Evaluation of Northeast Regional Aquaculture Center (NRAC) Funding

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University of New Hampshire
Elizabeth A. Fairchild, Ph.D.
Kelly Cullen, Ph.D.
Curt Grimm, Ph.D.
Tracy Keirns, Ph.D.
Andrew Smith, Ph.D.

Northeastern Regional Aquaculture Center

USDA United States Department of Agriculture

National Institute of Food and Agriculture

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Executive Summary

A multi-disciplinary team of researchers from the University of New Hampshire conducted an evaluation of completed projects funded by the Northeast Regional Aquaculture Center (NRAC) between 2005 and 2014 to assess: their economic impact on the aquaculture industry and overall economies in the Northeast; their effectiveness in solving problems currently confronting the aquaculture industry; the effectiveness of aquaculture research; and how to summarize lessons learned about why these projects are or are not effective in achieving their goals.

The research involved surveys with Project Collaborators (leaders of the projects), their research and extension, and industry collaborators who participated in the design and implementation of the project, as well as individuals working in the aquaculture industry in NRAC states. Data from these surveys were used in an economic impact study that estimated the economic impact of 32 NRAC-funded projects in the region and in individual states. A content analysis of aquaculture-related publications was also conducted to understand how widely NRAC studies are disseminated. The major findings of this evaluation, detailed in the following report are:

- All 12 Northeast states (excluding the District of Columbia), participated in a NRAC-funded project either as a Principal Collaborator or as an industry collaborator.
- 78% of all projects involved shellfish with the majority focused on oysters, the predominant product of the northeastern aquaculture industry. However, a significant number of projects (31%) studied finfish. Many projects addressed disease diagnosis and treatment, genetics, and other conditions affecting aquaculture production.
- Money invested in the 32 NRAC-funded projects reviewed has benefitted regional Gross Domestic Product (GDP), job growth, and state and local tax revenues. A modest investment of just over $4 million resulted in an increase of:
    - almost $79 million in GDP of NRAC states;
    - 777 new jobs;
    - over $4 million in state and local tax revenues;
    - over $9.5 million in federal tax revenues; and
    - nearly $33 million in additional external grant funding secured, not including matched funds.
- A multiplier of 5.3 resulted from NRAC funding that occurred between 2005 and 2016, but could in fact be as high as 21.9.
- Specific examples of important research projects were: development of dermo-resistant oysters, in which a $470,000 investment resulted in almost $13,000,000 in economic benefits; investment of $480,000 into the development of cross-bred Eastern oysters resulted in more than $12,000,000 in economic benefits.

- Those engaged in the aquaculture industry rated these projects as having been very important to critically important to the future of the industry.
- Importance of these projects to the Northeast aquaculture industry could be more widely disseminated to the aquaculture industry through use of electronic platforms (e.g., NRAC website, other informational websites, industry association listservs, social media), aquaculture industry publications, and technical assistance and capacity building programs. Extension organizations should play a greater role.
- Barriers that limit the expansion of the northeastern aquaculture industry include: the challenging, and often confusing, regulatory environment, financial risk, and the reduction of working waterfronts.

The findings of this study document the effectiveness of NRAC in identifying and funding projects that are important to the Northeast aquaculture industry and to the economies of Northeast states. Industry needs identified for future funding in this study include: research into the marketing of aquaculture products; research towards improved product survival, including control of predators and parasites, further studies into the development of disease resistant products, as well as the development of products able to survive in lower pH environments; and improving automation techniques. As noted above, significant improvements to the NRAC website to make it a “go-to” source for information for the aquaculture industry is a low cost, but high return investment.

Introduction

Global aquaculture production is increasing, accounting for about 50% of the world's food fish. However, within the United States (U.S.), growth in the aquaculture industry is far slower than the global rate (FAO, 2016). According to the 2012 Census of Aquaculture (USDA, 2014), from 2005 to 2013 the value of the U.S. aquaculture industry, measured by the value of products sold, increased by 126% to $1.37 billion. During that period, the number of U.S. farms declined by 28% (USDA, 2014) as did the amount of agricultural product (FAO, 2014). U.S. aquaculture production levels decreased from 600,000 mt in 2004 to 420,000 mt in 2013; U.S. production accounts for only 6% of the current global aquaculture production (FAO, 2014). One of the reasons for this downtrend is the decline in U.S. finfish production as cheaper (lower production costs), foreign products have become more available (FAO, 2014).

In the U.S., the U.S. Department of Agriculture (USDA) and the National Oceanic and Atmospheric Administration (NOAA) are the primary agencies overseeing aquaculture. From 1990-2015, they provided 80 cents of every dollar awarded by the federal government for aquaculture research (Love et al., 2017). Return on investment of federally-funded aquaculture research can be great, with one study calculating as high as a 37-fold increase (Love et al., 2017). Despite this large economic return, federal programs, with the exception of NOAA and the National Science Foundation (NSF), have not increased their strategic investments in support of aquaculture in the past 25 years (Love et al., 2017). Detailed studies on how effective individual aquaculture programs have been in leveraging research dollars and growing the aquaculture industry are few. This study analyzes the impacts to the U.S. northeastern aquaculture industry achieved by the Northeast Regional Aquaculture Center (NRAC), a division within the USDA's Regional Aquaculture Centers' program.

In the U.S., there are five Regional Aquaculture Centers (RACs) located in the northeastern, north central, southern, western, and tropical/subtropical Pacific regions of the country. The mission of these Centers, authorized by Congress in 1986, is to encourage cooperative and collaborative aquaculture research and extension educational programs that have regional or national application and impacts. Center programs complement and strengthen other existing research and extension educational programs provided by the USDA and other public institutions. The RAC program funding, originally authorized by the 1990 Farm Bill (Food, Agriculture Conservation, and Trade Act of 1990 - P.L. 101-624) through the USDA at $7.5 million, has routinely been appropriated at approximately $4.5 million, or about $750,000 to each RAC per year (NRAC, 2017). With the 2014 U.S. Farm Bill, the authorized funding amount was increased slightly to approximately $5 million, with NRAC receiving around $740,000 per year. Despite this long-lived program, there has never been an assessment of the RACs' impacts on the development of aquaculture in the U.S., either regionally or nationally. This study takes the first step by evaluating the impact that NRAC funding has had on aquaculture in the northeast region.

Northeast Regional Aquaculture Center

NRAC Mission

The Northeast Regional Aquaculture Center (NRAC), established in 1987, represents 12 states (Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, Pennsylvania, New Jersey, Delaware, Maryland, and West Virginia) plus the District of Columbia. Originally located at the

University of Massachusetts (UMASS), Dartmouth, NRAC's administrative headquarter relocated to the University of Maryland (UMD), College Park in 2005. NRAC's vision statement is to:

> *"… aid the industry to become economically viable and environmentally sustainable, helping aquaculture to become a significant component of Northeast agriculture and an essential complement to wild capture fisheries. NRAC will catalyze the economic development of an industry that comprises open and closed, fresh and salt-water systems - producing a wide array of fish, shellfish and other aquatic organisms - supported by progressive public and private research and development" (NRAC, 2017).*

NRAC also provides coordination of interregional and national programs through the National Coordinating Council for Aquaculture (NCC). This council is composed of the RAC directors and USDA aquaculture personnel. Along with the other RACs, NRAC assists with the periodic Aquaculture Extension Conferences.

NRAC Structure

The organizational structure of NRAC consists of a Board of Directors (BOD), the Technical Advisory Committee (TAC), and the Industry Advisory Committee (IAC). The BOD, which meets annually, is the body that governs policy changes and fiscal issues within NRAC, and supervises the Director of NRAC.

Currently, there are 10 appointed, unpaid members of the BOD who serve a two- or three-year term, which includes senior personnel, often directors of their institutes, from the NRAC region, and also includes representatives from the University of Maryland, an 1890 Land Grant University, Sea Grant, USDA/Agricultural Research Service (ARS), Extension, Experimental Station, the aquaculture industry, and the USDA/National Institute of Food and Agriculture (NIFA) Program. In addition, the Director of NRAC and the Chairs of the TAC and IAC are non-voting members of the NRAC BOD.

The TAC and IAC are committees composed of one representative per state or district. The TAC representatives stem from either academia, extension, or regulatory backgrounds while the IAC representatives originate from the aquaculture industry, be it farmer/grower, distributor/wholesaler, marketer, or another sector. These members are recommended to the NRAC Director who determines if they are qualified and interested, and then invites them to join for a three-year, unpaid term.

The TAC and IAC are referred to collectively as the Technical Industry Advisory Committee (TIAC), which meets annually. With their own areas of expertise and knowledge of the northeastern aquaculture community, as well as the Director's guidance (he is an ex-officio member of the TIAC) and the BOD Chair's guidance, the TIAC discusses industry needs and how research can help meet those needs. From these discussions, annual funding priorities for research projects are derived, which then are presented by the Chairs of the TAC and IAC to the BOD for approval.

In addition to formulating funding priorities, the TIAC reviews and rates pre-proposals of research projects submitted to NRAC. The Director then invites the Project Coordinators of recommended pre-proposals to submit full proposals to be considered for funding; only invited full proposals are accepted. The Chairs of the Committees, along with the BOD Chair and paid external reviewers, review and rank the full proposals; their recommendations on which projects should be funded then are brought before the

BOD by the TAC and IAC Chairs. Ultimately, it is the BOD that decides which projects receive funding by NRAC.

Funding Criteria for NRAC Projects

Although the nuances of the funding priorities change each year, the overarching goal remains constant: to resolve critical bottlenecks the aquaculture industry faces in the northeast region which will result in increased aquaculture production through applied aquaculture research and economic growth.

Research Projects

NRAC-funded aquaculture research projects must directly address one of the funding priorities listed in the Request for Proposals and clearly describe how the project will support aquaculture industry development in the northeastern U.S., explain how the project is both relevant to the priority research areas as determined by industry, and should demonstrate the benefits and/or potential impacts to farm-gate prices or profitability. Unique criteria for NRAC-funded research projects include the assistance, support, or endorsement of the northeastern aquaculture industry. Most funded projects have industry collaborators and often they are compensated for their involvement. In addition, projects must be regional and include team members, advisory panel members, and research and/or demonstration-outreach sites from two or more states and/or the District of Columbia in the NRAC region. Research projects need to clearly address how their outcomes are adaptable to the wider regional industry. Lastly, NRAC-funded aquaculture projects must have an integrated extension or outreach component to facilitate information dissemination, technology transfer, or training to the aquaculture industry throughout the Northeastern U.S.

Extension Projects

In addition to research projects, NRAC periodically funds extension projects which are derived from a Work Group process. In the Work Group process, either the TIAC or BOD develops a non-research project theme that is best addressed by a wide collaboration of aquaculture personnel, typically extension. The BOD identifies a Project Coordinator (PC) to lead the team effort. The PC forms a Steering Committee to guide the project development and together, the Committee and the PC recruit project collaborators and develop a proposal which is reviewed per research project guidelines. These types of projects focus on emerging issues the aquaculture industry is facing and workshops allow the experts and industry to discuss the sources of those issues and potential solutions for them.

Justification for an Assessment

The Project Coordinators of the NRAC-funded projects oversee all the administrative duties, including submitting mandatory progress, final, and, since 2013, impact reports. Even with this information, many important questions remain unanswered regarding how these projects have advanced aquaculture in the northeast. For example, we do not know if the research funded by NRAC has led to tangible differences in aquaculture industry size, aquaculture policy, practices, or production quality. Have these projects led to an increase in domestic aquaculture production? Has there been any growth in aquaculture jobs in the northeast? These questions, not to mention the overarching question – has NRAC funding made a difference? – have not been addressed formally. This is due, in part, because the outcomes of these projects do not occur immediately and can take years to be incorporated by stakeholders; by the time an impact has occurred, funding for the original project has long since been exhausted and the research team has moved onto other projects. In addition, since the NRAC project reports are completed by the

Project Coordinators (who are typically researchers), the perspectives of other participants and the larger aquaculture community are not well presented. The full ramifications of a project are rarely addressed.

Impartial, rigorous evaluation of any program is necessary to ensure they are effective and remain true to their missions. In 2015 the NRAC BOD requested a self-assessment of the impacts NRAC-funded aquaculture projects have had on the northeastern region within the context of the Overall Evaluation Goals.

Overall Evaluation Goals

The overall goal of this evaluation is to assess the scientific, socio-economic, and policy impacts of accomplishments achieved through NRAC's portfolio of recently funded aquaculture projects (2005-2014), including extension work group projects. Incorporated in this synthesis is how these projects have or have not helped move the aquaculture industry closer to solutions for the diversity of problems it faces within the region. From the resultant information, suggestions for achieving higher impacts are identified that NRAC should consider in its future funding initiatives.

Specific Objectives

Objective 1: Review the effectiveness of NRAC-funded projects (using targeted interviews and in-depth data collection and analysis) to assess their impacts to aquaculture permitting, siting, production, disease management, and harvesting programs across cultured species and production systems (inland, coastal, closed, integrated, etc.).

Objective 2: Summarize and describe lessons learned and outcomes generated (including, where possible an estimate of the return on investment) from projects funded through the NRAC Research and Workgroup processes.

Objective 3: Evaluate the effectiveness of project approaches to promote solutions for aquaculture source problems.

Objective 4: Produce science-based knowledge that can be utilized to set new funding priorities, which will yield more effective aquaculture research, education, and extension programs funded by NRAC.

Objective 5: Provide examples where the NRAC funding mechanisms have worked synergistically or where they have failed to develop synergies.

Objective 6: Deliver results of the synthesis to NRAC, the science community, and relevant stakeholder groups (e.g., industry, municipal, state and federal agencies, commodity organizations).

Study Methodology

Surveys

The Northeast Regional Aquaculture Center (NRAC) Funding Evaluation set out to understand the impact of NRAC-funded projects since 2005. The evaluation period was restricted to projects funded between 2005, when NRAC administration shifted from UMASS to UMD, and 2014[1], resulting in the selection of 32 NRAC-funded projects. The project start years are relatively evenly distributed over the evaluation period (Table 1) and study substantive areas of aquaculture (Table 2).

Table 1. Start Year of Project

	Tier I	
2005 – 2007	25%	(8)
2008 – 2010	41%	(13)
2011 – 2014	34%	(11)
Total	100%	(32)

Table 2. Substantive Area(s) of Projects

Multiple Areas Possible. Percentages do not add to 100%.

Marine Aquaculture	91%	(29)
Freshwater Aquaculture	16%	(5)
Shellfish	78%	(25)
Finfish	31%	(10)
Disease	50%	(16)
Genetics	38%	(12)
Culture Techniques	19%	(6)
Probiotics	9%	(3)
Other	31%	(10)

Using online surveys, information was collected from stakeholders with differing levels of connection to NRAC-funded projects. The first survey (Tier I) was conducted with the Project Coordinators (PCs) of the 32 selected projects. This group was surveyed on topics such as project development, project implementation, project outcomes, and dissemination from the perspective of the project PC. Because each study is unique, in instances when PCs had multiple studies, the PCs were asked to complete a separate survey for each study. PCs who completed the Tier I survey were asked to provide the names and contact information of industry collaborators and other research team members who participated in their project. These names were combined with the names of collaborators listed on the NRAC funding proposal (and de-duplicated), and this list became the sample for the second survey (Tier II), which targeted participants on NRAC projects other than the PC.

[1] Projects funded after 2014 were not included in the evaluation as they would not yet have been completed or had an impact on the industry.

Table 3. State of Tier I and Tier II Respondents

	Tier I		Tier II			
	Principal Coordinators		Completed Interviews: Collaborator		Population: Collaborator	
Connecticut	9%	(3)	6%	(8)	6%	(16)
Delaware	3%	(1)	6%	(9)	4%	(10)
District Of Columbia	0%	(0)	0%	(0)	0%	(0)
Massachusetts	19%	(6)	23%	(32)	20%	(55)
Maryland	3%	(1)	8%	(11)	7%	(20)
Maine	41%	(13)	11%	(15)	18%	(49)
New Hampshire	3%	(1)	4%	(6)	5%	(13)
New Jersey	6%	(2)	6%	(9)	9%	(26)
New York	6%	(2)	11%	(16)	8%	(20)
Pennsylvania	0%	(0)	2%	(3)	2%	(6)
Rhode Island	6%	(2)	13%	(19)	12%	(34)
Vermont	0%	(0)	0%	(0)	0%	(1)
West Virginia	3%	(1)	4%	(5)	3%	(7)
Other[2]	-	-	6%	(8)	5%	(14)
Total	100%	(32)	100%	(141)	100%	(271)

NRAC-funded projects are required to have representation from multiple states and most projects include collaborators from industry and extension as well. The Tier II survey of project collaborators included 271 people that were associated with the 32 NRAC projects (Table 3). The Tier II survey solicited the same information as the Tier I survey: project development, project implementation, project outcomes, and dissemination from the perspective of collaborators, as well as additional questions about the process of collaboration.

Lastly, to understand the impact of these 32 NRAC-funded projects to the industry-at-large, a third survey was developed (Tier III) to measure awareness of NRAC project outcomes, economic impacts of these outcomes on business, sources of information, and barriers to success, as perceived by the aquaculture industry in the NRAC region.

Tier I

All PCs received a letter from the NRAC Director on January 7, 2016 and an email from Dr. Elizabeth Fairchild on January 18, 2016. These communications notified each PC that their funded project was part of this study and that they would be contacted shortly by the University of New Hampshire Survey Center (UNHSC) asking them to complete a brief survey about their experiences on the project. On January 25, 2016, each PC received an email from the UNH Survey Center that included a description of the

[2] The range of support for NRAC-funded projects extends beyond the Northeast region. The 14 collaborators in the "other" category are from the following states and countries: United Kingdom (3), Washington (4), North Carolina (1), France (2), Florida (1), Canada (1), California (1), and Arkansas (1).

assessment project, a request to participate, and a unique link to access the online survey for each of their selected studies. Any emails returned undeliverable were researched and an updated email address was found and the invitation was resent. On January 29 and February 8, 2016 reminder emails were sent to all non-responders. Following these reminders any remaining non-responders were personally contacted by Dr. Fairchild via email or telephone to encourage participation.

Tier II

A list of all project collaborators was compiled based on the original research proposals submitted to (and funded by) NRAC and supplemented with a list of collaborators provided by PCs. This list was then screened to ensure each collaborator only received one invitation for each study they collaborated on. It was possible for a collaborator to receive multiple surveys for different studies. Additionally, it was possible for a collaborator to have also participated in the Tier I survey as a Project Coordinator. On March 25, 2016 each collaborator received an email invitation from the UNH Survey Center that included a description of the assessment project, a request to participate, and a dedicated link to access the online survey for each project they were listed as a collaborator. On April 4 and April 12, 2016 reminder emails were sent to all non-responders. Following these reminders, trained UNH Survey Center interviewers contacted each collaborator by phone to request participation from June 27, 2016 through July 27, 2016. Any collaborator that agreed to review a project was then sent a new email that included all outstanding survey links.

Tier III

The final phase of surveys targeted the aquaculture industry in the NRAC region. The sampling frame for Tier III was constructed using state supplied lists of licensed, private aquaculture growers or propagators. Each state agency that regulates aquaculture was contacted by Dr. Fairchild. In most states, lists of licensed or permitted aquaculture growers were released promptly to UNH, however in a few states, getting this information proved difficult or not possible.

- From ME, NH, VT, MA, RI, CT, DE, MD, and WV, lists of licensed or permitted aquaculture growers were released promptly to UNH. In some states, these lists were available online. In many states, regulators wanted information about how the lists would be used and what kind of confidentiality measures would be taken. Limited or no information was collected from NJ, NY, PA, and DC.
- In NJ, obtaining a grower list was difficult with the NJ Department of Agriculture citing confidentiality concerns and required the assistance of aquaculture extension agents to secure a list.
- In NY, a Freedom of Information Law (FOIL) request had to be filed to obtain aquaculture permit holders, which took three weeks to complete. No NY state contact was provided for further questions, nor was one identifiable on state websites. Another FOIL request was submitted for further questions which went unfilled.
- In PA, neither a list of propagators nor the means to communicate with them were obtained. The PA Department of Agriculture refused to release their propagator list citing standard protocol to maintain privacy of their permit holders. There was an offer to disseminate the survey for the UNHSC, but only to non-trout propagators. We agreed and sent the survey to the PA state Aquaculture Coordinator however, our inquiries (phone calls, emails) were never returned, nor were any of the surveys originating in PA received.

- Although urban aquaculture (aquaponics) is a budding industry in many cities, including the District of Columbia, we were unable to identify a contact person, agency, or program to provide us with any information about aquaculture growers and if aquaculture regulations exist in the District of Columbia. Therefore, there is no aquaculture industry information in this survey from the District of Columbia.

The lists provided by responsive states were compiled into a single database and screened for duplicate listings of businesses. If a contact name was found to be duplicated, it would only be removed if the business was also a duplicate. For this survey, our sampling frame was comprised of licensed aquaculture growers. Therefore, a grower who owned two distinct businesses (i.e., farms) received a separate survey for each business. At the same time, if a business transferred ownership, we contacted the new owner of the business. University-led aquaculture projects and baitfish growers were not included in the database. Aquaculture growers who were not required to obtain a permit or license by their home state (i.e., non-trout and black bass freshwater fish farmers in NY) were not included in the database either. UNH Survey Center staff used the internet and telephone calls to research any missing contact information such as email or telephone.

A hard-copy, pre-letter notification was mailed to aquaculture growers on January 3, 2017 and by email on January 5, 2017 for those growers where a mailing address was missing. On January 6, 2017 each industry member with an email address received an email invitation from the UNH Survey Center that included a description of the project, a request to participate, and a unique link to access the online survey. In addition, a flyer notifying aquaculture growers of the survey was included in the registration packet of all attendees of the Northeast Aquaculture Conference and Exposition, held January 11-13, 2017 in Providence, RI, and was posted on the East Coast Shellfish Growers Association listserv on January 24, 2017. On January 17, January 30, and February 8, 2017 reminder emails were sent to all non-responders. Following these reminders, trained UNH Survey Center interviewers contacted each industry member by phone to request participation from January 11, 2017 through February 15, 2017. Industry members were given the opportunity to complete the survey over the phone or have a new link sent to them by email. Any industry member who requested a new link was sent an email the next business day with their unique link to the survey.

Timing, sample size, and response rates for the three surveys are displayed in Tables 4 and 5 below.

Table 4. Field Period and Response Rates for Tier I – III NRAC Evaluation Surveys

	Tier I	Tier II	Tier III
Survey Start Date	January 25, 2016	March 25, 2016	January 6, 2017
Survey End Date	March 8, 2016	August 23, 2016	February 17, 2017
Sample Size	32	271	980
Completed	32	141	273
Response Rate	**100%**	**52%**	**28%**

Table 5. Tier III NRAC Evaluation Survey Response Rates by State and Water Type

	Fresh Water	Marine	Both	Completed Interviews	Sampling Frame	Response Rates
Connecticut	1	8	1	10	58	16%
District of Columbia	0	0	0	0	0	-
Delaware	2	0	0	2	3	67%
Massachusetts	6	90	2	98	323	27%
Maryland	4	17	0	21	177	11%
Maine	4	46	3	53	163	33%
New Hampshire	4	8	0	12	20	60%
New Jersey	1	17	0	18	67	26%
New York	5	22	1	28	89	31%
Pennsylvania	0	0	0	0	0	-
Rhode Island	0	20	0	20	51	39%
Vermont	4	0	0	4	9	44%
West Virginia	7	0	0	7	20	33%
Total		**273**		**273**	**980**	**28%**

Project Content Analysis

Original project proposals, progress reports, and, when available, final and impact reports written and submitted by project PCs to NRAC were reviewed for all 32 research projects to determine expected and realized project impacts and tabulate output metrics. For five projects still active at the time of this assessment, project impacts were not able to be determined, however some output metrics could be quantified based on submitted progress reports.

Project Impacts

From the final and impact reports, descriptions of anticipated benefits, impacts, and project accomplishments and conclusions were used to determine the overall impacts of the completed projects. Additional searches on NRAC-funded projects were performed using the information sources identified in the Tier II Survey (Question 42 - Please list the names of websites and magazines you commonly use to keep up to date on the aquaculture industry.) for the timespan 2006-2017. These sources included peer-reviewed journals (*Aquaculture, Journal of Aquatic Animal Health, Northern Aquaculture, Journal of the World Aquaculture Society,* and *Journal of Shellfish Research*), websites (American Fisheries Society, East Coast Shellfish Growers Association [and listserv], National Shellfish Association, Northeast Regional Aquaculture Center, World Aquaculture Society, and University of Maine Sea Grant), magazines (*Aquaculture* and *World Aquaculture Magazine*), and industry news publications (*Aquaculture North America, Fish Farming News*, and *Hatchery International*).

Output Metrics

Output metrics were quantified from final and impact reports which listed publications and presentations, and summarized impacts and accomplishments. Output metrics considered included: presentations and their geographic impact (i.e., regional, national, or international); publications, including NRAC fact sheets, peer-reviewed journal articles, non-peer-reviewed articles, student theses, and any other type of publication included in the reports; additional products which resulted from the project such as but not limited to workshops, training sessions, software, and biological products; and

when identifiable, number and type (high school, undergraduate, graduate) of students supported by the project. Some projects clearly described undergraduate and graduate student involvement, allowing student participation to be quantified easily. For projects that did not mention student involvement, project proposal budgets were examined to determine whether student funding was requested.

Overall Characteristics

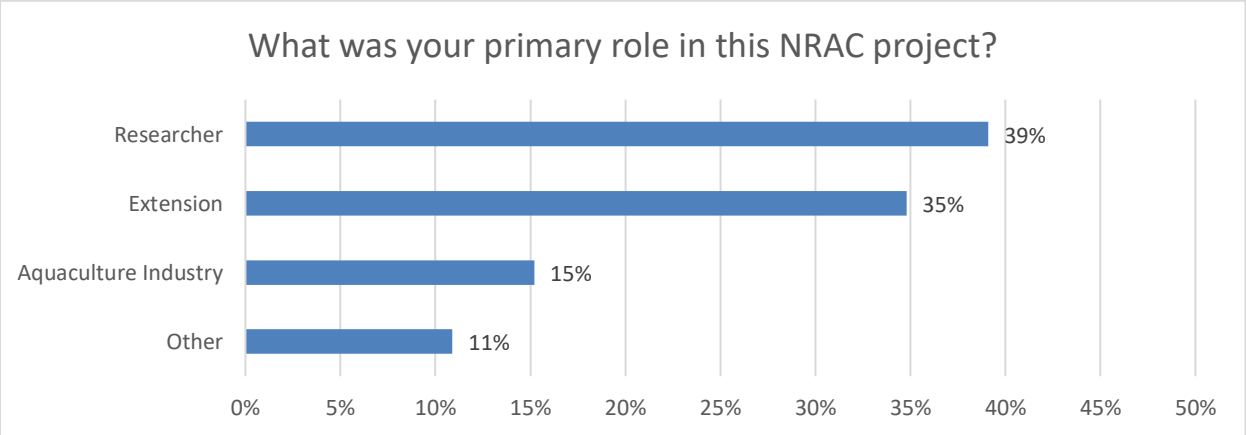
Research categories were used to classify the 32 projects included in this evaluation. Projects were coded by UNH researchers into categories based on recurring keywords in the project descriptions and reports, but selected by PCs and collaborators in the Tier I and Tier II surveys (Table 6). Projects coded as "other" included research areas such as outreach, tool, urchin culture, biosecurity, predator deterrent, restoration, mitigation, system design, and cost. Table 6 displays a close proportionality between the number and percentage of completed interviews in each research category in each tier. Due to multiple responses, percentages do not add to 100%.

Table 6. Research Category of NRAC-Funded Projects by Tier I and Tier II Respondents

	Tier I	Tier II
Marine Aquaculture	91% (29)	89% (125)
Freshwater Aquaculture	16% (5)	22% (31)
Shellfish	78% (25)	80% (113)
Finfish	31% (10)	37% (52)
Disease	50% (16)	54% (76)
Genetics	38% (12)	37% (52)
Culture Techniques	19% (6)	16% (22)
Probiotics	9% (3)	5% (7)
Other	31% (10)	40% (57)
Total Cases	**32**	**141**

All NRAC funded projects are required to include collaborators from other states in the NRAC region. The out-of-state collaborators include additional researchers, extension, and other members of the aquaculture industry. The respondents of the Tier II Collaborator Survey are represented by these different sectors with two-fifths of the respondents from the research sector, just over a third from extensions, and 15% from the aquaculture industry (Figure 1). Eleven percent (11%) of the Tier II respondents described their role in the aquaculture industry as representing multiple sectors. In additional 11% of the collaborators classified themselves as 'Other,' with some self-classification as 'Consultant,' or 'Government (municipal, state agencies) Employee.'

Figure 1. Primary Role of Tier II Respondents in Project



The aquaculture industry in the NRAC region is currently dominated by shellfish growers (USDA, 2014). The Tier III respondents reflect this. These growers are largely engaged in marine aquaculture (84%; Figure 2) and farm shellfish (76%; Figure 3) with 74% primarily farming oysters (Figure 4). The results of this study, particularly as seen in the economic analysis, are strongly influenced by the high, but representative, proportion of oyster farmers who completed the Tier III survey. Besides oysters, Tier III respondents farm quahog, soft shell clam, bay scallop, blue mussel, razor clam, and other shellfish, primarily sea scallops (Figure 4). Twelve percent (12%, n=37) of Tier III respondents raise freshwater fish (Figure 4). Of respondents who raise freshwater fish, 62% (n=23) raise trout species (Figure 5). There were no Tier III respondents who grow marine fish. Five percent of Tier III respondents culture macro algae (Figure 4), with sugar kelp being the dominant species grown (Figure 6). The majority (71%) of products grown by the Tier III respondents are intended for human consumption/food (Figure 7), though some farmed organisms have mixed use. Aquaculture products are also used for research, education, within the farm (i.e., micro algae), recreational harvest, in the pet industry (i.e., ornamental fishes), and other avenues (Figure 7).

Figure 2. Type of Water used by Aquaculturists: Tier III Respondents

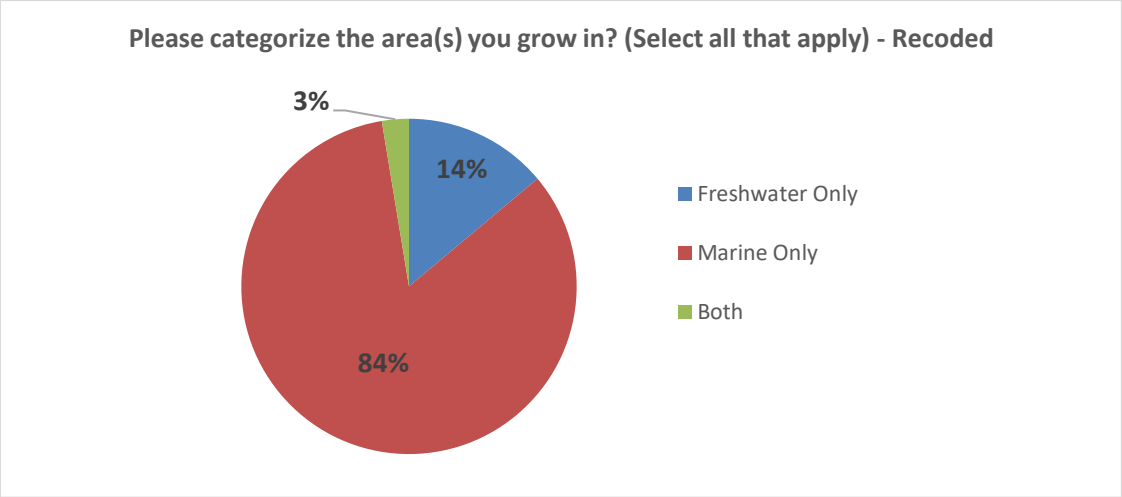


Figure 3. Aquacultured Organisms by Category: Tier III Respondents

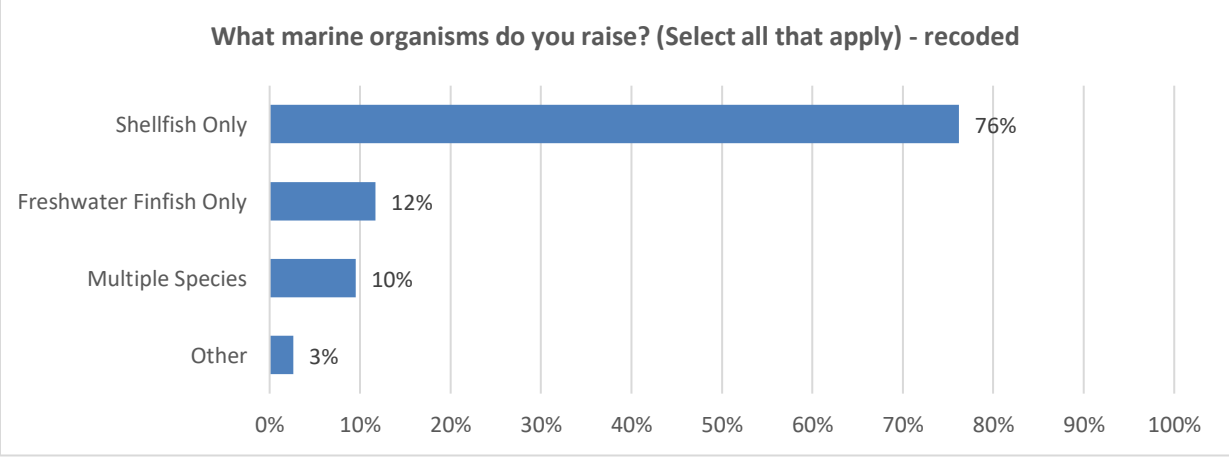


Figure 4. Types of Marine Organisms Cultivated: Tier III Respondents

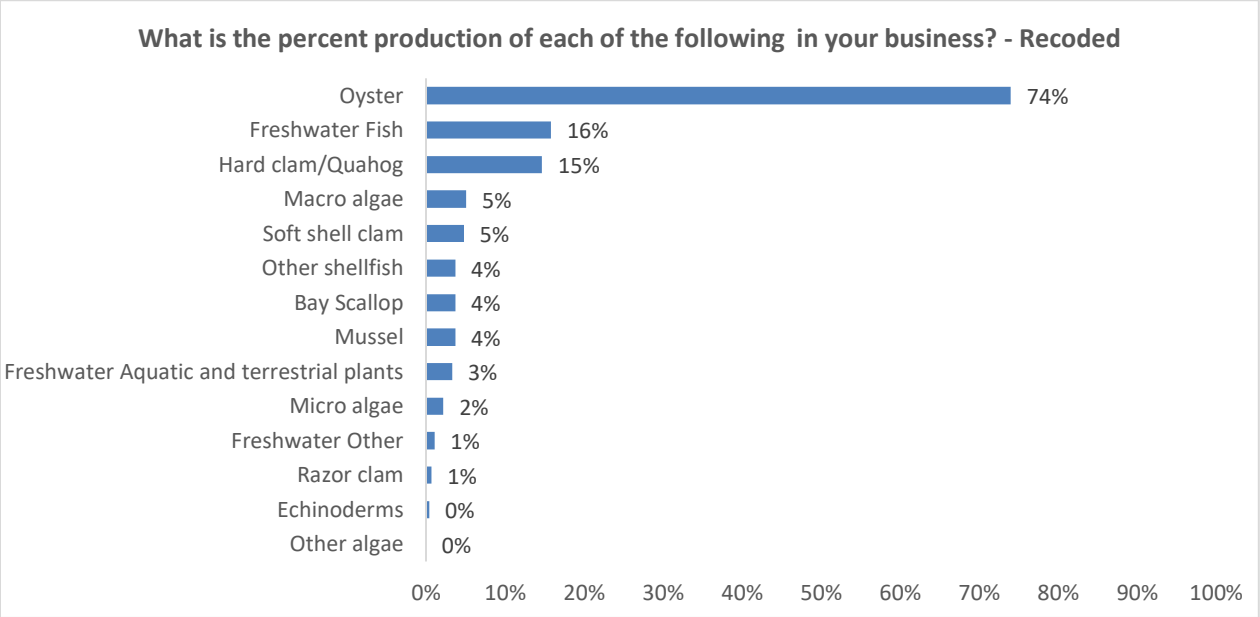


Figure 5. Types of Freshwater Fish Cultivated: Tier III Respondents

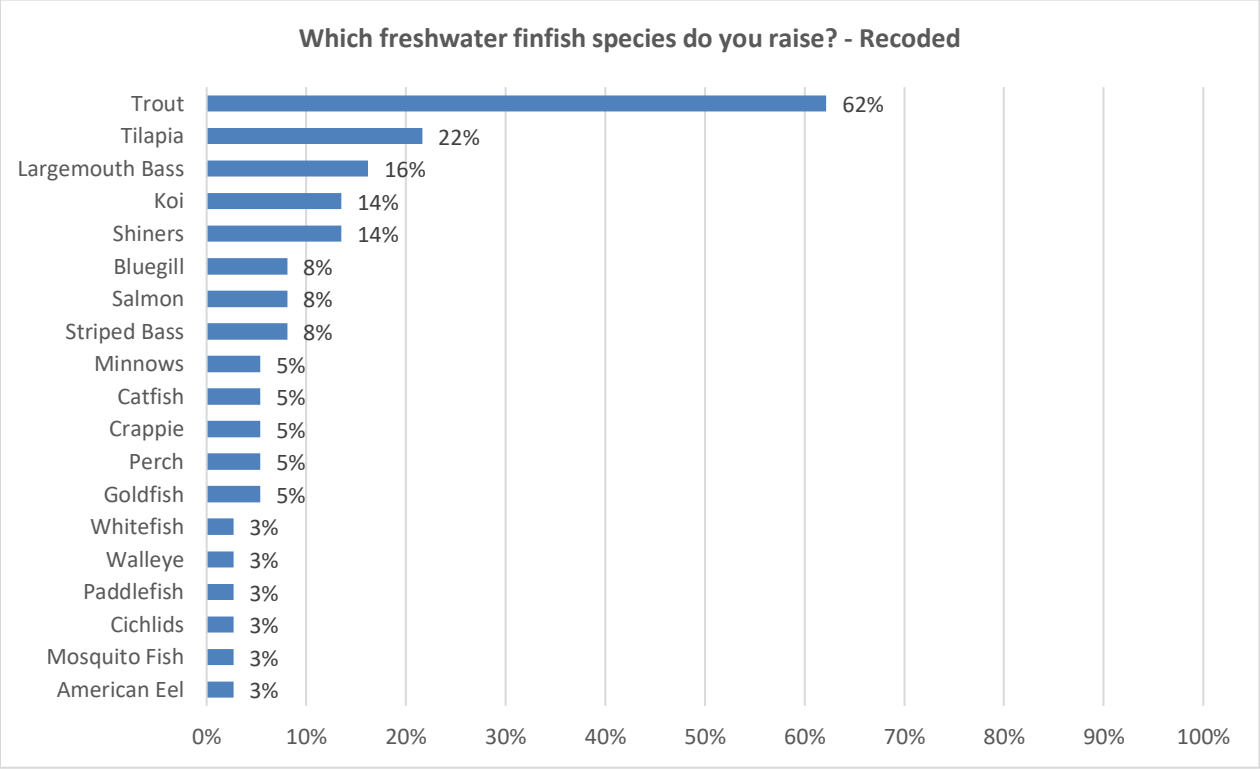


Figure 6. Types of Macro Algae Cultivated: Tier III Respondents

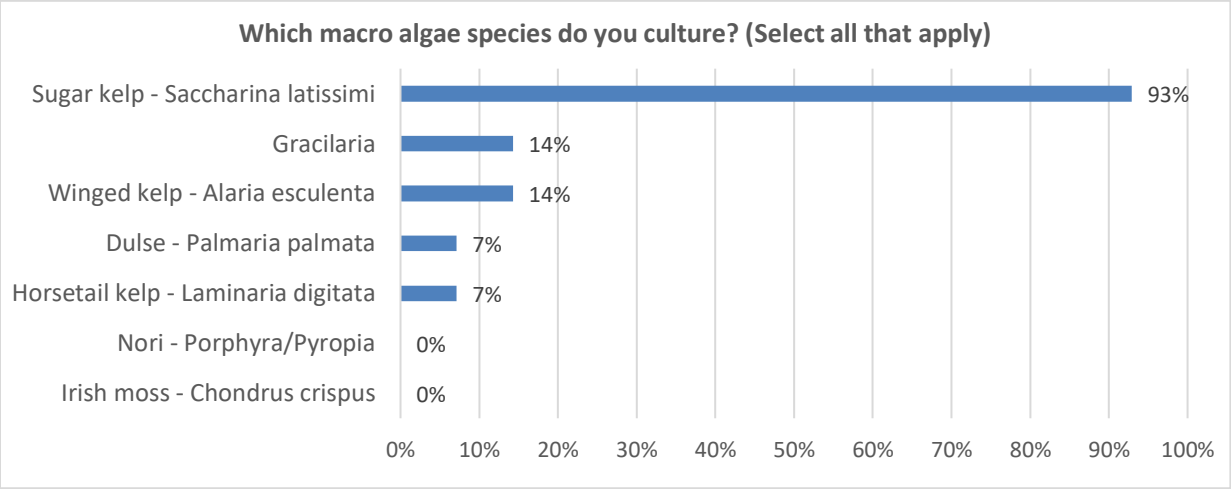
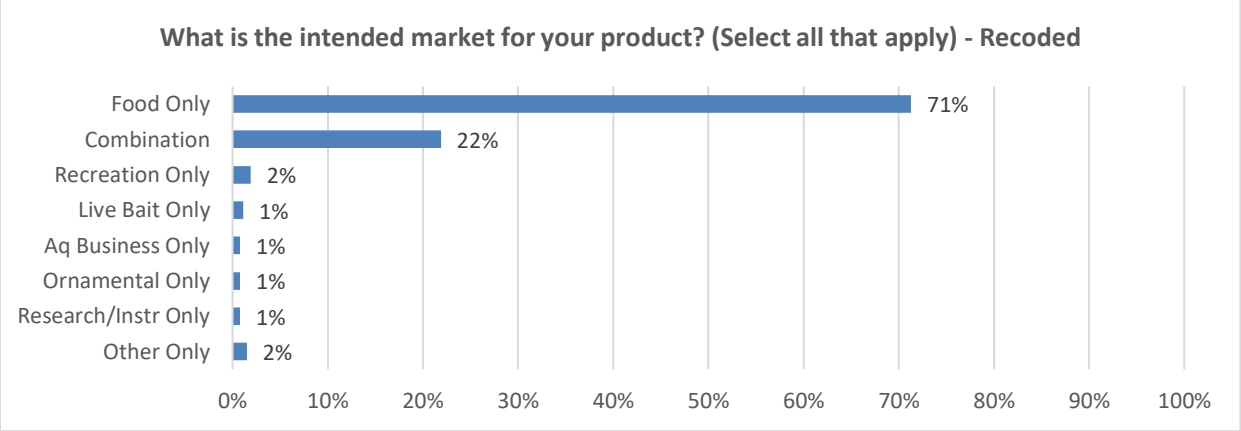
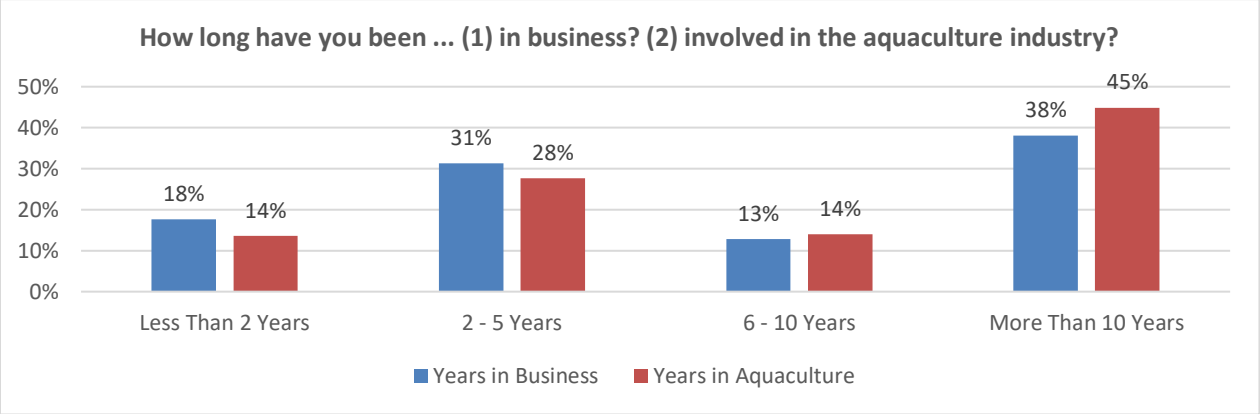


Figure 7. Intended Market of Aquaculture Product as Reported by Tier III Respondents



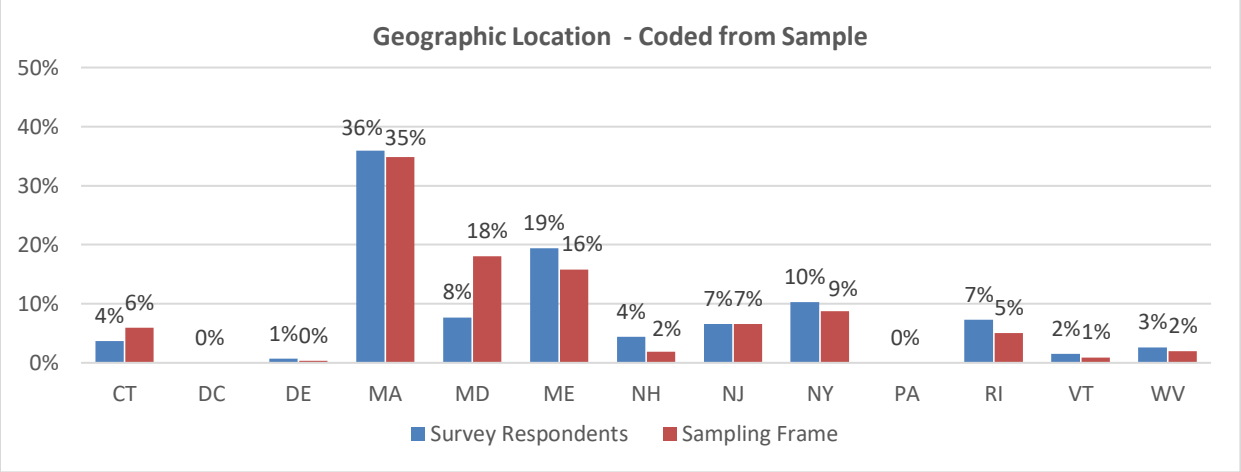
Over half (59%) of the Tier III respondents have been in the aquaculture industry for more than 5 years, while 45% have been in the industry for over 10 years (Figure 8). Additionally, over half (51%) also have been involved in their current business for more than 5 years.

Figure 8. Years in Aquaculture Industry Reported by Tier III Respondents



The Tier III survey respondents were geographically representative of the sampling frame with one exception. Maryland aquaculturists are underrepresented in the results (Figure 9).

Figure 9. Geographic Location of Tier III Respondents



Survey Findings

Major Impacts and Achievements of NRAC-Funded Aquaculture Projects

Project Coordinators and their collaborators were asked a series of questions about the impacts and achievements of the 32 NRAC-funded aquaculture projects. In both Tier I and Tier II surveys, respondents answered open-ended questions about what they thought were the most important achievements of their project for the aquaculture industry and for researchers. In addition, project impacts were documented in the project final reports written by the PCs. This information was aggregated and used to summarize the most meaningful achievements of the aquaculture projects to date.

Development of genetic markers to assess disease resistance in the Eastern oyster (2005-2008: $128,486)

- Discovered local oyster broodstock is more tolerant to local diseases.
- Found indication that DERMO proliferates to a lesser degree in oysters from a population that has experienced heavy disease pressure, suggesting local survivors of disease are good candidates for improved broodstock.
- Developed a set of genetic markers to be used to characterize disease tolerance potential in groups, strains, or families of oysters.
- Found shaking oysters activates mechanisms involved in host defense, inducing short-term disease resistance.
- Developed a quantitative polymerase chain reaction (qPCR) real-time assay for detection of DERMO that offers a low-cost alternative to current methods of diagnoses.

Effect of temperature on the infection of hard clams (*Mercenaria mercenaria*) by the protistan organism, QPX (2006-2008: $154,805)

- Led to a better understanding of which conditions increase hard clam susceptibility to QPX.
- Provided the rationale for examining strains of clams to use in aquaculture and for development of hard clams resistant to the disease QPX.
- Demonstrated the effects of temperature on the immune system of the hard clam and clam strain, and how those combinations might affect the clam's ability to ward off disease.

Economic analysis of an alternative raceway material (2006-2008: $107,096)

- Showed plastic (HDPE) "U" shaped tanks are a good alternative to concrete for medium and small sized trout aquaculture operations. Tanks were less expensive, easier to install and clean, and had design flexibility and resale capability.
- Utilized and advanced new, state of the art technology.
- Increased productivity and sustainability in several small trout farms.

Cross breeding and field trials of disease-resistant oysters (2006-2009: $248,436)

- Identified disease resistant strains of oysters and developed improved genetic lines of oysters (disease-resistant and fast growing) for the northeast, which have been integrated into breeding programs in commercial hatcheries throughout the NRAC region.

- Informed industry members about which lines of oysters would be the most appropriate for their farms.

Evaluation of hard clam, *Mercenaria mercenaria*, stocks for QPX-resistance (2006-2008: $71,173)

- Confirmed that southern hard clam strains become more heavily infected with QPX disease than northern (NJ or MA) strains when cultured in the northeast, leading to higher mortality and lost revenue at the farm.
- Showed that since growth rates of both clam strains were similar, there is little advantage to using southern strains in the northeast.

Development of JOD-resistant lines and markers for Eastern oyster aquaculture (2007-2010: $209,268)

- Identified genetic signatures in oysters that are associated with resistance to Juvenile Oyster Disease (JOD).
- Established a new line of oysters (NEH-RI) from the MSX and DERMO resistant lines that also survived JOD and SSO outbreaks in Rhode Island.
- Increased knowledge about mechanisms of disease resistance, leading to a resurgence of the East Coast Shellfish Breeding Consortium.

Development of environmental code of practice and BMPs for East Coast shellfish growers (2007-2009: $220,114)

- Through workshops, corrected shellfish growing practices and misunderstandings; identified important issues throughout the region and determined successful solutions; and improved relationships between industry members and state and federal regulators.
- Created a Best Management Practices (BMP) manual in which diverse shellfish growing methods, political structures, and environmental diversity have been considered in a standardized manner across state boundaries. The BMP manual has enjoyed wide-spread acceptance, not only in the Northeast region, but across the entire East Coast. The BMP manual has solidified the unity of the growing aquaculture industry.
- Developed a spreadsheet-based template for creation of individual shellfish farm plans, based on Best Management Practices (available at: http://www.ecsga.org/Pages/Resources/BMP.html). This has made it easier for shellfish growers to receive permits and leases.
- BMP manual adopted by several states as the official regulatory tool, and has been disseminated at workshops, conferences, and websites.

Evaluating restoration and mitigation of aquatic plant species and markets to advance commercialization of the industry (2007-2010: $449,903)

- Demonstrated methods to efficiently produce aquatic plants while reducing water pollution in different systems, including aquaponics which resulted in significant reduction of fish effluent nutrient levels.
- Expansion of native aquatic plant producers marketing to community associations for controlling nutrient aggregation in storm water ponds. This has led to increased visibility of aquatic plant

producers, and the increased profitability and perception of property values in communities applying the results of this project.

- Demonstrated alternative production practices that simultaneously provide nutrient mitigation and a secondary crop.
- Developed a new product - the bio-matrix floating wetland.
- Aided in the evaluation of improved sustainable effluent treatment options leading to eco-certification for a salmon hatchery.
- State agencies in Delaware adopted aquatic plant grow-out technology from the project to produce plants needed in restoration.
- Created database of Nitrogen and Phosphorus uptake of 12 native plant species for warm and cool climates in the northeast.

The infection cycle of VHS virus (2008-2012: $199,263)

- Measured fish susceptibility to viral infection (VHS), and specifically showed that Atlantic salmon and walleye have a relatively low risk while hybrid striped bass appear to have a moderate risk to the virus.
- Developed new diagnostic tools for viral pathogens and facility disinfection/containment guidelines, which led to greater biosecurity protocols to prevent transport and spread of VHS in fish in the Great Lakes Basin.
- Provided information through workshops about the emergence of VHS in the Great Lakes region that was essential to regulators and industry for scientifically-sound decision making in response to this invasive disease event. These decisions were made by multiple agencies across multiple states and impacted aquaculture industries throughout the Great Lakes Basin.

NRAC extension project (2008-2010: $299,944)

- Formalized a regional aquaculture extension network to foster interaction, communication, and collaboration among extension personnel and key aquaculture stakeholders in the Northeast region of the U.S.
- Provided high-quality educational products (fact sheets on new species and cultivation methods, State Aquaculture Situation and Outlook Reports) and activities (trade workshops, extension programs) to aid producers in the formation and management of their businesses, and aid other stakeholders in the decisions they make regarding aquaculture.
- Bridged findings from research to industry and vice versa to identify and solve industry problems.
- Educated state health regulators about the unique needs and problems associated with aquaculture.

Creation of a tetraploid broodstock for the bay scallop *Argopecten irradians* (2008-2012: $127,197)

- Showed, though biologically feasible, tetraploidy is not cost effective for the bay scallop industry due to high costs and length of time to produce broodstock, low survival beyond year two, and loss of genetic diversity in the hatchery seed.

- Allowed the industry to focus on other, more successful strategies by eliminating tetraploidy as a possibility.

Targeted biosecurity education and BMP development program for aquaculturists, extension agents, researchers and regulators (2008-2010: $89,920)

- Educated farmers about biosecurity by demonstrating appropriate biosecurity practices, including comprehensive fish health sampling, through hands-on workshops at the farms.
- Growers developed a better understanding of bio-security practices and either became more conscious of following existing policies at their farm or implemented new measures.
- Fostered interactions between fish health professionals, biosecurity auditors, regulators, researchers, educators, and aquaculturists.
- Developed and distributed a biosecurity manual and fact sheet for growers in the northeast region.

Investigation into the potential health and economic benefits of bivalve/finfish co-culture (2008-2010: $150,000)

- Resulted in knowledge about disease transmission in integrated multi-trophic aquaculture (IMTA) farms, specifically *Vibrio* transferred from blue mussels to cod.
- Found that when *Vibrio* was present, blue mussels removed it from the water column and concentrated viable bacteria in their digestive tissues, feces, and pseudofeces. Cod exposed to those infected feces had lower survival.

Deterring duck predation with underwater sound (2008-2011: $108,000)

- Showed that eider duck deterring device buoys were helpful in combination with other deterrents like chase boats, but not completely effective at keeping eider ducks from eating mussels grown on submerged longlines due to issues with battery charges, high costs, winter storms, and ducks habituating to the buoys.
- Documented that open submerged longline mussel cultures are heavily preyed on by eider ducks and require some sort of physical barrier to keep ducks away.

Evaluation of putatively QPX-resistant strains of Northern hard clams using field and genetic studies (2008-2010: $263,490)

- Worked towards the development of QPX-resistant strains of hard clams.
- Developed molecular tools to identify direct and indirect molecular mechanisms for disease resistance that can be exploited for genetic selection practices.
- Reaffirmed that hard clams selected from areas under intense disease pressure are a good source of select disease-resistant broodstock.
- Indicated that follow-up genetic and breeding technologies will assist the industry.
- Provided a commercial hatchery with the broodstock that performed best on Cape Cod farms so that faster growing, better surviving hard clam could be replicated and grown at other farms.

Assessment of grow-out strategies for the green sea urchin (2009-2013: $156,933)

- Demonstrated that sea urchin ranching is feasible in the northeast, but site selection and protection of sites are very important, and the efficiencies for land-based culture must be improved for it to be profitable.
- Noted one topic regularly discussed between the Maine Department of Marine Resources and the Sea Urchin Zone Council is how sea urchin fishing grounds can be restocked with hatchery seed.

Selection for enhanced disease resistance and growth performance in cross-bred oysters, *Crassostrea virginica* (2009-2013: $232,416)

- Advanced the eastern oyster breeding programs by continuing to identify and integrate disease-resistant oyster strains with faster growth rates into commercial hatcheries.
- Conducted field trials using the disease-resistant oyster strains to support results within the northeast region.
- Found that breeding survivors of local disease outbreaks can be used to develop new varieties of disease-resistant oysters.
- Made available information about the relative survival and growth characteristics of existing lines of oysters accessible to growers in the northeast, thereby allowing the industry to make informed decisions and industry hatcheries to plan which lines they will produce for growers in different parts of the region.
- Advocated for maintaining existing oyster lines, developing new lines, and continuing to use line crossing to obtain improved yield on oyster farms in the Northeast.

Breeding resistance to sea lice and ISAV in Atlantic salmon (2010-2012: $131,134)

- Demonstrated that there are genetic salmon traits for resistance to sea lice and conducted effective laboratory challenge studies.
- Provided information on the susceptibility of Atlantic salmon to sea lice infection and whether selective breeding in North American strains of Atlantic salmon for sea lice resistance is possible.
- Investigated the interactions of infectious salmon anemia virus (ISAV) and sea lice, highlighting the potential risks of lice-infected salmon contracting or transmitting ISAV.

Examination of finfish pathogen physiology and predictive ecology in bivalve integrated multi-trophic aquaculture (2010-2013: $200,000)

- Learned about the possible pathogen risks of implementing IMTA with mussels and salmon by showing that infectious pancreatic necrosis virus (IPNV) can be transmitted from exposed blue mussels and mussel feces to salmon, but not at high frequency.
- Contributed to the body of knowledge on the ecology of disease on integrated multitrophic aquaculture (IMTA) farms. The work from this and the associated NRAC-funded projects make up a significant amount of knowledge on this topic.
- Modeled economics of IMTA versus salmon monoculture and showed IMTA scenario has good returns.

Novel methodologies to overwinter cultured hard clams in the Northeast U.S. (2010-2013: $200,402)

- Determined if methods developed in Maine increase overwintering survival of hard clams were applicable to more southern regions. The methods were not transferrable, so growers have not wasted effort attempting them.
- Indicated that ME seed may have a genetic component allowing them to overwinter with lower mortality than NY or NJ strains, suggesting that overwintering performance is likely stock-specific and potentially could be resolved by genetic manipulation.

Assessment of environmental impacts of oyster aquaculture in New England waters (2010-2012: $199,994)

- Developed shellfish GIS software that incorporates the spatial and temporal presentation of site hydrodynamics, environmental forcing functions (temperature, salinity, food availability), and growth of the eastern oyster in bottom culture. This tool has been recognized and acknowledged as a key contribution, exemplifying how integrated modelling facilitates regulated development of a sustainable industry, including the optimization of production by farmers.
- Compiled information from several disciplines into one cohesive GIS platform with abilities to predict different development scenarios (i.e. time to market at a given bottom density throughout a whole estuary).
- Supported the concept that oyster aquaculture is good for the environment with surveys showing limited, but beneficial effects of oyster culture systems on the abundance and species richness of epibenthic, infauna and large, mobile fauna.

Optimization of hatchery and culture technology for razor clam (2011-2013: $93.616)

- Demonstrated in this preliminary project that razor clams are a viable alternative species and hatchery techniques can be refined to produce them.
- Generated interest for razor clams as an alternative species, particularly when the price per pound was significant. Growers were very keen on this species and continue to express interest and desire to work with razor clams in the future when seed is available from hatcheries.
- Cultivated a new species which could help the industry to diversify.

Developing improved management practices for mussel farming in southern New England (2011-2015: $199,799)

- Highlighted the potential economic benefits of blue mussel farming in Southern New England that can be conducted by fishermen using their boats, nautical skills, and technical knowledge.
- Built a consensus with marine stakeholders that mussel farming is a compatible enterprise within the context of many other marine activities.
- Demonstrated that a blue mussel farm can be sustainably run in New England and that there are measures available to keep major fouling organisms (tunicates) under control.
- Learned that mussel farming can be practiced productively in New England, and that the U.S. does not need to be dependent on PEI Canadian mussels.
- Identified suitable suppliers for seed in the northeast and ways to safely clean seed from tunicates.

- Trained growers how to use seed grading and stocking machines allowing them to save time on labor.
- Helped partnering mussel growers in MA and RI to double their farms and helped incentivize five new mussel lease sites in southern New England.

Aquaculture health hazards - developing outreach services to the region's farmers via extension and aquatic animal health (2011-2014: $196,312)

- Produced a HACCP-style guide of aquaculture hazards and risks with guidance on how to mitigate and avoid these risks through the collaborative efforts among multiple states. The industry has used the manual to improve everyday practices (e.g., stocking densities, environmental conditions, operational settings), deal with issues that come up (e.g., sudden appearance of disease, pests, or predators), and in developing farm plans to improve risk management at the farm. Local resource managers also have used the guide for local resource management.
- Developed and identified expertise throughout the region.

Development of more efficient methods of *Vibrio* sp. detection and identification of *Vibrio* sp. abundance in cultured oysters from Northeast US farms and from retail sites post-harvest (2012-2015: $190,360)

- Increased awareness of *Vibrio* in shellfish, which is a major concern across the shellfish aquaculture industry, especially since there are higher sales in months when harmful bacteria multiply more rapidly.
- Defined methods for diagnosis and best management practices for avoiding Vibrios, including better shipping methods.
- Showed that the FDA approved method (Most Probable Number (MPN)) does not accurately determine levels of Vibrios in oyster samples.
- Developed a new method (Multiplex quantitative PCR (mqPCR)) that is significantly more accurate than MPN methods in determining Vibrios and pathogenic gene abundance in oysters.
- Showed that natural *Vibrio* levels in oysters, sediment, and water column are very low during most of the year in the northeast, and that harvesting, restaurant handling, and shipping have significant effects on *Vibrio* levels and pathogenic genes in oysters post-harvest.
- Increased the safety of oysters as a live food product and decreased economic losses from shellfish bed closures.

Shellfish STEM-GIS development for improved siting and farm management (2010-2012: $117,000)

- Enhanced and expanded the shellfish GIS software (STEM-GIS/Shell-GIS) used to improve shellfish yield and profitability for suspension and bottom culture of the eastern oyster.
- Improved and validated the growth model for this GIS platform.
- Integrated this software tool with some state GIS mapping tools for more powerful site selection decision making.
- Stressed the need for better diagnostic/surveillance methods and better coordination between regulators and researchers.

Algal-bacterial interactions in shellfish hatcheries (2013-2014 Mini Grant: $18,488)

- Used DNA-based techniques to characterize the types of bacteria to species that colonize hatchery-scale cultures of important microalgae.
- Indicated that work on probiotics may help reduce catastrophic losses of bivalve larvae during hatchery-phase of production.

New tools to prevent bacterial diseases in shellfish hatcheries (2013-present: $199,514)

- This project is still underway so all impacts and achievements are not measurable yet.
- New disease management tools are being developed and tested. Probiotics and their effectiveness in protecting vulnerable shellfish larvae from pathogens are being evaluated to increase larval production in shellfish hatcheries.
- Accomplished proof of concept testing in shellfish hatcheries to demonstrate probiotic treatments can help minimize risks of bacterial infections.
- Commercial scale probiotics products are of great interest to shellfish hatcheries. Established connections with commercial ventures to translate the research into development which has led to the establishment of a new company in aquaculture health management - Bay Aquaculture Solutions.

Striped bass selection for marine culture (2013-present: $199,569)

- This project is still underway so all impacts and achievements are not measurable yet.
- New domestication protocols are being developed for striped bass. As a highly-regulated species along the east coast of the U.S., non-hybrid striped bass represent a prime species for aquaculture in recirculating systems and may outpace the growth of hybrid striped bass at larger sizes.
- Producing domestic striped bass crosses for a growth study.
- Developing less technical spawning protocols for domesticated striped bass and reproducing female striped bass for the first time using modified husbandry practices that do not rely on hormone induction procedures.

Genetic mark-assisted selection of Northeastern hard clams for QPX resistance (2013-present: $199,998)

- This project is still underway so all impacts and achievements are not measurable yet.
- Demonstrated that QPX-resistant strains of hard clams, grown beside non-resistant clams, had significantly less disease, and therefore, better rates of survival.
- Identifying genes responsible for resistance and starting the selection process for QPX-resistant clams.
- Expected results likely will improve aquaculture clam stocks and enhance their resistance to disease.
- These findings will provide renewed interest in growing hard clams, which is important, given the oyster-dominated industry's need to diversify.

Identification and isolation of novel probiotic bacteria for use in marine aquaculture (2013-2014 Mini Grant: $19,981)

- Identified and isolated five bacterial strains from the intestines of mummichogs that can inhibit the growth of marine pathogens and could be used as potential probiotic bacteria in fish culture.
- Found through tests with these bacterial isolates that probiotic bacterial use may increase larval fish growth.
- Developed this Mini Grant study into a full study with predicted national impacts when completed.
- Moving forward with a possible product/approach to help improve production.

Improved grow-out methodologies for Razor Clams (2014-present: $176,049)

- This project is still underway so all impacts and achievements are not measurable yet.
- Demonstrating potential for razor clams, an alternative species, by testing culture methods in the hatchery and the field.
- Working towards diversifying the northeast aquaculture industry.

NRAC supports applied aquaculture research. This is possible due to the high level of involvement by the aquaculture industry at all levels of the research program. This process begins with industry representation on the advisory committee (IAC) which brings forward industry needs and works collectively with scientists (TAC) to transform those needs into recommended research priorities. This involvement continues at the research project level with the mandatory requirement by NRAC that all research projects have at the very least endorsement, if not direct participation, by the aquaculture industry. This results in more than 80% of NRAC-funded aquaculture projects being (or having the intention of being) applied with the goal of contributing to practical improvements for the industry (Figure 10). In addition, the intended products derived from the NRAC-funded aquaculture projects are meant to improve aquaculture production by improving production techniques and product survival, increasing markets through diversification of products, and decreasing operating expenses (Figure 11). Dissemination of research findings to industry users is accomplished through an integrated extension plan, also a requirement of NRAC-funded projects. This is particularly noticeable in the content of final reports submitted to NRAC at the completion of each project; a primary output of NRAC-funded projects is education, specifically workshops and training sessions geared for the aquaculture industry (Figure 12). In addition, dedicated websites and software for farmers have been created, farm equipment has been designed and built, and most importantly, new species or strains have been cultivated (Figure 12) as identified above in Major Impacts and Achievements of NRAC-Funded Aquaculture Projects.

Figure 10. Benefits of NRAC Projects: Tier I and Tier II Respondents

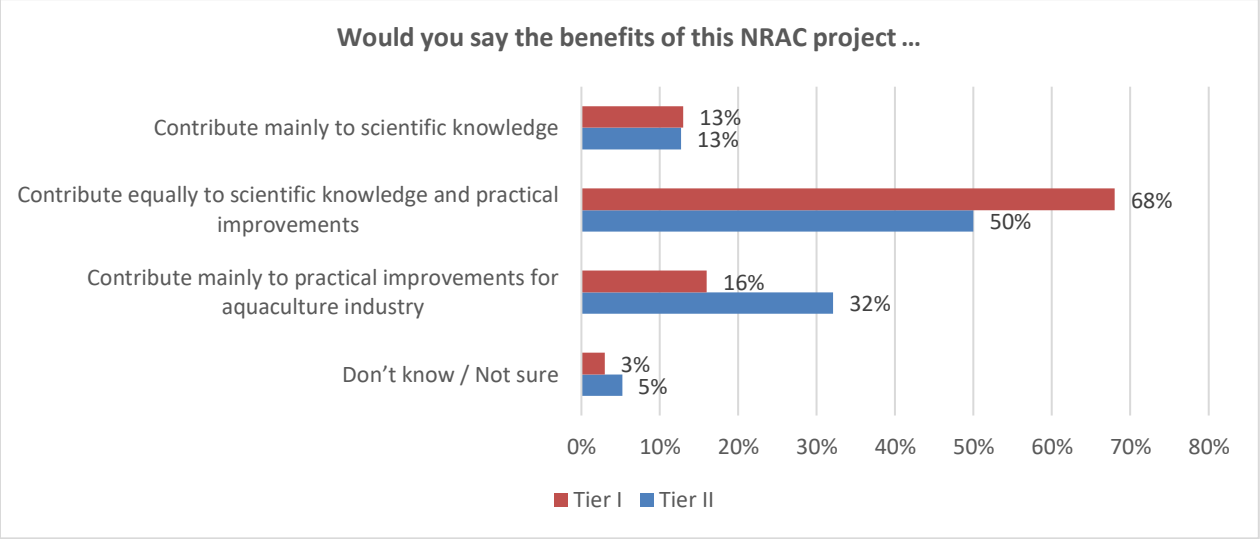


Figure 11. Most Tangible Products: Tier I and Tier II Respondents

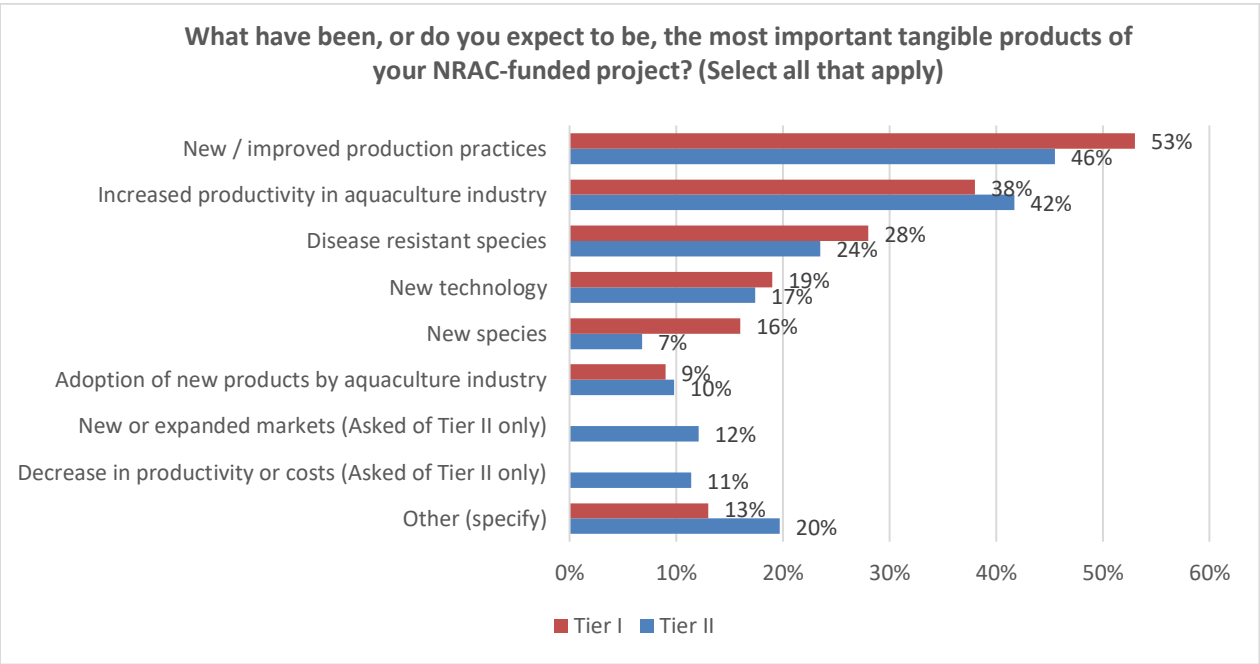
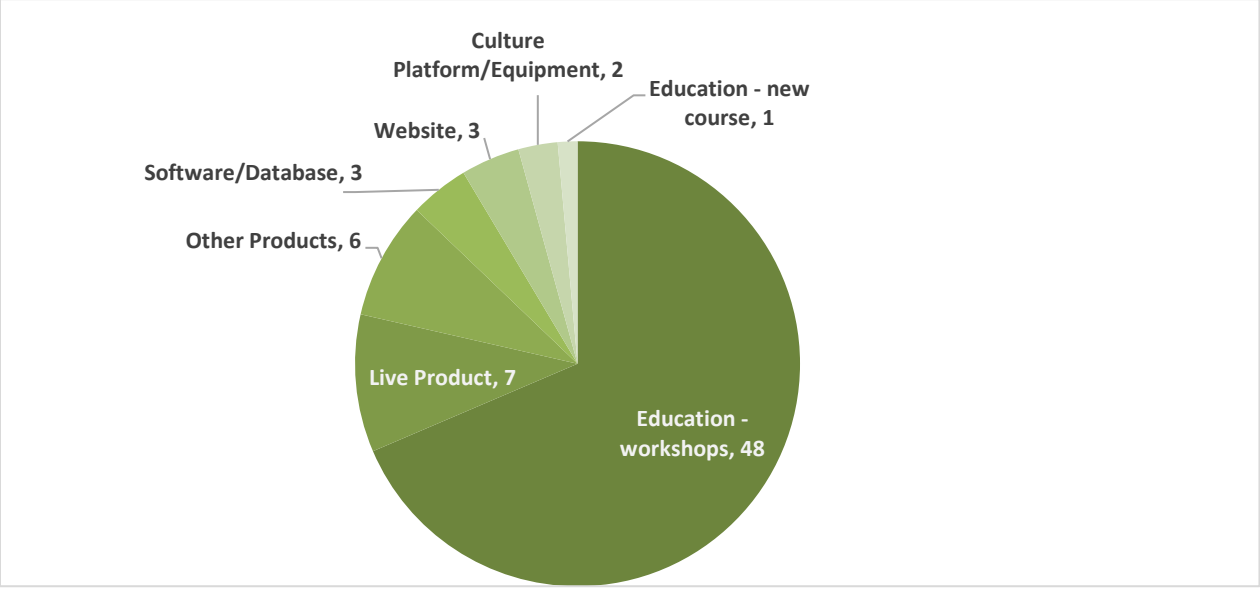


Figure 12. Number and Type of Products Resulting from NRAC Projects



Another reason for the success of NRAC-funded aquaculture projects is that they cross the divide between many different entities. Not only do researchers, extension, and industry stakeholders work collaboratively on an issue germane to the aquaculture industry, but they do so in a regional effort, working from multiple states. Both criteria are key to the development and implementation of meaningful and successful aquaculture projects. Project Coordinators and their collaborators are supported by diverse institutions throughout the NRAC region, with many projects supporting student education (Figure 13) and with heavy involvement stemming from Land Grant Universities and state Sea Grant programs (Figure 14). However, despite the multi-disciplinary approach of NRAC projects, representation from aquaculture regulators is lacking. Of the 250 collaborators listed on the 32 project proposals, only 7 collaborators (2.8%) were affiliated with state or federal agencies, and none of these were regulators.[3]

[3] State employees from Connecticut (1), New York (1), and Rhode Island (1) and one federal employee collaborated on a total of six of the 32 NRAC-funded aquaculture projects.

Figure 13. Student Involvement in NRAC Projects

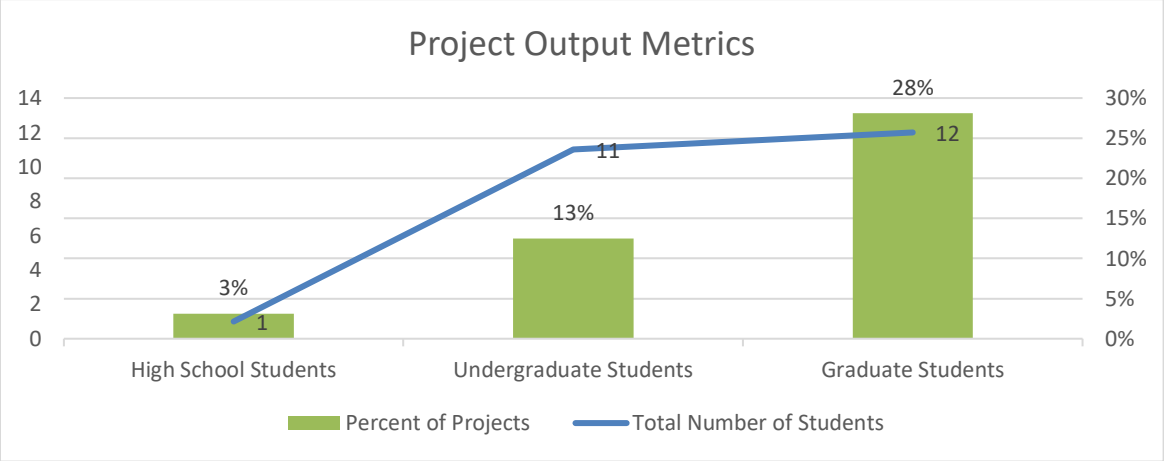
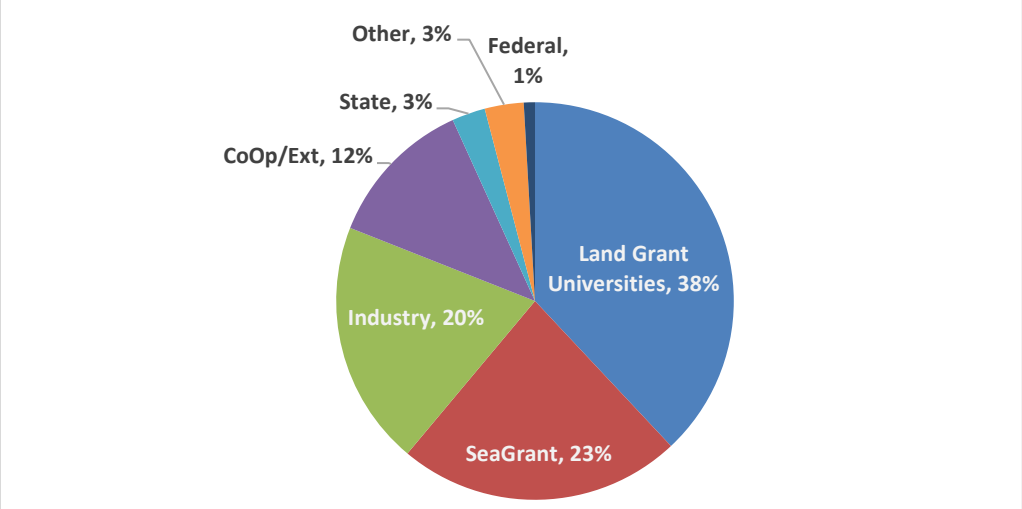


Figure 14. Collaborator Association from All NRAC Projects



When asked about what the three most important factors that have led to the success of their businesses were, Tier III respondents reported a variety of reasons, some of which NRAC likely played a role in (e.g., grants, siting, extension, product, quality, etc.). A resounding theme though was hard work (Figure 15).

Figure 15. Most Important Factors Leading to Success in Business Reported by Tier III Respondents

Factors Limiting the Impacts and Achievements of NRAC-Funded Aquaculture Projects

Most collaborators (86%) agreed that there were no barriers to getting the results and findings of their NRAC-funded projects disseminated more broadly within the aquaculture industry. However, both Tier I and Tier II respondents provided comments that could explain why some projects did not have as great an impact as others. A large proportion of PCs (44%) answered that budgeted funds were insufficient to widely disseminate the findings of their projects. One PC stated that "often results and recommendations take some time to distribute after the grant is over" and help in doing so would make a difference. Another PC pointed out (and several collaborators also noted) that timing is also an issue with project results often only available after termination of the project, when funds are exhausted, which then reduces opportunities for communicating the results effectively.

Many Tier II respondents thought that if outreach had been more integrated, project results and findings would have had greater dissemination. One collaborator answered that "generally, researchers don't think about outreach until the end of the project. Outreach should be considered from the beginning of the project and extension staff should know what's going on with the research before it's over." Extension collaborators repeatedly replied that PCs should integrate industry involvement and extension plans better, starting with the early planning stages of projects and by utilizing extension to connect researchers with aquaculture stakeholders who they don't already know. Recommendations were made to continue presenting at regional meetings, but have extension assist with translation and dissemination of relevant information. In addition, PCs should create nontechnical information geared for general consumption (public, industry). Short 5-minute videos to summarize issues and findings could be created by the PC's home institution's media services or via a dedicated NRAC service. In the same breath, Tier II respondents recognized that getting all outreach completed for a two-year project is very difficult. One respondent suggested funding outreach projects to convey findings of completed NRAC-funded research projects.

Many collaborators acknowledged that the northeast aquaculture industry is very diverse and that it can be difficult to reach all the potentially impacted stakeholders. The East Coast Shellfish Growers Association was recognized as a great example of a clearinghouse for information for the shellfish industry. However, a parallel group for the finfish industry does not exist in the NRAC region, thus limiting the scope of this assessment as we were unable to connect with many finfish growers, especially those in Pennsylvania. Not having the finfish sector well represented in the Tier III Survey affected the assessment of which NRAC-funded projects had the greatest impacts. Many projects were unknown to Tier III respondents. Therefore, our population list for the Tier III survey was not representative of certain aquaculture sectors. We reached shellfish growers primarily. The underlying message is that some projects may have been very impactful, but we are not able to draw conclusions based on our methods.

When asked to identify up to three greatest barriers to the success of their business, Tier III respondents clearly identified regulations as the most commonly perceived roadblock (Figure 16), though this likely is a commonality shared by other business owners. However, unlike other trades, especially those that are not agricultural nor located in aquatic environments, other constraints echoed repeatedly by Tier III respondents were cost, lengthy time to market, lack of access (siting, leases), and weather. These

opinions were largely voiced by shellfish culturists in marine waters. The situation may be different for finfish growers in freshwater.

Figure 16. Greatest Barriers to Success of Business Reported by Tier III Respondents

Economic Impact

Economic Methods

Input-output models for each state's economy were created to estimate the economic impacts that resulted from the research projects funded by NRAC during the period 2005-2014. While initial impacts on the aquaculture industry may be easily estimated, the resulting impact on each state's economy requires more in-depth analysis.

The basic input-output model assumes an *N* industry regional economy, usually decomposed by the Standard Industrial Classification (SIC) code, which produces a single output using the final products of its own and the other industries as inputs. Letting x_i denote the value of output for industry *i*, and a_{ij} denote the amount of good *i* necessary to produce one unit of good *j*, equilibrium in each market requires

$$x_i = \sum_{j=1}^{N} a_{ij} x_j + c_i, \; i = 1, 2, \ldots, N, \tag{1}$$

where c_i is final, or consumption, demand for the i^{th} good. In matrix notation, (1) becomes

$$\left(\mathbf{I} - \mathbf{A}\right)\mathbf{x} = \mathbf{c}, \tag{2}$$

where **I** is an *N*x*N* identity matrix and **A** is commonly referred to as the technology matrix (Simon and Blume, 1994). Solving (2) for **x** by inverting (**I-A**) yields

$$\mathbf{x} = \left(\mathbf{I} - \mathbf{A}\right)^{-1}\mathbf{c}, \tag{3}$$

which gives the value of output necessary for each market to be in equilibrium, conditional on the final demands **c**. IMPLAN assumes that all markets clear instantly, and that equilibrium is reached.

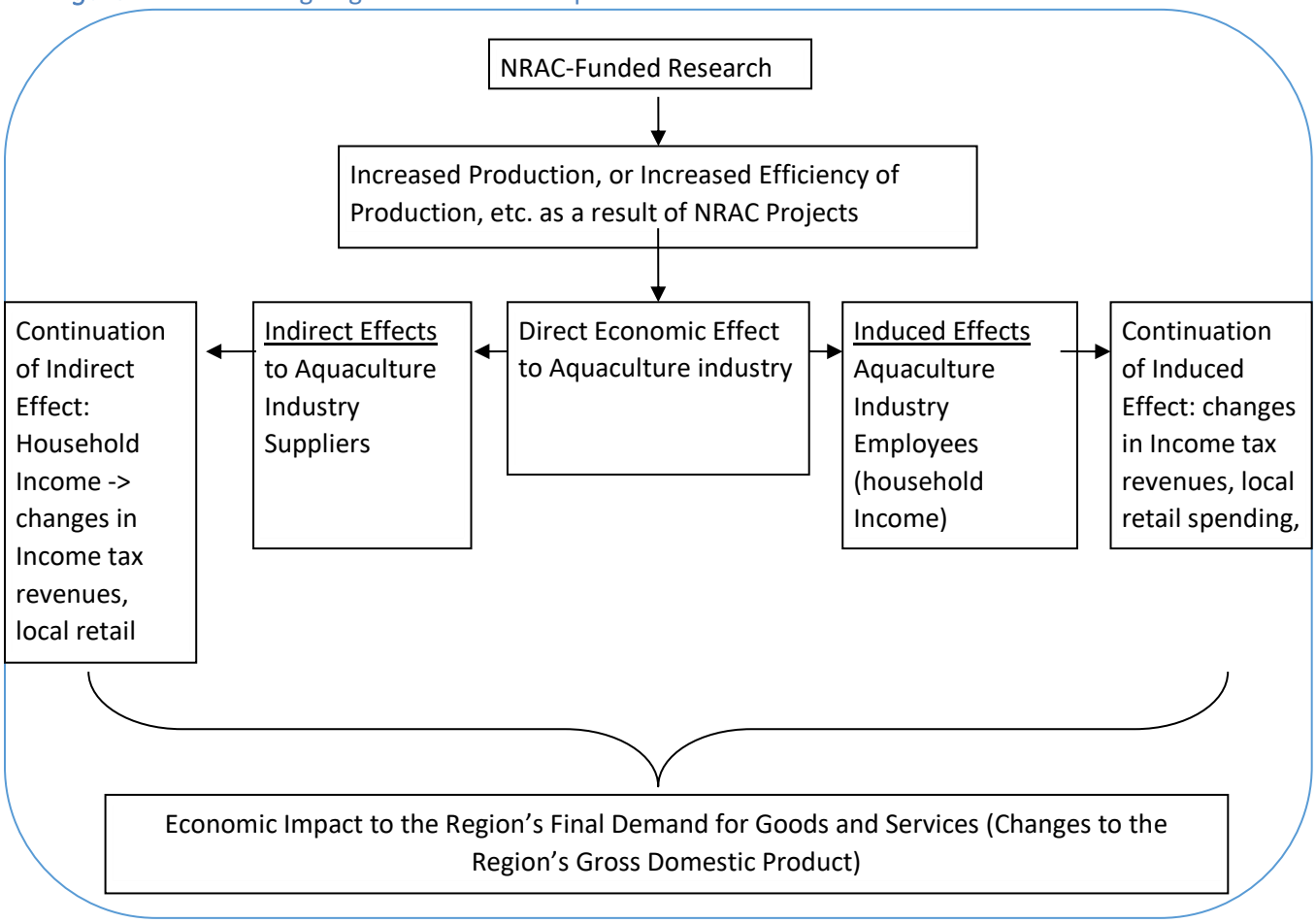
In practice, the model in (2) is augmented to include interactions between industry sectors and households, either through adding household consumption as a row in the final demand vector **c**, or using a social accounting matrix (SAM) structure in conjunction with the matrix **A**. The SAM essentially disaggregates the household consumption sector in a similar manner as the above decomposition of the production sectors, thus rendering the components of the consumption sector (and hence household income) endogenous to the model. In addition, the model can be calibrated to measure not only output, or gross sales, effects, but also employment, personal income, or value-added effects.

To perform regional economic analysis using an extended input-output model, the inverted matrix $\left(\mathbf{I} - \mathbf{A}\right)^{-1}$ is utilized to generate a matrix of multipliers that represents the total economic activity necessary to restore the regional economy to equilibrium given an exogenous change in the final demand vector **c**. In this context, data from the Investigator Reports and Stakeholder Surveys are used to perform a counter-factual analysis by estimating the gross revenues and/or employment of each industry as a direct result of NRAC-funded research (i.e. aquaculture harvesting) according to industry definition in the appropriate row of **c**. These are typically termed the "direct" effects of the research projects. However, due to the interactions between industries and households, simple aggregation of the direct effects

underestimates the impact of the research outcomes on the regional economy by neglecting the linkages.

The input-output model accounts for these additional effects, termed "indirect" and "induced," through the above matrix of multipliers obtained through (3). Indirect effects capture the linkages between local supplying industries and the final demand change, essentially by tracing the spending streams between economic sectors. For example, an initial change in final demand in one industry may result in changes in supplying activity in ten other sectors, which in turn affects the local suppliers of those ten industries, and so on. Induced effects describe the impact of household expenditures on the regional economy that result from changes in final demand. This linkage arises due to the fact that labor is an input into any production process, and benefits from economic activity through wage payments, thus affecting disposable income. The disposable income is at least partially spent locally, and therefore affects demand for local industry goods and services.

Figure 17. Estimating Regional Economic Impacts



Total regional economic impacts resulting from research outcomes of NRAC projects were estimated by summing the direct, indirect, and induced effects emanating out from the aquaculture industry

participants as predicted by an input-output model. Of course, these tools are considerably data-intensive, and require estimation of the inter-industry linkages within a local economy. Fortunately, private vendors such as IMPLAN (2016) build detailed input-output models at the county and state level, calibrated by using data collected by the federal and local governments, which are available for purchase by researchers.

Combining regional economic impact analysis with the other components of this assessment of NRAC funding gives policy makers a better idea of how past research projects affected the economic livelihood of people involved in the aquaculture industry and the resulting ripple effects throughout the economy. Each state was analyzed independently to see where impacts have resulted in the most significant changes. The model output includes estimates of changes in employment of 470 economic sectors, as well as changes to local tax revenue, and regional Gross Domestic Product.

Assumptions in the Impact Models

To model economic impacts, grant budgets were examined and funds were categorized based on type of expenditure (printing, telephone, retail spending, academic salaries, etc.). Spending that occurred out of the Northeast states, such as specialized equipment that was imported and researchers employed outside of the northeastern states, was not counted. A conservative approach was taken when accounting for expenditures included in this impact analysis. If it was unclear whether an expenditure was within the northeastern U.S. region, it was not counted. For example, if the grant covered attending a meeting or journal publication page charges, and the meeting and journal were not specified, those expenditures were excluded.

Further, we only counted information from the survey respondents. There are likely more positive impacts, especially from non-respondents in the Tier III survey. While an industry response rate of 28% is considered strong, 72% of the potential respondents were not included in this analysis. Further, other industry professionals (i.e., Pennsylvania propagators, others not on our mailing lists) were not sampled.

Realized impacts also are likely to be significantly higher once the newer research projects have a chance to release their findings to be implemented by the aquaculture industry.

Tier I Economic Impact

For the purposes of this study, each state is considered a local economy. Financial expenditures on all final and finished goods in any given economy result in what is called Gross Domestic Product (GDP), which is often simply called regional income. Depending on the types of goods and services purchased, the money spent may immediately “leak” out of the regional economy, or it may remain, which allows the money to be spent again in that economy. Funds that remain in a given economy that are re-spent add to local GDP, and thus create what is known as a multiplier effect.

Some federal grants may result in little to no multiplier effects, while others may have significant multiplier effects. Input-output models were created to estimate these effects for each of the northeastern states that experienced spending. Funds that were spent outside of the northeastern states are not included in this analysis.

Table 7. Economic Impacts to States' Economies from Grant Spending

State	Funding Amount	Change to State GDP	State Level Multiplier	Jobs		State and Local Tax Revenue	Federal Tax Revenue	Increase in GDP plus Taxes
CT	$496,751	$848,529	1.71	6.1[a]	(8.3)[b]	$42,182	$131,643	$1,022,354
DE	$98,620	$160,830	1.63	1.4	(1.8)	$5,897	$20,043	$186,770
MA	$804,447	$1,471,664	1.83	7.3	(11.4)	$61,644	$179,794	$1,713,102
MD	$315,458	$542,283	1.72	3.9	(5.4)	$29,707	$70,943	$642,933
ME	$578,283	$1,063,708	1.84	5.6	(9.3)	$64,329	$81,815	$1,209,852
NH	$146,800	$250,384	1.71	2.5	(3.2)	$8,739	$30,307	$289,430
NJ	$556,032	$990,501	1.78	5.5	(8.2)	$49,529	$136,237	$1,176,267
NY	$396,739	$678,109	1.71	4.1	(5.8)	$40,232	$89,376	$807,717
PA	$13,488	$24,251	1.80	0.2	(0.3)	$1,086	$2,780	$28,117
RI	$514,240	$907,483	1.76	7.2	(9.9)	$41,745	$118,385	$1,067,613
WV	$184,511	$288,091	1.56	3.2	(4.0)	$13,343	$33,993	$335,427
TOTAL	**$4,105,369**	**$7,225,833**	**Average 1.73**	**47**	**(67.6)**	**$358,433**	**$895,316**	**$8,479,582**

All dollar amounts are in 2015 dollars.

[a] Full time equivalent jobs funded by the grants

[b] Total full time equivalent jobs resulting from grants

The models indicate that each state experienced significant economic multipliers from the grant expenditures alone. Note that Vermont and Washington, DC are not included in this analysis. There were no grants reported that went to those areas (see Table 3). Adjusting all figures to 2015 dollars, NRAC funded $4.1 million from 2005 to 2016. This resulted in $7.2 million in increased state GDPs. The multipliers varied from 1.56 in West Virginia to 1.84 in Maine, with the average being 1.73. This means for every $1 in federal support, there was $1.73 of local income. This does not include the local and federal tax revenues that resulted from this spending. They were $358,433 in state and local taxes, and $895,316 in federal taxes collected. The grants funded 47 full time equivalent jobs during the research projects, and an additional 27.6 jobs from the resulting spending and multiplier effects.

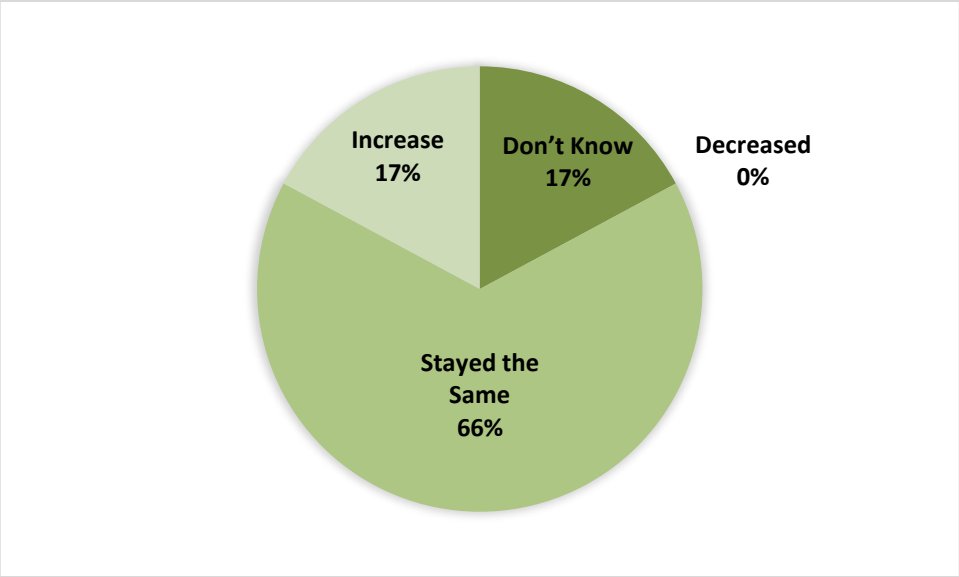
According to the IMPLAN input-output model, the initial multiplier from the funded grant work is **1.73**. These grants created a significant impact because they are labor intensive, and utilized local aquaculture practitioners and local laboratories. Another important characteristic of NRAC projects is that they include industry collaboration, so the focus is on applied research that is important to the aquaculture industry. This figure is expected as it falls in the middle of similar studies. Rios-Rull and Huo (2013) found multipliers of government spending in general average between 0.7 and 1.0. Umbach (2011) found a multiplier of 2.6 when looking at Publicly Funded Research Conducted by AAMC-Member Medical Schools and Teaching Hospitals. These impacts emanate from the initial grant funding only. Tier III survey results examine the impacts from innovations and entrepreneurial expansions that occurred because of NRAC projects.

Tier II Economic Impact

The second phase of the study reached out to the stakeholders that were directly involved in the research projects. These people included extension, members of the aquaculture industry, researchers, consultants, and local and state employees.

Members of the aquaculture industry who took part in NRAC-funded projects reported that their revenues either stayed the same or increased by 5-15% (approx. $26,268.12 per year, per business, hiring 3 part-time and 2 full-time employees). Most aquaculture industry members have kept their revenue levels constant as a result of NRAC-funded studies (Figure 18). While increases in revenues should be celebrated, keeping revenues constant is also a significant accomplishment as the overall U.S. aquaculture industry declined during the timeframe of these studies.

Figure 18. Changes in Revenues as a Result of NRAC-Funded Projects by Tier II Respondents



One of the most impressive statistics highlighting the success of these projects was the researchers' ability to secure additional funding as a result of these projects to expand their research. Combined, all the stakeholder groups reported a sum of $32,864,899 in additional external grant funding, not including matched funds, secured because of these projects. Extra care was taken to ensure that identified grant funding from collaborators was not double counted in this quantification.

As a direct result of the research findings derived from NRAC-funded aquaculture projects, additional funding was awarded from external funding sources such as: the Chesapeake Bay Trust; CP Seafoods; the East Coast Shellfish Growers Association; Environmental Protection Agency (EPA); Great Lakes Fishery Trust; Great Lakes Protection Fund; Maine Technology Institute; National Aquaculture Genome Project; Northeast Risk Management Education; National Oceanic and Atmospheric Administration (NOAA), including the Saltonstall-Kennedy Program and Sea Grant; National Science Foundation, including EPSCoR; Southeastern Massachusetts Aquaculture Center, United States Department of Agriculture (USDA), including the USDA Agriculture Economic Research Service, Agricultural Experiment Station Program, Agriculture and Food Research Initiative - Animal Health, Animal and Plant Health Inspection Service, Agricultural Research Service, Northeast Aquaculture Research Farm Network, NRAC, and the Small Business Innovation Research Program; and the United Kingdom Aquaculture Initiative (Natural

Environment Research Council and Biotechnology and Biological Sciences Research Council). These funds were not considered matching funds for the original NRAC grant.

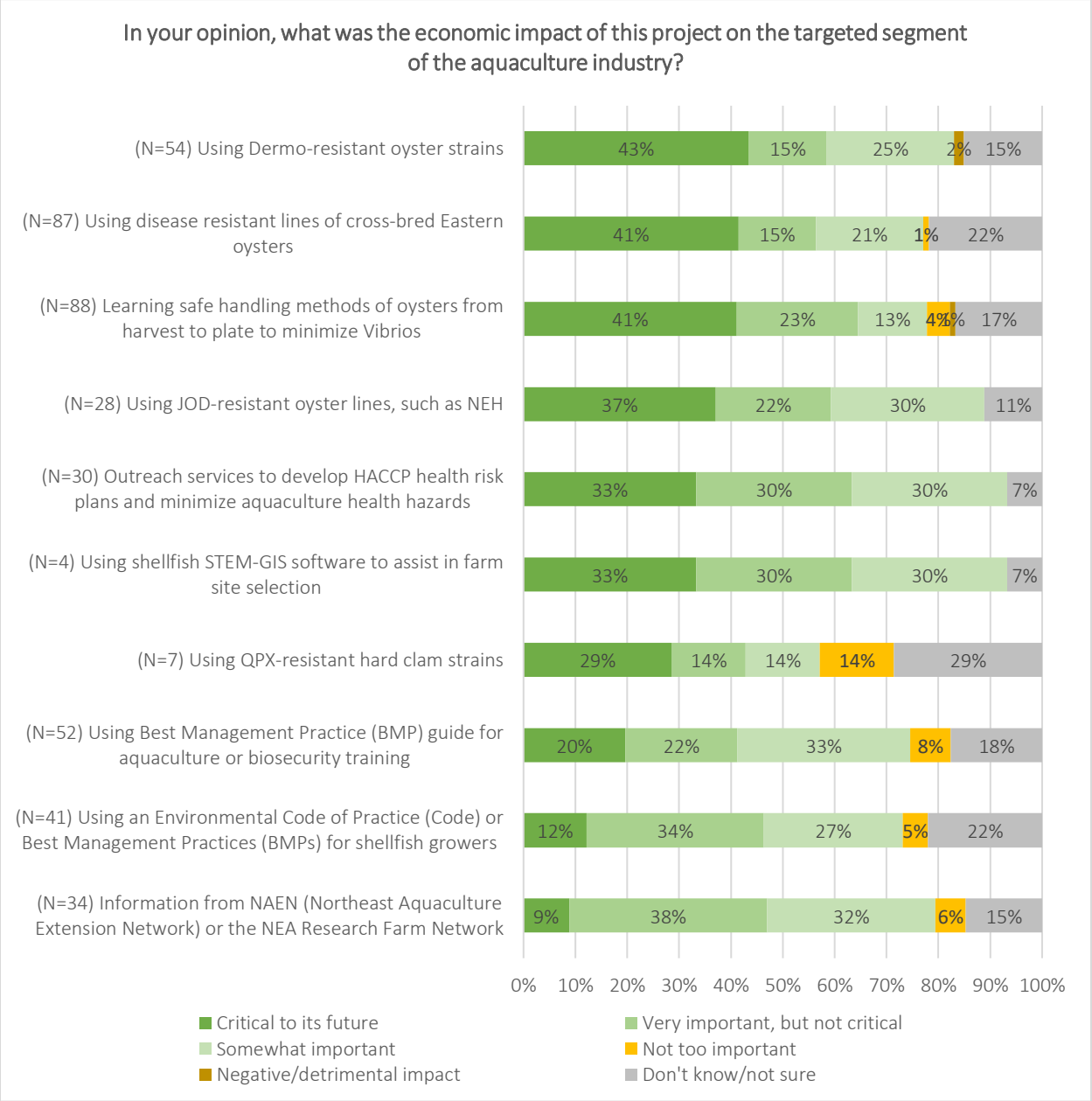
If expenditure patterns from these grants followed the same patterns as the NRAC grants, then the economic impacts would be similar to the NRAC funding. It is estimated that the leveraged grants would lead to a $56,856,275 increase to states' GDPs, an additional $2,869,380 in state and local tax revenues, and $7,167,314 in additional federal tax revenues. Because these figures are speculative, we do not include them in the final multiplier estimates.

Tier III Economic Impact

While this survey cannot estimate the total impact of the research conducted by NRAC grantees, it does serve as a lower bound from verified sources. A total of 271 surveys were completed by members of the aquaculture industry in the Northeast states. Tier III survey respondents were asked if their companies had benefited from any of the 32 NRAC-funded aquaculture projects and how and to what degree they had benefited. Possible effects included changes in efficiency, diversification of services or products, networking (e.g., with extension personnel, other growers, scientists, regulators, etc.), product survival, product growth or time to market, marketability, and product quality. In addition, respondents were asked if the project had impacted their business financially, how much their revenues changed over one year, and how personnel numbers changed. We assumed that aquaculture growers, for the most part, would not recognize NRAC-funded project titles, so we simplified the titles to an identifying key phrase. For example, the project "Economic analysis of an alternative raceway material" was recoded as "Using plastic 'U' shaped tanks for finfish culture instead of concrete tanks." When two NRAC projects addressed the same topic, we combined them, as one project was usually a continuation of the other.

The Tier III survey offered a brief overview of the NRAC projects so that practitioners could assess if those projects had an impact to their individual businesses. Many respondents did not know if their business benefited from NRAC research. A number of respondents were aware of specific NRAC projects, and indicated that the projects had a beneficial economic impact on the aquaculture industry (Figure 19) and the projects benefited their own businesses. Fifty-nine percent (59%) of respondents believe that their businesses have been positively impacted by NRAC projects. Many were unable to estimate how much the project impacted their revenues, but for those who could estimate, the average improvement was 28% or $34,173 per business for a total revenue increase of $9,329,125 for the survey respondents.

Figure 19. Perceived Economic Impact of Project on Industry – Tier III Respondents



The estimated impacts from the increase in revenue taken from the survey respondents illustrated an increase in the northeastern states' GDP of $14,547,749, and employment by 167.9 full time equivalent jobs (Table 8). State and local tax revenues increased by $871,839, and federal tax revenues increased by $1,477,109. The projects with the largest impacts focused on oysters, which represents the respondent population, and the majority of the aquaculture industry in the northeast.

Table 8. Total Economic Impact from Verified Sources

	Increase to States' GDP	Jobs	State and Local Tax Revenues	Federal Tax Revenues	Increase in GDP plus Taxes
NRAC Grants	$7,225,833	67.6	$358,433	$895,316	$8,479,582
Leverage from Grants	$56,856,275	541.2	$2,869,380	$7,167,314	$66,892,969
Aquaculture Industry Members*	$14,547,749	167.9	$871,839	$1,477,109	$16,896,697
TOTAL	**$78,629,857**	**777**	**$4,099,652**	**$9,539,739**	**$92,269,248**
* Only includes survey respondents. If these figures are extrapolated out to the industry as a whole, the amounts would be:	$51,956,246	99.6	$3,113,710	$5,275,389	$60,345,346

Love, et. al (2017) conducted a study of aquaculture research that spanned 26 years. They found a multiplier of 37 for the industry. This looked only at return on investment (ROI) for the aquaculture industry, and measured the ROI based on impacts stated in final reports, and extrapolated out to research grants that did not have an impact reporting protocol. In addition, the simplified model that assumed grant funding had a 1:1 impact on the industry. Those authors note that similar studies showed that it could take up to 17 years for research to realize fully the returns on investment. In this report, we only state impacts that were reported, and utilize IMPLAN Pro impact analysis to model economic impacts that emanate from grant projects, as reported in the following sections.

From the initial NRAC expenditures of $4,105,369, about $78.6 million was added to state GDPs (Table 8). This is a multiplier of 19. This large multiplier includes research funding that was leveraged because of NRAC grants. Since we cannot say if the additional grant funding would not have been secured without prior NRAC funding, this is not included in the final multiplier. In order to be most conservative, we look at only the impacts of the initial grant funding, plus the business growth of only aquaculture industry practitioners that responded to our survey (Tier III). This is a fraction of the whole industry, so the actual impact is likely much larger. In addition, it would be useful to re-assess the impacts a few years after the completion of the most recent NRAC projects that have not had a chance to be implemented by the industry. A conservative estimate of the multiplier resulting from NRAC funding that occurred between 2005 and 2016 is **5.3**. In other words, **for every $1 of NRAC aquaculture research funding spent**, there were economic activities from the performance of the research and increased value of aquaculture output that led to **an increase of states' GDPs of $5.30**.

It should be noted that if aquaculture industry estimates were extrapolated out to the entire industry, as in Love, et. al (2017), then the multiplier would increase to 21.9. If, as the same study mentions, it takes up to 17 years for revenues from research results to be fully realized, the multiplier would likely be significantly higher. Therefore**, the multiplier of 5.3 is extremely conservative and should be treated as a verifiable lower bound. The extrapolated multiplier of 21.9 is closer to reality**, but may still be a conservative estimate because not enough time has elapsed to see the research results fully integrated into the industry.

NRAC-Funded Projects with Greatest Economic Impacts

Projects relating to oysters were among the most successful of the NRAC-funded research in terms of generating economic impact (Table 9). Extension projects also had significant impact (Table 10).

Because two NRAC-funded oyster projects were related, in that one formed the basis for the other, they both addressed the same topic – using disease-resistant lines of cross-bred Eastern oysters, and both were led by the same Project Coordinator, the projects were not identified separately to Tier III survey respondents (Table 9). Therefore, their impact to the aquaculture industry is combined.

Table 9. Highlighted Oyster Projects with Greatest Economic Impact

NRAC Project Title	Project Phrase Recognized by Tier III Respondents
Cross breeding and field trials of disease-resistant oysters	Using disease resistant lines of cross-bred Eastern oysters
Selection for enhanced disease resistance and growth performance in cross-bred oysters, *Crassostrea virginica*	Using disease resistant lines of cross-bred Eastern oysters
Development of genetic markers to assess disease resistance in the Eastern oyster	Using Dermo-resistant oyster strains

Table 10. Highlighted Extension Projects with Greatest Economic Impact

NRAC Project Title	Project Phrase Recognized by Tier III Respondents
NRAC extension project (Northeast Aquaculture Extension Network)	Information from NAEN or the NEA Research Farm Network (For Example: State Aquaculture Situation and Outlook Reports, Fact Sheets, workshops/meetings such as the Milford Aquaculture Seminar, East Coast Commercial Fishermen's and Aquaculture Trade Exposition, or Annual Meeting of the National Shellfisheries Association)
Development of environmental code of practice and BMPs for East Coast shellfish growers	Using an Environmental Code of Practice (Code) or Best Management Practices (BMPs) for shellfish growers

Many respondents to the Tier III survey indicated that these projects had a measurable impact to their revenues (Table 11). The second column in Table 11 summarizes the reported increase in revenues because of one of the four highlighted projects. The third column used IMPLAN to estimate the number of full time equivalent jobs that resulted from the increase in aquaculture revenues, and the resulting indirect and induced spending. IMPAN also estimated the increase to states' GDPs, as well as increases in state, local, and federal taxes. The total impact from each of these projects is listed in the far-right

column. From these four projects alone, an additional $26 million dollars was generated, accounting for 28.5% of the estimated impacts to date (Tables 10, 11).

Table 11. Examples of Individual Projects and Their Industry Impacts

Project	Increase in Revenues due to Project	Jobs	Increase in States' GDP	State and Local Taxes	Federal Taxes	Total
Cross-bred Eastern Oysters	$7,137,125	128.5	$11,130,330	$666,989	$1,130,042	**$12,927,361**
Dermo-resistant Oysters	$6,698,875	120.6	$10,446,880	$626,033	$1,060,651	**$12,133,564**
NAEN or NEA	$377,500	6.8	$588,710	$35,279	$59,771	**$683,760**
Code or BMP	$305,625	5.5	$476,621	$28,562	$48,390	**$553,573**
TOTAL	**$14,519,125**	**261**	**$22,642541**	**$1,356,863**	**$2,298,854**	**$26,298,258**

Case Studies

Most Impactful Research Projects

Three research projects that focused on disease-resistance in Eastern oysters were the most impactful of the 32 NRAC-funded projects assessed, accounting for 27.2% of the economic impact (Tables 10, 11).

Because the following two projects were related in that one formed the basis for the other, they both addressed the same topic – using disease-resistant lines of cross-bred Eastern oysters, and both were led by the same Project Coordinator, the projects were not identified separately to Tier III survey respondents. Therefore, their impact to the aquaculture industry is combined.

1. **Cross breeding and field trials of disease-resistant oysters (2006-2009: $248,436)**
2. **Selection for enhanced disease resistance and growth performance in cross-bred oysters, *Crassostrea virginica* (2009-2013: $232,416)**

The research conducted under these awards was a collaboration between the University of Maine (ME), the Marine Biological Laboratory (MA), the Connecticut Bureau of Aquaculture (CT), Rutgers University (NJ), Martha's Vineyard Shellfish Group (MA), Roger Williams University (RI), University of Washington (WA), Cape Cod Cooperative Extension (MA), Maine Sea Grant (ME), and the Pemaquid Oyster Company (ME).

Oyster farm in the Damariscotta River, Maine. Photo by: C. Grimm

The culture of eastern oysters, *Crassostrea virginica*, accounts for the bulk of cultured shellfish production in the Northeast. Shellfish aquaculture has grown steadily in recent decades. The industry now includes more than 350 operations generating products with a gate value in excess of $50 million. Continued growth of the industry is favored by increased market demand coupled with declining traditional harvests for oysters. The industry faces significant risk from disease outbreaks which have historically resulted in crop losses of 90% or greater. Currently, there are no therapeutic approaches for reducing the impact of disease in oyster culture so the industry relies on genetic lines of oysters that have been bred for disease resistance. However, the expanding geographic distribution of disease causing parasites and an increasing incidence of co-infections by multiple parasites makes it difficult for oyster farmers to predict how many and which diseases will impact their farms during a culture cycle and puts their operations at substantial risk of crop loss due to disease.

The two NRAC-funded research projects used existing genetic lines (the UMFS, Clinton, and NEH lines) along with hybrids (created by crossing cross breeding between UMFS x Clinton, UMFS x NEH, and by crossing UMFS x NEH hybrids themselves to create an F2 line of oysters) to accelerate the generation of lines that are resistant to multiple diseases to help farmers increase production via improved survival, regardless of which disease is prevalent in any given site in any given year. Overall, little variation was found in growth between lines at industry participant sites where the research was conducted. In contrast, the vast majority of the line-specific differences in yield of market size oysters are due to line-

specific variation in disease-resistance and survival. The project results indicate that breeding survivors of local disease outbreaks can be used to develop new varieties of disease-resistant eastern oysters. More importantly, hybrid lines retain a significant amount of the disease-resistant properties of both parental lines used to generate a given cross and thus will have higher survival compared to the parental lines when grown at sites where there are co-infections. These results highlight the importance of maintaining existing oyster lines, developing new lines, and continuing to use line crossing to obtain improved yield on oyster farms in the Northeast.

Dissemination of the results and key information from this project have been paramount to its impact on the oyster industry. Given continued losses from disease in the region, the dissemination of the results from the project helps hatcheries make more informed decisions regarding which lines to cross if they choose to make crosses of their own and helps growers to make decisions about the lines that will provide highest survival at their sites, given diseases they expect to encounter. A noted strength of this project was the direct involvement of commercial growers, and being able to disseminate project findings directly to the industry. Several of the collaborators involved in this project met regularly with industry working groups, such as the Maine Oyster Growers Working Group, East Coast Shellfish Growers, and individual state aquaculture associations to present updates on the project. Outreach efforts continued after the funding for this project was exhausted by extension personnel in each state. Electronic media was used to post and store information gained from the project (with a central website developed). Results from both oyster projects were shared via email and posted on the website of the East Coast Shellfish Growers Association, and journal manuscripts on the production and disease-resistant characteristics of the lines used in the project were published. In addition, a special meeting of interested growers and hatchery operators was held at the Northeastern Aquaculture Conference and Expo (NACE) 2015 meeting in Portland, Maine to review project results, the availability of lines, and future research plans. Perhaps most importantly, the Darling Marine Center hatchery (University of Maine) is propagating the Clinton and UMFS lines while the Haskins Shellfish Lab (Rutgers University) continues to maintain the NEH lines and make these available to hatcheries and growers in the region.

> ***"Primary results on growth and disease resistance characteristics of oyster lines provide industry members with knowledge of which lines may be most appropriate for their farms."***

The two oyster disease projects alone provided more than $7 million in increased revenues directly reported from survey respondents. Given the limitations of the survey sample, and the fact that there was not a 100% response rate, the overall impact to the industry likely is significantly higher. When modeling the full economic impacts to the regions in this study, almost $13 million dollars was added to the state's GDP and to local and federal tax revenues. Again, this is based on a subset of the industry, so the impacts are likely much greater.

3. **Development of genetic markers to assess disease resistance in the Eastern oyster (2005-2008: $128,486)**

The research conducted under this award was a collaboration between the Marine Biological Laboratory (MA), Martha's Vineyard Shellfish Group (MA), the Connecticut Bureau of Aquaculture (CT), Roger Williams University (RI), Barnstable County's Cape Cod Cooperative Extension/Woods Hole Oceanographic Institute Sea Grant (MA), the Great Lakes WATER Institute (WI), and the Shellfish Department of Edgartown, Massachusetts (MA).

One of the major causes of decreased production for the oyster industry is disease, and one of the primary diseases that affects the adult eastern oyster, is Dermo which is caused by the parasite *Perkinsus marinus.* In the last decade, Dermo has markedly affected oyster culture in the more northern portion of the parasite's range (Connecticut, Rhode Island, and Massachusetts), in addition to states already identified as problematic (New York to the Gulf of Mexico). Oyster disease is of particular concern to shellfish farmers in the Northeast region, not only due to periodic devastating oyster losses, but also because disease indirectly affects the industry by slowing financial investments. Realizing that oyster disease is a primary concern for the industry, the goal of the proposed research was to assist in the development of disease-resistant eastern oyster broodstocks. Previous research had demonstrated that genetic factors can be selected to contribute to disease resistance in the eastern oyster. A majority of this prior work involved hatchery-based selection practices with limited acknowledgement on the performance of wild oyster populations that have survived heavy disease pressure.

"Research provided by universities [is] very crucial to oyster growers' success in providing disease resistance strains, faster growing species, and marketing improvements."

This project demonstrated seed originating from an isolated population of local wild oysters that had experienced heavy disease (Dermo) pressure over several years could significantly contribute to the development of disease resistance in cultured oysters. This was the first research project to document such a case from wild populations, and indicates that local survivors of disease are good candidates for improved broodstock. Genetic research was conducted on oyster populations in Connecticut. Massachusetts, and Rhode Island. Oysters more tolerant to Dermo were characterized in order to develop genetic markers and to understand the mechanisms involved in immunity more clearly.

The findings of this research project suggest that shellfish farmers will have improved oyster survival if they use local broodstock that has experienced persistent disease pressure. The superior broodstock identified by this project continues to be grown in Maine as part of other NRAC research. In addition, the gene expression data generated from this project is available for marker-assisted selection activities. These results are expected to not only be beneficial to the oyster industry, but to carry over into developing better broodstock in other shellfish.

These discoveries were communicated to northeastern hatcheries to help them to identify local, potentially Dermo-resistant broodstocks. This was done through numerous presentations at regional and national meetings such as the Milford Aquaculture Conference, NACE, and to the National Shellfish Association. Project collaborators. The Shellfish Department of Edgartown, MA, was especially instrumental in communicating with growers and other residents about the research being carried out

and the results of this research. The local press wrote several articles about the research project. One of the most successful avenues through which findings were communicated was a documentary produced by Gail Tipton at Martha's Vineyard Community Television; the research team was filmed sampling oysters, and the researchers and growers were interviewed. A project website also was developed and used to convey information to the public, including presentations given at meetings, project progress reports submitted to NRAC, a fact sheet developed for growers, and the documentary.

Once again, a single research project had an impact to industry revenues that far exceeded the sum of all NRAC grants. Reported increases in aquaculture revenues from survey respondents was almost $6.7 million. Impacts to states' GDPs plus local and federal tax revenues exceeded $12 million.

Most Impactful Extension Projects

Two Extension projects that successfully bridged the findings from research to industry stakeholders and addressed industry information needs had the largest impact on the northeast aquaculture industry.

1. **NRAC extension project (Northeast Aquaculture Extension Network) (2008-2010: $299,944)**

The Northeast Aquaculture Extension Network (NAEN), a regional aquaculture extension network formalized through NRAC, was represented by 30 aquaculture extension personnel representing all NRAC states (excluding the District of Columbia). Participants came from academia, Sea Grant programs, Cooperative Extension, and state aquaculture consortiums to participate in this NRAC-funded extension project.

NAEN has fostered interaction, communication, and collaboration among extension personnel and key aquaculture stakeholders in the Northeast US, and has provided high-quality educational products and activities that aid producers in the formation and management of their businesses, as well as aid other stakeholders with the decisions they make regarding aquaculture.

Jordan Shockley of Hoopers Island Oyster Aquaculture Co. demonstrates seed production in nursery upwellers. Photo by: D. Webster

The goal of this specific project was to produce and deliver accurate and credible science-based aquaculture information, educational materials, and outreach activities to key stakeholders in a manner that was efficient and effective. The primary target audience was comprised of practicing aquaculturists, new producers, seafood buyers and equipment suppliers, state and regional industry associations, financial institutions, and decision-makers such as state aquaculture coordinators, resource managers, politicians, and outreach professionals. The team's overarching goal was to develop and disseminate high-quality outreach products to facilitate NRAC's mission to increase *public awareness* of the social, economic, and environmental importance of commercial aquaculture in the Northeast U.S. By improving *producer knowledge*, the extension team's

efforts assisted NRAC in achieving its goal to increase both the value and volume of commercial freshwater and marine aquaculture products.

Based on an assessment of the outreach needs of the Northeastern aquaculture industry, conducted in 2007 by the NAEN and the Center for Survey Research and Analysis at the University of Connecticut, the NAEN slightly modified its outreach and education practices so that the most relevant information on emerging aquaculture issue and information for prospective producers was developed and delivered.

NAEN team produced seven fact sheets funded by this effort and 12 state aquaculture situation and outlook reports (provided gratis by the extension network). NAEN developed an Educational Resources web page for producers, and an NAEN web page targeting Extension professionals and those who serve in an outreach capacity. The team leader for the web site posted information related to the other components of the regional extension network development project: needs assessment, educational publications, research project overviews, and outreach activities. The web page had full public access with links to the NRAC Home Page. The page contained information and links related to professional development, funding opportunities, the *Journal of Extension*, program impact and assessment articles, and other similar resources to share useful information and assist regional extension personnel with their individual program development.

"[This project] bridged findings from research to industry and vice versa to identify and solve industry problems."

NAEN sponsored several meetings of regional importance, including the Farmed Fish Health Workshop, the Milford Aquaculture Seminar, the Cornell Recirculating Aquaculture Short Course, the East Coast Commercial Fishermen's and Aquaculture Trade Exposition, and an industry session at the Annual Meeting of the National Shellfisheries Association. NAEN also provided professional development funds for one Extension professional to attend the Cornell Short Course. All meetings were well attended and separately evaluated by the Network. Participants noted that attending these events resulted in increase in knowledge, use of new husbandry practices and/or species, and provided them greater ability to network with colleagues.

As part of their ongoing regional effort to provide outreach services to the region's aquaculture industry, NAEN submitted and was awarded a grant to establish the Northeast Aquaculture Research Farm Network. Funded by the National Sea Grant program, the Farm Network allows extension professionals working in collaboration with industry members to conduct applied research efforts on topics such as new gear and species, disease, and pest and predator monitoring.

Overall, key impacts of this NRAC-funded Extension project were connecting people and bridging findings from the research realm to application by the industry.

This collaborative project increased revenues of survey respondents by $377,500. States' GDPs, plus local and federal tax revenues were increased by $683,760 according to IMPLAN models. Again, this is a fraction of the total impacts to the aquaculture industry and the greater economy because the response rate was not 100%.

2. Development of environmental code of practice and BMPs for East Coast shellfish growers (2007-2009: $220,114)

This extension project was spearheaded by personnel from Aqua Technics Inc. (WA), Coastal Resource Specialists (MA), Rutgers Cooperative Extension (NJ), Cornell Cooperative Extension (NY), Delaware Sea Grant (DE), and Maryland Sea Grant/Cooperative Extension (MD).

The overall objectives of this extension project were to assist the East Coast shellfish aquaculture industry by developing an Environmental Code of Practice (Code) and model Best Management Practices (BMPs), and to encourage their use by individual companies.

Workshops were held with representatives from most NRAC states and attended by >100 participants, represented mostly by shellfish growers and regulators from state, county, and town governments. A small percentage of participants were extension agents, academics, and researchers. Workshops were used to identify issues common across the industry, the industry's philosophical perspectives about the issues, and the various solutions that have been used to address these issues. From this information, a shellfish aquaculture Code and BMP Manual was produced (Flimlin et al. 2010). In addition, the extension team developed a document that an individual can use to show how their own shellfish farm is being operated sustainably. The document covers the pertinent licenses that each individual state requires, a description of the farm geographically, mention of the seed stock used, types of growout gear, how and when the farm is maintained and product is harvested, transported, and stored and, finally, demonstrates an adherence to the individual's HACCP plan. This individual farm document can show prospective clients that the farm is operating in an environmentally sound fashion under a Code of Practice using BMP and allows for using it as a marketing tool similar to third party certification, but without further cost to the business.

In addition, through the workshops, consensus building and clarification of some misunderstandings were achieved as stakeholders from different sectors sat down together to discuss common issues. Many issues were recognized as being important throughout the region with some interesting and potentially successful solutions identified. The interactions by growers with other growers through the facilitated process may have improved relationships between industry members as well as state and federal regulators who may have not completely understood all the ramifications of the shellfish culture process prior to the workshops.

"We originally developed our own BMPs as a charge from the MD legislature. It covered six different areas of aquaculture. When we totally revised our leasing program in 2009…we decided the ECSGA manual developed through NRAC funding fit our needs very well and the Aquaculture Coordinating Council voted to adopt it." (Donald Webster, University of Maryland)

The major achievement of this NRAC extension project was the creation of a manual that crosses state boundaries and has had wide-spread acceptance not only in Northeast region but for the entire East Coast, where diverse shellfish growing methods, political structures, and environmental differences have all been taken into account in a standardized manner (Flimlin et al. 2010). Existence and use of the manual has led to an increase in public support of the industry, made it easier to obtain new sites for

shellfish aquaculture, and likely minimized additional government regulation. In all, project members think it has solidified the unity of the growing aquaculture industry.

This project increased reported revenues by over $300,000. The greater impacts to states' GDPs and tax revenues was $553,573.

Dissemination of NRAC Findings

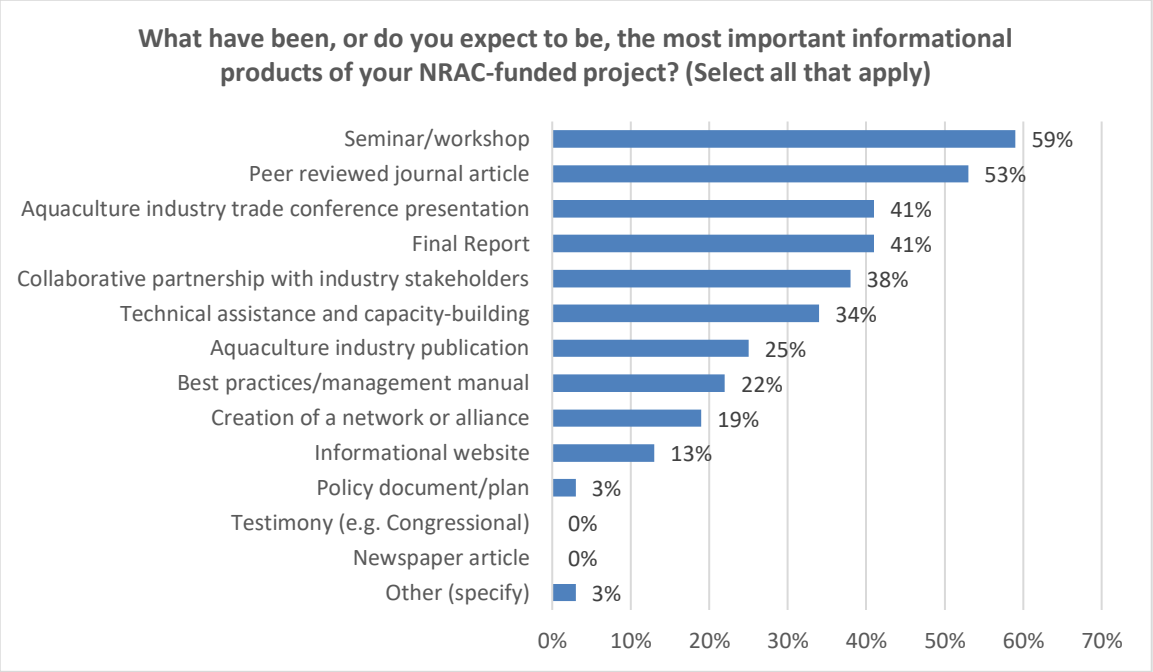
A key objective of applied research programs such as NRAC grants for aquaculture research is to have research findings utilized and appreciated by practitioners. To achieve this objective, research results must be presented in a form and in a place accessible to those stakeholders who can utilize the information. The evaluation team assessed the effectiveness of strategies used by NRAC-funded Project Coordinators and other researchers to disseminate their research so that it can be incorporated by the aquaculture industry stakeholders. A series of questions posed to PCs, collaborators, and industry stakeholders were designed to identify how and where grantees disseminate the findings of their research and where and how industry stakeholders access and utilize aquaculture research findings. The intent of this component of the evaluation is to look at the aquaculture research program from the perspective of the information producers - the principal investigators - and from the perspective of the potential information consumers - the industry stakeholders. Ideally the two perspectives align so that NRAC-funded projects effectively reach an audience of research consumers who can apply the findings in their businesses. The identification of processes and practices that facilitate or obstruct both the dissemination of research findings and their utilization can inform future NRAC grant programming.

Dissemination of Research Products

Tier I Response (Project Coordinator)

Each Project Coordinator (PC) was asked in the Tier I Survey to identify how they disseminate their research findings, that is, what they considered ***the most important products*** of their research (Figure 20).

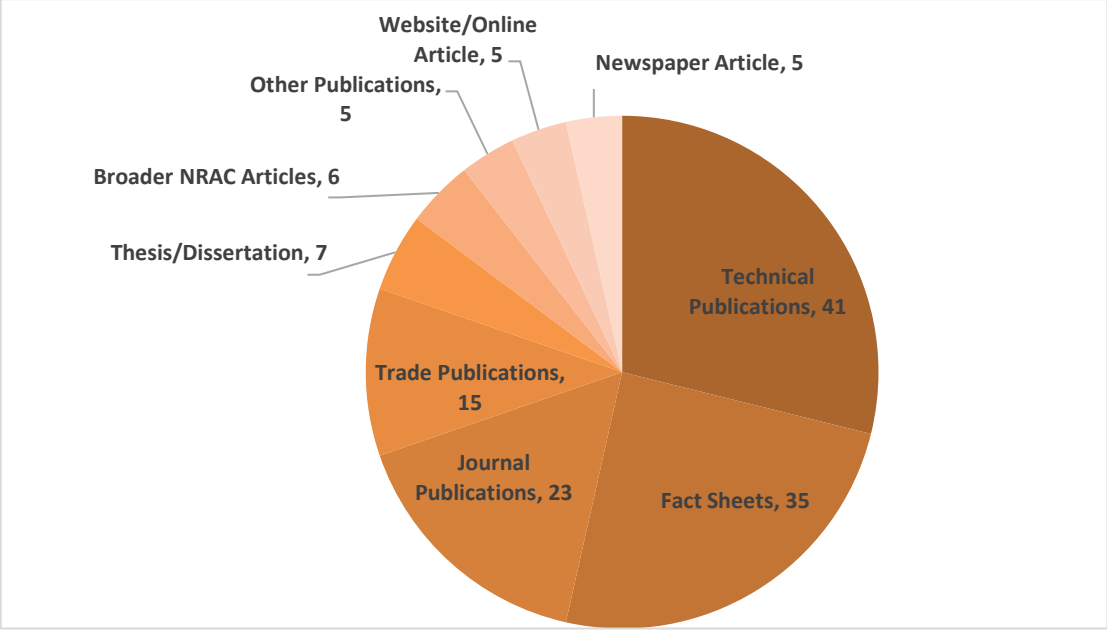
Figure 20. Most important informational products of NRAC-funded project: Tier I (Multiple responses possible. Percentages may sum to more than 100%.)



- The most frequently identified dissemination venues were seminars and workshops (59%) followed by peer reviewed journal articles (53%), and aquaculture industry trade conference presentations and the NRAC final report (both 41%).
- More than a third of the PCs also indicated that direct work with stakeholders through collaborative partnerships (38%) and technical assistance (34%) were important project products and venues to disseminate information.

A content analysis of project reports reveals that in terms of the number of different kinds of publications produced, the overwhelming majority (>65%) have been industry-oriented trade publications, technical reports, and fact sheets (Figure 21).

Figure 21. Number of Publications Resulting from NRAC Projects: 2006-2017

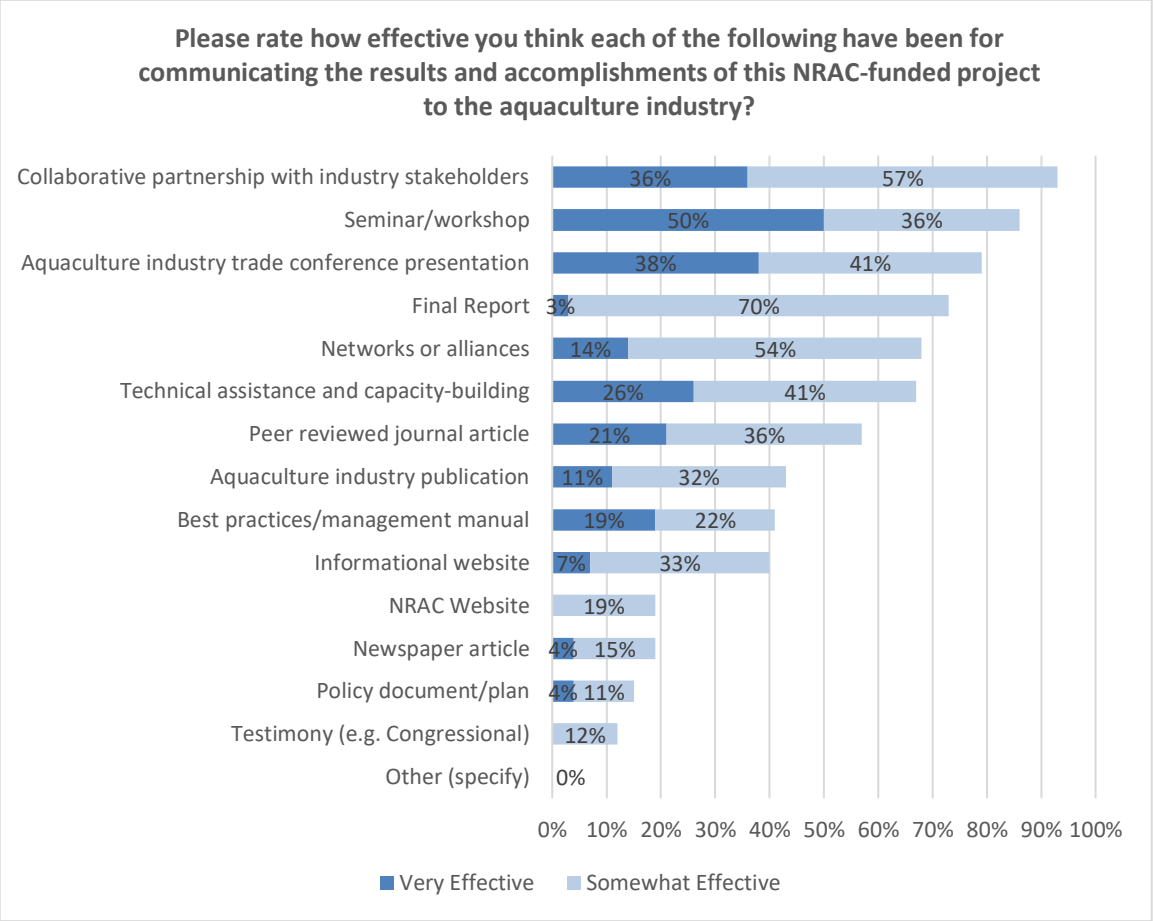


In sum, although peer reviewed articles that serve the PC's own professional needs were ranked the second most important informational product by the PCs, the importance placed on seminars and workshops, direct work with stakeholders, and the number of industry-oriented publications indicates that NRAC-funded researchers are making a conscious effort to reach practitioner audiences. In open-ended responses to a question about how they could improve or expand the ways they communicated results, many of the researchers thought that more workshops targeted toward industry audiences would be particularly effective. An example of one such response:

> *"...[communication can be improved] through additional regional workshops and presentations to collaborators and other interested members of the industry and state extension agents. While our project has included several conference presentations and discussions, it has been difficult to ensure that the appropriate audience attends those events. Even with advance notice and invitations to the events, industry members cannot always attend or have multiple reasons for attending conferences. Direct connection with the industry along with opportunity for extensive feedback will ensure better use of the information as well as developing plans for what comes next."*

PCs emphasis on connecting with industry practitioners is also clear in the responses to another question that asks ***how effective*** the different products have been in communicating research project results (Figure 22).

Figure 22. Perceived Effectiveness of Communication Methods NRAC-funded Project Findings to Aquaculture Industry: Tier I



When asked about the most effective means of communicating results, the PCs identified six products that they feel are more effective than peer-reviewed articles: technical assistance; collaborative partnerships; networks or alliances; industry trade conference presentations; seminars and workshops; and the NRAC final report (Figure 22). This indicates that although they recognize that journal articles are important vehicles to transmit research findings, they understand that they are not necessarily the most effective way to communicate results to aquaculture industry practitioners. The NRAC requirement that successful proposals must include collaboration between researchers and extension or industry obviously also plays an important role in orienting the research products towards audiences that can put the findings into practices. As one PC mentioned in an open-ended survey question, "*a particular strength of our project was the direct involvement of commercial growers.*"

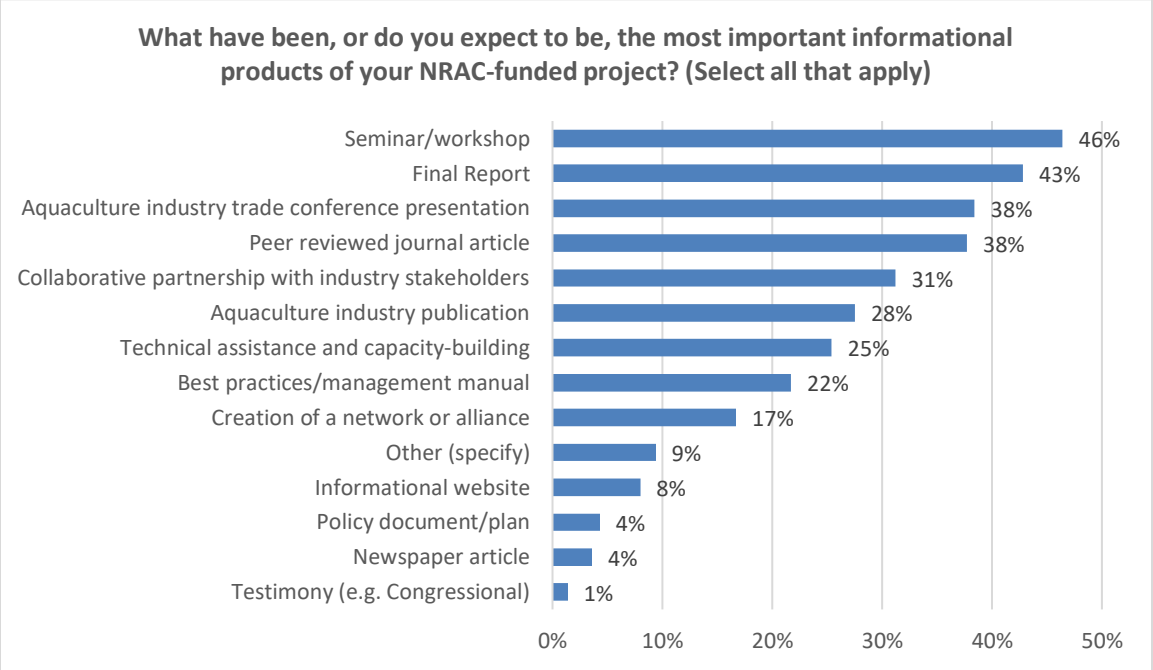
In terms of barriers to delivering the results/findings of NRAC-funded projects into the hands of potential users or others interested, the most common factor cited by researchers was that the budgeted funds were insufficient to accomplish all that could have been done (44%), followed distantly by difficulties translating the science into lay terms (19%), and not having the proper networks/connections (11%). When asked an open-ended question about suggestions for NRAC to ensure that the results/findings of

research are accessed and used by others, the researchers overwhelmingly called for NRAC to improve its website so that interested parties could find links to final reports and fact sheets more easily. There also were suggestions from several researchers for more emphasis on creating and disseminating accessible fact sheets.

Tier II Response (Collaborating Stakeholders)

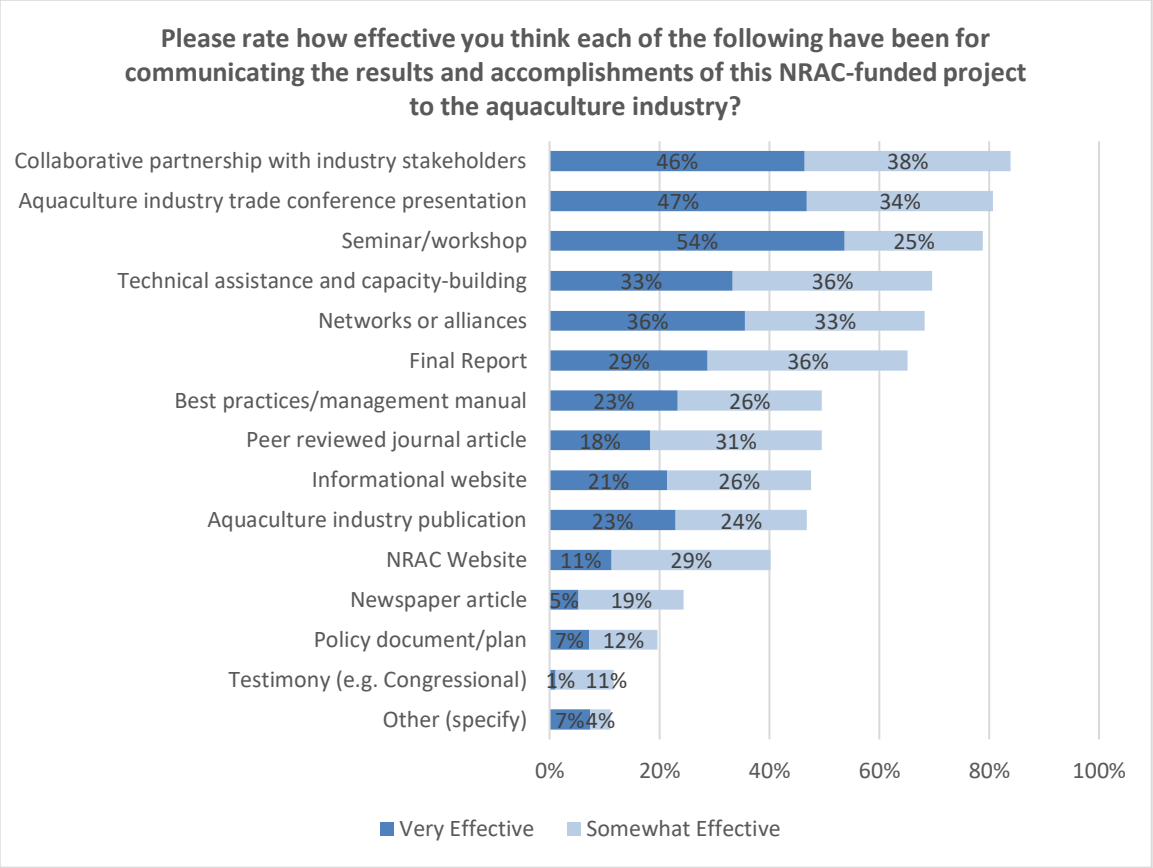
In the surveys conducted for this evaluation, the Tier II, collaborating stakeholders were asked about the different types of outlets that are available to access research findings that could improve aquaculture businesses. Using the same questions that were posed to the PCs, the collaborating stakeholders were asked what they thought were ***the most important informational products*** of the NRAC-funded project they participated in (Figure 23) and then they were asked what they thought would be ***the most effective*** outlets to communicate the results of the research they were part of (Figure 24).

Figure 23. Most important informational products of NRAC-funded project: Tier II (Multiple responses possible. Percentages may sum to more than 100%.)



The collaborating stakeholders' emphasis on the importance of seminars and workshops, industry trade conference presentations, technical assistance, and collaborative partnerships with stakeholders (Figure 23) is very much in line with what the PCs thought were important outlets for research findings (Figure 20). PCs also place a relatively high degree of importance to producing peer-reviewed journal articles and the final project report. When it came to the most effective informational products, there was, again, a high degree of correlation between the responses of the PCs and those of the collaborating stakeholders (Figures 21, 24). NRAC projects have not only generated useful information, they have brought stakeholders together and fused them into a team, a process and deliverable that could, and should, be broadly emulated.

Figure 24. Perceived Effectiveness of Communication Methods NRAC-funded Project Findings to Aquaculture Industry: Tier II



In an open-ended question, all of the non-extension collaborating stakeholders were asked ***how to improve or expand the way NRAC research findings are communicated*** and the extension collaborating stakeholders were asked ***how to improve or expand the way they communicated NRAC research findings and accomplishments***. As with researchers' responses to similar questions, the top response of Tier II collaborators was the need for a more effective NRAC website, particularly through the inclusion of "more dynamic, searchable information on funded projects." Additional NRAC Technical Bulletins or fact sheets (and the funding to create them) and more industry-oriented conferences and workshops were also mentioned by extension and non-extension stakeholders alike. Finally, from the extension collaborators there were numerous calls to work more closely with extension partners.

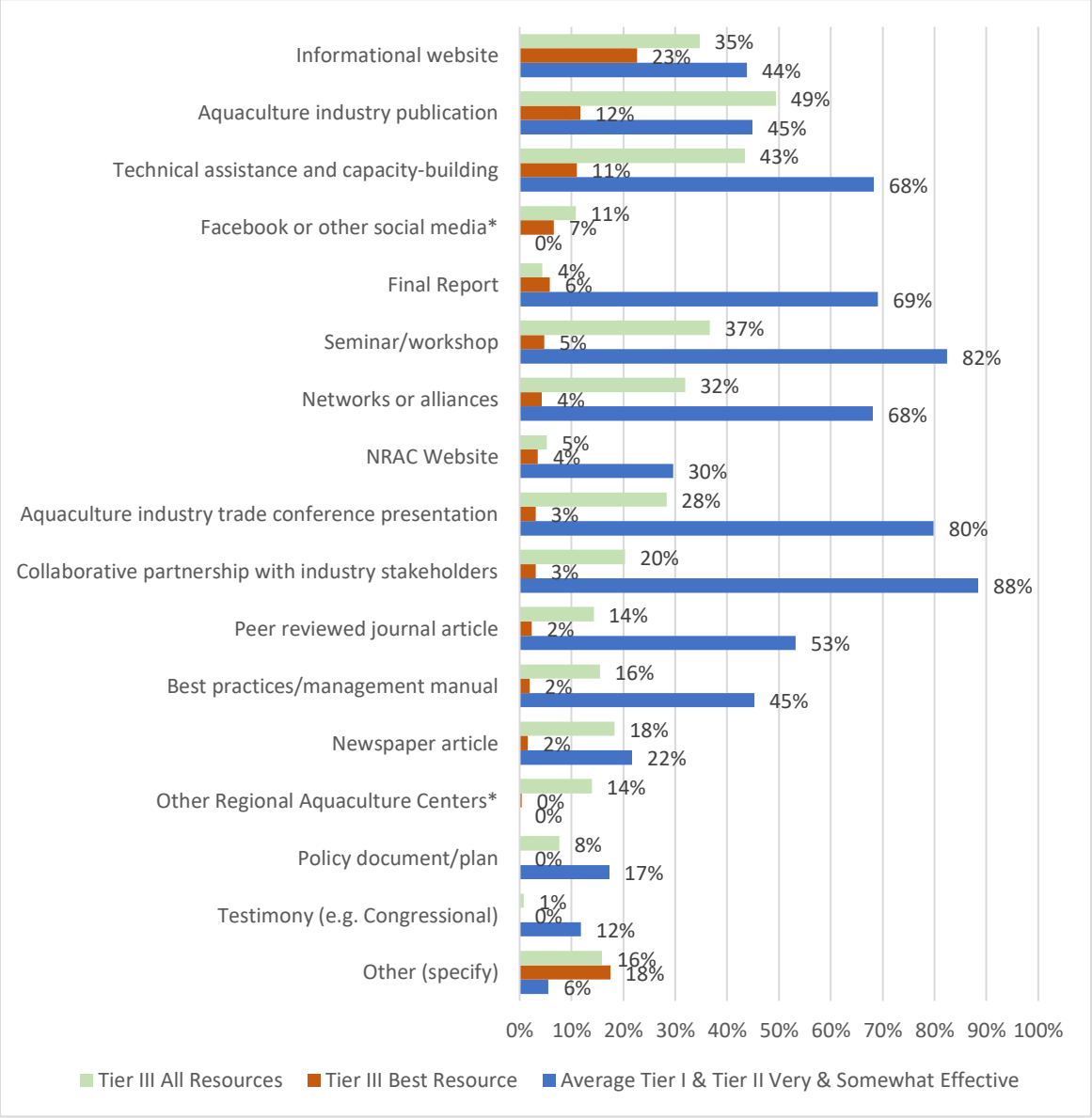
Very much along the same lines as the PCs, the collaborating stakeholders appear to be consciously trying to make research information available to assist the aquaculture industry in growing, developing, and addressing identified problems. Given that half of the collaborating stakeholders are in the aquaculture industry or in extension, this conclusion is not surprising. Their involvement in the research projects plays a positive role in helping that information to actually reach the intended audience.

Accessing and Obtaining Research Information

Response from Tier III (Aquaculture Industry Stakeholders)

Industry-wide stakeholders were asked two questions in the Tier III survey about types of outlets for research information that could help their aquaculture businesses. The first question asked them to indicate ***all of the different resources they turn to*** for research information and the second question asked them to indicate ***the one best source*** to obtain information that could impact their business. Figure 25 combines the responses from the industry stakeholders on all resources and the one best source with the responses regarding somewhat and very effective outlets for information from the PCs and the collaborating stakeholders surveys.

Figure 25. Researcher Ranked Effectiveness of Resource for Dissemination and Best and All Resources Used by Industry Stakeholders



** Not asked in Tier I and Tier II*

The red bars in Figure 25 represent the Tier III (industry stakeholders') responses about ***the single best source*** for information and thus they can only total 100 percent. The green bar displays the percentage of aquaculture industry stakeholders who selected an option as the first or second best option, while blue bars display the average percentage of Tier I (PCs) and Tier II (industry collaborators) who rated this method as very or somewhat effective.

Gary Wikfors of NMFS Milford Lab teaches phytoplankton production to Oyster Hatchery Short Course students. Photo by: D. Webster

The industry stakeholders' responses to questions about the information sources they use and those they feel are the most effective differ in several ways from the responses of the PCs and the collaborating stakeholders. Key among these differences are the industry stakeholders' reliance upon informational websites, aquaculture industry publications, and technical assistance and capacity-building. It is not that these information outlets were unimportant for the researchers and the collaborating stakeholders, it is just that among the different sources listed, they were not ranked as relatively high as they were by the industry stakeholders. One explanation for this is that the top information sources of the industry stakeholders are often arranged by people who synthesize and pass along findings from research rather than by researchers themselves. Several information dissemination outlets that the PCs and the collaborating stakeholders ranked relatively high in terms of effectiveness in reaching practitioners were not among the most popular single best sources, but they were listed as sources that were used by nearly 30% or more of the industry stakeholders. These include seminars/workshops, aquaculture industry trade conference presentations, and networks or alliances. The outlets with the largest gap between the effectiveness rankings of the PCs and collaborating stakeholders and those most used by the industry stakeholders include the NRAC final report and the NRAC website.

In conclusion, given that there is substantial overlap between the information resources that the industry stakeholders say that they use and the sources deemed somewhat and very effective by the PCs and collaborating stakeholders, it does seem that that the research information that is being produced is finding its way to those interested in consuming the information. Future NRAC guidance could make this information even more effective by emphasizing the importance of, and funding, the process of getting research findings onto informational websites, into aquaculture industry publications, and into the hands of those providing technical assistance and capacity-building activities.

Future directions and recommendations

This study clearly demonstrates the importance of NRAC-funded research to the regional aquaculture industry and to the regional economy. Recommendations from Project Coordinators, their research collaborators, and aquaculture industry stakeholders about critical issues they believe face the industry and ways that NRAC can serve the needs of the regional aquaculture industry are now examined.

Industry needs & future funding priorities

Aquaculture industry respondents were given an opportunity to document the issues they perceive as limits to their success. In addition, the East Coast Shellfish Growers Association (ECSGA), which represents over a thousand small shellfish farms from Maine to Florida that collectively harvest over $155M in farmed shellfish and provide thousands of jobs in rural coastal communities, identified their industry generated research priorities. These data sources were combined and correlated and the following general themes were identified:

Challenging regulatory environment:

- **Issue:** The permitting process is often expensive and time-consuming. Often multiple permits are needed from multiple agencies, and many permits must be renewed annually. Industry members consider some of these permits redundant and others, inconsistent. Industry stakeholders perceive this process as the biggest barrier to their success and something that needs to be improved upon.
- **Response:** Greater communication, regulatory support from state agencies, as well as local and federal agencies is necessary. The ability to renew regulatory permits for multiple years, as opposed to annually, clearer guidelines issued by townships on the duration of leases to farmers, and improved documentation of the beneficial impacts of shellfish on water quality and habitat will help farmers overcome some of their perceived barriers to success. A quantification of the value of ecosystem services associated with shellfish aquaculture could ease permit challenges. Combined, these responses may lead to nitrogen and carbon credit trading and payments for ecosystem services which will benefit both producers and the environment. Target regulators as the audience for outreach plans.

Financial risks:

- **Issue:** The financial risks for an aquaculture business are high. Initial costs for startup and purchasing equipment and supplies can be great. Often seed stock is limited and costly. Not only is finding sufficient capital investment difficult, financial risks increase as farms and businesses scale up. Maintaining funds until products are marketable is tough and cash flow can prove challenging.
- **Response:** Greater federal and state aid made available for aquaculture businesses. Information disseminated to help inform and aid farmers' decisions to invest in expensive purchases, such as equipment.

Disappearing working water fronts:

- **Issue:** There is a lack of access to shorelines and suitable farm sites due to development of waterfront properties and other social constraints. What once used to be working waterfronts are

now primarily private properties with owners who do not want to be disturbed by or see aquaculture activities. Concurrently, there is less access to infrastructure needed to operate farms (boat ramps, hoists, lay down yards, etc.). There is a lack of shared (co-op) style facilities with cost-sharing, whole-sale locations for direct sales and shipping.

- **Response:** Greater access to farms and infrastructure implemented to support aquaculture, surveys or projects helmed to identify non-utilized commercial shellfish leases, and outreach to cultivate greater understanding and acceptance by the public about working waterfronts and aquaculture.

Product Survival:

- **Issue:** Predation, disease, and variable survival continue to affect cultured shellfish and fish. One grower stated: "Research provided by universities [is] very crucial to oyster growers' success in providing disease resistance strains, faster growing species, and marketing improvements."
- **Response:** More research on the relationship of predators (e.g., crabs, rays, sea stars) and parasites (e.g., mud worms, boring sponge, tube worms, sea lice, oyster drills) to farmed products so that efficient, cost-effective control methods can be developed and implemented on the farm. Selective breeding programs for disease resistance, better production traits (fast growth, shell shape and density), tolerance to low pH (to adapt to changing ocean chemistry) are needed.

Farming techniques:

- **Issues:** Farmers identified a wide variety of constraints to increased production including difficulties in finding processing equipment (oysters) or not being able to professionally fabricate custom processing gear; finding reliable, good seed sources; dealing with biofouling and the labor costs required to combat it; harvesting oysters efficiently from muddy bottoms; inadequate policies and procedures for biotoxin monitoring; and the lack of reliable workforce.
- **Response:** As one farmer wrote, "Every grower has a unique set of problems and resources. The problems are associated with the growing environment such as weather, grow out method, water temperature and food source. It is very difficult to generalize to provide a common set of solutions." However, new tools, including quick testing results for "toxic" algae blooms at farms would help farmers as would more, better, and cheaper seed sources, better tools and access to equipment that mechanizes and automates the many labor-intensive jobs that farmers perform (sorting, counting, culling, cleaning), non-toxic antifouling coatings for culture gear, and a better trained work force.

Human health:

- **Issue:** Prevention of contaminated or infected shellfish from reaching market and making consumers sick is extremely important both from a human health standpoint and for the success of shellfish businesses. However, many seafood safety tests or assays do not differentiate between organisms that are harmful to people and those that are benign. Most sophisticated testing is lab-based and little to no technology exists that growers can use on their farms, thus, reducing lag time between sample collection and reporting of findings/recommendations is not currently available.

- **Response:** Development of rapid, cost effective testing to detect and quantify bacterial and viral pathogens and toxic algae in order to prevent tainted shellfish from reaching the market is needed, as are quantitative assays that differentiate pathogenic *Vibrio* strains from benign strains. Affordable methods to reduce the bacterial (esp. *Vibrio*) and viral levels in shellfish while preserving the product's flavor, texture, and shelf life will allow for a marketable live product. Refining data from the FDA's *Vibrio* Risk Calculator, and assays to differentiate and quantify infectious Norovirus particles from inactive viral RNA will help bring product safely and efficiently to market.

Education/Communication:

- **Issue:** There are public misconceptions about farm-raised fish, and generally in the NRAC region, a lack of support and organization for fish farmers, especially freshwater farmers. Many industry members noted that there is not enough communication between growers, and not enough information exists online; greater high-quality aquaponics information is desired. In addition, good labor seems hard to find.
- **Response:** There is a continued, and perhaps greater need now with the growth of the aquaculture industry, to bridge communication between industry and research and the public. Suggestions were made to have local, off-season gatherings each winter where growers could share experiences, problem solve, and collaborate. This would be a perfect vehicle to incorporate extension, researchers, and regulators. To ensure that appropriate research priorities are set by NRAC, more industry members should be involved at the IAC level, or even in (state) focus groups leading up to the annual TIAC meetings. The TAC should be cognizant of, and the IAC prevent from happening, the exaggeration of issues for the sake of securing grant funding. Developing training or certification programs for farm employees could improve personnel and increase productivity of businesses. Guide marketing efforts to inform the public.

NRAC – How to Improve

- **Issue:** There is widespread agreement that the NRAC website is not very functional or useful. Information on project results and technical bulletins or fact sheets are not indexed and difficult to find.
- **NRAC response:** The NRAC website needs a significant overhaul so that project products, including reports and bulletins, can be searched for by project, author, and topic. To the extent possible, it would be ideal to include links to related publications and other informational websites.

- **Issue:** The NRAC research grant requirement that oblige researchers to collaborate with other stakeholders in other states has been effective in getting projects which are more applied than many other sponsored academic research programs have, and orienting the researchers' information dissemination toward the aquaculture industry. However, there is room to encourage even more industry collaboration.
- **NRAC response:** RFA guidelines could require that projects include industry members as collaborators. Greater participation by the aquaculture industry likely will increase effective

dissemination of project findings to other practitioners, ensuing that results are more easily adopted and put into use.

- **Issue:** Although shellfish aquaculture dominates the Northeast aquaculture industry, finfish culture, especially of trout and salmon, represents a large sector. Despite this, there are relatively few NRAC projects focused on finfish as well as a lack of communication between NRAC and Pennsylvania aquaculture stakeholders.
- **NRAC response:** Waive the multi-state requirement for research projects originating from Maine if the focus is on Atlantic salmon, since Maine is the only state producing salmon in the NRAC region. Bridge the gap between NRAC and the Pennsylvania aquaculture industry by presenting to the Pennsylvania Aquaculture Advisory Committee; networking and promoting NRAC at U.S. trout meetings; and prioritizing filling vacant Pennsylvania TIAC seats. Remind state aquaculture extension agents that NRAC supports all aquaculture, not just shellfish aquaculture.

- **Issue:** Technical bulletins and fact sheets and informational websites that put research findings into lay terms that can be used by practitioners and extension workers are some of the best and most used information dissemination products. Collaborating and industry stakeholders would like to see more of these made available. However, these final outreach pieces can be temporally difficult to complete within a two-year project timeline.
- **NRAC response:** Make funds available within projects to prepare and disseminate technical bulletins, fact sheets, and topic-specific websites that translate research findings into formats useful for practitioners. Consider sponsoring a small, post-award funding category so PCs and extension agents can collaborate and produce fact sheets/website deliverables after all data have been synthesized, a final report approved, and the project has been concluded.

- **Issue:** Aquaculture industry conferences and workshops and industry trade publications were identified as effective mechanisms to get research findings into the hands of industry practitioners and there is room for more of these.
- **NRAC response:** Encourage, with funding and grant review processes, that researchers take steps necessary to get project findings presented at industry conferences and workshops and published in articles in industry trade publications.

Acknowledgements

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Appendices

Project Years	*Title* ***Project Coordinator*** *Project Collaborators*	*Amount*
2005 - 2008	Development of genetic markers to assess disease resistance in the Eastern oyster **Dr. Steven Roberts (Marine Biological Laboratory, MA)** *Roxanna Smolowitz (Marine Biological Laboratory, MA), Richard Karney (Martha's Vineyard Shellfish Group, MA), Inke Sunila, (State of Connecticut, CT), Dale Leavitt, (Roger Williams University, RI), William Walton, (Cape Cod Cooperative Extension and Woods Hole Oceanographic Institute Sea Grant, MA), Frederick Goetz, (Great Lakes WATER Institute, WI), Paul Bagnall, (Edgartown Shellfish Department, MA)*	*$128,486*
2006 - 2008	Effect of temperature on the infection of hard clams (*Mercenaria mercenaria*) by the protistan organism, QPX **Dr. Roxanna Smolowitz (Marine Biological Laboratory, MA)** *Dale Leavitt (Roger Williams University, RI), Sandra Shumway (University of Connecticut, CT), William Walton (Cape Cod Cooperative Extension, MA), Gary Wikfors (Northeast Fisheries Science Center, CT), Richard Kraus (Aquacultural Research Corporation, MA), Leslie Sturmer (Florida Sea Grant, FL), Steven Roberts (University of Washington, WA), Karen Buzby (West Virginia University, WV), Helene Hegaret (University of Connecticut, CT)*	*$154,805*
2006 - 2008	Economic analysis of an alternative raceway material **Dr. Gerard D'Souza (West Virginia University, WV)** *Kenneth Semmens (West Virginia University, WV), Daniel Miller (West Virginia University, WV), Charlie Conklin (Big Brown Fish Hatchery, PA)*	*$107,096*
2006 - 2008	Evaluation of hard clam, *Mercenaria mercenaria*, stocks for QPX-resistance **Dr. John Kraeuter (Rutgers University, NJ)** *Ximing Guo (Rutgers University, NJ), Susan Ford (Rutgers University, NJ), David Bushek (Rutgers University, NJ), Roxanna Smolowitz (Marine Biological Laboratory, MA), Gef Flimlin (Rutgers Cooperative Extension, NJ), William Walton (Auburn University, AL), George Mathis (Mathis and Mathis Inc, NJ), Diane Murphy (Cape Cod Cooperative Extension and Woods Hole Oceanographic Institute Sea Grant, MA)*	*$71,173*
2006 - 2009	Cross breeding and field trials of disease-resistant oysters **Dr. Paul Rawson (University of Maine, ME)** *Scott Lindell (Marine Biological Laboratory, MA), Ximing Guo (Rutgers University, NJ), Roxanna Smolowitz (Marine Biological Laboratory, MA), Steven Roberts (Marine Biological Laboratory, MA), Inke Sunila (State of Connecticut, CT), Richard Karney (Martha's Vineyard Shellfish Group, MA), Dale Leavitt (Roger Williams University, RI), William Walton (Cape Cod Cooperative Extension, MA), Tessa Getchis (Sea Grant Cooperative Extension, University of Connecticut, CT), Dana Morse (Maine Sea Grant and University of Maine Cooperative Extension, ME), Chris Davis (Maine Aquaculture Innovation Center, ME)*	*$248,436*
2007 - 2009	Development of environmental code of practice and BMPs for East Coast shellfish growers **Mr. Edwin Rhodes (East Coast Shellfish Growers Association, CT)** *Gef Flimlin (Rutgers Cooperative Extension, NJ), Sandra Macfarlane (Coastal Resource Specialists, MA), Kathy Rhodes (Aquatechnics Inc, CT), Don Webster (University of Maryland, MD), Gregg Rivara (Cornell University Cooperative Extension, NY), John Ewart (Delaware Sea Grant, University of Delaware, DE)*	*$220,114*

Project Years	*Title* ***Project Coordinator*** *Project Collaborators*	*Amount*
2007 - 2010	Development of JOD-resistant lines and markers for Eastern oyster aquaculture **Dr. Marta Gomez-Chiarri (University of Rhode Island, RI)** *Ximing Guo (Rutgers University, NJ), Dale Leavitt (Roger Williams University, RI), Perry Raso (Ocean State Aquaculture Association, RI)*	*$209,269*
2007 - 2010	Evaluating restoration and mitigation of aquatic plant species and markets to advance commercialization of the industry **Dr. Andy Lazur (University of Maryland, MD)** *Dennis McIntosh (Delaware State University, DE), Mike Pietrak (Maine Aquaculture Association, ME), Doug Lipton (University of Maryland, MD), Dan Terlizzi (University of Maryland Center of Marine Biotechnology, MD), Don Webster (University of Maryland, MD), Erin Markin Ryder (University of Maryland, MD), Court Stevenson (University of Maryland, MD), Karen Buzby (West Virginia University, WV), Todd West (West Virginia University, WV), Reginal Harrell (University of Maryland, MD)*	*$449,903*
2008 - 2010	NRAC extension project **Ms. Tessa Getchis (University of Connecticut, CT)** *David Alves, Rhode Island Coastal Resources Management Council, RI), Joseph Buttner (Salem State College, MA), John Ewart (Delaware Sea Grant, University of Delaware, DE), Ann Faulds (Pennsylvania Sea Grant, The Pennsylvania State University, PA), Gef Flimlin (Rutgers Cooperative Extension, NJ), Doris Hicks (Delaware Sea Grant, University of Delaware, DE), Craig Hollingsworth (University of Massachusetts Amherst, MA), Kenneth LaValley (New Hampshire Sea Grant, University of New Hampshire, NH), Andrew Lazur (Maryland Sea Grant, MD), Dale Leavitt (Roger Williams University, RI), Dennis McIntosh (Delaware State University, DE), Dana Morse (Maine Sea Grant and University of Maine Cooperative Extension, ME), Mike Pietrak (Maine Aquaculture Association, ME), Robert Pomeroy (University of Connecticut, CT), Michael A Rice (University of Rhode Island, RI), Tom Rippen (University of Maryland Eastern Shore, MD), Gregg Rivara (Cornell University Cooperative Extension, NY), Jackie Takacs (Maryland Sea Grant, MD), Dan Terlizzi (University of Maryland Center of Marine Biotechnology, MD), William Walton (Woods Hole Oceanographic Institute Sea Grant and Cape Cod Cooperative Extension, MA), Don Webster (University of Maryland, MD), Brandy Wilbur (Massachusetts Institute of Technology Sea Grant, MA)*	*$299,944*
2008 - 2010	Targeted biosecurity education and BMP development program for aquaculturists, extension agents, researchers and regulators **Dr. Michele Walsh (Micro Technologies, ME)** *Charles Conklin (State of Pennsylvania, PA), Phil Hulbert (New York Department of Conservation, NY), Dale Leavitt (Roger Williams University, RI), Mike Pietrak (Maine Aquaculture Association, ME), Ken Semmens (West Virginia University, WV)*	*$89,920*
2008 - 2010	Investigation into the potential health and economic benefits of bivalve/finfish co-culture **Dr. Ian Bricknell (University of Maine, ME)** *Deborah A Bouchard (University of Maine, ME), Sally Dixon Molloy (University of Maine, ME), Robert Pomeroy (University of Connecticut, CT), Susan Ford (Rutgers University, NJ), David Bushek (Rutgers University, NJ), Brenda Landau (Rutgers University, NJ), Mike Pietrak (University of Maine, ME)*	*$150,000*

Project Years	*Title* ***Project Coordinator*** *Project Collaborators*	*Amount*
2008 - 2010	Evaluation of putatively QPX-resistant strains of Northern hard clams using field and genetic studies **Dr. Scott Lindell (Marine Biological Laboratory, MA)** *John Kraeuter (Rutgers University, NJ), Steven Roberts (University of Washington, WA), Brian Beal (University of Maine, ME), Jeffrey Gardner (Shellfish for YOU, LLC, RI), Richard Kraus (Aquacultural Research Corporation, MA), Scott Laurie (Spring Creek Oyster Company, MA), Diane Murphy (Barnstable County Cooperative Extension, MA), David Bushek (Rutgers University, NJ)*	*$263,490*
2008 - 2011	Deterring duck predation with underwater sound **Mr. Erick Swanson (Maine Cultured Mussels Inc, ME)** *Clifford A Goudey (Massachusetts Institute of Technology, MA), Dana Morse (Maine Sea Grant and University of Maine Cooperative Extension, ME), Theo de Koning (Aquaculture Harvesters LLC, ME), Chip Davison (Great Eastern Mussel Farm Inc, ME)*	*$108,000*
2008 - 2012	The infection cycle of VHS virus **Dr. Paul Bowser (Cornell University, NY)** *James W Casey (Cornell University, NY), Dave MacNeill (New York Sea Grant, SUNY College at Oswego, NY), Mark Malchoff (Lake Champlain Sea Grant, Plattsburgh State University, NY), Eric Obert (Pennsylvania Sea Grant, PA)*	*$199,263*
2008 - 2012	Creation of a tetraploid broodstock for the bay scallop *Argopecten irradians* **Dr. Rick Karney (Martha's Vineyard Shellfish Group, MA)** *Amandine Surier (Martha's Vineyard Shellfish Group, MA), Ximing Guo (Rutgers University, NJ), John C Blake (Sweet Neck Farm, MA), Yongping Wang (Rutgers University, NJ), Emma Green-Beach (Martha's Vineyard Shellfish Group, MA)*	*$128,197*
2009 - 2013	Assessment of grow-out strategies for the green sea urchin **Dr. Nick Brown (University of Maine, ME)** *Larry Harris (University of New Hampshire, NH), Lisa Bragg (University of Maine, ME), Stephen Eddy (University of Maine, ME), Dana Morse (Maine Sea Grant and University of Maine Cooperative Extension, ME), Jim Wadsworth (Friendship International, ME)*	*$156,933*
2009 - 2013	Selection for enhanced disease resistance and growth performance in cross-bred oysters, *Crassostrea virginica* **Dr. Paul Rawson (University of Maine, ME)** *Ximing Guo (Rutgers University, NJ), Scott Lindell (Marine Biological Laboratory, MA), Inke Sunila (State of Connecticut, CT), Chris Davis (Maine Aquaculture Innovation Center, ME), Dana Morse (Maine Sea Grant and University of Maine Cooperative Extension, ME), Diane Murphy (Woods Hole Sea Grant and Cape Cod Cooperative Extension, MA)*	*$232,416*
2010 - 2012	Shellfish STEM-GIS development for improved siting and farm management **Dr. Chris Davis (Maine Aquaculture Innovation Center, ME)** *Carter Newell (Pemaquid Oyster Co., ME), John Richardson (Blue Hill Hydraulics, ME), Kevin Morris (Discovery Software, Ltd., UK), Anthony Hawkens (Plymouth Marine Laboratory, UK), Tessa Getchis (Sea Grant Cooperative Extension, University of Connecticut, CT)*	*$85,000*

Project Years	*Title* ***Project Coordinator*** *Project Collaborators*	*Amount*
2010 - 2012	Breeding resistance to sea lice and ISAV in Atlantic salmon **Dr. Ian Bricknell (University of Maine, ME)** *Deborah A Bouchard (University of Maine, ME), Chris Bartlet (Marine Technology Center, ME), William R Wolters (National Cold Water Marine Aquaculture Center, ME), Mark Fast (Stony Brook University, NY), David Miller (Cooke Aquaculture, ME)*	*$199,614*
2010 - 2012	Assessment of environmental impacts of oyster aquaculture in New England waters **Dr. Chris Davis (Maine Aquaculture Innovation Center, ME)** *Carter Newell (Pemaquid Oyster Co., ME), John Richardson (Blue Hill Hydraulics, ME), Daniel Cheney (Pacific Shellfish Institute, WA), Anthony Hawkens (Plymouth Marine Laboratory, UK), Tessa Getchis (Sea Grant Cooperative Extension, University of Connecticut, CT), Jeffrey McKeen (Pemaquid Oyster Company, Inc., ME), Stewart Hutchings (Dragon Oysters LLC, CT)*	*$199,994*
2010 - 2013	Examination of finfish pathogen physiology and predictive ecology in bivalve integrated multi-trophic aquaculture **Dr. Ian Bricknell (University of Maine, ME)** *Deborah A Bouchard (University of Maine, ME), Sally Dixon Molloy (University of Maine, ME), Robert Pomeroy (University of Connecticut, CT), Mike Pietrak (University of Maine, ME), Umi Muawanah (University of Connecticut, CT)*	*$200,000*
2010 - 2013	Novel methodologies to overwinter cultured hard clams in the Northeast US **Dr. David Bushek (Rutgers University, NJ)** *Brian F Beal (University of Maine at Machias, ME), V Monic A Bricelj (Rutgers University, NJ), Gef Flimlin (Rutgers Cooperative Extension, NJ), Chester B Zarnoch (Baruch College, City University of New York, NY), David Bushek (Rutgers University, NJ), George Mathis, Jr. (Mathis Clam Farm, NJ), Joseph Porada (Egypt Bay Aquafarms, ME), John Aldred (East Hampton Town Shellfish Hatchery, NY), John Dunne (East Hampton Town Shellfish Hatchery, NY)*	*$200,402*
2011 - 2013	Optimization of hatchery and culture technology for razor clam **Dr. Paul Rawson (University of Maine, ME)** *Dale Leavitt (Roger Williams University, RI), Diane Murphy (Woods Hole Sea Grant and Cape Cod Cooperative Extension, MA), Dana Morse (Maine Sea Grant and University of Maine Cooperative Extension, ME)*	*$93,616*

Project Years	*Title* ***Project Coordinator*** *Project Collaborators*	*Amount*
2011 - 2014	Aquaculture health hazards - developing outreach services to the region's farmers via extension and aquatic animal health **Ms. Tessa Getchis (University of Connecticut, CT)** *Deborah A Bouchard (University of Maine, ME), Joseph Buttner (Salem State College, MA), John Ewart (Delaware Sea Grant, University of Delaware, DE), Ann Faulds (Pennsylvania Sea Grant, The Pennsylvania State University, PA), Gef Flimlin (Rutgers Cooperative Extension, NJ), Doris Hicks (Delaware Sea Grant, University of Delaware, DE), Craig Hollingsworth (University of Massachusetts Amherst, MA), Robert Reynolds (Zephyr Marine Education Foundation, MA), Dale Leavitt (Roger Williams University, RI), Dennis McIntosh (Delaware State University, DE), Dana Morse (Maine Sea Grant and University of Maine Cooperative Extension, ME), Tom Rippen (University of Maryland Eastern Shore, MD), Gregg Rivara (Cornell University Cooperative Extension, NY), Roxanna Smolowitz (Roger Williams University, RI), Dan Terlizzi (University of Maryland Center of Marine Biotechnology, MD), Don Webster (University of Maryland, MD), Michael Chambers (New Hampshire Sea Grant, University of New Hampshire, NH), Diane Murphy (Woods Hole Sea Grant and Cape Cod Cooperative Extension, MA), Robert Pomeroy (University of Connecticut, CT), Josh Reitsma (Woods Hole Sea Grant and Cape Cod Cooperative Extension, MA), Michael A Rice (University of Rhode Island, RI)*	*$196,312*
2011 - 2015	Developing improved management practices for mussel farming in southern New England **Dr. Scott Lindell (Marine Biological Laboratory, MA)** *Mary R Carman (Woods Hole Oceanographic Institute, MA), Victoria Starczak (Woods Hole Oceanographic Institute, MA), Richard Karney (Martha's Vineyard Shellfish Group, MA), Michael Chambers (New Hampshire Sea Grant, University of New Hampshire, NH), Richard Langan (University of New Hampshire, NH), Dale Leavitt (Roger Williams University, RI), Gregory Mataronas (Sakonnet Point Mussels, RI), Michael Marchetti (Sakonnet Point Mussels, RI), Bill Silkes (American Mussel Harvesters, Inc., RI), Robert Reynolds (Zephyr Marine Education Foundation, MA), Stanley Larson (blue mussel farm owner, MA), Alec Gale (blue mussel farm owner, MA)*	*$199,799*
2012 - 2015	Development of more efficient methods of *Vibrio* sp. Detection and identification of *Vibrio* sp. abundance in cultured oysters from Northeast US farms and from retail sites post-harvest **Dr. Roxanna Smolowitz (Marine Biological Laboratory, MA)** *Diane Murphy (Woods Hole Sea Grant and Cape Cod Cooperative Extension, MA), Dale Leavitt (Roger Williams University, RI), Marta Gomez-Chiarri (University of Rhode Island, RI), Robert E Levin (University of Massachusetts Amherst, MA), Lisa Calvo (Rutgers University, NJ), Dana Morse (Maine Sea Grant and University of Maine Cooperative Extension, ME), Gregg Rivara (Cornell University Cooperative Extension, NY), Don Webster (University of Maryland, MD)*	*$190,360*
2013 - 2014	Algal-bacterial interactions in shellfish hatcheries **Dr. Paul Rawson (University of Maine, ME)** *Michael Devin (University of Maine, ME)*	*$18,488*
2013 - 2014	Identification and isolation of novel probiotic bacteria for use in marine aquaculture **Dr. Dennis McIntosh (Delaware State University, DE)** *Eric J Schott (IMET-University of Maryland Center for Environmental Science, MD), Harold J Schreier (University of Maryland Baltimore County, MD)*	*$19,981*

Project Years	*Title* ***Project Coordinator*** *Project Collaborators*	*Amount*
2013 - active	New tools to prevent bacterial diseases in shellfish hatcheries **Dr. David Rowley (University of Rhode Island, RI)** *Marta Gomez-Chiarri (University of Rhode Island, RI), Roxanna Smolowitz (Roger Williams University, RI), Dale Leavitt (Roger Williams University, RI), Paul Rawson (University of Maine, ME), Michael Devin (University of Maine, ME), David Worthen (University of Rhode Island, RI), Gary Wickfors (National Oceanic and Atmospheric Administration, CT), Hauke L Kite-Powell (Woods Hole Oceanographic Institute, MA)*	*$199,514*
2013 - active	Striped bass selection for marine culture **Dr. David Berlinsky (University of New Hampshire, NH)** *Curry Woods (University of Maryland, MD), Adam Fuller (Stuttgart National Aquaculture Research Center, AR), Adrienne Kovach (University of New Hampshire, NH), Kenneth LaValley (New Hampshire Sea Grant, University of New Hampshire, NH), Tessa Getchis (Sea Grant Cooperative Extension, University of Connecticut, CT)*	*$199,569*
2013 - active	Genetic mark-assisted selection of Northeastern hard clams for QPX resistance **Dr. Bassem Allam (Stony Brook University, NY)** *Ximing Guo (Rutgers University, NJ), Roxanna Smolowitz (Roger Williams University, RI), Emmanuelle Pales Espinosa (Stony Brook University, NY), Gregg Rivara (Cornell University Cooperative Extension, NY), Gef Flimlin (Rutgers Cooperative Extension, NJ), Diane Murphy (Woods Hole Sea Grant and Cape Cod Cooperative Extension, MA), Arnaud Tanguy (University of Paris 6, FR), Antoinette Clemetson (New York Sea Grant, NY)*	*$199,998*
2014 - active	Improved grow-out methodologies for Razor Clams **Dr. Paul Rawson (University of Maine, ME)** *Dale Leavitt (Roger Williams University, RI), Diane Murphy (Woods Hole Sea Grant and Cape Cod Cooperative Extension, MA), Dana Morse (Maine Sea Grant and University of Maine Cooperative Extension, ME)*	*$176,049*

Appendix B: Tier I - NRAC Evaluation Survey

Q1
Survey of Principal Investigators
Northeast Regional Aquaculture Center

On behalf of the Northeast Regional Aquaculture Center (NRAC), Elizabeth Fairchild, Research Assistant Professor in the UNH Department of Biological Sciences in collaboration with the UNH Survey Center and the UNH Carsey School of Public Policy seek your participation in the following survey. This survey is designed to help us assess the scientific, socio-economic, and policy impacts of accomplishments achieved through NRAC's portfolio of recently funded aquaculture projects, including extension workgroup projects. Incorporated in this synthesis will be the impact these projects have had on the aquaculture industry in the northeast, as well as, the identification of constraints that still limit the aquaculture industry.

From these results, research priority recommendations will be made to NRAC for future funding initiatives and results may be used for additional research. The findings will be presented as de-identified data or aggregated, but in some cases specific examples from particular projects may be used. Due to the small number of projects to be examined (approximately 30), the researchers cannot promise confidentiality. However, researchers at UNH will make every attempt to minimize the amount of identifiable data released in reports. Additionally, there are rare instances when the researcher is required to share personally-identifiable information (e.g., according to law, policy, or regulations).

To adhere to the highest professional research standards, we request your consent to complete the following set of questions. Your participation is voluntary; you may refuse to answer any question and can stop at any time without penalty. We will not ask about regulated activities, personal information, or other sensitive matters. We do not anticipate any risks to you, and the benefits of this research may be to improve the NRAC funding process. We estimate that it will take 10 minutes for you to complete the questions.

If you have questions about your rights as a participant in research, you may contact Julie Simpson at the UNH Research Integrity Services at 603-862-2003 or Julie.Simpson@unh.edu to discuss them. Please direct all other questions about this study to Elizabeth Fairchild at Elizabeth.Fairchild@unh.edu or call her at 603-862-4475.

The findings of the study will be available to all participants who request them. The questions refer to your NRAC funded project: ${e://Field/PROJTITLE}

If you do not wish to participate, simply close your browser. If you consent to participate, please click "Next".

Q2 How would you describe your primary professional responsibilities?
- ❍ Teaching (1)
- ❍ Research (2)
- ❍ Outreach (3)
- ❍ Industry (4)
- ❍ Other (5) _____

Project Development

Q3 How did you first hear about the NRAC request for proposals?
- ❍ From a colleague(s) (1)
- ❍ At a professional meeting (2)
- ❍ In an academic journal or newsletter (3)
- ❍ The NRAC website (4)
- ❍ Grant alert/bulletin/email (5)
- ❍ Other (specify) (6) _____
- ❍ Not sure / don't recall (7)

Q4 How did you come up with/develop your research questions for this project? (Click all that apply)
- ❑ Past research you conducted (1)
- ❑ Past research by colleagues in your academic field (2)
- ❑ Request from aquaculture industry (3)
- ❑ Request from a state agency (4)
- ❑ Request from a federal agency (5)
- ❑ Other (specify) (6) _____

Q5 How involved were individuals from the aquaculture industry in participating in the formulation of your research question?
- ❍ Not Involved (1)
- ❍ Minimally Involved (2)
- ❍ Moderately Involved (3)
- ❍ Very Involved (4)
- ❍ Don't Know/Not sure (5)

Q6 How involved were individuals from the aquaculture industry in participating in the preparation of your NRAC proposal?
- ❍ Not Involved (1)
- ❍ Minimally Involved (2)
- ❍ Moderately Involved (3)
- ❍ Very Involved (4)
- ❍ Don't Know/Not sure (5)

Q7 Do you have any comments or suggestions on the NRAC RFP guidelines?

Project Implementation

Q8 What percentage of the implementation/completion of your research on this project was conducted by each of the following? Percentages must add to 100 percent.

_____ Your research team (1)
_____ Co-PI's research teams at your university (2)
_____ Co-PI's research teams at other universities (3)
_____ Extension staff at your university (4)
_____ State agencies (5)
_____ Aquaculture industry partners (6)
_____ Outside labs / specialists (7)
_____ Other (specify) (8)

Q9 How important were each of the following to the successful completion of your NRAC funded research project?

	Very Important (1)	Somewhat Important (2)	Not Important (3)	Did Not Utilize (4)	Don't Know /Not Sure (5)
Your research team (1)	❍	❍	❍	❍	❍
Co-PI's research teams at your university (2)	❍	❍	❍	❍	❍
Co-PI's research teams at other universities (3)	❍	❍	❍	❍	❍
Extension staff at your university (4)	❍	❍	❍	❍	❍
State agencies (5)	❍	❍	❍	❍	❍
Aquaculture industry partners (6)	❍	❍	❍	❍	❍
Outside labs / specialists (7)	❍	❍	❍	❍	❍
Other (specify) (8)	❍	❍	❍	❍	❍

Q10 From the same list as above, please indicate the MOST important and second most important to the successful completion of your NRAC funded research project? Enter a "1" for the MOST important and a "2" for the second most important.

_____ Your research team (1)
_____ Co-PI's research teams at your university (2)
_____ Co-PI's research teams at other universities (3)
_____ Extension staff at your university (4)
_____ State agencies (5)
_____ Aquaculture industry partners (6)
_____ Outside labs / specialists (7)
_____ Other (specify) (8)

Q11 Project Outcomes Would you say the benefits of this NRAC project …

- ❍ Contribute mainly to scientific knowledge (1)
- ❍ Contribute equally to scientific knowledge and practical improvements (2)
- ❍ Contribute mainly to practical improvements for aquaculture industry (3)
- ❍ Don't know / Not sure (4)

Q12 What have been, or do you expect to be, the most important tangible products of your NRAC-funded project? (Click all that apply)

- ❑ New species (1)
- ❑ Disease resistant species (2)
- ❑ New technology (3)
- ❑ New / improved production practices (4)
- ❑ Increased productivity in aquaculture industry (5)
- ❑ Adoption of new products by aquaculture industry (6)
- ❑ Other (specify) (7)

Q13 What have been, or do you expect to be, the most important informational products of your NRAC-funded project? (Click all that apply)

- ❑ Final Report (1)
- ❑ Seminar/workshop (2)
- ❑ Peer reviewed journal article (3)
- ❑ Aquaculture industry publication (4)
- ❑ Best practices/management manual (5)
- ❑ Policy document/plan (6)
- ❑ Newspaper article (7)
- ❑ Aquaculture industry trade conference presentation (8)
- ❑ Informational website (9)
- ❑ Creation of a network or alliance (10)
- ❑ Collaborative partnership with industry stakeholders (11)
- ❑ Technical assistance and capacity-building (12)
- ❑ Testimony (e.g. Congressional) (13)
- ❑ Other (specify) (14) _____

Q14 Please rate how effective you think each of the following have been for communicating the results and accomplishments of your NRAC-funded project to the aquaculture industry.

	Very Effective (1)	Somewhat Effective (2)	Not Very Effective (3)	Not At All Effective (4)	Does Not Apply (5)
Final Report (1)	❍	❍	❍	❍	❍
Seminar/workshop (2)	❍	❍	❍	❍	❍
Peer reviewed journal article (3)	❍	❍	❍	❍	❍
Aquaculture industry trade publication (4)	❍	❍	❍	❍	❍
Best practices/management manual (5)	❍	❍	❍	❍	❍
Policy document/plan (6)	❍	❍	❍	❍	❍
Newspaper Article (7)	❍	❍	❍	❍	❍
Aquaculture industry trade conference presentation (8)	❍	❍	❍	❍	❍
Informational website (9)	❍	❍	❍	❍	❍
Networks or alliances (10)	❍	❍	❍	❍	❍
Collaborative partnership with industry stakeholders (11)	❍	❍	❍	❍	❍
Technical assistance and capacity-building (12)	❍	❍	❍	❍	❍
Testimony (e.g. Congressional) (13)	❍	❍	❍	❍	❍
NRAC Website (14)	❍	❍	❍	❍	❍
Other (15)	❍	❍	❍	❍	❍

Q15 If you had the opportunity to improve or expand the way you communicated the results and accomplishments of your NRAC research, how would you do it?

Q16 Which of the following, if any, do you perceive to be barriers to getting the results/findings of your NRAC-funded project into the hands of potential users or others interested in your research in the aquaculture industry? (Click all that apply)

- ❑ Not having the networks/connections (1)
- ❑ Translating the science to lay terms (2)
- ❑ I don't like disseminating the results/findings (3)
- ❑ I don't know how to disseminate the results/findings (4)
- ❑ Potential users are not interested in my research (5)
- ❑ Budgeted funds were insufficient (6)
- ❑ Other (specify) (7) _____

Q17 What impact did your NRAC-funded research project have on the following groups or industries?

	Major Impact (1)	Minor Impact (2)	No Impact (3)	Does Not Apply (4)
Science/social science researchers (1)	❍	❍	❍	❍
Local/small area aquaculture industry (2)	❍	❍	❍	❍
State aquaculture industry (3)	❍	❍	❍	❍
Regional aquaculture industry (4)	❍	❍	❍	❍
National / international aquaculture industry (5)	❍	❍	❍	❍
State policy-makers (agency staff, legislators, etc.) (6)	❍	❍	❍	❍
Regional policy-makers (aquaculture managers, fishery management councils.) (7)	❍	❍	❍	❍
National policy makers (agency staff, legislators, etc.) (8)	❍	❍	❍	❍
Environmental /conservation groups (9)	❍	❍	❍	❍
Consultants (10)	❍	❍	❍	❍
The general public (11)	❍	❍	❍	❍
Other (specify) (12)	❍	❍	❍	❍

Q18 Please provide examples of how others (for example, researchers, aquaculture industry, policy-makers) have used the findings/results of your project?

Q19 What do you think was the most important achievement of this project for the aquaculture industry?

Q20 What do you think was the most important achievement of this project for researchers?

Q21 In your opinion, what was the economic impact of this project on the targeted segment of the aquaculture industry?

- ❍ Critical to its future (1)
- ❍ Very important, but not critical (2)
- ❍ Somewhat important (3)
- ❍ Not too important (4)
- ❍ Don't know / Not sure (5)

Q22 Has this project led to you receiving subsequent research funding?
- ❍ Yes (1)
- ❍ No (2)
- ❍ Don't know/ Not sure (3)

Answer If Has this project led to your receiving subsequent research funding? Yes Is Selected
Q23 From whom did you receive subsequent funding?

Answer If Has this project led to your receiving subsequent research funding? Yes Is Selected
Q24 How much funding did you receive?

Q25 Did you use the results of other NRAC-funded research to develop the proposal this survey focuses on (listed on the bottom of the page)?
- ❍ Yes (1)
- ❍ No (2)
- ❍ Don't know/ Not sure (3)

Answer If Did you use the results of other NRAC-funded research to develop the proposal this survey focuses... Yes Is Selected
Q26 To the best of your knowledge, what NRAC-funded research was that?

Q27 Where do you go to find out the results/findings of other NRAC-funded research?
- ❍ From a colleague(s) (1)
- ❍ Professional seminar/workshop (2)
- ❍ Professional meeting/conference or other presentation (3)
- ❍ Academic journal or newsletter (4)
- ❍ Trade publication (5)
- ❍ Best practices/management manual (6)
- ❍ Newspaper article (7)
- ❍ NRAC website (8)
- ❍ Other (specify) (9) _____

Q28 What suggestions do you have for NRAC to ensure that the results/findings of your NRAC-funded research are accessed and used by others?

Q29 We will also be surveying people in the aquaculture industry about the impact of NRAC-funded projects. Please provide us with the names, companies, and e-mail or phone of up to 5 people in the aquaculture industry who were directly involved in your project.

	Name (1)	Company (2)	Email (3)	Phone (4)
1. (1)				
2. (2)				
3. (3)				
4. (4)				
5. (5)				

Q30 And please provide us with the names, companies, and e-mail or phone of up to 5 people in the aquaculture industry who may have benefitted from your findings/results.

	Name (1)	Company (2)	Email (3)	Phone (4)
1. (1)				
2. (2)				
3. (3)				
4. (4)				
5. (5)				

Q31 Finally, is there anyone else from your research team who should also complete this survey? Please provide their name and email address.

	Name (1)	Company (2)	Email (3)	Phone (4)
1. (1)				
2. (2)				
3. (3)				

Q32 Thank you for your participation. Please click "submit" to complete the survey.

Appendix B: Tier II - NRAC Evaluation Survey

Q1
Survey of Project Collaborators
Northeast Regional Aquaculture Center

On behalf of the Northeast Regional Aquaculture Center (NRAC) and in collaboration with University of New Hamphshire (UNH) Survey Center, the UNH Carsey School of Public Policy, and the UNH Department of Natural Resources and the Environment, Elizabeth Fairchild, Research Assistant Professor in the Department of Biological Sciences, seeks your participation in the following survey. This survey is designed to help us assess the scientific, socio-economic, and policy impacts of accomplishments achieved through NRAC's portfolio of recently funded aquaculture projects, including extension workgroup projects. Incorporated in this synthesis will be the impact these projects have had on the aquaculture industry in the northeast, as well as, the identification of constraints that still limit the aquaculture industry.

From these results, research priorities will be identified and recommendations will be made to NRAC for future funding initiatives. The findings will be presented as de-identified data or aggregated, but in some cases specific examples from particular projects may be used. Due to the small number of projects to be examined (approximately 30), the researchers cannot promise confidentiality. However, researchers at UNH will make every attempt to minimize the amount of identifiable data released in reports. Additionally, there are rare instances when the researcher is required to share personally-identifiable information (e.g., according to law, policy, or regulations).

To adhere to the highest professional research standards, we request your consent to complete the following set of questions. Your participation is voluntary; you may refuse to answer any question and can stop at any time without penalty. We will not ask about regulated activities, personal information, or other sensitive matters. We do not anticipate any risks to you, and the benefits of this research may be to improve the NRAC funding process. We estimate that it will take 10 minutes for you to complete the questions.

If you have questions about your rights as a participant in research you may contact Julie Simpson at the UNH Office of Sponsored Research at 603-862-2003 or Julie.Simpson@unh.edu to discuss them. Please direct all other questions about this study to Elizabeth Fairchild at Elizabeth.Fairchild@unh.edu or call her at 603-862-4475.

The findings of the study will be available to all participants who request them.

The questions refer to the NRAC funded project: ${e://Field/PROJTITLE}

If you do not wish to participate, simply close your browser. If you consent to participate, please click "Next".

Project Development

Q2 How much do you know about the Northeast Regional Aquaculture Center (NRAC)? (Select all that apply)

- ❍ I have not heard of NRAC (1)
- ❍ I have heard of NRAC, but I am unsure of what they do (2)
- ❍ I know of a project or two funded by NRAC, but have no direct involvement (3)
- ❍ I have used some of the products or techniques that came from NRAC funded projects (4)
- ❍ I have been involved with an NRAC funded study (5)
- ❍ I have been a major contributor to an NRAC funded study (6) _____
- ❍ I have been a Principal Investigator in an NRAC funded study (7) _____

Q3 What was your primary role in this NRAC project?

- ❍ Extension (1)
- ❍ Aquaculture industry (2)
- ❍ Researcher (4)
- ❍ Other (5) _____

Q4 How much interaction did you have with the Project Coordinator...

	Not Involved (1)	Minimally Involved (2)	Moderately Involved (3)	Very Involved (4)	Don't Know/Not sure (5)
... during the development of the proposal? (1)	❍	❍	❍	❍	❍
... during the project? (2)	❍	❍	❍	❍	❍
... after the project was completed? (3)	❍	❍	❍	❍	❍

Answer If What was your primary role in this NRAC project? Extension Is Selected

Q5 Were you able to complete all the extension tasks assigned to you?

- ❍ Yes (18)
- ❍ No (19)

Answer If What was your primary role in this NRAC project? Extension Is Selected

Q6 Were you given sufficient time to develop the extension plan during the proposal submission process?

- ❍ Yes (4)
- ❍ No (5)

Answer If What was your primary role in this NRAC project? Extension Is Selected

Q80 Were you given sufficient time to develop the extension plan during the project implementation?

- ❍ Yes (1)
- ❍ No (2)

Answer If What was your primary role in this NRAC project? Extension Is Selected

Q7 Were you given sufficient funds to execute the extension plan?

- ❍ Yes (5)
- ❍ No (6)

Answer If What was your primary role in this NRAC project? Extension Is Selected

Q81 Were you given sufficient time to execute the extension plan?

- ❍ Yes (1)
- ❍ No (2)

Answer If What was your primary role in this NRAC project? Extension Is Selected

Q8 Did you feel included in the mainstream process (i.e. project and team development, proposal process, project execution, and output and outreach activities)?

- ❍ Yes (4)
- ❍ No (5)

Answer If What was your primary role in this NRAC project? Extension Is Selected

Q9 Did the extension project change from when the proposal was submitted to the completion of the project?

- ❍ Yes (5)
- ❍ No (6)

Answer If Did the extension project change from when the proposal was submitted to the completion of the pr... Yes Is Selected

Q10 How did it change? Why did it change? What were the changes?

Q11 What kind of product or technique from this NRAC funded study were you involved with?

- ❍ New species (1)
- ❍ Disease resistant species (2)
- ❍ New technology (4)
- ❍ New/improved production practices (5)
- ❍ Increased productivity in aquaculture industry (6)
- ❍ Adoption of new products by aquaculture industry (7)
- ❍ Other (Specify) (8) _____

Answer If What was your primary role in this NRAC project? Aquaculture industry Is Selected

Q12 How did the product or technique affect your business?

	Increase (1)	Decrease (2)	No Change (3)	Don't Know (4)
Efficiency (2)	❍	❍	❍	❍
Profitability (3)	❍	❍	❍	❍
Diversification (4)	❍	❍	❍	❍
Risk mitigation (5)	❍	❍	❍	❍
Networking (6)	❍	❍	❍	❍
Other (specify): (7)	❍	❍	❍	❍

Answer If What was your primary role in this NRAC project? Extension Is Selected

Q13 Have you seen the product or technique affect aquaculture businesses?

	Increase (1)	Decrease (2)	No Change (3)	Don't Know (4)
Efficiency (2)	❍	❍	❍	❍
Profitability (3)	❍	❍	❍	❍
Diversification (4)	❍	❍	❍	❍
Risk mitigation (5)	❍	❍	❍	❍
Networking (6)	❍	❍	❍	❍
Other (specify): (7)	❍	❍	❍	❍

Answer If What was your primary role in this NRAC project? Aquaculture industry Is Selected

Q14 If your business was affected, did you see a change in revenues?

- ❍ Yes, revenues increased (1)
- ❍ Yes, revenues decreased (2)
- ❍ No, no changes (3)
- ❍ Don't know/Not sure (4)

Answer If If your business was affected, did you see a change in revenues? Yes, revenues increased Is Selected

Q15 How much did your revenues increase over 1 year?

- ❍ 0-10% (1)
- ❍ 11-20% (2)
- ❍ 21-30% (3)
- ❍ 31-40% (4)
- ❍ 41-50% (5)
- ❍ 51-60% (6)
- ❍ 61-70% (7)
- ❍ 71-80% (8)
- ❍ 81-90% (9)
- ❍ 91-100% (10)
- ❍ 101-150% (11)
- ❍ 151-200% (12)
- ❍ 201-300% (13)
- ❍ 301-400% (14)
- ❍ 401-500% (15)
- ❍ 501-750% (16)
- ❍ Over 750% (17)

Answer If If your business was affected, did you see a change in revenues? Yes, revenues decreased Is Selected

Q16 How much did your revenues decrease over 1 year?

- ❍ 0-10% (1)
- ❍ 11-20% (2)
- ❍ 21-30% (3)
- ❍ 31-40% (4)
- ❍ 41-50% (5)
- ❍ 51-60% (6)
- ❍ 61-70% (7)
- ❍ 71-80% (8)
- ❍ 81-90% (9)
- ❍ 91-100% (10)
- ❍ 101-150% (11)
- ❍ 151-200% (12)
- ❍ 201-300% (13)
- ❍ 301-400% (14)
- ❍ 401-500% (15)
- ❍ 501-750% (16)
- ❍ Over 750% (17)

Q17 How many employees did you have ...

	... before the project? (1)	... after the incorporation of the findings? (2)
Part time for one season (1)		
Part time for more than one season (2)		
Part time year round (3)		
Full time for one season (4)		
Full time for more than one season (5)		
Full time year round (6)		
Other (Specify) (7)		

Q18 Did you hire new employees as a result of research from this NRAC project? Please indicate the number of employees hired for each category below:

- ❑ Part time for one season (1) _____
- ❑ Part time for more than one season (2) _____
- ❑ Part time year round (3) _____
- ❑ Full time for one season (4) _____
- ❑ Full time for more than one season (5) _____
- ❑ Full time year round (6) _____
- ❑ Other (Specify) (7) _____
- ❑ Did not hire new employees as a result of research from this NRAC project (8)

NRAC Project Outcomes

Q19 Would you say the benefits of this NRAC project...

- ❍ Contribute mainly to scientific knowledge (1)
- ❍ Contribute equally to scientific knowledge and practical improvements (2)
- ❍ Contribute mainly to practical improvements for aquaculture industry (3)
- ❍ Don't Know/Not Sure (4)

Q20 Has this NRAC funded project helped you to leverage more funding to develop your business, research, or outreach capabilities?

- ❍ Yes (5)
- ❍ No (6)

Answer If Has this NRAC funded project helped you to leverage more funding to develop your business, research, or outreach capabilities? Yes Is Selected

Q21 How much?

Q22 What have been, or do you expect to be, the most important tangible products of this NRAC-funded project? (Select all that apply)

- ❑ New species (1)
- ❑ Disease resistant species (2)
- ❑ New technology (3)
- ❑ New/improved production practices (4)
- ❑ Increased productivity in aquaculture industry (5)
- ❑ Adoption of new products by aquaculture industry (6)
- ❑ New or expanded markets (7)
- ❑ Decrease in productivity or costs (8)
- ❑ Other (specify) (9) _____

Q23 What have been, or do you expect to be, the most important informational products of this NRAC-funded project? (Select all that apply)

- ❑ Final report (1)
- ❑ Seminar/workshop (2)
- ❑ Peer reviewed journal article (3)
- ❑ Aquaculture industry publication (4)
- ❑ Best practices/management manual (5)
- ❑ Policy document/plan (6)
- ❑ Newspaper article (7)
- ❑ Aquaculture industry trade conference presentation (8)
- ❑ Informational website (9)
- ❑ Creation of a network or alliance (10)
- ❑ Collaborative partnership with industry stakeholders (11)
- ❑ Technical assistance and capacity-building (12)
- ❑ Testimony (e.g. Congressional) (13)
- ❑ Other (Specify) (14) _____

Q24 Please rate how effective you think each of the following have been for communicating the results and accomplishments of this NRAC-funded project to the aquaculture industry?

	Very Effective (1)	Somewhat Effective (2)	Not Very Effective (3)	Not At All Effective (4)	Does not apply (5)
Final report (1)	❍	❍	❍	❍	❍
Seminar/workshop (2)	❍	❍	❍	❍	❍
Peer reviewed journal article (3)	❍	❍	❍	❍	❍
Aquaculture industry trade publication (4)	❍	❍	❍	❍	❍
Best practices/management manual (5)	❍	❍	❍	❍	❍
Policy document/plan (6)	❍	❍	❍	❍	❍
Newspaper Article (7)	❍	❍	❍	❍	❍
Aquaculture industry trade conference presentation (8)	❍	❍	❍	❍	❍
Informational website (9)	❍	❍	❍	❍	❍
Networks or alliances (10)	❍	❍	❍	❍	❍
Collaborative partnership with industry stakeholders (11)	❍	❍	❍	❍	❍
Technical assistance and capacity-building (12)	❍	❍	❍	❍	❍
Testimony (e.g. Congressional) (13)	❍	❍	❍	❍	❍
NRAC Website (14)	❍	❍	❍	❍	❍
Other (Specify) (15)	❍	❍	❍	❍	❍

Answer If What was your primary role in this NRAC project? Aquaculture industry Is Selected Or What was your primary role in this NRAC project? Researcher Is Selected Or What was your primary role in this NRAC project? Other Is Selected

Q25 If you had the opportunity to improve or expand the way NRAC research findings are communicated, how would you do it?

Answer If What was your primary role in this NRAC project? Extension Is Selected

Q26 If you had the opportunity to improve or expand the way you communicated NRAC research findings and accomplishments, how would you do it?

Answer If What was your primary role in this NRAC project? Extension Is Selected

Q27 What do you think researchers need to do to increase the potential impact NRAC research findings have?

Q28 As a collaborator, were there barriers to getting the results/findings of the NRAC-funded project disseminated more broadly within the aquaculture industry?

- ❍ Yes (1)
- ❍ No (2)

Answer If As a collaborator, were there barriers to getting the results/findings of the NRAC-funded project disseminated more broadly within the aquaculture industry? Yes Is Selected

Q29 What were those barriers?

Q30 Which of the following were barriers to getting the results/findings of this NRAC-funded project into the hands of potential users or others who might be interested in this research? (Select all that apply)

- ❑ Not having the networks/connections (1)
- ❑ Translating the science to lay terms (2)
- ❑ I don't like disseminating the results/findings (3)
- ❑ I don't know how to disseminate the results/findings (4)
- ❑ Potential users are not interested in this research (5)
- ❑ Lack of funding (6)
- ❑ Other (specify) (7) _____
- ❑ There were no barriers (8)

Q31 What impact do you think this NRAC-funded research project had on the following groups?

	Major Impact (1)	Minor Impact (2)	No Impact (3)	Does Not Apply (4)
Science/social science researchers (1)	❍	❍	❍	❍
Local/small area aquaculture industry (2)	❍	❍	❍	❍
State aquaculture industry (3)	❍	❍	❍	❍
Regional aquaculture industry (4)	❍	❍	❍	❍
National/international aquaculture industry (5)	❍	❍	❍	❍
State policy-makers (agency staff, legislators, etc.) (6)	❍	❍	❍	❍
Regional policy-makers (aquaculture managers, fishery management councils) (7)	❍	❍	❍	❍
National policy makers (agency staff, legislators, etc.) (8)	❍	❍	❍	❍
Environmental/conservation groups (9)	❍	❍	❍	❍
Consultants (10)	❍	❍	❍	❍
The general public (11)	❍	❍	❍	❍
Other (Specify) (12)	❍	❍	❍	❍

Q32 Please provide examples of how others (for example, researchers, aquaculture industry, policy-makers) have used the findings/results of this project?

Q33 What do you think was/were the most important achievement(s) of this project for the aquaculture industry?

Q34 What do you think was/were the most important achievement(s) of this project for researchers?

Q35 In your opinion, what was the economic impact of this project on the targeted segment of the aquaculture industry?

- ❍ Critical to its future (1)
- ❍ Very important, but not critical (2)
- ❍ Somewhat important (3)
- ❍ Not too important (4)
- ❍ Negative/detrimental impact (5)
- ❍ Don't know/Not sure (6)

Q36 Has this project led to you receiving subsequent funding?

- ❍ Yes (1)
- ❍ No (2)
- ❍ Don't know/ Not sure (3)

Answer If Has this project led to you receiving subsequent funding? Yes Is Selected

Q37 From whom did you receive subsequent funding? (please list all applicable funding sources)

Answer If Has this project led to you receiving subsequent funding? Yes Is Selected

Q38 How much funding did you receive? (please list amounts for each funding source listed above)

Q39 Do you use the results of other NRAC-funded research in your own research?

- ❍ Yes (1)
- ❍ No (2)
- ❍ Don't know/ Not sure (3)

Answer If Do you use the results of other NRAC-funded research in your own research? Yes Is Selected

Q40 How often and in what capacity?

Q41 Where do you go to find out the results/findings of other NRAC-funded research? (Select all that apply)

- ❑ From a colleague(s) (1)
- ❑ Professional seminar/workshop (2)
- ❑ Professional meeting/conference or other presentation (3)
- ❑ Academic journal or newsletter (4)
- ❑ Trade publication (5)
- ❑ Best practices/management manual (6)
- ❑ Newspaper article (7)
- ❑ Fact Sheets from the NRAC website (8)
- ❑ Annual Reports from the NRAC website (10)
- ❑ NRAC Website (12)
- ❑ Other Website (specify) (13) _____
- ❑ Other (specify) (9) _____

Q42 Please list the names of websites and magazines you commonly use to keep up to date on the aquaculture industry?

1 (1)
2 (2)
3 (3)
4 (4)
5 (5)
6 (6)
7 (7)
8 (8)
9 (9)
10 (10)

Q43 What suggestions do you have for NRAC to ensure that the results/findings of your NRAC-funded research are publicized to and used by others?

Final Questions

Q44

Answer If What was your primary role in this NRAC project? Aquaculture industry Is Selected

Q45 How long have you been in business?

Answer If What was your primary role in this NRAC project? Aquaculture industry Is Selected

Q46 What is your annual gross revenue?

- ❍ Less than $10,000 (4)
- ❍ $10,001-$20,000 (5)
- ❍ $20,001-$30,000 (6)
- ❍ $30,001-$40,000 (7)
- ❍ $40,001-$50,000 (8)
- ❍ $50,001-$75,000 (9)
- ❍ $75,001-$100,000 (10)
- ❍ $100,001-$150,000 (11)
- ❍ $150,001-$200,000 (12)
- ❍ $200,001-$300,000 (13)
- ❍ $300,001-$400,000 (14)
- ❍ $400,001-$500,000 (15)
- ❍ $500,001-$1,000,000 (16)
- ❍ Over $1,000,000 (17)

Q47 Based on your experiences, how willing would you be to collaborate on another NRAC-funded project?

- ❍ Very willing (2)
- ❍ Somewhat willing (3)
- ❍ Not very willing (4)
- ❍ Not at all willing (5)

Answer If Based on your experiences, how willing would you be to collaborate on another NRAC-funded project? Not Very Willing Is Selected Or Based on your experiences, how willing would you be to collaborate on another NRAC-funded project? Not at all Willing Is Selected

Q48 Why not?

Q49 Tell us about you. Please select all the areas that describe you.

- ❑ Grower (1)
- ❑ Retail (2)
- ❑ Agency/government (3)
- ❑ Supplier (4)
- ❑ Distributor (5)
- ❑ Researcher (6)

Answer If Tell us about you. Please select all the areas that describe you. Grower Is Selected

Q50 Please categorize the area(s) you grow in?

- ❑ Freshwater (1)
- ❑ Marine (2)

Answer If Please categorize the area(s) you grow in? Marine Is Selected

Q51 With what marine species do work?

- ❑ Finfish (1)
- ❑ Mollusks (2)
- ❑ Algae (3)
- ❑ Echinoderms (4)
- ❑ Other (5) _____

Answer If Please categorize the area(s) you grow in? Freshwater Is Selected

Q52 What aspect(s) of working with Freshwater Finfish do you deal with?

- ❑ Food (4)
- ❑ Recreation (5)
- ❑ Live bait (6)
- ❑ Research/Instruction/Bioassay (7)
- ❑ Ornamental (8)
- ❑ Hatchery (9)
- ❑ Other (10) _____

Answer If With what species do work? Finfish Is Selected

Q53 What aspect(s) of working with Marine Finfish do you deal with?

- ❑ Food (4)
- ❑ Live bait (6)
- ❑ Research/Instruction/Bioassay (7)
- ❑ Ornamental (8)
- ❑ Hatchery (9)
- ❑ Other (10) _____

Answer If Please categorize the area(s) you grow in? Marine Is Selected And With what marine species do work? Mollusk Is Selected

Q54 What type(s) of Mollusks do you deal with?

- ❑ Oyster (12)
- ❑ Hard clam (13)
- ❑ Soft shell clam (14)
- ❑ Mussel (15)
- ❑ Sea scallop (16)
- ❑ Bay scallop (17)
- ❑ Hatchery (18)
- ❑ Restoration (19)
- ❑ Other (10) _____

Answer If Please categorize the area(s) you grow in? Marine Is Selected And With what marine species do work? Algae Is Selected

Q55 What type of Algae do you deal with?

- ❑ Macro (12)
- ❑ Micro (13)
- ❑ Other (10) _____

Answer If Tell us about you. Please select all the areas ta describe you. Retail Is Selected

Q56 Please categorize the specific areas of retail you work in?

- ❑ Restaurant (4)
- ❑ Seafood market (5)
- ❑ Store (6)
- ❑ Other (please specify): (3) _____

Answer If Tell us about you. Please select all the areas ta describe you. Supplier Is Selected

Q57 Please categorize the specific areas you work in as a supplier?

- ❑ Equipment manufacturer (4)
- ❑ Equipment sales (5)
- ❑ Other (please specify): (3) _____

Answer If Tell us about you. Please select all the areas ta describe you. Distributor Is Selected

Q58 Please categorize the specific areas you distribute to?

- ❑ Local (1)
- ❑ Interstate (2)
- ❑ Other (please specify): (3) _____

Answer If Tell us about you. Please select all the areas ta describe you. Agencies/government Is Selected

Q59 Please categorize the specific agency you work with?

- ❑ State agency (e.g. Dept. of Natural Resources) (1)
- ❑ NOAA (4)
- ❑ USDA (5)
- ❑ Other federal agency (please specify): (6) _____
- ❑ Other (please specify): (3) _____

Q60 Of the above categories, what are your primary, secondary, and tertiary foci?

Primary (1)
Secondary (2)
Tertiary (3)

Q61 If you have any additional comments, please leave them here.

Q62 Thank you for your participation. Please click "submit" to complete the survey.

Appendix B: Tier III - NRAC Evaluation Survey

Aquaculture Industry Survey Northeast Regional Aquaculture Center

Q1

On behalf of the Northeast Regional Aquaculture Center (NRAC) and in collaboration with the University of New Hampshire (UNH) Survey Center, the UNH Carsey School of Public Policy, and the UNH Department of Natural Resources and the Environment, Elizabeth Fairchild, Research Associate Professor in the Department of Biological Sciences seeks your participation in the following survey. This survey is designed to help us assess the impact NRAC-funded research projects have had on the aquaculture industry in the northeast.

From these results, research priorities will be identified and recommendations will be made to NRAC for future funding initiatives. The findings will be presented as de-identified data or aggregated, even in some cases where specific examples from particular projects are used. Additionally, there are rare instances when the researcher is required to share personally-identifiable information (e.g., according to law, policy, or regulations).

To adhere to the highest professional research standards, we request your consent to complete the following set of questions. Your participation is voluntary; you may refuse to answer any question and can stop at any time without penalty. We will not ask about regulated activities, personal information, or other sensitive matters. We do not anticipate any risks to you, and the benefits of this research may be to improve the NRAC funding process. We estimate that it will take less than 10 minutes for you to complete the questions.

If you have questions about your rights as a participant in research you may contact Julie Simpson at the UNH Research Integrity Services at 603-862-2003 or Julie.Simpson@unh.edu to discuss them. Please direct all other questions about this study to Elizabeth Fairchild at Elizabeth.Fairchild@unh.edu or call her at 603-862-4475.

The findings of the study will be available to all participants who request them by contacting Elizabeth.Fairchild@unh.edu.

If you do not wish to participate, simply close your browser. If you consent to participate, please click “Next”.

About Your Business

Q2 Please categorize the area(s) you grow in: (select all that apply)

- ❑ Freshwater (1)
- ❑ Marine (2)

Q3 What is the intended market for your product? (select all that apply)

- ❑ Food (1)
- ❑ Recreation (2)
- ❑ Live bait (3)
- ❑ Research/Instruction/Bioassay (4)
- ❑ Ornamental (5)
- ❑ Use by you or other aquaculture businesses (6)
- ❑ Other (please specify) (7) _____

Display This Question:
If Please categorize the area(s) you grow in? Marine Is Selected

Q4 What marine organisms do you raise? (select all that apply)

- ❑ Finfish (1)
- ❑ Shellfish (2)
- ❑ Algae (3)
- ❑ Echinoderms (4)
- ❑ Other (please specify) (5) _____

Display This Question:
If What marine species do you raise (select all that apply) Finfish Is Selected

Q5 Which marine finfish species do you raise?

Display This Question:
If Please categorize the area(s) you grow in? Marine Is Selected
And With what marine species do work? Shellfish Is Selected

Q6 What type(s) of Shellfish do you culture? (select all that apply)

- ❑ Oyster (1)
- ❑ Hard clam/Quahog (2)
- ❑ Soft shell clam (3)
- ❑ Mussel (4)
- ❑ Bay scallop (5)
- ❑ Razor clam (6)
- ❑ Other (please specify) (7) _____

Display This Question:
If Please categorize the area(s) you grow in? Marine Is Selected
And With what marine species do work? Algae Is Selected

Q7 What type of Algae do you culture? (select all that apply)
- ❑ Macro (1)
- ❑ Micro (2)
- ❑ Other (please specify) (3) _____

Display This Question:
If What type of Algae do you culture? (select all that apply) Macro Is Selected

Q8 Which macro algae species do you culture?
- ❑ Winged kelp - *Alaria esculenta* (1)
- ❑ Horsetail kelp - *Laminaria digitate* (2)
- ❑ Sugar kelp - *Saccharina latissimi* (3)
- ❑ Irish moss - *Chondrus crispus* (4)
- ❑ *Gracilaria* (5)
- ❑ Nori - *Porphyra/Pyropia* (6)
- ❑ Other (please specify) (7) _____

Display This Question:
If About Your Business Please categorize the area(s) you grow in? (select all that apply) Freshwater Is Selected

Q9 What freshwater organisms do you raise?
- ❑ Fish (1)
- ❑ Aquatic and terrestrial plants (2)
- ❑ Other (please specify): (3) _____

Display This Question:
If What freshwater species do you grow? Fish Is Selected

Q10 Which freshwater finfish species do you raise? (please use scientific names where possible)

Q11 What is percent production of each of the following in your business? (total must add up to 100)

_____ Marine finfish (1)
_____ Freshwater finfish (2)
_____ Shellfish (3)
_____ Echinoderms (4)
_____ Marine macro algae (5)
_____ Marine micro algae (6)
_____ Freshwater and terrestrial plants (7)
_____ Other (please specify) (8)

Q12 Please categorize the specific areas you sell to? (select all that apply)

- ❑ Within state (1)
- ❑ Interstate (2)
- ❑ International (3)
- ❑ Other (please specify): (4) _____

Q13 How long have you been ...

	Less than 2 years (1)	2 to 5 years (2)	6 to 10 years (3)	More than 10 years (4)
... in business? (1)	❍	❍	❍	❍
... involved in the aquaculture industry? (2)	❍	❍	❍	❍

Q14 In the past year (2016), has your business …

- ❍ Lost money (1)
- ❍ Broke even (2)
- ❍ Made a profit less than $50,000 (3)
- ❍ Made a profit more than $50,000 (4)
- ❍ Unsure/have not calculated (5)
- ❍ Have not sold any product yet (6)

Q15 What were the total gross value of sales made by your business in 2016?

- ❍ Less than $10,000 (1)
- ❍ $10,001-$20,000 (2)
- ❍ $20,001-$30,000 (3)
- ❍ $30,001-$40,000 (4)
- ❍ $40,001-$50,000 (5)
- ❍ $50,001-$75,000 (6)
- ❍ $75,001-$100,000 (7)
- ❍ $100,001-$150,000 (8)
- ❍ $150,001-$200,000 (9)
- ❍ $200,001-$300,000 (10)
- ❍ $300,001-$400,000 (11)
- ❍ $400,001-$500,000 (12)
- ❍ $500,001-$1,000,000 (13)
- ❍ Over $1,000,000 (14)

NRAC Projects

Q16 How much do you know about the Northeast Regional Aquaculture Center (NRAC)? (select all that apply)

- ❑ I have not heard of NRAC (1)
- ❑ I have heard of NRAC, but I am unsure of what they do (2)
- ❑ I know of a project or two funded by NRAC, but have no direct involvement (3)
- ❑ I have used some of the products or techniques that came from NRAC funded projects (4)
- ❑ I have been involved with an NRAC funded study (5)
- ❑ I have been a major contributor to an NRAC funded study (6) _____
- ❑ I have been a Principal Investigator in an NRAC funded study (7) _____
- ❑ I have been a participant on the NRAC Industrial Advisory Committee (8)

Q17 Has your company benefited from any of the following? Please check all that have benefited your company.

If What type(s) of Shellfish do you culture? Is Blank
If What type(s) of Shellfish do you culture? Is Bay Scallop
If What type(s) of Shellfish do you culture? Is Mussel
If What type(s) of Shellfish do you culture? Is Oyster
If What type(s) of Shellfish do you culture? Is Hard clam/Quahog
If What type(s) of Shellfish do you culture? Is Razor clam

- ❑ Using probiotic bacteria products to improve survival of larval shellfish reared in hatcheries (1)

If What type(s) of Shellfish do you culture? Is Blank
If What type(s) of Shellfish do you culture? Is Razor clam

- ❑ New razor clam hatchery and grow-out methods or information gained from Razor Clam Roundtable meetings (2)

If What type(s) of Shellfish do you culture? Is Blank
If What type(s) of Shellfish do you culture? Is Hard clam/Quahog

- ❑ Using QPX-resistant hard clam strains (4)

If What type(s) of Shellfish do you culture? Is Blank
If What type(s) of Shellfish do you culture? Is Oyster

- ❑ Learning safe handling methods of oysters from harvest to plate to minimize Vibrios? For example, using better insulated shipping boxes, or pre-cooling oysters or boxes before shipping (5)

❑ If What type(s) of Shellfish do you culture? Is Blank
❑ If What type(s) of Shellfish do you culture? Is Bay Scallop
❑ If What type(s) of Shellfish do you culture? Is Mussel
❑ If What type(s) of Shellfish do you culture? Is Oyster
❑ If What type(s) of Shellfish do you culture? Is Hard clam/Quahog
❑ If What type(s) of Shellfish do you culture? Is Razor clam

- ❑ Using shellfish STEM-GIS (Shell-GIS) software to assist in farm site selection or shellfish seeding times and density (6)

If What type(s) of Shellfish do you culture? Is Blank
If What type(s) of Shellfish do you culture? Is Mussel

❑ Information on mussel farming from workshops or meetings, fact sheets, or hands-on training of seed or socking machines (7)

Everyone

❑ Outreach services to develop HACCP health risk plans and minimize aquaculture health hazards (8)

If What type(s) of Shellfish do you culture? Is Blank
If What type(s) of Shellfish do you culture? Is Mussel
If What type(s) of Shellfish do you culture? Is Marine finfish

❑ Growing mussels to reduce finfish pathogens (i.e., infectious salmon anemia virus, Vibrio) or sea lice transmission, or for a value-added product in an IMTA system (9)

If What type(s) of Shellfish do you culture? Is Blank
If What type(s) of Shellfish do you culture? Is Hard clam/Quahog

❑ Higher overwintering survival of hard clam seed by using cold-hardy stocks or field planting (10)

If What type(s) of Shellfish do you culture? Is Blank
If What type(s) of Shellfish do you culture? Is Oyster

❑ Using disease resistant lines of cross-bred Eastern oysters (11)

Everyone

❑ Information from NAEN (Northeast Aquaculture Extension Network) or the NEA Research Farm Network? For Example: State Aquaculture Situation and Outlook Reports, Fact Sheets, workshops/meetings such as the Milford Aquaculture Seminar, East Coast Commercial Fishermen's and Aquaculture Trade Exposition, or Annual Meeting of the National Shellfisheries Association (12)

If What type(s) of Shellfish do you culture? Is Blank
If What type(s) of Shellfish do you culture? Is Bay Scallop

❑ Learning that bay scallops are not good candidates for tetraploid technology (13)

Everyone

❑ Using Best Management Practice (BMP) guide for aquaculture or biosecurity training (14)

If What type(s) of Shellfish do you culture? Is Blank
If What type(s) of Shellfish do you culture? Is Mussel

❑ Using an underwater sound buoy to decrease duck predation of blue mussels (15)

If What type(s) of Shellfish do you culture? Is Blank
If What type(s) of Shellfish do you culture? Is Oyster

❑ Using JOD-resistant oyster lines, such as NEH (16)

If What type(s) of Shellfish do you culture? Is Blank
If What type(s) of Shellfish do you culture? Is Bay Scallop
If What type(s) of Shellfish do you culture? Is Mussel
If What type(s) of Shellfish do you culture? Is Oyster
If What type(s) of Shellfish do you culture? Is Hard clam/Quahog
If What type(s) of Shellfish do you culture? Is Razor clam

❑ Using an Environmental Code of Practice (Code) or Best Management Practices (BMPs) for shellfish growers (17)

If What type(s) of Shellfish do you culture? Is Blank
If What type(s) of Shellfish do you culture? Is Oyster

- ❑ Using Dermo-resistant oyster strains (18)

If What marine species do you raise? Other Is Selected

- ❑ Green sea urchin grow-out strategies (tank farming vs. sea ranching) (19)

If Freshwater Is Selected Or
If What marine species do you raise? Finfish Is Selected

- ❑ Learning about the susceptibility of finfish to and the prevention of Viral Hemorrhagic Septicemia Virus (VHSV Ivb) (20)

If What marine species do you raise? Finfish Is Selected

- ❑ New research using marine striped bass broodstock (21)

If What marine species do you raise? Finfish Is Selected

- ❑ Outreach on cod, steelhead trout, or striped bass raised in net pen systems (22)

If What marine species do you raise? Finfish Is Selected Or
If Freshwater Is Selected Or
If What marine species do you raise? Other Is Selected

- ❑ Using aquatic ornamental plants for nutrient removal or as a secondary crop in fish farming systems (23)

If What marine species do you raise? Finfish Is Selected

- ❑ Using Atlantic salmon families resistant to ISAV and sea lice (24)

If Freshwater Is Selected

- ❑ Using plastic "U" shaped tanks for finfish culture instead of concrete tanks (25)

If What marine species do you raise? Finfish Is Selected

- ❑ Using probiotic bacteria to prevent disease outbreaks in fish farming operations (27)

This Section Repeats for Every Phrase Selected

Q18 The following questions ask about the impact on your business from the results of the following project: ***${lm://Field/1}***

Q19 How did the product or technique affect your business?

	Increase (1)	Decrease (2)	No Change (3)	Don't Know (4)
Efficiency (1)	❍	❍	❍	❍
Diversification of services or products (2)	❍	❍	❍	❍
Networking (e.g., with extension personnel, other growers, scientists, regulators, etc.) (3)	❍	❍	❍	❍
Product survival (4)	❍	❍	❍	❍
Product growth or time to market (5)	❍	❍	❍	❍
Marketability (6)	❍	❍	❍	❍
Product quality (7)	❍	❍	❍	❍
Other (specify): (8)	❍	❍	❍	❍

Q20 How has this project impacted your business financially?

- ❍ It has had no impact on my company's profitability (1)
- ❍ It has made my business somewhat more profitable (2)
- ❍ It has made my business significantly more profitable (3)
- ❍ It has cost my business, but I expect it will pay off in the future (4)
- ❍ It has cost my business money that I don't expect to recoup in the future (5)
- ❍ Don't Know (6)

Answer If It has made my business somewhat more profitable Is Selected Or
It has made my business significantly more profitable Is Selected

Q21 How much did your revenues increase over 1 year?

- ❍ 0-10% (1)
- ❍ 11-20% (2)
- ❍ 21-30% (3)
- ❍ 31-40% (4)
- ❍ 41-50% (5)
- ❍ 51-60% (6)
- ❍ 61-70% (7)
- ❍ 71-80% (8)
- ❍ 81-90% (9)
- ❍ 91-100% (10)
- ❍ 101-150% (11)
- ❍ 151-200% (12)
- ❍ 201-300% (13)
- ❍ 301-400% (14)
- ❍ 401-500% (15)
- ❍ 501-750% (16)
- ❍ Over 750% (17)

Q22 Has your number of employees changed due to the use of this project?

- ❍ Yes (1)
- ❍ No (2)
- ❍ I don't know (3)

Display This Question:
If Has the number of employees changed as a result of this research? Yes Is Selected

Q23 How many employees did you have ...

	... before the project? (1)	... after the incorporation of project findings? (2)
Part time for one season (1)		
Part time for more than one season (2)		
Part time year round (3)		
Full time for one season (4)		
Full time for more than one season (5)		
Full time year round (6)		
Other (Specify) (7)		

Q24 In your opinion, what was the economic impact of this project on your segment of the aquaculture industry?

- ❍ Critical to its future (4)
- ❍ Very important, but not critical (5)
- ❍ Somewhat important (6)
- ❍ Not too important (7)
- ❍ Negative/detrimental impact (8)
- ❍ Don't know/Not sure (9)

Other Research (Asked of Everyone)

Q25 Are you aware of any other research projects that have made your business more successful?

- ❍ Yes (1)
- ❍ No (2)
- ❍ Not Sure (3)

Display This Question:
If Are you aware of any other research projects that have made your business more successful? Yes Is Selected

Q26 Please describe the research findings, where conducted, and name the researcher, if known.

Display This Question:
If Are you aware of any other research projects that have made your business more successful? Yes Is Selected

Q27 Specifically, how did this research help your business?

Display This Question:
If Other Research Are you aware of any other research projects that have made your business more suc... Yes Is Selected

Q28 How did these other research projects affect your business?

	Increase (1)	Decrease (2)	No Change (3)	Don't Know (4)
Efficiency (1)	❍	❍	❍	❍
Profitability (2)	❍	❍	❍	❍
Diversification of services or products (3)	❍	❍	❍	❍
Networking (with extension personnel, other growers, scientists, regulators, etc.) (4)	❍	❍	❍	❍
Product survival (5)	❍	❍	❍	❍
Product growth or time to market (6)	❍	❍	❍	❍
Marketability (7)	❍	❍	❍	❍
Product quality (8)	❍	❍	❍	❍
Other (specify): (9)	❍	❍	❍	❍

Aquaculture Industry Resources

Q29 Where do you get information about research that impacts your business? (select all that apply)

- ❑ NRAC Final report (1)
- ❑ Seminar/workshop (2)
- ❑ Peer reviewed journal article (3)
- ❑ Aquaculture industry publication (4)
- ❑ Best practices/management manual (5)
- ❑ Policy document/plan (6)
- ❑ Newspaper article (7)
- ❑ Aquaculture industry trade conference presentation (8)
- ❑ Informational website (9)
- ❑ Network or alliance (10)
- ❑ Collaborative partnership with researchers (11)
- ❑ Technical assistance and capacity-building (Cooperative Extension) (12)
- ❑ Testimony (e.g. Congressional) (13)
- ❑ NRAC website (14)
- ❑ Extension/Sea Grant aquaculture specialists (15)
- ❑ Other Regional Aquaculture Centers (16)
- ❑ Facebook or other social media (17)
- ❑ Other (Specify) (18) _____

Q30 What is the BEST way to inform you about research that might impact your business?

- ❍ NRAC Final report (1)
- ❍ Seminar/workshop (2)
- ❍ Peer reviewed journal article (3)
- ❍ Aquaculture industry publication (4)
- ❍ Best practices/management manual (5)
- ❍ Policy document/plan (6)
- ❍ Newspaper article (7)
- ❍ Aquaculture industry trade conference presentation (8)
- ❍ Informational website (9)
- ❍ Network or alliance (10)
- ❍ Collaborative partnership with researchers (11)
- ❍ Technical assistance and capacity-building (Cooperative Extension) (12)
- ❍ Testimony (e.g. Congressional) (13)
- ❍ NRAC website (14)
- ❍ Extension/Sea Grant aquaculture specialists (15)
- ❍ Other Regional Aquaculture Centers (16)
- ❍ Facebook or other social media (17)
- ❍ Industry Association listserv (18)
- ❍ Other (Specify) (19) _____

Q31 What are the most important factors that have led to the success of your business?

1. (1)
2. (2)
3. (3)

Q32 What are the greatest barriers to the success of your business?

1. (1)
2. (2)
3. (3)

Q33 If you have any additional comments, please leave them here.

Q34 Thank you for your participation. Please click "submit" to complete the survey.