Project Title: Assessing the Effectiveness of NCRAC Funded Research in Aquaculture Within the North Central Region [Termination Report]

Total Funds Committed: $74,722
Initial Project Schedule: September 1. 2020-August 31, 2021 [Extended to December 31, 2022]
Current Project Year: September 1, 2021-August 31, 2023
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Project Objectives

1. Review the effectiveness of NCRAC-funded projects.
    a. Conduct a comprehensive literature and document review of all NCRAC-funded projects since 1994.
    b. Identify anticipated project outcomes, impacts, and benefits from proposals.
    c. Identify reported outputs and outcomes from final reports and compare with that proposed.
2. Identify outcomes generated on aquaculture farms in the region; summarize and describe lessons learned.
    a. Web-based (Qualtrics) survey of all NCRAC aquaculture producers to identify which project outputs, outcomes, and impacts were of benefit to them.
3. Evaluate the effectiveness of project approaches to promote solutions for aquaculture source problems; provide examples where the NCRAC funding mechanisms have worked synergistically or where they have failed to develop synergies.
4. Deliver results of the synthesis to NCRAC, the science community, and relevant stakeholder groups

Project Summary

Since its inception in 1988, the North Central Regional Aquaculture Center (NCRAC) has funded numerous projects that have supported Extension services in the North Central Region (NCR) and addressed a wide range of topics including fish health, aquaponics, economics, pond management, and more. NCRAC-funded projects are performed with the intent of generating some form of beneficial impact on the aquaculture industry within the region. Examining whether NCRAC-funded projects have been attaining their intended purposes is important to ensuring NCRAC-funded projects are effective, and to assessing how these projects are improving and advancing the aquaculture industry in the NCR. Further, understanding the effectiveness of NCRAC-funded projects is critical to the planning and development of future research and Extension projects and programs. This project reviewed all NCRAC-funded projects between 1988 and 2019. Information obtained from the projects was used to develop a survey to elicit information on the benefits and impacts of the projects on aquaculture businesses in the NCR from aquaculture producers in the region. Results suggested that through NCRAC-funded projects, aquaculture farms in the NCR had gained awareness of a number of aquaculture-related issues, had adopted NCRAC project recommended practices, and those practices had contributed positively to improve production efficiencies and profitability of their businesses. Nevertheless, there are still some important issues that NCRAC needs to address to improve its activities or increase its support for aquaculture farms in the region.

Anticipated Benefits

The anticipated benefits of this work are knowledge gained on which NCRAC funded research and Extension projects had the greatest benefit to industry and why, which project approaches were more effective and why, and which NCRAC funded projects produced synergies and why. This information will be helpful to the planning and development of future NCRAC funded research and Extension projects and to the research and Extension community in the development of programs to maximize their impacts. This project will gauge the effectiveness of NCRAC-funded research and programs, and more importantly, assess how to improve them for the future to maximize the benefit to industry. Furthermore, the information produced by this study would allow for a more targeted approach to the quantification of NCRAC-funded research and Extension through an economic impact assessment in the future. Having information on which projects resulted in the greatest benefits to the region would allow for in-depth investigation of the quantitative effects of those activities and outcomes on industry within the NCRAC region.

Project Progress

Specific progress on each objective follows.

Objective 1. — A total of 125 projects were identified as projects that were funded by NCRAC between 1988 and 2019. Proposals and reports for two projects were not available. This means that either the proposals and/or reports of 123 of the 125 projects were accessible. However, brief descriptions and objectives of each of the 125 projects could be retrieved from the NCRAC website. A spreadsheet was developed to report the following metrics from each funded proposal when available: 1) project title and short descriptor of type of problem addressed; 2) category of the problem (i.e., fish health, extension, nutrition, aquaculture production, etc.); 3) species targeted; 4) objectives; 5) approaches planned; 6) outputs and deliverables planned; 7) anticipated benefits and impacts; 8) project budgets; 9) project investigators or participants and their institutions; 10) Extension liaisons; 11) industry advisory council liaisons; and 12) non-funded collaborators. The following were recorded from the final project reports when available: 1) any change in species targeted; 2) any change in approaches used; 3) outcomes and accomplishments reported; 4) benefits and impacts reported; 5) recommended follow-up activities; 6) reason for project termination; and 7) synergies identified. The spreadsheet also contains information on project start and end dates, whether there was an explicit extension component of the project, and an indication of the availability of proposals and project reports. Finally, a link to each funded project is provided in the spreadsheet.

Results showed that NCRAC has channeled a total of $13,798,880 towards the 125 projects. The 125 projects included: 1) Extension /education-related projects (n=31); 2) national aquaculture Investigational New Animal Drug/New Animal Drug Applications (INADs/NADAs) (n=2); 3) conferences/workshops/symposia (n=9); 4) white papers (n=2); 5) aquaculture drugs (n=11); 6) nutrition/diets (n=8); 7) VHS (n=1); 8) waste effluent (n=3); 9) aquaponics (n=1); 10) economics and marketing (n=8); 11) hybrid striped bass (n=7); 12) largemouth bass (n=2); 13) baitfish (n=2); 14) crayfish (n=1); 15) tilapia (n=2); 16) salmonids (n=4); 17) sunfish (n=6); 18) walleye (n=8); 19) yellow perch (n=12); and 20) others (n=5).

The top six project categories with the highest funding received over $1 million each, with yellow perch projects having the highest funding at over $1.96 million followed by Extension/education projects ($1.74 million) and walleye projects ($1.15 million). However, combining NCRAC's 'base' Extension projects and other Extension/education projects revealed that NCRAC spent more on Extension-related projects ($2.87 million) than any other project category during the study

period (Appendix Table A1). Funding amounts for six projects obtained from NCRAC's website were slightly different from what was reported in NCRAC's 2019 compendium. The difference in funding amount ranged from $1-$1,344 across the six projects. For consistency, funding amounts in Table A1 and the spreadsheet were kept the same as the amounts in the compendium, but the six projects with discrepancies in their funding amounts were noted in the spreadsheet.

Results showed that 46% (n=57) of the 125 projects did not focus on specific fish species, while 54% (n=68) focused on specific fish species or organisms. The majority (72%, n=41) of projects that did not target specific species were Extension projects and conferences/workshops/symposia funded by NCRAC. This was not surprising because most of the Extension projects broadly focused on developing strategies and educational programs to strengthen linkages between NCRAC and other aquaculture governing bodies and Extension work groups and enhancing aquaculture information transfer without focusing on specific species. Targeted species proposed were used in executing each research, but for one nutritional project that used zebrafish after proposing to use yellow perch and largemouth. While there were some changes in parts of the approaches planned in some projects, generally, each project was executed following the proposed approach. Among the 123 projects with accessible proposals and/or reports, 88% (n=108), 61% (n=75), and 50% (n=61), respectively explicitly identified at least one Extension liaison, industry advisory council liaison, and non-funded collaborator as a participant.

The number of outputs and deliverables (e.g., workshops/seminars, thesis/dissertation, hands-on training, bulletins, videos, newsletters, etc) were provided in the spreadsheet when traceable. In most reports, readers are directed to access deliverables such as publications, manuscripts, workshops, and conferences from a cumulative output for all NCRAC-funded projects in NCRAC's appendix of research publication. However, it was difficult to link individual outputs and deliverables to specific projects (125 projects) because the appendix contained a cumulative output for all NCRAC-funded activities. The inability to link outputs to specific projects made it difficult to identify which problem categories yielded greater outcomes and whether the proposed outputs were attained. However, a content analysis of the 2022 appendix indicated that NCRAC-funded projects have resulted in several scholarly presentations and publications that communicate and transfer aquaculture-related information to stakeholders, including: (1) 190 journal articles; (2) 56 fact sheets; (3) 29 bulletins; (4) 34 manuals/guides; (5) 21 videos/CDs; (6)11 white papers; (7) 10 books/book chapters (8) 7 website/online articles; (9) 6 monitoring sheets; and (10) 23 other publications. NCRAC-funded projects have also supported the education of some graduate students which was evident through 41 theses/dissertations.

Objective 2. — The survey analysis showed that through NCRAC-funded projects, NCR aquaculture producers had gained awareness of a number of issues, had adopted NCRAC project recommended practices, and those practices had contributed positively to improve production efficiencies and profitability of their businesses. NCRAC-funded Extension meetings and materials were key sources of aquaculture information for most respondents. Twenty-one to 73% of those who had participated in some type of Extension meeting listed NCRAC as the organizer. High percentages of survey respondents who participated in NCRAC-sponsored Extension meetings in the region and used NCRAC-sponsored Extension materials found the information presented to be applicable; of those who did report it to be applicable, the majority reported having adopted it on their farms, and that it resulted in positive impacts on various aspects of their businesses, such as improving production efficiency, fish growth, fish survival, and overall production. The majority of respondents who had reached out to Extension agents in the NCR revealed that it was easy to get hold of Extension personnel. This reflects the impact of NCRAC's effort to make aquaculture Extension specialists easily accessible in the region.

Information shared from NCRAC-sponsored projects had increased producer awareness of

important aspects of the production of the species they raised. High percentages of respondents who raised yellow perch, walleye/hybrid walleye, sunfish, trout, tilapia, and baitfish were familiar with information on culture technologies of the species they raised and had adopted the recommended culture technologies. Data from the Census of Aquaculture shows that the value of sales of yellow perch, walleye, largemouth bass, tilapia, and trout in the NCR have increased in the last two decades (USDA 2018). Growth in yellow perch and walleye farming in the NCR in the last two decades can partly be attributed to NCRAC's investment in yellow perch and walleye farming methods. While many factors affect market demand and increasing prices over time have contributed to increased sales, the availability of farming technologies for these species developed by NCRAC likely contributed to this growth in sales. The number of aquaculture farms has decreased in the NCR as it has nationally, likely driven by economies of scale common in aquaculture production and marketing.

NCRAC's VHS and AIS-HACCP educational programs and training made respondents aware of VHS and AIS-HACCP principles. Most respondents tested their fish regularly for VHS and disinfected their farm equipment and employee clothing and footwear regularly after they had become aware of VHS. Implementing AIS-HACCP principles helped 31% of respondents to fulfill the needed requirement to operate their businesses and helped the majority of respondents to reduce the risk of their farms spreading AIS.

The highest percentage of our respondents who had participated in some type of Extension meeting found fish health-related topics shared at the Extension meetings to be applicable to their businesses. NCRAC has committed some of its resources to prevent fish diseases and improve fish health management on aquaculture farms in the region by sponsoring projects that focused on areas like fish drugs, fish nutrition and feeding, and VHS. Partly due to NCRAC's research efforts, several aquaculture drugs have been approved and have been adopted by producers in the region. The survey results showed that the use of oxytetracycline to control *Aeromonas* spp, Chloramine-T to control gill disease, hydrogen peroxide as a parasiticide, MS-222 as an anesthetic, and formalin as a fungicide/parasiticide which were approved in part of NCRAC's drug approval projects and efforts had been adopted by over a quarter (33-58%) of respondents.

Objective 3. — Based on analysis of survey responses and knowledge of project investigators about the NCR aquaculture industry, the following project approaches were found to be effective: (1) Extension projects; (2) projects with strong engagement of Extension from conception to termination; (3) culture method projects; and (4) quick response to a major farm level issue in the region—for example, VHS.
Fifty-nine of the 125 funded projects were financed synergistically, attracting an additional $12.1 million in leveraged funding support from other federal agencies, universities, and other industry stakeholders. Universities, federal agencies, and industry stakeholders supported NCRAC projects with $8.46 million, $1.57 million, and $1.42 million, respectively, between 1988 and 2019. Six hundred and seventy-one thousand was also provided by other stakeholders during that period. Collectively, seven yellow perch projects that aimed at advancing yellow aquaculture received about $2.47 million from other sponsors. Six other project categories (salmonids, sunfish, walleye, conferences/workshops/symposia, base Extension, and waste and effluent) received over $1 million each in funding awards from other sponsors (Appendix Table A2).

Objective 4. — A workshop (webinar) was organized on August 24, 2022, to share results of objectives 1 and 2 with stakeholders. Participants of the webinar included NCRAC officials, researchers, and aquaculture producers. Results will also be shared at the NCRAC annual meeting (February 14-16, 2023, Wisconsin), NCR aquaculture conference (February 17-18, 2023, Wisconsin), and aquaculture America (February 23-26, 2023, Louisiana). A synthesis report that summarizes project methods and results has been developed. Furthermore, a fact sheet and an

infographic summarizing overall project results are in preparation.

Outreach Overview
See objective 4.

Target Audiences
The target audience for the efforts in this project are NCRAC organization members, research and Extension faculty within the North Central Region, and aquaculture industry members within the North Central Region.

Deliverables (Outputs)
See Objectives 1-4 under project progress.

Outcomes/Impacts
- Provides NCRAC with insights on the funded projects that have been beneficial for aquaculture producers in the NCR.
- Identified additional priority needs of aquaculture producers in the NCR for future research and Extension projects.
- Provides recommendations for NCRAC to improve its activities to further increase its research and Extension support for aquaculture businesses.

Recommended Follow-Up Activities:

❖ ***Programmatic Recommendations***

1. Continued recent enhanced support for Extension projects and specialists to further increase Extension presence and direct farm level support through farm visits and timely response to farmer problems.
2. Effective integration and engagement of Extension from initial planning and conception through pre- and full- proposal development and throughout all phases of project implementation. Researchers should first approach Extension agents to identify high priority industry needs, and be willing to write proposals that address industry needs even if it requires involving other collaborators outside their disciplines and/or outside their region.
3. There is a need to clarify the core mission of NCRAC internally. There are different perspectives within NCRAC as to whether its mission is to primarily develop new aquaculture businesses or to support existing aquaculture businesses with their problems, or some mix of the two. There should be repeated clear guidance from the NCRAC office and BOD on the core mission, goals, and objectives of NCRAC, including being sent with invitation to meetings and reminders prior to meetings.
    i. The discussions around the core mission of NCRAC should include that of how to balance the needs of the various species groups in the region, especially the major species groups of trout, baitfish, and sportfish, with those of other sectors. As reference, Shell (1983) recommended that research portfolios should focus 75% of research efforts on solving immediate, day-to-day problems, 20% to problems expected 3 to 5 years in the future, and 5 to 10% on basic problems with little immediate application.
4. Create orienting and on-boarding package for people new to NCRAC and there should also be a condensed version for those seeking membership of NCRAC, including IAC, TC, and BOD. In addition to on-boarding materials, there should be an orientation meeting between those who are new to NCRAC, the Director of NCRAC, TC chairs, and chair of IAC.
5. NCRAC needs to strengthen and increase cooperation among Extension agents, researchers, and producers not only in listening sessions but in identification of specific regional

aquaculture needs. Greater effort is needed to design projects on industry needs with which producers are willing to collaborate through on-farm trials.

6. Furthermore, researchers should be required to share progress through quarterly meetings with the industry and Extension liaisons on the project, and project results summarized through appropriate Extension deliverables.

7. Enhanced communication
    i. There is a need for greater communication within NCRAC, within the NCR, with the aquaculture community outside the region, and with the public. The NCRAC website needs to be an updated repository of information, accompanied by email (and potentially other social media) notices that go out frequently on: 1) notices of projects funded; 2) notices of termination reports posted recently on the website; 3) notices of new postings of project outputs on the website, including recently published journal articles, fact sheets, videos, webinar recordings, etc.; and 4) press releases of significant findings. P.I.'s should be expected to provide notification of the availability of these materials for posting on the website.
    ii. There is a need for a variety of approaches or formats of outputs that are used to deliver information to farmers. The most preferred way for survey respondents to receive new information was from workshops and conferences, followed by fact sheets, and email notices that should form the backbone of an expanded communications program, and revitalization of listservs in the region, including NCRAC listservs.
    iii. There is a need for more communication with the general public to increase awareness of aquaculture related issues in the region.
    iv. To enhance collaboration within the region, an inventory of research and Extension capacity, including facility and expertise should be developed and made available throughout the region.
    v. NCRAC should list contact information of aquaculture Extension agents in the region, their specialties, and the areas they oversee on the NCRAC website. Forty-two percent of survey respondents who reported not having reached out to Extension agents indicated that they did not have contact information for Extension agents.
    vi. NCRAC should continue to provide links to the other RACs on the NCRAC website. Survey results showed that NCR producers solicited information not just from NCRAC but from other RAC websites also, including reaching out to Extension agents outside the NCR.

8. Measures to reduce the regulatory burden on aquaculture businesses in the NCR are needed. Regulations were the primary barrier to the success of most of respondent's businesses. NCRAC should work closely with NCR aquaculturists to identify how the Center can assist aquaculturists to meet regulations requirements for their businesses without difficulties. Researchers can address scientific questions relevant to policy options and Extension specialists can provide summaries of scientific research and facilitate meetings between regulators and producers. Out of cycle funding and other leveraged funds could be used for Extension specialists to engage with stakeholders relative to changes made to the regulatory environment. NCRAC should form a committee (consisting of producers, researchers, and Extension agents) that will identify which regulatory issues to address and the best mechanisms that can be used to address regulatory issues in the region. Recent studies have reported that regulatory enforcement results in increased production costs and lost revenues in aquaculture operations (van Senten et al. 2018; Engle et al. 2019; van Senten et al. 2020).

9. There is a need to develop an on-going impact-monitoring program that can lead to economic estimates of impacts. The end point of a NCRAC project needs to be more than publication of a journal article or fact sheet. A committee should be formed within NCRAC to develop a set of guidelines that require P.I.'s to include metrics for evaluation of the impact of the project, for pre-proposal and full proposals, and then report on the metrics in annual reports and termination reports. An impact monitoring program could include short surveys administered at local and regional meetings that ask whether farmers are interested in more information on project results, and whether they have adopted and used results of previously funded NCRAC projects and how it affected their farms.
10. NCRAC should continue to organize and host its regional aquaculture conferences and seminars. Consideration should be given to expanding these to reach more states in the region; producers requested such meetings in all 12 states. NCRAC could offer to send a representative on an ongoing basis to state aquaculture association meetings to give updates of NCRACs activities.

❖ ***Procedural Recommendations***

- The main limitation of this study was the difficulty in tracing all outputs associated with funded projects. It is recommended that lists of all outputs (journal articles, fact sheets, etc.) be included in the termination reports posted on the website in addition to including them in the listing of all outputs over time. A process needs to be put in place to send annual requests to P.I.'s of previously completed projects to provide details of publications and outputs from projects that occurred after the official ending date of the project. This could consist of either the Director or the Administrative officer sending the request out on an annual basis. The updated list of publications and outputs should then be posted on the same page on the website as the already posted termination reports.
- Fact sheets were reported to be widely used as well as the NCRAC website. Attention needs to continue to be paid to maintaining the NCRAC website up-to-date as a repository of NCRAC information, including maintaining fact sheets current. NCRAC should continue to emphasize the preparation of fact sheets from each completed project accompanying the termination report.
- All project funding amounts posted on the NCRAC website should be crosschecked to ensure accuracy and consistency across termination reports, compendiums, appendices, and other relevant documents.

Impacts Summary

Relevance. — From its inception, NCRAC has funded in excess of 112 research and Extension projects. Each of these projects was performed with the intent of generating some form of beneficial impact on the aquaculture industry within the region. This study provided an assessment of these projects.

*Respons*e. — A comprehensive literature review of NCRAC funded research from 1994 to 2019. In addition to a survey of NCRAC region aquaculture producers to identify which NCRAC funded projects or activities have been beneficial to industry.

Results. — This study contributed to the understanding of which projects have resulted in improved productivity and profitability of aquaculture in the North Central Region. Growth of yellow perch and walleye aquaculture production, in particular, was enhanced through NCRAC funded projects.

Recap. — This study had shown that NCRAC funding attracted a similar level of supplemental funding to address several industry priorities, resulting in improved productivity and profitability

of aquaculture in the region.

Publications, Manuscripts, Workshops, and Conferences

Engle, C. R., J. van Senten, and G. Fornshell. 2019. Regulatory costs on US salmonid farms. Journal of the World Aquaculture Society, 50(3):522-549.

Shell, E.W. 1983. Fish Farming Research. Alabama Agricultural Experiment Station, Auburn University, Auburn, Alabama.

United States Department of Agriculture-National Agricultural Statistics Service (USDA-NASS). 2018. 2018 Census of Aquaculture. Available: https://www.nass.usda.gov/Publications/AgCensus/2017/Online_Resources/Aquaculture/index.php (March 6, 2022)

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