

Bridging Extension and Industry Needs in Northeastern United States Aquaculture to Strengthen Competency Development

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Abstract

Aquaculture extension and outreach professionals in the Northeastern United States are working in a sector shaped by evolving industry needs, workforce turnover, and complex position requirements. This study employed a mixed-methods design to converge findings from an extension competency assessment, an aquaculture industry needs assessment, and an evaluation of a professional development program targeting aquaculture extension professionals. Across these data sources, aquaculture extension professionals identified priority gaps in constituent engagement, project management, external funding, meeting facilitation, behavior change, and evaluation. Industry respondents identified disease management and regulatory navigation as the highest-priority extension support topics and reported generally positive satisfaction with extension services. Professional development participants self-reported increased knowledge across meeting facilitation, program evaluation, and engaging underrepresented communities, as well as improved regional connectedness. Findings provide baseline evidence that can inform aquaculture extension onboarding, professional development, and regional network-building. We recommend that aquaculture extension leaders and educators prioritize professional development in facilitation, evaluation, and stakeholder engagement, expand training on disease management and regulatory navigation, strengthen regional networking opportunities, and incorporate industry- and field-based learning experiences into their future extension competency development.

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Introduction and Problem Statement

The global aquaculture industry is a major contributor to economic development and food security, with global fisheries and aquaculture production reaching 223.2 million tons in 2022 and projected to continue increasing over the next decade (Food and Agriculture Organization of the United Nations [FAO], 2024). The United States (US) Northeast (NE) Region accounts for 40% of the country's marine aquaculture sales (National Marine Fisheries Service, 2022). A well-developed aquaculture sector provides safe, nutritious, sustainable seafood, creates employment and business opportunities, and can improve community-wide resilience (Engle et al., 2025). Extension education and advisory services have played a critical role in NE aquaculture development (Fairchild et al., 2017), notably via Cooperative Extension and Sea Grant Programs. In recent years, the NE aquaculture extension workforce has experienced substantial turnover due to retirements and the hiring of new professionals. Limited transfer of institutional knowledge and industry relationships may constrain newer professionals' ability to address industry needs (Fairchild et al., 2017).

To help address this challenge, the United States Department of Agriculture funded the Northeastern Regional Aquaculture Center (NRAC) to revitalize the Northeast Aquaculture Extension Network (NAEN), a collaborative of aquaculture extension (and outreach) professionals working to strengthen regional aquaculture extension capacity. Notably, the NAEN carried out both extension and industry needs assessments and designed a professional development program with the aim of enhancing extension professionals' preparedness to support industry needs while building competencies for career success. This study utilizes a convergent mixed-methods approach to examine the NAEN's holistic effort, providing a foundational understanding of NE US aquaculture industry needs, how extension is meeting those needs, and what areas of professional development are needed to further extension's ability to assist the industry.

Theoretical and Conceptual Framework

This study was guided by a competency-based professional development framework. Competency-based professional development frameworks emphasize identifying context-specific competencies and using needs assessments to guide curriculum and professional development (Harder et al., 2010; Lakai et al., 2014; Suvedi & Kaplowitz, 2016). Literature has broadly suggested that impactful extension depends on competencies in communication, facilitation, program development, evaluation, and stakeholder engagement (Suvedi & Kaplowitz, 2016).

This study addresses two competency-development priorities identified in previous research: the unique competency needs of aquaculture extension professionals and the importance of supporting early-career professionals through targeted needs assessment and professional development (Carlton et al., 2023; Diaz et al., 2020; Schwarz & Gibson, 2010). Needs assessment techniques, targeting educators and/or stakeholders, have been recommended as a

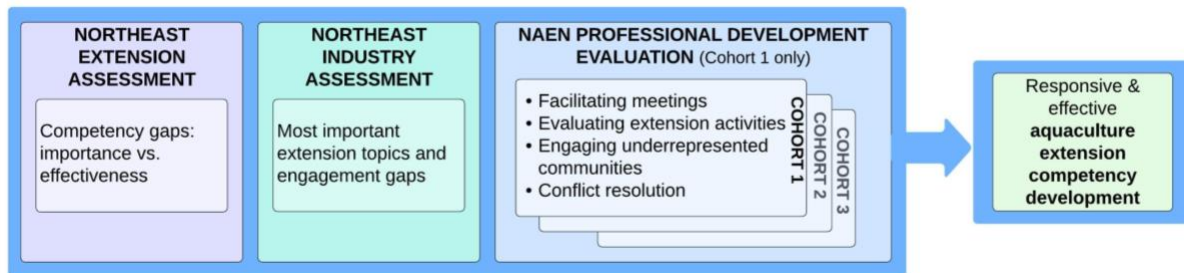
foundational step in addressing both aquaculture-specific and entry-level competencies (Lakai et al., 2014; Schwarz & Gibson, 2010). These systematic explorations can ensure training and onboarding programs effectively allocate resources and focus on addressing the most pressing gaps across cohorts of participants (Lakai et al., 2014; Schwarz & Gibson, 2010).

NE US Aquaculture Extension Competency Development

Our study applies the competency-based professional development framework within convergent mixed-methods research to integrate insights from extension professional competency needs, industry extension needs, and a related professional development effort in the NE US aquaculture context (see Figure 1). The outputs of this study serve to provide timely, baseline knowledge that can inform further extension research and programming, especially responsive competency development curriculum design.

Figure 1

Competency Assessment and Development Approach Converging Three Data Sources



In addition to its overview of this study's competency data sources, Figure 1 also summarizes the major professional development topics included in Cohort 1. The six-month program combined virtual sessions with an in-person workshop emphasizing facilitation, evaluation, stakeholder engagement, networking, and industry-informed learning experiences. The program intentionally emphasized peer learning and regional relationship building.

Purpose

The purpose of this study was to examine how pairing needs assessments with professional development programming can strengthen aquaculture extension professionals' capacities to address industry needs in the NE US. We endeavored for this study to provide baseline knowledge that extension programs could use to better support new aquaculture-focused agents. As a convergent mixed-methods study, we considered three objectives across three different assessments:

1. Identify competency gaps among aquaculture extension professionals
2. Identify extension support needs within the aquaculture industry
3. Evaluate an extension professional development program designed to address competency and industry needs

Methods

Design and Instrumentation

We used a convergent mixed-methods design in which extension competency, industry needs, and professional development data were collected concurrently and integrated during interpretation rather than sequentially (Creswell & Plano Clark, 2018). The assessments were developed using needs assessment principles (Witkin & Altschuld, 1995) and competency-development literature (Suvedi & Kaplowitz, 2016). The extension assessment measured perceived importance and effectiveness across competencies related to constituent engagement, project management, educational approaches, behavior change, program development, and evaluation using 5-point Likert-type scales. The target audience for the extension assessment was extension professionals in the NE US, including all experience levels. The industry assessment measured the importance of extension support topics and satisfaction with extension engagement using 5-point scales; its target audience was private industry operators (i.e., exclusive of extension agents) although professionals in industry-supporting roles could also participate. The professional development evaluation used parallel pre- and post-surveys to assess changes in Cohort 1 participants' knowledge and connectedness; all program participants, who were early career extension professionals, were encouraged to complete the assessment. All data collection tools also included open-ended/qualitative questions.

Data Collection and Participants

We used purposive and snowball sampling, via regional aquaculture and Extension listservs, to recruit both respondents to the extension competency and industry needs assessments and participants in the professional development program (Plowright, 2011). The industry assessment included 36 respondents representing multiple Northeastern states, with most respondents located in Maine and Massachusetts. The extension assessment was conducted in 2025 and included 28 respondents representing 10 NE states; 64% were between 31 and 45 years old and 50% had eight or fewer years of Extension experience. An earlier 2022 assessment informed the professional development program planning but is not included in this analysis given the value in providing updated 2025 data. The professional development evaluation included Cohort 1 participants using pre-program ($n = 12$) and post-program ($n = 7$) surveys.

Data Analysis

We analyzed quantitative data in IBM Statistical Package for the Social Sciences using descriptive statistics (means, frequencies, and percentages). Internal consistency was assessed using Cronbach's alpha coefficients (see α ; Ary et al., 2019). Extension competency gaps were prioritized using the Borich (1980) needs assessment model, which calculates mean weighted discrepancy scores (MWDS) based on differences between perceived importance and effectiveness. Higher MWDS values indicate greater professional development needs. Qualitative responses from Extension professionals, industry stakeholders, and program participants were analyzed thematically following Creswell and Plano Clark (2018). Data were

coded using a semi-deductive approach that incorporated concepts reflected in the quantitative assessments while allowing new themes to emerge. Three analysts reviewed findings, discussed themes, and documented analytic decisions to enhance trustworthiness (Lincoln & Guba, 1985). Finally, quantitative and qualitative findings were compared side-by-side to develop interpretations based on areas of convergence and divergence across study objectives.

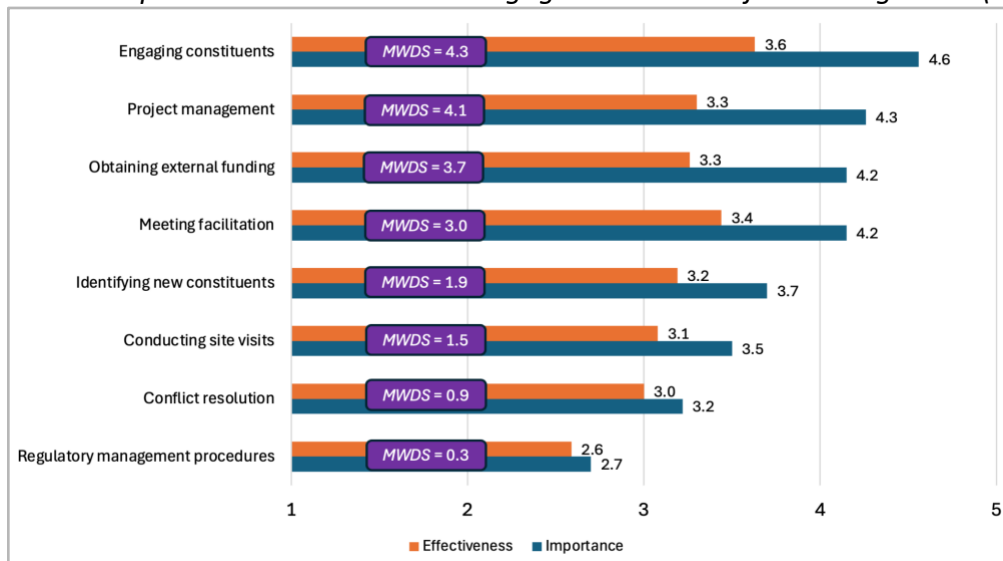
Findings

Objective One: Identify Competency Gaps Among Aquaculture Extension Professionals

Figure 2 shows the largest competency gaps in constituent engagement, project management, external funding, and meeting facilitation.

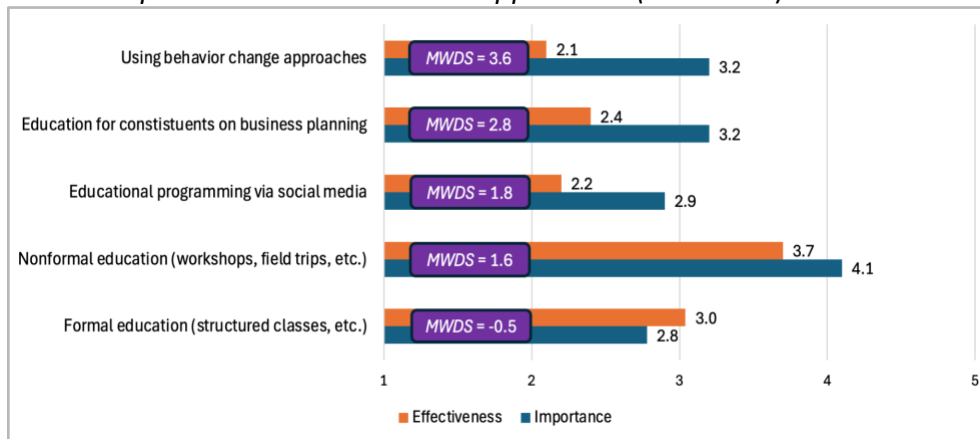
Figure 2

Skillset Gaps Related to Constituent Engagement and Project Management (n = 26–27)



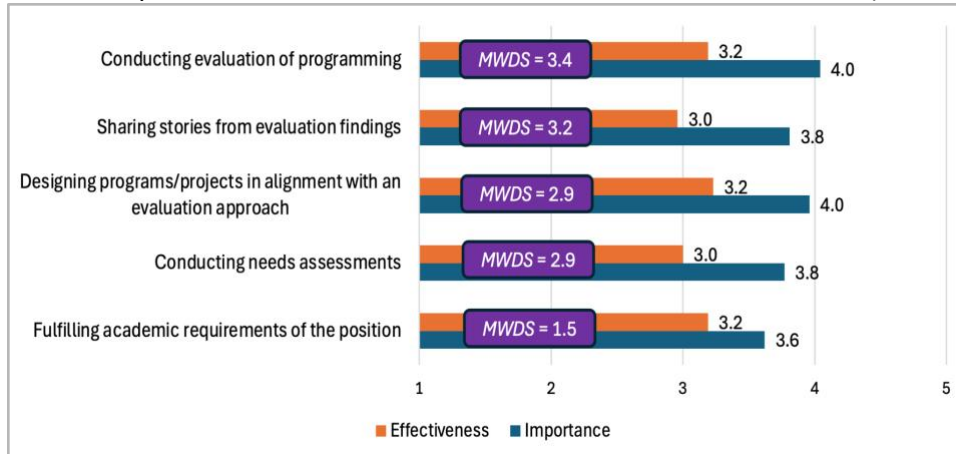
Note. Effectiveness $\alpha = 0.86$ and importance $\alpha = 0.72$.

Figure 3 shows behavior change approaches as the largest educational competency gap (e.g., social marketing, theory-informed or peer-to-peer education, demonstrations).

Figure 3*Skillset Gaps Related to Educational Approaches (n = 25–27)*

Note. Effectiveness $\alpha = 0.74$ and importance $\alpha = 0.82$.

Lastly, Figure 4 identifies evaluation-related competencies as additional priority professional development needs.

Figure 4*Skillset Gaps Related to Evaluation, Research, and Communication (n = 26)*

Note. Effectiveness $\alpha = 0.86$ and importance $\alpha = 0.83$.

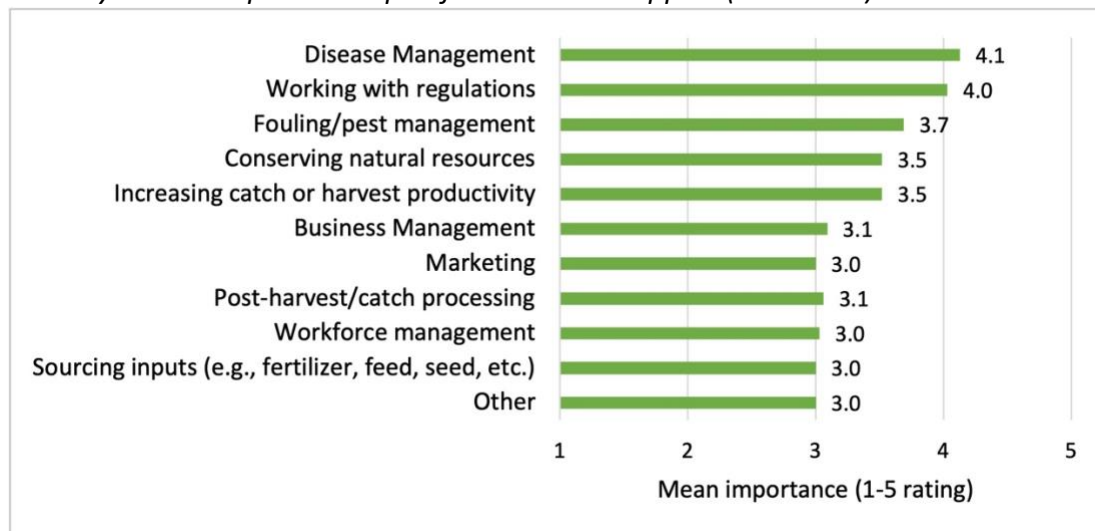
Extension professionals also had the option to provide qualitative feedback in the assessment. Themes (and number of quotes), summarized interpretations, and exemplary quotes are included in Table 1.

Table 1*Extension Professionals' Open-ended Feedback*

Themes	Interpretation	Exemplary Quotes
Administrative and Reporting Demands (<i>n</i> = 4)	Challenges managing evaluation, reporting, and data systems while meeting multiple organizational requirements.	"Evaluation data management. I've got so many spreadsheets and reporting systems and I don't know how to organize the data..."
Interdisciplinary Collaboration and Policy Literacy (<i>n</i> = 4)	Need to work across disciplines and better understand aquaculture policy and decision-making processes.	"Understanding [the] politics of aquaculture. Ability to work with elected leaders and agency personnel on shared needs..."
Industry-Relevant Knowledge and Applied Skills (<i>n</i> = 3)	Need for stronger technical, economic, and industry-specific knowledge to support producers effectively.	"Technical skills in aquaculture production" and "Economics of aquaculture."
Support for Professional Development (<i>n</i> = 3)	Importance of continued funding and accessible professional development opportunities.	"With the current financial climate, will need to continue financial support most likely for participants."

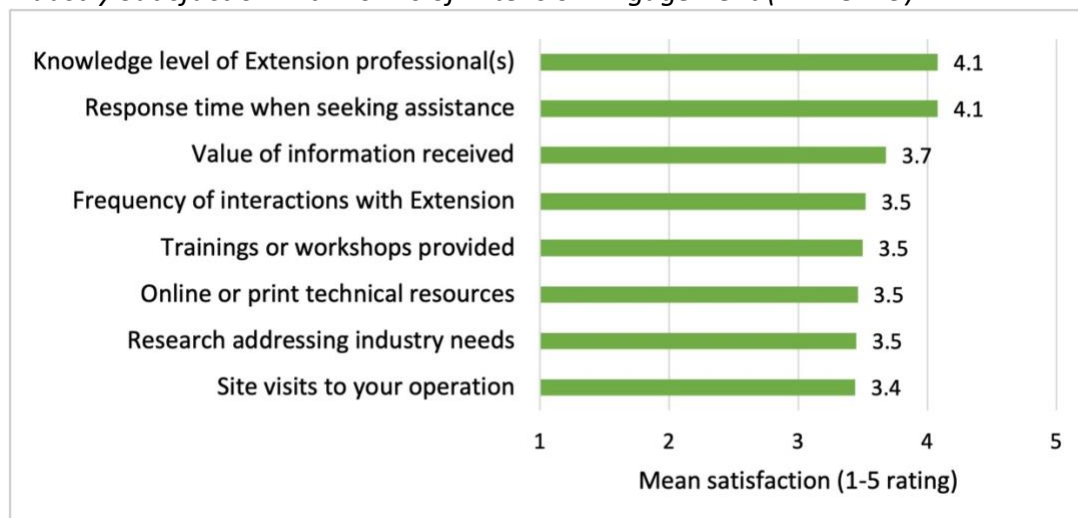
Objective Two: Identify Extension Support Needs Within the Aquaculture Industry

Most industry respondents reported producing shellfish (*n* = 28), followed by finfish (*n* = 9) and seaweed (*n* = 8) (multiple responses permitted). Growout production was their most common activity (*n* = 25), followed by hatchery (*n* = 11) and nursery production (*n* = 10). Additional respondent roles included wholesalers/distributors and "other" roles (i.e., research and development) not otherwise listed (*n* = 6 each), seafood processors (*n* = 5), nonprofit organizations and state/municipal resource managers (*n* = 3 each), and equipment suppliers (*n* = 1). The most critical extension topics to address for industry were disease management and working with regulations (see Figure 5). The "second tier" of important topics included fouling/pest management, conserving natural resources, and increasing catch or harvest productivity.

Figure 5*Industry's Most Important Topics for Extension Support (n = 31–32)*

Note. Importance of topics $\alpha = 0.91$.

Quantitative data suggest industry stakeholders were moderately to very satisfied with extension engagement (all ratings > 3.0; see Figure 6). Respondents were most satisfied with extension response time and knowledge level and least satisfied with site visits and research to address their needs.

Figure 6*Industry Satisfaction with Forms of Extension Engagement (n = 18–29)*

Note. $\alpha = 0.97$.

Industry professionals also had the option to provide qualitative feedback in the industry-focused assessment. Themes (and number of quotes), summarized interpretations, and exemplary quotes are included in Table 2.

Table 2

Industry Actors' Open-ended Feedback

Themes	Interpretation	Exemplary Quotes
Responsive, relationship-based engagement (<i>n</i> = 4)	Industry values extension agents who communicate well, meet stakeholders where they are, and maintain contact.	"Maine extension agents are great at making sure they are meeting industry and regulators where they are at."
Industry applied aquaculture expertise (<i>n</i> = 3)	Some respondents want more specialized, timely, industry-relevant knowledge.	"They are available, and they communicate well, but they do not have the specialized knowledge that members of the commercial industry have..."
Timely, field-informed problem solving (<i>n</i> = 3)	Respondents emphasized urgency, field experience, and support for complex production problems.	"Time is money. Needs are timely - not when extension gets around to it."
Scalable and efficient resource delivery (<i>n</i> = 3)	Industry wants improved methods, tools, and outreach products delivered quickly and broadly.	"There is a need to develop a more nimble model of outreach..."
Access to aquaculture extension (<i>n</i> = 3)	In some states or situations, respondents reported limited or no access to aquaculture Extension personnel.	"West Virginia does not have an aquaculture extension agent."

Objective Three: Evaluate an Extension Professional Development Program Designed to Address Competency and Industry Needs

Based on the availability of reliable data from pre- and post-professional development program surveys, only Cohort 1 results are included in this paper. Respondents reported substantive knowledge gains in meeting facilitation, particularly in conflict management, leveraging social capital, and responding to disruptive behaviors (see Table 3).

Table 3*Knowledge Change: Meeting Facilitation (Pre n = 12; Post n = 7)*

Knowledge topic	Pre <i>M</i>	Post <i>M</i>	<i>MΔ</i>
The relationship between dignity and conflict	2.1	3.7	1.6
Leveraging social capital to better facilitate	2.3	3.6	1.3
Responding to disruptive behaviors when facilitating	2.4	3.6	1.2
Preventing disruptive behaviors when facilitating	2.4	3.4	1.0
Helping groups come to agreement on decisions	2.6	3.6	1.0
Facilitating proposed next steps to follow the meeting	3.0	3.9	0.9
Identifying different roles for participants in meetings	3.1	3.9	0.8
Using appropriate process tools and techniques to achieve meeting objectives	2.8	3.6	0.8
Using an agenda effectively to facilitate meetings	3.3	4.0	0.7

Participants also demonstrated consistent improvements across program evaluation competencies, with the largest gains related to participant sampling and using evaluation findings (see Table 4).

Table 4*Knowledge Change: Program Evaluation (Pre n = 12; Post n = 7)*

Knowledge topic	Pre <i>M</i>	Post <i>M</i>	<i>MΔ</i>
Engaging target participants to collect appropriate data (e.g., sampling)	2.7	3.7	1.0
Using evaluation findings to improve programming	2.8	3.7	1.0
Developing short-, medium-, and long-term outcomes for a project or program	2.8	3.7	0.9
Using online survey tools to collect data (e.g., Qualtrics, Google Forms)	3.1	4.0	0.9
Analyzing evaluation data	2.7	3.6	0.9
Reporting evaluation findings	3.0	3.9	0.9
Building survey tools to measure program outcomes	2.7	3.4	0.8
Writing measurable program or project objectives	2.8	3.6	0.7
Collecting data to record results and outcomes of field visits	2.8	3.6	0.7

Participants' knowledge also increased across competencies related to engaging underrepresented communities, particularly understanding barriers to participation and challenges associated with engaging new communities (see Table 5).

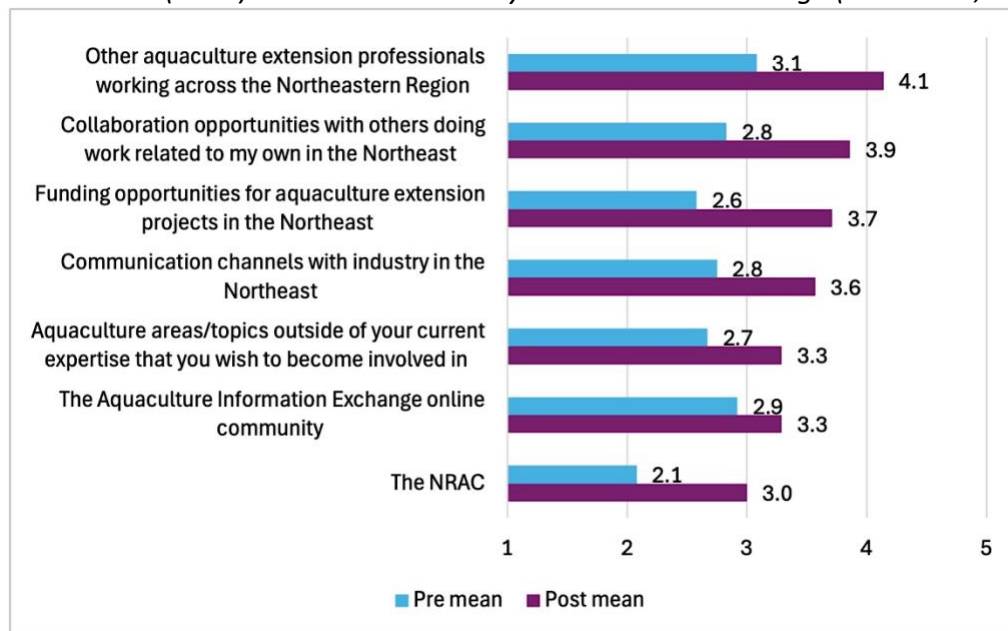
Table 5*Knowledge Change: Engaging Underrepresented Communities (Pre n = 12; Post n = 7)*

Knowledge topic	Pre <i>M</i>	Post <i>M</i>	<i>MΔ</i>
Pitfalls encountered when engaging new communities	2.3	3.3	1.0
The barriers for people of diverse identities to engage with Extension	2.3	3.3	1.0
Honoring cultural differences during meeting facilitation	2.4	3.3	0.9
Identifying communities missing or excluded from programming	2.3	3.1	0.8
Self-awareness of one's cultural/social identities, assumptions, values, norms, experience of privilege and oppression, and how they shape one's worldview	3.1	3.9	0.8
Ensuring equitable participation where all voices are heard	3.2	3.7	0.5
Creating safe spaces for educating, dialogue, and meetings	3.2	3.6	0.4
Engaging a previously unengaged community	2.7	3.0	0.3
The value of incorporating previously unengaged communities into extension programming	3.0	3.3	0.3

The program evaluation also assessed participant connectedness, aligned with the program's emphasis on networking and peer learning. Figure 7 illustrates increased perceived connectedness across all measured areas, with the largest gains related to other aquaculture extension professionals, collaboration opportunities, and funding opportunities in the Northeast.

Figure 7

First Cohort (2024) Pre- and Post-survey Connectedness Change (Pre n = 12; Post n = 7)



Lastly, program participants expressed that the Cohort 1 training was valuable. Approximately 86% of Cohort 1 participants responded via the post-survey that they would “definitely” participate in a future NAEN series, and the remaining 14% responded “Leaning towards yes.” Our analysis of four qualitative comments from Cohort 1 participants identified opportunities to strengthen future, related programming. Respondents recommended a more compressed timeline to maintain engagement, additional networking and field-based experiences to strengthen professional relationships, and greater emphasis on action-oriented collaboration and industry perspectives during virtual sessions.

Conclusions, Discussion, and Recommendations

By integrating insights on extension competency, industry expectations, and professional development outcomes, this study provides a framework for informing aquaculture extension competency development in the NE US. The findings identified priority competency gaps, industry priorities for extension support, and evidence that participants gained valuable knowledge and regional connections via a targeted professional development program.

The competency assessment identified priority gaps in facilitation, stakeholder engagement, behavior change, evaluation, project management, and external funding. Similar patterns have been reported across extension systems, although priorities vary by context, reinforcing the value of region-specific needs assessments (Carroll et al., 2025; Donaldson et al., 2023; Lakai et al., 2014; Schwarz & Gibson, 2010). Consistent with previous research, these findings suggest many extension professionals enter their roles with strong technical expertise but

comparatively limited preparation in facilitation, program design, behavior change, and evaluation (Diaz et al., 2020; Donaldson et al., 2023; Suvedi & Kaplowitz, 2016).

Our industry needs assessment revealed that disease management is the most important technical topic that extension can address to support industry. Due to the complexity of their environment, shell- and fin-fish are susceptible to various infections, making disease control a vital task in aquaculture (Cain, 2022). Moreover, this could include food-borne pathogens, particularly important in shellfish and uncooked food. The findings also show that aquaculture industry members need extension support in working within complex regulatory frameworks. Studies indicate such regulations are strict and complex, often burdening farms (Anderson et al., 2019; Engle et al., 2025; Lester et al., 2022). In all, industry respondents reported overall high levels of satisfaction in their current interactions with extension professionals — most notably, knowledge and response time. However, both quantitative and qualitative findings revealed concerns regarding specialized technical expertise, timeliness, and access to aquaculture extension personnel in some locations. Moreover, desires were evident for more frequent extension visits to farms as well as improved reaction time to emerging issues.

In our professional development program evaluation, participants reported increased knowledge across all targeted competencies, including several identified as priority needs in the competency assessment. They also reported greater regional connectedness, suggesting that cohort-based professional development may strengthen both individual competencies and professional networks. These findings are consistent with previous studies demonstrating the value of targeted professional development and peer learning among extension professionals (Landini, 2021; Suvedi & Ghimire, 2015; Suvedi & Kaplowitz, 2016). Notably, the intentional design of networking and learning exchange among extension professionals can allow for co-creation of knowledge and implementation of innovative extension strategies (Landini, 2021).

Overall, this study provides insights into extension competency and industry needs in the NE US aquaculture context along with a practical model to design similar assessment and responsive training efforts globally. Because this study relied on relatively small, regional samples and self-reported outcomes, the findings should be interpreted as baseline evidence rather than broadly generalizable conclusions. Future research should compare these gaps and opportunities in other regions, evaluate longer-term impacts of competency development on extension practice and stakeholder outcomes, and explore the extent to which networking and connectedness enhance extension impact. Together, in a practical sense, these findings support prioritizing professional development in facilitation, evaluation, and stakeholder engagement while integrating industry priorities into aquaculture extension competency development.

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