Physiological and Economic Evaluation of Cold Banking Walleye (Sander vitreus) Fingerlings for Year-Round Market Supply

Theme A: Aquaculture Production – Targeted Research area 3 and 4; Early Life Stages, Enhanced Growth Technology

Theme E: Sustainability and Economics – Targeted Research area 1 and 2; Sustainability life cycle assessment (LCA) of farms/products, Imports/Wild/Farmed comparison sustainability study in NCR

Chairperson: Tyler Firkus, University of Wisconsin-Steven Point

Co-Investigator: Kwamena Quagrainie, Purdue University

Co-Investigator: Christopher Hartleb, University of Wisconsin-Stevens Point

Extension Liaison: Emma Hauser, University of Wisconsin-Stevens Point, Wisconsin Sea Grant

Industry Liaison: Colin Bursik, Aqua Garden LLC.

Industry Liaison: Mike Neukirchen, Fountain Fresh LLC.

Industry Liaison: Annie Schmitz, Woods & Waters Fish Farm

Funding Request: $126,469.95

Duration: 2 years

Objectives:

1. Evaluate various ages at which walleye fingerlings can be cold banked.
2. Quantify and compare growth rates, survival rates, feed conversion, and costs of cold banking walleye fingerlings at different ages.
3. Use cost information from cold banking trials to compare the economic viability of cold banking relative to multiple cohorts (utilizing out-of-season spawning), and single cohort (not implementing cohort staggering methods) for producing walleye as a food fish.
4. Provide feed trained fingerlings to industry partners.
5. Develop outreach deliverables including direct (hands on demonstration, tours, technical assistance) and indirect (presentations, publications, technical videos) targeting industry on the results of this project.

Deliverables:

The ability to stagger cohorts of walleye so that market-sized individuals are available year-round is a critically important component to the success and viability of the walleye food-fish aquaculture industry. If successful, the research proposed by this project will demonstrate the economic and practical viability of cold banking as a cohort staggering method (Objective 1 & 2). Using the results of the trial, we will produce a cold-banking SOP and update the *Walleye*

Culture Guide and accompanying video series that provides practical hands-on guidance for best practices when raising walleye. If the study finds that cold-banking is not an optimal approach and cannot be performed early enough during walleye grow-out to efficiently use space and minimize feed costs, then it will allow future efforts to focus more intensively on the development and optimization of out-of-season spawning as a cohort staggering method. Regardless of the result of the study, the proposed research will inform the development of economic models and enterprise budgets that will help prospective fish farmers evaluate and weigh the relative costs of each cohort staggering practice (Objective 3). These enterprise budgets will be made available directly on UWSP NADF's website and sent directly to percid fish farmers in the region.

In addition to the deliverables from the research and outreach components of this project, the feed-trained walleye remaining at the end of the project will be donated to individual fish farmers. Currently, there are few options available for fish farmers to obtain feed-trained walleye fingerlings. UWSP NADF has been supporting the walleye food fish industry by raising feed-trained fingerling walleye and donating them to fish farmers. This practice is planned to continue as long as funding to raise them is obtained, and hopefully the broodstock and larviculture operation can be passed to private hands to ensure the long-term success of the walleye aquaculture industry going forward (see logic model).

Proposed Budget: Institution, PI, Objectives, Year, Total

Proposed Summary Budget by Year

Proposed Summary by Year				
Category	NCRAC Funds			
Year 1	Objective	UWSP (T.F.)	Purdue (K.Q.)	Project Total
Salaries, Wages, and Fringe Benefits	1, 2, 3, 4, &5	$31,517.20	$16,555.00	$48,072.20
Nonexpendable equipment				
Materials and Supplies		$10,250.00	$400.00	$10,650.00
Travels		$2,600.00	$1,500.00	$4,100.00
All Other Direct Costs				
Total		$44,367.20	$18,455.00	$62,812.20
Category	NCRAC Funds			
Year 2	Objective	UWSP (T.F.)	Purdue (K.Q.)	Project Total
Salaries, Wages, and Fringe Benefits	1, 2,3, 4, &5	$33,110.75	$17,217.00	$50,327.75
Nonexpendable equipment				
Materials and Supplies		$8,820.00	$400.00	$9,220.00
Travels		$2,600.00	$1,500.00	$4,100.00
All Other Direct Costs				
Total		$44,530.75	$19,117.00	$63,647.75

Category	NCRAC Funds			
Total Year 1 and Year 2	Objective	UWSP (T.F.)	Purdue (K.Q.)	Project Total
Salaries, Wages, and Fringe Benefits		$64,627.95	$33,772.00	$98,349.95
Nonexpendable equipment				
Materials and Supplies		$19,070	$800.00	$19,870.00
Travels		$5,200.00	$3,000.00	$8,200.00
All Other Direct Costs				
Total		$88,897.95	$37,572.00	$126,469.95

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Project Summary

The capacity to bring walleye (*Sander vitreus*) to market at various points during the year remains a challenge for food fish commercialization. One option is to cold bank walleye fingerlings where they are exposed to cold temperatures for a period to slow growth rates before being brought back on to warm water temperatures to resume growth. Although cold banking is a promising approach, there has been little research on adapting the method for walleye producers. It is uncertain how soon after hatching walleye can be cold-banked. This information is important for understanding how much space and feed would be required to cold bank walleye. In addition to the applied research on the practical limitations of cold banking, economic analysis of the viability of the various approaches for staggering cohorts is critical. This project would evaluate the viability of cold banking walleye both biologically and economically. We will expose fingerling walleye to 1-month cold banking periods at two different ages (60 days post hatch, 120 days post hatch) and evaluate growth rates (before, during, and after cold banking), survival rates, feed requirements, tank volume requirements, and the total cost among treatments. We will use cost information from this study (and previous projects) to evaluate and compare the economic viability of cold banking relative to out-of-season spawning to evaluate which cohort staggering method is most cost effective.

Justification

Walleye (*Sander vitreus*) are one of the most valued food fish in the North Central Region (Summerfelt et al., 2010). Currently, only a small aquaculture industry exists for walleye with the bulk of market supply originating from wild Canadian fisheries and imported into the United States. In 2023, 2,000 metric tons (4.4 million pounds) of walleye were imported into the USA from Canada as food-fish with a total value of $31.9 million (National Oceanic and Atmospheric Administration (NOAA) Fisheries, 2024). Because of the large demand for walleye and the high value of fillets, aquaculture production of walleye has an opportunity to find a niche. Recently, substantial research progress with captive broodstocks (Firkus et al., 2024), larviculture (Neibauer et al., 2024; Rieger and Summerfelt, 1997), diet optimization (Fischer et al., 2022; Summerfelt et al., 2011), and culture best-practices (Hauser et al., 2023; Summerfelt, 2004; Summerfelt et al., 2011) have made walleye a viable commercial species. Three private LLCs have started operations in Wisconsin, and two additional companies in the region are in various stages of design or construction of facilities geared towards raising walleye commercially for the food fish industry. Although the growth of the walleye industry is exciting, critical unknowns about how to best stagger walleye cohorts so that market-size fish are available for sale year-round (rather than once-per-year) need to be addressed before the industry can thrive and compete with wild-caught imports. The ability for the aquaculture industry to provide a fresh-never-frozen alternative to frozen imported fillets is likely to be an important component of walleye aquaculture's niche, but having fresh market-size walleye available at any time of the calendar year is much more difficult than having a single harvest and freezing product. Walleye take approximately 14-18 months to reach market size, so having market sized fish available year-round requires some form of cohort staggering.

One possible approach is inducing out-of-season spawning in a captive population of walleye broodstock so that eggs are available at different points during the year. Some preliminary work on this approach has been completed with varying degrees of success (Dabrowski et al., 2000; Firkus et al., 2024; Garcia-Abiado et al., 2004; Malison et al., 1998). Current research suggests that there are physiological limitations to shifting spawning and doing so can result in reduced gamete quality, lower fry survival rates, and lower early growth rates (Firkus et al., 2024). Additionally, out-of-season spawning is highly labor intensive, requires additional space for captive broodstock, and requires costly system designs that allow for broodstocks to be kept on separate photothermal regimes. In addition, because out-of-season spawning requires intensive larviculture practices to take place multiple times each year, the costs and time investment for this approach are high. Due to these constraints, out-of-season spawning is biologically and economically challenging.

One alternative approach for cohort staggering is the use of cold banking. Cold banking involves exposing fingerling walleye to cold water temperatures to slow growth rates before bringing batches of cold banked walleye into warmer water temperatures at different times. Staggering the time at which groups of walleye are exposed to warmer temperatures allows for the growth to final market size to be staggered throughout the year. While the cold banking approach would avoid some of the difficulties associated with out-of-season spawning, there have been few studies that have assessed the viability of this method. One study did find that cold banking walleye fingerlings was possible at 190 days post hatch and did not adversely influence survival or post-cold banking growth rates (Harder et al., 2014, 2013). These results are promising, but further work is needed to evaluate how early after hatching that walleye fingerlings can be cold banked (to reduce space and feed requirements) and how the costs of cold banking compare with other methods. The earlier walleye can be cold-banked (i.e. younger age), the less space and feed would be required to hold the fish. Depending on how early cold banking of walleye fingerlings can be achieved, it may be a more economical approach for staggering cohorts of walleye than utilizing out-of-season spawning.

Because the walleye food-fish aquaculture industry is in its infancy, there is currently little information available to guide best practices or demonstrate an economically viable business model. Therefore, modeling the economic feasibility of potential approaches is vitally important for facilitating the successful growth and development of the walleye aquaculture industry.

Related Current and Previous Work

The ability to organize an aquaculture operation so that market-size individuals can be harvested at multiple times during a calendar year is a keystone to the success and viability of any aquaculture species. For most aquaculture species, operations rely on natural variation in growth rates of individual fish in a single cohort and partially harvest market-sized individuals from the population at regular intervals. With sufficiently large variation in growth rates, this method can be used to maintain a year-round supply of fresh fish. This approach is less viable for walleye as the time to reach minimum market size is approximately 14-18 months and size variation is generally minimal. Although the walleye aquaculture industry could attempt to rely on a single annual harvest and provide frozen fillets to the market outside of harvest season, providing a fresh-never-frozen produce will likely be an important component for successfully competing imported frozen walleye fillets from Canada. Therefore, identifying the most suitable and economical method for staggering cohorts of walleye is critical for the future success of this species for food fish aquaculture.

Out-of-season spawning is an infrequently applied approach for most aquaculture species as broodstock are typically acquired from the wild for most aquaculture species (Berlinsky et al., 2020). Additionally, fish raised in captivity often have reduced fecundity and poor gamete quality (Mylonas et al., 2010) making the development of a captive broodstock difficult. Despite these challenges, out-of-season spawning has been established for several aquaculture species such as Atlantic salmon (Skjærven et al., 2020), pikeperch/zander (Hermelink et al., 2013; Müller-Belecke and Zienert, 2008; Zakęś, 2007), Eurasian perch (Migaud et al., 2004; Żarski et al., 2019), and largemouth bass (Hussein et al., 2020) where gametes are available year-round from dedicated intensively-reared broodstock operations. Because out-of-season spawning is successful for other percid species (pikeperch/zander and Eurasian perch), similar techniques may make sense for walleye. However, there are several reasons why methods that work well for pikeperch/zander and other percids may not be optimal for walleye. Walleye are generally much more thermally sensitive than other percids and require cooler winter water temperatures for successful reproduction (Hokanson, 1977). Therefore, providing the environmental conditions needed to induce out-of-season spawning is much more difficult for walleye than it is for other percid species. Successful attempts to induce out-of-season spawning have been made with walleye, but they have either achieved only slight alterations in spawning timing or required the use of wild-caught walleye that were brought into warmed water conditions early (Dabrowski et al., 2000; Garcia-Abiado et al., 2004; Malison et al., 1998). Attempts to conduct out-of-season spawning intensively have been successful but resulted in tradeoffs in fecundity and gamete quality (Firkus et al., 2024). While this approach may be viable with more refinement, it would currently be difficult to implement economically at scale.

Cold banking methods are also relatively rare in aquaculture but show promise as a more economical method of cohort staggering than out-of-season-spawning. Cobia (*Rachycentron canadum*) aquaculture practices occasionally use cold banking to stagger production and achieve a year-round market size product (Schwarz et al., 2007). Two pilot studies have been conducted with walleye (Harder et al., 2014, 2013) and yellow perch (Shewmon, 2005) that suggested cold banking is a viable approach for cohort staggering and results in minimal adverse effects. While these trials are promising, more work is needed to determine if cold banking can be an economically viable option for cohort staggering. The walleye pilot study implemented cold banking practices at 190 days post hatch when fish were 55.6 g (189.8 mm). While this size and age appeared to be well suited for cold banking, it is not optimal in terms of tank space and feed requirements. If it is possible to initiate cold banking with younger and smaller fish, far less tank space would be needed to achieve the same results allowing more space to be dedicated towards grow-out operations. This proposed project would expand on previous work and investigate how early walleye could be cold banked without influencing survival or post-cold-bank growth rates. It additionally plans to model the economic costs of each approach so that current and future walleye fish farms can best plan their operations.

Statement Regarding Duplication of Research

The research activities proposed in this project are original research and do not duplicate any previously funded projects based on records from the USDA Current Research Information System and NOAA database. The following keywords have been used to search for funded projects and publications: cold banking, staggered cohorts, walleye, and production economics. Previous work has been done on the viability of cold banking for walleye (Harder et al., 2014, 2013), and found that there were minimal adverse effects for cold-banked fish. While this previous study provides a good foundation for the proposed work, assessment of the earliest age at which walleye can be cold banked as well as the economic viability of cold-banking relative to other cohort staggering options is necessary.

Anticipated Benefits

We expect that this project will yield valuable insights for the walleye aquaculture industry. Because walleye aquaculture is still new, many questions needing research support develop as farmers begin planning their operations. This proposal idea was developed as the result of questions raised by three different fish farmers focusing on walleye in the North Central Region who are planning on expanding their current grow-out operations (Aqua Garden LLC, Fountain Fresh LLC, Woods and Waters Fish Farm Inc.), and one group hoping to build a large walleye food fish operation (Bluewater Farms LLC). Currently, these fish farms recognize the importance of providing a fresh product outside of the typical availability of frozen imported fillets, but do not feel like there is enough research available to confidently choose between out-of-season spawning and cold-banking approaches. The research and economic analysis proposed in this project will determine if a cold banking approach is the best option for walleye fish farm operations, or if further resources should be invested into optimizing out-of-season spawning. Furthermore, the economic analysis proposed in this project would provide a blueprint for prospective farmers to develop their business plans. The investigators on this project have previously developed budgeting tools and business plan models to guide farmers on best practices. This project will expand those current resources and serve as a direct benefit to the farmers already using them.

Objective(s)

1. Evaluate various ages at which walleye fingerlings can be cold banked.
2. Quantify and compare growth rates, survival rates, feed conversion, and costs of cold banking walleye fingerlings at different ages

3. Use cost information from cold banking trials to compare the economic viability of cold banking relative to multiple cohorts (utilizing out-of-season spawning), and single cohort (not implementing cohort staggering methods) for producing walleye as a food fish.
4. Provide feed trained fingerlings to industry partners
5. Develop outreach deliverables including direct (hands on demonstration, tours, technical assistance) and indirect (presentations, publications, technical videos) targeting industry on the results of this project.

Deliverable(s)

The ability to stagger cohorts of walleye so that market-sized individuals are available year-round is a critically important component to the success and viability of the walleye food-fish aquaculture industry. If successful, the research proposed by this project will demonstrate the economic and practical viability of cold banking as a cohort staggering method (Objective 1 & 2). Using the results of the trial, we will produce a cold banking SOP and update the *Walleye Culture Guide* and accompanying video series that provides practical hands-on guidance for best practices when raising walleye. If the study finds that cold banking is not an optimal approach and cannot be performed early enough during walleye grow-out to efficiently use space and minimize feed costs, then it will allow future efforts to focus more intensively on the development and optimization of out-of-season spawning as a cohort staggering method. Regardless of the result of the study, the proposed research will incorporate the development of economic models and enterprise budgets that will help prospective fish farmers evaluate and weigh the relative costs of each cohort staggering practice (Objective 3). These enterprise budgets will be made available directly on UWSP NADF website and sent directly to percid fish farmers in the region.

In addition to the deliverables from the research and outreach components of this project, the feed-trained walleye remaining at the end of the project will be donated to individual fish farmers. Currently, there are few options available for fish farmers to obtain feed-trained walleye fingerlings. UWSP NADF has been supporting the walleye food fish industry by raising feed-trained fingerling walleye and donating them to fish farmers. This practice is planned to continue as long as funding to raise them is obtained, and hopefully the broodstock and larviculture operation can be delivered to private operations to ensure the long-term success of the walleye aquaculture industry going forward (see logic model).

Procedures

Objective 1: In April of year 1, eggs and milt will be collected from captive walleye broodstock at the University of Wisconsin – Stevens Point Northern Aquaculture Demonstration Facility (NADF). Eggs will be fertilized, water hardened, disinfected with iodine, and hatched in a McDonald jar incubation system. At four days post-hatch (DPH), all larval walleye from the same treatment will be pooled and stocked into 240 L (63gal) round fiberglass rearing tanks. Each tank will be supplied with 20°C (68°F) water containing ball clay (KT OM-4, L&R

Specialties, MO) at 2 L/min (0.5 gal/min) to provide increased turbidity that reduces cannibalism and clinging behavior (Rieger and Summerfelt, 1997). Larval walleye will be fed a commercial starter diet (Otohime B1, B2, C1, C2, Reed Mariculture, San Diego, CA) found to be optimal for larval walleye performance (Fischer et al., 2022). Walleye will be raised in these systems for 30 DPH before being combined and assigned to a treatment (60d cold bank, 120d cold bank, or no cold bank control) and stocked into replicated small-scale RAS (n=2 per treatment). The no cold bank control treatment will be maintained at 20°C (68°F) for the duration of the study (when average weight reaches 300 g, 10.6 oz, expected at ~330 DPH). In the 60d cold bank treatment, temperatures in the two corresponding RAS systems will be cooled to 8°C (46°F) at 60 DPH and held for a 60-day cold bank period. In the 120d cold bank treatment, temperatures will be cooled to 8°C (46°F) at 120 DPH and held for a 60-day cold bank period (Figure 2). After the respective cold bank periods, each treatment will be warmed back to 20°C (68°F) and maintained at this grow out temperature until the completion of the study (average weight reaching 300g, 10.6oz, expected at ~420 DPH).

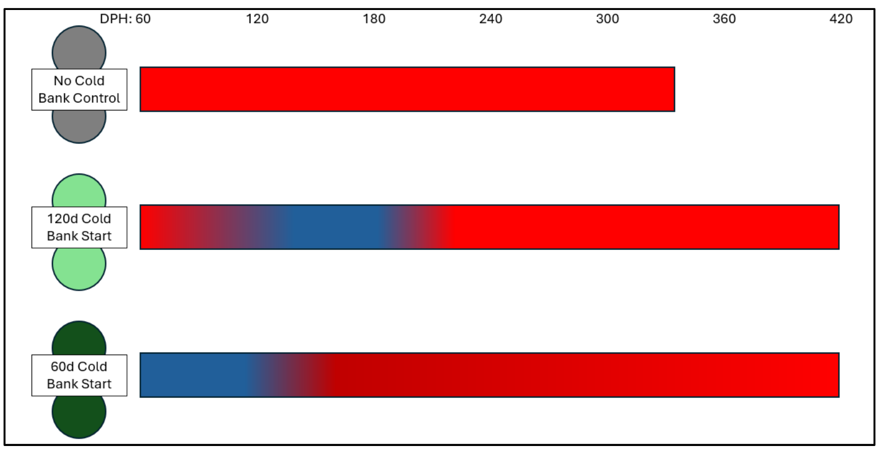

Figure 2: Graphical depiction of the experimental cold banking treatments. Red portions of each bar indicate time when temperatures will be held at 20°C, while blue portions of each bar indicate time when temperatures will be held at 8°C (46°F). Days-post-hatch are shown on the top of the figure.

Objective 2: From 60 DPH through the end of the study (when each treatment reaches an average weight of 300g, 10.6 oz), water quality will be checked daily and maintained at optimal levels. A weekly sub-sample of 15 fish from each treatment will be taken to evaluate fish length, weight, and condition indices to quantify growth rates and fish health. Any mortalities will be enumerated so survival rates can be compared among treatments. Growth rates, condition indices, and survival rates will be compared among treatments using ANOVA with Tukey HSD post hoc testing. Cold banking regimes will be considered successful if survival rates are not significantly different from the no cold bank control treatment and growth rates resume to original levels prior to cold banking. Total feed usage will be monitored to allow for feed conversion rate calculations. All costs associated with each treatment will be tracked to inform economic analysis in objective 3.

Objective 3: Because walleye aquaculture is a budding industry, there is currently little information available to aid new and prospective businesses with planning their operations. Currently, enterprise budget tools focusing on walleye grow out in a variety of systems are very limited (Firkus 2024) but there are budgeting tools available for other major aquaculture species (Engle et al., 2020; Hegde et al., 2022). Enterprise budgeting is a useful tool for the important planning required to bring walleye to market year-round. It will be used in this project to develop various management strategies of cold banking regimes to assess the viability of the various approaches for staggering cohorts of walleye production. We will expand current budgeting tools to account for the relative costs of the various methods for staggering cohorts. Using the information gleaned from this study regarding the feed and system costs for cold banking and utilizing data from previous studies that recorded costs for out-of-season spawning, we will build tools that allow producers to weigh the relative costs of each approach. The most important considerations for producers are the capital costs required for the specific system component, the operating expenses and cost of goods sold, differences in labor requirements, and the facility space needed for the different methods of cohort staggering.

Objective 4: Because the walleye industry is in the very early stages of development, it can be difficult for producers to find reliable supplies of feed trained walleye fingerlings. Because this project would result in the production of feed trained walleye fingerlings, we plan to make these available to walleye food fish producers at the completion of the study. Because the walleye produced at UWSP NADF are from an in-house broodstock and strain and most states only allow stocking of walleye in their native basins, we will only make any resulting fingerlings available to operations focusing on food fish production.

Objective 5: Due to the complexity in equipment, management practices and systems needed for indoor walleye production, the UWSP NADF has been a critical resource to farmers interested in walleye culture. The facility has existing partnerships with current and prospective walleye producers in Wisconsin and elsewhere in the NCR, providing technical assistance as needed as well as donations of eggs, fry and feed trained fingerlings. This project will provide direct outreach before, during and after the project's completion and includes technical assistance and demonstrational facility tours (which can also be virtual) as well as farm visits to interested businesses as a part of objective 4. This direct interaction with industry regarding this project is critical for technology transfer and directly meets the needs of the individual farmer. The facility will also organize a special session on intensive walleye production at the annual Wisconsin Aquaculture Association conference, to showcase project results as well as share best management practices at the larval and grow out stages. This session will also initiate additional partnerships with interested local farmers. In-direct outreach deliverables will include updated chapters in the existing UWSP NADF Walleye Culture Guide and new how-to videos uploaded to the UWSP NADF Walleye Culture Video Manual, both incorporating outcomes of this research and if cold banking may be a viable option. In addition, results will be published in an aquaculture related journal as well as articles through the UWSP NADF newsletter, Wisconsin Sea Grant's Aquatic Sciences Chronicle, and related aquaculture article outlets such as Aquaculture Magazine or Hatchery International. Travel is being requested to share updates and results of this project at regional and national events including the Wisconsin Aquaculture Association Conference, NCRAC conference, and Aquaculture America. The facility will utilize its existing platforms (website, social sites, partnering sites) as well as regional and national aquaculture networks to showcase this project's outreach deliverables and invite interested parties to directly connect with us. The facility is well connected with Wisconsin Sea Grant, Wisconsin Aquaculture Association, NCRAC, National Aquaculture Association, and US Aquaculture Society to help share the outcomes of this project.

Outreach and Evaluation Plan

The UWSP NADF is well suited to provide direct outreach to industry through hands-on demonstration and tours as well as direct technical assistance to farmers, which also includes farm visits. The industry will be able to see this project in action through in-person tours as well as virtual tour options. The facility has existing partnerships with current walleye growers as well as those interested in pursuing walleye. The results of this project will be directly shared with these partners as well as additional interested farmers, providing technical assistance and farm visits on how best to incorporate the results of this project into their current or future operations. The facility has a strong following for their newsletter, website, and YouTube channel. Project overview, updates and results will be shared through these avenues as well as partnering networks and others, mentioned above. This project's impact will be evaluated by both the number of farmers directly and indirectly reached. Direct reach includes tours, technical assistance, and consultations. Due to the important interactions with direct outreach, we will be able to evaluate whether the farmers are incorporating cold banking currently or in the future, as well as utilization of the economic budgeting tools created. Evaluations will also be reported on indirect outreach, reporting the number of views regarding presentations, videos, and downloads of project deliverables. This project will not only evaluate the number of audiences that are accessing the information, but also the number of farmers that are incorporating the project results, in which we will develop statements describing these impacts on their production and business.

Facilities

University of Wisconsin-Steven Point

The University of Wisconsin-Stevens Point (UWSP) Northern Aquaculture Demonstration Facility (NADF) is a one-of-a-kind research facility equipped with modern, high tech, and commercially scaled aquaculture systems designed for aquaculture research. NADF is recognized as an international leader in intensive walleye aquaculture and has been working with walleye for over 15 years. For this project, NADF has a dedicated walleye larviculture system equipped with a Bell jar incubation system, 27 x 240 L (63 gal) tanks, a biosecure water supply, and infrastructure designed to maintain appropriate temperature, turbidity, and water chemistry. For the cold banking trials, NADF has six small-scale replicated RAS each containing separate biofilters, UV filtration, speece cones, and chilling units. The facility has a dedicated staff specifically trained in walleye culture, and who have helped develop some of the current best practices used in walleye aquaculture. More information can be found at the facility's webpage (aquaculture.uwsp.edu). Furthermore, NADF staff have been heavily invested in facilitating the development of the walleye aquaculture industry. We currently work closely with the three recently started LLCs focusing on walleye culture by providing technical expertise, walleye fingerlings, and business planning guidance. We also work directly with many prospective aquaculture companies interested in working with walleye.

Quagrainie Economics Lab, Purdue

Dr. Quagrainie is a faculty member in the Department of Agricultural Economics at Purdue University. He has a dedicated office space and computers with access to relevant economic analysis software as well as access to a wide array of applied economics expertise in agribusiness, production, farm management, consumption, international development, trade, macroeconomics policy implications. Purdue University has a dedicated Aquaculture team, with members residing in different departments in the college.

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Logic Model

Situation:

- Farmers raising walleye for food fish operations are currently unsure what method to use for staggering production so that market-sized fish can be sold year-round.
- Although research has identified viable options (*i.e.* out-of-season spawning, cold-banking), considerable uncertainty exists about the drawbacks of each approach and the relative economic costs.
- If cold-banking can be implemented when walleye are very young, it may be a cost-effective and efficient approach to staggering cohorts of fish.

Goal:

Investigate how early walleye can be cold-banked without influencing survival or post-cold-bank growth rates. Additionally, model the economic costs of each cohort staggering approach so that current and future walleye fish farms can best plan their operations.

Objectives:

1. Evaluate various ages at which walleye fingerlings can be cold banked.
2. Quantify and compare growth rates, survival rates, feed conversion, and costs of cold banking walleye fingerlings at different ages
3. Use cost information from cold banking trials to compare the economic viability of cold banking relative to multiple cohorts (utilizing out-of-season spawning), and single cohort (not implementing cohort staggering methods) for producing walleye as a food fish.
4. Provide feed trained fingerlings to industry partners
5. Develop outreach deliverables including direct (hands on demonstration, tours, technical assistance) and indirect (presentations, publications, technical videos) targeting industry on the results of this project.

Inputs	Outputs		Outcomes		
	Activities	Participation	Short-term	Mid-term	Long-term
• Faculty, Staff, Extension, industry partners, and students in NCRAC • Preliminary data and previous studies • Lab facility space, systems, and office space • Inquiry and imput from walleye farmers • Previous economic analysis for various system types	• Lab research trialing cold-banking at different starting points • Economic modeling of cold-banking relative to other cohort staggering methods • Data dissemination, extension delivery of findings, outreach/education, walleye culture guide and video series • Providing feed trained walleye fingerlings to industry • Presentation of findings to research community and industry community at meetings	• Faculty, research staff, students, university community, interns, volunteers • Aquaculture producers, particularly ones focused on starting walleye operations • Business planning and extension community	• New knowledge of physiological constraints of cold-banking for walleye • Tools for implementing cold-banking practices • Economic analysis of the relative costs of cohort staggering options • Continued support of existing walleye industry by providing fingerlings	• Informed decision making during facility development and bioplanning in walleye food fish operations • Transfer of walleye life stage operations from NADF to private hands • Guidance of future research focus towards most economically viable practices	• Expansion of walleye food-fish (and stocking) aquaculture industry • Establishment of walleye as a new aquaculture species on the regional and national scale • Reduce reliance on imported seafood products • Reduce pressure on wild fisheries

Project Leaders

State	Name/Institution	Area of Specialization
WI	Tyler Firkus, Ph.D. University of Wisconsin – Stevens Point	Fish Physiology/Aquaculture
IN	Kwamena Quaqranine, Ph.D. Purdue University	Aquaculture economics
WI	Christopher Hartleb University of Wisconsin Stevens Point	Aquaculture
WI	Emma Hauser Wisconsin Sea Grant, University of Wisconsin Stevens Point	Outreach/Communication

Budget

Budget Justification Per Institution

University of Wisconsin-Stevens Point

Tyler Firkus

Objective 1, 2, 3 & 4 Total budget = $88,897.95

Year-1 Budget ($44,367.20)

A. Salary, Wages and Fringe Benefits (**$31,517.20**). Accounts for ½ of LTE staff appointment with fringe benefits.

B. Nonexpendable Equipment: No budget is required for this.

C. Materials and Supplies (**$10,250**): The budget is required to cover cost for commercial feed ($5,500), consumable supplies for system equipment ($3000), fish treatments ($1,250) and office supplies for outreach activities ($500).

D. Travel **($2,600**): The cost for travel for Year-1 is to cover domestic travel of the PI to workshops or conference ($2,000) and visit local farms for discussion and transport of fry and fingerlings to industry- ($600).

E. All Other Direct Costs: No budget is required for this.

Year-2 Budget (total, $44,530.75)

A. Salary, Wages and Fringe Benefits (**$33,110.75**). Accounts for ½ of LTE staff appointment with fringe benefits.

B. Nonexpendable Equipment: No budget is required for this.

C. Materials and Supplies (**$8,820**): The budget is required to cover cost for commercial feed ($4,200), consumable supplies for system equipment ($3,000), fish treatments ($1,120) and office supplies for outreach activities ($500).

D. Travel **($2,600**): The cost for travel for Year-1 is to cover domestic travel of the PI to a conference ($2,000) and visit local farms for PI and other members to set up farm testing and data collection ($600).

E. All Other Direct Costs: No budget is required for this.

ORGANIZATION AND ADDRESS University: University of Wisconsin Stevens Point Address: 2100 Main St City, State, ZIP: Stevens Point, Wisconsin 54481				**USDA AWARD NO.** Year 1: Objective 1, 2, 3, 4, & 5			
PROJECT DIRECTOR(S) PI Name: Tyler Firkus				Duration Proposed Months: __ **Funds Requested by Proposer**	Duration Proposed Months: ____ **Funds Approved by CSREES** (If different)	Non-Federal Proposed Cost-Sharing/ Matching Funds (If required)	Non-federal Cost-Sharing/ Matching Funds Approved by CSREES (If Different)
A. Salaries and Wages	**CSREES FUNDED WORK MONTHS**						
1. No. of Senior Personnel	Calendar	Academic	Summer				
a. ___ (Co)-PD(s)							
b. ___ Senior Associates							
2. No. of Other Personnel (Non-Faculty)							
a. ___ Research Associates-Postdoctorates . . .							
b. _1__ Other Professionals				21,008.00			
c. ___ Paraprofessionals							
d. ___ Graduate Students							
e. ___ Prebaccalaureate Students							
f. ___ Secretarial-Clerical							
g. ___ Technical, Shop and Other							
Total Salaries and Wages							
B. Fringe Benefits (If charged as Direct Costs)				10,509.2			
C. Total Salaries, Wages, and Fringe Benefits (A plus B)				31,517.20			
D. Nonexpendable Equipment (Attach supporting data. List items and dollar amounts for each item.)							
E. Materials and Supplies				10,250.00			
F. Travel				2,600.00			
G. Publication Costs/Page Charges							
H. Computer (ADPE) Costs							
I. Student Assistance/Support (Scholarships/fellowships, stipends/tuition, cost of education, etc. Attach list of items and dollar amounts for each item.)							
J. All Other Direct Costs (In budget narrative, list items and dollar amounts and provide supporting data for each item.)							
K. Total Direct Costs (C through I)				44,367.20			
L. F&A/Indirect Costs. (If applicable, specify rate(s) and base(s) for on/off campus activity. Where both are involved, identify itemized costs in on/off campus bases.)							
M. Total Direct and F&A/Indirect Costs (J plus K)							
N. Other							
O. Total Amount of This Request				44,367.20			

P. Carryover -- (If Applicable) . . . . **Federal Funds: $** **Non-Federal funds: $** **Total $**

Q. Cost Sharing/Matching (Breakdown of total amounts shown in line O)	Leave Blank	
Cash (both Applicant and Third Party)		
Non-Cash Contributions (both Applicant and Third Party)		

NAME AND TITLE (Type or print)	**SIGNATURE** (required for revised budget only)	**DATE**
Project Director: Tyler Firkus, Assistant Director NADF		8/23/2024
Authorized Organizational Representative		

Signature (for optional use)		

ORGANIZATION AND ADDRESS University: University of Wisconsin Stevens Point Address: 2100 Main St City, State, ZIP: Stevens Point, Wisconsin 54481				**USDA AWARD NO.** Year 2: Objective 1, 2, 3, 4, & 5			
PROJECT DIRECTOR(S) PI Name: Tyler Firkus				Duration Proposed Months: __ **Funds Requested by Proposer**	Duration Proposed Months: ____ **Funds Approved by CSREES** (If different)	Non-Federal Proposed Cost-Sharing/ Matching Funds (If required)	Non-federal Cost-Sharing/ Matching Funds Approved by CSREES (If Different)
A. Salaries and Wages	**CSREES FUNDED WORK MONTHS**						
1. No. of Senior Personnel	Calendar	Academic	Summer				
a. ___ (Co)-PD(s)							
b. ___ Senior Associates							
2. No. of Other Personnel (Non-Faculty) a. ___ Research Associates-Postdoctorates							
b. _1__ Other Professionals				21,428.16			
c. ___ Paraprofessionals							
d. ___ Graduate Students							
e. ___ Prebaccalaureate Students							
f. ___ Secretarial-Clerical							
g. ___ Technical, Shop and Other							
Total Salaries and Wages							
B. Fringe Benefits (If charged as Direct Costs)				11,682.59			
C. Total Salaries, Wages, and Fringe Benefits (A plus B)				33,110.75			
D. Nonexpendable Equipment (Attach supporting data. List items and dollar amounts for each item.)							
E. Materials and Supplies				8,820.00			
F. Travel				2,600.00			
G. Publication Costs/Page Charges							
H. Computer (ADPE) Costs							
I. Student Assistance/Support (Scholarships/fellowships, stipends/tuition, cost of education, etc. Attach list of items and dollar amounts for each item.)							
J. All Other Direct Costs (In budget narrative, list items and dollar amounts and provide supporting data for each item.)							
K. Total Direct Costs (C through I)				44,530.75			
L. F&A/Indirect Costs. (If applicable, specify rate(s) and base(s) for on/off campus activity. Where both are involved, identify itemized costs in on/off campus bases.)							
M. Total Direct and F&A/Indirect Costs (J plus K)							
N. Other							
O. Total Amount of This Request				44,530.75			

P. Carryover -- (If Applicable) . . . . **Federal Funds: $** **Non-Federal funds: $** **Total $**

Q. Cost Sharing/Matching (Breakdown of total amounts shown in line O)	Leave Blank	
Cash (both Applicant and Third Party)		
Non-Cash Contributions (both Applicant and Third Party)		

NAME AND TITLE (Type or print)	**SIGNATURE** (required for revised budget only)	**DATE**
Project Director **Tyler Firkus, Assistant Director NADF**		8/23/2024

Authorized Organizational Representative		
Signature (for optional use)		

ORGANIZATION AND ADDRESS University: University of Wisconsin Stevens Point Address: 2100 Main St City, State, ZIP: Stevens Point, Wisconsin 54481				USDA AWARD NO. Year 1&2: Objective 1, 2, 3, 4, & 5			
PROJECT DIRECTOR(S) PI Name: Tyler Firkus				Duration Proposed Months: __ **Funds Requested by Proposer**	Duration Proposed Months: ____ **Funds Approved by CSREES** (If different)	Non-Federal Proposed Cost-Sharing/ Matching Funds (If required)	Non-federal Cost-Sharing/ Matching Funds Approved by CSREES (If Different)
A. Salaries and Wages 1. No. of Senior Personnel	**CSREES FUNDED WORK MONTHS**						
	Calendar	Academic	Summer				
a. ___ (Co)-PD(s)							
b. ___ Senior Associates							
2. No. of Other Personnel (Non-Faculty)							
a. ___ Research Associates-Postdoctorates . . .							
b. _1__ Other Professionals				42,436.16			
c. ___ Paraprofessionals							
d. ___ Graduate Students							
e. ___ Prebaccalaureate Students							
f. ___ Secretarial-Clerical							
g. ___ Technical, Shop and Other							
Total Salaries and Wages							
B. Fringe Benefits (If charged as Direct Costs)				22,191.79			
C. Total Salaries, Wages, and Fringe Benefits (A plus B)				64,627.95			
D. Nonexpendable Equipment (Attach supporting data. List items and dollar amounts for each item.)							
E. Materials and Supplies				19,070.00			
F. Travel				5,200.00			
G. Publication Costs/Page Charges							
H. Computer (ADPE) Costs							
I. Student Assistance/Support (Scholarships/fellowships, stipends/tuition, cost of education, etc. Attach list of items and dollar amounts for each item.)							
J. All Other Direct Costs (In budget narrative, list items and dollar amounts and provide supporting data for each item.)							
K. Total Direct Costs (C through I)				88,897.95			
L. F&A/Indirect Costs. (If applicable, specify rate(s) and base(s) for on/off campus activity. Where both are involved, identify itemized costs in on/off campus bases.)							
M. Total Direct and F&A/Indirect Costs (J plus K)							
N. Other							
O. Total Amount of This Request				88,897.95			

P. Carryover -- (If Applicable) . . . . **Federal Funds: $** **Non-Federal funds: $** **Total $**

Q. Cost Sharing/Matching (Breakdown of total amounts shown in line O)	Leave Blank	
Cash (both Applicant and Third Party)		
Non-Cash Contributions (both Applicant and Third Party)		

NAME AND TITLE (Type or print)	**SIGNATURE** (required for revised budget only)	**DATE**
Project Director **Tyler Firkus, Assistant Director NADF**		8/23/2024
Authorized Organizational Representative		

Signature (for optional use)		

<u>Purdue University</u>

Kwamena Quagrainie

Objective 3 Total budget = $37,571

<u>Year-1 Budget ($18,455.00)</u>

A. ¼ time graduate student Salary, Wages and Fringe Benefits ($**16,555** =$15,300 salary + $1,255 benefits).

B. Nonexpendable Equipment: No budget is required for this.

C. Materials and Supplies: $400 for software program

D. Travel Domestic travel cost for PI to workshops or conference ($1,500).

E. All Other Direct Costs:

<u>Year-2 Budget</u>

A. ¼ time graduate student Salary, Wages and Fringe Benefits ($**17,217** =$15,912 salary + $1,305 benefits)

B. Nonexpendable Equipment: No budget is required for this.

C. Materials and Supplies $400 for software accessories

D. Travel Domestic travel cost for PI to workshops or conference ($1,500).:

E. All Other Direct Costs**:**

ORGANIZATION AND ADDRESS University: Purdue University Address: 403 Mitch Daniels Blvd City, State, ZIP: West Lafayette, IN 47907				**USDA AWARD NO.** Year 1: Objective 3			
PROJECT DIRECTOR(S) PI Name: Kwamena Quagrainie				Duration Proposed Months: __ **Funds Requested by Proposer**	Duration Proposed Months: ____ **Funds Approved by CSREES** (If different)	Non-Federal Proposed Cost-Sharing/ Matching Funds (If required)	Non-federal Cost-Sharing/ Matching Funds Approved by CSREES (If Different)
A. Salaries and Wages 1. No. of Senior Personnel	**CSREES FUNDED WORK MONTHS**						
	Calendar	Academic	Summer				
a. ___ (Co)-PD(s)							
b. ___ Senior Associates							
2. No. of Other Personnel (Non-Faculty) a. ___ Research Associates-Postdoctorates . . .							
b. ___ Other Professionals							
c. ___ Paraprofessionals							
d. _1__ Graduate Students				15,300.00			
e. ___ Prebaccalaureate Students							
f. ___ Secretarial-Clerical							
g. ___ Technical, Shop and Other							
Total Salaries and Wages							
B. Fringe Benefits (If charged as Direct Costs)				1,255.00			
C. Total Salaries, Wages, and Fringe Benefits (A plus B)				16,555.00			
D. Nonexpendable Equipment (Attach supporting data. List items and dollar amounts for each item.)							
E. Materials and Supplies				400.00			
F. Travel				1,500			
G. Publication Costs/Page Charges							
H. Computer (ADPE) Costs							
I. Student Assistance/Support (Scholarships/fellowships, stipends/tuition, cost of education, etc. Attach list of items and dollar amounts for each item.)							
J. All Other Direct Costs (In budget narrative, list items and dollar amounts and provide supporting data for each item.)							
K. Total Direct Costs (C through I)				18,455.00			
L. F&A/Indirect Costs. (If applicable, specify rate(s) and base(s) for on/off campus activity. Where both are involved, identify itemized costs in on/off campus bases.)							
M. Total Direct and F&A/Indirect Costs (J plus K)							
N. Other							
O. Total Amount of This Request				18,455.00			

P. Carryover -- (If Applicable) . . . . **Federal Funds: $** **Non-Federal funds: $** **Total $**

Q. Cost Sharing/Matching (Breakdown of total amounts shown in line O)	Leave Blank	
Cash (both Applicant and Third Party)		
Non-Cash Contributions (both Applicant and Third Party)		

NAME AND TITLE (Type or print)	**SIGNATURE** (required for revised budget only)	**DATE**
Project Director **Kwamena Quagrainie**		8/23/2024
Authorized Organizational Representative		

Signature (for optional use)		

ORGANIZATION AND ADDRESS University: Purdue University Address: 403 Mitch Daniels Blvd City, State, ZIP: West Lafayette, IN 47907 PROJECT DIRECTOR(S) PI Name: Kwamena Quagrainie				**USDA AWARD NO.** Year 2: Objective 3			
				Duration Proposed Months: __ **Funds Requested by Proposer**	Duration Proposed Months: ____ **Funds Approved by CSREES** (If different)	Non-Federal Proposed Cost-Sharing/ Matching Funds (If required)	Non-federal Cost-Sharing/ Matching Funds Approved by CSREES (If Different)
A. Salaries and Wages	**CSREES FUNDED WORK MONTHS**						
1. No. of Senior Personnel	Calendar	Academic	Summer				
a. ___ (Co)-PD(s)							
b. ___ Senior Associates							
2. No. of Other Personnel (Non-Faculty)							
a. ___ Research Associates-Postdoctorates . . .							
b. ___ Other Professionals							
c. ___ Paraprofessionals							
d. _1__ Graduate Students				15,912.00			
e. ___ Prebaccalaureate Students							
f. ___ Secretarial-Clerical							
g. ___ Technical, Shop and Other							
Total Salaries and Wages							
B. Fringe Benefits (If charged as Direct Costs)				1,305.00			
C. Total Salaries, Wages, and Fringe Benefits (A plus B)				17,217.00			
D. Nonexpendable Equipment (Attach supporting data. List items and dollar amounts for each item.)							
E. Materials and Supplies				400.00			
F. Travel				1,500			
G. Publication Costs/Page Charges							
H. Computer (ADPE) Costs							
I. Student Assistance/Support (Scholarships/fellowships, stipends/tuition, cost of education, etc. Attach list of items and dollar amounts for each item.)							
J. All Other Direct Costs (In budget narrative, list items and dollar amounts and provide supporting data for each item.)							
K. Total Direct Costs (C through I)				19,117.00			
L. F&A/Indirect Costs. (If applicable, specify rate(s) and base(s) for on/off campus activity. Where both are involved, identify itemized costs in on/off campus bases.)							
M. Total Direct and F&A/Indirect Costs (J plus K)							
N. Other							
O. Total Amount of This Request				19,117.00			

P. Carryover -- (If Applicable) . . . . **Federal Funds: $** **Non-Federal funds: $** **Total $**

Q. Cost Sharing/Matching (Breakdown of total amounts shown in line O)	Leave Blank	
Cash (both Applicant and Third Party)		
Non-Cash Contributions (both Applicant and Third Party)		

NAME AND TITLE (Type or print)	**SIGNATURE** (required for revised budget only)	**DATE**
Project Director **Kwamena Quagrainie**		8/23/2024
Authorized Organizational Representative		

Signature (for optional use)		

ORGANIZATION AND ADDRESS University: Purdue University Address: 403 Mitch Daniels Blvd City, State, ZIP: West Lafayette, IN 47907 PROJECT DIRECTOR(S) PI Name: Kwamena Quagrainie				**USDA AWARD NO.** Year 1&2: Objective 3			
				Duration Proposed Months: __ **Funds Requested by Proposer**	Duration Proposed Months: ____ **Funds Approved by CSREES** (If different)	Non-Federal Proposed Cost-Sharing/ Matching Funds (If required)	Non-federal Cost-Sharing/ Matching Funds Approved by CSREES (If Different)
A. Salaries and Wages 1. No. of Senior Personnel	**CSREES FUNDED WORK MONTHS**						
	Calendar	Academic	Summer				
a. ___ (Co)-PD(s)							
b. ___ Senior Associates							
2. No. of Other Personnel (Non-Faculty) a. ___ Research Associates-Postdoctorates . . .							
b. ___ Other Professionals							
c. ___ Paraprofessionals							
d. _1__ Graduate Students				31,212.00			
e. ___ Prebaccalaureate Students							
f. ___ Secretarial-Clerical							
g. ___ Technical, Shop and Other							
Total Salaries and Wages							
B. Fringe Benefits (If charged as Direct Costs)				2,560.00			
C. Total Salaries, Wages, and Fringe Benefits (A plus B)				33,772.00			
D. Nonexpendable Equipment (Attach supporting data. List items and dollar amounts for each item.)							
E. Materials and Supplies				800.00			
F. Travel				3,000			
G. Publication Costs/Page Charges							
H. Computer (ADPE) Costs							
I. Student Assistance/Support (Scholarships/fellowships, stipends/tuition, cost of education, etc. Attach list of items and dollar amounts for each item.)							
J. All Other Direct Costs (In budget narrative, list items and dollar amounts and provide supporting data for each item.)							
K. Total Direct Costs (C through I)				37,572.00			
L. F&A/Indirect Costs. (If applicable, specify rate(s) and base(s) for on/off campus activity. Where both are involved, identify itemized costs in on/off campus bases.)							
M. Total Direct and F&A/Indirect Costs (J plus K)							
N. Other							
O. Total Amount of This Request				37,572.00			

P. Carryover -- (If Applicable) . . . . **Federal Funds: $** **Non-Federal funds: $** **Total $**

Q. Cost Sharing/Matching (Breakdown of total amounts shown in line O)	Leave Blank	
Cash (both Applicant and Third Party)		
Non-Cash Contributions (both Applicant and Third Party)		

NAME AND TITLE (Type or print)	**SIGNATURE** (required for revised budget only)	**DATE**
Project Director **Kwamena Quagrainie**		8/23/2024
Authorized Organizational Representative		

Signature (for optional use)		

Budget Summary

Proposed Summary by Year				
Category	NCRAC Funds			
Year 1	Objective	UWSP (T.F.)	Purdue (K.Q.)	Project Total
Salaries, Wages, and Fringe Benefits	1, 2, 3, 4, &5	$31,517.20	$16,555.00	$48,072.20
Nonexpendable equipment				
Materials and Supplies		$10,250.00	$400.00	$10,650.00
Travels		$2,600.00	$1,500.00	$4,100.00
All Other Direct Costs				
Total		$44,367.20	$18,455.00	$62,812.20
Category	NCRAC Funds			
Year 2	Objective	UWSP (T.F.)	Purdue (K.Q.)	Project Total
Salaries, Wages, and Fringe Benefits	1, 2,3, 4, &5	$33,110.75	$17,217.00	$50,327.75
Nonexpendable equipment				
Materials and Supplies		$8,820.00	$400.00	$9,220.00
Travels		$2,600.00	$1,500.00	$4,100.00
All Other Direct Costs				
Total		$44,530.75	$19,117.00	$63,647.75
Category	NCRAC Funds			
Total Year 1 and Year 2	Objective	UWSP (T.F.)	Purdue (K.Q.)	Project Total
Salaries, Wages, and Fringe Benefits		$64,627.95	$33,772.00	$98,349.95
Nonexpendable equipment				
Materials and Supplies		$19,070	$800.00	$19,870.00
Travels		$5,200.00	$3,000.00	$8,200.00
All Other Direct Costs				
Total		$88,897.95	$37,572.00	$126,469.95

Schedule for Completion of objectives

Start Date: January 2025

Completion Date: December 2026

Participating Institutions and Co-Principal Investigators

University of Wisconsin – Stevens Point

Tyler Firkus, Ph.D.

Christopher Hartleb, Ph.D.

Emma Hauser

Purdue University

Kwamena Quagrainie, Ph.D.

VITA

Name: **Tyler J. Firkus**
UW-Stevens Point Northern Aquaculture Demonstration Facility
Address: 36445 State Highway 13, Bayfield, WI 54814
Phone: (715) 779 3461
Email: tyfirkus@uwsp.edu

EDUCATION
PhD – Fisheries And Wildlife & Environmental Toxicology, Michigan State University. 2021
Msc - Zoology And Physiology, University Of Wyoming, 2016.
Bsc - Biology, University Of St. Thomas, 2013.

POSITIONS
RESEARCH PROGRAM MANAGER/FACILITY OPERATIONS MANAGER – Northern Aquaculture Demonstration Facility, Bayfield, WI. University of Wisconsin Stevens Point (2022-present).

PHD CANDIDATE – Michigan State University, East Lansing, MI. (2016-2021).

SCIENTIFIC AND PROFESSIONAL ORGANIZATIONS

World Aquaculture Society
U.S. Aquaculture Society
National Aquaculture Association
Wisconsin Aquaculture Association

SELECTED PUBLICATIONS

Tyler J. Firkus, Konstadia Lika, Noah Dean, Cheryl A. Murphy. 2023. The Consequences of Sea Lamprey Parasitism on Lake Trout Energy Budgets. Conservation Physiology. 11(1).

Fischer, G.J., Firkus, T.J., Holmes, K., Blaufuss, P.C., Amberg, J.J. and Hartleb, C.F., 2022. Diet influences survival and growth of intensively reared larval saugeye (Sander vitreus× Sander canadensis). Aquaculture, Fish and Fisheries, 2(6), pp.450-457.

Tyler J. Firkus, Fredrick W. Goetz, Gregory J. Fischer, Cheryl A. Murphy. 2022. The influence of life history on the response to parasitism: Differential response to non-lethal sea lamprey parasitism by two lake charr ecomorphs. 2022. Integrative and Comparative Biology. 62(1):104-120.

Oliver M.N. Bullingham, Tyler J. Firkus, Fredrick W. Goetz, Cheryl A. Murphy, Sarah L. Alderman. 2022. Lake charr (Salvelinus namaycush) clotting response may act as a plasma biomarker of sea lamprey (Petromyzon marinus) parasitism: Implications for management and wound assessment. Journal of Great Lakes Research. 48(1):207-217.

Cheryl A. Murphy, A. Albers, Janice, N. Armstrong, Brandon, M., Firkus, Tyler, J., Ivan L. 2022. Emerging Toxicological methods for fisheries biologists in the Twenty-first Century. 2022. In Methods for Fish Biology 2nd Edition. P. 551-592.

Tyler J. Firkus, Cheryl A. Murphy, Jean V. Adams, Ted J. Treska, Gregory J. Fischer. 2021. Assessing the assumptions of classification agreement, accuracy, and predictable healing time of sea lamprey wounds on lake trout. Journal of Great Lakes Research. 47:S368-S377.

Tyler J. Firkus, Frank J. Rahel, Harold L. Bergman, Brian D. Cherrington. 2018. Warmed winter water temperatures alter reproduction in two fish species. Environmental Management. 601(2):291-303.

VITA

Emma M. Hauser
Aquaculture Outreach Specialist
UW-Stevens Point Northern Aquaculture Demonstration Facility
Wisconsin Sea Grant
P.O. Box 165
Bayfield, WI 54814
Telephone: (715)779-3262
Email: ewiermaa@uwsp.edu

EDUCATION

B. S., Ecology and Environmental Biology, 2012. University of Wisconsin-Eau Claire

POSITIONS

Aquaculture Outreach Specialist, University of Wisconsin Stevens Point Northern Aquaculture Demonstration Facility, University of Wisconsin-Stevens Point and Wisconsin Sea Grant Institute (2014-present)
Aquaculture Technician, University of Wisconsin Stevens Point Northern Aquaculture Demonstration Facility, University of Wisconsin-Stevens Point (2014)
Program Coordinator, Alliance for the Great Lakes, Duluth, MN (2013-2014)
Research Assistant, University of Wisconsin-Eau Claire (2011)
Education Program Coordinator, Longfellow Elementary School, Chippewa Falls, WI (2010-2011)

SCIENTIFIC AND PROFESSIONAL ORGANIZATIONS

World Aquaculture Society/U.S. Aquaculture Society- Member
Wisconsin Aquaculture Association- Member
North Central Region Aquaculture Center -Technical Advisory Committee for Extension/Board Member
Sea Grant Fisheries, Aquaculture and Seafood Group
National Aquaculture Extension Steering Committee Member

PROFESSIONAL CERTIFICATIONS:

Working with Fish in Research Settings – Collaborative Institutional Training Initiative (CITI) 2023
PIs and Students Working with Fish- Collaborative Institutional Training Initiative (CITI) 2023

SELECTED PUBLICATIONS:

Hauser, E., T. Firkus, K. Holmes, J. Neibauer, C. Branville, C. Hartleb, G. Fischer. 2023. Walleye Culture Guide. University of Wisconsin-Stevens Point Northern Aquaculture Demonstration Facility. Bayfield, Wisconsin.

Seilheimer, T.S., E. Hauser, and L.N. Jescovitch. 2021. "Fisheries, Hatcheries, and Aquaculture—What's the Difference?" Choices. Quarter 4. Available online: https://www.choicesmagazine.org/choices-magazine/theme-articles/the-economics-of-us-aquaculture/fisheries-hatcheries-and-aquaculturewhats-the-difference

Jescovitch, L., Nelson, E., Titus Seilheimer, T., Hauser, E., and A. Schrank. (2021, March). Introducing the Great Lakes Aquaculture Collaborative: Fostering an Aquaculture Event during COVID-19. Aquaculture Magazine. 52(1), 45-48.

University of Wisconsin-Stevens Point Northern Aquaculture Demonstration Facility. (2021, March 17). Commercialization of Walleye - Out of Season Spawning [Video]. YouTube. https://www.youtube.com/watch?v=Swfdbp1mW5k&t=4s

University of Wisconsin-Stevens Point Northern Aquaculture Demonstration Facility. (2020, December 15). Nanobubble Oxygenation in Recirculating Aquaculture Systems [Video]. YouTube. https://www.youtube.com/watch?v=emr0Qfxi_3k

University of Wisconsin-Stevens Point Northern Aquaculture Demonstration Facility. (2020, November24). Aquaculture Systems- A Basic Overview [Video]. YouTube. https://www.youtube.com/watch?v=8pMxhXdrEo8

Fischer, G., Hauser, E., Good, C., Davidson, J., and S. Summerfelt. (2020, June/July). Overcoming barriers to support the growth of land-based Atlantic salmon production. Aquaculture Magazine. 46(3), 70-75.

Kwamena K. Quagrainie
Department of Agricultural Economics / Illinois-Indiana Sea Grant
Purdue University, 403 Mitch Daniels Blvd, West Lafayette, IN 47907
Tel: 765-494-4200 | kquagrai@purdue.edu

Professional Preparation

Institution	Field	Degree, Year
University of Alberta, Canada	Agricultural Economics	Ph.D., 2000

Research and Professional Experience

2018–Present: Clinical Engagement Professor and Extension Specialist, Purdue University / Illinois–Indiana Sea Grant

Publications in Refereed Journal

1. Jung, J., Quagrainie, K.K., and Widmar, N. "Quantifying Online and Social Media Information About Seafood in the United States." Journal of the World Aquaculture Society (In press).
2. Tao, J., Quagrainie, K.K., Foster, K.A., and Widmar, N.O. "Online Media Sentiment Analysis of Shrimp and Salmon in the United States." Aquaculture (In press).
3. Tao, J., Bradford, T.L., Quagrainie, K.K., Foster, K.A., and Widmar, N.O. "Comparative Case Study of Small-Scale Fish Processing for Local Seafood Supply." Journal of Food Products Marketing (In press).
4. Bradford, T.L., and Quagrainie, K.K. "Online Media Sentiment Analysis for U.S. Oysters." Aquaculture, Fish and Fisheries (In press).
5. Carlton, J. S., Shambach, A. M., and Quagrainie, K.K. Aquaculture Extension Capacity in the USDA North-Central Region: Results from a Survey. Journal of Human Sciences and Extension, 11(1), 13, 2023. https://doi.org/10.55533/2325-5226.1385.
6. Quagraine, K., de Souza, S. V., Athnos, A., Etumnu, C., Knudson, W., Kinnunen, R., & Hitchens, P.. The seafood basket: Application of zero-inflated model to fish count purchase. Aquaculture, 565, 2022. https://doi.org/10.1016/j.aquaculture.2022.739097.
7. Athnos, A., Valle de Souza, S., Quagrainie, K., Etumnu, C., Knudson, W., Kinnunen, R., & Hitchens, P.. Are U.S. consumers willing to pay more by the lake? An analysis of preferences for Great Lakes region fish. Agricultural and Resource Economics Review, 1-26, 2022. https://doi.org/10.1017/age.2022.18.
8. Flores, R. M. V., Preckel, P. V., Quagrainie, K. K., Widmar, N. O., Silva, L., da Costa, J. I., Pinho, S. M., Portella, M. C., Branco, T. C., and Filho, M. X. P. Efficiency tests for screening production strategies in a lettuce-juvenile tilapia aquaponics system in Brazil. Aquaculture International, 1-22, 2022. https://doi.org/10.1007/s10499-022-00912-9.
9. Pinho, S. M., Flores, R. M. V., David, L. H., Emerenciano, M. G., Quagrainie, K. K., andPortella, M. C. Economic comparison between conventional aquaponics and FLOCponics systems. Aquaculture, 552(15), 2022. https://doi.org/10.1016/j.aquaculture.2022.737987.
10. Flores, R. M. V., Widmar, N. O., Quagrainie, K., Preckel, P. V., & Pedroza Filho, M. X. Establishing Linkages Between Consumer Fish Knowledge and Demand for Fillet Attributes in Brazilian Supermarkets. Journal of International Food & Agribusiness Marketing, 34:4, 368-388, 2021. https://doi.org/10.1080/08974438.2021.1900016
11. Quagrainie, K.K. Consumer Willingness to Pay for a Saline Fish Species Grown in the US Midwest: The Case of Striped Bass, *Morone saxatilis*. Journal of the World Aquaculture Society. 50(1); 163-171, 2019. https://doi.org/10.1111/jwas.12464.

Extension Publications

1. Quagrainie, K.K., Bradford, T.L., Tao, J., and Shambach, A.M. (2023). "Handbook on Processing Fish for Small-Scale Fish Farmers." Illinois-Indiana Sea Grant Report IISG23-SFA-BRC-044. Available at: https://iiseagrant.org/publications/handbook-on-processing-fish-for-small-scale-fish-farmers.
2. Quagrainie, K. K. and Shambach, A. M. (2022). "A Guide to Small-Scale Fish Processing Using Local Kitchen Facilities." FNR-628-W / IISG22-SAF-BRC-012. https://iiseagrant.org/publications/a-guide-to-small-scale-fish-processing-using-local-kitchen-facilities/.
3. Quagrainie, K. K. "Seafood Survey Results: Consumer Purchase Preferences". Illinois-Indiana Sea Grant Report IISG21-SAF-RLA-009. https://iiseagrant.org/wp-content/uploads/2021/04/Seafood-Survey-Results-Consumer-Purchase-Preferences-1.pdf.

CHRISTOPHER F. HARTLEB

Curriculum Vitae

Department of Biology
University of Wisconsin-Stevens Point
2101 Fourth Avenue
Stevens Point, WI 54481
715-346-3228
http://www.uwsp.edu/biology
Email: CHartleb@uwsp.edu

204875 Lake Drive
Rosholt, WI 54473
715-321-4247
http://aquaculture.uwsp.edu

Education

1996	Ph.D., Zoology (Fisheries Ecology), University of Maine, Maine Cooperative Fish & Wildlife Research Unit, Orono, ME. Dissertation: Ecology and performance of stocked brook trout (*Salvelinus fontinalis*) in two Maine ponds.
1992	M.S., Zoology, University of New Hampshire, Durham, NH. Thesis: The effects of a thermocline and light gradients on the feeding behavior of pumpkinseed sunfish (*Lepomis gibbosus*).
1990	B.S., Biology, Rensselaer Polytechnic Institute, Troy, NY. Thesis: Physiological ecology of seed germination in *Myriophyllum spicatum* L.

Employment History

2007-Present	Professor, Department of Biology & Adjunct Professor Water Resources & Sustainable and Resilient Food Systems, University of Wisconsin-Stevens Point, WI. Coordinator: Aquaculture Minor.
2014-2019	Director, Aquaponics Innovation Center, College of Letters & Science, University of Wisconsin-Stevens Point, Montello, WI.
2006-Present	Director, Northern Aquaculture Demonstration Facility, College of Letters & Science, University of Wisconsin-Stevens Point, Bayfield, WI.
2001-2007	Associate Professor, Department of Biology & Adjunct Professor Water Resources, University of Wisconsin-Stevens Point, WI.

Select Publications

2023 Fischer, G.L., C.F. Hartleb, K. Holmes, C. Hansum, and N. Tintle. Lake herring (Coregonus artedii) aquaculture best-practices: Randomized experiments from eggs to juvenile. North American Journal of Aquaculture. 85: 13-20.

2022 Ghamkhar, R., C. Hartleb, Z. Rabas, and A. Hicks. Evaluation of environmental and economic implications of a cold-weather aquaponic food production system using life cycle assessment and economic analysis. J. of Industrial Ecology 10:1-13

Fischer, G.J., Firkus, T.J., Holmes, K., Blaufuss, P.C., Amberg, J.J., Hartleb, C.F. Diet influences survival and growth of intensively reared larval saugeye (Sander vitreus × Sander canadensis). *Aquaculture, Fish and Fisheries* 2(6):450-457. https://doi.org/10.1002/aff2.86

Letters of Support

Dear NCRAC Proposal Review Committee:

This letter is submitted in support of the proposal titled, *Economic and physiological evaluation of methods for staggering the time to reach market size for walleye*. If funded, the proposed work would be highly beneficial to the future of walleye aquaculture, and be able to kick-start the industry without waiting on domesticated broodstock for year round egg availability.

I own and operate AquaGarden LLC, which is currently the only private business in Wisconsin raising walleye to market size indoors. Since the company began, we have been partnering with UWSP Northern Aquaculture Demonstration Facility for technical assistance, access to feed trained fingerlings as well as educational opportunities and workforce support for raising walleye in indoor systems. We attribute many of our successes in raising walleye in a recirculating system to NADF and very much appreciate their support along the way.

I look forward to continuing this partnership with UWSP NADF as well as utilizing the results of this project at my facility. Currently, AquaGarden does not have a larval system in place for feed training walleye and therefore our production of fish requires the purchase of feed-trained fingerlings only once per year. Cold banking would enable our company to raise various cohorts of fish, which would greatly enhance and grow our business.

Walleye aquaculture is a budding industry with a ton of interest behind it, with a few problems to solve. This research and development of cold banking walleye will enable us to develop standard operating procedures which will improve food conversion efficiency and enable us to supply our high-demand markets year-round.

I hope that this work is funded and look forward to collaborating.

Thank you,

Colin Bursik
AquaGarden LLC
Rice Lake, WI

C/O:
Tyler Firkus, PhD
UWSP-NADF

FountainFresh

Dear NCRAC Proposal Review Committee:

This letter is submitted in support of the proposal titled, *Economic and physiological evaluation of methods for staggering the time to reach market size for walleye*. If funded, the proposed work would have the potential to advance walleye larviculture and address one of the major bottlenecks to walleye industry expansion, year-round availability of eggs and fingerlings for production.

The capacity to bring walleye to market at various points during the year remains a challenge for food fish commercialization. While efforts are being made to create a domesticated broodstock to provide eggs year-round, cold banking may be a viable and efficient way for producers to stagger production.

I own and operate FountainFresh LLC, which is currently the only private business in Wisconsin successfully raising walleye indoors to sell as feed trained fingerlings. My operation is at the cutting edge of walleye aquaculture and seeks to be at the forefront of new developments. There are still many challenges in walleye aquaculture, so it is great to see research projects like this one that have the potential to directly benefit the industry and our operations specifically.

Furthermore, it is my opinion that research to further the commercialization of Walleyes as a viable food source be funded. I rely on the Northern Aquaculture Demonstration Facility to provide this data to help the sustainability of my business.

I am interested in both the biological results from cold banking but also the economic analysis and the viability for this approach, in which this project also looks to investigate. I have worked with the UWSP Northern Aquaculture Demonstration Facility for several years to develop my facility and incorporate management practices for culturing walleye indoors. I look forward to continuing this partnership as well as utilizing the results of this project at my facility.

I hope that this work is funded and look forward to collaborating.

Thank you,

Mike Neukirchen
FountainFresh LLC
Wisconsin Rapids, WI
715.459.6161

Dear NCRAC Proposal Review Committee:

This letter is submitted as support for the project proposal titled, *Economic and physiological evaluation of methods for staggering the time to reach market size for walleye*. The proposed work would be impactful for walleye aquaculture for food fish production and has the potential to advance the industry forward without needing to rely on commercial domesticated broodstock, which currently does not exist in a commercial capacity.

Woods and Waters Fish Farm uses traditional pond systems but has modernized buildings onsite with indoor recirculating systems. We originally started primarily stocking lakes and private ponds but along the way, there was a clear demand for fish in the food market. In 2022, a fish processing addition was built on the farm in preparation for launching a pilot run of fresh yellow perch fillets. We primarily focus on hatching and raising yellow perch for the food industry while continuing to have a variety of species for pond stocking. Woods and Waters Fish Farm is highly interested in expanding our food fish operation by incorporating walleye.

In the past, we have collaborated with UWSP Northern Aquaculture Demonstration Facility for technical assistance as well as obtaining feed-trained walleye fingerlings. We look forward to continuing this partnership with UWSP NADF as well as utilizing the results of this project at our facility.

I hope that this work is funded and look forward to collaborating.

Thank you,

Annie Schmitz

Annie Schmitz
Lead Fisheries Biologist
Woods & Waters Fish Farm
Juneau, Wisconsin