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Aquaculture Extension Capacity in the USDA North-Central Region: Results from a Survey

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We surveyed Agriculture and Natural Resources Extension staff across the USDA North-Central Region about aquaculture programming. Overall, 47%, 35%, and 15% of respondents indicated that stakeholders had contacted them about aquaponics, finfish aquaculture, and shrimp aquaculture, respectively. Approximately 8% of respondents indicated that they offered aquaculture or aquaponics programming; 45% and 55% indicated that they did not offer aquaculture and aquaponics programming, respectively, but were interested in offering it. These results indicate that there is interest in increasing Extension capacity in fish farming either by hiring new staff or through train-the-trainer models.

Keywords: aquaculture, aquaponics, Extension, fish farming, midwest

Introduction

Developing and maintaining an ecologically, economically, and politically sustainable food supply is a significant ongoing challenge that invites many potential solutions with varying sets of trade-offs. Fish farming can help address global food issues. When aquaculture is done in a sustainable manner, it creates a source of protein that is healthy (McManus et al., 2011), relieves pressure on overfished wild fish populations, and can create sustainable jobs in the aquaculture sector and support industries across many areas of the country (Botta et al., 2021; Broughton et al., 2013).

The United States is a major consumer of seafood, with annual per-capita consumption increasing from 15.0 pounds in 2011 to 19.2 pounds in 2019 (National Marine Fisheries Service, 2021). However, more than 85% of the farm-raised and wild-capture seafood consumed in the United States is imported. Edible seafood (including wild-capture and farm-raised fish and shellfish) is the second-largest natural resources trade deficit in the United States, behind only oil (U.S. Census Bureau, 2021). Despite the trade deficit, many people have started fish farming in the United States, either producing fish via traditional aquaculture systems or fish and produce in aquaponics systems, with mixed success (Naomasa et al., 2013; Tokunaga et al., 2015). Producers often see aquaculture or aquaponics as an opportunity to farm sustainably and supply

food from local sources, though many also cite low profitability and regulations as barriers to business expansion (Hartenstine, 2022).

There is significant federal interest in aquaculture and aquaponics, as evidenced by increasing federal investment in aquaculture and aquaponics research. In the 1950s and 1960s, federal funding for aquaculture research started to emerge, but it was not until the 1980s that federal investment in the industry became more direct and consistent. Between 1990 and 2015, the U.S. federal government funded nearly 3,000 aquaculture-related research projects, totaling over \$1 billion, with an average increase of six grants and \$3.3 million each year (Love et al., 2017). Anecdotally, the trend of increased federal investment in domestic aquaculture and aquaponics is continuing. While much of the funding continues to come through the United States Department of Agriculture (USDA), Sea Grant, a National Oceanic and Atmospheric Administration (NOAA)-funded network of 34 university-based programs focused on outreach, education, and research related to coastal and Great Lakes natural resource and environmental issues, has increased its investment in aquaculture as well. In 2019, Sea Grant approved \$16 million in federal funding awards that supported 42 aquaculture research and Extension projects, and increased aquaculture investment has been specifically mentioned in recent NOAA budget justifications (NOAA, 2021).

Connecting research with aquaculture and aquaponics producers, consumers, and policymakers can be challenging due to the limited overlap between stakeholders in these different arenas. Extension often plays a connecting role, serving as a boundary organization at the interface of researchers, practitioners, and policymakers and facilitating better outcomes (Prokopy et al., 2015). Spanning the boundaries of these arenas is critical to meeting long-term sustainability challenges (Goodrich et al., 2020), and Extension's long history of serving this role puts it in a position to enable and facilitate co-production models to create useful and usable research to aid a developing industry (Prokopy et al., 2017).

Although a strong Cooperative Extension Service (CES) infrastructure could help develop the aquaculture industry and facilitate the co-production of aquaculture knowledge, the infrastructure may not be developed uniformly across the United States. In this manuscript, we explore the existing land grant university agriculture and natural resources Extension infrastructure in the USDA North-Central Region by addressing the following research questions:

1. To what extent is there aquaculture and aquaponics programming occurring within the USDA North-Central Region?
2. To what extent is their interest in additional aquaculture programming within the USDA North-Central Region?

This work was conducted as part of a larger aquaculture programming needs assessment in the region. It is important to note that Agriculture and Natural Resources (ANR) staff of CES do not

necessarily work directly with aquaculture producers or even indirectly in aquaculture at all. However, given that ANR staff work on food production and other natural resources issues with a variety of stakeholders, understanding their aquaculture programming offerings and needs is key to understanding aquaculture Extension in the region.

Methods

Study Population

Our population is ANR Extension personnel within the USDA North-Central Region, a 12-state area consisting of North Dakota, South Dakota, Nebraska, Kansas, Minnesota, Iowa, Missouri, Wisconsin, Illinois, Indiana, Michigan, and Ohio. The North-Central Region is home to 68.3 million people and several large cities, but it also includes significant rural areas (U.S. Census Bureau, 2019). Although growth in aquaculture production in the region has been minimal over the last 10 years (USDA, 2019), large population centers and significant farming infrastructure give the North-Central Region strong potential for aquaculture growth as the industry grows (Carlton et al., 2021). Currently, aquaculture sales range from \$7.7 million in Missouri in 2018 to no documented farm sales in North Dakota (USDA, 2019). Aquaculture production methods differ across the region, including outdoor pond production and various types of indoor, land-based production systems. Given the North-Central Region's status as a major agricultural center in the United States, it is of particular interest as a potential place for aquaculture-related industry and Extension.

Survey Design

The survey included questions related to three types of aquacultures: fish farming, shrimp farming, and aquaponics. For each of the aquaculture types, we asked respondents whether stakeholders had contacted them about the types and the respondents' perceptions of commercial and educational interest in the types. We also asked respondents if they provide aquaculture and aquaponics programming. See Table 1 for specific questions, wordings, and scales.

Table 1. Overview of Survey Questions

Construct	Item	Response scale
Contact	Do you have stakeholders who contact you regarding (aquaculture type)?	0: No 1: Yes
Commercial interest	How would you rank the level of interest in commercial (aquaculture type) in your geographic area?	1: No interest 2: Slight interest 3: Moderate interest 4: Strong interest
K–12 education interest	How would you rank the level of interest in (aquaculture type) from K–12 educators as a curriculum topic in your geographic area?	1: No interest 2: Slight interest 3: Moderate interest 4: Strong interest

Construct	Item	Response scale
Aquaculture programming	Do you provide aquaculture programming (i.e., fish farming, shrimp farming, or both) to your stakeholders?	0: No 1: Yes
Aquaponics programming	Do you provide aquaponics programs to your stakeholders?	0: No 1: Yes

Survey Implementation

We used state and county Extension websites to find the names and contact information of CES personnel working in ANR to participate in the survey. The survey was implemented via Qualtrics and administered in February of 2020, prior to the widespread shutdowns and quarantines related to SARS CoV-2 pandemic in the United States. The survey included multiple reminders, as adapted from Dillman et al. (2009). We contacted a total of 541 Extension personnel and received 160 responses, a 29.6% response rate. Michigan had a substantially higher response rate than other states (45.5%), North Dakota had a lower response rate (11.6%), and South Dakota had no respondents of the 19 Extension staff we contacted (Table 2). The reasons for the differences across states are not clear, and though there was no apparent correlation between state response rate and aquaculture sales reported by USDA (USDA, 2019), the three states with the lowest response rate (Kansas, North Dakota, and South Dakota) were also the states with the lowest aquaculture sales. Given the nature of our survey questions and the relatively small numbers of ANR personnel and aquaculture markets in North and South Dakota, we do not believe any non-response bias would substantially influence our conclusions.

Table 2. Response Rate by State

State	Response Rate (%)
Michigan	45.5
Iowa	36.8
Illinois	35.7
Ohio	32.9
Missouri	32.0
Indiana	31.6
Nebraska	31.5
Wisconsin	28.0
Minnesota	26.3
Kansas	26.2
North Dakota	11.6
South Dakota	0

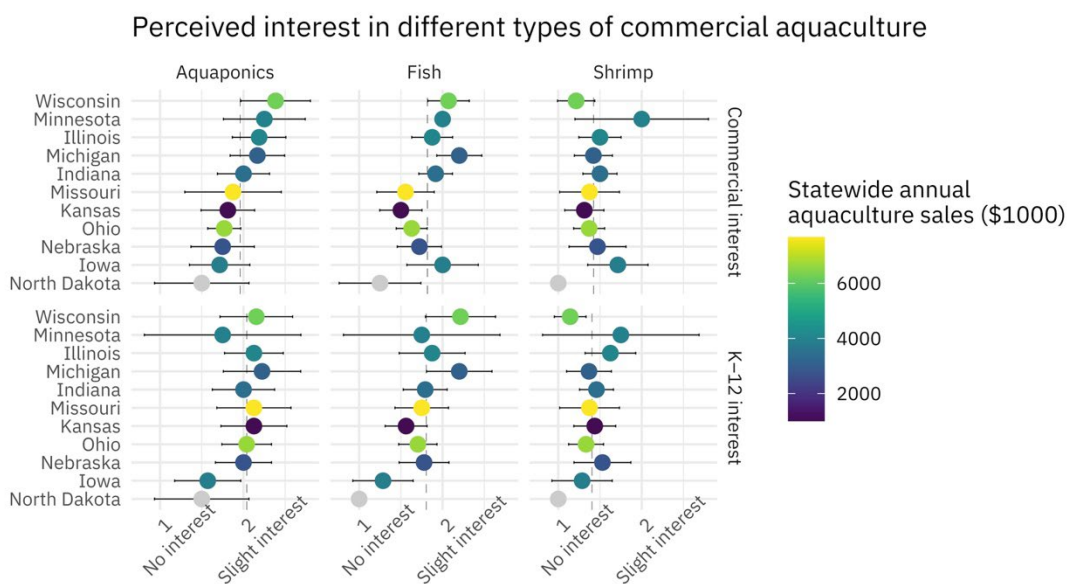
Results

Overall, 47%, 35%, and 15% of respondents indicated that stakeholders had contacted them about commercial aquaponics, finfish aquaculture, and shrimp aquaculture, respectively. The respondents' estimates of stakeholder interest in commercial and K-12 aquaculture are presented overall in Table 3 and by state in Figure 1.

Table 3. Respondents' Overall Estimates of Stakeholder Interest in Different Types of Aquaculture

Item	Mean (1: no interest, 4: strong interest)	95% CI
Commercial interest aquaponics	1.96	1.84–2.08
Commercial interest fish	1.82	1.74–1.90
Commercial interest shrimp	1.42	1.34–1.50
K-12 interest aquaponics	2.04	1.92–2.16
K-12 interest fish	1.80	1.68–1.92
K-12 interest shrimp	1.40	1.30–1.50

Figure 1. Perceived Stakeholder Interest in Aquaculture by Sector and State



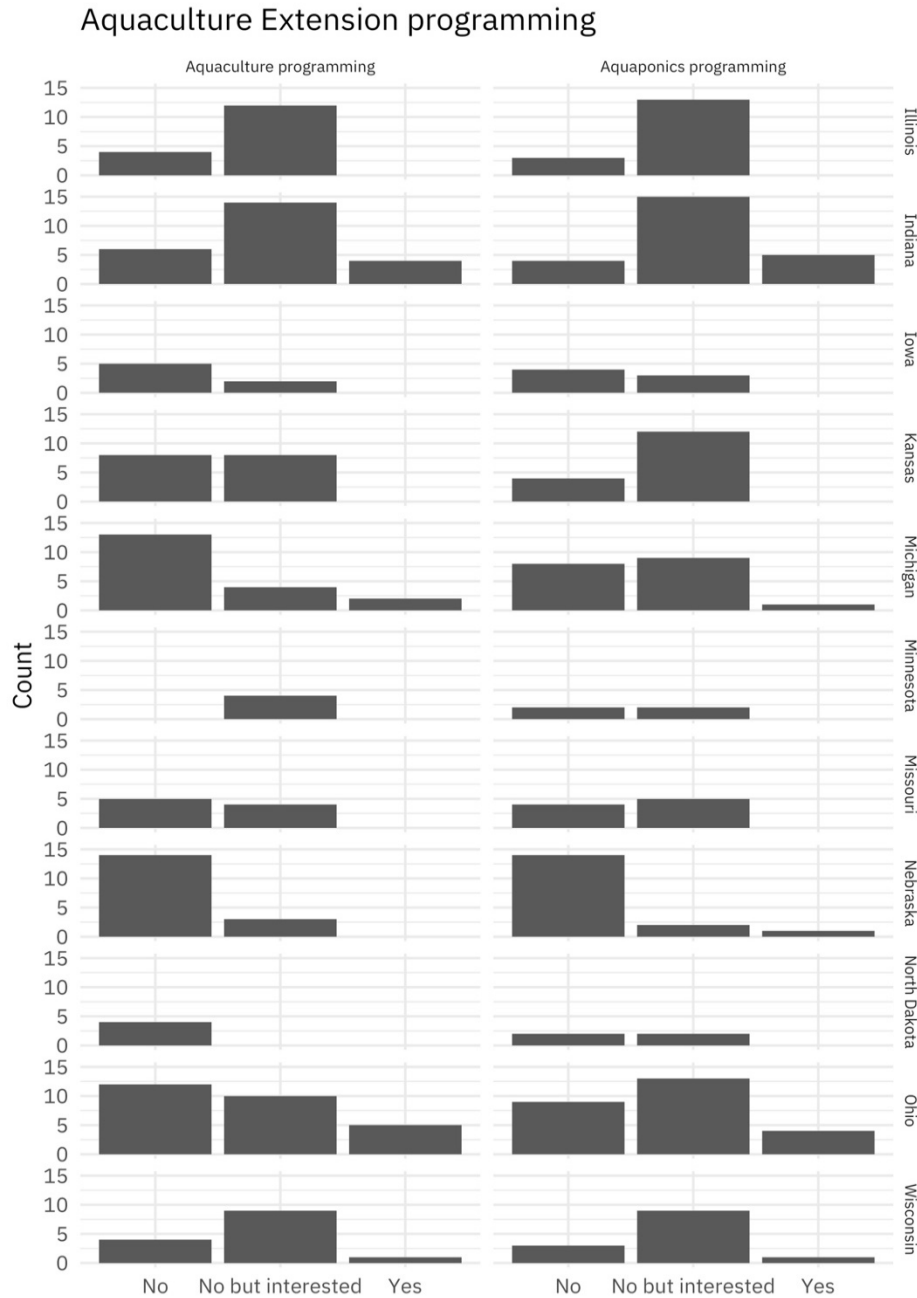
Data: Survey of USDA North-Central Region ANR Extension staff

Note. Dashed lines represent the sector-wide average.

Approximately 8% of respondents indicated that they currently offer aquaculture programming, 48% indicated that they did not offer aquaculture programming and were not interested in offering it, and 45% indicated that they did not offer aquaculture programming but were interested in offering it.

Regarding aquaponics, 8% of respondents indicated that they currently offer aquaponics programming, 37% indicated that they did not offer and were not interested in offering aquaponics programming, and 55% indicated that they did not offer but were interested in offering aquaponics programming. Only six respondents indicated that what they currently covered provided information on aquaculture marketing. The state-by-state data for aquaculture and aquaponics programming are visualized in Figure 2.

Figure 2. Aquaculture and Aquaponics Programming by State



Data: Survey of USDA North-Central Region ANR Extension staff

Discussion

Although few ANR Extension staff currently offer aquaculture or aquaponics programming in the North-Central Region, over half of the respondents indicated that they were interested in offering aquaculture-related programming. This finding perhaps reflects the stakeholder contact findings, where approximately half (47%) of respondents indicated that they had stakeholders contact them about aquaponics programming, and around a third (35%) indicated that stakeholders had contacted them about aquaculture programming.

Though many ANR Extension staff are interested in offering aquaculture programming, respondents indicated a slight-to-moderate interest in aquaculture among stakeholders throughout the North-Central region. Although we did not ask whether the interest is on the production or consumption side, given the role of ANR Extension in the region, most of the interest was likely on the production side. Despite the sometimes-wide confidence intervals, interest in aquaponics was consistently the highest and shrimp consistently the lowest across states in the region.

The high interest among ANR personnel and moderate interest among stakeholders could indicate that Extension has a chance to spur additional interest in aquaculture or aquaponics through education and programming. It could also indicate that stakeholder interest is limited to certain segments of stakeholders that could be effectively targeted either via a state or regional aquaculture specialist or by a train-the-trainer model in which local ANR staff work with aquaculture specialists to develop programming.

As it stands, these data show that the current capacity for aquaculture Extension in the North-Central Region is limited in many states, though there is potential interest in developing additional capacity. If private and federal investment in aquaculture research and production continues, existing Extension efforts may be insufficient to meet increased demand. Extension personnel can serve as key boundary workers, helping to bridge and broker scientific, practical, and traditional knowledge (Goodrich et al., 2020); enabling the co-production of useful knowledge (e.g., Prokopy et al., 2017); and helping to develop and maintain practical knowledge networks (Moss et al., 2019). Although private industry can often serve in these boundary roles, as well (Goodrich et al., 2020; Prokopy et al., 2017), insufficient investment in Extension may limit the number of people serving the Midwestern aquaculture industry.

Our survey data show that there is interest in expanding Extension capacity. Potential increased demand could be met via additional funding for aquaculture Extension or via careful leverage of ongoing aquaculture programming, such as recent USDA, NOAA, and Sea Grant efforts, including the Sea Grant-funded Great Lakes Aquaculture Collaborative or EatMidwestFish.org, co-funded by NOAA and the USDA North-Central Regional Aquaculture Center. Additionally, train-the-trainer programs have been shown to be an effective model for leveraging existing Extension resources to achieve greater impact in related areas like food safety (e.g., Martin et al.,

1999; Richards et al., 2012) and entrepreneurship and farm business management (e.g., Brumfield et al., 2017; Fields et al., 2012). Funding agencies could also continue to encourage or require research projects to integrate Extension into their research proposals, although integrating Extension in a meaningful way is challenging and ideally requires engagement with Extension personnel throughout the research cycle, from project design to project completion. However, given the continued federal investment in aquaculture research and that Extension can be a critical component to industry growth, finding a way to increase capacity may help the investment pay dividends.

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