

A COMPARATIVE CASE STUDY OF VIRGINIA AND NORTH CAROLINA'S OYSTER AQUACULTURE DEVELOPMENT

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Any inaccuracies are the responsibility of the North Carolina Rural Economic Development Center.

INTRODUCTION

This case study underscores the potential for oyster aquaculture to be a greater source of income and economic stability for North Carolina's commercial fishing industry, as well as for the coastal economy as a whole. North Carolina shellfish aquaculture has made steady progress in the last decade, but it is not enough to match our competition or market opportunity. Being equal to the opportunity requires stronger collaboration among state entrepreneurial commercial fishing operations.

The situation in North Carolina lies in stark relief to that of Virginia, which has systematically and strongly committed itself to embracing the science of 21st century shellfish aquaculture. Virginia's effort has resulted in new processes for growing oysters, as well as genetic breeding programs that are now commonly used in agriculture.

Virginia is not alone in recognizing the critical role of aquaculture. "Aquaculture is one of the few options for increasing global production of fisheries in the 21st century," said Dr. Colin Nash, who is widely regarded as one of the world's foremost aquaculture experts. "Fish and shellfish, produced either through aquaculture or by harvest of the natural resources, currently provides between 15% and 20% of all animal proteins for human consumption, and they will continue to be important contributors to the enormous global demand. However, after quickly rising from 20 to 100 million tonnes since the ending of the Second World War, the annual harvest of the world's oceans began to level off about a decade ago. It has remained more or less static ever since. Therefore, it is up to aquaculture to produce any future increase in the global total."¹

Future production will be met, but by whom? North Carolina watermen are as worthy as fishing communities anywhere in the world. They can and should be beneficiaries and actors in this opportunity.

This comparative case study begins with assessing economic impact of oyster aquaculture in the two states. A review is then made of the policy and research development in each state. A summary is given of market demand research carried out by the research team. Finally, on page 15 a review panel is suggested and questions to frame its deliberation.

North Carolina has a proud tradition of supporting its farming communities. This tradition reinforces what is central to the heritage and values we think of when we reflect on who we are as a state. Our commercial fishing community, while small, is worthy of this same respect and partnership. While heritage matters a great deal, it is equally critical that the commercial fishing industry embrace new ways of thinking and doing if it is to get past merely surviving, to a future in which watermen can thrive. This case study points to one opportunity to come that requires a renewed commitment today.

Economic impact

To begin the comparison of shellfish aquaculture in Virginia and North Carolina, we start with a bottom-line comparison of the economic impact in each state. In 2012, the direct economic impact (product sales) of shellfish aquaculture in Virginia was an estimated \$36.2 million. Cultured clams, the more established product, accounted for \$26.8 million, while oysters accounted for \$9.5 million, according to a recently released economic analysis by the Virginia Institute of Marine Science and the Virginia Sea Grant programⁱⁱ.

In 2012, North Carolina total shellfish aquaculture sales had a value of an estimated \$908,975 – 97 percent less than the direct economic impact in Virginia.ⁱⁱⁱ

If we look at oysters alone, in Virginia oyster aquaculture operations generated \$9.5 million in 2012. North Carolina produced \$595,446 of oysters from aquaculture operations of various kinds. Virginia oyster aquaculture revenue exceeded by \$6.3 million the entire harvest of wild and cultured North Carolina oysters. Table 1 below highlights the bottom line. Over a seven-year period, there was explosive growth in oyster aquaculture sales in Virginia and practically flat growth in North Carolina's. To put it another way, for every dollar of sales in North Carolina in 2005, there was 93 cents sold in Virginia. By 2012, for every dollar of oysters from an aquaculture operation in North Carolina, \$16.05 was sold in Virginia.

Year	Virginia	North Carolina
2005	\$240,000	\$257,143
2006	\$930,000	\$306,698
2007	\$1,440,000	\$272,154
2008	\$2,842,000	\$221,946
2009	\$3,276,000	\$154,054
2010	\$5,239,000	\$247,074
2011	\$6,990,000	\$332,565
2012	\$9,554,000	\$595,446

Table 1. Oyster Aquaculture Sales in Virginia and North Carolina^{iv}

The number of cultured oysters sold by Virginia growers increased from 800,000 in 2005 to 28.1 million in 2012^v. This is a remarkable growth rate. This translates to a revenue growth of \$9.3 million over a seven-year period. Of Virginia's \$9.5 million in sales in 2012, 74 percent were to out-of-state buyers. This explains in part why Virginia oysters are found in North Carolina grocery stores and oyster bars.

The VIMS/Virginia Sea Grant economic analysis also carried out an IMPLAN analysis, a common econometric model that estimates economic impact from direct, indirect and induced outputs and income. This broad analysis indicates a shellfish aquaculture industry impact of \$81 million dollars. There is no similar IMPLAN estimate for North Carolina shellfish aquaculture but it is safe to assume that it is small in comparison to Virginia.

Growing incomes is the bottom line for fishing communities. The VIMS/Virginia Sea Grant report estimates income values from shellfish aquaculture's direct, indirect and induced impact to be a little over \$40 million in 2012.

What is shellfish aquaculture?

Shellfish, unlike finfish, stay put once its free-floating larvae sets on a shell or hard substrate. Historically, extensive oyster beds were found throughout the Chesapeake Bay and sounds of North Carolina. The natural propagation of oysters takes place in the late spring and summer when larvae float on the currents till finding a hard substrate on which to latch. The shell begins growing and the oyster enters the three-year cycle necessary to reach legal harvest size.

Until the early 20th century, oyster harvesting was a manual exercise that required the use of tongs or similar hand tools to bring oysters to the surface. With the development of mechanical dredges that were dragged over the top of beds, the harvest of oysters skyrocketed to meet a strong national demand for oysters. With the increased use of mechanical dredges in North Carolina, 1.8 million bushels of wild oysters were harvested in 1902^{vi}. This was the peak in North Carolina for the 20th century. However, over-harvesting, periodic public health concerns, and declining habitat reduced the oyster harvest to 83,188 bushels in 2012.^{vii}

Oyster aquaculture can take place with different levels of intensity, each requiring a degree of active intervention in the reproduction and/or growth cycle of the oyster. An essential but relatively passive intervention is the rehabilitation of oyster beds and sanctuaries for wild populations to reestablish. North Carolina's efforts in this area have been strong in recent years. A second level of intervention is the placement of hatchery-produced spat-on-shell on otherwise wild/natural beds, which then grow through the three-year cycle of maturation.

Oyster aquaculture at its most intensive level, and the level of intensity increasingly used today, has two characteristics: 1) a far more active intervention in genetic development of broodstock and lines that are designed for faster growth, disease resistance, and levels of salinity tolerance; 2) an active "farm" operation, where the oysters are grown until ready for harvest. This system requires the planting of immature oysters in bags or cages either on the bottom or floating on the water's surface. These oyster farms are constructed in public waters where a private lease has been designated by the state.

Culturing shellfish can be more cost effective than farming finfish and can offer environmental benefits that finfish aquaculture does not. Several pounds of plant and/or animal-based feed are required to grow one pound of farmed finfish. Oysters, on the other hand, are filter feeders that require only clean water. They consume microscopic sea life that drift with the ocean currents, so shellfish do not pollute waters with excess feed. A single clam or oyster can filter up to 50 gallons of water a day. This filtering ability also enables shellfish to remove nutrients flowing into coastal waters from agricultural and urban development runoff that can over stimulate the growth of algae, leading to decreasing oxygen levels that are harmful to aquatic life. Shellfish also remove carbon dioxide from the water by incorporating carbon in their shells, which also enhances the vitality of marine life. A thriving shellfish population actually improves the quality of marine waters.^{viii} Other recent research demonstrates that wild oyster reefs also provide economic value for shoreline stabilization.^{ix}

Price is another advantage that cultured oysters have over wild-caught oysters. In comparison to wild-caught oysters, cultured oysters garner higher prices, both in the price per bushel and per oyster. This price difference can be attributed to the marketability of cultured oysters and the fact that cultured oysters can be offered year round, especially when wild-caught oysters are out of season, leading to higher price point. Cultured oysters also tend to be more consistent in size and quality.^x

OYSTER AQUACULTURE IN VIRGINIA

Oyster aquaculture has grown in the past decade to become a mature method for producing seafood along the Eastern United States. A number of states, along with the National Oceanic and Atmospheric Administration (NOAA), have dedicated financial assistance and policy guidance to develop oyster aquaculture infrastructure. Intensive shellfish aquaculture operations in other East Coast states have dramatically increased supply during the last decade, and this is especially the case in the Commonwealth of Virginia.

Policy

Virginia's shellfish aquaculture programs have the advantage of growing in the context of a strong, historic shellfish industry and culture. This has given the state a head start and comparative advantage. In response to disease threats to wild populations of shellfish, in 1992 Virginia established the Virginia Aquaculture Advisory Board. This board has a broad mandate to advise the Marine Resources Commission on "policy matters related to aquaculture." This advisory board became the advocate for state investment in shellfish aquaculture research and commercialization.

In 2006, the Virginia Secretary of Natural Resources and the Commissioner of Marine Resources convened a Blue Ribbon Oyster Panel that met eight times from 2006 through 2007. The panel, which included former Gov. Linwood Holton, had high-level participation from the private and public sectors, as well as nonprofits. The panel made comprehensive recommendations for increased state funding of \$1.3 million to restore the oyster industry. The recommendations included proposals to expand private hatchery capacity, enhance the role of aquaculture to support economic goals, aquaculture training, and habitat restoration.^{xi}

Research and outreach

In 1997 the Virginia Institute of Marine Science recruited Dr. Stan Allen, a national leader in oyster breeding and genetics. This led to the creation of the Aquaculture Genetics and Breeding Technology Center (ABC). The program's primary objective was to examine two parasites found in the Chesapeake Bay that were decimating the oyster population, and to discover a way to rebuild stocks. Two approaches were adopted: (1) to create domesticated lines of oysters that can survive the disease and (2) to introduce new species of disease-resistant oysters. In pursuit of these goals, the hatchery releases brood stock every year to Virginia hatcheries. The program expects each year's lines to be improved over previous years' stock. In the five years from 2004 to 2009, the number of brood stock released has grown from 100 to 7,000.^{xii}

Virginia oyster aquaculture “continues to evolve from the traditional extensive planting of ‘shell on the bottom’ to more intensive, contained aquaculture utilizing cages, racks, floats, and the like.” Although the traditional practice is to transplant wild oyster seed to leased growing grounds where the grower gives little attention to the bed until harvest two or three years later, fewer growers in Virginia waters now follow these practices.^{xiii} Figure 1 shows the significant rise in cultured oysters harvested in Virginia over time.

Virginia has also partnered with oyster aquaculture's growing commercial community, conducting outreach to watermen who are interested in developing shellfish farms, and even reaching out to wholesale buyers and high-end restaurants, in order to better develop oysters with the most-prized traits.^{xiv}

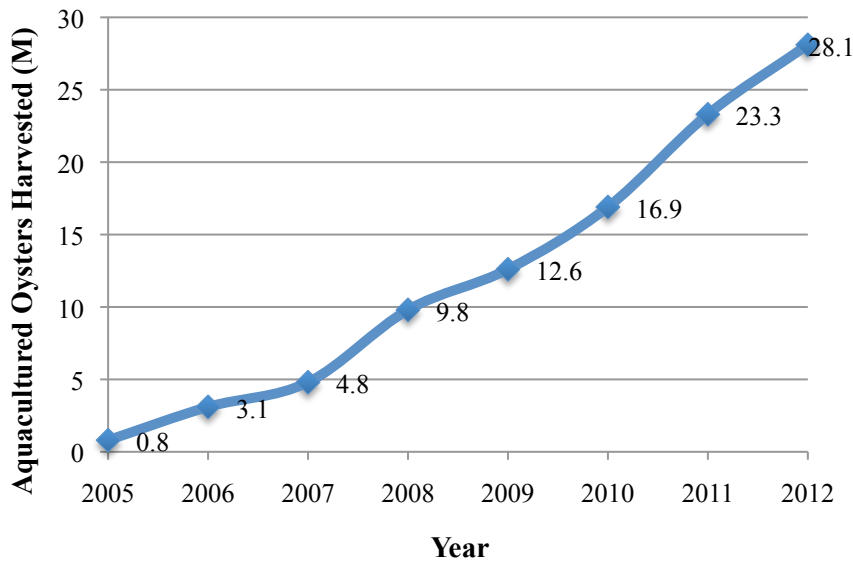


Figure 1. Cultured Oysters Harvested in Virginia

Shellfish bed leases

Virginia follows a riparian right-to-lease policy. An eligible landowner is granted a riparian right to lease adjacent waters for planting oysters up to one-half an acre in size.

The program allows for any tidal waters that are not under a riparian lease, designated as part of the public shellfish fishery, or prohibited by federal law, to be leased for oyster aquaculture under a general permit. Applications for oyster leases may only be made by residents of the Commonwealth of Virginia, a political subdivision of the Commonwealth of Virginia, or an oyster business chartered under Virginia law, in which at least 60 percent of the corporate stock is owned by Virginia residents.

Except for the Chesapeake Bay aquaculture, individual leases may not exceed 250 acres. In addition, no person may lease more than 3,000 total acres of water for aquaculture, except for Chesapeake Bay, where 5,000 acres of aquaculture leasehold may be assigned to one person.

Virginia also takes a non-traditional approach to shellfish aquaculture fees. The Commonwealth charges each business for its operational “structures,” the bags or other temporary enclosures used to raise clams or oysters. For up to 500 structures the fee is \$125 annually. It then increases on a sliding scale so that operations with more than 2,500 structures are paying \$1,000 annually.

OYSTER AQUACULTURE IN NORTH CAROLINA

Policy

The North Carolina General Assembly, concerned in 1994 with declining and diseased oyster stock, created the Blue Ribbon Advisory Council on Oysters (BRACO). The 19-member panel was assembled to make policy and management recommendations to assist the Marine Fisheries Commission and the Joint Legislative Commission on Seafood and Aquaculture. The Council determined that Louisiana, Connecticut, Washington and Virginia had strong private lease shellfish operations. The Council determined that North Carolina's efforts on behalf of traditional oyster operations were insufficient, and that additional technical support for private oyster aquaculture was needed. Improving and expanding oyster culture was a major recommendation of the report.^{xv}

Based on BRACO's recommendations, the Division of Marine Fisheries in 2001 released a new oyster management plan. This plan highlighted the BRACO finding that the “best hope for maintaining the oyster resource in the face of current disease challenges is through private culture and recommended improvements to the shellfish lease program be given the highest priority.”^{xvi}

The 2001 DMF fisheries Management Plan for Oysters released the following findings and recommendations related to oyster aquaculture:

1. An estimated 11 percent of the state's oyster harvest is produced on shellfish leases.
2. Although there is insufficient data to calculate optimum yield for an oyster harvest, the available indicators suggest that the wild harvest is not excessive.
3. Recommended adoption of a statutory policy statement supporting shellfish culture if it does not interfere with traditional fishing practices.
4. Recommended that the public be better informed about the roles of the Department of Agriculture and the Department of Environment and Natural Resource in shellfish aquaculture.
5. Recommended the amending of shellfish lease production rules.
6. Recommended that water-column lease fees be made more reasonable.
7. Recommended that research continue on the use of hatchery-reared oyster stock and that findings be implemented as appropriate.
8. Recommended additional funding for research, disease and education centers for shellfish culture.
9. Recommended additional funding to develop and implement coordination plans to assess areas for shellfish leasing.

Research and outreach

In 2005, the North Carolina Oyster Hatchery Planning Advisory Team, comprised of representatives from university marine science centers, nonprofits, community colleges and NCDMF under the direction of the North Carolina Aquariums, recommended to the General Assembly a program to: 1) produce oyster seed to facilitate statewide restoration projects; 2) develop training and outreach programs to foster oyster marine aquaculture (mariculture) and restoration; and 3) research best practices for oyster mariculture and restoration, including the development of selected lines that exhibit enhanced performance under North Carolina growing conditions.

As part of these recommendations, a system of three coastal hatcheries was planned. However, in 2008 the Legislature allocated only \$4.3 million for the construction of one research hatchery at the University of North Carolina at Wilmington. Since it began operations in 2011, the facility's operating expenses have been incorporated into the university's operating budget, and support for the ongoing research program has come from a mix of university and extramural sources. The facility is not operating at full capacity and carrying out long-term research is difficult without long-range budget commitments.^{xvii}

North Carolina has a broad based academic commitment to aquaculture research. At North Carolina State University, cold water, warm water and mariculture research is underway. Researchers are working on a pilot projects to produce striped bass and sturgeon. CMAST is conducting research on the post-harvest processing of oysters for the half-shell market.^{xviii} This research is a critical link to growing market demand by assuring that food safety conditions are maximized. The UNCW aquaculture program has a marine finfish focus, in addition to research collaborations with private sector partners with the aim of commercialization.^{xix}

With funding from NOAA, shellfish aquaculture research in North Carolina is being carried out by a three-member team: Dr. Marc Turano of North Carolina Sea Grant, Dr. Martin Posey of UNCW and Troy Alphin, a UNCW doctoral student. The team aims to determine the current scope of shellfish aquaculture, develop a geographic information system for the optimal placement of shellfish aquaculture operations, to determine economic inputs and outputs, and to identify potential economic impacts.^{xx} While a formidable technical challenge, the GIS element of the project is a highly innovative strategy.

Survey work carried out by the Sea Grant/UNCW team highlights the following:^{xxi}

1. Most growers generate less than one-third of their income from shellfish production — the majority indicated they received 5 percent or less of their income from aquaculture.

Growers said their main source of earnings was derived from commercial fishing, shore-based employment or some other source.

2. In North Carolina, farmed shellfish comprise two-thirds of all marine aquaculture.^{xxii} As of 2012, the state had 227 shellfish leaseholders and 2,229 acres dedicated to the production of clams and oysters.
3. The price for a bushel of cultured oysters ranged from \$25 to \$38 and averaged \$32. The price of a single oyster ranged from 30 to 45 cents and averaged 35 cents.
4. Respondents noted that declining water quality was the prime factor limiting their expansion plans; however, stricter fisheries regulation, the complexity of marketing, and the low availability of loans and grants for growers also were noted as limiting factors.
5. Respondents offered a mixed assessment on the five-year outlook for shellfish aquaculture. About 42 percent believed the industry would grow, 38 percent said it would decline, and 20 percent thought the industry would remain stable.

Shellfish bed leases

North Carolina currently has more than 277 shellfish leases covering approximately 2,000 acres. The leasing of shellfish beds has at times in certain areas been an issue of controversy. The legislative moratorium on new leases remains in place for Core Sound. The acceptance of shellfish aquaculture in the area has marginally improved. After a decline of some years, the number of leaseholders has increased substantially, though total acreage is down. With more intensive use of bag and cage cultivation, which requires water-column leases, it is notable that between 1998 and 2012, the number of water-column leases increased from seven to 16. The total acreage grew from 16 to 26 acres.^{xxiii} The implementation of the DMF Oyster Fisheries Management recommendation to reduce water-column lease fees may have contributed to this growth.

North Carolina Sea Grant continues to support projects to restore the oyster population and prevent disease. Sea Grant results has demonstrated the feasibility of oyster hatcheries in the state. On the basis of its findings, Sea Grant has recommended establishing oyster sanctuaries along the western shore of Pamlico Sound. Researchers also identified the best designs and materials for building or restoring oyster reefs.^{xxiv}

In 2010, oyster restoration research led to a \$5 million grant under the American Recovery and Reinvestment Act to restore 49 acres of oyster reefs in local waters. The research that led to this award was conducted using funds from the N.C. Fishery Resource Grant Program, funded by the N.C. General Assembly, and administered by Sea Grant.^{xxv}

Aquaculture training is available for those wishing to farm oysters as a business opportunity. Carteret Community College (CCC) offers courses that can be transferred to a four-year marine biology program at UNCW or East Carolina University, and also offers classes to those who are not interested in pursuing a higher degree. CCC offers three learning paths: 1) a 12-hour program of introductory courses that leads to a certificate; 2) a full-time, one-year program that includes the certificate course, plus training in more advanced techniques; 3) a full-time, two-year course of study that leads to an associate's degree. The associate's degree program includes the certificate and diploma program courses, plus advanced instruction in aquaculture, such as water quality, genetics, breeding, nutrition and diseases.^{xxvi}

Brunswick Community College also offers an aquaculture program, though its curriculum focuses on freshwater aquaculture. It also offers a cooperative arrangement with Carteret CCC for distance learning opportunities.^{xxvii}

NORTH CAROLINA MARKETPLACE CHARACTERISTICS

The marketplace for cultured shellfish is primarily defined by three stages: production, distribution and consumption. The ECU/Sea Grant research team convened a focus group to learn from North Carolina stakeholders, which led to insight regarding the price and distribution challenges that affect the local shellfish industry. Distribution of shellfish from coastal areas to other regions of the state can be complicated because refrigeration is required to keep product fresh. In addition, Sysco, a national restaurant supplier, can deliver shellfish with its other supplies, so restaurateurs may be likely to order from the company as a matter of convenience. Shellfish aquaculture producers suggested that they would benefit from an aggregation facility and more clearly defined distribution routes across the state.

Consumer Preferences

The ECU/Sea Grant team explored consumer preferences for oysters and clams by collecting survey data from attendees at three seafood events held in North Carolina (see Appendix 1). A total of 181 surveys were collected. Three of those surveys either was left blank or contained excessive missing data and, as a result, were removed from the data set. This resulted in a final sample size of 178 consumers (60% female, 40% male, average age 45). The following analysis is based on those 178 surveys; however, the results are not a perfect representation of the data due to two reasons. First, this survey was given to people attending a seafood-based event; as such, the data is not based on a purely random sample. Second, in some instances, surveys were partially completed. For example, a respondent may have not provided age or gender information, or may have responded only to questions involving oysters and not clams. In these cases, certain items were discarded during analysis so the results could be based on the answers of those who responded to each question.

Out of those who responded, researchers found that 50 percent prefer oysters, 12.5 percent prefer clams, 36.3 percent like both oysters and clams, and 1.2 percent like neither. The “neither” figure is likely lower than the general population because it is safe to assume that people going to a seafood festival would like many different kinds of seafood.

Although most people do not eat oysters or clams very often, they also reported that they do not view these types of seafood to be eaten primarily for a special occasion or in a particular season. Nearly two-thirds of all respondents had this view, while less than one-third reported that they do believe oysters or clams are for a special occasion. If a consumer believes that oysters or clams can be eaten any time of year for any reason, it would follow that the consumer would eat these types of seafood more often. However, the data indicate that consumers are eating oysters and clams as if they were special-occasion seafood. One explanation may be that consumers see oysters and clams as not being available year round. When asked how likely they would be to eat shellfish more often if they were available year round, nearly 42 percent responded that they would be “very likely” (see Figure 2 below).

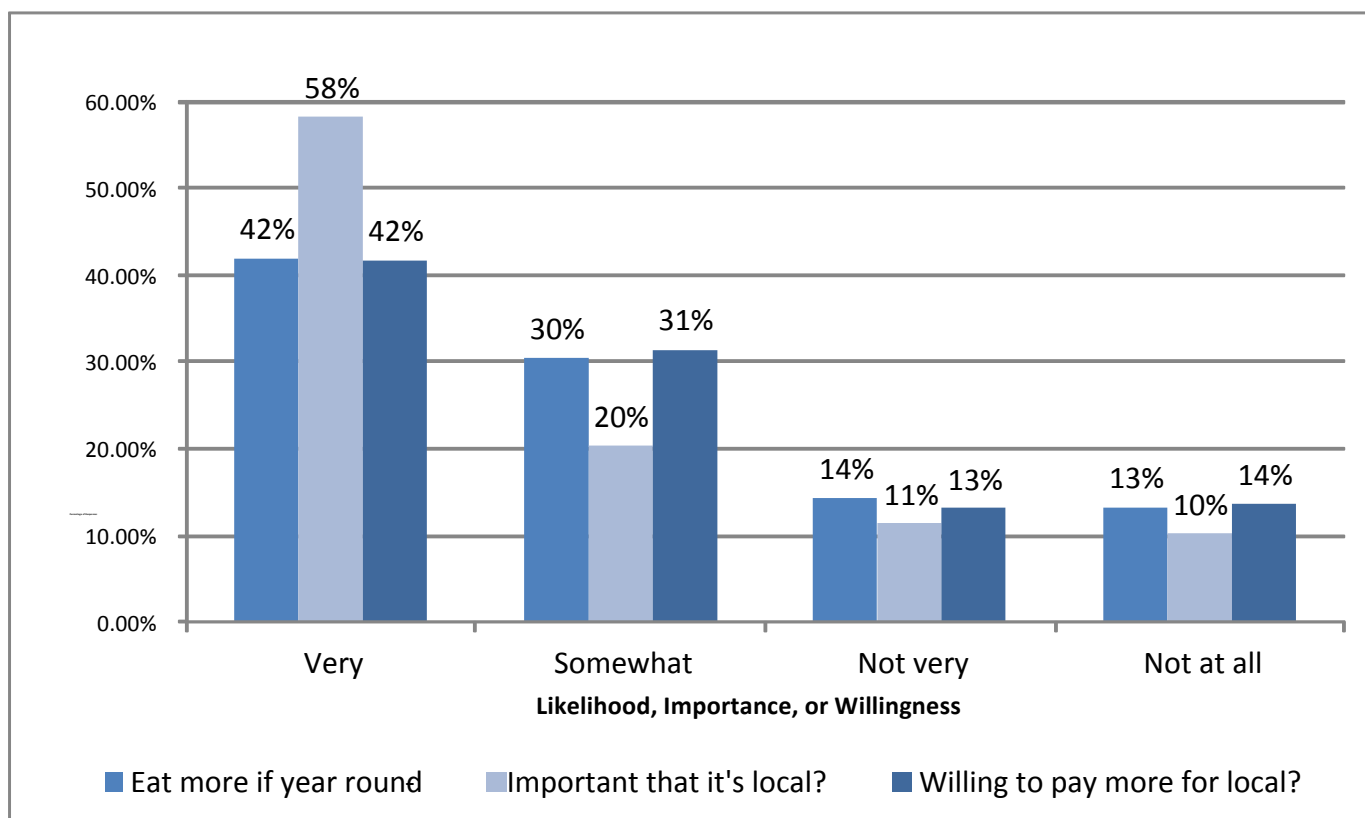
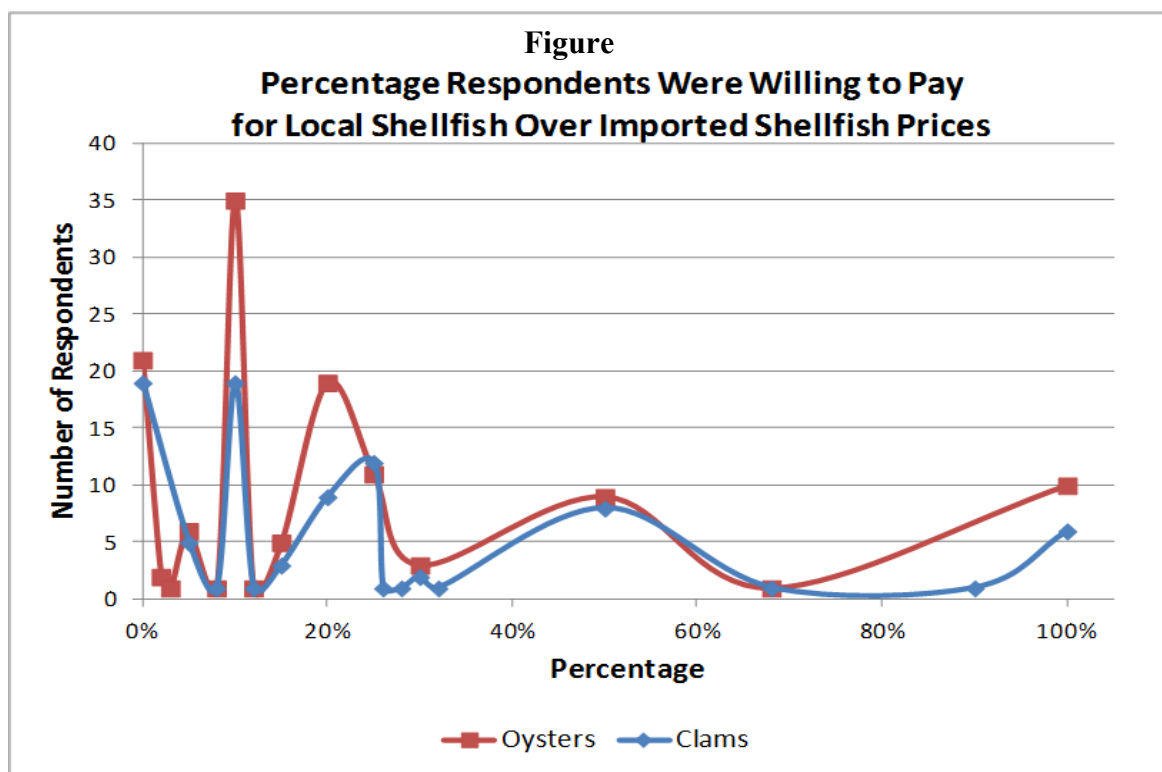


Figure 2: Likelihood of Eating Year Round, Importance of Local Shellfish and Willingness to Pay More for Local

People also were asked how important it is that the shellfish they buy is harvested in North Carolina. Analysis indicates that 58 percent of respondents said that buying local product is very important to them, with the percentages dropping off dramatically with less importance. Supporting local businesses continues to be an emerging trend, so these responses likely reflect consumers' true interests in local seafood.

Consumer willingness to pay

Respondents were also asked how willing they would be to pay more for locally harvested seafood as opposed to oysters or clams from another state. The responses were recorded as a percentage ranging from 0 percent (not willing to pay any more for local shellfish) to 100 percent (willing to pay twice the current price of local shellfish). Figure 11 shows how much more consumers would be willing to pay for North Carolina shellfish, as opposed to shellfish from another state.



The data indicates that survey consumers tend to be more willing to pay more for local oysters than clams. The most common responses reported were 0 percent, 10 percent and 20 percent more for local shellfish. Nearly 17 percent of respondents were unwilling to pay any more for local clams, while 21 percent said they would pay no more for oysters. An explanation for this unwillingness could be that people do not want to pay more for something they should have

easier access to; it would be more logical to pay more for a product that had to be imported from another state. Of the respondents, 28 percent and 21 percent of respondents were willing to pay up to 10 percent more for local oysters and clams, respectively. This shows that there is some elasticity when it comes to pricing because consumers understand that sometimes you have to pay more when a product (or particular source of a product) is very important to you. With only 15 percent and 10 percent of respondents willing to pay 20 percent more for local oysters and clams, respectively, it is clear that shellfish consumers do not want to pay additional costs for a product already in North Carolina. No more than 8 percent of all respondents were willing to pay twice the cost of imported shellfish. Shellfish consumers are willing to pay more, just not by very much.

In sum, this case study suggests that consumer demand for oysters in North Carolina is currently being supplied in large part with product from Virginia and the Gulf Coast. This presents an opportunity for aquaculture farmers in North Carolina to expand operations and profitably enter (1) a market with established demand for their product, (2) a category in which a limited amount of local product is currently available, and (3) an environment in which consumers want to buy local. In fact, the origin of perishable food products in general, and seafood in particular, is an important consideration among consumers because “local” often suggests freshness and higher quality.^{xxviii}

NEXT STEPS

North Carolina has abundant marine and coastal natural resources that, if protected, can be both pristine and economically productive. Shellfish aquaculture is perhaps the only form of aquaculture in which the associated activities result in inherently positive environmental improvements.

North Carolina also has a solid base of shellfish aquaculture capacity, activity and development. These benchmarks, however, are not strong enough to significantly advance economic impact, especially given the exceptional research and commercialization advances in Virginia.

More than ten years have passed since the 2001 North Carolina Division of Marine Fisheries Oyster Fisheries Management Plan was put in place to implement recommendations of the Blue Ribbon commission of the 1990s. Given that research and commercialization developments in oyster aquaculture have accelerated rapidly in the past 10 years, it is appropriate for a new high-level discussion of how the State of North Carolina can better coordinate and support the emergent opportunities in the field. This assessment should include the North Carolina Secretaries of Agriculture and the Department of Environment and Natural Resources, and the Vice President of Research for the University of North Carolina system. This discussion might consider the following questions:

1. Are we supporting as strongly as we should the industry's basic needs? Improvements in oyster genetics and hatchery development will be required in order to significantly advance the sector.
2. Are there inter-department collaborative efficiencies that have not been tapped that could strengthen the development of shellfish aquaculture opportunities?
3. It has been said that you are what you measure – would the industry benefit from economic modeling that assesses potential economic impacts set to production benchmarks? Related to this, is it possible to develop an economic valuation of the ecosystem benefits of North Carolina shellfish aquaculture? Clear answers to both would more firmly establish the public benefit value necessary to validate both public and private investment.
4. For oyster aquaculture to gain wider adaptation by existing commercial fishermen, are there equipment cost-share programs, risk-mitigation measures, or cooperative ventures that would accelerate adaptation by some in the industry?
5. Can the regulatory process for both leasing shellfish bed and aquaculture operation permits be streamlined to allow for easier entry to new business operations?
6. Finally, periodic research and practitioner exchanges have taken place between North Carolina and Virginia oyster aquaculture interests. Would the state of North Carolina benefit from a strong partnership with Virginia stakeholders?

The bottom line of increasing economic value from oyster aquaculture opportunities, even if it were to match Virginia's, is small relative to the overall North Carolina economy. For the state's commercial fishermen and their families, however, an additional source of water-related income would have a stabilizing impact far greater than would appear simply by looking at total economic output. Diversification and modernization is critical to the survival of North Carolina's commercial seafood industry. Not all watermen will embrace change, but there is a core group of entrepreneurs who will. They are worthy of both support and a deeper partnership with the state of North Carolina.

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- ⁱⁱⁱ North Carolina Division of Marine Fisheries
- ^{iv} Virginia values were calculated by average yearly price per oyster by total number estimated to be sold, extrapolated from Murry and Hudson. *Virginia Shellfish Aquaculture Situation and Outlook Report*. March 2013. North Carolina values come from North Carolina Division of Marine Fisheries estimates.
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