interviews with subject-matter experts, and analyses of NC EcoTech’s priority industries—aquaculture and coastal resilience—to examine how emerging technologies have the potential to drive growth in the Blue Economy. Based on our experience working with NC EcoTech to build the aquaculture and coastal resilience industries using ecotech, and on the research described above, we offer recommendations for local, regional, and state leaders to:

- develop a **statewide strategy** to guide Blue Economy growth in North Carolina;
- invest in **Blue Economy technology development**, deployment, and coordination;
- assess and **modernize aquaculture regulations**; and
- fund **pilot projects** to test the integration of new technologies and processes in Blue Economy industries.

Together, these actions have the potential to develop North Carolina into a national—and eventually global—hub for Blue Economy technology research, development, and deployment.

Methodology

For this policy brief, we drew upon a combination of research on the economic development landscape in North Carolina and the broader Blue Economy industry. The focus on aquaculture and coastal resilience within this brief was informed by NC EcoTech’s efforts and our research on existing assets and businesses in the state. Between 2023 and 2025, we collected and analyzed a range of publicly available economic and environmental data to inform NC EcoTech’s industry and geographic prioritization. In this brief, we refer to data from the National Agricultural Statistics Service, the US Department of Agriculture Census of Aquaculture, and the North Carolina Division of Marine Fisheries’ *2024 License and Statistics Section Annual Report*.⁹ To supplement knowledge, fill gaps, and understand perspectives on future policy, we conducted four expert interviews. Among those interviewed were academics, practitioners, and venture capital investors whose work centers on aquaculture, coastal resilience, and the Blue Economy in and outside of North Carolina. We generated the policy recommendations based on our own analyses and on the experts’ inputs.

The New Blue Economy: Integrating New Technologies Across Established Industries in North Carolina

The Blue Economy consists of economic activities that fall under established industry verticals (i.e., niche markets within the same general industry) such as aquaculture, boat manufacturing, commercial fishing, maritime shipping, and coastal resilience. Incorporating new and compounding technology advances in robotics, biotechnology, advanced mobility, materials science, and artificial intelligence presents an opportunity for efficiencies and market expansion. North Carolina could be well poised to take advantage of these opportunities given its existing strengths and research in areas such as materials science and engineering, advanced manufacturing and biomanufacturing, advanced mobility, and materials and computational science.^{10–12}

North Carolina also has a strong base of public and private organizations working to innovate within the Blue Economy, including small businesses and

industry leaders in related technology areas. More than 20 ocean- and marine-based research centers are working independently on solutions for coastal resilience, aquaculture, offshore wind energy, and marine technologies, including Carteret Community College's Aquaculture Technology Program, Duke University's Marine Lab, East Carolina University's Coastal Studies Institute, North Carolina State University's (NC State's) Marine Aquaculture Research Center, and UNCW's Aquaculture Facility. In addition, the state demonstrates broad capacity for innovation, venture capital, and startup support organizations through its renowned universities, technology- and research-based companies in the Research Triangle region, and a statewide network of Small Business Technology Development Centers.

Although North Carolina already has many of the essential components needed to grow the "New Blue Economy," much of this work is happening in silos, thereby thwarting growth opportunities for the state. Information sharing and coordination efforts are not at a scale to accelerate meaningful growth. With greater coordination and a focus on connecting those in the state with new research and technologies to businesses who can use them, North Carolina could more fully realize the economic development potential of its Blue Economy.

Over the past decade, grassroots efforts to connect disparate parts of the ecosystem have steadily built momentum. For example, UNCW's Center for Innovation and Entrepreneurship hosts the annual Ocean Innovation Conference, a national event assembling innovators and industry leaders focused on advancing ocean technologies and solutions.¹³

NC EcoTech is one group in North Carolina that is homing in on the growth opportunities from integrating new and emerging technologies into existing Blue Economy industries. NC EcoTech is working to identify, test, and help businesses integrate ecotech into their systems. Ecotech is an "emerging and disruptive branch of applied science that combines living ecosystems and their derivatives with emerging scientific tools to produce and enhance products and processes."¹⁴ These innovations work with nature to reduce costs, energy, and time, and generate new jobs, tax revenue, and business

opportunities.^{15–16} Ecotech can originate as external technologies applied to natural environments—such as monitoring flooding and ecosystem health with drones and sensors, developing offshore renewable energy, and applying genetic engineering to coastal species. It can also originate as nature-based solutions that are enhanced with technology—such as living shorelines that use vegetation to prevent erosion, aquaculture farms optimized for sustainability and carbon capture, and advances in materials science that draw inspiration from nature.

Below we examine some of the opportunities and challenges to growing NC EcoTech's priority Blue Economy industries: aquaculture and coastal resilience.

North Carolina's Aquaculture Opportunities and Challenges

To meet growing consumer demand for seafood, the United States relies heavily on imports. In 2023, the US seafood trade deficit reached \$20.3 billion, with imports accounting for approximately 80 percent of total seafood consumption.¹⁷ Expanding domestic production—particularly in finfish and shellfish—could reduce import reliance and keep dollars in the US economy.

Aquaculture in North Carolina remains a relatively small industry but its economic history, cultural ties, and a growing base of successful businesses anchor its promise for growth in the near to medium future. In 2023, North Carolina accounted for just 1.7 percent of the \$1.9 billion US aquaculture market, generating \$33.2 million in sales across 95 farms (see Table 1). These data from the United States Department of Agriculture's (USDA's) 2023 Census of Aquaculture¹⁸ underestimate industry sales totals and economic impact, because they show only farm sales and do not include sales further down the value chain from processing, distribution, or retail. As a comparison, NC State Extension estimated the total value of North Carolina aquaculture to be about \$60 million in 2019.¹⁹ Yet the USDA data are useful for comparing North Carolina's industry over time and relative to the rest of the country.

North Carolina's aquaculture industry shows strong potential for growth—particularly in bass, trout, and oysters. From 2013 to 2023, North Carolina's

Table 1: North Carolina sales in aquaculture, by species: 2005, 2013, and 2023

NC aquaculture	Sales (\$ millions)			% of national sales		
	2005	2013	2023	2005	2013	2023
Mollusks, total	\$0.8	\$0.3	\$1.5	0.1%	0.1%	0.3%
Clams	\$0.6	\$0.3	\$0.1	0.2%	0.2%	0.1%
Oyster	\$0.2	\$0.1	\$1.4	0.0%	0.0%	0.4%
Food fish	\$23.1	\$23.4	\$30.4	3.3%	3.3%	3.7%
Bass	\$6.7	\$9.0	\$10.3	17.8%	17.8%	40.7%
Catfish ^a	\$6.1	\$4.4	–	1.2%	1.2%	–
Trout	\$6.6	\$6.9	\$15.6	6.3%	6.3%	11.7%
Total NC aquaculture	\$24.7	\$25.1	\$33.2	1.8%	1.8%	1.7%

^a Data unavailable for catfish in 2023.

Source: National Agriculture Statistics Service, US Department of Agriculture, 2024.¹⁸

aquaculture sales increased 2.8 percent annually. Within this category, trout sales increased 9 percent and oyster sales increased 34 percent annually. Taking oysters as an example, continued growth by small farmers in the next 10 years at a third of the rate from the past 10 years, 11 percent, would mimic the growth of the industry in other places like Massachusetts over the past decade.²⁰ This expansion would create 520 jobs in North Carolina and generate \$27 million in extra economic impact to the state. Jobs and revenue could also be generated by farming other species.²¹

North Carolina is home to several established aquaculture businesses, such as Carolina Fisheries (striped bass), Carolina Classics Catfish, Marshallberg Farm (Russian sturgeon), and Sunburst Trout Farms. Although these companies provide proof of concept for profitable aquaculture production and processing in North Carolina, promoting future growth and remaining competitive in the aquaculture industry will depend on integrating advanced technologies—including artificial intelligence (AI), smart sensors, genetic tools, and automation—into production systems. These tools represent an exciting frontier for making local aquaculture environmentally sustainable, cost-competitive with imports, and scalable. They might also help farmers overcome threats from mortality events among shellfish crops or from hurricanes and other environmental disasters, thus alleviating risk and enabling future research. Leadership in these technologies could position North Carolina firms as global leaders in

applied aquaculture systems and solutions. In many cases, these technological solutions could be exported to other producers.

One promising innovation is recirculating aquaculture systems (RASs). These land-based systems recycle water and use advanced filtration, making them resource-efficient and environmentally sustainable. RASs could be a game-changer for North Carolina because they enable controlled, year-round production of high-market-value species. There is potential to retrofit closed or inactive farms for aquaculture use—for example, turning former livestock operations into cutting-edge fish farms—with more widespread applications of RASs.

RASs can be challenging for many smaller producers to implement, however, because of their high up-front costs and friction with current regulations. RASs are costly to install and are energy intensive, making them most applicable for high value-added products. Currently one of the few commercial farms in North Carolina using RAS technology is Marshallberg Farm, producer of Russian sturgeon caviar. RASs have been implemented extensively in other parts of the world but have not yet been widely adopted or deployed in the US. According to our interviews, current regulations hinder the ability of many aquaculture producers to implement RASs because they can limit the amount producers can discharge into nearby water sources. With well-implemented RASs, any water discharged would be cleaner than in previous methods of aquaculture production.

As of 2025, Norwegian aquaculture giant Hima Seafood, a leader in environmentally friendly RASs for farming salmon and trout, is considering a large facility in North Carolina for raising rainbow trout. The scale of such a project could transform the industry in the state. Hima's investment in its Norwegian trout farm was around \$250 million and now produces 9,000 tons of trout annually. US facilities would aim to produce over double that amount, at 23,000 tons, equating to \$104 million in sales at current prices, which would effectively double the number of trout grown in the US and dramatically reduce or eliminate the need for imported farmed trout.²² North Carolina, currently third among states in trout farming behind Idaho and Washington, would become a national leader in the industry and create additional jobs and revenue from construction, suppliers, and partners to a new facility.

Intentionally investing in strengthening the aquaculture supply chain is another strategy worth consideration. The state of Virginia has a more mature seafood supply chain and is a worthwhile comparison to North Carolina because of the states' similar climates and natural ecosystems. In 2023, Virginia had \$104.2 million in aquaculture sales from 146 farms, compared to North Carolina's \$33.2 million in sales from 95 farms despite the similar climates.¹⁸ Virginia is the largest producer of oysters on the East Coast and of hard clams nationwide, with \$51.8 million in annual hard clam sales.¹⁸ Its aquaculture industry is anchored by Cherrystone Aqua-Farms, which purchases clams from smaller farmers and distributes to major retailers such as Wegmans.²³ The industry supply chain contains hatcheries, producers, processors, wholesalers, distributors, retailers, and customers. By contrast, many North Carolina farms lack hatcheries or buyers within the local network, thereby forcing growers to take on multiple roles or to source products from outside the state, which increases transportation costs and limits local competition. More developed supply chains could help North Carolina achieve the growth needed to catch or surpass its neighbor.

North Carolina's Coastal Resilience Opportunities and Challenges

Another potential opportunity for growth in North Carolina's Blue Economy is coastal resilience. Traditionally, erosion prevention along coasts has relied on fixed bulkheads and other impermeable infrastructure solutions that are costly, unsightly, and disruptive of ecosystems. Innovations in living shorelines and adaptable barriers to prevent erosion and protect vulnerable areas apply cutting-edge smart sensors, advanced shoreline modeling, and nature-based infrastructure as a cost-efficient and environmentally friendly alternative.²⁴

In North Carolina, local demand for coastal resilience is increasing, driven by sea-level rise and severe weather events that could impact the state's 320 miles of Atlantic coastline and its 12,000 miles of shoreline along sounds, estuaries, bays, river deltas, and marshes. Up to 92 percent of this coastline is experiencing erosion.²⁵ The Federal Emergency Management Agency estimates that expected damage costs for hurricanes and flooding in eastern North Carolina are \$1.41 billion annually.²⁶

Oysters: Aquaculture and coastal resilience intersect

Besides providing a sustainable and profitable source of protein, oyster beds absorb wave impacts, reduce coastal erosion and the risk of flooding, and filter pollutants from water. Oysters are a growing industry in North Carolina. The USDA 2023 Census of Aquaculture estimated that North Carolina had 26 oyster farms and produced \$1.4 million in sales. These numbers were up from eight farms producing just \$72,000 in sales 10 years prior. These figures include only the farm's sale price and not additional value added between farm and table. Other analyses have shown that this is a conservative estimate; for instance, one study found that farmed oysters contributed \$14.7 million and 283 jobs to the state's economy in 2022.²¹

The landscape represents an opportunity for piloting innovative shoreline protection solutions that can be applied to coastlines worldwide.

Small businesses in North Carolina, including civil engineering firms, environmental consultants, oyster restoration companies, and habitat restoration specialists, are developing and deploying these

Figure 1: Examples of Sandbar Oyster Company's Oyster Catcher™ substrates

Note: Sandbar Oyster Company's Oyster Catcher substrate is a biodegradable hardscape composed of plant-fiber cloths and a mineral-based hardening agent that can be formed into many versatile shapes. The photos in the top row represent products before being settled with oysters, and the bottom-row photos represent ones colonized with oysters. Left-hand photos show reef-building tables, center photos show sediment-accumulation pillows, and right-hand photos show spat-catching tufts.

Source: Sandbar Oyster Company; used by permission.

technologies. While many focus primarily on local installations, some are patenting their technologies and could reach external markets:

- **Natrx** provides 3D-printed coastline infrastructure and deployment strategies for controlling erosion and reestablishing natural shorelines, combining technologies from additive manufacturing, materials science, AI monitoring, and ecosystem modeling.²⁷
- **Native Shorelines** has developed the proprietary QuickReef® system, an innovative living-shoreline product that uses structures built from a chemical compound that mimics oyster shells to prevent coastal erosion.²⁸
- **Sandbar Oyster Company** has a patent-pending biodegradable hardscape material composed of plant fibers to create living shorelines, restore oyster habitats, and aid aquaculture (photos appear in Figure 1). These materials aid in the gradual accumulation of grasses, sand, rock, and shellfish that revitalize shorelines over time.²⁹

Clients for these businesses include private developers, local and state governments, federal agencies (e.g., US Army Corps of Engineers), and regional nonprofits (e.g., the North Carolina Coastal Federation).

The state could experience the impact of coastal resilience both in terms of economic activity such as jobs and revenue, and in terms of cost savings from mitigating damages from coastal erosion due to storms and rising seas, which causes \$500 million per year in coastal property loss across the US.³⁰ One report estimated that North Carolina's shorelines were the third most costly to protect among all states and could require expenditures of as much as \$34.8 billion on seawalls to counteract erosion by 2040.³¹ However, nature-based solutions for reducing erosion are proving to be cost-effective and could be in high demand. An analysis of erosion protection on the Gulf Coast estimated that nature-based solutions such as wetlands and oyster reefs could save \$64.6 billion over the next 20 years in that region, with a benefit-to-cost ratio of 3.5.³² Innovation in ecotech solutions

could produce significant savings for taxpayers as well as jobs designing, producing, and implementing nature-based solutions.

Actions to Support Growth in North Carolina's Blue Economy

This policy brief argues that the Blue Economy is an actionable area for economic development that builds upon existing strengths. Whereas North Carolina has many unique assets—including a diverse coastal ecosystem, strong research institutions, and an emerging Blue Economy innovation sector—the state is missing vital components needed to jumpstart growth, such as developed supply chains and regulatory clarity. A statewide strategy could pinpoint crucial gaps such as these that need to be addressed. With the right infrastructure and coordination, per the following recommendations, North Carolina could maximize the return on its existing assets and potentially become a national leader in the Blue Economy.

Recommendations presented below aim to foster the growth of this industry within North Carolina. Recommendations were generated based on an assessment of North Carolina's current position within the Blue Economy industry. We believe they represent a pragmatic path forward.

Develop a Statewide Strategy to Guide Blue Economy Growth

North Carolina could create a forward-looking road map ensuring sustained leadership and cross-sector alignment for sustainable economic growth. This road map could consider ways to connect and harness the existing Blue Economy ecosystem assets while identifying and filling gaps. The road map could present strategies to leverage the innovation taking place at research centers, implement pilot projects to test new technologies, and attract Blue Economy-related entrepreneurial support and venture capital investment. Our initial assessments have indicated that coastal resilience and aquaculture verticals would be good starting points for sector expansion. A rigorous strategic plan could identify additional verticals to prioritize.

Hawaii,³³ Massachusetts,³⁴ and Mississippi³⁵ are examples of states that have created and implemented Blue Economy or ocean strategies, with leadership coming from the state level.

Invest in Blue Economy Technology Development, Deployment, and Coordination

To maximize the impact of research, development, and commercialization in the Blue Economy, North Carolina's road map could include a coordinated approach to identify and support promising new technologies to expand market opportunities. This method would help to address the fragmented approach to growing the sector that we see today. Better information sharing and coordination of relevant research taking place in North Carolina's universities and industries would strengthen the Blue Economy innovation ecosystem and economic development efforts. One strategy to advance these goals would be for the state to establish a central hub to serve as a collaborative platform for research, development, and commercialization in the Blue Economy. This hub would bring together stakeholders from higher education, industry, and government to align goals, share data, and accelerate innovation in a more focused cohesive fashion. A hub could help:

- identify technologies in other domains that could drive expansion of the Blue Economy sector and its impact;
- coordinate research and development efforts across institutions; and
- attract startup investments from Blue Economy venture capital entities, such as Hatch Blue and SeaAhead; the Walmart Foundation; or established aquaculture industry leaders.

Organizations like NC EcoTech, NC Sea Grant, and NC State's Coastal Resilience and Sustainability Initiative, which play essential roles as ecosystem builders and connectors, could expand their efforts to bridge these types of gaps while supporting workforce development, business creation, and industry needs.

Assess and Modernize Aquaculture Regulations

A critical step in growing the Blue Economy in North Carolina would be assessing and then modernizing existing aquaculture regulations. Current regulatory

frameworks do not encompass all aquaculture farming techniques and can prove incompatible with the latest technologies, thus creating unnecessary and extensive barriers to growth and innovation. As discussed above, RASs—even though they can actively and efficiently filter pollutants out of water that is discharged into waterways—are sometimes incompatible with current regulations, which creates a barrier to broader adoption and investment. Interviewees perceived regulations around aquaculture to be unclear and enforced inconsistently or on a case-by-case basis, making planning and investing in new technologies difficult.

These regulations would not need to compromise on ecosystem health or allow additional pollutants—they could introduce clarity and highlight clear paths for businesses that use technologically advanced systems that avoid the environmental degradation seen in less-regulated markets. Hima Seafood has publicly expressed its view that its ability to get permits will determine whether its large RAS trout farm project will move forward in North Carolina.^{22,36} A more navigable, transparent system is essential—to attract investors, to support the growth of local businesses, and to expand the ability to test new technologies. Initiatives could also work proactively to identify sites for aquaculture production and to clear the way for private investment.

Fund Pilot Projects

Many potential ecotech systems and solutions for aquaculture and coastal-resilience industries have not been applied to use cases. Piloting these technologies in the state would allow for local adoption and adaptation and would position North Carolina as an exporter of cutting-edge solutions. The state and others could invest in pilot projects across North Carolina that test and adapt innovative technologies and production processes to serve as models for future industry growth.

For example, NC EcoTech is working toward a pilot project that aims to transform a decommissioned wastewater treatment plant into a state-of-the-art aquaculture facility. This project would incorporate advanced technologies such as monitoring, modeling, and automation systems, which have strong

international track records but are not yet widely used in the US. In addition to boosting local aquaculture production and creating a replicable business model, the project could serve as a demonstration site exhibiting ways to successfully integrate environmental protections such as oyster reefs and engineered wetlands to mitigate the impacts of sea-level rise and saltwater intrusion.

Conclusion

North Carolina has an opportunity to grow its Blue Economy industry through developing and applying new and emerging technologies across established industries like aquaculture and coastal resilience. These industries are poised to grow by developing and adopting new and advanced technologies. Ecosystem facilitators such as NC EcoTech are laying the groundwork for growth, but achieving this vision will require public and private leadership in (1) coordinating technology development and adoption efforts, (2) implementing a regulatory framework that enables investment, and (3) supporting pilot studies that apply these new technologies. Investment in these areas could further diversify the state's economy, reduce the state's and country's reliance on imported seafood, and add to the existing vibrant innovation ecosystem in North Carolina.

Data Availability Statement

The data supporting the current study are referenced within this publication.

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About the Authors

Jess Wilkinson is an economic development researcher in the Center for Applied Economics and Strategy at RTI International.

<https://orcid.org/0009-0007-0427-3259> (jwilkinson@rti.org)

Adams Bailey, PhD, is a research economist in the Center for Applied Economics and Strategy at RTI International. <https://orcid.org/0000-0003-4093-8450> (abailey@rti.org)

Sara Lawrence is the senior director for Applied Economics and Strategy at RTI International. <https://orcid.org/0000-0001-7870-9560> (slawrence@rti.org)

RTI Press Associate Editor

Timothy Slade

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Cover photo: A research assistant at an aqua farm facility at the University of North Carolina Wilmington checks water flow rates in tanks holding microscopic fish larvae. Photo courtesy of Chuck Liddy/Raleigh News & Observer/Tribune News Service via Getty Images.

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RTI International, 3040 E. Cornwallis Road, Durham, NC 27713-2852 USA

+1.919.541.6000 rtipress@rti.org www.rti.org

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