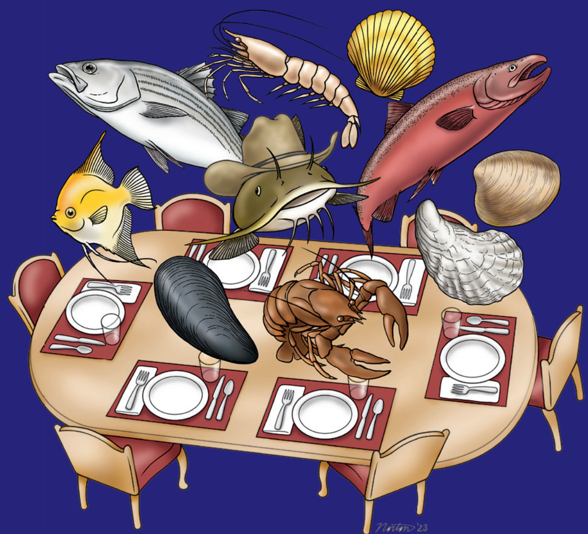
AQUACULTURE AMERICA 2024



Setting the Table for U.S. Aquaculture

FEBRUARY 18-21, 2024

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San Antonio, Texas

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WELCOME

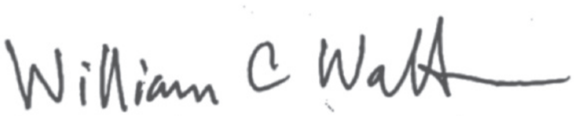
Welcome to Aquaculture America 2024! On behalf of the conference sponsors — the United States Aquaculture Society, the National Aquaculture Association (NAA) and the Aquaculture Suppliers Association (ASA), it is my pleasure to welcome you back to in-person conferences and to San Antonio, Texas,

This year's theme is "Setting the Table for US Aquaculture". With the recent calls for expansion of aquaculture in the US and abroad, there is tremendous optimism and enthusiasm for a growing aquaculture industry. The Steering & Program Committee hoped to capture the energy of our attendees and focus on how we, collectively, move forward on that path. Where are the opportunities, where are the hurdles? What ingredients do we need to grow a sustainable US aquaculture industry? We welcome your attendance at this meeting and encourage you to think about these questions and raise the questions that you have.

This year, we continue the example of last year's meeting by enjoying presentations by two plenary speakers. Robert Jones will speak to the synergy between aquaculture and the environment and how this approach provides a path for the growth of the aquaculture industry while also achieving environmental outcomes. Loni Greninger will talk about what aquaculture has meant to tribal stewardship and what it means going forward, as part of a comprehensive and inclusive approach towards the growth of aquaculture.

Finally, I want to thank the other members of the Steering and Program Committees: Josh Patterson, Matt Hawkyard, Omolola Betiku and Paul Zajicek. John and Noah Cooksey and their staff were essential to this process and we can't thank them enough.

We hope you enjoy the conference, the trade show, the receptions, happy hours, and all that the history and culture of San Antonio have to offer.



Bill Walton, Ph.D.
Steering Committee Chair
United States Aquaculture Society Immediate Past-President 2023-2024

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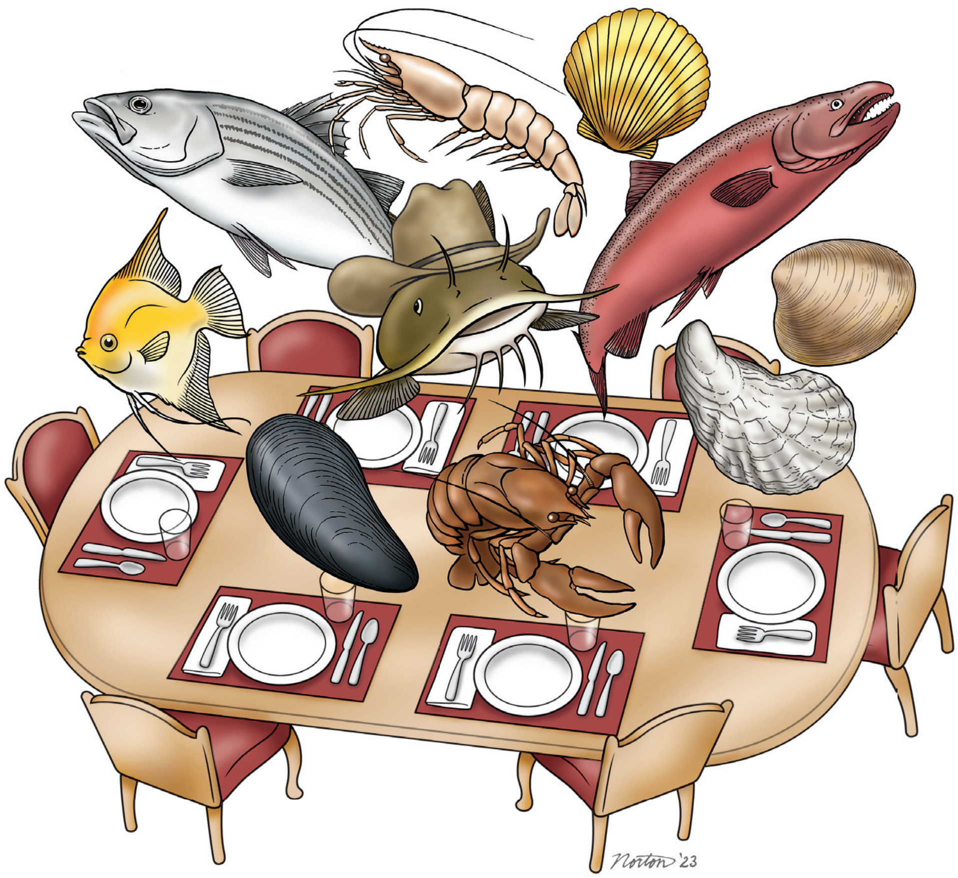

ABSTRACTS

ASSESSING MUCOSAL MICROBIOME ADAPTATION TO TEMPERATURE CHANGES IN REDBAND TROUT (*Oncorhynchus mykiss gairdeneri*) POPULATIONS

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In an era marked by rising global temperature, understanding the complex interplay between organisms and their environment is vital for informed conservation efforts. Redband trout (*Oncorhynchus mykiss gairdneri*), a subspecies of rainbow trout, holds a distinct ecological niche within the diverse landscapes of Northwest America. Redband trout is inherently adapted to coldwater habitats, however, the species faces a challenge with the escalating global temperatures associated with climate change.

Considering the challenges posed by global warming on coldwater habitats, particularly affecting species like the redband trout, there is a critical need to understand the holistic biological interactions that might contribute to its overall fitness. Currently, research on Redband trout as a holobiont unit is limited. Consequently, our study focused on analyzing the environmental and genetic factors that shape microbial composition and examine their impact on microbial functions, which in turn could affect the overall fitness of redband trout to warmer temperatures. We conducted two seasonal field samplings (summer and winter) and a common-garden study (Fig. 1), where trout from disparate thermal habitats were acclimated to identical temperature regimens (constant: 15°C, 18°C, 21°C, and diel: 13-17°C, 16-20°C, 19-23°C). Samples included mucosa from gills, skin, and digesta of redband trout, along with sediment and water samples from desert, cool montane, and cold montane creeks, as well as the common-garden system.

To investigate bacterial and archaeal taxonomic information (alpha and beta diversity), 16S rRNA sequencing was utilized, and the data was analyzed using DADA2 and Phyloseq. Whereas Nanopore sequencing was carried out to reveal microbial functions and relative abundance of Bacterial and non-Bacterial sequences. GTseq was used to genotype SNPs in individual fish, where neutral and adaptive markers were analyzed based on the habitat the trout was from. Our research explores the interaction between redband trout and its microbiome as a possible mechanism contributing to variations in traits, from genetic makeup to observable characteristics, in response to changes in temperature. The forthcoming results will focus on comparing microbial compositions (bacterial and non-bacterial) between different tissues and sites, encompassing both the host and the environment. Furthermore, the investigation will parse the gene by environment (GxE) regulation, integrating insights from both field and laboratory studies. Additionally, the study will explore pathogen levels along thermal gradients, shedding light on potential associations between microbial communities and temperature variations.

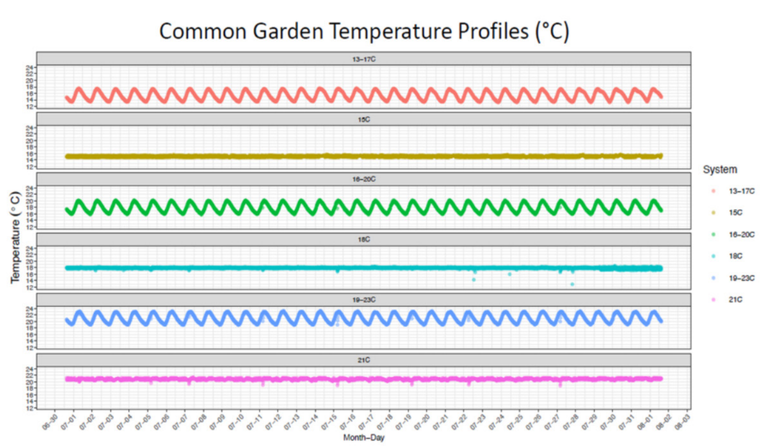

Figure 1: Temperature profiles of common-garden RAS setup

PHYSIOLOGICAL STRESS RESPONSES OF HYBRID CATFISH (*Ictalurus punctatus* ♀ × *I. furcatus* ♂) DURING HARVEST, TRANSPORT, AND PROCESSING

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Catfish production represented 56% of the total freshwater aquaculture production in the United States in 2020. Hybrid catfish (female channel catfish *Ictalurus punctatus* × male blue catfish *I. furcatus*) is rapidly replacing the channel catfish as the fish of choice in the catfish industry of the southern United States. Hybrid catfish appear to tolerate handling and transport well, but no studies have specifically addressed these stressors. This study aimed to comprehensively evaluate the survival rates and physiological stress responses of hybrid catfish across multiple stages of their handling, harvesting from ponds, transport, unloading, and subsequent electrical stunning at the processing plant. Hybrid catfish from ten earthen ponds were observed and sampled before and after they were seined, held in a holding net (sock) in the pond, loaded into truck-mounted transport tanks, and unloaded into holding tanks at the processor. Fish were also sampled after being electrically stunned before processing. Blood samples from 12 individual fish from each sampling point were collected and immediately centrifuged to yield 1.2 mL of pooled plasma. Samples were stored at -80°C until analyzed. The ten independent harvest and transport events were monitored over a year-long period to explore the influence of water temperature on survival and various physiological responses in hybrid catfish. Plasma cortisol, glucose, lactate, and osmolality were monitored as indicators of the primary stress response, the secondary stress response, the degree of anaerobic metabolism, and water balance, respectively. Cortisol was determined by enzyme-linked immunoassay; glucose was determined by the glucose oxidase method; lactate was determined by the lactate oxidase method; and osmolality was determined with a vapor pressure osmometer.

The preliminary analysis of results indicated that harvesting and transporting processes significantly increased cortisol concentrations in both warm (25–32°C) and cool (9–16°C) water temperatures. Moreover, the harvesting, transporting, and unloading process significantly affected plasma glucose and lactate concentrations but not plasma osmolality. Despite the observed stress responses, the overall survival rates remained high, suggesting the fish's remarkable ability to withstand and adapt to the challenges posed by harvest and transport processes. Based on our findings, it appears that hybrid catfish tolerate harvest and transport well under current management practices. The fish survived, demonstrated an expected stress response, appeared to remain largely aerobic during the events, and maintained water balance.

INCLUSION OF FRASS FROM BLACK SOLDIER FLY *Hermetia illucens* LARVAE IN AQUAFEEDS MODULATES IMMUNE GENE EXPRESSION IN CHANNEL CATFISH *Ictalurus punctatus*

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The larval waste, exoskeleton shedding, and leftover feed components of the black soldier fly and its larvae makeup the byproduct known as frass. Channel catfish (*Ictalurus punctatus*) were the subject of a 10-week feed study to assess different dietary amounts of frass inclusion and how this would affect both systemic and mucosal tissue gene expression, especially in regard to growth and immune related genes. Fish were divided in quadruplicate aquaria and five experimental diets comprising 0, 50, 100, 200, and 300 g of frass per kilogram of feed was fed twice daily. At the end of the trial, liver, head kidney, gill, and intestine samples were collected for gene expression analyses. First, liver and intestine samples from fish fed either low (50 g/kg) or high (300 g/kg) frass diet were used for transcriptome analysis via Illumina RNA sequencing to determine global differential gene expression when compared to control (no frass) diet. Differentially expressed genes (DEGs) included the upregulation of growth-related genes such as glucose-6-phosphatase and myostatin, as well as innate immune receptors and effector molecules including toll-like receptor 5, apolipoprotein A1, C-type lectin and lysozyme. Based on these initial screenings of low/high frass using RNA sequencing, a more thorough evaluation of immune gene expression of all tissues sampled, and all levels of frass inclusion, was further conducted. Using targeted quantitative PCR panels for both innate and adaptive immune genes from channel catfish, differential expression of genes was identified, including innate receptors (TLR1, TLR5, TLR9, TLR20A), proinflammatory cytokines (IL-1β type a, IL-1β type b, IL-17, IFN-γ, and TNFα), chemokines (CFC3 and CFD), and hepcidin in both systemic (liver and head kidney) and mucosal (gill and intestine) tissues. Overall, frass from black soldier fly larvae inclusion in formulated diets was found to alter global gene expression and activate innate and adaptive immunity in channel catfish, which has the potential to be used as a functional dietary ingredient to support disease resistance in addition to previously-demonstrated growth benefits.

LOW METHIONINE AVAILABILITY DURING *IN VITRO* MUSCLE GROWTH ALTERS CIRCADIAN-REGULATED GENE EXPRESSION PATTERNS IN RAINBOW TROUT (*Oncorhynchus mykiss*)

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In animal agriculture, aquaculture is on the rise due to the deficit in seafood production relative to its increased consumption in the US. This fast-paced growth needs a sustainable, economic approach to support production which in part is dependent on aquafeeds. The go-to choices for aquafeed preparation are fish meal sources because of their nutrient-dense and protein-rich profiles, thus fish sources are overexploited to support industry production. Current sustainable alternatives to mitigate the overuse of fish sources by the industry include plant-based diets due to their availability and known nutritional profiles. However, plant protein sources lack the essential amino acid methionine.

Methionine is important in protein synthesis (E.g., proteins in skeletal muscle that could add to fillet yield in fish, further improving industry outcomes) and gene regulation via epigenetic mechanisms. For instance, methionine availability regulates factors associated with *in vitro* muscle growth through epigenetic modulation in rainbow trout. Methionine, a methyl donor, was implicated in changing the DNA methylation patterns of circadian-regulated genes associated with *in vitro* myogenesis in our current study. However, as observed in most organisms, differential methylation status is not always correlated to changes in gene expression. This study investigated the normal circadian-regulated gene expression patterns with, without, and on reintroducing methionine during *in vitro* myogenesis. Data will shed light on the potential implication of methionine availability on muscle growth with insights on supplementation for plant-based feeds and its effects on the growth of commercially important species in aquaculture.

BLACK SOLDIER FLY LARVAE MEAL IN PRACTICAL DIETS FOR PACIFIC WHITE SHRIMP, *Litopenaeus vannamei*: AN ASSESSMENT OF RESPONSES TO LAURIC ACID

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The increasing cost and limited production of marine-based feedstuffs has prompted the industry to develop and evaluate alternative protein sources that are cost effective and nutritionally viable for use in aquaculture feeds. One such alternative protein source is black soldier fly larvae meal (BSFM), which is rich in protein and lipids. In the lipid fraction of BSFM, lauric acid (C12:0; hereafter C12) is a major fatty acid which has been found to have virucidal and bactericidal properties.

An 8-week growth trial was conducted to access the responses of Pacific white shrimp to purified C12 and two BSFMs: a control meal with basal levels of C12 and another C12 enriched by using coconut as substrate for larval growth. The experiment was designed with seven diets comprising a BSFM- and C12-free negative control diet (NCTL), three diets supplemented with purified C12 (D1-D3), and another three diets containing different levels of each BSFM partially replacing dietary soybean meal on a isonitrogenous basis (D5 to D7). At the commencement of the feeding trial, hand-sorted groups of 12 shrimp (initial weight = 1.2g/shrimp) were stocked in 35, 110 L glass aquaria operating as a recirculating aquaculture system and were fed the randomly assigned diets (n = 5) four times daily. Water quality parameters were maintained within adequate ranges for Pacific white shrimp.

At the conclusion of the feeding trial the growth rate (GR) of the shrimp fed the BSFM diets was higher than that of groups fed purified C12 diets ($P<0.05$; Table 1). The combination of the BSFMs in D6 supported higher protein retention (PR) compared to purified C12 diets and D7, while energy retention (ER) was higher in shrimp fed D5 than in those fed purified C12 diets and D7 ($P<0.05$). Data on shrimp whole-body proximate composition, fatty acid profiles, and diet digestibility will be presented. Overall, our findings with Pacific white shrimp indicate that i) dietary levels of C12 up to 1.6% are not detrimental to production performance; ii) BSFM containing up to 2.3% C12 and included at 11% in diets are well accepted and support good production performance; iii) BSF larvae can be successfully enriched with C12 with potential health benefits.

Table 1. Growth performance of Pacific white shrimp fed the experimental diets for 8 weeks.

		Purified Lauric Acid Diets (% C12)			Black Soldier Fly Diets (% C12)		
	NCTL	D2 (0.6)	D3 (1.0)	D4 (1.6)	D5 (0.9)	D6 (1.5)	D7 (2.3)
FW	11.7±0.2^{abc}	11.2±0.2^{bc}	11.4±0.3^{bc}	10.9±0.2^{c}	12.8±0.4^{a}	12.1±0.2^{ab}	11.7±0.3^{abc}
GR	1.30±0.02^{abc}	1.24± 0.01^{bc}	1.27±0.03^{bc}	1.21± 0.02^{c}	1.43±0.05^{a}	1.36±0.03^{ab}	1.31±0.04^{abc}
PR	32.1±0.9^{abc}	31.4±0.7^{bc}	30.1± 0.7^{c}	30.1± 0.7^{c}	34.1±2.0^{ab}	35.0±1.0^{a}	30.8±1.1^{bc}
ER	16.2±0.6^{abc}	15.8±0.3^{bc}	15.5± 0.3^{c}	15.3±0.4^{c}	17.9±1.1^{a}	17.4±0.4^{ab}	15.7±0.6^{bc}

FW = final weight (g), GR = growth rate (g/shrimp/week), PR and ER = protein and energy retention (%)

SHRIMP AQUACULTURE IN BANGLADESH: CURRENT TREND AND FUTURE PROSPECTS

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Shrimp aquaculture is a vital sector of Bangladesh's economy, providing export revenue USD 300.26 million in 2022 and livelihoods for millions. Bangladesh is currently the 9th largest shrimp producer in the world, primarily cultivating black tiger shrimp (*Penaeus monodon*) and giant river prawn (*Macrobrachium rosenbergii*). The industry has evolved from traditional to intensive, technology-driven farming systems, leading to increased production and export volumes.

However, the sector faces several challenges. Biological challenges include disease outbreaks caused by viral pathogens such as the white spot syndrome virus (WSSV), early mortality syndrome (EMS), and bacterial infestations like Acute hepatopancreatic necrosis disease (AHPND), vibriosis. Environmental challenges encompass water quality, mangrove conservation, effluent management, and land use conflicts. Social challenges involve ethical labor practices and human rights. The sector's future lies in addressing these challenges while seeking growth and diversification. The implementation of advanced technologies like recirculating aquaculture systems (RAS), biofloc technology, and genetic improvement programs are anticipated to enhance disease resilience and production efficiency. Sustainable practices such as certification schemes and organic farming are expected to expand market access and consumer demand. Responsible land use and mangrove conservation are crucial for mitigating environmental impacts and supporting biodiversity. Government and industry collaboration are essential for ensuring the sector's economic and environmental sustainability. Investments in research, infrastructure, and training will significantly influence the future of shrimp aquaculture in Bangladesh.

TABLE 1. Fish and shrimp export during the fiscal year 2017018 to 2021-22 from Bangladesh (Value: million USD).

Fiscal year	**Total frozen and live fish export**	**Shrimp export**
2017-2018	508.43	408.11
2018-2019	500.4	361.14
2019-2020	456.11	332.65
2020-2021	477.37	328.84
2021-2022	532.94	407.25

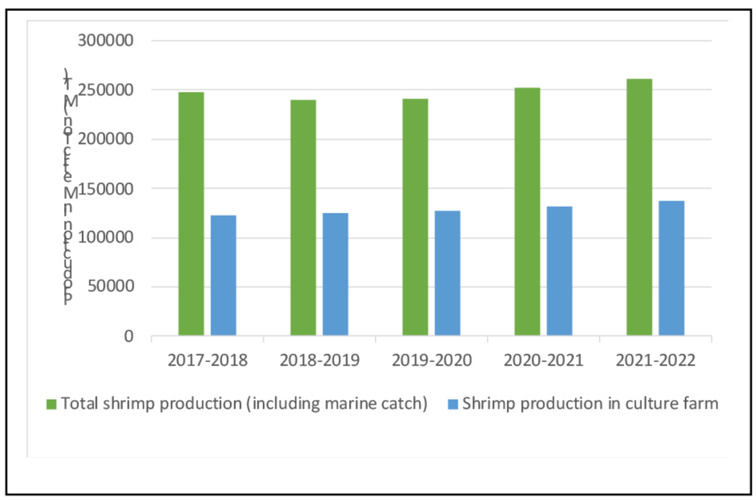

Figure 1. Shrimp production trends during last 5 fiscal years (metric ton).

GENE EXPRESSION SIGNATURE, GENETIC POLYMORPHISM, AND MICROBIOME BIOMARKERS ASSOCIATED WITH FILLET PINK COLOR IN RAINBOW TROUT

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The characteristic pink-reddish color in the salmonid fillet is an important, appealing quality trait for consumers and producers. The color results from diet supplementation with carotenoids, which accounts for up to 20-30% of the feed cost. Pigment retention in the muscle is a highly variable phenotype. In this study, we aimed to understand the molecular and microbiome basis for the variation in fillet color when fish families produced by the NCCCWA (YC 2020) were fed an astaxanthin-supplemented diet. We used RNA-Seq to study the transcriptome profile in the muscle, liver and pyloric caecum from fish families with pink-reddish fillet coloration (Red) versus those with lighter pale coloration (White). More DEGs were identified in the muscle (5,148) and liver (3,180) than in the pyloric caecum (272). Genes involved in lipid/carotenoid metabolism and transport, ribosomal activities, mitochondrial functions, and stress homeostasis were uniquely enriched in the muscle and liver. For instance, the two beta carotene genes (BCO1 and BCO2) were significantly under-represented in the muscle of the red fillet group, favoring more carotenoid retention. Enriched genes in the pyloric caecum were involved in intestinal absorption and transport of carotenoids and lipids. In addition, the analysis revealed the modulation of several genes with immune functions in the pyloric caecum, liver, and muscle.

In the same fish population, using 16S sequencing, we identified bacteria taxa showing differential abundance between the white versus the red fillet group. The red fillet group has enrichment (LDA score > 1.5) of taxa *Leuconostoc lactis*, *Corynebacterium variabile*, *Jeotgalicoccus halotolerans*, and *Leucobacter chromiireducens*. In contrast, the white fillet group has an enriched presence of *mycoplasma*, *Lachnoclostridium*, and *Oceanobacillus indicireducens*. The enriched bacterial taxa in the red fillet group have probiotic functions and can generate carotenoid pigments. Bacteria taxa enriched in the white fillet group are either commensal, parasitic, or capable of reducing indigo dye.

Separately, GWAS analysis was performed on unpigmented diet-fed fish families produced by the NCCCWA (YC 2010 & 2012). SNP-harboring genes associated with fillet color are involved in carotenoid metabolism, myoglobin homeostasis, lipid oxidation, and maintenance of muscle integrity. Overall, our results revealed that fillet color is likely determined by carotenoid, lipid metabolism, and iron homeostasis.

This work extends our understanding of carotenoid metabolism in rainbow trout through the interaction between gene polymorphism, gene expression, gut microbiota and their relationship with fillet color. The genetic and microbial markers identified could be prioritized in breeding programs to enhance fillet color.

PALATABILITY ASSESSMENT OF FORMULATED DIETS INCORPORATED WITH BLACK SOLDIER FLY PROTEIN FOR RED DRUM (*Sciaenops ocellatus)*

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The contribution of protein to the high cost of production of aquaculture feeds cannot be overemphasized as it takes a larger percentage of the overall production cost when compared to other ingredients. Formulated aquafeeds are incorporated with large amounts of protein in the form of fish meal, but the unstable supply of fish meal due to the reduction in natural fish stock and the continuous high demand for fish has led to its increase in price and unpredictability in terms of availability in the market. Hence there is a need to develop an alternative to fish meal. The palatability of new ingredient is an important factor to be considered when formulating aquaculture diets as it will contribute largely to the consumption and digestibility of the feed by either making the feed more or less attractive to the fish. Creating a desirable chemosensory feed that fish could readily locate and ingest, guarantees food consumption and low waste of uneaten feed. Hence, the objective of the current study was to perform a palatability assessment trial on Black Soldier Fly protein when used as a substitute for fish meal protein at different inclusion levels (25%, 50%, and 100%) on experimental diets for Red drum (*Sciaenops ocellatus*). Thirty red drum juveniles with an initial average weight of approximately 120g were stocked into 15 experimental tanks. Diets were randomly assigned to the tanks for assessment. Each diet had 3 replicates. Palatability assessment included a 12 day-period for feeding the experimental diets. Each assessment was repeated four times with a seven-day washout period between assessments. There were two feeding strategies tested 1) immediate change in the diet from the control to the test diets (Immediate Feeding Strategy), and 2) gradual change from the control to the test diets (Habituated Feeding Strategy). The Habituated Feeding Strategy group only used the 50% inclusion level as the test diet whereas the Immediate Feeding Strategy group used all three inclusion levels. This resulted in 5 different experimental groups (Control, Immediate 25%, Immediate 50%, Immediate 100% and Habituated 50%). Our preliminary results suggest that the control diet, 25%, and 100% BSF replacement diets presented the same palatability response in Red drum.

REPLACEMENT OF MENHADEN FISH MEAL PROTEIN BY SINGLE CELL PROTEIN MEAL IN THE DIET OF JUVENILE BLACK SEA BASS, *Centropristis striata*

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Single cell protein such as bacterial meal are rich in protein sources (>50%) with high levels of nucleotides and are very palatable and devoid of anti-nutritional factors. Single cell meal (SCM) (*Methylorubrum sp* -strain KB203, JUV™, KnipBio, Lowell, MA) are grown by aerobic fermentation at 30°C and dried to make a feed ingredient. Eight iso-nitrogenous (48% crude protein) and isolipidic (13%) experimental diets were formulated and prepared to replace menhaden fish meal protein (MFP, 59.5% crude protein) by SCM (50.4% crude protein) for juvenile black sea bass, *Centropristis striata*. Test diets were prepared replacing 0, 7.4, 14.8, 29.6, 44.4, 59.2, 74.0, and 88.8% of MFP by supplementing SCM at 0, 2.5, 5, 10, 15, 20, 25 and 30% in the diets. A control diet (0% replacement) was formulated with high fish meal (30%) and other practical protein sources, including solvent extracted soybean meal, and poultry by product meal. All other nutrients in the diets were added according to recent information on nutrient requirements for black sea bass. Twenty fish were stocked in each of twenty-four 75-L tanks in a controlled-environment laboratory of a recirculating aquaculture system and each test diet was fed to triplicate groups of fish (mean weight = 2.68 ± 0.14 g) for 56 days. Fish were fed twice per day (09:00 and 16:00 h) to apparent satiation. The water salinity was 34 mg/L and temperature ranges 22-24 °C and all other water quality parameters were maintained optimal during the feeding trial.

\Growth performance, including weight gain, specific growth rate and feed utilization were evaluated. The percent body weight gain among the fish fed the test diets were not significantly different (P<0.05) although the group fed 15% SCM showed the highest mean value (Figure 1). Survival was higher than 90% among treatments with no significant differences. The proximate composition, amino acid and fatty acid analysis of diets and fish tissues were analyzed.

Results to date suggest that black sea bass juveniles are able to utilize high levels of single cell protein replacing fishmeal without affecting fish growth. The body composition data will be compared with the growth data, and an optimal SCM supplementation level in the diet of juvenile black sea bass will be recommended.

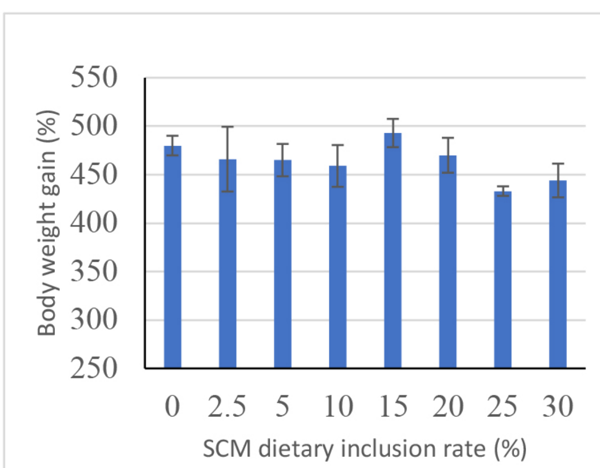

Figure 1: Effects of SCM supplementation on % body weight gain of juvenile black sea bass.

REDUCING RISK IN DESIGN AND OPERATION OF OCEAN AQUACULTURE HOW TO MAINTAIN SAFETY OF ASSET, PERSONNEL AND PREVENT FISH ESCAPE FOR EXPOSED HIGH VOLUME, ADVANCED FISH FARMS

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INTRODUCTION

We see a growing trend that mariculture is growing out of sheltered, near-shore areas and moved to locations further offshore. There are several advantages applying this solution. Better fish welfare, less conflicts with interests in the ocean space as well as possibility to scale up output volume without compromising environmental sustainability are some of them. As the world's population grows, the options for producing enough food are becoming limited. The oceans offer a vast opportunity to meet this demand with sustainable, safe and efficient offshore fish farming.

Adding safety to offshore fish farming projects is mainly ensured by providing uniformity, transparency, and predictability and thereby reducing project risk. We need to be ensured that facilities for aquaculture can handle harsh environment and still contain the fish safely.

MAIN APPROACH

The main areas of concern when it comes to ensuring safe and reliable offshore fish farming units may be categories into: Asset integrity, personnel safety, fish welfare and prevention of fish escape.

Asset integrity includes structural strength, stability, mooring, technical arrangement, and solutions on board together with reliability of essential equipment installed.

Personnel safety is mainly addressing arrangement for emergency escape and fire safety. This included lifesaving appliances, launching equipment and similar as well as fire detection and -extinguishing. It is common to apply well know maritime codes as acceptance criteria for personnel safety. SOLAS is a good example followed by local flag- or shelf states interpretation of requirements embedded in this maritime code.

Fish welfare and requirements related to this varies depending on local authorities. It is essential to verify the reliability of technology utilized to monitor environment of the fish. Instrumentation indicating oxygen level, temperature, salinity, turbidity is subject for special attention. Maximum acceptable level of biomass is also a crucial parameter that needs to be monitored.

Fish control or prevention of escape is the main function of a fish farming unit. Structural integrity of net system and ropes together with capability of fish transfer systems are crucial items in fish control. Flexible net systems utilized in rigid high volume steel fish farming installation has proven to be exposed to fatigue and need to be attended to in particular. Wear and tear of net due to cleaning and handling is also a concern. Several of reported incidents related to fish escape happens while handling of fish – for example crowding due to de-licing or transfer. Equipment contributing to these operations needs to be specially attended to.

The four different items are considered equally important for safe and sustainable fish farming offshore. These elements are also closely interconnected where integrity of one may support several others.

CONCLUSION

There is a significant potential to utilize competence from traditional offshore and maritime industry to help operators of exposed fish farming units to identify operational risks by applying technical rules and requirements from classification. As opposed to the offshore oil and gas industry, classification may not be obligatory in aquaculture, but it turns out that many developers and operators nonetheless choose to follow class requirements and recommendations.

Combining the well-known classification concept from maritime industry with balanced aquaculture-based requirements provides a robust and cost-efficient solutions to reducing risk in operation of offshore fish farming installations.

INDUSTRIALIZATION OF OCEAN FISH FARMING CONTRIBUTING TO BOOST SUPPLY OF MARINE PROTEINS – SOLUTIONS AND CHALLENGES

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INTRODUCTION

All aquaculture market projections uncover a dramatic supply-demand imbalance in the next two to three decades. Focusing on fin fish supply specifically uncovers that output level is close to a saturation point for traditional areas with sheltered aquaculture. Currently the response to this situation is the fact that fish farming is growing out of sheltered, near-shore areas and moved to locations further offshore together with several new land-based RAS/flow-through plants being established around the world. A number of innovative solutions is being tried out in offshore fish farming in the process of industrialization. The objective is a higher output volume of fin fish combined with improved fish welfare. As the world's population grows, the options for producing enough healthy, sustainable food are becoming limited. Several interesting solutions for efficient, large-scaled fish farming in offshore/exposed environment are in the pipeline.

MAIN APPROACH

There are several advantages applying the solution with advanced, high volume fish farming installations to increase supply of marine proteins. Better fish welfare, less conflicts with interests in the ocean space as well as possibility to scale up output volume without compromising environmental sustainability - to mention a few.

The numerous consepts planned and implemented may be split into three main categories: Open trusswork with traditional net or grating, semi-closed units and at last closed aquaculture installation. The first may be split into two where most are operating at the ocean surface while an increasing number of designs have the option of submerged position to avoid splash-zone issues at rough sea states. These have all a number of advantages and weaknesses that have to be considered and evaluated. The various solutions ability to perform depends on a long list of aspects. The essential parameters to be taken into consideration assessing performance are among other things:

- Oxygen level in sea water. Essential for fish welfare is the ability to keep continuous O2-level above lower limit in all parts of the fish farming installation. In-depth analysis has to be performed to ensure no "dead pockets" where the fish density at periods of low water circulation may be too high.
- Crowding and live transfer of fish. These are processes that cause significant stess and physical strain. Again, resulting in reduced resistance towards diseases, etc and may lead to great losses of fish combined with low fish welfare. The industrialized solutions applied for offshore fish farming often utilized advanced mechanical systems to facilitate these processes, failure will lead to operational interruption and fish escape.
- Dead fish handling and ensilage processing. Typically, automated processes that involves much less manual handling compared to traditional sheltered methodology where these task are not carried out at the pen, but rather on the feed barge, etc.
- Logistics of supplies and goods going both on and off the fish farming installation result in several and more advanced marine operations compared with traditional fish farming. Higher sea states with more dynamics in both supply vessel and offshore fish farming installation is a major risk contributor to be mitigated when emergency preparedness is planned.
- Personnel safety. Personnel safety is mainly addressing arrangement for emergency escape and fire safety on board. This included lifesaving appliances, launching equipment and similar as well as fire detection and -extinguishing. In addition, other common safety items such as falling objects, working at hights and pinching/crushing have to be taken into account.

Other similar issues such as hygiene and cleaning as well as feed handling & -control could also be included discussing the total operational performance of a high-volume fish farming installation.

CONCLUSION

To address and mitigate issues mentioned above there is a significant potential to utilize competence from traditional offshore- and maritime industry to support operators of exposed fish farming units in design and tuning operational modes for efficient production. The industry is currently very much exploring possibilities and collecting experience from the various concepts being planned and put in operations. This learning journey is an important phase in the development of offshore fish farming to become a significant contributor in feeding future generations with sustainable and healthy marine proteins.

UNLOCKING THE POWER OF DIGITAL ASSET MANAGEMENT - NAVIGATING THE POSSIBILITIES AND OVERCOMING THE CHALLENGES

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INTRODUCTION

Smart aqua operations are developing to be a common solution in modern aqua-culture installations. Real time monitoring of fish condition combined with surveying the integrity of fish farm itself are considered competitive advantages. The aquaculture industry is in the middle of a major transition as vessels and fish farms are transformed into sensor hubs, generating data, and linking in an expanding interconnected web.

MAIN APPROACH

Essential elements to consider for a strategy supporting the transformation may be split into four main categories: 1) Management, recourses and capabilities focusing on utilizing/developing potential in organisation. 2) Integrated systems, tools and connectivity addressing primarily IT infrastructure and data management. 3) Technology and efficient solutions dealing with automation, autonomy, and remote operations. And lastly 4) Energy efficient- and enhanced performance embracing energy efficiency together with sustainability enhancing concepts.

Digital asset management is a term often used in this context where inspection as well as operational decisions are based on continuous data streams supplied by sensors on board.

Digitally driven condition-based maintenance result in improved reliability by continuously assessing the condition of fish farming installation together with the fish in it. The objective is to identify potential issues before they become major problems and take proactive measures to prevent failures and unplanned downtime.

Digital asset management can help improve efficiency and reduce operational costs. For example, by identifying equipment that needs maintenance or replacement, fish farmers can avoid costly breakdowns and reduce downtime.

The digitally driven operational monitoring is based on the process of capture information, analyse date collected, learn plus synthesis, and finally act accordingly.

The integrity of these solutions is mainly based on the reliability of sensors and their location at the fish farm. Operational onboard servers together with data transfers solutions and intermediate storage are also essential aspects in the utilization of digital asset management infrastructure. Stability and performance of software applied to process/analyse collected data represents a significant risk and needs to be verified. Finally safe data transfer and cyber security are essential items in the overall digital performance.

While digital asset management can offer several benefits, there are also a number of potential risks and challenges associated with relying on this technology. Together with data security risks and technical issues, challenges related to data quality is a major concern. The monitoring system relies on high-quality, accurate data to provide meaningful insights into asset condition and performance.

CONCLUSION

Smart aqua is an efficient operational concept that all operators are chasing, but can you trust the status and green lights on your operational dashboard? The industry is expected to put significant effort into assuring the integrity of the data-streams continuously feeding information to our operational decision-making tools. We are identifying the most efficient approach on how we mitigate the dramatic risks introduced as advanced digital technology is applied in operations of fish farms.

EVALUATION OF CONCENTRATING MICROALGAE *Isochrysis galbana* AND *Tetraselmis suecica* USING FRESHWATER OVERLAYS

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Various cultures of microalgae are used in many industries such as the formulation of feed, wastewater treatment, fertilizers, and biofuel production. *Isochrysis galbana* and *Tetraselmis suecica* are commonly used microalgae in bivalve cultivation systems. In these systems, microalgae supply has been estimated to run at almost half of the bivalve hatchery operating costs and is prone to be unreliable due to easy contamination leading to crashing. Nonetheless, standard algae cultures are much less concentrated since the cells are free-swimming. Concentrated algae cultures are significant for feed management and storage in aquaculture since they allow more cells to be harvested. We aimed to standardize a protocol for concentrating algae cultures via freshwater overlays at 8, 16, 24, and 32 ppt.

I. galbana and *T. suecica* were grown in 200mL bottles that were inoculated with 5mL of established stock. Cell counts were collected using a hemocytometer to create growth curve charts and establish when the stationary phase was reached. *I. galbana* took 7 days to reach the stationary phase while *T. suecica* took 6 days. After the stationary phase counts were collected, freshwater overlays were introduced.

I. galbana had 3 layers form while *T. suecica* had only 2 layers form. Figures 1 and 2 show it is best to harvest concentrated algae after 24 hours because at 48 hours the concentration decreases. Overall, 24 ppt seems to be the most suitable to achieve the highest concentration with freshwater overlays. In summary, freshwater overlays hold promise for concentrating algae.

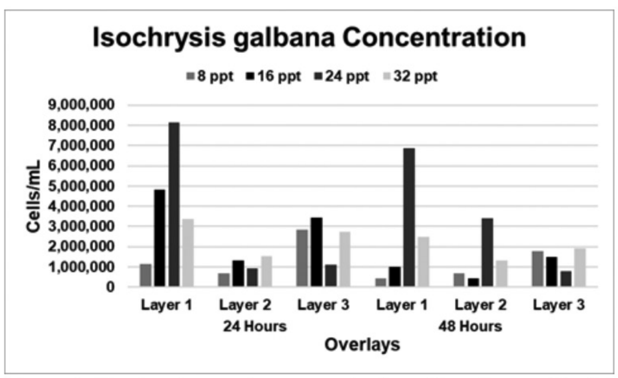

Figure 1: Freshwater overlay concentration of I. galbana after 24 and 48 hours.

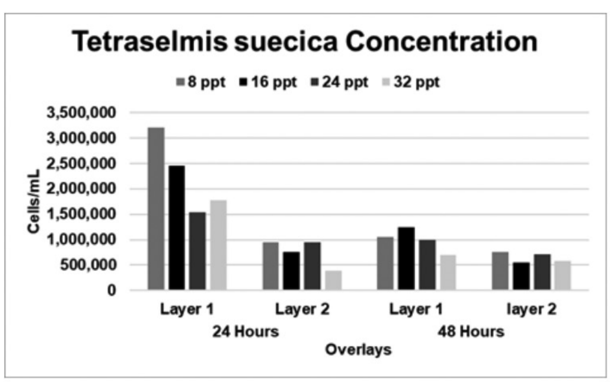

Figure 2: Freshwater overlay concentration of T. suecica after 24 and 48 hours.

AUTOMATED PRAWN FEED SYSTEM (PFS) WITH PROGRAMMABLE TIMER

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The objective of this project is to design, build and test an experimental scale feeding system tailored for prawn agricultural production, catering to prawns from their early stages of life to maturity. The Prawn Feed System (PFS) addresses the current limitations in feeding system's versatility, particularly regarding feeding portions and scheduling. The PFS allows users to set their desired feeding times and adjust feed quantities according to specific needs. Key considerations included compatibility with a 55-gallon drum with a 2-foot diameter, preventing feed obstructions, ensuring use of food-safe materials, and allowing user input feed times.

The system (Fig. 1), was designed on SolidWorks and 3D Printed in Polylactic Acid (PLA). It features two feed towers (T) (Fig 2), each housing four compartments (C) (each 9 in^3 volume), vertically stacked with swinging hatch doors (HD) that separate them, securely held in place by solenoid locks. Once the solenoid is retracted, the weight of the hatch door alone allows gravity to guide them. Control of the locks is managed through an Arduino based system with an 8-channel relay, RTC (Real-Time Clock), an LCD, and a user-friendly interface featuring six buttons for customized feeding schedules. Opposing sides of the towers have sliding doors that are moved vertically. When placing the feed, the user must lift the tower door (TD) and place the feed one tower at a time. To reset the doors the trap must be rotated to allow the hatch doors to fall back into place. An AC-DC converter, providing 12V, is plugged into a standard outlet to power the system.

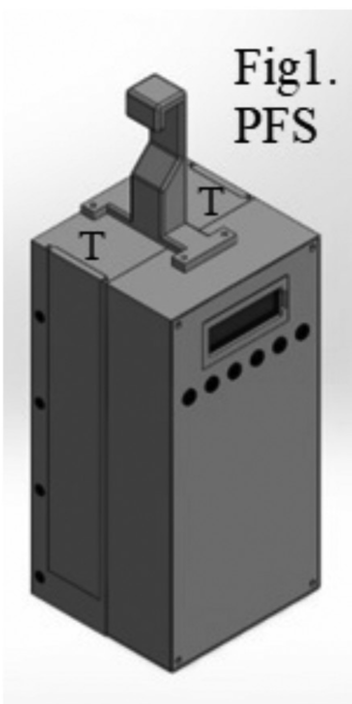

Fig1. PFS

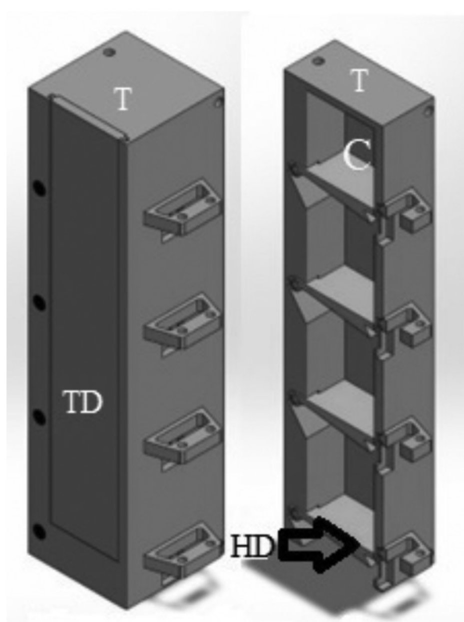

Fig 2. Tower and Cross Section

GENOMIC EVALUATION AND GENETIC PARAMETERS FOR ACUTE HEPATOPANCREATIC NECROSIS DISEASE (AHPND) RESISTANCE IN *Penaeus vannamei* (Pacific White Shrimp): INSIGHTS FROM CONTROLLED CHALLENGE EXPERIMENTS AND POPULATION GENOMICS

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This study aims to evaluate the feasibility of a genomic evaluation program for Acute hepatopancreatic necrosis disease (AHPND) resistance in a commercial population of *Penaeus vannamei.* AHPND is caused by a strain of *Vibrio parahaemolyticus* (Vp_{AHPND}) producing a binary toxin. It is a World Organization for Animal Health (WOAH, Paris, France)-listed bacterial disease that has caused severe economic losses to the shrimp industry worldwide in recent years. The working hypothesis of this study is that the genetic variation in a commercial *P. vannamei* population allows an efficient genomic selection program. To investigate the genetic parameters for AHPND resistance, two controlled challenge experiments were performed at the Shrimp Improvement System biosafety laboratory in Miami, Florida. In the first experiment, an immersion challenge protocol was followed where 2400 Specific Pathogen Free (SPF) *P. vannamei* post larvae from 40 families were challenged with Vp_{AHPND}. Each family consisted of 60 animals, with half of the families representing a fast-growth (FG) line and the remaining half representing a slow-growth (SG) line. The bioassay was terminated at 3 days post-challenge. In the second experiment, individuals from the best and worst performing families (N=20 families each) were selected and challenged with the same bacteria. In both challenges, survival was recorded as a binary of dead or alive at the end of the three-day challenge experiment. In each challenge, 30 animals in each family were kept for a growth control test. Variance components and breeding values were estimated under an animal threshold binary model using a Gibbs sampler. Population structure analysis was conducted using data on 1,024 shrimps from the control population. Animals were genotyped on a commercial shrimp Single Nucleotide Polymorphism (SNP) with 50k markers (Center for Aquaculture Technologies, San Diego, CA). Estimation of genetic parameters was done within lines and by combining all data records. In the first challenge, the FG line mortality was 40%, and the SG line mortality was 20%. The average hazard risk ratio (HRR) of survival was 80% greater for the FG line than the SG line ($P<0.05$) based on survival analysis with a 31% mortality rate combining all data records. The posterior mean estimates of heritabilities were 0.14(±0.06) for FG, 0.16(±0.07) for SG, and 0.38(±0.08), combining all records. In the second challenge, the SG and FG mortality averaged at 65% and 78%, respectively. The SG line had a 38% reduced risk of mortality compared to the FG line ($P<0.05$) with a 71% mortality rate combining all data records. The posterior mean estimates of heritabilities were 0.23(±0.08) for FG, 0.47(±0.13) for SG, and 0.34(±0.06), combining all records. Population structure analysis using genotyped individuals revealed distinct, non-overlapping ancestry between the two genetic lines. The results suggest that a breeding program for AHPND resistance is feasible. Moreover, the heritabilities suggest that both lines will respond to selection due to the presence of additive genetic variation for APHND-survivability. The next step of this project is to use the phenotypes and genomic information on the challenged animals to implement a genomic selection program. Additionally, high throughput laboratory results and histopathology scores will be introduced as correlated traits in the genetic evaluation.

STRIPED BASS (*Morone saxatilis*) EGG QUALITY: PROTEOMIC PROFILING OF PREOVULATORY OOCYTES AND OVULATED EGGS VIA MACHINE LEARNING

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Striped bass (SB, *Morone saxatilis*) are an important aquaculture fish as a parental species of hybrid striped bass, the fourth largest finfish aquaculture industry in the US. The predominant hybrid produced in this industry is a cross of white bass (*M. chrysops*) females and SB males known as the "reciprocal" cross. However, decades of domestication through the *National Program for Genetic Improvement and Selective Breeding for the Hybrid Striped Bass Industry* have led to substantial improvements in the captive breeding of SB, such as spawning without exogenous hormone compounds, thus facilitating a standalone SB industry to emerge.

The consistent production of high-quality eggs to support a reliable supply of seedstock is critical and often a major bottleneck in expanding finfish production, as has historically been the case with SB. Previous research on gene expression profiles of the SB ovarian transcriptome identified a transcriptomic signature highly predictive of egg quality. To expand upon these findings and identify the proteomic components underlying egg quality in these fish, tandem mass spectrometry (nano-LC-MS/MS) and a novel ensemble machine learning approach was used to profile the proteome of preovulatory oocytes (PV, post-vitellogenic, obtained prior to the natural spawning season begin in April) and ovulated eggs (OV, obtained after final ovarian maturation) collected from four-year-old domestic female SB (N=16, mean $\pm$ standard deviation weight: 3.35 $\pm$ 0.11 kg, total length: 583.6 $\pm$ 7.1 mm). The PV and OV represented high- and low-quality spawns, whereby spawns resulting in $\geq$ 50.0 % of eggs producing viable 4-hour embryos (n=8 of 16 spawns) were designated as high-quality and spawns resulting in $\leq$ 30.0 % of eggs producing viable 4-hour embryos (n=8 of 16 spawns) low-quality. The resulting proteomic profiles suggest direct and complex linkages between cytoskeleton structure and protein biosynthesis/degradation processes (ribosome, ubiquitin-26S proteasome) as being major differentiating factors between PV and OV quality and stage. These findings complement the previously modeled transcriptome profiles and collectively highlight pathways of importance during early development in high quality PV and OV and provide greater insight into cellular dysfunction occurring in low quality PV and OV. These findings can be considered in the design of future research to determine the parental factors (e.g., genetic, dietary, husbandry) underlying the discrepancy between females producing high- and low-quality spawns and subsequently the breeding strategy for domestic SB.

ECOLOGICAL ASSESSMENT OF ENVIRONMENTAL HEALTH AND OYSTER AQUACULTURE GROW-OUT CONDITIONS IN REHOBOTH BAY, DELAWARE

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Oyster aquaculture leases returned to the Delaware Inland Bays (Rehoboth Bay) in 2017 boosting local economies, improving water quality, and providing important habitats for fish and invertebrates. Efforts to monitor and identify relationships between cage depth, oyster condition, water nutrient levels, and pathogens responsible for oyster mortality are vital to successfully manage the re-emerging Eastern oyster (*Crassostrea virginica*) industry and restoration in the area. This project will analyze targeted pathogen levels and water quality and correlate these with oyster health at a recently established aquaculture lease.

Pathogen identification is conducted using cultured water and oyster samples collected at surface and bottom depths. The polymerase chain reaction (PCR) and quantitative polymerase chain reaction (qPCR) approaches will be used for the detection of oyster pathogenic vibrios—*Vibrio coralliilyticus* and *Vibrio tubiashii*—and parasites responsible for the oyster diseases MSX (*Haplosporidium nelsoni*) and dermo (*Perkinsus marinus)*. In-situ water quality data and samples are collected from the same depths and further analyzed for nutrient content.

Oyster condition index (CI) is calculated using Hopkin's Formula; low CI indicates the oyster and potential offspring are more vulnerable to disease and environmental stressors. The data provided from this study will contribute to a greater understanding of current farming strategies and habitat suitability of study sites in this re-emerging industry.

COLLEGE OF THE FLORIDA KEYS AQUACULTURE SOCIETY SUBUNIT

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The College of the Florida Keys Aquaculture Society is an active USAS Student SubUnit. The society are active members of the Florida Keys community helping restore the tanks at Reef Relief and the local Lower Keys Medical Center. Members get the chance to learn how to breed marine ornamentals and learn how to frag soft corals. Members then attend local frag swaps to sell aquacultured marine ornamental fish and corals. Every year the society participates in Community Day as a fundraiser to sell raffle tickets and homemade clownfish cookies. The society also participates in Sugarloaf Middle School Marine Science Night every year. This is an opportunity for the college and society to inspire students who are interested in marine science and show them all the different opportunities down the road. Every summer, the lab hosts a summer camp for 7-11 and 12–15-year-olds. Summer camp focuses on teaching youth how to set up and maintain a saltwater fish tank with emphasis on aquaculture. The College of the Florida Keys Aquaculture Society is also a member of the Marine Aquarium Society of North America (MASNA). The society participates in Mote Ocean Fest, conferences like Aquaculture America, Marine Aquarium Conference of North America (MACNA), and the yearly all around Florida trip.

QUANTIFICATION AND CHARACTERIZATION OF TILAPIA WASTE COLLECTION IN FLOATING IN-POND RACEWAYS WITH *O. niloticus*

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In aquaculture in general rising cage culture has been the most economical, low investment and profitable out of any aquaculture technology ever. However, this highly adaptable technology do not came without its own problems. As aquaculture increase production in lake and reservoirs, especially in warm climates around the world, pollution of aquatic environment become more and more visible. Many countries are looking for alternatives for the solution or at least a contribution to solve this problem. Others countries are taking more drastic measurement by cutting fish producer permits, and lower the number of cages allowed on those waters. Floating IPRS could be a significant contributor to the problem by keeping production, jobs in the industry and extract fish fecal material off the aquatic environment. This study made an effort to quantify the amount of fecal material from tilapia nilotica culture in floating IPRS. Eight experimental units floating IPRS (FIPRS) of 14.3 m³ each, installed in a pond of 0.1868 Ha. with a total of 6,073 m³, stocked with tilapia nilotica at 1928 fish per cell at 133 fish/m³ average weight of 42 grams. Four units designated for commercial diet A and four for diet B. Tilapia grow diet A=0.421.5 kg and diet B=0.371 kg (t-student $p=0.008$). Condition Factor K: diet A=2.16 and B=2.14 ($p=0.44$) indicating low feed intake. Correlation between feed intake and weigh of dry fecal material was done by regression analysis: diet A: $R=0.33$, $r^2=0.11$, $p=0.27$; and diet B: $R=0.42$, $r^2=0.18$, $p=0.15$. Both diets indicate a medium strength correlation and low Coefficient dependence between feed given and dry fecal matter, and no statistical significance. On the characterization of tilapia fecal material. Student t-test was performed on total Nitrogen, C/N Ratio, Phosphorus, Potash and finally Sodium comparing those elements for the two study diets, none of them show any statistical significance at level of $p = 0.05$ in either overall average or from day 1 to day 77 fed with 38% CP and after day 77, fed with 32% CP. Zamorano University Soil Laboratory report on Macro and Micro-nutrients (N, P, K, Fe, Mg, Mn, Ca and Na and others no reported here) indicate far higher levels as recommended for most agriculture row crop. Especial consideration should be taken on high level of Sodium. Use of tilapia waste as agriculture fertilizer should be taken diluted, or mix with a filler before use, otherwise it could cause serious damage to row crop.

TILAPIA NILOTICA FEED INTAKE AND PERCENT OF WASTE IN DRY MATTER

DIET A		DIET B	
Feed/kg	% Fecal matter	Feed/kg	% Fecal matter
5.45	0.02%	5.45	0.01%
8.18	0.56%	8.18	0.26%
2.73	1.47%	2.73	0.48%
8.18	2.14%	8.18	3.24%
24.54	1.76%	24.54	0.95%
20.45	0.45%	20.45	5.67%
20.00	0.94%	20.00	8.22%
19.068	0.61%	19.07	8.22%
23.326	0.46%	21.04	0.91%
22.7	0.25%	22.7	7.94%
18.36	0.07%	18.41	0.33%
22.95	0.03%	22.95	0.26%
16.36	1.75%	16.36	0.57%

MACRO AND MICRO NUTRIENT IN TILAPIA NILOTICA WASTE LAB ANALYSIS

Element	Ave. Diet A	Range	Ave. Diet B	Range	Range for most agriculture crops
pH	6.56	(6.48 - 6.66)	6.55	(6.3 - 6.77)	
C %	6.71	(3.58 - 9.72)	8.8275	(4.93 - 15.11)	
N Total %	0.58	(0.31 - 0.84)	0.7575	(0.42 - 1.3)	0.10 - 0.20
C/N Ratio	5.55	(3.14 - 8.17)	5.9	(4.26 - 9.04)	
P mg/kg	3174	(1715 - 6415)	2324.75	(615 - 4882)	13 - 30
K mg/kg	3236.5	(2537 - 4219)	2957.75	(2445 - 3783)	150 - 280
Fe mg/kg	636.5	(378 - 961)	519.5	(472 - 613)	56 - 112
Mn mg/kg	1094.5	(631 - 1630)	976.25	(590 - 1045)	28 - 112
Ca mg/kg	12413.25	(8395 - 19079)	9905.75	(5873 - 15592))	1000 - 2500
Mg mg/kg	920	(674 - 1186)	794.5	(553 - 949)	180 - 250
Na mg/kg	4794	(3191 - 5521)	4816.75	(3196 - 6123)	<230

THE RELATION BETWEEN AUTOMATIC AERATION RATE AND EXPECTED DISSOLVED OXYGEN ON PACIFIC WHITE SHRIMP (*Litopenaeus vannamei*) SEMI-INTENSIVE OUTDOOR POND PRODUCTION

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Aeration is considered one of the most critical factors in shrimp farming as it affects the metabolism of not only the shrimp but all living organisms in the system. To maintain proper dissolved oxygen (DO) concentrations in the water is critical, as low exposure can cause stress, therefore lower resistance to disease and inhibition of growth of the culture species. Although the effect of low dissolved oxygen has been widely studied, these have been mostly done in a short-term hypoxia study setting, and little to no research has been done with respect to diurnal cycles of this variable. Even though this concept is simple, the execution of DO management is not simple, it is dependent on numerous factors and there are numerous anecdotal recommendations. To help elucidate the effects of DO management on shrimp performance a research trial was conducted. The trial was aimed to determine the effects of three lower DO set point for automatic aeration systems in earthen shrimp pond by evaluating the effects of the setpoints on shrimp production as well as water quality parameters. In fifteen earthen ponds of 0.1 ha, juvenile shrimp of 0.030g were stocked at a density of 25ind/m^2. Distinct values for minimal dissolved oxygen (DO) levels that trigger automatic aeration activation were explored as treatments, namely 2.5, 3.5, and 4.5 mg/L. Shrimp were fed using the AQ1 passive acoustic monitoring system, the feeding was set to not feed while aeration was below the given aeration levels. Each treatment with five repetitions each, to assess their influence on shrimp health and farm productivity. Shrimp growth performance and water quality indicators were monitored every week. At the end of the 79–81-day trial, results showed that different aeration control strategies had no significant effect in terms of growth performance, feed inputs or productivity parameters. The final weight of the shrimp ranged between 33.3-33.6 g, with average final yields of 7,500-8,500kg per ha. Nonetheless, electrical costs mean values between treatments were significantly different, meaning that higher DO concentration treatments had a higher cost to supply aeration. Water quality parameters also showed no significant difference, except for morning and afternoon DO records.

Figure 1. Total average for morning (5:00-5:45am) dissolved oxygen during 11 weeks of pond production of Pacific white shrimp.

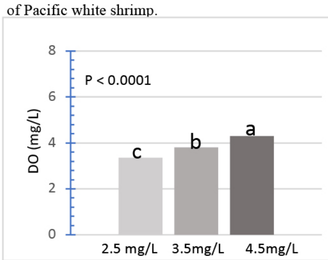

Table 1. Production results of *L. vannamei* reared with three automatic aeration activation set points with incremental lower limits under semi-intensive conditions in 15 outdoor ponds (0.1 ha) over an 11-week period.

Treatment	2.5 mg/L	3.5 mg/L	4.5 mg/L	PSE	p-value
Weight (g)	33.30	33.81	33.64	0.595	0.835
Weight Gain (%)	850.21	835.68	757.24	40.931	0.238
Survival (%)	101.70	97.90	89.65	5.087	0.235
FCR	1.05	1.03	1.12	0.073	0.656

AQUACULTURE OUTREACH AT AUBURN UNIVERSITY

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The US Aquaculture Society Student Subunit at Auburn University has been at the forefront of promoting aquaculture within the campus and the city of Auburn since 2016, through innovative initiatives such as the annual shrimp sale. The annual shrimp sale includes vending thousands of pounds of fresh shrimp to the local community that are cultivated and harvested by students of the organization. This shows our exemplary effort for the high-quality products that can be achieved through sustainable aquaculture implementation. The subunit also hosts fruitful social events such as bowling and water-themed trivia nights to foster beneficial relationships among the aquaculture community. Additionally, the subunit provides substantial scholarships through the sale and distribution of creative merchandise to members disseminating their research at conferences. Through our extensive efforts, the USAS Student Subunit at Auburn University has made significant strides in promoting the importance of sustainable aquaculture practices throughout our community.

UNDERSTANDING FACTORS INFLUENCING THE ENVIRONMENTAL, ECONOMIC AND SOCIAL SUSTAINABILITY OF AQUACULTURE SYSTEMS

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Globally, aquaculture production has been the food production technology with the highest growth rate in recent decades. While this is a strong indication of economic sustainability, there are significant differences between species and locations. Moreover, the rapid growth has led to the environmental sustainability of the industry being questioned, although also here the picture is getting nuanced as some sectors have better performance than others. The rapid production growth also leads to societal change, and this is creating a further sustainability challenge for the industry.

A challenge when one is interested in comparing different production systems is that comparable data is generally not available beyond production numbers. In this paper we will use data collected using the Aquaculture Performance Indicators for 58 aquaculture production systems to investigate which factors are most important for sustainability for the tree sustainability pillars. The analysis is conducted using regression trees and random forest estimation.

The preliminary results indicate that for all three pillars, general societal factors related to governance and economic conditions are more important than aquaculture specific measures. For both economic and societal sustainability, the ability for collective actions and viable industry organizations are also important.

ECONOMICS OF RISK IN U.S. AQUACULTURE SYSTEMS AND MARKETS

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Aquaculture is in general considered a risky sector. Most often, disease or market prices are listed as the biggest risks, but the sources of risk and their impact varies significantly by sector. The core of this project is a risk model that can be parameterized to reflect the circumstances in different U.S. aquaculture sectors from shellfish via ponds to RAS, and for different species. We started with shellfish models which are unique in that the species are not fed, a feature that makes other biophysical risks more important. The basic framework was expanded to fed aquaculture with different degrees of capital intensity and control. A number of studies were conducted to investigate different market and supply side sources for risk, while the production component primarily was due to interviews with producers. As a separate component, the model was also adopted to investigate the capital requirements for a farmer facing a given risk profile who wanted to avoided to by wiped out by a single shock with a specified probability.

ASSESSING EASTERN OYSTER *Crassostrea virginica* PREDATION UTILIZING REAL TIME MONITORING AND eDNA ANALYSIS IN DELAWARE INLAND BAYS

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Eastern oysters (*Crassostrea virginica*) are keystone species that are recognized for their ecological and economic benefits in Delaware. Predation is a stressor that can hinder both the recruitment and distribution of oysters (Johnson and Smee 2014). *C. virginica* are prey for different species of fish, crustaceans and gastropods (Newell et al. 2007). In order to assess oyster predation and species diversity, real-time monitoring and environmental DNA analysis are conducted at different locations around Rehoboth Bay, Delaware. The sites include pilot artificial reefs, private aquaculture farms, and control sites without any oysters or habitat structure.

Underwater cameras are deployed every two weeks from June to October. Once retrieved, the camera footage is reviewed for any signs of aquatic life and all documented species are identified and recorded for comparisons between sampling sites (Fig. 1). Environmental DNA (eDNA) analysis serves as a complimentary method for species identification and to assess the potential for eDNA as a tool for environmental monitoring (Fig. 2).

On-site water quality monitoring along with collected water samples are also used to perform nutrient analysis and assess chemical and physical water quality conditions which will be used to determine the aragonite saturation state. The aragonite saturation state will help to assess the impacts of ocean acidification on the calcification process of *C. virginica* and how this may impact predation. This study will help to promote oyster restoration efforts and sustainable aquaculture in the Delaware Inland Bays.

Figure 1. Demonstrates the species diversity observed at each site.

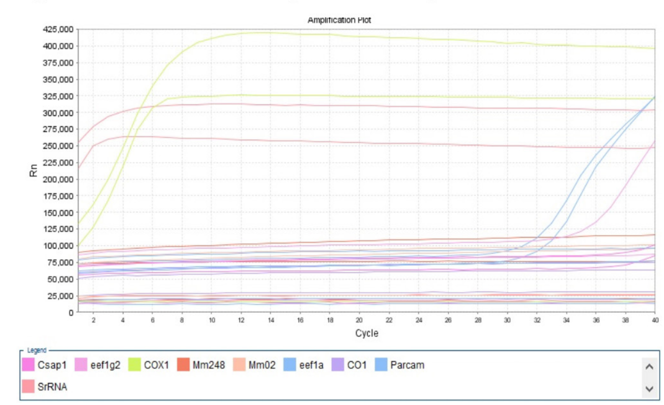

Figure 2. Demonstrates the amplification of targeted species primers.

"CRACKING THE SHELL": LESSONS LEARNED FROM A COLLABORATIVE APPROACH TO DEVELOPING HATCHERY PRODUCTION OF THE ATLANTIC SEA SCALLOP, *Placopecten magellanicus*

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The Atlantic sea scallop, *Placopecten magellanicus*, is becoming a valuable, commercially-farmed product in Maine's overall aquaculture industry, supplementing the domestic supply of wild-caught scallops. Although most successful aquaculture industries throughout the world are supported by commercial hatcheries, solving problems inherent with husbandry methods during the hatchery phase for sea scallop larvae is a major challenge to overcome. Sea scallops have one of the longest larval periods of any scallop, requiring up to 45 days to successful settlement. This lengthy larval phase has proved to be a challenge, especially when coupled with larval sensitivity to environmental conditions and hatchery expenses. Despite this, related scallop species in other parts of the world with similarly-long larval phases are being cultured in commercial hatcheries. Although there have been some research-scale successes with Atlantic sea scallop hatchery production, repeatable, large-scale seed production has remained elusive and unreliable. No commercial hatchery for Atlantic sea scallops exists in the U.S., or elsewhere.

This project focuses on "cracking the code" of early stage sea scallop culture to improve survival and growth, thereby developing guidelines for successful husbandry that can be replicated reliably to help sustain and grow the sea scallop aquaculture industry in Maine. Three hatcheries are engaged in this effort: Mook Sea Farm, the University of Maine's Darling Marine Center, and the Downeast Institute. Here, we describe findings and lessons learned from three years of this collaborative effort to produce hatchery-reared sea scallops. Completed hatchery experiments that will be discussed include conditioning and spawning trials, larval culture in static versus flowthrough systems, effects of buffered seawater on larval growth and survival, and effects of temperature on larval growth and survival.

To date, Mook Sea Farm has produced successful cohorts three years in a row, with post-settlement nursery culture occurring at the Darling Marine Center. Future plans for hatchery-produced spat include engaging established sea scallop farmers in Maine to estimate growth and performance of these animals in open-water farm sites.

STATUS OF THE U.S. FARM-RAISED CATFISH INDUSTRY - 2023

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U.S. farm-raised catfish acreage decreased by 4% from 23,525 hectares in 2022 to 22,604 hectares in 2023. U.S. acreage has decreased by 72% since its high of 79,600 hectares in 2002. The primary factors associated with this decrease are high feed costs, low fish prices, market disruptions, and increased competition from cheaper imports.

American catfish producers continue to improve production efficiencies (Figure 1). As recently as 2012, gross yield was only 5,333 kg/ha. Producers were yielding 7,693 kg/ha in 2022. The primary technologies leading to these increases are hybrid catfish (channel catfish *Ictalurus punctatus* females X blue catfish *Ictalurus furcatus* males), improved production systems like intensively-aerated small ponds and split-ponds, and improved fish health treatments such as vaccines and rapid diagnostic tools.

Feed prices continue to remain high. The average price for 32% floating catfish feed for the first 8 months of 2023 was $621 per metric ton. This is up from $595 for the same period in 2022.

During the first 10 months of 2023, the U.S. imported 185,667 mt of processed Siluriformes products. This import level is 29% lower than the same period in 2022.

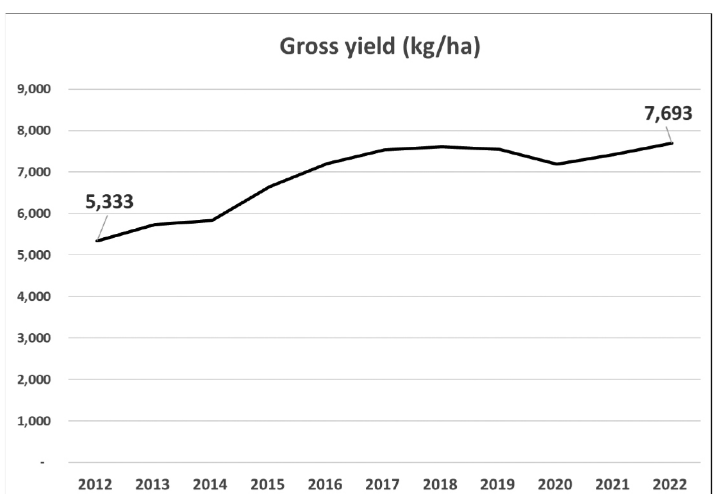

Figure 1. Gross yield in U.S. farm-raised catfish ponds.

THE UNITED STATES FISH AND WILDLIFE SERVICE FISH HEALTH CENTERS AND THE ROLE THEY PLAY IN AQUATIC ANIMAL HEALTH IN SUPPORT OF CONSERVATION AQUACULTURE

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The U.S. Fish and Wildlife Service Fish Health Centers (USFWS FHCs) operate as part of the Fish and Aquatic Conservation Program to provide aquatic animal health services and information that contribute to health, survival, restoration and enhancement of fish and other aquatic species in support of national and regional priorities. Centers collaborate with partners to provide diagnostics, monitoring, investigations, certifications and training related to free-ranging and cultured populations. Centers coordinate the Wild Fish Health Survey and address emerging pathogen concerns through applied research and innovative management strategies. Work at the FHC directly has applications for the conservation of natural resources and the aquaculture industry, generally.

The USFWS operates six FHCs and one Fish Health Program across the nation. Each of Center is an individual diagnostic laboratory capable of supporting the health of hatchery-reared fish, monitoring the health in wild aquatic animal populations, including early detection and surveillance of aquatic invasive species, including New Zealand mudsnails, zebra mussels, and Invasive Carp, and helping conduct aquatic animal health investigations.

The FHCs works with federal, State and Tribal partners to ensure that aquatic animals cultured across the nation are healthy and can be moved across the nation safely. Data collected at FHCs is being used to attest to the health status of wild fish and species maintained to supplement listed and endangered species.

Examples of how the FHCs serve the interests of conservation of natural resources and/or non-commercial aquaculture will be presented: A study on thiamin deficiency in free-ranging Pacific salmon returning to hatcheries in Idaho and Washington and methods used to supplement some salmon broodfish with thiamin to improve juvenile survival of wild and hatchery-origin fish; A FHC study to develop non-lethal sampling methods for the detection of pathogens on Atlantic Salmon; A pilot project developing methods for the use of somatic (diploid) cells collected from threatened/endangered fish species for rapid diagnostic, detect and monitor emerging aquatic animal pathogens, as well as improving existing pathogen detection method; An investigation of the health of freshwater mussels, that investigates unionid mussel mortality events for etiological agents ; A study how to prevent pathogenesis in the endangered Wyoming toad.

NIGERIA'S NEW BLUE ECONOMY MINISTRY AND MARINE RESOURCES: A PANACEA FOR SUSTAINABLE ECONOMY GROWTH

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The blue economy is a term used to describe the sustainable use of ocean and coastal resources for economic growth. It encompasses a wide range of sectors, including fisheries, aquaculture, tourism, maritime transportation, renewable energy, and coastal infrastructure development. The ocean economy supports 90% of global trade and provides millions of jobs. It includes shipping, tourism, and offshore energy valued at US$24 trillion. Marine fisheries and reefs, sea grass and mangroves are worth US$6.9 trillion; trade and transport US$5.2 trillion; and coastline productivity and carbon absorption US4$12.1 trillion. The blue economy is estimated to be worth more than US$1.5 trillion per year globally, and it provides over 30 million jobs. It is also a vital source of food and nutrition for billions of people around the world. The blue economy recognizes the importance of oceans and their resources to the global economy and society, and it seeks to promote economic development while also ensuring the long-term sustainability of ocean resources and the health of marine ecosystems. Nigeria coastline stretches for 420 nautical miles and covers an Exclusive Economic Zone of 200 nautical miles. Its maritime interests span the Gulf of Guinea, covering roughly 574,800 square nautical miles with a 2,874 nautical mile coastline. This paper will focus on the opportunities around blue economies and marine resources with significant potential to create jobs, improve livelihoods, and generate income from fisheries, aquaculture, fish reef, tourism, shipping and renewable energy. The paper will also address the issues of governance, safety and security, rule of law and transparency, respect for human rights, sustainable economic opportunity and human development.

ESTABLISHING PREDICTIVE METRICS FOR ATLANTIC SALMON *Salmo salar* BROODSTOCK AND OFFSPRING

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Eggs are an essential catalyst to a successful Atlantic salmon aquaculture operation. Embryo survival sets the bar for onsite productivity, fuels local conservation initiatives through multiplier eggs, and provides revenue for the regional aquaculture economy. The USDA's National Marine Cold Water Aquaculture Center (NMCWAC) located in Franklin, Maine, houses the largest applied *S. salar* selective breeding program in the United States. The NMCWAC operates with the goal of genetically improving N. American lines of *S. salar* for aquaculture production. Throughout the past 20 years embryo survival has trended downward, where the USDA could rely upon 85% survival in 2009, reducing to survival of 22.7%, and 17.8% in the years of 2021, and 2022, respectively. Embryo survival is accessed at the point of "eye up" a developmental benchmark, by which the retinal pigment is visible through the chorion. Embryo's that have reached eye up were successfully fertilized, cleaved, undergone gastrulation, and completed epiboly, thus being less vulnerable to handling.

While accessing viability at eye up offers ease, we lack a true understanding of ceased development prior to this benchmark. Our pilot study revealed reduced survival during stages of mid-late somitogenesis, and vascularization of the vitelline plexus. To further undercover the etiologies of mortality morphometrics tightly linked to developmental state were captured throughout *S. salar* embryogenesis. A suite of growth metrics; total length, eye diameter, yolk- sac volume, and egg diameter were collected. While physiological morphometrics of percent vascularization, and heart development were tracked to establish a metric that may be indicative of subsequent development, or cohort success. Following the morphological and physiological shifts throughout critical stages in *S. salar* development will undercover the etiologies of reduced survival while simultaneously defining a suite of morphometrics that inform a biomarker indicative of broodstock success.

THE EFFECTS OF STOCKING DENSITY ON GROWTH OF JUVENILE PACIFIC WHITE SHRIMP (*Litopenaeus vannamei*) IN A MIXOTROPHIC WATER SYSTEM

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Stocking density is a pivotal factor in shrimp cultivation. High stocking density can enhance shrimp yields, yet it necessitates greater feed input, potentially leading to water quality degradation. High stocking density has the potential to influence shrimp growth, survival rate, and contribute to stress due to overcrowding. The objective of this study was to evaluate the response of *L. vannamei* cultured at different stocking densities in a mixotrophic system. The experiment was conducted in an outdoor mixotrophic water recirculating aquaculture system consisting of 20, 800L culture tanks. The shrimp were stocked at 50, 100, 200, 300, and 400 shrimp/m^3 and raised for 8-weeks. All treatments (4 replicates each) were provided a commercial shrimp diet (Zeigler Shrimp Grower HI-35, CP 35%) four times per day via hand feeding. Feed inputs were proportional to stocking density. At the end of the study, significant differences in growth and feed conversion ratio (FCR) between treatments were observed. The highest mean weight (16.8 g) and weight gain percentage (4040%) were recorded in shrimp cultured at 50 shrimp/m^3. A decrease in the final mean weight, weight gain (%), and survival (%) were observed with an increase in stocking density. FCR and final biomass both increased with increasing density. A higher biomass is desirable from a producer standpoint, and higher stocking densities would potentially make this possible. However, overcrowding due to elevated stocking densities has the potential to result in reduced survival, elevated FCR, and diminished water quality. Therefore, ensuring a harmonious balance among stocking density, growth expectations, and water quality management is essential for optimizing shrimp growth in mixotrophic systems.

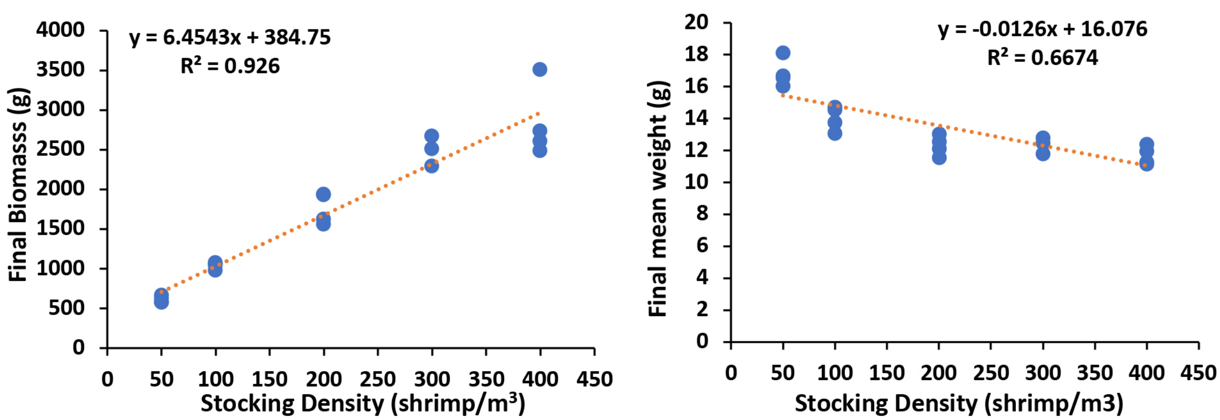

Figure 1: Final biomass and mean weight at different stocking densities in an 8-weeks trial in a mixotrophic system.

THE EFFECTS OF DIFFERENT FEED SIZES ON THE GROWTH OF PACIFIC WHITE SHRIMP (*Litopenaeus vannamei*) IN A BIOFLOC SYSTEM

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Understanding the distinct behavioral and physical dietary preferences of shrimp is crucial for establishing the feeding needs of these animals, given their unique and slow continuous feeding behavior. Pellet size could impact the physical attributes of the diet, feeding behavior, and biological performance. The breakdown of diet particles into smaller pieces, either due to pellet breakdown after immersion or shrimp manipulation, leads to direct nutrient losses, generating fines that may contribute to poor water quality and increased operational costs. Hence, it is crucial to identify the optimal diet size to improve both the physical performance of the pellet and the biological performance of the animal. The objective of this study was to evaluate the response of *L. vannamei* fed different sized feed in a biofloc system. The experiment was conducted in an outdoor biofloc recirculating aquaculture system consisting of 20, 800L culture tanks. The shrimp were stocked (1.7 g) at 44 shrimp/m^3 and raised for 8-weeks. Different sized feed each with 35% CP (1.5 mm, 2.0 mm, and 2.5 mm) were fed for 8-weeks as three treatments. During the first four weeks, a 1.5 mm feed was fed and then switched to 2.5 mm feed for the remaining four weeks as the fourth treatment. This resulted in a total of four treatments with five replicates each. Significant differences in growth and feed conversion ratio (FCR) between treatments were observed. The highest biomass (661.1g) and mean weight (20.0 g) were recorded in shrimp fed 1.5mm feed for first four weeks and 2.5mm feed for the last four weeks. An increase in the biomass, mean weight, and weight gain were observed with an increase in feed size. FCR decreased with the increase in feed size. The findings from this study indicate that offering shrimp an adequately sized feed tailored to their specific growth stages contributes to maximizing their growth potential. In conclusion, the research underscores the importance of fine-tuning diet size to the specific growth stages within a biofloc system to improve both the physical and biological performance of *L. vannamei*.

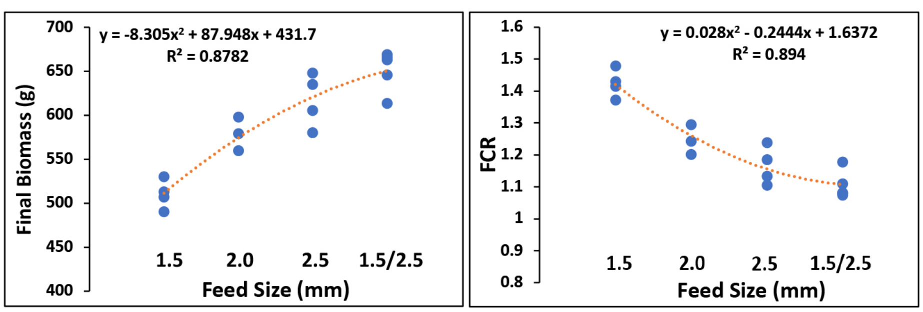

Figure 1: Final biomass and FCR with different sized feed during a 8-week trial in a biofloc system.

FEDERAL LEGISLATIVE UPDATE ON OFFSHORE AQUACULTURE

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Offshore aquaculture in the U.S. has the unique potential to improve American food security and nutrition, enhance coastal resiliency, create quality jobs, help restore species and habitats, and ensure that seafood (both wild-caught and farmed) continues to be an important part of the global food supply.

Yet, U.S. aquaculture is currently constrained by the absence of an efficient and affordable permitting process, particularly in U.S. federal waters. Stronger America Through Seafood has been working to pass bi-partisan legislation to create a predictable and efficient regulatory system to allow the industry to expand to U.S. waters.

Join SATS Campaign Manager, Drue Banta Winters, for an overview on the federal legislative landscape around offshore aquaculture this Congress. Learn about SATS efforts to move the bipartisan bill, Advancing the Quality and Understanding of American Aquaculture (AQUAA) Act and other bills that have been introduced this Congress. Learn more about the shifting dynamics on this issue and find out how you can show your support for US aquaculture to help move legislation forward.

SHALLOW WATER OYSTER GROWOUT FOR TEXAS' LOWER LAGUNA MADRE (LLM)

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In 2019, Texas became the last US coastal state to allow cultivated oyster mariculture (COM). Included in the legislation is a 200 ft buffer for seagrass habitat. This is significant for the LLM in South Padre Island (SPI) which is home to over 60 percent of the state's seagrass beds making many prime areas for COM unusable. The LLM area is home to many economically disadvantaged people. The shallow-water oyster grow-out system is being developed and tested at UTRGV's Experimental Field Station, in a shallow strip of water that is mostly devoid of sea grass located North of the SPI Convention Center in approved shellfish growing water. The ideal system would allow for anyone to start up an oyster grow out operation with minimal investment, easy maintenance and locally sourced materials.

The system uses anchored lines seeded with oysters held horizontally above the seabed. Lines are held above the bottom using ¾ inch PVC stakes that are put into the substrate leaving 6 inches in the water column. The version of the stake that has been the most efficient and cost effective has a fluted bottom (FB) (Fig. 1) vs no flute. FB been tested for two years and has withstood various severe weather conditions including Northers and tropical storms. Next is the stake top. Multiple versions of this have proven to be effective to differing degrees. The first iteration was a nail bent (NB) and attached to the stake at about half an inch below its highest point. On multiple occasions ropes have come loose with this version which increases the workload of the farmer and the possibility of crop loss. The second iteration had a pinched top (PT) that the line snapped into and has been the most successful for maintenance and stability. However initial installation was tricky, needed a special tool and required more time and effort than NB. A third iteration currently being developed takes from previous designs. This iteration (Clip top) should be easy to install and requires very little maintenance. It is being 3D printed using PETG filament. This system provides a low maintenance, low startup cost solution for the LLM which takes seagrass limitations into account.

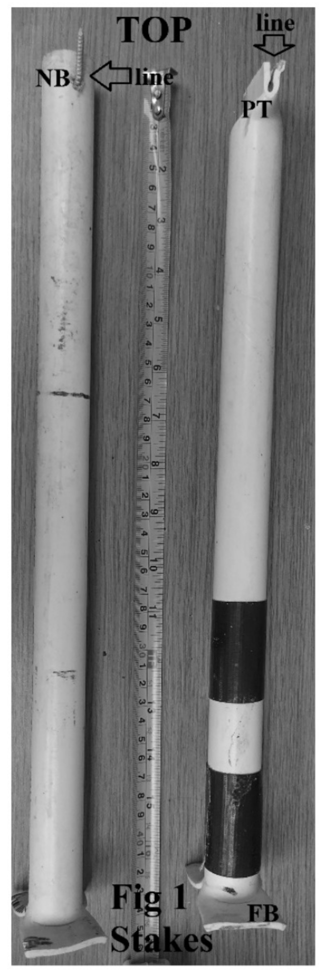

Fig 1
Stakes

AQUACULTURE OPPORTUNITY AREAS: NATIONAL UPDATES

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NOAA is continuing to encourage U.S. aquaculture development through the identification of Aquaculture Opportunity Areas (AOAs). NOAA is working with its federal and state partners to develop a process to identify geographic areas containing locations suitable for commercial aquaculture and complete a programmatic National Environmental Policy Act (NEPA) analysis for each area to assess the impact of siting aquaculture facilities there.

The AOA process will result in the identification of geographic areas that, through scientific analysis and public engagement, are determined to be environmentally, socially, and economically suitable for multiple aquaculture farm sites of varying types. NOAA will combine input received through consultation and coordination with Federal and non-Federal stakeholders, public comments, and spatial modeling by NOAA's National Centers for Coastal Ocean Science (NCCOS) that is based on the best available science.

NOAA began the process to identify AOAs in Federal waters within the Gulf of Mexico and off Southern California in 2020 and within state waters of Alaska in 2023. NOAA will provide updates on our progress in these regions, including continued opportunities for stakeholder input into the process.

OFFSHORE AQUACULTURE IN THE AMERICAS: FROM R&D TO COMMERCIALIZATION

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Following decades of R&D, technological advances and slow yet steady progress towards production, offshore marine fish aquaculture has reached the commercialization stage in the Americas. Full cycle aquaculture technology of several commercially important species has become or is quickly becoming available. Hatcheries are now capable of spawning broodstock and producing juveniles of species such as cobia (*Rachycentron canadum*), Hamachi/kampachi (*Seriola rivoliana, S. lalandi / S. dorsalis*), pompanos (*Trachinotus carolinus*), snappers (*Lutjanus guttatus, L. peru and L. campechanus*), yellowtail snapper (*Ocyurus chrysurus*), totoaba (*Totoaba macdonaldi*), red drum (*Sciaenops ocellatus*), mahi-mahi (*Coryphaena hippurus*), tripletail (*Lobotes surinamensis*), olive flounder (*Paralichthys olivaceus*) – among others. Steady supply of high-quality juveniles of certain species is still limited, but it is unlikely that this will remain a bottleneck for industry expansion. For certain species, technology is ahead of the industry. For example, the limitations for expanding commercial growout operations for species such as the red snapper and the olive flounder are mainly due to a lack of interest in investing in new facilities or systems for raising them.

Open ocean/offshore aquaculture, recirculating aquaculture systems (RAS) and flow-through in-line raceways are all viable options. Large scale production required to achieve commercial viability require advanced technologies demanding high levels of investment and long-term commitment. Hence, fish produced in these systems must be sold at high prices to compensate the high capital and operating costs required, limiting their demand in a highly competitive white fish market. Most of the production is being done with a few species (cobia, Seriola, snappers, totoaba) in cages in the open ocean. Commercial production is taking place in several countries, yet the economic viability remains mostly elusive in the Americas and the Caribbean – where the industry is still in its infancy. Infrastructure and logistics exist, as well as market demand. Technology continues to expand rapidly. Challenges such as optimizing genetics, nutrition, and diseases control must be tackled to secure commercial viability. Automation is progressing fast and being constantly refined. Machine learning and artificial intelligence tools are becoming available and being incorporated to perfect systems automation. The development of practical, specialized feeds for all developmental stages of species such as cobia, snappers and Seriola remains a challenge. FCRs are still high, limiting performance and increasing production costs.

Although still incipient when compared to the Asian and European continents, commercial aquaculture production of marine fish in the Americas has become a reality.

AQUACULTURE RESEARCH AND OPPORTUNITIES AT FLORIDA A&M UNIVERSITY

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The World Bank and Food and Agricultural Organization (FAO) have estimated that world fish food consumption will increase by 20% by 2030. In addition to health benefits and food security, aquaculture has been playing significant roles in world development by promoting economic growth and providing jobs. The aquaculture industry's success and recognized contribution to global food security rely on meeting the constant demand for trained personnel caring for cultured fish species. Florida Agricultural and Mechanical University (FAMU) is a historically black college and university (HBCU) with about 10,000 student populations. Aquaculture research at the university started about two years ago, with a complete recirculating system for freshwater fishes. In addition, there are twelve large earthen ponds where pilot studies with farmers can be conducted. Fish species, including bluegill, tilapia, and catfish, are housed for nutritional and microbiome research. Other fish species are being added based on the research needs. There are opportunities for undergraduate paid research internships. Also, the university provides scholarship opportunities for graduate degrees in aquaculture. The FAMU aquaculture facility is student-driven, which offers the opportunity to learn and master the daily routines of the culturing system. The university collaborates with other HBCUs and other universities to provide outstanding knowledge to our students through various programs. For instance, two students who interned in the undergraduate summer research have been accepted to the University of Minnesota Veterinary Medicine Program through the VetLEAD program. Several of these opportunities are available to undergraduate and graduate students who received training in aquaculture. The main goal is to ensure our students succeed by acquiring adequate aquaculture training in teaching, research, and extension for successful careers through this facility.

DIGITAL CAMPAIGN STRATEGIES TO ADVANCE PUBLIC SUPPORT FOR AQUACULTURE IN MAINE

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Historically, the US aquaculture sector has shied away from proactive communications, focusing instead on responding to the criticisms that have plagued the sector for decades. Even when aquaculture businesses and organizations tackle communications projects, they typically consist of myth-busting fact sheets, FAQ pages, and crisis communications tactics. While these can be useful, relying on reactive PR alone is not enough to turn the tide of public opinion. Tactics like these have put the US aquaculture sector on the defense, perpetuating its "guilty until proven innocent" status. Furthermore, the sector is challenged to break out of its echo chamber and reach new audiences, rather than preaching to the proverbial choir. It is clear that a new approach, coupled with significant investment, is desperately needed to help this sector advance in the 21st century.

Maine has recognized this need and taken action. This lightning talk will showcase how Maine is developing and implementing effective digital campaigns that tell the story of Maine's aquaculture farmers and reach beyond typical followers to engage new audiences. Topics covered will include broad strategy development, target audiences, key messages, and objectives related to the campaign, as well as specific types of content, tools, metrics, and analytics used to measure success and fine-tune strategy over time.

NUTRACEUTICAL EFFECTS ON THE MODULATION OF PHYSIOLOGICAL AND IMMUNOLOHICAL RESPONSES IN TILAPIA

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A possible solution to the growing demand for quality protein is an increase in aquaculture. A downfall of aquaculture is that the fish in the aquaculture system often become very stressed due to overcrowding, poor water quality, constant handling, or transportation. This stress leads to a decrease in immune responses and their susceptibility to diseases. These diseases are then treated with chemical drugs. This leads to issues as chemicals may be released into the environment through watersheds or can leave traces in the fish that are then consumed by humans. The solution to this issue could be the use of nutraceuticals. Previous research, performed at our lab, have shown to modulate stress and immune responses in fish using different kinds of nutraceuticals. Currently, we are investing the effects of astaxanthin and tryptophan in tilapia, reared in recirculating aquaculture system and in aquaponics system. We will present our findings in the Aquaculture America 2024 conference.

EFFECT OF HEMPSEED MEAL ON APPARENT DIGESTIBILITY COEFFICIENTS IN LARGEMOUTH BASS *Micropterus nigricans*

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Globally the hemp industry production has increased due to the discovery of its nutritional and medicinal benefits. Hemp seed meal (HSM) has shown promise as an alternative protein source in aquaculture feeds due to its sustainable production and nutritional qualities, especially essential and non-essential amino acids. Therefore, the purpose of this digestibility trial was to evaluate HSM as an alternative protein source for largemouth bass (*Micropterus nigricans)*.

An 11-week digestibility trial was conducted to investigate the digestibility of two HSM ingredients P30 and P50, with P50 having higher protein content. Four diets were formulated: reference, soybean meal (SBM), P30, and P50. Once a week fecal matter was collected from each of four replicate tanks with 20 fish each through the stripping method. Fecal matter was pooled by tank, dried at 65°C for 24 hours, and stored at 20°C pending chemical analysis. The apparent digestibility coefficient **(**ADCs) of dry matter, crude protein, phosphorus, and various essential and non-essential amino acids were assessed. The study revealed significantly lower ADCs of crude protein in the reference treatment when compared to the SBM, P30, and P50 diets. Additionally, the P50 diet exhibited significantly higher dry matter ADCs when compared to the reference diet. Further analysis of ADCs for specific amino acids, including Aspartate, Serine, Cysteine, and Arginine, indicated higher ADCs in P50, P30, and SBM diets when compared to the reference diet. This research sheds light on the potential of HEM as a complementary source of nutrients and energy in largemouth bass feeds.

THE IDENTIFICATION AND CHARACTERIZATION OF *VASA* and *NANOS-2* GENES IN THE OVARY OF WHITE CRAPPIE *(Pomoxis annularis)* AND BLACK CRAPPIE *(P. nigromaculatus)*

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White crappie (*Pomoxis annularis*) and black crappie (*P. nigromaculatus*), both members of the Centrarchidae family, are two popular sport fish species in lakes and reservoirs throughout the USA. The *Vasa* and *Nanos-2* genes have been widely used as molecular markers for identifying germ cells in various fish species. However, these two genes have not yet been investigated or reported in crappie species. Identifying and characterizing these genes can have significant implications for germplasm conservation and production of hybrid crappie using innovative hatchery technology, such as xenogenesis.

Conserved sequences of these two genes were identified by comparing available nucleotide sequences from the database of five different fish species: largemouth bass (*Micropterus salmoides*), catfish (*Ictalurus punctatus*), tilapia (*Oreochromis niloticus*), medaka (*Oryzias latipes*), and zebrafish (*Danio rerio*). Subsequently, primers were designed based on the conserved regions of these five different fish species to perform quantitative polymerase chain reaction (qPCR) and to determine the expression levels of the target genes in the ovary of crappie species.

The primers designed from conserved regions proved effective for amplifying and identifying the *Vasa* and *Nanos-2* genes in the crappie ovaries. Both target genes were found to be expressed in the ovaries of both crappie species. Gel electrophoresis was conducted to visualize the qPCR products, confirming the successful amplification of *Vasa* and *Nanos-2* genes. The results demonstrated the conserved nature of these genes in both white and black crappies.

AQUACULTURE OPPORTUNITY AREA IDENTIFICATION IN ALASKA

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As a follow-up to our June 1, 2023 announcement beginning the process to identify Aquaculture Opportunity Areas (AOAs) in Alaska state waters, in partnership with the State of Alaska, NOAA Fisheries published a Request for Information (RFI) in October 2023 seeking public input for 60 days. This RFI requested data, comments, views, information, analysis, and suggestions from the public to support the identification of AOAs in Alaska state waters, including feedback on siting parameters that can be used to select potential study areas for further analysis.

This presentation, highlights the process of identifying AOAs in Alaska state waters, and the feedback NOAA received during the RFI period to help inform NOAA as it works with Federal, State, and Local agencies, appropriate Regional Fishery Management Councils, and in coordination with appropriate Tribal governments to identify AOAs.

MINORITIES IN AQUACULTURE: WORKFORCE DEVELOPMENT & CAREER OPPORTUNITIES

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Minorities in Aquaculture (MIA) is a 501(c)3 nonprofit organization that works to bridge the gap between minority individuals aspiring to build careers in aquaculture and the industry's workforce development needs, requirements & goals. Through MIA's empowering network of 200+ women of color globally, a variety of aquaculture knowledge, intentional resource allocation, and career development opportunities, the organization strives to facilitate & promote a more inclusive and sustainable future for the aquaculture sector.

Since MIA's launch in October of 2020, the organization has fully funded 17 women of color in aquaculture internships nationwide [New Hampshire, Maine, Maryland, South Carolina, Florida, Alaska & California]; has successfully raised awareness nationally and internationally about diversity, equity, and inclusion in aquaculture; and demonstrated the significance in building the industry's future workforce and responsive DEI approaches. This program offers a broader aquaculture focus for all women, trans, non-binary and gender nonconforming individuals of color, with environmental and entrepreneurial interests by providing an immersive training experience in aquaculture. Over an eight week internship, selected candidates work alongside aquaculturists at a host farms nationwide to learn regular farm operations and maintenance, and will have the opportunity to engage with aquaculturists, the MIA team, and industry connections/partners as mentors. Most importantly, MIA's internships are specifically tailored to each applicant's interests, ensuring maximum exposure of the intern's desired aquaculture knowledge and hands-on skills that will assist their unique career development. Minorities In Aquaculture is allowing underrepresented and often under-resourced groups to capitalize on a local and viable career in the increasingly prevalent field of aquaculture, which in-turn, will create more qualified employees and industry leaders that are highly needed in all sectors of aquaculture locally and globally.

DIET DEVELOPMENT FOR PURPLE URCHIN *Strongylocentrotus purpuratus* CULTURE ON THE WEST COAST

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Purple sea urchins (*Strongylocentrotus purpuratus*) are an abundant urchin species in the eastern North Pacific, with a habitat range spanning the entirety of the west coast of the United States. In many areas, unchecked population growth has resulted in the destruction of kelp forests, urchins' primary food source in the wild, and the creation of "urchin barrens". An emerging industry of small-scale producers focused on the harvest and ranching of wild-caught urchins for the uni market provides an opportunity to diversify the domestic aquaculture sector and promote long-term aquatic ecosystem health.

For the last two years, the Bozeman Fish Technology Center (Bozeman, MT) has been working with The Nature Conservancy and UC Davis Bodega Marine Laboratory (Bodega Bay, CA) to develop an open-source diet formulation for purple urchins being cultured for the uni market. Here, we will present results from two 8-week feeding trials as well as qualitative outcomes of how select diets performed in a commercial farm setting. Feeding trial 1 tested four experimental diets (20% crude protein, 6% fat) and examined how formulations using various protein sources (marine animal, terrestrial animal, terrestrial plant, and marine plant) affected pellet stability, palatability, gonad growth (gonadosomatic index, GSI), and product quality. Generally, the marine animal and marine plant formulations performed well and a blend of the two was used to develop an enhanced base formulation for use in feeding trial 2. In feeding trial 2, four experimental diets were tested against a commercially available urchin diet. The four experimental diets consisted of the enhanced base formulation as well as the base formulation with the addition of one of three different carotenoid sources: Panaferd (0.27% diet dry weight), b-carotene (20% product; 0.25% diet dry weight), or dulse (13.94%). Generally, the experimental diets increased GSI similarly or better than the commercial diet. Further, the diets with the addition of a carotenoid source resulted in an increase in the % mango color of the uni with Panaferd and b-carotene at 40-43% and dulse at 33% compared to the base experimental diet at 20%. Currently, the availability of dried dulse is limited in the United States encouraging the use of Panaferd or b-carotene in future formulations.

Three additional feeding trials are scheduled to examine: (1) protein and starch nutrient targets, (2) ingredient selection, and (3) the use of an algae finishing diet. These upcoming initiatives and how they support the development of a domestically-available urchin diet will also be discussed.

DECREASING DIET PH WITH HYDROCHLORIC ACID REDUCES GROWTH PERFORMANCE IN RAINBOW TROUT *Oncorhynchus mykiss*

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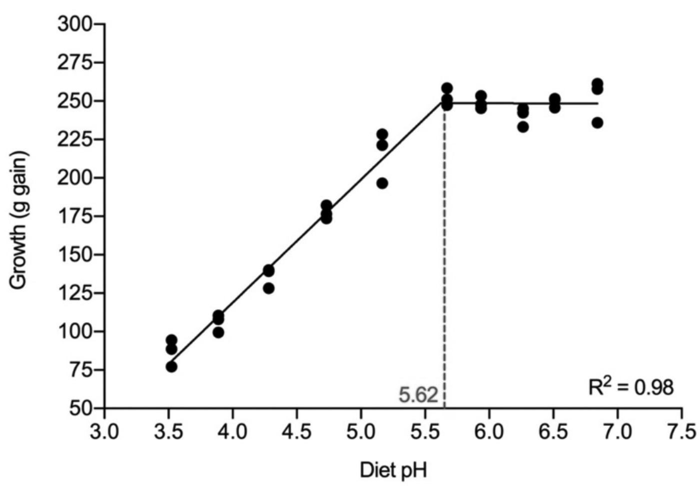
Dietary acidification, decreasing the pH of the diet, has been used in the aquaculture industry to inhibit microbial growth and promote fish and gut health. However, research has shown that acidification also has the ability to enhance growth and digestibility metrics across a variety of aquaculture target species, including rainbow trout, red drum, and barramundi. Currently, typical commercial aquafeeds exhibit a pH of approximately 6.0 and are not designed to maximize the biological potential of the fish based on pH.

After feeding, fish must decrease stomach pH to facilitate digestion. This drop is initiated by parietal cells in the stomach epithelium that secrete protons (H^+) into the stomach lumen and bicarbonate ions (HCO_3^-) into the bloodstream. Termed the alkaline tide, this process is energetically expensive and can last up to 48 hours in trout. In this study, we examined the effect of diet pH on growth performance and postprandial gut pH, blood chemistry, and metabolism in rainbow trout.

A 12-week feeding trial was conducted with rainbow trout (*Oncorhynchus mykiss*, Troutlodge Inc., Sumner, WA). Experimental diets (n=10) were formulated at 45% crude protein, 15% fat with amino acid supplementation to meet or exceed the known nutritional requirements of this species. This practical trout formulation expressed a mash pH = 5.7 without modification. Experimental diets ranged from pH = 3.5 to 6.8. Diet pH was modified through the addition of hydrochloric acid (diets 1-6, pH 3.5 - 5.7) or sodium hydroxide (diets 7-10, pH 5.9 - 6.8). Diets with a pH below 5.6-5.7 resulted in a decrease in growth and feed intake. Diets with a pH below 5.3 resulted in a decrease in feed efficiency. Additional results examining digestibility, feed evacuation rate, and the physiological and metabolic state of the fish post-feeding will be presented and discussed as they relate to the performance data. It remains unclear what drove the discrepancy between the negative results seen in this study and the benefits of dietary acidification published in the literature for the same or other fish species.



EVALUATING MICROALGAE PRODUCTION AND RESOURCE PARTITIONING IN AN OYSTER HATCHERY

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Operating a successful oyster hatchery involves balancing various activities, all competing for limited resources (e.g., time, space, personnel, and equipment). A hatchery is responsible for conditioning broodstock, spawning, raising and setting larvae, and in many cases, spat grow-out as well as algal culture. Algal culture is an essential component of hatchery operations that provides food for broodstock and larvae. Large quantities of algal species must be available during the entire hatchery production season. Therefore, allocating hatchery resources efficiently is imperative to successfully maintaining algal cultures in addition to performing all other hatchery activities. This study proposed to use industrial engineering tools to simulate hatchery operations, beginning with "hanging-bag" microalgae culture activities. To meet this goal, process diagrams outlining daily algae production steps were created, time data for algae production steps were collected, a model simulating daily algae production was developed, and the resources required (e.g., time, personnel, equipment, cost) to meet daily algae production needs were evaluated.

To begin simulating hatchery operations, daily tasks were identified, outlined (Figure 1), and put into a simulation model. Daily tasks were defined as tasks that must be completed everyday regardless of the quantity of larvae or seed currently in the hatchery. Initial results revealed that one operator (a hatchery employee) required 2.3 hours to complete all daily tasks (Step 1 – 25, Figure 1). This included 1.8 hours to complete Start of Day tasks (Steps 1 – 17) and 0.6 hours to complete End of Day tasks (Steps 18 – 25). Of these tasks, the majority of effort (70%) was dedicated to steps pertaining to algal culture. If two operators performed daily tasks concurrently, one focusing on algal culture tasks, both finished in under 1.5 hours. Further work will evaluate the most efficient resource partitioning to complete daily algal culture tasks in addition to other required hatchery activities.

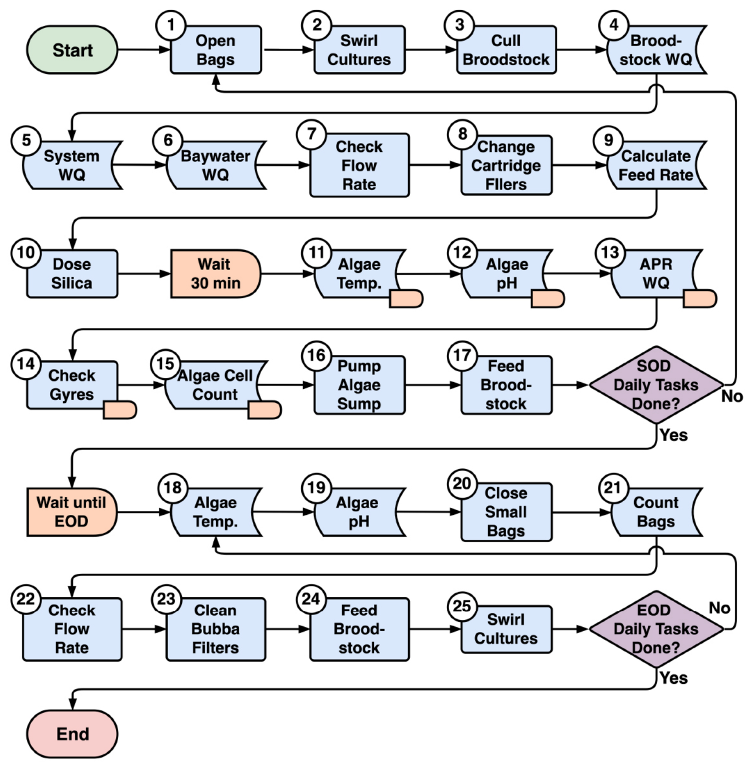

Figure 1. Process flow diagram detailing the daily tasks. Shapes indicate the following: ovals, start and end of the process; rectangles, steps in the process; rectangles with two curved sides, data is recorded; rectangles with one curved side, a delay; diamonds, quality assurance steps; small delay shapes, steps can be performed during a wait time; and arrows, the flow of materials. SOD stands for Start of Day and EOD stands for End of Day.

ADVANCING AQUACULTURE ECONOMICS, MARKETING RESEARCH AND EXTENSION: A NATIONAL INITIATIVE THROUGH PARTNER SEA GRANT PROGRAMS

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Despite the recent growth of aquaculture in the United States, there are still many economic and marketing challenges that producers face. Steep regulatory compliance costs, import pressure, and the rising cost of inputs cause uncertainty, increased market risk, and potential business collapse. Identifying these issues, a geographically diverse group of economists and Extension specialists were assembled to build partnerships within the industry in order to provide resources and information. In addition, an Industry Advisory Board (IAB) which comprises aquaculture experts across various sectors, and an Economics and Extension Advisory Board (EEAB), were created to guide the research team throughout the duration of the project.

To meet the goals of the project, the team has devised a list of objectives. The first, is to assess the current economics and marketing tools for U.S. aquaculture, and conduct a needs assessment of the "Aquaculture Hubs" by developing and distributing an online survey. Next, is the development of new business planning tools, market analysis, risk assessment, and economic impact estimates using primary data to reflect an accurate condition of the industry. Existing tools will also be updated with the most recent data to build a robust, current picture of U.S. aquaculture. Using these materials and additional resources, in-person training workshops will be hosted in five regions across the country, including Puerto Rico and Hawai'i, to teach how the tools can be used on farms and the benefits of business planning. A recording will be made of the trainings and the materials developed throughout this project will be made publicly available on the *Aquaculture Information Exchange* (AIE). The AIE is a new online resource that will host an "Economics and Marketing" group where current and future materials can be shared in one location, accessible to researchers, Extension, and farmers.

While the economic and marketing tools will be a pragmatic output from this study, the overarching goal is to build partnerships across academia, Extension, and industry to create more meaningful, needs based research to advance economics and marketing of U.S. aquaculture.

SUBLETHAL EFFECTS OF LOW-DOSE EXPOSURE TO IMIDACLOPRID ON SUBADULT FEMALE AMERICAN LOBSTERS *Homarus americanus*

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Atlantic salmon, *Salmo salar,* farms face the ongoing challenge of managing sea lice *Lepeophtheirus salmonis* and *Caligus elongatus*, infestations due to reduced sensitivity to extensively used chemotherapeutants. Imidacloprid is a neonicotinoid insecticide that has been implemented as a novel chemotherapeutant to mitigate sea lice infestations on European salmonid farms. Prior to its consideration for use in the Northwest Atlantic, we tested the effects of imidacloprid waste-water and dispersal concentrations on the ecologically and commercially valuable nontarget species, the American lobster, *Homarus americanus*. Behavior and hemolymph biochemistry of subadult female lobsters were assessed following a 120-minute exposure to the imidacloprid concentrations 0, 0.3 or 30 µg/L. Observations were repeated after a five-day recovery period to evaluate chronic effects. Defensive behaviors were found to be significantly reduced for lobsters from the 0.3 and 30 µg/L imidacloprid concentration groups compared to the control group, and some remained significantly reduced five days after exposure. Interestingly, overall hemolymph endpoints indicative of stress (L-lactate, crustacean hyperglycemic hormone, and total protein) were not significantly different across treatments. This highlights the importance of behavioral endpoint observations, as limited upstream endpoints may not always capture the full impact downstream. These findings suggest that low environmentally relevant concentrations of imidacloprid could impair lobster behaviors of ecological and economic importance.

RELATIONSHIPS BETWEEN WEIGHT LOSS DURING SHORT-TERM FEED DEPRIVATION, FEED CONVERSION EFFICIENCY AND GROWTH IN DELTA SELECT AND DELTA CONTROL LINE CHANNEL CATFISH FAMILIES

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Feed conversion efficiency is an economically important trait in nearly all livestock production and improving feed conversion in farm-raised catfish through selective breeding would benefit producers. However, selection of improved feed conversion efficiency would require measuring feed intake in individual fish which is time consuming and not accurate. Weight loss during feed deprivation is correlated with feed conversion efficiency in several fish species, suggesting weight loss during feed deprivation could be used to indirectly select for improved feed conversion efficiency.

Trials were conducted to determine relationships among weight loss and feed conversion efficiency with Delta Select and Delta Control line channel catfish fingerlings. Weight loss was measured for 79 Delta Select line families and 20 Delta Control line families in replicate feed deprivation trials. Weight loss was higher for Delta Controls than Delta Selects. The 10 Delta Select families with the highest weight loss, 10 Delta Select families with the lowest weight loss, and 10 random Delta Control families were used in a feeding trial. Initial weight, final weight, percent weight gain, and percent feed consumption were not different among Delta Select groups but were higher than the Delta Control. Feed conversion and survival were similar for all groups. Catfish from the feeding trial were used in a third feed deprivation trial. Family means for weight loss were positively correlated across all three feed deprivation trials but were not correlated with feed conversion indicating selection for weight-loss would not improve feed conversion. The percent of total variance associated with replicate family tank was much higher than the variance associated with family (~ 75% vs. 25%) for weight loss, FCR and RFI. Understanding the basis for the large replicate tank variance and reducing it through improved experimental design or accounting for it by statistical methods would improve assessment of feed conversion efficiency in channel catfish.

Results of this study indicate weight-loss during feed deprivation is not a good predictor of feed conversion efficiency in channel catfish. The faster growth of Delta Select catfish is primarily due to increased feed consumption. Studies to understand the basis for the large variance associated with replicate tank within family for weight-loss and feed conversion efficiency are currently being conducted.

SUSTAINABLE HARVEST: FARMING PACIFIC WHITELEG SHRIMP *Litopenaeus vannamei* UNDER SUPERSATURATED DISSOLVED OXYGEN LEVELS

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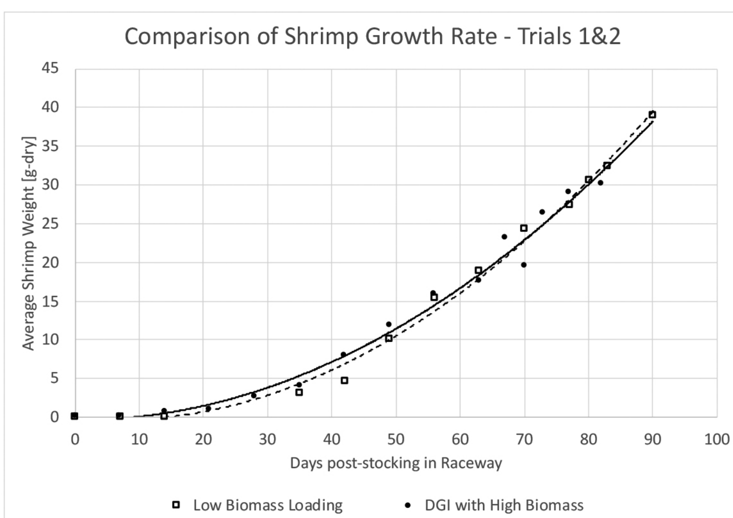
Two trials were conducted to determine the effects of growing Pacific Whiteleg Shrimp (*Litopenaeus vannamei*) with high raceway stocking (equivalent to more than 7kg/m^2 at 39g maturity) in typical low-salinity water. In the first trial, bubble aeration was used until the oxygen demand could not be met, and then a partial shrimp harvest was completed each time the biomass loading reached about 4kg/m^2. In the second trial, an oxygen infusion process was used to provide raceway dissolved oxygen concentrations at 150% of atmospheric saturation, allowing essentially all the animals to reach maturity.

The two three-month trials (90-day nominal maturation) were conducted in a greenhouse-enclosed concrete raceway with a bottom area of 97.9m^2 and an average water depth of 57cm. The water was held at about 30°C, with a salinity of 13ppt. A recirculation system (RAS) was used to biologically control NH_3 and NO_2^- and partial water exchanges were completed as required to control NO_3^-. The initial stocking was approximately 21,000 post-larvae shrimp in each case, with an estimated 25% loss on planting for an expected 15750 live animals. For the second trial, dissolved oxygen was maintained at 50% above atmospheric saturation by the Fuel Tech, Dissolved Gas Infusion (DGI) technology across all growth phases.

In the DGI trial, excellent survival and growth was achieved and a mean weight of 42g was reached in about 100 days with a survivability of about 50%. In fact, the individual shrimp growth curves show no significant change from the trial in which selective harvesting was required. High PL stocking and reliable DO dosing with automatic controls dramatically increased total production as compared to the first trial.

Other observations from the trial include no evidence of trimethyl amine odor at harvest, no evidence of oxidation, no evidence of excessively fast metabolism, no evidence of osmotic shock and no evidence of gas bubble disease, suggesting that in low-salinity water maintaining dissolved oxygen levels above saturation without the presence of bubbles increases the yield while minimizing detrimental effects of high oxygen levels.



ONLINE MEDIA SENTIMENT ANALYSIS FOR U.S. OYSTERS

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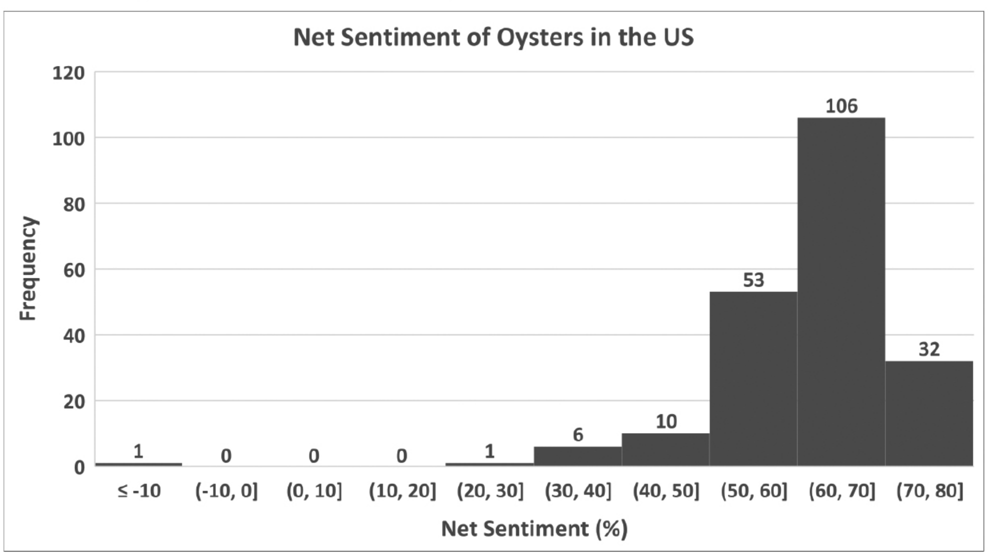
Oysters, a beloved seafood delicacy, are produced through natural wild harvest, managed natural production, and aquaculture. Oyster production provides environmental benefits since oysters improve water quality and foster reef ecosystems. The present study analyzed online sentiment and mentions associated with oysters, differentiating between farmed and wild oysters, from January 2019 to December 2022, a total of 209 weeks. Understanding consumer sentiment is crucial for the industry to adapt to consumer preferences and enhance oyster demand. Research demonstrates the relevance of sentiment analysis in evaluating consumer perception, informing market strategies, assessing demand, and managing brand reputation. Insights from net sentiment analysis highlight the need for the oyster industry to proactively engage with consumers and address their concerns to maintain a positive reputation and sustain growth.

The analysis indicates a predominantly positive sentiment toward oysters, with both farmed and wild oysters enjoying a favorable perception, albeit with minor concerns and criticisms (Figure 1). The study identified key positive and negative words associated with oyster mentions, such as “great”, “love”, and “delicious” for positive and “bad”, “not eat”, and “raw oyster” for negative. These words shed light on the factors influencing public sentiment. Analysis revealed fluctuations in net sentiment because of personal experiences with oysters, extreme flooding, questionable commercial farming permit allowances, and the closing of major oyster bays. This analysis provided insight into public reactions to specific events and developments within the industry.

Oysters generally received a positive net sentiment during the study period of 209 weeks (Figure 1). In 194 out of the 209 weeks, net sentiment was over 50%. This is a very high percentage net sentiment overall considering 0 is neutral.

Figure 1. Net Sentiment of Oysters in the US



BEST MANAGEMENT PRACTICES (BMPS) FOR OYSTER AQUACULTURE IN MAINE

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Maine has experienced notable growth in oyster aquaculture over the past decade. This was initially led by the expansion of existing farms, and supplemented by the entrance and subsequent growth of a new cohort of oyster farmers. From a social perspective, an increase in the number and size of oyster farms has led to increased user conflict due to lease siting, lost gear, etc. From a production perspective, especially the newer farmers must understand how to grow their farms from nascent to full-scale while maintaining safe, high-quality products.

The Best Management Practices (BMPs) for oyster aquaculture in Maine provide oyster farmers with a guide on how to best site, set-up, and operate their farms following best practices set by the sector. The BMPs address the social, production, and economic aspects that influence oyster aquaculture in Maine and provide farmers with steps to success in each category. This work builds on the Maine Aquaculture Innovation Center's work detailing how to improve and leverage social license for aquaculture in Maine.

EXPANDING YOUR STATE'S BLUE ECONOMY - LESSONS AND FINDINGS FROM MAINE

Christian Brayden*, Caroline Noblet, Keith Evans, Kanae Tokunaga, Katherine Maltby, Keri Kaczor

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Maine's aquaculture sector has experienced moderate growth over the past 8 years - but has remained constrained by saturated in-state markets and producers' challenges to move product to the out-of-state consumer. This project, funded by the OAR National Sea Grant College Program award #NA21OAR4170086, looks to use Maine as a case study to improve our understanding of potential new and underserved markets for aquaculture seafood.

This presentation will report on findings from the following aspects of the project: (1) focus groups, interviews, and a survey on Maine sector-wide marketing barriers and opportunities; (2) semi-structured interviews of (a) seafood dealers and wholesalers and (b) market destinations (e.g. restaurants, grocery stores, etc. beyond Maine); and (3) a regional survey and a national survey exploring restaurant and at-home consumer preferences for seafood. The presentation will also share lessons learned to help states across the U.S. facilitate the process of expanding their aquaculture sector.

SATISFYING NORWEGIAN APPETITES: DECODING REGIONAL SHRIMP DEMAND

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Ingrid Kristine Pettersen

This study investigates the regional demand for shrimp in Norway by employing the linear approximated Almost Ideal Demand System (LA/AIDS) framework. Shrimp consumption has grown significantly globally, with Norway being no exception. The LA/AIDS model allows us to examine the demand patterns, price elasticity, and expenditure elasticity of shrimp across different regions in Norway. We utilize comprehensive data on regional shrimp consumption, prices, and household expenditures to estimate and analyze the demand parameters. Our findings reveal consistent patterns across regions, with fresh Coldwater shrimp emerging as a dominant competitor, often substituting for other shrimp species. Furthermore, regional variations in substitution relationships highlight the nuanced nature of the market, with differences in the intensity of competition and the extent of substitution effects.

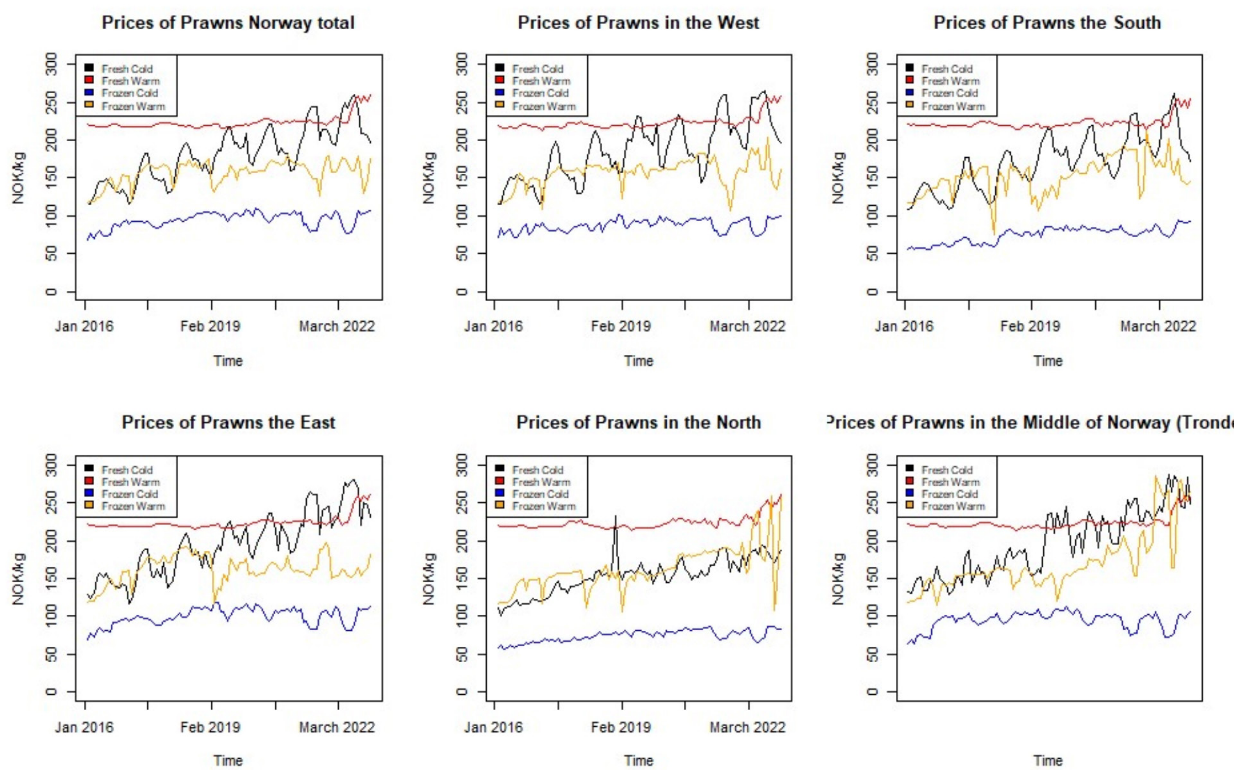

Figure 1 Prices of different products of shrimps

TRANSFORMATIVE AQUAPONICS: GROWING AQUACULTURE IN URBAN AREAS

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No abstract required for this session.

OPTIMIZING EGG DISINFECTION FOR DEMSERAL SPAWNING SPECIES

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Clownfish are the most ubiquitous marine aquarium aquaculture species. Despite the success of the clownfish aquaculture, there is still a need to improve larval rearing methods due to the high variability of hatch, survival, and deformity rates. One way to improve these parameters is by disinfecting embryos just prior to hatching. Disinfecting embryos can reduce or eliminate bacteria, fungi, or protozoans from being transferred to the larval system. Common disinfection treatments include hydrogen peroxide, iodine, and formalin. This study aims to determine effective concentrations needed to disinfect embryos and spawning substrates.

Three disinfectants were tested at various concentrations on common clownfish (*Amphiprion ocellaris)* embryos. Range finding experiments evaluated povidone iodine (100 ppm, 250 ppm, and 500 ppm), hydrogen peroxide (1,000 ppm, 5,000 ppm, and 10,000 ppm), and formalin (10 ppm, 100 ppm, 200 ppm), along with a seawater control for each treatment. *A. ocellaris* breeding pairs were conditioned to spawn on acetyl sheets. One day before hatching (8-9 days), the acetyl sheet was removed from the tank, and the sheet was cut into four equal groups of embryos. Each sheet was exposed to various disinfectant concentrations for 5 minutes. After 5 minutes, embryos were transferred into clean seawater and reaffixed to a ceramic tile for hatching. The tile was placed in 20 L of seawater in a custom 3-D printed hatching apparatus that orients the tile at a 60-degree angle and holds a wooden air diffuser to aerate the embryos (Figure 1). The embryos were held in complete darkness to hatch overnight. The next morning, numbers of unhatched embryos, living hatched larvae, and dead hatched larvae were enumerated to determine the percent hatch and percent survival.

Determining effective embryo disinfection methods improves larval rearing efficiency by helping to reduce harmful microbial communities and increase hatch rate. In turn, this will help to reduce economic losses in research and production facilities rearing clownfish.

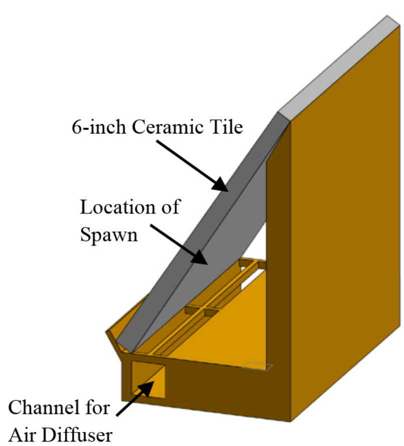

FIGURE 1. Hatching Apparatus (orange), showing the ceramic tile (grey) oriented above the aeration channel.

ASSESSMENT OF COINFECTION WITH *Flavobacterium covae* AND CHANNEL CATFISH VIRUS IN CHANNEL CATFISH *Ictalurus punctatus* FINGERLINGS

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In U.S. channel catfish (*Ictalurus punctatus*) production, bacterial pathogens such as *Edwardsiella ictaluri*, *Aeromonas hydrophila*, and columnaris-causing bacteria (*Flavobacterium* spp.) are primarily responsible for disease within production ponds. Further, channel catfish virus (CCV) has also played a role in production mortality and mainly impacts fry and fingerling production. In a pond-rearing environment, catfish are simultaneously exposed to multiple aquatic pathogens, and issues with water quality and stress can influence pathogen and host dynamics. Pathogen coinfections may increase the severity of the constituent pathogens and elevate mortality, thus potentiating economic losses for U.S. producers. A recent study assessed and characterized the effects of bacterial and viral coinfection in juvenile channel catfish. Single infections of *F. covae* (ALG-00-530) and CCV (2013-CCV-DRB), alongside a mixed treatment group, were incorporated into the experimental design.

With respect to experimental treatment groups, the single virulent *F. covae* infection (immersed in a final concentration of 3.05 x 10^5 CFU mL^{-1}; 30 mL of inoculum in 10L of rearing water) resulted in a total cumulative percent mortality (CPM) of 21.3 ± 6.7 %. The CCV group (immersed in 10 L of rearing water with 6 mL of a 1.05 x 10^8 PFU mL^{-1} viral stock added) was 77.0 ± 9.2 %. A coinfection half-dose combination (15 mL of *F. covae* and 3 mL of CCV in 10 L of rearing water) of each pathogen demonstrated pronounced mortality (100.0 ± 0.0 %) over 13 days following the initial challenge.

Trial results indicate changes in both catfish mortality levels and trends from simultaneous exposure to multiple pathogens. A further understanding of the channel catfish immune response via transcriptomic analyses may also elucidate host factors involved in mixed infection exposures. Reducing disease outbreaks in catfish farming is critical to enhancing production yields and quality products, and comprehending infection dynamics of pathogens coinfections will provide more insight into targeted control measures for catfish health.

PHOTOSYNTHESIS IN ENHANCED CATFISH PRODUCTION SYSTEMS

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Efforts at Clemson University (from 1990-2001) focused on intensification of fish culture and reduction in water discharge by enhancing algal photosynthesis in a "high-rate algal pond' combined with raceway fish culture in a technique entitled the Partitioned Aquaculture System (PAS). Work at Clemson in the earliest 1/40-acre prototype PAS units suggested maximum algal productivity of 9.9 gm-C/m^2-day at 0.65 m water depth and water velocity of 0.29 ft/sec (12.5 cm/s), with average algal density of 66 mg/l. At a water velocity of 0.072 ft/sec algal productivity averaged 6.5 gm-C/m^2-day at an algal density of 48 mg/l. One third acre and 2.0-acre PAS prototypes used slowly rotating paddlewheels to circulate water through shallow (1.5 ft) channelized ponds (95% of area), increasing algal photosynthesis and enhancing treatment rate of nitrogenous waste (NH3). Catfish were confined to 5% of the total area in high-density raceways (6.0 lb/ft^3) at mixing/aeration energy of 4.5 hp/acre. At that time, conventional catfish ponds (CP) were utilizing 100% of pond volume/area for fish culture at aeration energy of 2.0 hp/acre. The Split-Pond (SP), developed at the National Warm-water Aquaculture Center (NWAC) beginning in 2002, represented a lower cost adaptation of Clemson's PAS. Prototype SPs at NWAC range in size from 5.0-7.0 acres utilizing 5.7-7.0 hp/acre mixing/aeration, with fish culture confined to 20-25% of surface area with 75-80% devoted to waste treatment. NWAC also reported on evaluation of prototype 2.0-4.0 acre, intensively aerated catfish ponds (IP) utilizing 100% of pond volume for fish culture at elevated aeration energy levels of 6.5-7.9 hp/acre.

A performance analysis of prototype CP, SP and IP and PAS units suggested fish carrying capacity in CP of 5,000-7,500 lb/acre, PAS at 15,000-18,000 lb/acre, SP at 12,330-19,000 lb/acre and IP at 9,200-18,245 lb/acre. Average/maximum sustained feed loading was 100/150 lb/acre-day for CP, 160/250 for PAS, 110/280 for SP, and 84/270 for IP. The PAS, SP and IP are all highly photosynthetic systems however, the PAS provides the highest degree of net photosynthesis and ammonia removal. Average daily photosynthesis in the PAS was projected at 5.9 gm-C/m^2 with 4.6 in the SP, 5.1 in the IP and 1.0 in the CP. Maximum photosynthesis in the PAS (fully loaded) at 250 lb feed/acre-day) was projected at 8.2 gm-C/m^2-day (81% of small PAS units). The PAS aggressively re-mineralizes settled algal biomass, in which the released nutrients are recaptured as additional algal biomass. The SP aggressively removes algal biomass (via sedimentation in the waste treatment zone, WTZ) and promotes nitrification and denitrification in a WTZ anoxic layer. The IP provides a higher degree of settled algal storage in the sediment. Consequently, the IP is more subject to sporadic release of sediment ammonia driven by climatic changes, whereas the PAS and SP provide more consistent operator control of oxygen and nitrogen flux.

The PAS was designed to provide maximum nitrogen treatment via enhanced algal photosynthesis. Capital costs for PAS are similar to in-pond raceways at $22,630/acre with a breakeven catfish production cost of $1.32/lb. In contrast, SP capital cost is projected at $6,904/acre with BEC of $0.92/lb and IP at $8,380/acre with BEC of $0.93/lb. The SP provides 78% of the net photosynthetic capability of the PAS at 70% of the production cost/lb. The IP provides 87% of the net photosynthesis at 69% of the production cost/lb. The IP requires minimal modification of existing ponds, the major cost being addition/maintenance of aerators. The SP requires substantial modification of existing ponds, but provides more consistent/reliable treatment of ammonia nitrogen. In addition, SP provide advantages in fish feeding/harvesting and predator control. Fish farmers have reported excessive accumulation of ammonia (3-6 ppm) in IP, particularly during winter months.

Max Oxygen Flux (lb/acre-day)

	Gross-Phot	Resp	Net-Phot	%Res	% Fish
PAS	+240	-60	+180	25%	120%
SP	+270	-130	+140	52%	78%
IP	+314	-157	+157	50%	66%
CP	+72	-40	+32	56%	64%

Max Nitrogen Flux (lb/acre-day)

	Feed	Recycle	Phot	Nitrify
PAS	+6.1	+5.8	-11.9	0
SP	+5.0	+3.7	-8.7	20%
IP	+6.9	+3.6	-10.5	0
CP	+2.2	+0.5	-2.2	0

TANK CULTURE OF YELLOWFIN TUNA *Thunnus albacares*: REFLECTING ON 27 YEARS OF BROODSTOCK MANAGEMENT AND SUSTAINED YEAR-ROUND SPAWNING FOR RESEARCH PURPOSES

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In 1996, the Inter-American Tropical Tuna Commission (IATTC) stocked its first yellowfin tuna (YFT) *Thunnus albacares* broodstock fish in a semi-recirculated concrete tank (17 m diam x 6 m depth, 1,362 m^3 volume) at the Achotines Laboratory, Republic of Panama. Today, after 27 years and more than 5,800 natural spawning events, we summarize the broodstock management, reproductive biology, and spawning profile observed during these years.

YFT were captured off the coast of the Peninsula de Azuero, in the Panama Bight, at an average size of 59 cm fork length (FL) and transported to the Laboratory, where they were weighed, measured, and kept in quarantine tanks to conduct prophylactic treatments. Subsequently, the fish were held in tanks of 170 m^3 volume until reaching an average size of 74 cm FL and 8.8 kg in weight (WT), when they were transferred to the main broodstock tank (T1). Since 1996, a total of 236 fish became broodstock fish in the main tank, of which 50% were males, and 50% females. The average yearly relative mortality was 55%, and the main cause of death was wall strikes, followed by death by starvation and blindness. The average residence time in T1 was 1.4 years, and the fish with the longest residence time in captivity spent 5.8 years in T1 and had an estimated age of 7 years.

Broodstock was fed a diet of fresh fish (sardines) and squid at approximately 3–4% body weight per day, with a supplement of vitamin and mineral pre-mix. Estimated growth rates in FL ranged from approximately 12 to 68 cm $year^{-1}$, and in WT, ranged from approximately 9 to 46 kg $year^{-1}$.

From October 1996 to October 2023, a total of 1.87 billion eggs of yellowfin tuna were collected from T1, averaging 67 million eggs per year. Eggs were collected in 80% of the 328 analyzed months. Spawning occurred at water temperatures ranging from 23.3 to 29.7 °C and spawning generally ceased during the lower temperature ranges (< 24 °C), when coastal upwelling occurred from January through March. An analysis of the average egg production per mature female biomass per month was conducted, and the standardized egg production was compared with water quality parameters measured daily such as temperature, salinity, pH and dissolved oxygen, with a linear regression.

The yellowfin tuna broodstock program of the IATTC not only represents an important milestone for the management and conservation of the species, enabling research on the various aspects of early life history, but it also demonstrates feasibility towards the aquaculture development for commercial purposes.

STERILITY IS A FOUNDATIONAL TRAIT FOR THE COMMERCIALIZATION OF GENOME EDITING AND GENETIC BIOTECHNOLOGIES

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Aquaculture is growing to meet the needs of an increasing world population, and aquaculture genetics must move quickly to help producers meet the expectations of consumers and retailers. Genome Editing offers the opportunity to make targeted changes in the genome, introducing variation that will result in rapid and substantial improvements in performance, health and sustainability. To responsibly introduce fish which harness the power of genetic technologies such as Genome Editing into commercial production systems, the farmed fish should be sterile or otherwise contained. The ability to produce sterile progeny from broodstock for aquaculture also has significant benefits to productivity and environmental sustainability. We describe the development of a strategy to generate, breed and mass-produce sterile fish.

Our strategy for mass producing sterile fish is designed to produce monosex, sterile populations. We first investigated gene mutations in two evolutionarily conserved pathways, one governing sex differentiation and the other sexual competency. We created edits in genes necessary for spermiogenesis and steroid hormone synthesis causing male sterility and masculinization, respectively. Double gene edit combinations for these genes produced all-male sterile populations. Likewise, we created variants in genes whose inactivation caused females to develop arrested or string-like ovaries lacking oocytes. We further disrupted genes causing genetic males to develop as females. Double gene edit combinations for these genes produced all-female, sterile populations.

Propagation of the double KO lines was achieved via germ cell transplantation from a juvenile edited donor into a germ cell free wild-type recipient embryo. In the resulting recipients, the induced edits had no effect as the genes targeted are not expressed in germ cells. With this approach, we generated fertile broodstock that successfully mass-produced sterile, monosex populations. We expect that adoption of this technology will result in broad economic and environmental benefits for aquaculture, and as a foundation upon which to build additional genetic technologies.

HARNESSING EFFICIENT GENETIC IMPROVEMENT TO MAXIMIZE ECONOMIC RETURN

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Selective breeding is the process of improving one or more desirable traits of a cultured species through the selection of superior parents for the next generation. Phenotypes that can be selected directly such as growth are relatively easy to measure and select for in most breeding programs. Indirect or complex traits such as robustness or selecting for a combination of important traits is more complicated both to measure and to fit into a statistical broodstock selection model. In this talk we will briefly discuss the general concepts and common strategies for breeding program management, from the simplest requiring the least amount of investment to the more complex, requiring greater investment but delivering greater genetic gains across more traits. More importantly, we will illustrate the use of the phenotypes and genotypes for a breeding program and how the breeding strategy should be designed to maximize economic returns by balancing input costs with the expected genetic and economic gains for a commercial aquaculture producer.

In summary, there are multiple options for enhanced selective breeding program management, each requiring different inputs and investment with varying potential returns and gains. Key to the design of a genetic improvement program is the consideration of each program's breeding goals, size, and available budget along with selection of appropriate tools to support such a design. Tools under consideration range from relatively simple mass selection plans, through sophisticated genomic selection strategies, to incorporation of brand new technologies like genome editing.

iDENTIFICATION OF THE CRITICAL LOADING CONDITIONS ON AN OFFSHORE MUSSEL FARM PERTAINING TO RANDOMNESS AND RELATIVE DIRECTIONAL VARIABILITY OF WAVE AND CURRENTS

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Offshore aquaculture presents an engineering challenge and opportunity to meet the rising demand for seafood in the United States while ensuring long-term resource conservation [1]. The primary objective of our research is to conduct a comprehensive structural analysis of offshore mussel farm systems under the influence of random ocean dynamics that considers the effects of relative directional variability in addition to the magnitude of current and wave forces. The intent of this investigation is to focus on potential worst-case, current-wave combinations for the specification of critical components, including mooring lines, headlines, and the cultivated mussel droppers and flotation elements. Our methodology utilizes advanced numerical Finite Element Analysis (FEA) simulations [2], with environmental condition inputs based on extensive mussel farm engineering studies for offshore sites in New England. The outcome of our study has the potential to offer engineers and aquaculture practitioners valuable insights to the optimal orientation of a mussel farm in prevailing seas that are stochastic in nature.

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DEVELOPING TOOLS AND STRATEGIES FOR PREVENTION OF ATYPICAL FURUNCULOSIS IN SABLEFISH *Anoplopoma fimbria*

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Sablefish (black cod) represent a promising and high-value species for marine aquaculture in the US. Research efforts to optimize culture strategies and methods have been ongoing for more than 2 decades and this species is commercially produced using land-based RAS in combination with net-pen grow out in Canada. To set the stage for expanded production of farmed sablefish in the US, NOAA Fisheries has prioritized research projects and partnerships to address remaining challenges. One such challenge that affects production of this species is the disease furunculosis. This appears to be the primary disease threat for sablefish and is caused by an atypical strain(s) of *Aeromonas salmonicida*, a gram negative bacterium. Although antibiotic treatments exist and can reduce mortality once an outbreak occurs, disease prevention through vaccination would be more desirable and has been identified as a high-priority need within the industry. Projects that are ongoing focus on vaccination methods and strategies that have the potential to prevent furunculosis or minimize its impact during an outbreak. These vaccine projects will be discussed and include an oral vaccination study that assesses the potential for utilizing a simple killed *A. salmonicida* vaccine delivered orally via alginate/gelatin micro-particles to young fish as a way to minimize handling stress associated with injection vaccination. Another project that is underway is aimed at developing attenuated atypical *A. salmonicida* strains that could be administered via immersion during early juvenile stages. To create attenuated vaccine candidates, a known virulent strain of atypical *A. salmonicida* (T30) was passaged in culture on TSA media containing increasing concentrations of the antibiotics rifampicin and novobiocin. In addition, three putatively virulent atypical strains of *A. salmonicida* (recently isolated from infected sablefish showing clinical signs of furunculosis) were passed in a similar manner. The resistant isolates are being tested for attenuation against their respective 'parent' strains with the aim of determining if attenuated strains that are not pathogenic to sablefish were produced. If fully attenuated strains are confirmed, these strains would be considered potential vaccine candidates and their ability to elicit a protective immune response will be further assessed.

INVESTIGATING SEX DETERMINATION AND DIFFERENTIATION IN PACIFIC OYSTERS *Crassostrea gigas:* NEW APPROACHES AND APPLICATIONS

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Pacific oysters (*Crassostrea gigas*) are the most widely cultivated shellfish species in the world. In the US, *C. gigas* is one of the main commercial shellfish species with total landings in 2022 reaching over 5 million pounds and a total value of over 31 million dollars (NOAA Fisheries report 2022). Because of its high commercial value, *C. gigas* is currently the target of efforts dedicated to improving production and quality. Knowing the sex of individual oysters at the time of spawn is critical for crossing of animals in breeding programs.

While Pacific oysters are dioecious (females and males are separate individuals) they lack any secondary sex characteristics making the sexing of individuals a significant challenge. Critical for the development of efficient sexing tools and for strategies to develop non-fertile oysters is the understanding of genetic and environmental control of sex in the Pacific oyster. We are using next generation sequencing of DNA and RNA combined with high-throughput qPCR to identify early markers of sex determination and working in the development of rapid assays. Currently, a set of five markers show strong promise as tools for molecular sexing. An update on ongoing research and findings will be presented.

YELLOW TANG (*Zebrasoma flavescens*) AQUACULTURE: GOING FROM LAB SCALE SUCCESS TO COMMERCIAL SCALE PRODUCTION IN HAWAII

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Yellow Tang (Zebrasoma flavescens) was the most heavily collected reef species from Hawaii with nearly 300,000 fish being removed from reefs annually for the aquarium trade. Recent legislation in Hawaii has temporally suspended the collection of aquarium species, pending the acceptance of a recently completed, comprehensive environmental impact study. Therefore, this highly popular, and iconic, species will (at least for the foreseeable future) need to be obtained from aquacultured sources. In 2015, Oceanic Institute of Hawaii Pacific University (OI) was successful in overcoming the tremendous challenges culturing this important species. For the first time, the culture of Yellow Tang was shown to be technically possible, and this achievement provided significant hope that other reef species might also be able to be cultured using similar methods. Over the past several years, this has indeed been shown to be the case, with dozens of new species being cultured by facilities around the world owing in large part to the technical achievements (the barriers being broken down) by OI.

The recent successful culture of several coral reef species for the marine aquarium trade has sparked renewed excitement and enthusiasm for this alternative, and perhaps more sustainable, supply of marine ornamental organisms. However, despite these exciting successes, commercial adoption of production methods remains low due to the limited efficiency of current production methods (low numbers of juveniles being produced at relatively high costs compared to wild supplies). Current efforts at OI seeks to address these challenges by building upon prior successes and in collaboration with Biota Aquariums, LLC aims to significantly improve the yield of Yellow Tang production. Improving the yield (egg to juvenile) will have the most profound effect on lowering total cost of production thereby greatly improving commercialization potential for this, and likely other Acanthuridae, species.

This presentation will provide a synopsis of marine ornamental research activities (past and present) at OI and highlight the current state of commercialization potential for this species. Specifically, we will elaborate on the results from long-term support from the USDA Center for Tropical and subtropical Aquaculture over many decades, and the resulting partnership between private and public funding that made this achievement possible. We will also review the current mean production yield experienced after several years of commercial-scale culture effort and review opportunities for improved production for this, and other marine ornamental species in Hawaii.

PROMOTING HEALTHIER DIETS: ANALYZING THE EFFECTS OF SEAFOOD INCLUSION IN THE WIC PROGRAM

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Seafood contributes considerably to healthy diets and has been increasingly recognized for its contribution to global food security and nutrition. Besides their nutritional contribution, 90% of Americans do not consume the recommended amounts of seafood. In light of that, the 2020 dietary guidelines for Americans recommended that the U.S. population for all ages consume more seafood. This recommendation is accompanied by a policy design that added canned seafood to food packages for the Women, Infants, and Children's Supplemental Nutrition (WIC) program, which serves to safeguard the health of low-income pregnant, postpartum, and breastfeeding women, infants, and children up to age five who are at nutritional risk by providing nutritious foods to supplement diets. This article's first objective is to estimate the effect of belonging to the WIC program on seafood purchases. To do this, we used HomeScan Nielsen Consumer panel data for the U.S., which provides information on households' food purchases, demographics, and self-reported WIC participation status. Our results on the effect of WIC participation on seafood purchases indicate that eligible people using the program increase their seafood purchases by about 22%. Our second objective is to analyze how the policy of adding seafood to the WIC program influences their seafood purchase trends. Given the previous results, we expected that canned seafood purchases would increase in the targeted group. Although making dietary changes is difficult because habits are highly persistent, our results are in line with the literature in two contributions. The first is that updates to the WIC program have reflected increased purchases of the target products, which is in line with the Dietary Guidelines for Americans. The second implication is that focusing efforts on small changes can deliver better results toward the transition to a healthier diet for vulnerable groups.

CHARACTERIZATION OF WILD AND SELECTIVELY BRED OYSTERS IN SOUTHERN NEW ENGLAND

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Farming of eastern oysters (*Crassostrea virginica*) is an important industry for meeting consumer demand for shellfish. Unfortunately slow growth and disease related mortality have been a challenge for growers. In response, various selectively bred lines of oysters have been created for farmers. Unfortunately these lines do not perform as well in diverse locations due to genotype by environment interactions. Selective breeding on native New England oysters has been proposed as an alternative for farmers in this region. The goal of this project is to characterize the potential wild populations of oysters for a breeding program based on genetics and performance in New England. Oysters from two wild populations in Rhode Island (GH and NR), one population in Connecticut (CT) and one population in Massachusetts (MV) and two commonly used commercial lines (CL1 and CL2) were collected, genotyped and spawned. The genotypes of the broodstock were used to evaluate genetic diversity and genetic differentiation between populations. The progeny of these oysters were grown at a site in Rhode Island over a 15 month growing period. Growth and survival were measured (55 oysters x 3 bags per stock) from July 2021 to October 2022 and then processed for disease testing and genotyping. To investigate the impact of grow-out sites on stock performance, lineages CL1, CL2, MV and GH were grown at two additional sites in Rhode Island from July 2022 to October 2023. For the stocks grown during the 2021-2022 growing period we saw significant differences in percent mortality ranging from 7.9% for CT to 81.9% for NR. These stocks also had significantly different harvest sizes with an average oyster size of 48 mm (SD=8) for NR and an average oyster size of 79 mm (SD=13) for CL2. Disease intensity also varied between lines with an average dermo intensity of 1.5 for CL2 and an average dermo intensity of 3.9 for CL1. At all sites and for both growing periods, MV had smaller size while the commercial lines grew much larger. In terms of survival however, there were differences between lines relative to one another with GH having relatively high survival at two of the sites and a relatively low survival at one site. For the genotyped broodstock (2021 year class), pairwise Fst values ranged from 0.007 to 0.048 while Fis values ranged from -0.036 to 0.142. This shows that wild lineages are affected by genotype by environment interactions that affect their performance. This suggests that the incorporation of multiple wild populations will be needed for establishing a breeding program. However, because of low pairwise Fst between populations it is not necessary to include all of them.

EFFECT OF ORGANIC ACIDS AND ESSENTIAL OILS IN GROWTH AND GENE EXPRESSION HYBRID STRIPED BASS

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Two prominent feed additives, organic acids (OA) and phytogenic compounds (essential oils or EO), are emerging as potential antimicrobial agents, although their modes of action vary based on bacterial type. While organic acids are recognized for their potential in enhancing nutrient utilization and antimicrobial properties across several animal industries, including aquaculture, essential oils are complex mixtures of volatile compounds known for their antioxidant, anti-inflammatory, and antimicrobial activities. A 12-week study, 15 g hybrid striped bass (HSB) were fed to apparent satiation with diets incorporating organic acids (sodium butyrate and sodium diformate), essential oils (carvacrol, thymol, allicin, and cinnamaldehyde), or a combined OA and EO formulation. The study aimed to assess the effects of these additives on HSB growth performance and health indices. Essential oil supplementation led to greater weight gains in fish compared to organic acid supplementation. However, health parameters, including hepatosomatic index (HSI) and intraperitoneal fat (IPF), showed variable outcomes. Analyses on SOD activity, glucose, lactate, and TBARS revealed no significant variations in glucose, lactate, and SOD activity across treatments. However, significant differences in TBARS were observed in the essential oil blend and the organic acid blend. For the gene expression. Intestinal *HSP70* was upregulated for allicin but downregulated in all treatments in the liver. *MetA* was upregulated in all intestinal treatments and specifically by cinnamaldehyde in the liver; all other treatments were downregulated. *TGFβ* was downregulated in all treatments except for cinnamaldehyde in the intestine. *CYP1A1* was upregulated by cinnamaldehyde in the intestine and upregulated in the liver across treatments.

Table 1. Performance measures of hybrid striped bass fed with diets containing essential oils or organic acids over 12 weeks

Treatment	Final Weight	Hepatosomatic Index (HSI)	Intraperitoneal Fat (IPF)
Control	78.93 ± 6.00^{d}	4.26 ± 0.14^{a}	6.18 ± 0.35^{cd}
Allicin	108.02 ± 7.09^{bcd}	3.30 ± 0.13^{ab}	6.42 ± 0.28^{bcd}
Carvacrol	133.97 ± 8.27^{ab}	3.14 ± 0.13^{b}	7.54 ± 0.38^{a}
Cinnamaldehyde	108.74 ± 8.31^{bcd}	3.66 ± 0.14^{ab}	6.35 ± 0.37^{bcd}
Thymol	113.57 ± 10.68^{abc}	3.31 ± 0.07^{ab}	6.81 ± 0.23^{abc}
EO Blend	115.21 ± 6.69^{abc}	2.99 ± 0.13^{b}	6.53 ± 0.30^{bcd}
Sodium Butyrate	95.81 ± 7.43^{cd}	3.56 ± 0.24^{ab}	6.47 ± 0.34^{bcd}
Sodium Diformate	98.35 ± 9.38^{cd}	3.20 ± 0.20^{b}	6.41 ± 0.23^{bcd}
OA Blend	94.20 ± 10.16^{cd}	3.64 ± 0.10^{ab}	5.94 ± 0.28^{d}
OA/EO Blend	144.61 ± 7.27^{a}	3.21 ± 0.09^{b}	7.10 ± 0.22^{ab}

THE EFFECTS OF MARINE RECIRCULATING AQUACULTURE SYSTEM EFFLUENT EXCHANGE RATE ON NUTRIENT UTILIZATION BY *Salicornia virginica* IN A PILOT SCALE INTEGRATED MULTI-TROPHIC AQUACULTURE SYSTEM

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The Recirculating Aquaculture System (RAS) technology in North Carolina has potential economic benefits for producing market-stage fish for regional markets as well as supplying fingerlings to offshore cage culture operations in the U.S. However, the discharge of effluent from RAS, rich in nutrients, poses environmental risks. Integrated Multi-Trophic Aquaculture (IMTA) can mitigate these risks by balancing marine finfish culture with a salt-tolerant plant, *Salicornia virginica*, which can remove nutrients from the effluent and be used as a valuable crop for humans, livestock, fish, and as a seed oil source. The research aims to optimize production of *S. virginica* in a RAS-Geotube-Salicornia IMTA system at a pilot commercial scale and to evaluate nutrient and water mass balance relationships. The goal is to develop an uncomplicated, low-maintenance, and cost-effective system for RAS waste management with implications for the siting and the economics of operating intensive mariculture facilities in NC and other areas of the US.

An experiment was conducted to investigate the effects of water exchange rate on nutrient removal and plant yield of *S. virginica* grown in grow beds receiving effluent from a marine RAS (34-m3) producing black sea bass *Centropristis striata*. Effluent was clarified using geotextile fabric bag (Geotube) and filtered with an additional 25 um bag filter before application to the experimental system growing *S. virginica*. The experimental system consisted of twelve 200 L rectangular tanks (grow beds, 92 cm l x 92 cm w x 28 cm depth) operated at a volume of 150 L and a depth of 18 cm (deep-water culture system). Each grow bed contained twelve 50 mm grow cups containing expanded clay media and supported by a polystyrene foam base. *S. virginica* (grown from seed) were planted in each grow cup at a mean fresh weight of 117.8 ± 7.14 g. To study the effects of water exchange in the grow beds on plant growth and nutrient removal, two treatment exchange rates were compared; low exchange (100%/d, 150 L/d) and high exchange (300%/day, 450 L/d). Grow beds without plants were also maintained at a low exchange (100%/d, 150 L/d) as a control treatment. Four replicate grow beds were maintained per treatment. Influent and effluent water from the grow beds were collected every 21 days and analyzed for nitrogen and phosphorus concentration to evaluate nutrient removal efficiency. Plant biomass in each grow cup was taken at the beginning and the end of the experiment. Results on plant yields and nutrient concentrations and removal rates after 135 days of study under each treatment and recommendations for scale-up to a pilot commercial scale system will be presented.

The initial nutrient sample (d8) showed significant differences in nutrient removal efficiency. The nitrate removal efficiency was highest in the Low treatment (36.4 ± 1.66%) compared to the High treatment (10.6 ± 0.45%) and the Control (7.39 ± 1.39%). Phosphorus removal was higher in the Low treatment (12.74 ± 1.4%) than the Control (7.50 ± 0.91%) which was higher than the High treatment (1.80 ± 1.04%). The nitrate (initial = 19.3 mg/l) and phosphorus (initial = 5.83 mg/l) concentration in the Low treatment were reduced to 12.3 ± 0.32 mg/l and 5.06 ± 0.08 mg/l, High treatment to 17.3 ± 0.09 mg/l and 5.73 ± 0.06 mg/l, and the Control to 17.9 ± 0.37 mg/l and 5.39 ± 0.05 mg/l, respectively.

IS THE CURRENT CHILEAN LEGAL FRAMEWORK CONDUCIVE TO OFFSHORE AQUACULTURE EXPANSION?

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Since 2018, the Chilean government, through its economic development agency CORFO, has provided funding for two significant projects aimed at developing the technology required to enable Offshore Aquaculture. One of these projects, led by the company EcoSea Farming in collaboration with Universidad Andres Bello, has conducted a review of the existing legal framework to assess whether modifications are necessary to permit new aquaculture licenses in the Territorial Sea (TS), Contiguous Zone (CZ), and the Exclusive Economic Zone (EEZ) in Chile's ocean.

The current legal framework in Chile does not provide a specific definition of Offshore Aquaculture. However, various concepts have been proposed to describe the conditions under which this activity could take place. The General Fisheries and Aquaculture Law (LGPA), also known as Law No. 18,892, governs aquaculture within its Title VI "Aquaculture." It establishes the legal provisions for the development of aquaculture activities, including matters concerning concession titles issued for the practice of this activity on national public-use properties.

Figure 1 illustrates the process of acquiring an aquaculture concession in Chile, which primarily involves four institutions. The ultimate granting authority resides in the Undersecretary of Armed Forces (UAF). The UAF's jurisdiction is confined to the Territorial Sea (TS). Additionally, Executive Resolution No. 7181, dated August 10, 2015, designates five-mile sea bands for artisanal fishing purposes. Currently, all aquaculture concessions are situated within the first nautical mile, although the UAF has the discretion to allocate concessions within five nautical miles. To mitigate the impact on artisanal fishing, it will be advantageous to allocate concessions beyond the initial five-mile zone. Therefore, it is recommended that offshore aquaculture operations be conducted in Chilean maritime areas within the Territorial Sea, extending up to 12 nautical miles westward from the coastline, without necessitating modifications to the existing legal framework.

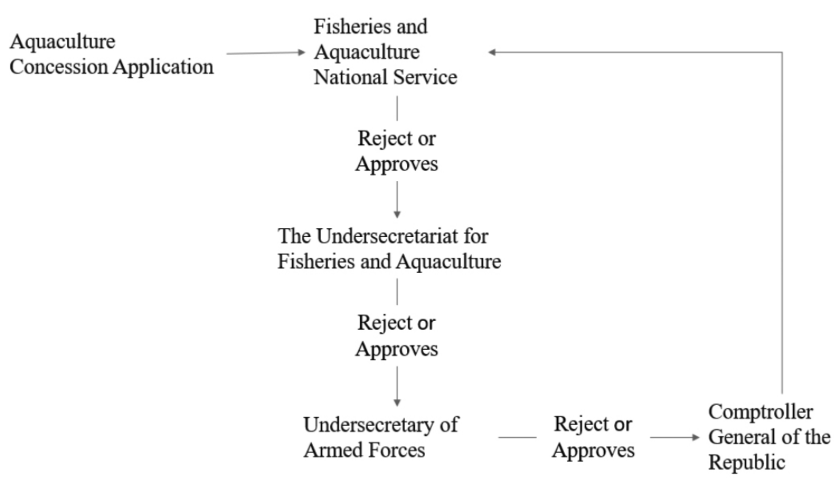

Figure 1: Current process to obtain an aquaculture concession.

THE RACE FOR OFFSHORE AQUACULTURE DEVELOPMENT: THE EXPERIENCES OF NORWAY, CHILE, NEW ZEALAND, AUSTRALIA, AND THE UNITED STATES

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Salmon farming is one of the most recognizable and controversial forms of aquaculture. However, according to the 2022 report on the State of Fisheries and Aquaculture of the Food and Agriculture Organization of the United Nations, salmon farming represents only 4% of the major aquaculture finfish species produced worldwide. Norway, Chile, Scotland, and Canada are the leading producers in the industry.

Despite the industry's development in these four countries, the rapid growth of salmon aquaculture has faced environmental issues and negative perceptions, which have hindered its expansion. To mitigate the impact on coastal environments, several countries, including Chile and Norway, have explored the development of a new framework to facilitate offshore aquaculture. This research reviewed the processes in five countries—Norway, Chile, New Zealand, Australia, and the United States—in their efforts to permit offshore aquaculture in their oceans.

Table 1 presents the results of this research. Norway has made significant efforts to advance offshore aquaculture, approving modifications to its legal framework to facilitate the issuance of new 'offshore' licenses. Chile has been developing technology and exploring its ocean for suitable Aquaculture Opportunity Areas, but they still need to establish a new legal framework. New Zealand, Australia, and the United States have also made progress in enabling offshore aquaculture, including the development of technology, identification of suitable areas in offshore conditions, and engaging relevant stakeholders in discussions about offshore aquaculture.

TABLE 1: Summary of the most relevant milestones to allowed Offshore Aquaculture.

	Norway	Chile	New Zealand	Australia	United States
Definition of offshore aquaculture in its legal framework	A	I	A	A	I
Determination of oceanic area for research	A	W	A	A	A
Study of satellite information	A	A	W	W	A
Procedures for issuing offshore aquaculture License	A	W	A	W	I
Development of offshore technology	A	A	A	A	A
In situ oceanographic study	I	I	A	W	A
Socialization with relevant offshore aquaculture stakeholders	A	W	A	A	A

A: Affirmative, I: In Process, W: Without information

GROWTH OF THE MACROALGA *Ulva lactuca* CULTIVATED IN DIFFERENT BIOFLOC STRATEGIES IN AN INTEGRATED SYSTEM

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Different fertilizations will favor the predominance of different groups of bacteria in the biofloc system, and can affects the cost, management and the performance of the organisms. The aim of this work is to evaluate the growth of the macroalga *Ulva lactuca* when cultivated in an integrated system with shrimp *Penaeus vannamei* and fish *Oreochromis niloticus* using a chemoautotrophic system and a mixed system.

The experiment was carried out in an agricultural greenhouse with constant aeration and lasted 56 days. Two treatments was used with three replicates each: Chemoautotrophic system: system with prior fertilization (35 days before stocking the animals) with ammonium chloride and sodium nitrite to reach a concentration of 1 mg L^{-1} in the water; and Mixed system: use of an inoculum (40%) of biofloc from an growout shrimp farm. Each treatment had three systems, each consisting of a 4 m^3 tank where the shrimp were kept (350 shrimp m^{-2}). The water circulated by gravity to a 0.7 m^3 tank with fish (7 fish m^{-3}). The water from the fish tank was pumped into the 0.35 m^3 macroalgae tank (0.1 g m^{-3}) and returned by gravity to the shrimp tanks. The macroalgae was kept inside the tank using a circular structure with a diameter of 0.60 m near the surface. The initial weight of the macroalgae was 502.7 ±0.50 g, and every 20 days the macroalgae were removed from the tank and weighed. The biomass produced was removed and the initial weight of the macroalgae was maintained. Nutrient and solids analyses were carried out twice a week.

There was no significant difference ($p \geq 0.05$) between the treatments in the average biomass gain (Table 1). However, there was greater specific growth of the macroalgae on day 56 in the Chemoautotrophic treatment compared to the Mixed system. Significant differences were found between treatments in ammonia, nitrite and total suspended solids (TSS).

The reuse of water from an shrimp cultivation provided greater stability, showing low concentrations of ammonia and nitrite, similar to that found by Ferreira et al (2021). The greater growth of the macroalgae in the last weighing in the chemoautotrophic system may be due to a lower concentration of total suspended solids, allowing more light to enter (Carvalho et al. 2023).

Growing the macroalgae in a mixed system proved to be viable due to its biomass production over the course of cultivation and greater control of nitrogen. In addition to being a system that reuses water from an existing crop, it is also more economical and sustainable.

GROWTH AND NUTRIENT ABSORPTION BY THE MACROALGA *Ulva lactuca* IN BIOFLOC EFFLUENT

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Only 22% of the nitrogen introduced into the system is converted into biomass, much of which is discarded into the environment (Silva et al. 2003). As a way of treating effluent, macroalgae can be added to take advantage of the nutrients and produce biomass. However, different types of biofloc can affect the organism's performance. The aim of this study was to evaluate the growth and absorption of nutrients by the macroalga *Ulva lactuca* in two biofloc systems: chemoautotrophic and mixed/mature.

The experiment was carried out in an agricultural greenhouse with constant aeration and lasted 15 days. After 56 days of cultivation in an integrated system, the animals were harvested and the effluent from the cultivation was directed into 6 tanks with a useful volume of 3.5 m^3. The macroalgae were stocked in each tank at a density of 1g m^3 and an initial weight of 3.52±0.15 kg. Two biofloc strategies were used, the chemoautotrophic system presented 25.0±0.0, 2.43±0.21 and 131.7±79.7 mg L^{-1} at the end of cultivation. And the mature/mixed system showed 32.3±2.0, 2.17±0.35 and 346.7±115.6 mg L^{-1} at the end of cultivation, resulting in two treatments (Chemoautotrophic and Mixed) with three replicates each. The macroalgae was kept in the tank using a rectangular structure measuring 1x1x0.3 (length x width x depth). At the end of the 15 days, the macroalgae were weighed after removing excess moisture. Nutrients were analyzed three times a week and total suspended solids were analyzed at the end of the experiment.

As a result, the nitrate removal rate was significantly different ($p \leq 0.05$) between the treatments, showing that in the mixed treatment there was greater absorption of nitrate by the macroalgae. And in total suspended solids there was a higher concentration in the mixed treatment (Table 1).

The greater absorption of nitrate in the mixed treatment is probably due to the N:P ratio which was closer to the ideal for macroalgae in this treatment, 30:1 being the ideal ratio according to Duke et al (1995). The increase in phosphate concentration in both treatments is due to the decomposition of the floc and the release of phosphorus (Silva et al. 2013). The absence of an organism to move the flake led to a decrease in the concentration of solids in the experiment, even with aeration, and thus to its decomposition.

Growing the macroalgae in a mixed biofloc system as an effluent treatment resulted in greater nitrate absorption, as well as biomass production.

Table 1. Performance of macroalgae and water quality in the chemoautotrophic and mature/mixed treatments.

	Chemoautotrophic system	**Mixed system**
Biomass gain (kg – FW)	2.46 ± 0.13	2.95 ± 1.03
RGR (% dia $^{-1}$)	3.53 ± 0.15	3.99 ± 1.12
Removal rate nitrate (%)	14.67 ± 7.25 b	28.02 ± 10.71 a
Removal rate phosphate (%)	-68.21 ± 43.54	-62.48 ± 23.47
TSS (mg L^{-1})	127.50 ± 57.52 a	280.00 ± 68.25 b

RGR; relative growth rate; TSS total suspended solids; Different letters show a significant difference after Student's t-test.

SPAWNING AN AQUACULTURE PROGRAM FOR PUBLIC AQUARIUMS

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Approximately 25% of marine species utilize coral reef habitats throughout their lifetime. Reef fisheries' have an estimated commercial and recreational value of $200 million annually in the U.S. alone. It is predicted that 70% of coral reefs will be lost worldwide in the next 40 years without proper management. The decrease of marine fish populations is one of the many contributing factors leading to the demise of living coral reef habitats, 30% of which are already in critical condition. An estimated 90% of marine ornamental fish in public and home aquariums are obtained from wild sources. Larval culture is an attractive alternative to wild capture in that it reduces the stress and mortality that occurs from transportation, acclimation, and disease. A unified effort to identify and catalog fish eggs collected from natural spawning events in public aquaria has led to many of the recent developments in successful rearing of ornamental fish eggs and larvae. Public aquariums can continue to contribute to conservation efforts and to the reduction of wild-caught fish in the future by committing to purchase tank-reared fish and growing their own.

This study discusses the current problems with the marine aquarium trade and explores ways to advance sustainable and economic aquaculture through the public aquariums. A literature review was conducted to answer questions such as the roles of public aquariums in conservation, the expenses associated with small-scale larval culture research, the projected impacts of aquaculture on wild fish populations, and how to increase public awareness on the benefits of aquaculture. Modelling accomplished aquaculture ventures, such as those with food fish, sports fisheries, other aquarium programs, and commercial ornamental productions, will ensure that the costs of producing marine ornamentals will be offset by the rewards.

Public aquariums have been paramount in helping people to understand how they can directly contribute to conservation efforts today. The Texas State Aquarium sees as many as 625,000 visitors annually, reaching an additional 60,000 people through educational outreach programs each year. Although only 20% of marine ornamental fish in the aquarium trade are sold to public aquariums, there is a unique opportunity to disseminate information and products to households, which comprise up to 70% of the ornamental fish market. In-house rearing can reinforce sustainable practices by reiterating the importance of wild reef habitats, highlighting fish lifecycles throughout exhibits, and potentially making tank-bred ornamentals available to the residential market.

CHARACTERIZATION OF MONOSEX COBIA *Rachycentron canadum* GROWTH AND YIELD FOR COMMERCIAL AQUACULTURE

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Cobia, *Rachycentron canadum*, is a fast-growing marine fish species with great potential for the commercial aquaculture industry; previous studies indicated sexual dimorphism, with females reported to grow faster/bigger than males. This study, conducted by Open Blue's R&D department and partly funded by SENACYT (Panama government science & technology secretary), focuses as primary objective on characterizing the growth performance and finished product yield of monosex Cobia (Rachycentron canadum) in a commercial aquaculture impact setting.

The study involved a 12-month controlled trial in which Cobia was raised under standardized culture conditions. PCR was employed for precise sex determination, followed by the division of groups into triplicate tanks with all-female, all-male, and 50/50 mixed populations.

Subsequently, a 15-day acclimation phase was implemented, and tanks were subjected to routine sampling every four weeks, commencing at an initial average body weight (ABW) of 493.7g, and continuing until they reached the target harvest size range for cobia (3-4kg ABW). Data on average body weight (ABW), FCR, and SGR were calculated following sampling at regular intervals, and finished product yield, including fillet quality and quantity, was evaluated.

Results indicated significant differences in ABW, FCR, and SGR between female monosex, and male monosex Cobia, favoring females, starting from the fifth month (2.13kg vs 1.86kg). These differences were maintained over time and were accentuated upon reaching the ninth month, showing significant differences between all groups at the end of the trial (3.94kg all-females, 3.49kg mixed group, 2.86kg all-males).

Female monosex Cobia exhibited improved growth rates and feed efficiency, suggesting cost-effective aquaculture potential.

In conclusion, this study demonstrates an enhanced growth in monosex all-female Cobia groups and suggest high-impact cost reduction benefits associated to all-female monosex Cobia in commercial aquaculture.

TABLE 1. Results overview.

Attribute	Females	Mixed	Males
Initial ABW	517g ^{a}	481g ^{a}	481g ^{a}
bFCR	4.75 ^{a}	5.41 ^{b}	9.66 ^{c}
Final ABW	3945g ^{a}	3494g ^{b}	2857g ^{c}
Fillet yield	34.82% ^{a}	35.81% ^{a}	34.49% ^{a}

Source: Open Blue R&D Laboratory, 2023.

DEVELOPMENT OF OVARIAN FLUID METABOLOMIC ANALYSIS FOR REPRODUCTIVE BIOMARKER DISCOVERY IN ATLANTIC SALMON

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Atlantic salmon aquaculture production has seen declines of more than 35% in the past two decades due, in part, to decreased embryo survival rates. In response to a need for the rapid assessment of brookstock reproductive performance, NIST is developing new broodstock quality assessment tools for aquaculture managers based on metabolite markers from salmon biofluids. The utilization of Nuclear Magnetic Resonance (NMR)-based metabolomics for the identification of small metabolites in organismal tissues and biofluids has proven to be a powerful and sensitive molecular technology for biomarker discovery. Changes in fish reproductive function are reflected in metabolic changes to sustain this energy-demanding process in different stages of gonadal development or growth. These changes alter the biochemical composition of biofluids. Metabolomic profiles of mucus, ovarian fluid and plasma of high- and low-yield broodstock are being assessed using NMR metabolomics to identify biomarkers of broodstock reproductive performance. Among different biofluids, ovarian fluid plays a crucial role in the preservation of egg viability and in promoting fertilization, thus providing a promising biological matrix for the identification of putative biomarkers of reproductive success in female broodstock.

Currently, the processing of fish ovarian fluid for NMR-based metabolomic analysis has yet to be investigated. Therefore, we evaluated the performance of four ovarian fluid preparation methods 1) methanol precipitation, 2) ultrafiltration, 3) lyophilization, 4) dilution, in terms of spectral reproducibility, NMR spectral quality, and signal-to-noise ratio. Additionally, the effects of blood contamination on the metabolite profiles were assessed by comparing two distinct pools of ovarian fluid with different degrees of suspected hemolysis (low vs. high). In collaboration with University of Maine and USDA, ovarian fluid was collected from broodstock female Atlantic salmon at the USDA-ARS National Cold Water Marine Aquaculture Center (NCWMAC) in Franklin, ME. Polar metabolites across the different methods were analyzed by NMR spectroscopy at the NIST laboratories at Hollings Marine Laboratory in Charleston, SC.

Our results show that ultrafiltration allowed efficient removal of macromolecules from the samples with significant improvement in overall spectral quality. The addition of a concentration step to the ultrafiltration protocol provided enhanced signal-to-noise ratio. Additionally, the degree of hemolysis of samples could confound the analysis for reproductive quality, as we observed significant differences in metabolite profiles of high and low hemolysis: thus, sample hemolysis should be carefully evaluated prior to conducting metabolomic analysis of ovarian fluid samples. The identification of putative biomarkers of reproductive success in broodstock Atlantic salmon will be used for the development of on-site screening tools for farm managers to guide the selection of the best fish to use for breeding, while providing new insights into biochemical factors underlying reproductive performance, and could improve the economic viability of the Atlantic salmon aquaculture industry.

THE IMPACT OF ECOLOGICAL DISTURBANCES ON LOW MOBILITY SEAFOOD INDUSTRIES: A STUDY OF STONE CRAB AND OYSTER AQUACULTURE IN THE FACE OF HARMFUL ALGAL BLOOMS

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This research investigates the causal effects of ecological disturbances, particularly Harmful Algal Blooms (HABs), on low-mobility fisheries and aquaculture sectors, specifically focusing on Florida's stone crab and oyster industries. Employing the Causal Forest algorithm, we analyze the complex dynamics within Coupled Human-Natural Systems (CHANS) and how these disturbances affect stone crab fisheries and oyster aquaculture.

Our study examines the impact of HABs on the stone crab fishery along Florida's West Coast, which accounts for 96.3% of the state's stone crab landings and contributes significantly to the economy with an annual impact of $27.8 million.

We use a machine learning approach to elucidate the impact of HAB on these seafood industries, namely, Causal Forest. This model-agnostic approach recursively partitions the data based on observed covariates, constructing subgroups where the differences in causal effects are maximal. This approach is adept at capturing the complex interactions among multidimensional variables and their respective nonlinear relationships typical in coupled human-nature systems (CHANS). Thus, our analysis emphasizes the differential effects of EDs on resource users tied to low-mobility operations.

Additionally, our research involves a comparative analysis of the stone crab fishery and oyster farming, industries that, while similar in their low mobility nature, operate under different regulatory frameworks. The stone crab industry faces seasonal closures, whereas oyster farming benefits from year-round production policies. This distinction provides a valuable perspective to assess the impact of regulatory differences on resilience and adaptability in the face of ecological challenges.

Our comprehensive analysis aims to shed light on how these varying regulatory environments influence the sustainability and resilience of low-mobility aquaculture and fisheries. The insights from this study are critical in formulating informed policies and management strategies that mitigate the immediate effects of environmental disruptions and enhance the long-term viability of these sectors amid changing ecological conditions.

GLOBAL WARMING AND NANOPLASTIC TOXICITY

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Plastics have low density, longevity, excellent barrier properties and relatively low cost, due to these features they are ideal materials for a wide range of manufacturing and packaging applications. According to records, a continuously increasing global annual production of plastics have around 300 million t and this total continues to grow at about 4 % per year. Due to the chemically linked by weak secondary bonds or by physical interaction of polymers, eventually, nano-sized particles from any size of the plastic would spread to the transient environment. The worrying part is that 'smaller particles are generally more toxic than the corresponding bulk material at the same mass concentration'. On the other hand, increasing nanoplastics (NPs) pollution may lead to unknown environmental risks when considered together with climate change, which has the potential to become an increasingly important environmental issue in the coming decades.

In vivo studies have shown that nano-sized plastic exposure has resulted in bioaccumulation within the body even brain, leading to oxidative DNA damage in the brain regions where it bioaccumulates, compromising immune responses, induction liver lesions and ultimately affecting behavior, physiology and metabolism [1]. Moreover, according to the results of our recent studies, these toxic effects can become more dramatic with low temperature increases [2–5].

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A NEW OPPORTUNITY TO EVALUATE OPEN OCEAN AQUACULTURE SYSTEMS, WAVE ENERGY CONVERTER DEVICES, AND INSTRUMENTATION AT A PERMITTED SITE IN THE GULF OF MAINE

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The University of New Hampshire (UNH) recently acquired an aquaculture permit from the Army Corp of Engineers and New Hampshire Fish and Game to culture shellfish and macroalgae offshore. The 53-ha site is located 4.4 km offshore Rye Harbor, NH in 35 m water depth. This site is totally exposed to Northeast storms with seas over 10 m in height and currents up to 0.6 m/sec. This research and demonstration farm will evaluate new ocean aquaculture technologies that minimize the risk of marine mammal entanglement. Wave energy converters will be field tested for durability and efficiency and power production. Instrumentation will be deployed to transmit real time information back ashore to monitor wave height, current speed and direction, temperature, dissolved oxygen, pH, turbidity and chlorophyl.

UNH has a rich history developing offshore farming equipment and practices with industry partners [1, 2]. They have established world class facilities including the Jere Chase Ocean Engineering Lab (https://marine.unh.edu/research-centers/facilities/jere-chase-ocean-engineering-laboratory), the Atlantic Marine Energy Center (https://www.amec-us.org/), and the Judd Gregg Marine Research Complex and pier (https://marine.unh.edu/facility/judd-gregg-marine-research-complex). They have numerous research vessels and marine operational staff that can dive, deploy and recovery equipment.

This site will be available to researchers, fishermen farmers, and industry members that are interested in building the blue economy.

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PERPETUATION OF ALBINO CHANNEL CATFISH (*Ictalurus punctatus*) THROUGH THE USE OF XENOGENESIS

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Albino channel catfish, *Ictalurus punctatus,* are naturally and externally marked. If repeated crosses of cloned lines of albinos could be repeatedly mated during the spawning season and year after year, a genetically constant control could be utilized for every genetic experiment for perpetuity, and in a communal evaluation the genetic control can be sampled, harvested and the traits recorded without any tagging or DNA analysis. However, a couple of factors prevent this powerful methodology from becoming a reality. Albino channel catfish females have poor reproductive performance. Compounding that limitation is the difficulty of producing clonal lines and the severe inbreeding depression displayed by the homozygous clones limiting their viability. Xenogenesis is a potential tool to overcome these obstacles, as it is a form of surrogacy where the host grows the gonads, thus the breeding value from the donor. Thus, stem cells from series of albino donors could be introduced to a series of triploid host, wild-type fry. Multiple sets of stem cells from a single albino are introduced to multiple fry resulting in multiple heterozygous clonal gonads. At least 2 albino xenogenic lines are used and then periodically one fish from each line is mated together. The resulting progeny from each mating should have the same mix of genes and performance in each repeat mating. The end goal is a process that can be regenerated over multiple generations. To initiate this process, triploid channel catfish fry were injected with either 80,000 or 100,000 albino stem cells labeled with PKH26 dye from 4 to 6 days post-hatch (DPH). Then at 45 and 90 DPH, growth performances, survival, proliferation, and colonization of donor cells were evaluated. The colonization of donor cells were examined in the recipient through the fluorescence of PKH26 dye, allowing the calculate of the percentage of cell and cluster areas. Gonads of recipients were extracted and observed under a fluorescent microscope and will be further analyzed to determine the quantity of colonization. All samples, regardless of presence of PKH26, will be verified with PCR and gel electrophoresis to confirm xenogenic individuals. Ultimate success is the production of 100% albino progeny by the xenogenic hosts.

PROBIOTICS ENHANCE GROWTH, IMMUNE RESPONSES AND *Nocardia seriolae* RESISTANCE IN GREY MULLET (*Mugil cephalus*)

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Grey mullet (*Mugil cephalus*), a high value aquacultural species in Taiwan, is frequently affected by *Nocardia seriolae* resulting serious economic lost. Nocardiosis is characterized by chronic infections with subtle clinical manifestations, rendering prevention and management challenging. Because probiotic intervention has been reported as an eco-friendly way to prevent disease, the present study aimed to enhance the health status of grey mullet and fortify their resistance against *N. seriolae* through probiotic intervention.

In this study, potential probiotics were selected with criteria including resilience within the gastrointestinal milieu, biological safety, and the capacity to produce digestive enzymes and exhibit antibacterial properties. Then, the selected probiotics were mixed with feed and given to the grey mullet twice a day. After 28 days, the expression of immune gene in spleen was determined using RT-qPCR. Moreover, 15 fish of each group were challenged with *Nocardia seriolae*, and survival rate was recorded for 35 days.

The results showed that *Lactobacillus rhamnosus*, *L. reuteri*, and *Bacillus subtilis* natto were identified as suitable probiotics. The groups receiving probiotic supplementation exhibited superior growth performance compared to the control group. Remarkable enhancements were particularly evident in the groups supplemented with *L. reuteri* and *B. subtilis* natto. Immune gene regulation analyses indicated significant upregulation of pro-inflammatory factors, namely IL-1β and TNF-α, in the groups receiving *L. rhamnosus* and *L. reuteri*. Additionally, these probiotics induced anti-Nocardia immune responses (Fig. 1) and elevated survival rates post-infection (Fig. 2). In conclusion, the probiotic strains promise the protection against *N. seriolae* infections in grey mullet aquaculture.

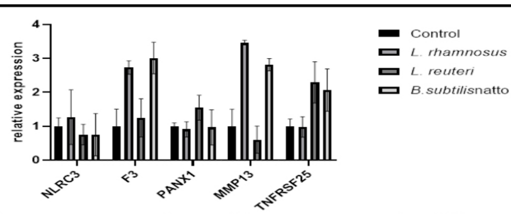

Figure 1. Expressions of immune gene in different groups. * p<0.05

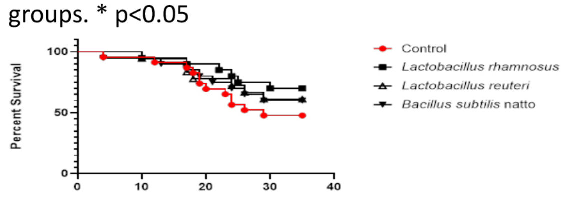

Figure 2. Survival after challenge * p<0.05

EMPOWERING WOMEN THROUGH AQUACULTURE

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Aquaculture presents a unique opportunity in U.S. marine-based industries to build inclusivity and equity into the industry while it is growing and expanding into new frontiers. From the vantage point of federal opportunities to support an inclusive aquaculture industry, leadership from NOAA Fisheries will share how they are supporting and encouraging women's engagement in aquaculture and why it is so important that women have access and opportunities to fully participate and lead in the industry.

THE EFFECT OF STOCKING DENSITY ON THE PRODUCTION AND HEALTH OF OLIVE FLOUNDER *Paralichthys olivaceus* IN NURSERY-LEVEL RAS

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The olive flounder (*Paralichthys olivaceus*) sometimes referred to as Japanese flounder is a highly valued fish in East Asia due to its rapid growth, excellent aquaculture performance, and high market value. This species has been domesticated in Korea starting in the 1980's and has potential as a lucrative aquaculture candidate in U.S. as well. Recirculating aquaculture systems (RAS) reduce the amount of water and space required to intensively produce seafood products. In landlocked states such as Kentucky, where shrimp production in RAS systems has been growing, olive flounder can be reared in the same flat-bottom culture tanks used for shrimp. Although clear water RAS has a somewhat high up-front cost, it can be an effective strategy for intensive rearing of olive flounder at nursery stage as it not only ensures higher productivity but also maintains optimum water quality of the culture system. Rearing fingerlings in separate nursery tanks at high density ensures better utilization of space and animal inventory. Stocking density is one of the major factors affecting animal welfare and system productivity. The level of stress resulting from high stocking density may also affect energy and metabolism, potentially affecting growth rates and suppressing the immune response. This research focuses on assessing the effect of stocking density on production and health of olive flounder at nursery level in RAS.

In this study, fingerling (20-30 gm) olive flounder were stocked at three different densities: 1.2, 2.4 and 3.6 kg/m^3 in 1.2 cubic meter fiberglass tanks. Each of these three treatments were replicated in three randomly assigned tanks connected to a common sump and shared filtration systems. To maintain a clear water RAS, water from the tanks passed through a drum filter with 40 μm screen, foam fractionator, and a moving bed bioreactor (MBBR) aerobic bio filter. Ozone (O_3) gas was injected into the fractionator reaction chamber and water then passed through a UV radiation lamp to destroy ozone and further sterilize the water. In order to prevent the accumulation of nitrate, an anaerobic MBBR denitrification chamber was also used. To assess the health of olive flounder, stress indicators including glucose level, plasma cortisol level, growth hormone and Insulin like growth factor (IGF-1) were also analyzed using a Dynex DS2 System (Chantilly, Virginia, USA) an automated ELISA (Enzyme-linked immunosorbent assay) processor.

Results from this experiment are pending but expected to show significant differences in the average weight, growth rate, total harvest, FCR, and condition factor between fish raised in the different stocking densities. We expect that fish may grow slower as density increases, but that the number and biomass of fish produced at high density will likely offset this reduction. It is also expected that the level of stress hormones will be significantly different among the three-treatment levels, increasing with augmented density, especially towards the end of the experiment. Overall, at the end of the research project we are expecting to better understand the tradeoffs that come with density level so we can make recommendations to farmers.

TIMELINE OF EGG-BROODSTOCK LIPID INCORPORATION IN CALIFORNIA YELLOWTAIL *Seriola dorsalis*

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Lipids play a vital role in fueling early developmental activities in fish, especially in building essential tissues crucial for good growth and egg quality. Although existing broodstock research has ascertained that eggs are heavily influenced by broodstock diet, there is currently no information regarding this timeline of nutritional incorporation. The objective of this study is to determine the duration required for broodstock to transfer fatty acids from their diet to the eggs.

In 2021, nine California yellowtail, *Seriola dorsalis,* broodstock were fed alternating diets of commercial pellets (Vitalis PRIMA: Skretting, Norway) and cut-bait diet. The diets were switched every 6 weeks and the experiment was replicated twice. Biochemical and biometric data from spawns were collected and statistically analyzed by grouping spawns based on diet type and days after diet switch.

Neutral fractions of the eggs were found to have incorporated higher amounts of LNA (linolenic acid) and LA (linoleic acid) from Vitalis diet, which are essential fatty acid precursors, but higher amounts of EPA (eicosapentaenoic acid), an omega-3 fatty acid, from cutbait diet (Figure 1). Most importantly, our results showed overall fatty acids from both diets were fully incorporated by both polar and neutral fraction of the eggs within just 10 days following the diet switch. This understanding of nutritional incorporation from broodstock diet to eggs will help producers develop more informed feeding plans when testing new feeds or supplementation. These findings can also encourage producers to explore the use of cutbait to more sustainable pelleted diets as well as open new doors for future broodstock nutrition research.

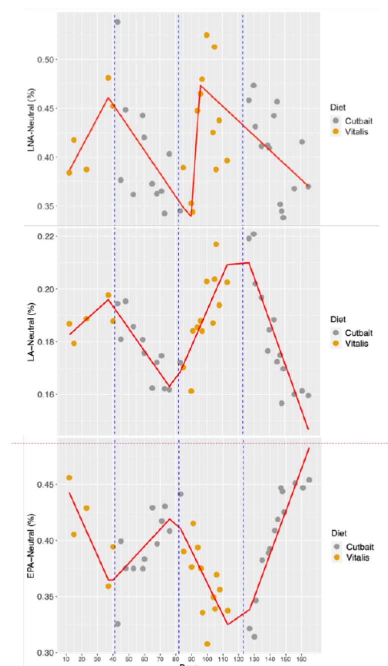

FIGURE 1: The timeline of nutrient incorporation visualized in a piecewise regression scatterplot of LNA, LA and EPA in California Yellowtail (CYT) spawns. CYT were fed alternating diets of cutbait and Vitalis over a period of 41 days each.

POSTPRANDIAL AMMONIA EXCRETION OF CHANNEL CATFISH

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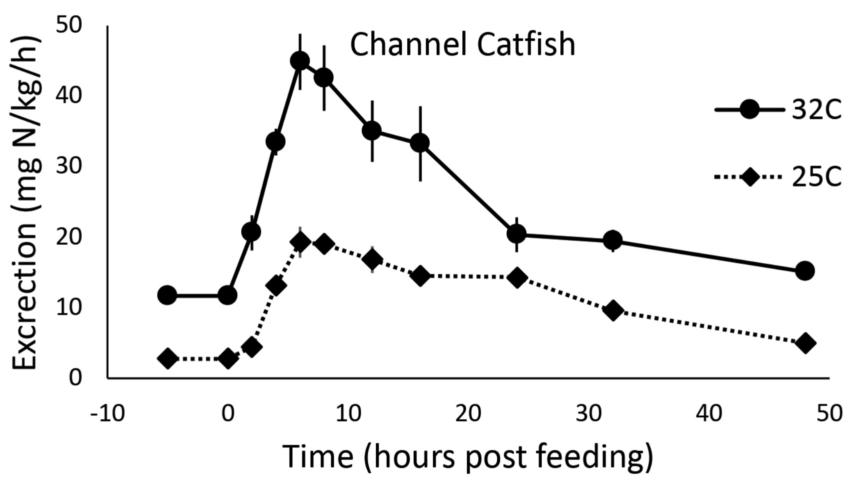
Exogenous feed is the main source of nitrogen in catfish aquaculture production systems. Nitrogenous waste is excreted as ammonia by catfishes across their gills after proteins are broken down during digestion. If allowed to accumulate to toxic levels, high ammonia concentration can lead to reduced appetite, reduced growth, and possibly death. Excretion rates for catfishes may vary depending on different variables, including temperature, which was measured in this study. Channel catfish (Ictalurus punctatus) were fasted for 72 hours prior to starting the excretion trials and measurements taken at 48, 36, and 12 hours before feeding. The fish were 46% protein feed to satiation at timepoint 0. Measurements were started 2 hours post feeding, taken every two hours until timepoint 8, and then every 4-12 hours until 48 hours post feeding. The first trial of this study was performed at 25 °C, where excretion rates were significantly higher within 4 hours post feeding and peaked between 6-12 hours post feeding. Excretion remained significantly elevated until 32 hours post feeding. The second trial was conducted at 32 °C and excretion was significantly elevated within 2 hours post feeding, peaked between 6-8 hours post feeding, and concluded before hour 48. However, peak excretion rates at 32°C (44.9 ± 4.0 mg N/kg/h) were more than double that of the same fish at 25 °C (19.3 ± 2.2 mg N/kg/h). At higher temperatures, catfish nitrogen excretion increases sooner and to a higher rate after consuming a meal, but the duration of the postprandial response is the same.



MICROBIOLOGY AS A TOOL FOR COMPLEMENTING STUDIES ON ANAEROBIC DIGESTION OF WASTE SOLIDS FROM RECIRCULATING AQUACULTURE SYSTEMS

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Anaerobic digestion (AD) is a biological process occurring in the absence of oxygen, where microorganisms degrade organic matter to produce biogas, a mixture of methane (CH_4), carbon dioxide (CO_2), and trace gases like hydrogen sulfide (H_2S) and ammonia (NH_3). The CH_4 in the biogas can then be used to run boilers or generators for heat and electricity production. While anaerobic digestion can be a suitable technique for waste treatment for different waste streams from a recirculating aquaculture system (RAS) farm, the components of the waste may lead to several challenges that inhibit the stable functioning of biological processes within a digester. These challenges include low solids content, high salinity, low carbon to nitrogen ratio, high fat content, and high sulfur content. Typically, all these issues result in reduced microbial activity that ultimately affects the biogas quality and quantity.

In the last few years, tools for studying microbiological processes have evolved significantly and have allowed for substantially more in-depth studies of processes like anaerobic digestion. Tools like next-generation sequencing (NGS) have allowed for the sequencing and study of a large number of genes simultaneously. In addition to anaerobic digestion, these tools can offer significant insight into the function of biofilters, membrane biological reactors, and aquaponics systems for improving their performance and optimization. In this presentation, the challenges and opportunities for using tools like next generation sequencing (NGS) for microbial analysis in anaerobic digestion studies will be explored.

LIPOSOME-CONTAINING COMPLEX PARTICLES AS A NOVEL METHOD FOR DELIVERY OF ESSENTIAL NUTRIENTS TO MARINE FINFISH LARVAE

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Domestic production of marine finfish is limited, in part, by the industry's ability to produce sufficient quantities of high-quality juveniles, which can be partially attributed to inadequate nutrition during the larval stage. Existing larval microparticulate diets (i.e. microdiets) have several limitations that hamper their use as a replacement for cultured live feeds (*Artemia* and rotifers). Microdiets are prone to high rates of nutrient leaching when suspended in seawater which reduces the nutrient content of the ingested feed and potentially degrades water quality. In addition, these microdiets possess fast sinking rates, which can lead to low feed uptake and poor feed efficiencies for slow-swimming larvae. Ultimately, these factors may result in deficient nutrition for the larvae, which manifests as poor larval growth, low rates of survival, increased rates of malformations, and disease. Recent studies using liposomes containing water-soluble payloads have proved efficient at delivering essential nutrients to marine finfish. This is done by using liposomes to enrich live feeds, which are then consumed by early-stage larvae. Liposomes can also be incorporated into larger alginate-based carrier particles, hereafter referred to as liposome-containing complex particles (LCP), and can be ingested by larvae. These particles have the potential to deliver water-soluble compounds as well as a suite of macro- and micronutrients directly to fish larvae. This novel diet type has shown low rates of nutrient leaching in comparison to existing liquid and commercial type microdiets. In addition, LCP have been tested in preliminary growth studies with Inland silverside (*Menidia beryllina*) larvae and resulted in positive growth and high survival.

We hypothesize that liposome-containing complex particles will be able to efficiently deliver free amino acids and other key water-soluble nutrients to marine finfish larvae. The objectives of this research were to: 1) optimize buoyancy of LCP to increase rates of capture and ingestion by fish larvae; 2) evaluate payload efficiencies (i.e. encapsulation and retention efficiency) of core materials within liposomes and complex particles; 3) compare feed uptake rates, digestibility, and acceptability of LCP with those of commercial-type microdiets; and 4) evaluate success and viability of these diets for California yellowtail (*Seriola dorsalis*), a valuable commercial species. If successful, liposome-containing complex particles have the potential to transform the way marine finfish larvae are fed in commercial hatcheries. This diet type may increase larval growth, improve survival outcomes, and reduce malformation rates, thereby increasing overall production output from commercial hatcheries. Moreover, LCP may have broader uses beyond the delivery of water-soluble nutrients and act as an efficient delivery method for vaccines, antibiotics, and other bioactive compounds.

ENHANCING FOOD SAFETY GUIDANCE FOR HARVESTING FOOD-GRADE SEAWEED

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Interest in local seaweed production is increasing across the US. However, little seaweed specific guidance on best practices for harvesting, handling, and assessing source/harvest related hazards is available to local producers. As this emerging industry grows, it is important to provide food safety resources and guidance to ensure safe production and harvest of domestic food products.

The lack of data on chemical hazards associated with specific seaweed species grown in different regions makes regulating and controlling food safety challenging. Through review of available resources and known contaminants of concern in New York waters, New York Sea Grant has developed a guide for harvesting food-grade seaweed. The guide outlines specific environmental contaminants identified as moderate or major hazards and sets threshold concentrations for such contaminants in seaweed destined for consumption.

Thresholds were determined for those that did not have existing domestic or international standards. The calculations were based on published World Health Organization tolerable weekly or monthly intake values or the Center for Disease Control's minimal risk level values. Calculations were designed to limit exposure to ¼ the published harmful levels assuming a single serving was consumed daily.

While this resource is a start to guide NY production, continued discussions around best practices for harvesting food-grade seaweed are important as the emerging industry continues to grow. This is especially important for the evaluation and determination of contaminant thresholds to ensure current and future recommendations are effective and ensure safe products make it to market.

Table 1: Food-grade seaweed contaminant thresholds.

Contaminant	Tolerance	Reference
Inorganic Arsenic	3 mg/kg	ANSES
Cadmium	0.5 mg/kg	ANSES
Iodine	2000 mg/kg	ANSES
Mercury	1 ppm	US FDA CPG
Lead	5 mg/kg	ANSES
Aluminum	400 mg/kg	WHO PWTI*
Pesticide Residue	0.05 ppm	40 CFR 180 Sub. C
PCBs	2 ppm	21 CFR 109
Dioxins**	3,500 pg/kg	WHO PMTI*
PFAS	0.0028 mg/kg	CDC MRL*

*Tolerance was calculated to ensure no more than 1/4 the tolerable daily intake was consumed per 15 g (dry) serving, assuming 1 serving per day.
**and dioxin-like compounds

EXPLORING OPPORTUNITIES TO ENHANCE THE PROCESSING AND MARKETING OF AQUATIC FOODS

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In response to the COVID-10 pandemic, New York Sea Grant initiated two statewide task force efforts to directly engage industry and agencies impacted by the social and economic challenges imposed by the pandemic. New York Sea Grant coordinated monthly calls to create a space for industry and agency challenges to be shared and facilitated discussions around potential opportunities for supporting the industry and addressing these challenges.

With the major challenges identified revolving around changing markets and loss of sales, the group decided that additional guidance and resources around how to access various markets and the regulatory requirements of doing so would be beneficial. With the support of agency and industry partners, NY Sea Grant drafted regulatory guides and topical resources to clarify how seafood and seaweed business could adapt and access different markets.

To further support changing business models for New York producers, NY Sea Grant allocated funds to support free seafood safety trainings for producers and processors. This allowed new and existing business to gain the necessary training to process and market seafood products in the state.

The task force also identified education and consumer awareness as an ongoing hurdle. To help address this NY Sea Grant partnered with colleagues at Cornell Cooperative Extension of Suffolk County to develop an incentives program to increase awareness of, and demand for, New York farmed and fished seafood. The sticker depicted to the right was one element of the program to promote NY farmed and fished. Based on post program evaluations, more than 60% of participating retailers indicated up to a 20% increase in the sale of NY farmed or fished seafood when offering the purchase incentives provided by New York Sea Grant.

These efforts to support New York's seafood and emerging seaweed industries have led to the development of various regulatory and processing guides and nutrition and marketing resources; free seafood safety training opportunities; and increased sales of NY products. New York Sea Grant plans to continue facilitating task force efforts to afford the industry an opportunity to regularly interact with one another and regulators to address emerging needs and share opportunities.

ECONOMIC IMPACT OF SHELLFISH CLOSURES IN VIRGINIA

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Shellfish aquaculture is the largest sector of the Virginia aquaculture industry, responsible for 84% of the sales value of the industry. Oysters and hard clams are the main species raised on Virginia farms, demonstrating a 44% growth from 2013 to 2018. These species filter nutrients from the water and rely on the environmental quality of the Chesapeake Bay to grow healthy shellfish. To minimize the risk of disease from molluscan shellfish and crustacea products at the wholesale level, the Virginia Department of Health created the Division of Shellfish Safety (DSS). This division is responsible for protecting the health of molluscan shellfish and crustacea consumers by ensuring that shellfish growing waters are appropriately classified for harvesting and that molluscan shellfish and crustacea processing facilities meet sanitation standards. VDH DSS imposes shellfish growing area closures when routine seawater sampling detects fecal pollutant averages in higher concentrations than the allowed standard levels or when one inch or more of rainfall affects conditionally approved areas. This action is essential to protect farmers and consumers from runoff pollutants and contaminants in the bay. It reduces the risks of contaminated shellfish making it into the seafood supply chain, potentially necessitating shellfish recalls. However, closures disrupt shellfish farm activities, including the disruption of sales and marketing activities, causing an economic impact on shellfish farms. Therefore, we developed and implemented a short and targeted survey to assess the effects of shellfish closures on farmers in Virginia for 2021 and 2022. The impact of shellfish closures on labor income was estimated at $0.64/acre/day in 2021 and on sales at $0.47/acre/day in 2021 and $1.35/acre/day in 2022. Based on the rates these impacts affect the shellfish industry, the total sale loss in Virginia due to closures was estimated to be $2,169,801 in 2021, $4,895,087 in 2022, and labor income was $1,477,311, which represents the loss of 89 jobs in 2021. These impacts account for 2.12% of the total direct effects on sales output, 9% of jobs and labor income of the shellfish industry in 2021, and 4.66% of sales output in 2022. Tracking the sources of contaminants and increasing access to leasable grounds/waters were pointed out as the preferred alternatives to reduce the negative economic effects of closures. Despite the limited engagement of participants in providing complete responses, this study provides shellfish growers with insights into strategies to mitigate sales losses during shellfish closure events, enhancing their resilience and sustainability.

THE *Isochrysis* CRISIS: GROWTH TRIALS OF *Isochrysis galbana* WITH INSTANT SALT MIXES AT THE COLLEGE OF THE FLORIDA KEYS

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Algae are one of the most important animals on earth as they filter every part of water around the world and create most of the oxygen that we breathe. *Isochrysis galbana*, a brown algae species used in closed-loop aquaculture production as a phytoplankton food source, has had little success at The College of the Florida Keys (CFK) Tropical Ornamental aquaculture lab until recent trials with different instant aquaria salts to create a well-balanced base. Our objective was to demonstrate and compare the different saltwater mixes that can be used in cultivating brown algae. *Isochrysis* and other green algae's that are grown at the CFK lab play a very important part in the aquaculture system as they are utilized as a source of food and nutrients for many primary producers. The samples were grown according to the standard measures but with different salt bases; 1) unsterilized (or "raw") salt water, and two different industry-produced mixes from 2) Live Aquaria and 3) REEF salt. CFK lab had previous success in cultivation with the species when *Isochrysis galbana* was kept at a stable salinity of 35. The raw seawater sample grew over a 1–2-day period with salinity that averaged 40ppt. The samples mixed into each artificial reef salt took about a week or more to actually grow color and cultivated the algae. Most algae samples became successful until being overpowered by chlorophyta in the same room. The samples overtime grew greener and the Isochrysis cells began to lose their color and form.

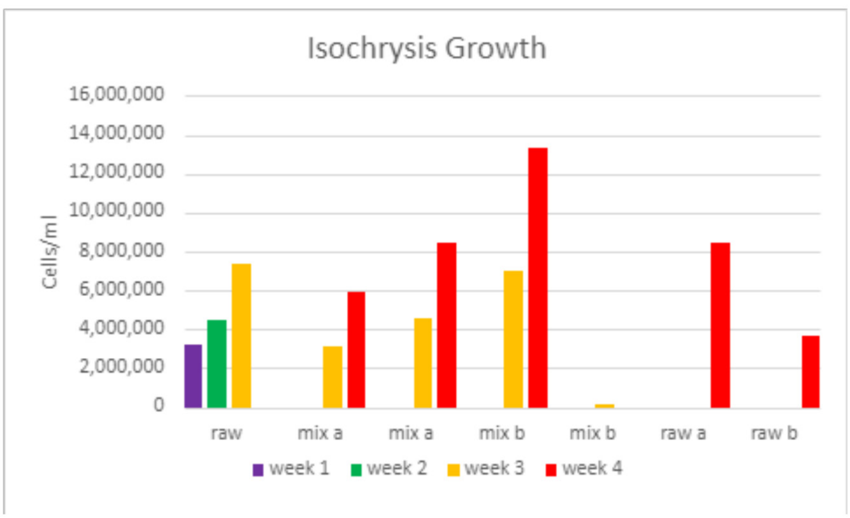

Figure 1. This shows the growth over time of each induvial mix type through cell count.

WHO'S WHO IN MAINE AQUACULTURE? UNDERSTANDING THE LANDSCAPE OF AQUACULTURE PRIORITIES AND FUNDING

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The Maine aquaculture sector has seen rapid growth in the last 15 years and is looked to as an area of economic development potential for the state. While there are many actors engaged in aquaculture development, there is less clarity around whose priorities are shaping the direction of the sector, how those priorities have evolved over time, and who benefits. Our study sought to answer the following question: Who has shaped aquaculture development priorities in Maine, and how? Through the analysis of public testimony submitted in response to aquaculture-related bills before the Maine legislature between 2017 and 2023 and aquaculture grant funding received by Maine organizations since 2017, we categorized the role of different actors and priorities shaping aquaculture development in Maine.

Our analysis of testimony submitted in response to aquaculture-related bills found consistent participation by a handful of actors (state agencies, advocacy groups, and NGOs) commenting on multiple pieces of legislation. Aquaculture growers and private citizens accounted for 33 and 27 percent of the testimony submitted respectively, but were concentrated largely on a few particularly contentious pieces of legislation. We found a dramatic increase in aquaculture-related legislation in 2023, which was likely in response to a few contentious aquaculture projects that garnered widespread public attention. We found that the two entities that submitted testimony most frequently – the Maine Department of Marine Resources and the Maine Aquaculture Association– achieved their desired outcomes (e.g., bill passed or failed) on the majority of bills for which they submitted testimony, and that these two actors were nearly always aligned in their positions on bills before the legislature.

Our analysis of funding found that while the largest number of grants were awarded to aquaculture farmers (43%) followed by academic or research institutions (29%), the greatest proportion of funding went to institutions (68%) with farmers receiving 15% of the total amount awarded. Looking at which aquaculture species were funded, we found that projects focused on oysters (24%) and multiple species (21%) received the greatest number of grants, while the greatest proportion of grant funding went toward seaweed (46%) and finfish (16%) focused projects. This analysis provided one lens through which to understand the funding landscape, but was limited in the amount of information that was publicly available and eligibility and other criteria varying by grant opportunity.

Aquaculture priorities as articulated by the state of Maine, and more recently by collaborative entities like the Maine Aquaculture Hub, have shifted over time but have maintained a strong focus on economic and aggregate growth of the sector, despite evidence that Mainers hold a variety of other values related to aquaculture development. Our analysis and collective experience working with the aquaculture sector offers insight into whose priorities are included as aquaculture is developed and the implications for equity and inclusion in the Maine aquaculture sector.

CHAPERONE-MEDIATED AUTOPHAGY REGULATES NUTRIENT METABOLISM, ENERGY BALANCE, AND OXIDATIVE STRESS IN RAINBOW TROUT

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Chaperone-mediated autophagy (CMA) is a lysosomal-dependent proteolytic pathway recognized in mammals as significant for maintenance of cellular homeostasis during physiological and metabolic stress. The CMA mechanism has only recently been described as present in fish, thus its biological function is not well understood in these species. The objective of this study was to characterize the role of CMA as a metabolic regulator in rainbow trout through a loss-of-function approach. Chaperone-mediated autophagy was disrupted by CRISPR/Cas9-induced excision of the 9a exon within the *lamp2a* gene, thereby inhibiting the CMA rate-limiting process of protein substrate binding to the lysosomal membrane. Growth and nutrient metabolism and partitioning were characterized in wild type controls and *lamp2a* knockout (KO) rainbow trout during a high-carbohydrate nutritional challenge.

At 23 weeks post-hatch, KOs exhibited 20% greater body weight than controls; this value increased to a 30% body weight difference after 7 weeks of consuming a high carbohydrate diet (Fig 1). Gene expression analysis in brain suggested an increased appetite contributed to faster growth in KOs ($P<0.05$). Hepatic lipid profile was also affected, with increased monounsaturated fatty acids and decreased polyunsaturated fatty acids in KOs relative to controls ($P<0.01$). Elevated expression of genes associated with lipid metabolism ($P<0.05$) suggesting an increased capacity for lipid synthesis in KOs. Hepatic proteome analysis indicated *lamp2a* KO affected the abundance of proteins linked with glucose, lipid, and glutathione metabolism, as well as mitochondrial respiration and proteasome activity (Fig 2,3).

Findings indicate that CMA is a central mechanism regulating growth, metabolism, energy production, and oxidative stress in rainbow trout. Further characterizing how CMA responds to metabolic, environmental, and immunological stressors will reveal how fish regulate cellular homeostasis under metabolic stress and contribute to development of strategies that improve production efficiency.

Fig 1. Body weight trends

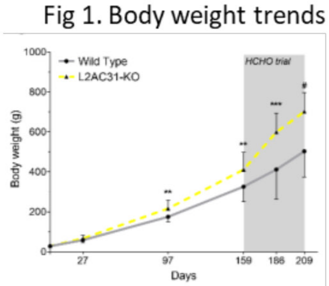


Fig 2. Up-regulated processes

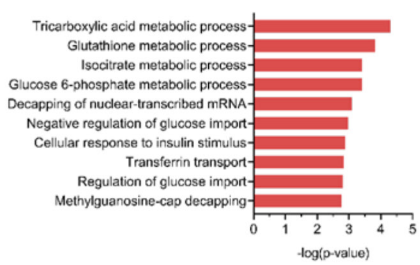
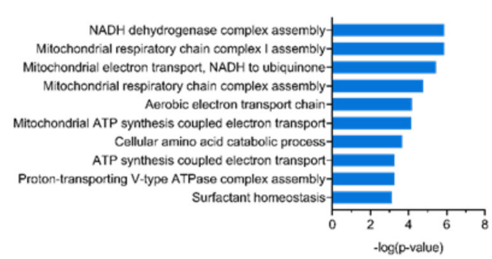


Fig 3. Down-regulated processes



INTRODUCTION AND STATUS OF THE US SEAWEED INDUSTRY

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Seaweed (macroalgae) has been cultivated in Asia for decades, however, only recently gained traction in the United States. As a result, challenges have emerged resulting in multiple efforts to assist in addressing these challenges. This introductory presentation will provide the audience with an overview of global perspectives and the current status of the US seaweed industry. Current challenges and opportunities will be explored, providing the context to set the stage for session's presentations.

CREATING A PLATFORM FOR MULTI SECTOR COLLABORATION

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Sea Grant's National Seaweed Hub (https://seaweedhub.extension.uconn.edu/) serves as a central clearinghouse for available science-based, non-advocate, and practical resources related to the emerging domestic seaweed aquaculture industry. Advocacy-driven messaging has fueled interest in seaweed farming; however, existing practical challenges have led to frustration from relevant sectors. There was a need to address emerging challenges and provide responsive, non-advocate resources in a publicly accessible format. To accomplish this, Sea Grant Extension and National Sea Grant Law Center staff established virtual, multisector work groups representing diverse regions and roles in the seaweed industry (prospective and current farmers, regulatory agencies, non-profit organizations, academia, processors, culinary professionals, and others) to identify national needs and opportunities and develop achievable strategies or work plans to address emerging challenges.

Sea Grant Extension and Law Center staff employed several methods and tools to guide the virtual work groups in accomplishing their tasks including Zoom Video Communications polling feature and MIRO white board platforms. Despite the COVID-19 pandemic, the utilization of a virtual meeting platform provided the ability for various sectors, separated by great distances, to collaborate and accomplish project tasks. As a result, resources developed are responsive to multiple sectors' needs, can be implemented by a variety of stakeholders, and more sectors are collaborating on projects and exchanging information, setting a pathway for long-term success.

EVALUATION OF ACID SILAGE TECHNOLOGY USING DIFFERENT CATFISH PROCESSING WASTE

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After filleting and processing catfish, the waste generated can reach up to 50%, which could be further processed and generate additional revenue for the catfish industry. Acid silage is a potential low-cost and straightforward technology that can be applied to the catfish remains and be sold as a feed ingredient or supplement. In this study, the acid silage was applied to catfish viscera, frames, and a composite sample of catfish remains (whole-waste; heads, viscera, and frames). The samples were incubated for 7 days, using two concentrations of hydrochloric acid - HCl (5 and 7%), as a promoter for acid hydrolysis to each waste source using three replicates. The silages were homogenized daily, and pH and temperature were assessed on days 3, 5, and 7. After seven days of incubation, the emulsifying stability and foaming capacity were measured. Data was analyzed as a 3 × 2 factorial with the waste source and acid levels as the main factors. Silages incubated with 7% HCL showed higher values for the variables analyzed (Table 1). The waste sources affected the pH, and a higher pH value was observed for the whole-waste silage. A higher foaming capacity was observed for the silage manufactured with frames, possibly due to the higher muscle content in this residue. Catfish waste was amenable to acid silage, and additional processing methods (enzymatic and microbial) are being currently tested.

Table 1. Acid silage of catfish waste in different concentrations of hydrochloric acid (5 and 7%).

Variables	HCl	Waste			Average	P-value		
		Whole waste	Viscera	Frames		Waste	HCl	Waste × HCl
T °C	5%	28.9±0.1	28.3±0.4	28.5± 0.6	28.6±0.4^{A}			
	7%	29.3±0.3	28.9±0.6	29.3± 0.6	29.2±0.5^{B}	0.18	0.013*	0.72
	Average	29.1±0.3	28.6±0.6	28.9± 0.7				
pH	5%	3.63±0.2	1.63±0.1	2.9±0.1	2.72±0.9^{A}			
	7%	3.13±0.4	1.40±0.1	2.23±0.1	2.26±0.8^{B}	0.000*	0.000*	0.12
	Average	3.38±0.4^{a}	1.52±0.2^{c}	2.57±0.4^{b}				
Emulsifying stability	5%	32.0±2.0	34.0±2	34±2	33.3±2^{A}			
	7%	37.3±1.2	36.0±4.0	36±2	36.4±2.4^{B}	0.96	0.016*	0.39
	Average	34.7±3.3	35.0±3.0	35±2.1				
Foaming capacity	5%	10±0	0±0	25±5	11.6±11.2^{A}			
	7%	15±5	10±0	35±5	20.0±11.9^{B}	0.000*	0.003*	0.39
	Average	12.5±4.2^{a}	5±5.5^{a}	30±7.1^{b}				

IMPACT OF DIETARY LIPID-TO-CARBOHYDRATE RATIOS ON GROWTH PERFORMANCE, HEALTH, AND HEAT SHOCK TOLERANCE IN JUVENILE YELLOW PERCH (*Perca flavescens*)

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Yellow perch (Perca Flavescens) play a crucial role as both a food source and an ecologically significant species in the Midwest region of the United States. Despite their importance in aquaculture, cost-effective feed for yellow perch remains elusive. A common issue observed in yellow perch fed commercial feeds is the development of fatty liver and excessive visceral lipid accumulation. Addressing this challenge requires a comprehensive understanding of their nutrient requirements. The primary objective of this study was to determine the optimal carbohydrate-to-lipid (L/C) ratio in fish feed and assess its impact on growth performance, health, and stress tolerance in yellow perch.

Yellow perch (initial body weight, 8.9 ± 0.27g, n=21) were subjected to five lab test diets, all containing 50% protein, with varying lipid (11 to 19%) and carbohydrate (14-22%) levels to produce different L/C ratios (0.50, 0.65, 0.83, 1.06, and 1.36), and two commonly used commercial diets. A 12-week feeding trial was conducted within an indoor flow through aquaculture system (21-23°C) with three replicate tanks (20 fish per tank) for each treatment. The results revealed that fish fed a diet with a L/C ratio of 0.65 achieved the highest growth, significantly outperforming fish fed the test diet with a ratio of 1.36 and a commercial diet with a ratio of 0.80 ($P<0.05$). Although protein efficiency did not significantly differ among fish fed the five lab test diets, both the two commercial diets and the diet with a 0.65 ratio demonstrated better protein efficiency. Gender differences were observed in terms of morphology, with female fish showing a higher visceral fat index and hepatosomatic index than males. Conversely, males exhibited a higher gonadosomatic index than females. Additionally, males were found to be more sensitive to heat shock stress based on mortality compared to females across all dietary treatments. This preliminary study suggests that a diet with lipid and carbohydrate levels ranging from 11-15% and 18-22%, or a ratio of L/C at 0.65 is suitable for yellow perch under the current conditions. Diets with lipid content exceeding 16% may not be optimal for fish growth. Further validation of these findings will be conducted as the project progresses. The outcome of this study aims to offer a more comprehensive understanding of the nutritional requirements for yellow perch, benefiting aquaculture practices and ecological preservation.

Table 1: The performance of yellow perch fed different diets for 12 weeks.

Dietary lipid/carbohydrate ratios	**Weight Gain (%)**	**SGR (%body weight. day^{-1})**	**Feed conversion ratio**	**Protein Efficiency**
0.50	311.9 ± 22.1^{ab}	1.68 ± 0.06^{ab}	1.22 ± 0.06^{a}	1.53 ± 0.07^{bc}
0.65	335.6 ± 44.6^{a}	1.75 ± 0.13^{a}	1.14 ± 0.13^{a}	1.64 ± 0.19^{abc}
0.83	304.2 ± 21.8^{ab}	1.66 ± 0.06^{ab}	1.22 ± 0.07^{a}	1.45 ± 0.09^{c}
1.06	275.6 ± 5.8^{ab}	158 ± 0.02^{ab}	1.25 ± 0.02^{a}	1.43 ± 0.01^{c}
1.36	255.0 ± 5.1^{b}	1.51 ± 0.05^{b}	1.29 ± 0.35^{a}	1.38 ± 0.03^{c}
0.4 (commercial diet 1)	274.6 ± 14.6^{ab}	1.57 ± 0.05^{ab}	1.25 ± 0.05^{a}	1.84 ± 0.07^{a}
0.8 (commercial diet 2)	259.3 ± 18.9^{b}	1.52 ± 0.06^{b}	1.24 ± 0.08^{a}	1.79 ± 0.11^{ab}

OFFSHORE BOTTOM CULTURE OF SEA SCALLOPS IN THE GULF OF MAINE: A BIOLOGICAL AND ECONOMIC FEASIBILITY ANALYSIS

Commercialization of "Ropeless" On-Bottom Sea Scallop Aquaculture in the Gulf of Maine: Development of Hatchery and Growout Protocols

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The Atlantic sea scallop, *Placopecten magellanicus*, shows great potential as an aquaculture species in the Northeast United States. With the availability of affordable and reliable acoustic release technologies, scallops can be cultured in bottom gear in ideal conditions without vertical buoy lines thereby eliminating entanglement risk to whales and other marine organisms. The major objective of this project is to develop an efficient and economical growout protocol to support the Atlantic sea scallop aquaculture industry. During a preliminary year-long trial we identified a shallow nearshore site and deep offshore site where we achieved high survival (>90%) and rapid growth (>0.12 mm/day). In our current study we are quantifying ideal water quality parameters, testing various cage designs, and evaluating stocking densities to maximize survival and growth. We are also determining the correlation between adductor mussel weight and external characteristics, to develop a more reliable metric for assessing time to harvest. Based on the results from the growout study we will develop an economic model to evaluate the viability of a "ropeless" bottom culture of scallops using condos.

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COMPARISON AND EFFICACY OF SOY-BASED INGREDIENTS IN PRACTICAL DIETS FOR FLORIDA POMPANO *Trachinotus carolinus*

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Three trials were performed to better understand how soy processed in different ways impacts the growth, feed conversion ratio, and health of the Florida pompano (*Trachinotus carolinus*). First two growout trials were performed to evaluate the efficacy of an open soy-based diet in comparison to a commercially produced, fishmeal-based diet. Trial one utilized 6 replicates and was terminated after 42 days of growout. Overall biomass (p=0.026), weight gain (p=0.006), and FCR (p=0.015) being significantly different between both treatments, with results showing overall preference for commercially produced fishmeal diet over the soy-based diet. The second trial was run over the course of 56 days, and upon termination there were no statistically significant differences due to diets. Histological samples taken upon termination of distal intestine showed no statistical differences in symptoms indicative of soy-induced enteritis (lamina propria thickness, goblet cell frequency, central stroma widening, and vacuolization) between the practical soy diet or the commercial fishmeal diet. To improve soy-based feed formulations we evaluated soy-based ingredients processed under different conditions. Nine experimental diets with varying soy sources were formulated in combination with 14% poultry by product meal and 6% corn protein concentrate and designed to be iso-nitrogenous and isolipidic at 40% protein and 8% lipid. A basal diet comprised of 49.97% solvent extracted soybean meal (SBM) was compared with diets containing low oligosaccharide soybean meal (SBM-LO), soy protein concentrate (SPC), fermented soybean meal (Fer-SBM), and expeller extruded soybean meal (EE-SBM) at varying levels of replacement of solvent extracted soybean meal. Juvenile Florida pompano (4.82 ± 0.08 grams) were offered randomly assigned diets in quadruplicate for 76 days. Upon termination, there were no significant differences in weight (p=0.493), survival (p=0.925), or FCR (p=0.874) in fish offered any of the experimental diets. Histological analysis of distal intestine samples showed no statistical differences in lamina propria thickness, goblet cell frequency, or vacuolization, however there was significant differences in lamina propria thickness between samples offered SPC at 100% replacement and Fer-SBM at 50% replacement. Based on the current study, it can be inferred that Florida pompano offered a soy-based diet show no adverse effects in terms of growth or health when compared to a diet primarily composed of fishmeal. Despite no significant differences between soy sources, fish offered EE-SBM at 25% replacement performed best, having the highest overall weight and percent weight gain as well as having the lowest feed conversion rate.

TRACKING DOWN AND CHARACTERIZING DIVERGENT STRAINS OF VIRAL SHRIMP PATHOGENS THROUGH MOLECULAR HISTOLOGY: THE CASE OF A NEW GENOTYPE OF *Decapod hepanhamaparvovirus*

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Emerging diseases pose a substantial threat to global shrimp farming sustainability. This study explores the presence of pathogens in *Penaeus vannamei* samples from a several Latin American countries experiencing slow growth, employing routine histopathological examination. Unusual nuclei were noted in hepatopancreas epithelial cells. We introduce an innovative approach, merging laser dissection microscopy, whole genome amplification, and next-generation sequencing to accelerate pathogen discovery in cultured shrimp via histological tissue.

Through laser microdissection we selectively isolated 5-15 infected cells from hepatopancreas tubules. DNA extraction utilized the PicoPure™ DNA Extraction Kit, with subsequent amplification via the SeqPlex DNA Amplification Kit due to limited DNA quantity. Sequencing occurred on an Illumina HiSeq Platform, and *de novo* assembly was executed using the Geneious Prime assembler. Our findings unveiled a divergent viral sequence, belonging to the *Densovirinae* sub-family, approximately 6300 nt long. This novel Parvovirus displayed 85-90% identity to *Penaeus monodon hepadensovirus* 1. Novel sensitive molecular diagnostic methods (e.g., polymerase chain reaction and *in situ* hybridization) confirmed the identity of the virus (Fig 1). Additionally, robust phylogenetic analysis is underway to clarify the taxonomic affiliation of this potential pathogen. Research indicates a rising trend in hepatopancreas diseases, hinting at multi-pathogen involvement in complex diseases like White Feces Syndrome, Glass Postlarva, and Growth Retardation Disease of *Macrobrachium rosenbergii*, possibly originating from a pathobiome. The role of the identified Parvovirus in these diseases is unknown, emphasizing the importance of the newly developed diagnostic methods to evaluate the presence of this pathogen in shrimp populations to understand its impact on complex hepatopancreas diseases.

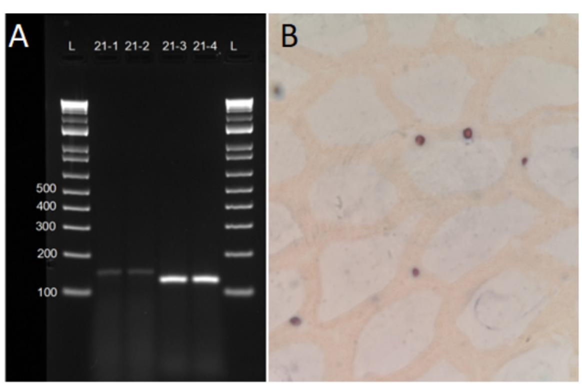

Fig 1. (A) Specific PCR and (B) ISH methods for the novel DHPV strain.

RICKETTSIALES-LIKE ORGANISM IN CULTURED PLEASURE OYSTER *Crassostrea corteziensis* FROM MÉXICO, PREVALENCE AND INTENSITY

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Fastidious endosymbiotic Rickettsiales-like organisms (RLO) have been consistently identified in the digestive diverticula of cultured pleasure oysters (*Crassostrea corteziensis*) in Nayarit, Mexico, since 2007. While these bacteria have been linked to mortality events and production losses in some mollusk species, the nature of their relationship with pleasure oysters remains largely unknown. Further investigations are necessary to determine whether these bacteria require special attention in *C. corteziensis*.

This study focused on characterizing the morphological features of the RLO through histology and SEM, and assessing their taxonomic affiliations via 16S rRNA amplicon sequencing. From 2007 to 2017, the prevalence and intensity of RLO were recorded by histology. The RLO were observed within circular basophilic cytoplasmic membrane-bound vacuoles (MBV) (Fig 1), with an average length and width of 15.70±15.24 μm and 15.42±14.95 μm, respectively. Apart from cell hypertrophy, no tissue alterations were observed in areas adjacent to the RLO. Individual bacteria within the MBV were coccoid in shape, with an average length of 0.65±0.12 μm and an average width of 0.38±0.09 μm. The bacterial microbiota of selected samples revealed the presence of intracellular parasite operational taxonomic units (OTUs) corresponding to the families *Rickettsiaceae* and *Anaplasmataceae*, suggesting an association of the RLO with the order *Rickettsiales*. Throughout the study period, a mean prevalence of 5% was observed, with 89% of organisms exhibiting low intensity (G1: 30-61 RLO) of the MBV. A higher prevalence occurred during warmer months. The absence of tissue alterations, low prevalence, and low intensity of the MBV imply that RLO in *C. corteziensis* act as commensal endosymbionts with minimal risk to oyster production in Nayarit, Mexico. However, regular monitoring is essential to detect any variations in this relationship, particularly in scenarios of extreme environmental fluctuations.

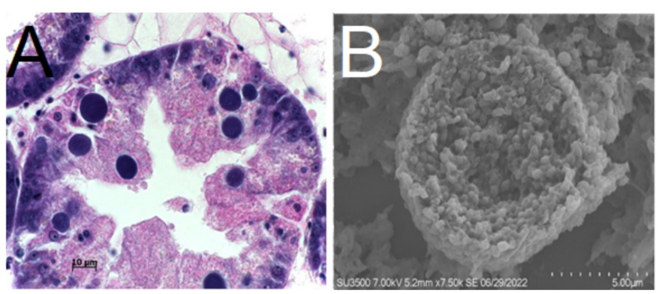

Fig 1. Intracellular membrane bound vacuoles (MBV) in the epithelial cells of the digestive tubules of *C. corteziensis* observed by scanning electron microscopy (SEM) (H&E stain). (A) Histological section of a digestive tubule with several RLO. (B) Close-up of a MBV where individual bacteria are observable by SEM.

NOAA FISHERIES ALASKA AQUACULTURE PROGRAM 2023: COMMUNICATING SCIENCE AND POLICY TO BROAD AUDIENCES

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Alaska's aquaculture industry is currently a small-scale, but rapidly growing, economic opportunity for coastal Alaskan communities. One of the keys to sustainably developing aquaculture is strong communication between NOAA, state groups, industry, and the public. During fiscal year 2023, the NOAA Fisheries Alaska Aquaculture Program pursued a variety of initiatives to support the developing aquaculture industry, including several communications projects. These projects included a video documenting the collaborations between researchers and aquaculture farmers, the 2023 NOAA Fisheries Alaska Aquaculture Accomplishments Report, a classroom aquaculture demonstration and accompanying curriculum, and stakeholder outreach to support Alaska's new Aquaculture Opportunity Area initiative. Takeaway lessons from these projects included the importance of diverse communication methods, tailoring aquaculture for use in classroom settings, and the easily forgotten strength of in-person outreach as a supplement to other communications work.

FIGURE 1: Left: The 2023 NOAA Fisheries Alaska Aquaculture Accomplishments Report. Right: Alaska Sea Grant Fellow James Currie collects video media for an aquaculture documentary. Credit: NOAA Fisheries

RHODE ISLAND SEA GRANT'S EFFORTS TO SUPPORT AND INFORM THE SEAFOOD SECTOR DURING THE PANDEMIC

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When the COVID-19 pandemic threatened to interrupt and debilitate the Rhode Island seafood sector, the state, Rhode Island Sea Grant, and a host of partners worked with the industry to develop lifelines to encourage stability and a customer base. While the seafood sector was hit hard, food insecure people in the state also suffered. The need and demand for healthy, sustained food sources in the state has always been present and the pandemic exacerbated the needs, with one in four households in Rhode Island lacking adequate food (see Status Report on Hunger, 2021). Utilizing and leveraging these well-defined and well-managed channels, with partners that have been leaders in these efforts, RISG worked with the existing seafood distribution channels to provide awareness, handling, and preparation experience for oysters, to encourage opportunities for oysters to be used in the future.

Also, since the COVID-19 pandemic disrupted seafood supply chains across the country, fishermen were forced to seek out and develop new ways to market catch. Dockside sales of finfish represented one of these new markets in Rhode Island, complementing long-standing efforts to strengthen connections between local seafood harvesters and consumers. In April 2020, with support from RISG, the RIDEM created a new emergency authorization for fishermen to sell finfish directly to consumers from their vessels at the dock.

RISG also purchased thermometers for the fishing industry help them determine COVID-19 infections which allowed healthy individuals to return to work safely in the confined quarters of fishing boats. The Rhode Island Sea Grant Legal Program (RISGLP) also provided rapid response to state fishermen by working with stakeholders to clarify legal issues associated with the DSDL program, in particular, clarifying issues related to the interaction of the DSDL program with RIDOH food business licensing requirements.

The aquaculture industry was also hit had by COVID-19. RISG responded by: a) conducting an industry survey of impacts to assess need and appropriate and rapid RISG responses; b) link growers with free small business support and guidance through Venture Café and District Hall Providence; c) host a series of webinars on funding support and how to navigate federal/state grants and support for growers; d) distributing a weekly eNewsletter to growers featuring resources, deadlines, events, and support for the industry; and e) directly purchasing local RI oysters to distribute to food insecure communities to help build a future market to this local, sustainable product.

ASSESSING NITROGEN DYNAMICS IN A CLOSED, INTEGRATED AQUAPONICS SYSTEM

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Integrated multi-trophic aquaculture (IMTA) recycles fish waste through varying trophic levels that are within the same system. In this system, nitrogen-rich waste from prawns and fish and uneaten feed are broken down (regenerated) by bacteria and then taken up by plants, minimalizing waste and discharge of nutrients. The difficulty lies with balancing the system with appropriate species that can handle the different levels of nitrogen waste effectively because high ammonium and nitrite levels can become toxic to fish or prawns.

The goal of this project is to develop a model of nitrogen dynamics to minimize waste and nitrogen building while maximizing crop efficiency. Water quality parameters (including pH, temperature, specific conductivity, chlorophyll, blue-green algae, and dissolved oxygen), along with ambient nutrient concentrations (ammonium, nitrate, nitrite, urea, and ortho-phosphate), were measured over a six-month sampling period. Additionally, monthly water incubations were conducted to quantify rates of ammonium uptake regeneration, as well as nitrification. Ambient dissolved urea and nitrite concentrations in the water were 7.00 ± 4.72 mg L^{-1} and 0.03 ± 0.01 mg L^{-1}, respectively, which are well below levels toxic to fish. This demonstrates that the nitrogen balance was maintained by high rates of microbial activity.

Ammonium regeneration rates were higher than bacterial uptake rates, indicating that the microbial community provides a quick turnover of nitrogen subsequently available to plants. Ultimately, this system is scalable based on the results showing that the ratio of plants to fish maintains a steady state of dissolved nitrogen concentrations. Based on the ratio of the total number of crops in the system, tomato plants, fish (adults and juveniles), and crayfish, this system should be scalable by the approximate ratio of 1 tomato plant to 10 fish to 4 crayfish. This model can then be used to provide a template for future producers to be successful with the IMTA system developed at BGSU.

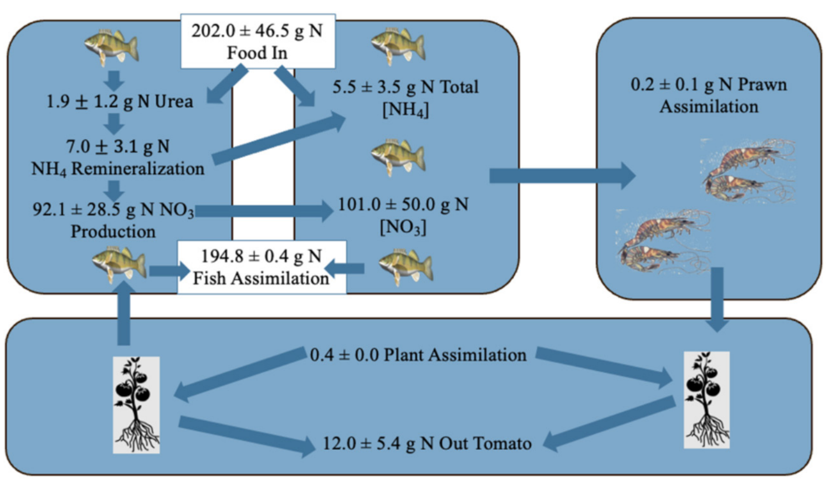

Figure 1. IMTA Nitrogen Mass Balance: Monthly

ANTIBIOTIC SENSITIVITY OF BACTERIA OBSERVED IN AQUACULTURE SPECIES IN WEST ALABAMA; 7 YEAR TREND

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West Alabama aquaculture farmers use antibiotics as a feed additive to treat major bacterial diseases including *Edwardsiella ictuluri*, *Edwardsiella piscicida*, virulent *Aeromonas hydrophila*, nonvirulent *Aeromonas* (*hydrophila, veronii, sobria, caviae*) and *Flavobacterium covae* (columnaris). When farmers wish to use antibiotics, personnel at the disease laboratory at the Alabama Fish Farming Center (AFFC) test the bacteria for resistance using antibiotic discs. However, other bacterial diseases have been used to test sensitivity to the approved antibiotics. These diseases include *Pleisiomonas* spp, *Clostridium spp*, and *Streptococcus inea*. In this study, bacterial cases brought into the Alabama Fish Farming Center from year 2015-2023 were tested using antibiotic sensitivity disks for the FDA approved Aquaflor (florfenicol), Terramycin 200, and Romet (sulfadimethoxine + ormetoprim) antibiotics. During the last two years, the AFFC personnel have started to do Minimum Inhibitory Concentrations for several additional antibiotics. There is evidence that these various bacteria are building resistance to the common antibiotics used to treat bacterial disease outbreaks. Sensitivity for all were determined as: diameter of 0-10 mm as resistant, 11-19 mm as intermediate and greater than 20 as susceptible. The data will show the resistance present amongst different diseases in West Alabama and how it has progressed over seven years.

EVALUATION OF GROWTH AND SEX PROPORTIONS IN THREE STRAINS OF NILE TILAPIA *Oreochromis niloticus* PRODUCED BY TWO METHODS OF SEX CONTROL

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Tilapia are one of the most important groups of food fishes and a globally traded commodity. Nile Tilapia (NT) is the most cultured species among tilapias due to its commercially valuable traits. NT contributes to nearly 9% of total inland aquaculture production worldwide. The growing intensification of NT has led to the need for genetic improvement and sex control. Large-scale selective breeding programs such as Genetically Improved Farmed Tilapia (GIFT) have enhanced growth performance. Sex control methods include genetic improvement (YY males), and the use of synthetic hormones (sex reversal). Kentucky State University (KSU) addresses hormone use in NT culture and YY male technology as an alternative by evaluating intraspecific crosses of commercial strains. This study assessed the productivity traits of three genetically enhanced strains of all-male NT produced by two methods of sex control. Objectives included: (1) production of genetically male NT (GMT), (2) growth evaluation of each strain for a 90-day production trial, and (3) assessment of sex proportion amongst strains.

Experimental fish were reared in recirculating aquaculture systems at KSU's Aquaculture Research Center, Frankfort, KY. GMT were produced through intraspecific hybridization of YY males (Fishgen Ltd) and XX females (GIFT, Louisiana Specialty Aquaculture LLC). Two additional strains of sex-reversed tilapia (SRT) produced by a commercial hatchery were obtained. All three strains (SRT-1, SRT-2, and GMT) were fed three times per day to satiation during the growth period (Figure 1). Total weight gain (WG), total feed input (TFI), feed conversion ratio (FCR), condition factor (K), and sex proportion were analyzed. Preliminary data obtained during the first six weeks revealed differences in growth rates between SRT-1, SRT-2, and GMT (Figure 2). Total feed input corresponds with growth trends illustrated in Figure 2. FCR results for SRT-1, SRT-2, and GMT were 0.917, 0.948, and 0.92. Condition factor was similar between SRT-1 (K = 2.374) and SRT-2 (K = 2.352), but lower for GMT (2.099). Sex proportion has not yet been identified. Preliminary results suggest that SRT-1 and SRT-2 may have traits of greater commercial value.

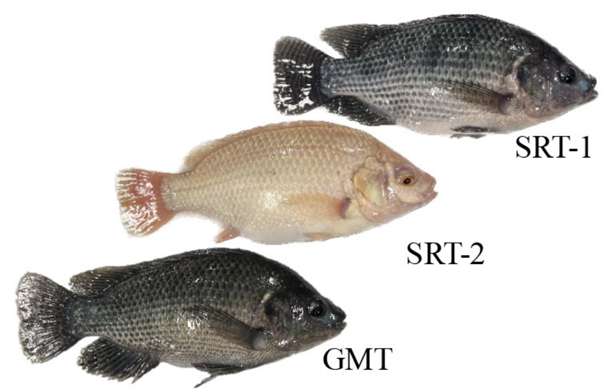

Figure 1. Representative images of three NT strains.

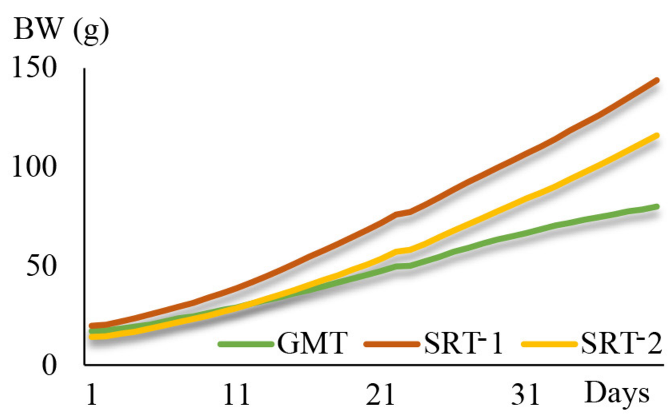

Figure 2. Growth performance is based on collected data (1 – 23 d) and predicted values (24 - 41 d).

USE OF REMOTE-CONTROLLED AUTOMATED FEEDERS TO IMPROVE INDOOR HATCHERY PRODUCTION

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Feed delivery is an essential challenge in aquaculture, ultimately impacting the long-term production yield of any cultured organism. In fish, the long-term benefits of optimal early-life feeding include greater survival, growth, and fecundity. Efficient feed delivery requires that fish feeding demands be reliably satisfied by optimizing feed timing and availability. New automated technologies provide remote capabilities through mobile devices, real-time monitoring, and online management of feeding schedules. These innovations in feeding technologies have the potential to increase efficiencies in fish larviculture and nursery practices. This report details the observations of employing remote-controlled automated feeders for juvenile fish production.

DXOPHIEX (DXO, Amazon Inc.) automated fish feeders were used for six months in nursery recirculating systems at the Aquaculture Production Technologies Laboratory, Kentucky State University, Frankfort, KY (Figure 1). This allowed for remote-controlled capabilities with Wi-Fi connection through mobile device application. Feed storage capacity was 200 mL, and dispense rates were controlled by an adjustable release tab on the rotating component. Dispensed feed amounts were calculated based on starting feed weight, 15 rotation counts, three release settings (light, medium, and heavy), and three feed sizes (0.3, 0.8, and 1.5-mm).

Figure 1. DXO feeder above nursery tank.

DXO automated feeders provided a predominantly reliable means of feed delivery. Dispense rates were found to be consistent for each feed size (Figure 2). Benefits include less time input, precise control, and increased overall efficiency. Drawbacks include electricity hazards and failure. Automated feeders such as the one used in this study allow for increased efficiency and control of feeding. This contributes to better management and improved hatchery production.

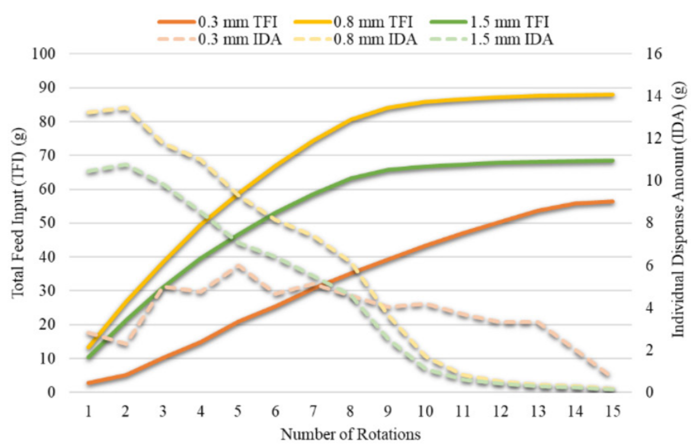

Figure 2. Total feed input and individual dispense amount for 15 rotations of each feed size on the heavy release setting.

PETUNIA GROWTH RESPONSE TO CONTAINER SUBSTRATE AMENDED WITH DEWATERED AQUACULTURE EFFLUENT AND TWO DIFFERENT SOURCES OF WATER

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This experiment evaluated petunia *Petunia × hybrida* 'Celebrity' growth response to amended commercial potting mix (F3B) with increased amounts (0%, 5%, 10%, 25% or 50 % container volume) of dewatered aquaculture effluent (AE). Petunias were fertigated with either a 20N–4.4P–16.6K water soluble fertilizer at 250 mg/L nitrogen or municipal water. The experiment was a completely randomized 2 × 5 factorial design with eight single-pot replications per treatment. At 39 days after planting, a significant ($P \leq 0.05$) substrate and water interaction existed for petunia growth index, bloom count, fresh weight, and dry weight. The 100% F3B, 5% AE, and 10% AE substrates benefited with a significantly ($P \leq 0.05$) greater bloom count, fresh weight, and dry weight when fertigation was used; however, the water source had no effect on petunia bloom count, fresh weight, or dry weight for substrate amended with greater than 25% AE. Fertigating substrates amended with 25% or greater AE did not improve petunia growth. When applying municipal water to the containerized petunias, fresh weight and dry weight were the greatest in treatments amended with 25% AE. Results demonstrate a farmer operating a freshwater, recirculating aquaculture system and treating their discharged effluent with geotextile technology for horticulture production could replace a commercial potting mix with dewatered aquaculture effluent at 25% container volume and not have to fertigate with a water soluble fertilizer to obtain a marketable plant.

EVALUATING THE FEASIBILITY OF INTEGRATING MULTI-VESSEL MEMBRANE BIOLOGICAL REACTORS WITHIN RAS: EFFECTS ON WATER QUALITY, WATER USE, AND RAINBOW TROUT *Oncorhynchus mykiss* PERFORMANCE

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Membrane biological reactors (MBRs) utilize ultrafiltration membranes that create a clean filtrate, while microbial processes occurring within mixed liquor solids facilitate nitrification and denitrification. Onsite research has shown that MBRs effectively reduce waste concentrations in aquaculture effluents and have potential for integration within RAS. For example, a recent Freshwater Institute study found that single-vessel MBRs receiving RAS backwash produced acceptable water quality for rainbow trout *Oncorhynchus mykiss* and led to significant water savings. However, a range of operational deficiencies were identified including rapid membrane fouling, incomplete denitrification, and challenges to maintain low oxygen levels and proper mixing of the activated sludge. These systems were redesigned by decoupling the membranes and the aerobic and anoxic zones for improved access and control of each treatment process.

Six replicated RAS (9.5 m^3 volume) were used for the next study, three of which were integrated with the redesigned systems along with Mempulse® MBR modules and a novel air scouring technology (Dupont, Indiana, USA). The other three RAS were operated without MBRs and enough flushing to maintain ≤ 75 mg/L nitrate-nitrogen (NO_3-N) in the fish culture water. Equal numbers of 1-kg rainbow trout were stocked in each RAS to begin. Granulated sugar was continuously added to the MBRs as a supplemental carbon source at a rate of ~0.23 kg/ per kg feed using repurposed belt feeders. Approximately 2,000 L/day of backwash was added to the MBRs and a similar permeate flow was returned to RAS. After 3.5-months of operation, low-dose ozone was used to improve water quality.

Water use was dramatically reduced in RAS equipped with MBRs. The mean system hydraulic retention time in MBR RAS was 82 days vs. 5 days in typically operated RAS. Water quality concentrations were maintained within acceptable limits. Average NO_3-N in RAS with and without MBRs was 78 ± 2 and 68 ± 1 mg/L, respectively. When operating with ozone, MBR RAS maintained comparable color and turbidity despite limited dilution. Moreover, rainbow trout growth was similar between treatments. After 4.7-months of production, trout in RAS with and without MBRs weighed 2.807 ± 0.033 and 2.800 ± 0.129 kg, respectively. Changes to MBR design and operation solved the challenges encountered during the initial study; however, new problems were identified including solids clogging behind restricted valves of small diameter (1.27 cm) pipes. Overall, however, MBRs appear to be a viable water treatment option that substantially reduces RAS water use, which could enable facility siting in water-limited areas and/or expansion of fish production volumes.

QUEEN CONCH MOBILE MARICULTURE LABS FOR FLORIDA AND THE CARIBBEAN

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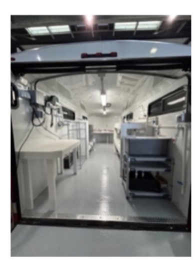
The largest molluscan fishery in the Caribbean is queen conch *Aliger gigas*. High demand for conch meat, coupled with overharvesting and degradation of coastal seagrass habitats, has led to substantial declines in certain populations. For example, queen conch populations remain very low in Florida despite total closure since 1986. In The Bahamas, where conch serves as a crucial protein source for local consumption and generates significant revenue, the fishery is experiencing a decline in many areas and product export is now banned. Local regulations, along with queen conch being a CITES Appendix II species, provide a framework for sustainable fishery management. However, NOAA Fisheries has recently proposed a rule to list the queen conch as a threatened species under the Endangered Species Act to prevent this important seagrass ecosystem and fishery species from reaching endangered status.

FAU Harbor Branch Queen Conch Lab's vision is to establish a queen conch farm in every Caribbean country as one of many solutions to assist with restoration. This vision started in 2019 with a partnership SK NOAA-funded queen conch hatchery at a Puerto Rico Fishing Association. Soon after, a queen conch hatchery was launched at the Curaçao Sea Aquarium. Since this time, the concept of Mobile Queen Conch Labs was conceived to reach more locations. The first Mobile Lab concept was developed and built for Great Exuma, Bahamas, in a partnership between Dr. Megan Davis of FAU and Catherine Booker of Bahamas National Trust, with funding from the Richard Schneider Trust. With support from Builders Initiative, two Mobile Labs will be established at the Queen Conch Mariculture Center in Grand Bahama, in close partnership with Blue Action Lab. As part of this funding, a Mobile Lab will also be stationed at the Harbor Branch Aquaculture Park for international training purposes. Additional Mobile Labs are underway for Jamaica, Puerto Rico, and Great Exuma. The Mobile Queen Conch Lab Hatchery (20' x 8') is fully equipped to grow queen conch from egg mass stage to early juvenile stage, with the capacity to grow up to 2,000 conch per year. The lab is designed to operate on solar power with backup batteries and an inverter. The saltwater growing systems can be water flow-through or recirculation. Key components include an egg mass incubation tank, larval rearing tanks with aeration, metamorphosis tanks, and a microalgae culture area. The Mobile Labs are installed by ocean engineers and scientists at FAU and then shipped to the various Caribbean locations.

A QUEEN CONCH FARM IN EVERY CARIBBEAN COUNTRY

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The queen conch (*Aliger gigas*) is the largest molluscan fishery in the Caribbean. High demand for its meat, coupled with overharvesting and degradation of coastal seagrass habitats, has led to substantial declines in its population. Local regulations, along with CITES Appendix II guidelines, assist with fishery management of the species but additional measures need to be taken. Recently, NOAA Fisheries announced a proposed rule to list queen conch as an Endangered Species Act threatened species to prevent it from becoming endangered.

FAU Harbor Branch Oceanographic Institute's Queen Conch Lab (QCL) works to provide the aquaculture of queen conch to help restore the species across its range and to realize the vision for a queen conch farm in every Caribbean country. This is a bold vision with many facets that need to be taken into consideration and cannot be accomplished alone. Along with the species and ecosystem, a core motivation for the QCL's work is to support the people who depend on the fishery. This species has a deep cultural space within the communities of the Caribbean. It serves as a crucial protein source for local consumption and generates significant revenue from harvests; in fact, whole communities have been formed around the existence of the species.

QCL sees the socioeconomic benefits of placing conch farms within communities to encourage workforce development, employment, training, and regional outreach, all with the goal of supporting restoration and forming new bonds with the queen conch. Giving fisherfolk and community members a significant role to play in restoration, and valuing their practical knowledge, allows the QCL to transfer knowledge of the conch's life cycle and the role it plays in the seagrass habitats with greater ease and trust.

There are currently six community-based, partnership conch farms across five countries: Puerto Rico, The Bahamas, Curaçao, Jamaica, and Florida, with others interested (see Figure). Since each farm is located in a different country or territory, there are key differences to be taken into consideration. These include the local culture, language, skill level, government, permitting, geography, and the environmental conditions of each place. To train staff in places that are so diverse begins with considering the commonalities, which include strategic partners and sponsors, community, communication, and the queen conch itself. This presentation provides insights into the social dimensions of what it takes to create community-based farms to assist with restoring the queen of the sea.

FISH MEAL INDUSTRY IN INDIA- PRESENT AND FUTURE

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The utilization of fishmeal over the past six decades has been shaped by evolving demands from various countries. In the early 1960s, the pig and poultry industry collectively dominated the global fish meal market. By the 1980s, the aquaculture feed industry emerged as a significant player in utilizing fish meal as a raw material in feed production. The escalating demand for high-quality and cost-effective animal protein heightened the importance of aquaculture as a primary protein source. This evolution endowed the sector with commercial value, transforming it into a key domestic supplier of much-needed high-quality animal protein and essential nutrients, while also generating employment opportunities and cash income. The sector has demonstrated an impressive overall growth rate of over 11.0 percent per year since 1984. Presently, global fishmeal production stands at around 5 million tonnes, with aquaculture contributing close to 4 million tonnes. According to the report, the global aqua feed market is projected to expand from US$ 61.8 billion in 2023 to US$ 88.0 billion by 2028, exhibiting a Compound Annual Growth Rate (CAGR) of 7.3% during the forecast period (2023-2028). In India, the major sectors which contribute to the foreign exchange earnings are sea food and fish meal. While the first sector received reasonable consolation from the governments, the second sector has been remaining comparatively ignored. Planners and policy makers have to pay extra attention for improving the overall value of the sector by means of ensuring quality of the product, welfare of the stakeholders and sustainability of the various marine species with potential to contribute without affecting the per capita fish availability of the nation. Indian Marine Ingredients Association (IMIA) is a non-profit organization that aims to promote and develop sustainable practices in the Indian fishmeal and fish oil industry by working hand in hand with various scientific organizations, universities, fishermen organizations, governmental and non – governmental bodies. It is expected that Indian fish meal industry will make a giant leap in the coming years with the support of the aforementioned entities.

IMPACT OF THE COVID-19 PANDEMIC AND INFLATION ON GLOBAL TRADE IN ORNAMENTAL FISH: IMPLICATIONS FOR THE UNITED STATES

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Global trade in ornamental fish has expanded over time. International trade (exports and imports) increased steadily from US$411.3 million in 2001 to a peak of US$723.5 million in 2011, then declined to US$647.8 million in 2019. The COVID-19 pandemic and worldwide inflation have affected the ornamental fish trade. Ornamental fish is considered a luxury commodity in terms of its demand, which is more sensitive to its price and consumers' income. Therefore, analyzing the impacts of the pandemic-induced shock and inflation on demand and trade of ornamental fish is critical. This study has examined the impact of the COVID-19 pandemic on the performance of ornamental fish trade globally, compared to the long-term trends and with a special focus on the United States. Also, it has quantified the impacts of inflation on the ornamental fish trade (export and import) by the United States. The study has identified the shift in top exporters and major export destinations of ornamental fish. Besides, it has measured major exporters' comparative advantage and competitiveness in the ornamental fish trade. It has used the revealed symmetric comparative advantage (RSCA) index to quantify the comparative advantage of top exporters in exporting ornamental fish and the Vollrath index to measure their revealed competitiveness in the ornamental fish trade. Our study showed a significant change in major producers and importers in the world over the last two decades. The pandemic has increased the risks and biosafety concerns. The pandemic and inflation have negatively affected global trade. The U.S. enjoyed a comparative advantage in the export of ornamental fish throughout the study period (2001-2022). There was a steep decline in ornamental exports globally and by the U.S. during the pandemic and inflationary period. However, the U.S. has observed a consistent upward trajectory on the import front even during the pandemic and inflation, with a notable spike in 2021. This escalation is likely attributable to amplified domestic demand during the pandemic. United States exporters also face steep price competition. Attractive fish with an assurance of high-quality certified ornamental fish export benefits the United States exporters.

IMPACT OF TRADE RESTRICTIONS ON FISH AND FISHERY PRODUCTS TRADE BETWEEN THE UNITED STATES AND CHINA

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The trade relationship between the United States and China increased, particularly after China's admission into the World Trade Organization (WTO) in 2001. China is a major source of fish and fishery products imported by the United States and one of the top destinations for these products exported by the USA. The present study analyzes the long-term trends (2001 to 2023) in fish and fishery products trade (export, import, and re-export), comparative advantage, and competitiveness in trade between the USA and China. We have used the revealed symmetric comparative advantage (RSCA) index to quantify the comparative advantage and the Vollrath index to measure the revealed competitiveness of the United States fish and fishery products trade with China. Between 2001 and 2017, the US exports of such products to China increased 11 times, from US$ 103.2 million in 2001 to US$ 1235.7 million in 2017. During this period, imports from China increased by 2.7 times, from US$ 549.1 million in 2001 to US$ 2025.9 million in 2017. Interdependence in trade between these two countries increased over time. In 2018, the United States and China initiated trade restrictions and imposed new tariffs on different commodities, including seafood products, popularly known as a "trade war". From 2020 onwards, the COVID-19 pandemic has also hindered trade between the two countries. Most recently, inflation has been affecting trade. We have documented trade regulatory measures on fish and other seafood items carried out by both governments and quantified the impacts of the so-called "trade war," the pandemic, and rising inflation on trade, comparative advantage, and competitiveness of the United States. Finally, we articulate the implications of the research findings for promoting fish and fishery products trade between the two countries.

ESTABLISHING AN ATLANTIC SALMON (*Salmo salar L.*) PRIMARY GILL CELL LINE FOR ADVANCING RESEARCH ON INFECTIOUS SALMON ANEMIA VIRUS (ISAV) HPR0

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Infectious Salmon Anemia Virus (ISAV), belonging to the *Orthomyxoviridae* family, consists of eight negative single-stranded RNA segments and is the causative agent of infectious salmon anemia (ISA), a severe disease of Atlantic salmon (*Salmo salar L.*). ISA can cause significant mortalities of up to 90% in infected aquacultured Atlantic salmon. ISAV can be classified into two subtype groups: a highly virulent HPR-delete variant and avirulent non-delete variant (ISAV-HPR0). Whether or not avirulent HPR0 leads to virulent HPR-delete remains in question. Understanding the dynamics between these two variants could play a vital role in helping to control disease outbreaks caused by ISAV-delete and thus lead to a more economically sustainable Atlantic salmon aquaculture industry. One major hurdle to better understanding the role that ISAV-HPR0 plays in virulence and disease is due to the inability to propagate and amplify ISAV-HPR0 in cell lines. Because ISAV-HPR0 appears to mainly target Atlantic salmon epithelial gill cells, a method for culturing primary gill cells from Atlantic salmon was developed. In repeated trials, 100% confluency was obtained in 25cm^2 cell culture flasks, but subculture of these cells was not achieved. Establishing Atlantic primary gill cell lines could lead to the amplification of ISAV-HPR0 for further investigation of the relationship between virulent HPR-delete and avirulent HPR0. With the ability to culture primary gill cells, continued research aims at preparing primary gill cells from Atlantic salmon that have tested positive for ISAV HPR0 to determine if amplification of the viral agent can be achieved in these cells.

LOWERING THE COST OF GENOMIC SELECTION BY GENOTYPING MICROHAPLOTYPES

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A lack of genetically improved strains is consistently noted as an impediment to growth of the aquaculture industry. Genomic selection can help address this need by increasing the rate of genetic improvement in breeding programs. However, the required genotyping is often cost-prohibitive. Genotyping costs are exacerbated by the high number of aquaculture species, which impedes the reduction of costs through a shared genetic panel (e.g., a high-density SNP array). The aquaculture industry needs a genotyping strategy for genomic selection that can be applied at low volumes across a wide range of species.

One previously described solution is to reserve high-density genotyping for key individuals and apply a low-density SNP panel along with pedigree-based imputation to the remaining individuals. We examined the possibility of further lowering the cost of this strategy by targeting microhaplotypes instead of SNPs in the low-density panel, which could allow smaller panels to be used. We simulated Pacific oyster, eastern oyster, and Atlantic salmon breeding programs for three generations and compared imputation and GEBV accuracy using low-density panels targeting SNPs or microhaplotypes. Panels targeting microhaplotypes yielded higher imputation and GEBV accuracy than that of equally sized panels targeting SNPs. In the Pacific and eastern oyster simulations, close to the maximum imputation and GEBV accuracy was reached when the low-density panel contained 150 - 250 microhaplotypes or 350 - 450 SNPs. In the Atlantic salmon simulations, this level of accuracy was reached with low-density panels of 350 - 450 microhaplotypes or 650 - 750 SNPs. Using low-density panels targeting microhaplotypes instead of SNPs can allow programs to genotype fewer loci, thereby reducing the cost of genotyping. This will make genomic selection feasible for a wider range of aquaculture breeding programs.

CAN FORMULATED FEED REPLACE FROZEN BLOODWORMS FOR FEEDING LAKE STURGEON *Acipenser Fulvescens*)?

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Lake sturgeon, currently designated as species of special concern or threatened in several Great Lakes Region states, have demonstrated successful growth and nutrient retention in previous studies involving young juvenile specimens (3-80 g body weight (BW)) fed formulated feed. This study aims to identify the optimal feeding rate for lake sturgeon and compare their performance with fish fed frozen bloodworms, a commonly used feed in lake sturgeon hatcheries for conservation purposes.

In this investigation, lake sturgeon with an average initial BW of 100.7±1.4 g (n=21) were fed a commercial feed (45% protein and 12% lipid) over a four-week period. Six feeding rates were tested: 0.25%, 0.5%, 1.0%, 1.5%, 2.0%, and 3.0% of BW per day. A reference group was fed frozen bloodworms at a rate of 1.20% dry weight of BW per day. The fish received three daily meals, with three tanks per treatment and 12 fish per tank. At the end of the feeding trial, the fish underwent an acute heat shock test, involving subjecting them to stress at 30°C for 20 hours. Results indicated that the optimal feeding rates for sturgeon fed the commercial feed were 2.8% and 1.87% of BW daily, based on specific growth rate and feed efficiency, respectively. Positive correlations were observed between feeding rates and condition factor, hepatosomatic index, and visceral fat. Increasing the feeding rate led to the accumulation of lipid and energy in the whole fish ($P<0.05$). Overall, growth performance and nutritional composition were comparable ($P>0.05$) between fish fed the commercial diet at 1.5% of BW per day and those fed frozen bloodworms. Serum glucose levels increased with higher feeding rates, displaying a positive response to heat shock stress in all treatment groups. Acute heat shock significantly increased the alpha-diversity of gut microbiomes and elevated serum cortisol levels in sturgeon, with bloodworm-fed fish exhibiting higher cortisol levels compared to fish fed the commercial feed at the 1.5% feeding rate. This suggests that fish fed bloodworms may be more vulnerable to stress. These findings imply that formulated feed can be a suitable alternative to bloodworms for raising lake sturgeon for stocking purposes.

Table 1. Growth performance and stress response of lake sturgeon fed formulated feed and bloodworm.

Treatment	Growth performance					Basal		Heat shock	
	WG %	FCR	CF	HSI %	VSI %	glucose mmol/L	cortisol ng/ml	glucose mmol/L	cortisol ng/ml
1.5%- feed	58.8±1.1	0.70±0.01	0.39±0.00	1.9±0.0	8.3±0.4	3.4±0.2	1.1±0.3a,x	3.8±0.1	3.1±0.4a,y
Bloodworm	53.7±1.4	0.51±0.01	0.38±0.01	2.1±0.1	8.8±0.1	3.3±0.1	3.1±0.0b,x	3.9±0.2	7.7±2.8b,y

Data were presented as mean ± SE, n=3. The letters a and b indicate the difference ($P<0.05$) between treatments. WG, weight gain percentage; FCR, feed conversion ratio; HSI, hepatosomatic index; VSI, visceral index.

ESTIMATION OF FOOD DEMAND AND NUTRIENT ELASTICITIES: A DISAGGEDATED ANALYSIS OF THE BANGLADESH HOUSEHOLD INCOME AND EXPENDITURE SURVEY DATA OF 2000, 2005, 2010, AND 2016

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We have analyzed the Bangladesh Household Income and Expenditure Survey (HIES) data from years 2000, 2005, 2010, and 2016 to estimates food and protein demand elasticities for fish, meat, poultry, and poultry eggs. We have used Quadratic Almost Ideal Demand System (QAIDS) models to estimate demand elasticities. For derivation of nutrient (protein) elasticities, we have matched consumption information in HIES with nutritional contents of the food consumed. The results of the QUAIDS model are divided into two levels: aggregate animal protein-source level and disaggregated fish level. At the aggregate level, we have investigated the demand for fish with other sources of protein that include meat, poultry, and poultry eggs. Meat consists of beef, buffalo, and mutton. Poultry and poultry eggs are comprised of hen and duck. For fish, we disaggregated into 12 different categories, covering both aquaculture and capture species. To calculate the expenditure elasticity, we have divided the HIES data into four quantiles, segregated based on the yearly expenditure of the households.

At the aggregate level, on average, the own-price elasticities of sources of animal protein vary from -0.32 to -3.79, demonstrating the heterogeneity of demand for animal protein across the years. The own-price elasticities of fish can be considered almost unitary elastic, except for the year 2000. Expenditure elasticities of all sources of animal protein are positive, indicating that fish, meat, poultry, and poultry egg are considered a normal good by households, regardless of their wealth status.

At the disaggregate level, the own-price elasticities of fish species produced through aquaculture, particularly tilapia, pangasius, and exotic carps are greater than one, and they follow a downward trend across the years. Their own-price protein elasticities are less than 1, and a small decline in demand with a change in price. Own-price elasticities of hilsa and Indian carps are greater than one; however, they decline across the years. The own-price protein elasticities of Indian carps and hilsa are inelastic and these elasticities do not decline much across the years. Most of the cross-price elasticities and cross-price protein elasticities of fish across the species are positive implying that majority of the fish species are substitutes to each other. On the other hand, fish species like exotic carps, shol/gojar/taki, tilapia/puti, small fish species (mala/kachi/chapila) are found to be complements with pangasius and airbreathing fish for years 2000 and 2005. Expenditure elasticities and expenditure protein elasticities of fish across the species over the four survey years are found to be positive, indicating that fish in general is considered as the normal good in Bangladesh. However, expenditure elasticities of hilsa are elastic with a value greater than one. This suggests that hilsa is a luxury fish in Bangladesh.

FACILITIES SHOWCASE: THE UNIVERSITY OF FLORIDA’S TROPICAL AQUACULTURE LABORATORY

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The University of Florida’s Tropical Aquaculture Lab (TAL) is part of the Program in Fisheries and Aquatic Sciences within the School of Forest, Fisheries, and Geomatics Sciences, at the UF Institute of Food and Agricultural Sciences. This laboratory was started in 1996 to better address the needs of the Florida ornamental aquaculture industry. Fish health and applied aquaculture production research were two of the early programs at the TAL. These programs have since expanded to include disciplines such as aquatic ecology, physiology, non-native species ecology and management, reproduction, restoration aquaculture, as well as extension programming in public and youth education. The facilities at the TAL have also expanded over time to now include a 5,000 square foot office building and disease diagnostic laboratory, a hatchery facility, 5 greenhouses, and a 6.5 acre fish farm with 48 ponds. This infrastructure allows the faculty, staff, and students of the TAL the flexbility to address a broad diversity of research foci in an interdisciplinary fashion. Partenerships with Hillsborough Community College, USDA APHIS Wildlife Services and USDA APHIS Veterinary Services, have helped to further strengthen aquaculture programming at the TAL and broaden the resources available to the Florida aquaculture community. Serving Florida’s aquaculture industry by solving problems and creating opportunities, the TAL is committed to working with stakeholders to promote the growth and resilience of US aquaculture.

EVALUATION OF LOW SALINITY CULTURE PROTOCOLS FOR HOGFISH *Lachnolaimus maximus*

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Hogfish (*Lachnolaimus maximus*), a popular sport and food fish, are highly sought after by anglers and have historically experienced overfishing through parts of their range. Aquaculture and stock enhancement are potential tools that can be used to supplement wild harvest and improve wild stocks, but limited understanding of biological and technical aspects of hogfish culture has stymied these efforts. We sought to characterize the osmoregulatory capacity of hogfish as osmoregulation can be metabolically expensive and limit somatic growth and production efficiency. Culturing fish in isosmotic environments could reduce bioenergetic requirements, thereby improving growth. To better understand this capacity in hogfish we conducted four experiments: survival after acute salinity transfers from 32 g/L to 4, 8, 16, 24, & 32 g/L, physiological (plasma chloride, plasma osmolality, muscle water content, and hematocrit) tolerance of acute transfer to 8 g/L, physiological tolerance of gradual transfer to 12 g/L, and finally an exploration of low salinity culture at 16 g/L and 32 g/L to assess effects on growth and feed conversion.

Results of these experiments show hogfish survived at ≥8 g/L for 96 hours (Fig. 1), however, plasma chloride, plasma osmolality, and muscle water content were significantly altered at 8 g/L and mortalities were noted during long term retention at 8 g/L. Gradual transfer to 12 g/L yielded no significant physiological alterations compared with acute transfer to the same salinity for the parameters measured. Furthermore, growth indices for hogfish in 16 g/L and 32 g/L were similar though the variance in metrics suggest a need for further exploration. This suggests that hogfish should be tolerant of rapid transfer to salinities as low as 12 g/L and that growth may be unaffected by low salinity culture down to 16 g/L salinity. Results from this research will help guide future aquaculture and stock enhancement efforts for hogfish and add to the growing body of literature for this valuable marine species.

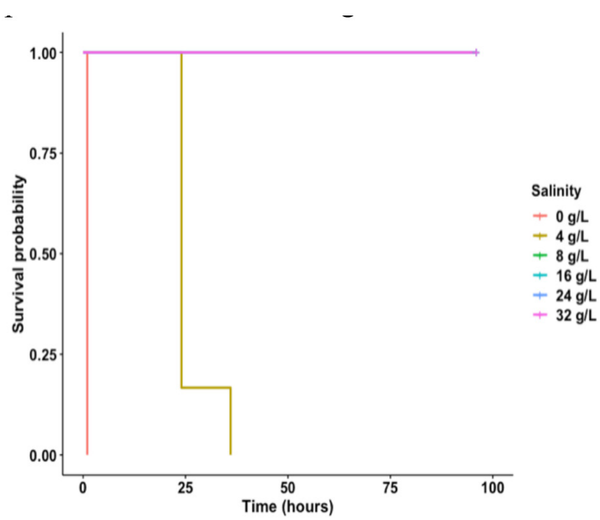

Figure 1. Survival plot for hogfish acute salinity transfer experiment using a Kaplan-Meier model. Fish were transferred to 0 g/L, 4 g/L, 8 g/L, 16 g/L, 24 g/L, and 32 g/L and monitored for survival over 96 hours. For all treatments except 0 g/L and 4 g/L there were 0 mortalities for the duration of the experiment.

IDENTIFYING OPTIMAL THERMAL REGIME FOR RAISING NILE TILAPIA AND LETTUCE IN AN AQUAPONIC SYSTEM

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Aquaponics is a fast-growing subsector of aquaculture that combines recirculating aquaculture with hydroponic plant production. The most common pairing of fish and plants in commercial systems currently is Nile tilapia and lettuce. Nile tilapia and lettuce have different thermal preferences for growing. Nile tilapia perform best in warm water around 30°C, while lettuce tends to grow best at cool temperatures around 20°C. Hence, the objective of this study was to evaluate the performance of four heat-tolerant lettuce varieties and Nile tilapia across a thermal range of 18-30°C in four-degree intervals. A heat tolerant variety was selected from each of the four main category of lettuce, resulting in four varieties of lettuce being used in this study (Parris Island, Butterhead, Black Seeded Simpson and Iceberg Batavian). Each of the 20 aquaponic systems used in this study consisted of a 114L fish tank, a 100L deep water culture hydroponic unit and a 19L biofilter. The experiment involved 4 treatments (18, 22, 26, 30°C) with five replicated systems. Eight tilapia (initial weight: 95.4 ± 0.95g) were stocked in each of the 20 fish tanks. Three replicates from each of the four varieties were used in each system (12 plants/ system). The experiment was conducted for five weeks. Water quality parameters were maintained at adequate levels for both tilapia and lettuce. At the termination of the study, lettuce was harvested and both wet and dry weights were collected. Tilapia were harvested and total biomass was recorded. Weight gain of tilapia was significantly better at 26 and 30°C than at 18 and 22°C. All four varieties of lettuce preformed significantly better at 30 °C than at 18 or 22 °C ($p< 0.05$). The current study suggests that a temperature of 26°C could be used when culturing tilapia and lettuce in an aquaponic system. However, additional studies are needed to determine if other heat-tolerant leafy greens are truly tolerant of higher temperatures.

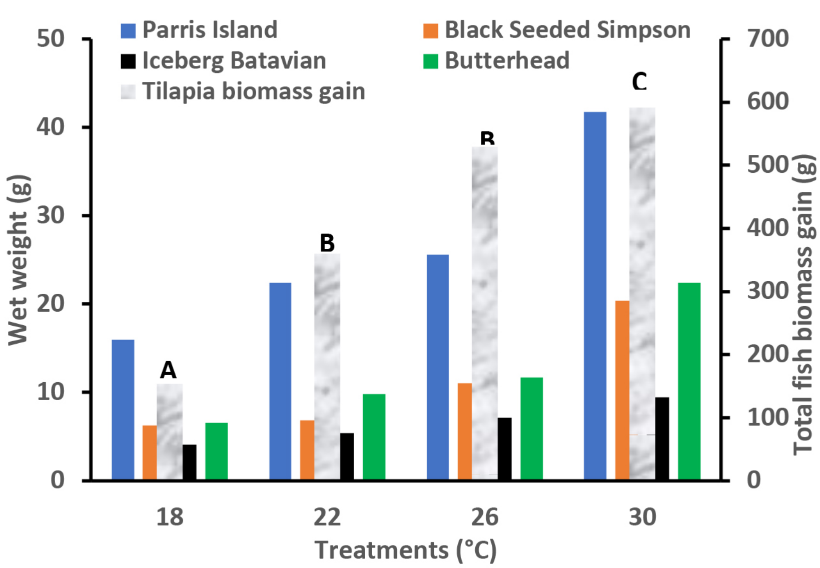

Figure 1: Growth performance of Nile tilapia and four lettuce varieties in an aquaponic system at the end of 5-week trial. All lettuce variety wet weights are on the primary Y-axis (left) and fish biomass gain is on secondary Y-axis

CATFISH IN KENYA TO OYSTERS IN OREGON: MY PATH FROM EXPEDITIONARY TO EXTENSION AQUACULTURE

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The first ten years of my military service had prepared me for a lot, but being asked to travel to Kenya in the summer of 2012 to represent the U.S. Navy's Maritime Civil Affairs Command (MCAC) as the Aquaculture Liaison still managed to surprise me. In 2009, the Government of Kenya built nearly 50,000 fish ponds across Kenya, but did not have the resources to train each of the novice fish farmers how to effectively manage their ponds. In 2012, this program expanded to what was previously the Coast Province of Kenya, and the Government of Kenya asked MCAC to join others in providing outreach and education to Program Officers and fish farmers. I spent nearly two months on the ground, working with farmers from Msambweni to Mkondoni to advance efforts in rearing and selling tilapia and catfish.

Although my background is in commercial, marine fisheries, my work in Kenya helped to create an interest in aquaculture that persists today. That experience demonstrated firsthand the vital importance of providing alternate sources of both nutrition and livelihoods, as well as the time, effort, and money required to develop novel industries. I have continued to refine my work in aquaculture, moving on to shellfish and seaweeds, always with an emphasis on the human dimensions of aquaculture operations. With Oregon Sea Grant, I have focused on supporting the local industry, to include needs assessments, workforce development planning, and permitting guidance.

Despite the significant difference in my work more than a decade ago in Africa and my work today in the Pacific Northwest, there have been unifying themes throughout. In this presentation, I will discuss my early work with expeditionary aquaculture, my current work with Extension, and highlight the many lessons learned and challenges that persist across geographies and economies.

A FUNNY THING HAPPENED ON MY WAY TO BECOMING A MARINE BIOLOGIST

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Many children realize early that they are heart-wired to love the ocean so they seek out a marine science education and career. Some even stick with ocean science and research, only to find themselves wondering about a life in policy. The goal of this session is to hear from one woman's experience working her way from marine biologist(-ish) to ocean conservation policy advocate to leading an aquaculture campaign at a global nonprofit intent on developing U.S. offshore aquaculture that it is sustainable and equitable.

This presentation will cover an overview of Ruth's professional aquaculture policy career and include her personal reflections on (1) why working in U.S. federal aquaculture policy is a great area of work as an American woman, (2) how U.S. aquaculture policy requires intentional growth informed by a large, diverse coalition to ensure the domestic industry develops inclusively and equitably, (3) challenges that women and nonbinary individuals may face as they progress in their careers and (4) recommendations on what more established professional women can do to lessen the hurdles and champion a next wave of aquaculture leaders.

GROW IT HERE, DO IT RIGHT: THE COALITION FOR SUSTAINABLE AQUACULTURE

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The Coalition for Sustainable Aquaculture (CSA) is a partnership dedicated to growing sustainable and equitable offshore aquaculture industry in the United States. Composed of environmental advocates, industry leaders, and award-winning chefs, the CSA recognizes that it is possible and beneficial to grow more seafood at home, but environmental and social risks are very real and must be addressed. This session will provide an overview of the CSA and its goal to ensure the U.S. charts a responsible path forward for farming in offshore waters.

OVERVIEW OF CANADA'S AQUACULTURE MONITORING PROGRAM

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Finfish and shellfish aquaculture activities can be associated with environmental variations induced by the release of compounds (e.g., organic matter, trace metals, drugs, pesticides) and pelagic depletions (e.g., phytoplankton and zooplankton). These effects are better characterized near and within aquaculture lease areas but less is known about environmental variation induced in the far-field. Fisheries and Oceans Canada initiated the Aquaculture Monitoring Program (AMP) in 2017 to conduct long-term environmental monitoring outside of aquaculture lease areas. AMP includes data collection, sampling, and analysis with the objective to detect, monitor, and model aquaculture-related changes to the benthic and pelagic environment near select coastal aquaculture locations. Parameters measured include sediment grain size, organic matter, trace metals, sulfides, infauna communities, drugs, seston, phytoplankton, and zooplankton. A national database is being developed to store data from sampling activities. Information from this program is being used to support research initiatives and will be used to inform decision making. The program is also allowing for the development of nationally consistent methods for sample collection, sample analysis, and statistical design as well as research on new innovative monitoring approaches.

INVESTIGATING PRACTICAL STRATEGIES FOR POST-HARVEST REMOVAL OF OFF-FLAVORS IN FARMED FISH

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Of the many challenges involved in sustaining economically-viable aquacultural operations, consistent quality and flavor of farmed fish products may have the largest potential to influence consumer preferences. In particular, occurrence of "musty" or "earthy" flavors in fish is undesirable and decreases product values. 2-Methylisoborneol (MIB) and geosmin (GSM) are often responsible for these off-flavors, and accumulation in farmed fish can be both rapid and sporadic depending upon the microbial content of rearing waters. Although much effort is involved in removing MIB and GSM prior to harvest, fish fillets with detectable levels of MIB or GSM can occasionally reach consumers. Strategies for post-harvest off-flavor removal must consider the overall quality of the final product, so harsh treatment conditions involving chemical oxidants are not practical. Fillet treatments involving marination in weakly acidic media have been reported to reduce the off-flavors in fish, though the exact conditions and optimal parameters have not been defined. MIB and GSM degradation in weakly acidic water containing ascorbic, citric, and maleic acid were evaluated and quantified using instrumental analyses to assess the practical feasibility of post-harvest off-flavor removal in fillets. 1000-fold reduction of MIB concentrations were observed at pH 2.4, while only moderate GSM degradation occurred at pH values below 2. Near-complete regeneration of MIB and GSM upon neutralization of acidic solutions was observed, suggesting limited efficacy of acidic treatments in off-flavor fish products.

SHORT AND LONG-TERM AQUAPONIC PROGRAMMING AT VIRGINIA STATE UNIVERSITY

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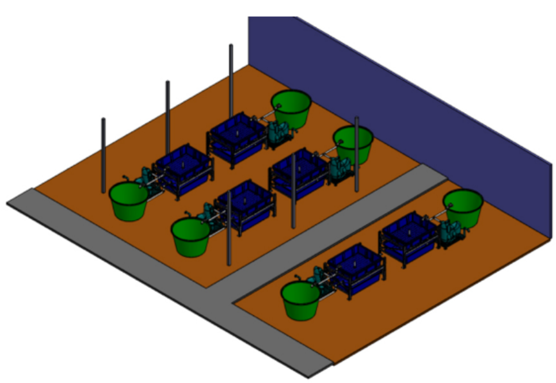
Aquaponic production provides many benefits to some of the shortcomings of traditional agriculture (soil-based; wild caught), especially when considering the future effects of climate change. For example, aquaponic production can be located anywhere (indoors, rooftops, abandoned buildings, etc.) with access to electricity and freshwater, allowing for year-round production of both aquatic organisms and organic plants. Additionally, aquaponic systems are extremely efficient in terms of resource usage (freshwater, arable land, nutrients), where in some cases these systems can produce 30x more food per acre of land and consume 90% less freshwater than traditional soil-based agriculture. Currently there is a large economic push and incentivization for CEA operations in Virginia, making this is an opportunistic time for short- and long-term development of aquaponic programming at Virginia State University and Virginia Cooperative Extension.

When considering how to develop VSU's aquaponic programming, four main program pillar areas were considered that include: 1) Public perception (marketing, surveys, resource usage metrics, etc.), 2) Farmer support (stocking programs, workforce development, educational videos/offerings, producer guides, etc.), 3) Innovation (vertical designs, alternative designs, nanobubbles, alternative species, etc.), and 4) Value-add (freeze drying, mineralization/emulsion, compost, etc.). Using these four program pillar areas short- (1-3 years) and long-term (3-5+ years) programming was developed to support existing aquaponic producers within VA as well as create a landscape that stimulates further development of the industry within VA and the US.

Examples of short-term programming include ***pilot-scale*** replicated research systems (Figure 1), Mobile Aquaponic Demonstration and Education Unit (MADE-U), nanobubble integration into aquaponic design, vertical/alternative system design, multi-state collaborations (KYSU, UA, VT, etc.), continuous generation of producer educational materials (production guides, factsheets, etc.), and annual extension agent training and public workshops. Examples of long-term programming include fish stocking and plant genetic programs, establishment of workforce pipeline with industry partners, mass archive of educational materials, and a VSU Aquaponic Center of Excellence.

FIGURE 1. Six replicated pilot-scale aquaponic systems (300 gal/system) located in Controlled Greenhouse



LEVERAGING TECHNOLOGY FOR SUSTAINABLE PRACTICES: NAVIGATING THE TRANSFORMATIVE SEAS OF THE U.S. AQUACULTURE, WILD FISHERY AND SEAWEED INDUSTRY THROUGH TECHNOLOGICAL ADVANCEMENTS AND INNOVATIONS

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This study focuses on the application of technology to enhance sustainability in the seafood industry, specifically in seaweed farming, fishing, and aquaculture. The study involved research and interviews with various stakeholders in the industry, including seaweed farmers, fishery operators, aquaculture farmers, and industry experts in Washington and New York states. The study identified several challenges, including unclear regulations and guidelines, environmental concerns, property right issues, and a lack of industry knowledge. The study also found limited adoption of remote sensing technology, primarily due to a lack of awareness and understanding among farmers. The research suggests that educational initiatives could help familiarize farmers with the potential uses of remote sensing and other innovative technologies. The study also highlights the diverse range of tools used by farmers and identifies challenges related to water quality, climate, and salinity. The desired improvements include technological advancements and non-technological improvements such as consumer patronage and better regulations. The study concludes with recommendations for improving the sustainability of these industries and suggests that addressing these challenges could help to further expand the industry and reduce the country's reliance on imported seaweed. The ultimate goal is to leverage innovative technology and effective strategies to create a more sustainable and thriving seafood industry.

DEVELOPING A SMART FISH SMOKING TECHNOLOGY FOR CATFISH AQUACULTURE IN THE NIGER DELTA, NIGERIA

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Directed by Professor Michael F Tlusty

Fish is an important component of the Nigerian diet, and the aquaculture industry is expanding to meet the increasing demand caused by the decline in wild capture fishery (FAO, 2017b; Ozigbo, 2014). Nigeria, particularly the coastal regions like the Niger Delta, has immense potential for aquaculture development (FAO, 2017b; Ozigbo, 2014). Among the various fish species, catfish (Clarias spp.) is highly sought after due to its native status, affordability compared to other animal proteins, and absence of religious taboos associated with beef and pork (Olagunju, 2007; FDF, 2008).

Aquaculture plays a vital role in ensuring food security and sovereignty in Nigeria, and smoking fish is the primary method of preservation in the absence of cold storage facilities and cold chains (PIND, 2014b). Smoking not only extends the shelf life of fish but also enhances its flavor, reduces waste, and increases protein availability. Smoked fish has emerged as a popular alternative to fresh fish, with a significant consumption rate in the Niger Delta region (PIND, 2014b). The demand for smoked fish, both domestically and internationally, continues to grow.

However, the current fish smoking practices pose sustainability challenges for the sector. Traditional smoking technology, heavily relied upon by farmers, has been associated with environmental and health hazards. Additionally, the burden of smoking falls disproportionately on women, who are primarily responsible for the process.

Addressing these challenges is crucial to ensure that the future of the Nigerian aquaculture industry is environmentally sustainable and does not compromise the health of those involved in smoking or consuming the fish.

This study aims to evaluate the feasibility of a new catfish processing technology, in the Niger Delta. This technology offers a faster, safer, and more user-friendly alternative to existing methods. Its implementation is expected to enhance the safety and quality of the final product by eliminating polycyclic aromatic hydrocarbon (PAH) residues on the fish, increase profitability for processors, improve working conditions for fish farmers (especially women), reduce environmental damage caused by catfish farming, enhance the industry's resilience to climate change, and contribute to achieving several sustainable development goals, including good health and well-being (SDG 3), gender equality (SDG 5), decent work and economic growth (SDG 8), and climate action (SDG 13).

USING DATA MONITORING TO COLLECT DISSOLVED OXYGEN AND TEMPERATURE WHEN ACCESSING WATER QUALITY AND ITS IMPACT ON FISH HEALTH, AN INTRODUCTION TO THE MINIDOT® CLEAR LOGGER

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Aquafarm and hatchery managers, transporters and researchers make decisions regarding fish health based on water quality. Water quality management is an essential tool for any aquaculture operation and is affected by variables that can drastically affect fish health and production procedures. Aquasend®, a brand of Precision Measurement Engineering, has introduced the miniDOT® Clear Logger to researchers and managers in various segments of aquaculture as a reliable, easy-to-use logger with quick access to data.

The miniDOT® Clear Logger is a completely submersible instrument that records measurements in real-time displayed through an internal LCD screen, granting quick access to water quality data. The oxygen sensor is an optode that measures dissolved oxygen concentration in water through a fluorescence method. These features allow users to view vital water quality data just by looking at the device to save valuable time if dissolved oxygen or temperature levels begin to rapidly shift.

During my presentation, I will give an overview of the miniDOT® Clear and the feedback we have experienced since its introduction to aquaculture and the three major uses that have emerged. Aquatic transport is one segment where the logger is proving to be an essential tool. No matter the fish species being transported, from largemouth bass to tilapia or even sturgeon, it is crucial to maintain proper oxygen levels and temperatures. Each fish species has unique habitat requirements most often revolving around dissolved oxygen levels and temperature. The logger is currently being used by transporters who do not have the resources to invest in trucks and tanks equipped with oxygen systems. These transporters have utilized the logger to quickly monitor water quality levels, therefore reducing fish stress levels and ensuring a quality product upon arrival.

Other use scenarios include aquaponics systems where monitoring water paraments of dissolved oxygen and temperature is essential to maintain conditions for both fish and plants. Low DO threatens the health of fish and the quality and quantity of plants grown. These same researchers have also identified the portability and visual access to water quality data during the research process, whether in the field or in the lab. The Logger has proven to be an essential tool to not only collect water quality data but to aid researchers and their students in accessing water quality in real-time while affording the ability to react based on quality data.

GONADAL PRODUCTION AND QUALITY ENHANCEMENT IN THE RED SEA URCHIN (*Mesocentrotus franciscanus*) FED WITH DULSE (*Devaleraea mollis)* AND SEA LETTUCE (*Ulva lactuca*) HARVESTED FROM A LAND-BASED INTEGRATED MULTI-TROPHIC AQUACULTURE (IMTA) SYSTEM

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The red sea urchin (RSU, *Mesocentrotus franciscanus*) is the largest echinoid in kelp forest communities along the west coast of North America, and is a well-established commercial fishery in California. Over-grazing by sea urchins is contributing to the decimation of kelp forests, creating "urchin barrens". Urchins on barrens have little to no commercial value because of their low gonadosomatic index (GSI). Harvesting urchins from barrens and enhancing their gonad through aquaculture has the potential to transform these destructive grazers into high-quality seafood that also benefits the ecological restoration of kelp forests. In addition to developing formulated diets, seaweeds cultivated with nutrient-enriched effluents in integrated multi-trophic aquaculture (IMTA) systems are considered as good food resources for urchins.

We integrated green macroalgae sea lettuce *Ulva lactuca* and red macroalgae dulse *Devaleraea mollis* cultures in the effluent stream of white seabass *Atractoscion nobilis* tanks in a land-based integrated multi-trophic aquaculture (IMTA) system. Harvested *U. lactuca* and *D. mollis* were then fed three times per week to RSUs for eight weeks. Biochemical components of *U. lactuca* and *D. mollis* were measured. Sub-samples of RSUs were dissected to assess the GSI (Gonad wet weight/whole urchin wet weight × 100), and gonad quality at the middle and end of the experiment.

The results showed that GSI of RSUs fed with IMTA-harvested *U. lactuca* and *D. mollis* was 4.64±0.66 % and 6.35±1.30 % at the end of trial, respectively, with an average weekly GSI increase of 0.18 ± 0.07 %/week and 0.37 ± 0.07 %/week. Gonad color changed from dark brown at the beginning to bright yellow/orange in the end. RSUs fed with either *U. lactuca* or *D. mollis* all reached Grade B at the end compared to Grade D at the beginning (Grade A: premium; Grade B: high; Grade C: mediocre; Grade D: unacceptable). The taste of gonads was categorized as "normal" when assessed by a local distributor. The results indicated that *U. lactuca* and *D. mollis* cultured in IMTA systems can be used as a sole food source for gonad enhancement of RSUs. Biochemical composition of the seaweeds is pending.

Figure 1. From left to right: cultured RSUs; Dissected RSUs; weighing gonad; measuring texture.

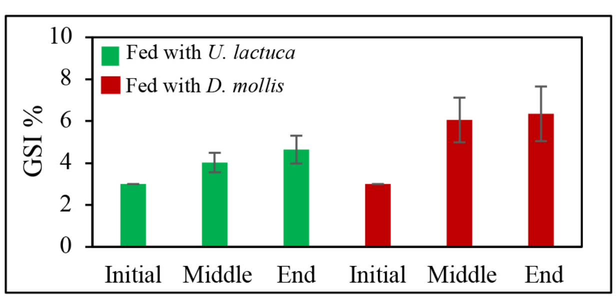

Figure 2. GSI of RSUs fed with *U. lactuca* and *D. mollis*.

SHELLFISH AQUACULTURE. TRENDS AND CHALLENGES FOCUSED ON MEDITERRANEAN BASIN

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Globally, aquaculture productions continue to increase, and will soon surpass even the production of capture fisheries, which have reached the limit. In 2020, global total production of marine ecosystems was estimated at 178 million tons, of which 90 million tons (51%) from capture fisheries and the remaining 88 million tons (49%) from aquaculture activities. Therefore, aquaculture continues to grow faster than the other main food production sectors.

In general, abalone, arkshells, clams, conchs, cockles, mussels, oysters, pectens, scallops, winkles, and aquatic plants production alone, accounting for almost 31% (approx. 54 million tons) of the total global productions. Specifically, non−fed species currently account for about half of aquaculture productions and offer a potentially significant contribution to the sustainable growth of the global aquatic food supply.

Shellfish farming alone accounts for a large portion of global productions; reaching about 54 million tons of live weight in 2020. The main productions are mainly attributable to the families Mytilidae, Veneridae, and Ostreidae. Coastal areas and wetlands devoted to the production of these important low-cost protein sources are at risk of impact due to climate change. Moreover, the response of these fragile ecosystems is highly dependent on both the magnitude of change and their physical characteristics.

Today, most of the bivalve molluscs consumed are farmed, produced in a number of European countries, North America, China and Chile. The European Union, the United States of America, China, and the Republic of Korea account for the bulk of import demand. Demand for bivalves has remained relatively steady over time, and the species have benefited from a positive perception among consumers as a healthy and sustainable food option. In 2020, global exports of bivalve molluscs totalled USD 4.3 billion, representing around 2.8 percent of the value of global exports of aquatic products.

This preliminary study aims to highlight globally, and then focus on the Mediterranean basin, what are the productions related to the main species of bivalve molluscs reared, the trade and food balances, also highlighting what are the trends and will be the future challenges of these sustainable extensive aquaculture practices.

PARTHENOGENESIS IN ELASMOBRANCHS: FIRST CASE IN THE COMMON SMOOTH–HOUND *Mustelus mustelus*

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Parthenogenesis, or "virgin birth", has been described in all vertebrate taxa except mammals. Some vertebrate species adopt obligate parthenogenesis due to the absence of males in the population (e.g., the desert lizard *Cnemidophorus uniparens*). However, in species that normally reproduce sexually, ticopartenogenesis occurs exceptionally. Most vertebrates, such as varanids, elasmobranchs, and some snakes, implement facultative parthenogenesis, changing their adaptive strategy according to circumstances. However, the triggers for parthenogenesis are still unclear, but the lack of male specimens is thought to play an important role.

Parthenogenesis in elasmobranchs has been described in captive animals, given the difficulty of documenting it in wild. Specifically, cases of parthenogenesis have been documented for viviparous species such as the Bonnethead *Sphyrna tiburo* (2001), the Blacktip shark *Carcharhinus limbatus* (2007), and the Whitetip reef shark *Triaenodon obesus* (2012). This reproductive phenomenon has also been observed in oviparous species. Between 2002 and 2005, it was documented for the Whitespotted bamboo shark *Chiloscyllium plagiosum*. Subsequently, for the Zebra shark *Stegostoma tigrinum* (2008; 2017), and in 2014, multiple parthenogenesis was documented for the Swellshark *Cephaloscyllium ventriosum*.

In this study, the common Smooth–hound were reared for 13 years in a public aquarium (Cala Gonone Aquarium; Sardinia, Italy) in absence of conspecific males. However, a quite annual young production was precisely observed in absence of males. The storage of sperm in the female reproductive tract has been documented in several species of female elasmobranchs, from weeks up to 45 months. Using 13 species–specific microsatellite loci, the alternate hypothesis was tested here that the offspring were the result of long–term sperm storage or parthenogenesis. Moreover, each offspring was reconducted to its proper mother.

Perkinsus spp. INFECTIONS IN GROOVED CARPET SHELL *Ruditapes decussatus* FROM NATURAL BANKS OF SARDINIAN WETLANDS, ITALY

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Perkinsus spp. displays a remarkably broad spectrum of host organisms, and all stages after settlement are susceptible (even if infection intensity increases with the age of the host.). Documented hosts encompass various clam species such as Sydney cockle *Anadara trapezia*, little‒neck cockles *Austrovenus stutchburyi*, grooved carpet shell *Ruditapes decussatus*, Japanese carpet shell *R. philippinarum*, etc. Additionally, oysters (e.g., Jinjiang Oyster *Crassostrea ariakensis*, black‒lipped pearl oyster *Pinctada margaritifera*, etc.) are confirmed hosts. Within the known geographic range, other bivalve and gastropod species may potentially fall prey to this parasite. Notably, members of the Arcidae, Malleidae, Isognomonidae, Chamidae, and Veneridae families exhibit particular susceptibility.

This has substantial implications for both the fisheries and aquaculture sectors, resulting in substantial economic losses. Prevalence is highly variable depending on host and environmental conditions, but it is often 100%. Infections in clam hosts can be lethal depending on environmental conditions, and death may occur 1 or 2 years after infection.

Histology remains a pivotal and conventional diagnostic method for detecting *Perkinsus* spp., although polymerase chain reaction (PCR), *in situ* Hybridization (ISH), and transmission electron microscopy (TEM) are recommended to provide a species‒specific diagnosis. This study investigates *Perkinsus* spp. infections in wild Grooved carpet shell *R. decussatus* collected from three distinct brackish environments in Sardinia, Italy (i.e., Calich, Porto Pozzo, and Santa Gilla) dedicated to extensive aquaculture.

Histological analysis of tissue sections from each clam (n=300) was performed to identify the presence of *Perkinsus* spp., determine its prevalence, and assess the immune response in target organs and infected tissue (i.e., connective tissue of all organs, and haemocytes). *Perkinsus* spp. were retrieved in all sites, with varying infection percentages and a substantial host immune response. The highest prevalence was recorded in clams from Calich lagoon, particularly in the digestive gland (37%) and gills (68%). Porto Pozzo and Santa Gilla lagoons displayed a gill prevalence of 23%. Anyway, the prevalence of *Perkinsus* spp. in the kidney was less frequent across all sampling sites, with parasite presence ranging from 7% (Porto Pozzo lagoon) to 22% (Calich lagoon). The presence of haemocytes infiltration, observed across all sites and organs, was significantly correlated with the protozoan *Perkinsus* spp. ($p<0.001$). *R. decussatus* were found to be suitable as biological indicators sensitive to environmental stressors, such as perkinsosis. However, further monitoring plans in these areas are essential.

Vibrio aestuarianus CORRELATION WITH TISSUE LESIONS IN CULTIVATED OYSTERS *Magallana gigas* IN SARDINIA, ITALY: MOLECULAR AND *in situ* HYBRIDIZATION APPROACHES

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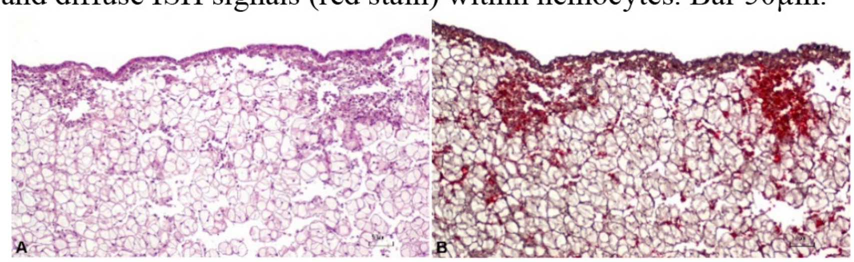
Vibrio aestuarianus subsp. *francensis* has been identified as a pathogenic agent responsible for recurring mortality in adult Pacific cupped oysters (*Magallana gigas*) in several countries. However, studies attribute these mortalities to the interaction of environmental factors and pathogens. Little information available in the literature highlights the need to clarify the mechanisms of action of *V. aestuarianus* in *M. gigas*. The objective of this study was to apply an *in situ* hybridization (ISH) system (RNAscope®) to detect the presence of *Vibrio* spp. in *M. gigas*.

Twenty‒eight oysters (*M. gigas*) were manually collected during a mortality event (October 2016‒March 2017) from San Teodoro lagoon, one of Sardinia's leading oyster culture facilities, with a water temperature of 14°C. The collected samples were investigated by molecular, histopathological, and *in situ* hybridization (ISH) techniques.

In 29% of the oysters, the mantle exhibited a moderate to severe, nodular to multifocal hemocytic inflammatory infiltrate associated with a concentration of *V. aestuarianus* greater than 10^4 copies/µL in qPCR. ISH demonstrated the presence of *Vibrio* spp. in 78% of the subjects associated with an inflammatory process in the mantle and gills, with a stronger and diffuse signal in oysters displaying moderate to severe inflammation ($r=0.66$, $p<0.05$) (Figure 1). Our results suggest that *V. aestuarianus* is a major contributor to oysters mortality.

Figure 1. Oyster mantle. A: severe and multifocal hemocytic inflammatory response. H&E Bar 50µm. B: Vibrio spp. stronger and diffuse ISH signals (red stain) within hemocytes. Bar 50µm.



I DIDN'T REALIZE, IT WAS ALWAYS AQUACULTURE

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It recently occurred to me that beginning with my undergraduate senior project, my work has always involved aquaculture. However, because the culturing was a means to another end, I didn't consider it to be aquaculture.

My undergraduate senior thesis project asked if fish made choices. I learned how to keep the water clear and keep the fish calm for my experiments, and also look for signs of infection as well as how to treat them with salt. But this wasn't aquaculture, was it?

My first job as a research associate was to use my senior thesis methods to assess how exposure to crude oil affected this choice behavior (and how they responded to a hologram). I now had many tanks of fish to care for and kept track of all the dominance interactions in the control and treatment groups. But surely, this wasn't aquaculture.

Graduate school extended my studies into the visual search behavior of fish on zooplankton. Water clarity was crucial for the studies as well as maintaining healthy fish and cultures of algae to feed cultures of zooplankton for my experiments. But I didn't think this was aquaculture.

My post-doctoral research led me to the retinal development of many different species of fish. I learned histology and molecular biology methods to study the changes in the eye. Once again, I had to rear my subject species which ranged from winter flounder to African cichlids. I have continued my study of eye development to the present day, examining salmon, lake sturgeon, muskellunge and arctic grayling. I was able to collaborate with Michigan DNR hatcheries and facilities at Stanford University and Woods Hole Oceanographic Institute for help rearing the species. Yes, they were aqua culturists, but was I?

For many years now, I have been a Biology professor at LSSU. But it wasn't until 2011, that I advised three fisheries sophomores in a business plan competition. Their plan was to raise fish as a business. As we learned about the aquaculture industry, and its potential to address global food insecurity and water scarcity, the students gravitated to aquaponics. Their business plan won the judge's choice award, and they created a company, Superior AquaSystems LLC. I now supervise an active student aquaculture club that is a student sub-unit of USAS, and believe my focus is now aquaculture. But now I realize, it was always aquaculture.

ASSESSING THE FEASIBILITY OF LAND-BASED CO-CULTURE OF PURPLE SEA URCHINS *Strongylocentrotus purpuratus* AND PACIFIC DULSE *Devaleraea mollis* IN OREGON

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Expanding populations of purple sea urchins (*Strongylocentrotus purpuratus*) have decimated many kelp beds along the US West Coast, resulting in expansive "urchin barrens". Sea urchins harvested from barrens are typically devoid of gonad tissue and have little to no market value. Promoting gonad development within barren-sourced urchins through supplemental feeding in land-based tanks is one strategy to regain market value. Pacific dulse (*Devaleraea mollis*) is a nutritious red macroalgae commercially produced in land-based tanks that may serve as both a nutritious food source and an *in situ* biofilter in dulse-urchin co-culture systems.

A series of experiments were conducted in central and southern Oregon to quantify the rate that purple sea urchins consume Pacific dulse, the rate of gonad growth when fed a mono-algal diet of Pacific dulse, and the effect of sea urchin stocking density on gonad growth and survival. Results were then used to estimate the cost of purple urchin gonad enhancement in a simple small-farm model assuming different levels of Pacific dulse productivity due to seasonal availability of ambient photosynthetically active radiation (PAR; 7.5 to 40.0 mol photon m^{-2} d^{-1}).

Purple urchins readily consumed Pacific dulse, with size-specific feed consumption rates ranging from 6% to 2% BW d^{-1} for 30 g to 160 g animals, respectively. A mono-algal diet of Pacific dulse supported rapid gonad growth in both semi-commercial and research-scale trials. Gonad production, however, was significantly affected by urchin stocking density ($p<0.01$), with gonad index increasing from a base-line of 2.5% BW to 12.5% BW in the highest density treatment and 18.5% BW in the lowest density treatment (Figure 1). Predicted co-culture production costs were strongly affected by dulse productivity with break-even prices ranging from below \$5 to over \$14 urchin^{-1} depending on ambient light levels.

Gonad enhancement of barren-sourced purple urchins was successful in land-based tanks when fed a mono-algal diet of Pacific dulse. While biologically feasible, these results demonstrate the importance of considering seasonal variation in dulse productivity when assessing farm profitability. Alternate feed sources should be considered during periods of low solar radiation.

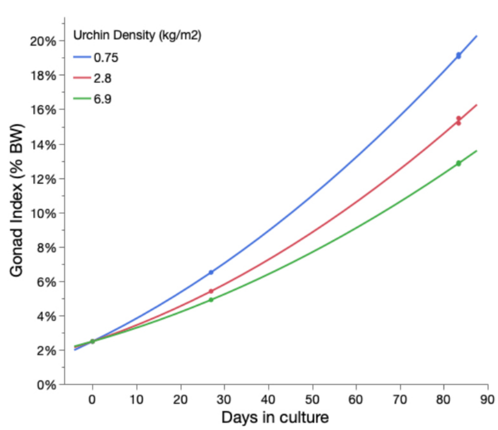

Figure 1. Effect of stocking density (kg urchin m^{-2}) on purple sea urchin gonad index (%BW) over an 85-day growth trial.

BLACK SOLDIER FLY LARVAE *Hermetia illucens* OIL AS A POTENTIAL NUTRACEUTICAL INGREDIENT IN DIETS FOR HYBRID CATFISH *Ictalurus punctatus* × *I. furcatus*

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Insects are promising bioconverting organisms and they can play a major role in addressing the issues related to organic wastes worldwide. A promising insect is the black soldier fly larvae (*Hermetia illucens*, BSFL), which can convert organic wastes into raw materials for animal feeds. However, BSFL meal production process results in large amounts of oil as a by-product. The oil from BSFL is rich in saturated fatty acids (SFAs), and lauric acid (LA, C12:0) is the predominant fatty acid. It has been previously reported that dietary lauric acid supplementation can reduce the proliferation of pathogenic microorganisms in the fish gastrointestinal tract, inhibiting inflammation and stimulating growth performance. Thus, the present study evaluated the potential of BSFL oil as a substitute for catfish oil in diets of hybrid catfish juveniles.

Nine hundred hybrid catfish juveniles (~17.4 g initial weight) were equally distributed in 30, 110-L aquaria, operating as a recirculating system. Experimental diets were formulated to be isoproteic (40% of crude protein) and isocaloric (20.45 MJ kg^{-1} of digestible energy) containing BSFL oil as a substitute for catfish oil at 0, 25%, 50%, 75% and 100% replacement levels. Fish were fed to apparent satiation twice a day for 60 days. At the end of the feeding trial, fish had ~474% weight gain, and significant differences were observed for weight gain (P=0.03) (Figure 1), feed efficiency (P=0.004), viscerosomatic indices (P=0.03) and total weight gain (P=0.01). No differences were detected for the hepatosomatic index, intraperitoneal fat ratio, hematocrit, hemoglobin, and feed intake. Fillet samples were collected for fatty acid analysis and results are pending. Fish were fed their assigned experimental feed for an additional week, and digesta samples were collected from the posterior segment of the intestine, and DNA was extracted for 16S rRNA sequencing. The intestinal microbiome results are also pending. At the end of the experiment, all fish were moved to a flow-through system, and they were subjected to a bacterial challenge using 7×10^6 CFU/g of *Aeromonas hydrophila* delivered through intraperitoneal injection. The dietary treatments did not have a significant effect on survival after the bacterial challenge. It can be concluded from the preliminary results of this feeding trial, that up to 50% of the catfish oil can be replaced with BSFL oil without any detrimental effects on production performance or compromising the disease resistance of hybrid catfish juveniles against *A. hydrophila*.

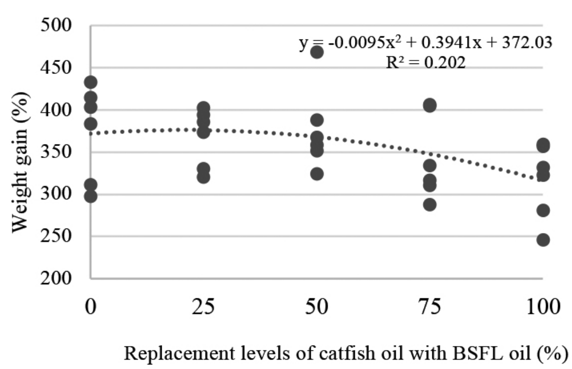

Figure 1. Weight gain of hybrid catfish fed the experimental diets for 60 days.

HIGH-DENSITY PELLET IMPROVES HOMOGENEITY AMONG JUVENILES TAMBAQUI *Colossoma macropomum*

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The aim of this study was to evaluate the influence of bulk density of the pellet diet on feeding and aggressiveness, as well as the production performance and homogeneity of the batch of tambaqui juveniles. To manufacture the experimental diets, the single screw extruder settings were adjusted to produce pellets (equal diet formulation) with different bulk densities: high-density (HD), medium-density (MD), and low-density (LD). The study was divided into three trials. Trial 1: assessment of the physical quality of pellets: bulk density (BD), floatability (F), expansion (E), water solubility index (WSI), water absorvation index (WAI), pellet durability index (PDI), water stability (WS), and sinking velocity (SV). Trial 2: 48 fish were used to assess the aggressiveness of tambaqui juveniles when offered the experimental pellets. Fish were distributed in 12 aquariums (55L; n=4; 4 fish/aquarium) in a completely randomized design with three treatments (HD, MD, and LD). For the behavioral interactions analysis, fish were recorded for 3 days, for 5 minutes after feeding, with a total of 360 minutes of observation. Ethograms of feeding behavior and aggressive interaction were elaborated and used to quantify the frequency of the respective behavioral units. To investigate the influence of bulk density on production performance (Trial 3), 225 tambaqui juveniles were equally distributed in 15 circular polyethylene tanks (260 L), in a completely randomized design using the same dietary treatments (n=5, 15 fish/tank). Fish were fed four times a day with 3% of biomass for 9 weeks. In trial 1, all variables were significantly affected by the density of the pellets, except for WSI and WAI. An inverse relationship between E and BD was observed, in which pellets with higher E presented lower BD. LD presented 75.33% of F, and pellets from MD and HD sank as soon as they reached the water, with sinking velocity of 3.22 ± 0.40 and 7.37 ± 0.94 cm/s, respectively. PDI was lower for LD diets, with 99.69 ± 0.03, due to the increase in E, which results in pellets with thinner walls and less resistance to mechanical stress. In trial 2, the time of feed consumption of fish fed LD was longer, totaling 8.7 ± 2.8 minutes. However, HD and MD were similar, with 0.2 ± 2.4 and 0.2 ± 3.9 min, respectively. It is likely that the physical characteristic of the LD of floating in static water, demotivated fish to fed with the same motivation as the fish fed HD and MD, which immediately sank when reaching the water. However, fish fed MD presented higher aggressiveness and social instability in relation to fish fed HD and LD pellets. The longer period that the feed pellets stay in the water column, more competition is displayed by the tambaqui while feeding. Tambaqui from trial 3, had higher feed intake when offered HD and MD pellets when compared to the fish fed LD. Despite no significant differences were observed for the weight gain data, fish fed with HD presented lower variance in total weight (15.9% of the coefficient of variation). HD pellet is suitable for feeding tambaqui juveniles, resulting in a more stable social hierarchy with lower aggressiveness and more homogeneous batch of fish.

EFFECTS OF BACILLUS SUBTILIS AS A SINGLE STRAIN PROBIOTIC ON GROWTH, DISEASE RESISTANCE AND IMMUNE RESPONSE OF STRIPED CATFISH (*Pangasius hypophthalmus*)

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The present study investigated the potential role of Bacillus subtilis as probiotic in striped catfish (*Pangasius hypophthalmus*). Fish (initial weight=150.00±2.63 g, n=180) were stocked in circular tanks. Four isonitrogenous (30%) and isolipidic (3.29%) diets were formulated having supplementation of *B. subtilis* at four different levels (P0; 0, P1: 1×10^6, P2: 1×10^8 and P3: 1×10^{10} CFU/g).

Each treatment had three replicates, while each replicate had fifteen fish. The trial started in the second week of July and continued for eight weeks. Growth, feed conversion ratio, crude protein content, the concentration of amylase and protease, the profile of both dispensable and non-dispensable amino acids in all four dietary groups increased with a gradual increase of *B. subtilis* in the diet. At the end of growth experiment, fish in all four groups were exposed to Staphylococcus aureus (5×10^5 CFU/ml). After S. aureus challenge, fish fed with *B. subtilis* responded better to damage caused by reactive oxygen species and lipid peroxidation and better survival rate. The catalase and superoxide dismutase level also increased in response to bacterial challenge in B. subtilis fed groups. On the other hand, the concentration of malondialdehyde gradually decreased in these groups (+veP0>P1>P2>P3). It is concluded that supplementation of B. subtilis as a probiotic improved the growth, protein content, antioxidant response and immunocompetency against S. aureus in striped catfish. The optimum dosage of B. subtilis, at a concentration of 1×1010 CFU/g, resulted in the most favorable outcomes in striped catfish. This single bacterial strain can be used as an effective probiotic in large scale production of aquafeed for striped catfish.

Table Summary of growth parameters in four dietary groups at the end of the growth experiment. Different superscripts across the rows represent the variance between treatments were applied as a result of one-way ANOVA.

Parameters	P0	P1	P2	P3
TBW (g)	217.73±2.51^a	228.02±8.43^a	254.06±5.82^b	398.01±16.97^c
TBL (cm)	27.07±0.17^a	27.73±0.28^a	28.01±0.28^b	32.39±0.39 ^{c}
SGR (%/day)	0.66± 0.02^a	0.71±0.01^b	0.87±0.01^c	1.61±0.03^d
FCR	2.55±0.01^d	2.13±0.02^c	1.71±0.01^b	0.89±0.02^a
K (%)	1.10±0.01^b	1.07±0.01^a	1.16±0.01^c	1.17±0.01^c
HSI (%)	1.01±0.01^a	1.32±0.01^c	1.31±0.01^b	1.49±0.01 ^{d}
VSI (%)	2.98±0.02^a	3.19±0.04^b	3.36±0.03^c	2.98±0.01^a

P0: 0, P1: 1×10^6, P2: 1×10^8 and P3: 1×10^{10} CFU/g of *B. subtilis*), TBW-total body weight, TBL- total body length, SGR- specific growth rate, FCR-feed conversion ratio, K- condition factor, HSI-hepatosomatic index, VSI-viscerosomatic index

CAN OMNIVOROUS FRESHWATER FISH UTILIZE AFRICAN PALM WEEVIL *Rhynchophorus phoenicis* OIL? ASSESSING THE DIETARY EFFECT ON GROWTH, HEALTH STATUS, AND HISTOMORPHOLOGY OF AFRICAN CATFISH *Clarias gariepinus*

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To achieve sustainable aquaculture production and ensure global competitiveness in animal protein supply, more effort must be geared towards the use of alternative ingredients in fish feed production. Expanded research on the use of alternative oils indicates that vegetable oil might be a suitable substitute without much effect on fish performance; however, the foreseeable competition in the near future for vegetable oils may pose a danger to the aquaculture industry. Hence, the aim of this study was to unravel the dietary influence of African palm weevil oil on the growth performance, serum biochemistry, lipid peroxidation products, antioxidant enzyme response, and organ integrity of African catfish (*Clarias gariepinus*) juveniles. Four isonitrogenous (383.18 g/kg) diets were formulated, wherein the control diet was prepared using soybean oil (SO) as the main dietary oil source, and this was replaced with palm weevil oil (PWO) in the treatment diets at 50% (PW-50), 75% (PW-75), or 100% (PW-100). African catfish (180, average weight: 18.76±0.043) were stocked at 15 fish per 50-L tank in triplicate. Fish were hand-fed to apparent satiation twice daily for 45 days.

The result of the trial indicates the highest weight gain (WG), specific growth rate (SGR), and thermal growth coefficient (TGC) values were found in the control (SO)-fed fish, which is similar to the PWO 50% but differs significantly from others ($p<0.05$). The FCR and PPV showed linear and quadratic trends, with a significantly lowest and highest value recorded in fish fed control and PWO 50% compared to other dietary groups ($p<0.05$). The PER value decreases linearly ($p<0.001$) as the level of PWO increases. Lysozyme, total immunoglobulin, and SOD activity were found to be higher in fish fed PWO-75% and PWO-50%, respectively, compared to other dietary groups ($p<0.05$). No significant effect was observed in the ALT, AST, and C-reactive proteins among the groups. The fish fed PWO-100% had the lowest recorded values of villus height, area of absorption, and cryptal depth ($p<0.05$). In summary, the results of the current findings showed that African palm weevil-derived oil could be used up to 50% in the diet of African catfish without any adverse effect on fish performance or health.

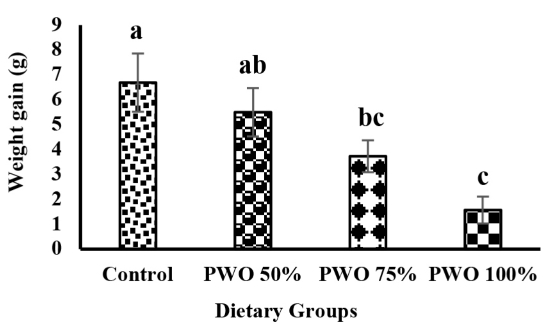

Fig 1: Growth performance

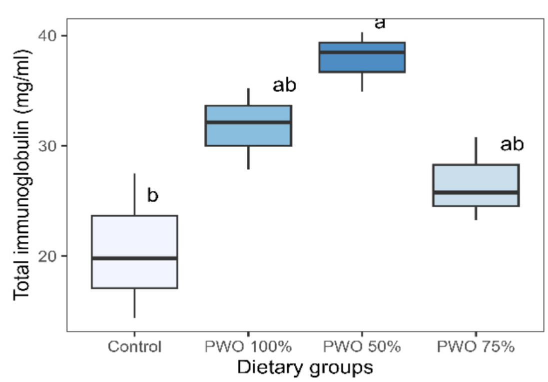

Fig 2: Total immunoglobulin

SET YOURSELF UP FOR SUCCESS FOR PERMIT REVIEW UNDER SECTION 7 OF THE ENDANGERED SPECIES ACT

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The Endangered Species Act (ESA) of 1973 provides a framework to conserve and protect threatened and endangered species. Section 7 of the ESA: (1) authorizes federal agencies to carry out programs for the conservation of endangered and threatened species and (2) requires federal agencies to consult with NOAA Fisheries on activities that may impact any ESA-listed species or designated critical habitat under NOAA Fisheries' purview. For aquaculture, the ESA Section 7 consultation process comes into play when a federal agency, such as the Army Corps of Engineers or Environmental Protection Agency, proposes to issue a permit for aquaculture operations. That federal agency requests consultation with NOAA Fisheries and the permit cannot be issued until the consultation is completed.

The consultation can often be a significant part of the permitting process, and it is imperative that applicants and federal agencies understand what information should be provided to efficiently and successfully complete the consultation process. The information needed to complete review of an aquaculture project will vary by project specifics and location but includes such things as project location and size, gear characteristics, pile driving, vessel transit areas, and information on construction, maintenance, and decommissioning. Aquaculture specific information includes farm size and layout, anchoring and mooring specifications, vessel size, speed, and route to the farm, species being cultured, diagrams of the gear, and more. In this presentation, we will provide an overview of Section 7 of the ESA, offer guidance on the information needed to successfully complete a consultation on an aquaculture operation, and identify tools that can assist applicants with completing this process in a timely fashion.

REPLACING SOY PROTEIN WITH INSECT MEAL IN A FISHMEAL FREE DIET FOR ATLANTIC SALMON *Salmo salar*

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In the coming years, conventional agriculture will fall short of meeting global protein requirements. Today, fishmeal is considered a gold standard protein ingredient in pet food and livestock feed due to its amino acid composition and digestibility characteristics. However, the global supply of fishmeal is capped at 5-7M tons per year because there are limited fish in the sea. Volatile prices and environmental concerns have left many investors and consumers seeking alternatives to fishmeal, a market worth \$9.5B annually. Insect farming could help fill growing gaps in agricultural supply chains. Research trials have shown that the amino acid profiles and digestibility of insect species could make them an ideal ingredient in the \$25B pet food market and the \$100B aquaculture feed industry.

The Place laboratory has worked with the yellow mealworm supplier Instar Farms to investigate the possibility of using the darkling beetle larvae called yellow mealworms (*Tenebrio molitor*) as a replacement for fishmeal. This work has resulted in a shortening of the production schedule, an improvement in the amino acid content of the insect meal, and the establishment of secondary products from the waste material (e.g. chitin).

The Place lab seeks to further test the viability of insect meal replacers with commercial partners at Stratium. The latest project involves a comparative study, evaluating the potential of black soldier fly (*Hermetia illucens*) larvae meal. Six groups of salmon are part of the experiment, with three groups fed a diet containing 25% black soldier fly larvae (BSFL) meal and three groups with an equivalent amount of soy meal. The study focuses on assessing the nutritional impact of incorporating BSFL into salmon diets, considering growth performance, feed conversion efficiency, and overall health.

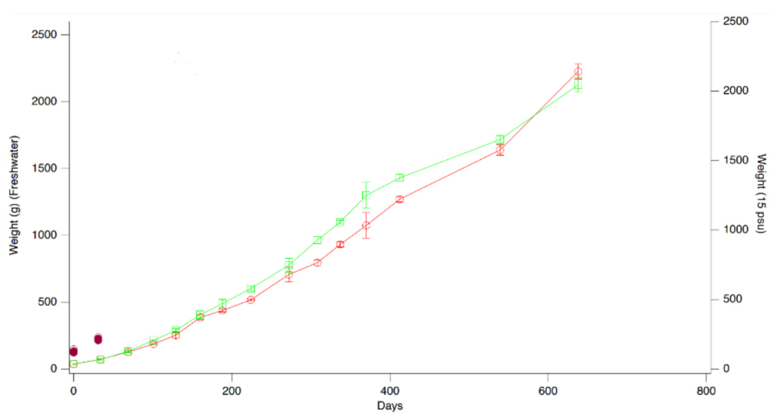

Fig. 1. Growth Curves of Atlantic Salmon Fed Different Protein Sources: A graph illustrating the growth performance of Atlantic salmon from the *T. molitor* project - 25% fish meal (green) vs 25% yellow mealworm (red), and the first two data points for the BSFL project - comparing 25% BSFL diet (purple outline) vs 25% soy meal diet (solid purple).

MINERAL NANOPARTICLES SUPPLEMENTATION IN THE DIETS OF CHANNEL CATFISH *Ictalurus punctatus*

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In recent years, the application of micronutrient nanoparticles as dietary supplements has increased in aquaculture research. Nanoparticles have increased surface area, which may facilitate their bioavailability; thereby, improving micronutrient uptake and metabolism. The aim of this study was to evaluate the effects of dietary iron and copper nanoparticles on growth performance and health of channel catfish. A feeding trial was carried out for 9 weeks to evaluate the control (basal iron and copper) and the nanoparticle treatments: iron nanoparticles (FeNP), copper nanoparticles (CuNP), and iron nanoparticles + copper nanoparticles (Fe+CuNP). Iron and copper were included in the control and treatment diets at 500 mg Fe/kg of feed and 10 mg Cu/kg of feed. The growth performance, hematocrit, and the experimental bacterial challenge against *Edwardsiella ictaluri* have been evaluated. Digesta samples also were collected to evaluate the intestinal microbiota. The DNA samples were extracted, and they will be subjected to 16S rRNA sequencing using Illumina MiSeq. The hematological and immunological parameters and iron quantification in the liver are being analyzed. No significant statistical differences were observed for growth parameters and the bacterial challenge. Interestingly, for hematological parameters, the hematocrit of fish fed with the treatment CuNP was significantly lower compared to the control.

In conclusion, iron nanoparticle supplementation is an innovative strategy to enhance catfish iron uptake. However, the bulk iron and iron nanoparticles did not show statistical differences in this trial. The present study evaluated only a high concentration of iron supplementation. It is hypothesized that, studies evaluating lower concentrations of bulk iron and iron in nanoparticles may possibly show significant differences due to the higher bioavailability of nanoparticles. Furthermore, the statistical difference in hematological parameters between control and CuNP treatments shows the importance of iron supplementation to fish health.

Table 1. Hematocrit of channel catfish fed the experimental diets for 9 weeks. Superscript letters written in lower case means significant differences. Data are shown in average ± Standard deviation.

Variables	Treatments			
	Control	CuNP	FeNP	Fe+CuNP
Hematocrit (%)	30.0 ± 3.7^{a}	19.9 ± 3.8^{b}	24.8 ± 3.1^{ab}	25.4 ± 2.7^{ab}

CAN PERCID AQUACULTURE BE PROFITABLE: AN ECONOMIC ANALYSIS AND BUDGETING TOOL FOR WALLEYE PRODUCERS

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Walleye culture for foodfish is a rapidly emerging market in the North Central Region of the US. The first two private walleye farms began operations in 2021 with several other facilities currently being planned. Beginning operations with a relatively unproven species is a risky endeavour for new fish farmers, and developing a business model can be immensely difficult given the high degree of inherent uncertainty. The University of Wisconsin-Stevens Point Northern Aquaculture Demonstration Facility has approximately 15 years of experience raising walleye in various culture systems through all life stages and has been at the forefront of the development of the private walleye industry. The aim of this study is to apply the knowledge gained during this time about walleye feed rates, growth performance, culture system requirements, and operational costs to develop a economic model and budgeting tool for current and prospective walleye fish farmers. To focus our model, we assumed that the fish farmer will receive walleye as 1g feed trained fingerlings and grow them out to a ~1lb market size. The model accounts for all operating costs including feed, labor, oxygen, electricity, natural gas, permitting, maintenance, insurance, marketing, processing, and other overheads, and provides default values for each cost that can be manually adjusted by fish farmers to reflect their individual operations. Using default values in our simulation, a fish farm would have to start with 35,576 walleye fingerlings to breakeven on operating costs at a market price of $20/lb of filleted and processed walleye. Fish feed constituted the largest cost (23.7%) followed closely by fingerling procurement (22.0%) and labor (19.8%). The model allows for parameters to be adjusted so fish farmers can test various scenarios and evaluate the viability of their operations. We hope this model and tool can serve as a valuable resource for current and prospective walleye fish farmers alike.

INTENSIVE PRODUCTION OF WALLEYE *Zander vitreus* IN FLOW-THROUGH AND RECIRCULATING WATER SYSTEMS FROM START TO FINISH INCLUDING HATCHERY DESIGN IMPLICATIONS

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Walleye *(Zander vitreus*) is one of the most culturally important and sought-after species of freshwater sport fish in North America. Walleye stocking is a major program of many fisheries agencies in North America; at least 32 state, federal, and provincial agencies reported stocking walleye between 1986 and 1991. All life stages are cultured intensively and extensively including Eggs, Fry, Small Fingerlings(summer), Extended Growth Fingerlings(fall), Yearlings and Adults-Broodstock. Typically eggs and fry are cultured indoors, and the other life stages are reared utilizing external outdoor ponds of various types. More recently, indoor, intensive systems are being utilized for culture of all life stages with new and improved equipment as well as formulated feeds. Many state, federal, tribal and private entities are designing and constructing new facilities for rearing Walleye and other cool water fish intensively for stocking programs. This presentation will discuss the biology, design and application of intensive systems for conservation, enhancement, and sportfish management programs as it relates to Walleye.

BRACKISH WATER AQUAPONICS—WHAT WE HAVE LEARNED

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Inland, indoor brackish water aquaculture is growing in popularity throughout the world, particularly in temperate areas of Europe, Asia, and North America. These aquaculture operations can provide niche products to local markets, typically at high prices. However, these aquaculture systems often accumulate high levels of nitrate and phosphate due to limited water exchange. When water is discharged or exchanged from these systems, the high levels of salt make it unsuitable for fertilizer while the high levels of N and P limit the amount of discharge allowed due to local laws and regulations. Aquaponics may provide producers an avenue to remove N and P through plant production, gaining an additional form of income while retaining valuable salt water. While halophytic and glycophytic plant species have been studied for their suitability in brackish water aquaculture, the management of these plants and the systems they are produced in are different than freshwater.

At Kentucky State University researchers have been investigating the potential of brackish water aquaponics. To date, 18 different plant species have been tested for their tolerance to and performance in varying concentrations of salt water. Furthermore, trials have been conducted that investigate the potential for animal production in plant beds, the effects of high levels of nitrogen on plant performance in a saline environment, enhancing salinity tolerance through the supplementation of different nutrients like iron, and the effects of suspended solids in brackish water on the health and vigor of plant root systems.

Although these trials have shed light on the performance and adaptability of numerous plant species in brackish water, there have been many lessons learned regarding system design and plant husbandry. Pest management of saline-stressed plants, seed germination and plant propagation methods, salt acclimation and accumulation processes, media choices, nutrient availability and manipulation, lighting requirements and water quality testing that work well in freshwater aquaponics have, in many cases, been found to work poorly or fail entirely in brackish water aquaponics. This presentation will cover many of these findings that are not hard data, but more tips and tricks that have resulted in successful brackish water plant production.

NEXT GEN USDA - PREPARING HISPANIC AND OTHER UNDERREPRESENTED STUDENTS IN FISHERIES AND AQUACULTURE

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The University of Arizona, New Mexico State University and Santa Fe Community College have partnered to receive a grant from USDA-NIFA focused on preparing the Next Generation of professional scientists for various agencies within the USDA. Surveys have reported that most agencies within the USDA (and other Federal Departments) rarely reflect American society. The numbers of Hispanic, Black, Native American and women are significantly lower in the professional ranks than in our general population. This Next-Gen grant will specifically address these shortages through a focused program recruiting young people to consider education in fisheries and aquaculture science and then supporting their education with scholarships, internships and introductions to working professionals.

The program will start at the high school level with close coordination with Future Farmer of America and other agricultural and natural resource programs taught in Arizona and New Mexico high schools. The community college and university faculty will meet with high school instructors to identify promising students who will be informed about the opportunity to receive financial and personal support while pursuing fisheries and aquaculture focused curriculum at community college and university. Scholarships, work-study, and internships will be used to facilitate their path through 2+2 (community college to university) or 4-year university degree programs. There are also funds for capacity building within the three academic institutions to accommodate additional students and update equipment and supplies. The grant will also support a small number of graduate students focused on areas of identified shortages in professional USDA staff.

USDA agencies looking for increased diversity include the Animal and Plant Health Inspection Service, Agriculture Research Service, Foreign Agricultural Service, Forest Service, Food and Nutrition Service, FDA Center for Food Safety and Applied Nutrition, Division of Seafood Safety, and Natural Resources Conservation Service. While USDA professionals will be our target it is obvious that other Federal agencies also hire professionals in aquaculture and fisheries including the US Fish and Wildlife Service, Bureau of Reclamation, National Marine Fisheries Service, Bureau of Land Management, and Environmental Protection Agency. Of course, Arizona Game and Fish and New Mexico Fish and Game also hire fisheries professionals.
The grant program is being supported with industry in-kind contributions with farms and hatcheries offering to host interns for summer work. This kind of real world experience will be especially important as these young professionals will be able to graduate and contribute their professional duties with USDA from their first day on the job.

2023 GLOBAL REVIEW OF TILAPIA PRODUCTION AND MARKETS

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2023 has been a mixed year for tilapia production but a generally bright year for the markets. The best estimates are that global production and consumption was close to 7 million metric tons. China's production has increased slightly with more fish density per pond or hectare and a few new farms. But we also have reports that a significant number of farmers switched to higher value crops (largemouth bass, catfish, dace, and shrimp). Exports were not much changed, but domestic consumption continued to increase in spots and more value-added products were reaching into new markets.

Indonesian production has edged up with domestic demand remaining strong and the high-quality exports of value-added products continuing. Egypt maintains it's close position behind Indonesia as the third biggest producer of tilapia. Domestic demand for tilapia in Egypt continues strong, but the low prices that people can afford reduces the sales prices that the farmers can get. Some exports to the Gulf States, mostly purchased by employers to feed migrant workforce from Asian countries, have buoyed the Egyptian farmers. Saudi Arabia has announced plans to build new tilapia farms, but these still seem to be in planning stages.

Tilapia production in India and Brazil were more positive. In both countries production increased and domestic markets remained strong with increased consumption. Neither country has become a major exporter yet, but the potential is certainly there. Ecuador production and exports of tilapia products have lagged somewhat as some ponds that shifted from shrimp to tilapia have shifted back to shrimp. There are still some polyculture operations, but the expected expansion of polyculture has not occurred. This might change if any novel disease issue in shrimp should arise.

In the other major producing countries of Bangladesh, Vietnam, Thailand and the Philippines, production and markets have been well balanced with growth matched with increasing domestic production. Hopes for growth and potential for exports from Myanmar have been dashed as the domestic economy and seafood exports have cratered under the mismanagement of the military junta.

US production of tilapia was essentially unchanged in 2023 and still just a fraction of that compared to other countries. Imports and consumption seemed to have increased slightly. Domestic production continues to go primarily to various Asian groceries and restaurants which pay the best prices to the US farmers.

The continuing high prices for wild-caught fish have also provided opportunities for tilapia to be used as substitute in various recipes. Aquafeed prices moderated somewhat from the rapid run-up in the last couple of years. As tilapia effectively utilize more plant-based proteins, the sharp increase in fishmeal and fish oil prices has not been a factor. However, the use of alternative protein sources is still of interest to the farmers who are counting on some of these novel ingredients to provide some deflationary relief on aquafeeds.

FARM SCIENCE: HARNESSING BASIC FIELD RESEARCH METHODS TO IMPROVE FARM MANAGEMENT AND PRODUCTIVITY

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There are many factors that can impact oyster survival and performance on a farm ranging from the genetic characteristics of the broodstock, to hatchery practices, nursery practices, farm practices, environmental conditions, and everything in between. It can seem impossible for growers to pinpoint the causes of animal success and performance in a way that might lead to meaningful management decisions.

At Hog Island Oyster Company (CA) we are trying to incorporate basic techniques from field biology into our farm program so that we can make better management decisions. In this presentation we will show our research efforts from 2022 and 2023, and discuss ways we hope this field data will add resolution to our observations on the larger farm and aid in making better decisions about seed sourcing, gear siting and overall farm management.

DON'T BE AFRAID TO GO OFF THE BEATEN PATH

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Dallas Flickinger originally went to Southern Illinois University – Carbondale to get a degree in Zoology because he wanted to do conservation work with turtles. He soon found out that this line of work is not abundant and he shifted his focus to studies related to aquatic ecology. He earned his BS and moved on to Middle Tennessee State University for a MS because work was difficult to find during that time period. One day he decided that aquaculture would be his last chance to have a career. At the same time, he wanted to do something unique. He e-mailed Wagner Valenti one late night to see if there were any scholarships in Brazil to do a doctorate. To his shock Wagner e-mailed back within ten minutes and the rest is history. He lived and worked in Brazil for nearly ten years before returning to the United States. Dallas now has a doctorate of science in aquaculture and is a professor of aquaculture at Lincoln University of Missouri.

FROM GUTS TO GLORY: MATURATION DIET AFFECTS ON GROWTH OF *Mycteroperca bonaci* AT THE COLLEGE OF THE FLORIDA KEYS

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The aquaculture potential of Black Grouper (*Mycteroperca bonaci*) within the southeastern United States has yet to be realized mainly due to challenges with their aggressive behavior with fellow tank inhabitants, limitations in space for adequate long term broodstock holding, and success in simulating natural spawning conditions. The College of the Florida Keys Southernmost Marine Aquaculture and Research Training (SMART) center located in the heart of the Florida Keys National Marine Sanctuary has worked with the *M.bonaci* species since awarded grant funding by the Gulf States Marine Fisheries Commission in 2020. Titled: 'From Guts to Glory', the project focuses on housing and maturing female brood (45cm-75cm) in an indoor recirculating aquaculture system equipped with natural spawning stimuli (photoperiod control, temperature regulation, and audio stimulus with male courtship calls) and using cryogenically preserved male *M.bonaci* gametes for in-vitro fertilization.

Alternating between diets for our inhouse female broodstock, we saw an average growth of 0.16mm per day since their initial acclimation into our 2,700-gallon indoor RAS in early April 2022. The broodstock maturation diet alternates between threadfin herring *(Opisthonema oglinum),* pink shrimp (*Penaeus Duorarum*), and homemade "maturation sausages" made from formulated dry powder (MadMac) mixed with raw ground seafoods. Batches of our maturation sausages include ground threadfin herring, pink shrimp, shortfin squid *(Illex illecebrosus)* and vitamin additives: garlic extract (500mg) for appetite stimulation and Super B Complex for immune support.

To prepare for winter spawning in 2024, we will begin our natural spawning simulation conditions by lowering their in-tank temperature to reflect the change in seasons. These "seasons" begin with a 2-month summer at 29°C to increase metabolism followed by a steady decline towards a prolonged winter at 21°C. This period of controlled winter will urge the brooding females into a state of egg production where injectable hormones will be used to induce spawning in tandem with the natural spawning stimuli. Once gravid, females will be strip spawned inhouse and in-vitro fertilization will be attempted for the first time with the *M.bonaci* species.

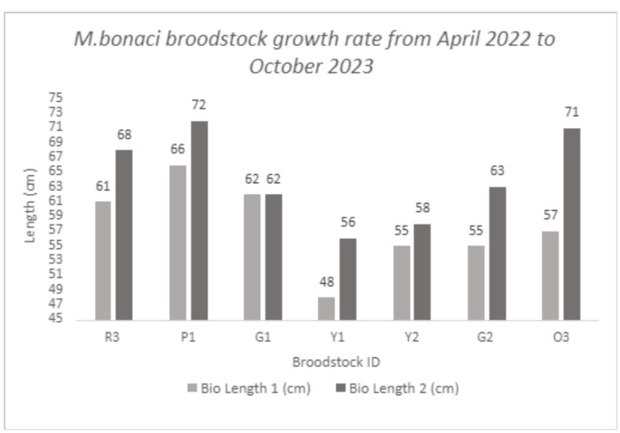

Figure 1 Seven total female broodstock growth rates from delivery on April 8th, 2022, to October 1st, 2023. Broodstock identification is read as the first initial of their dorsal tag color followed by their tank number (Example: female with a pink dorsal tag in tank 1 is "P1").

FROM GUTS TO GLORY: INCORPORATING IMTA WITH *Mycteroperca bonaci* AQUACULTURE AT THE COLLEGE OF THE FLORIDA KEYS

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In 2020, the Gulf States Marine Fisheries Commission (GSMFC) funded "From Guts to Glory" (GTG) within the College of the Florida Keys Southernmost Marine Aquaculture and Research Training (SMART) Center. Introducing black grouper (*Mycteroperca bonaci*) aquaculture, our project goals are to house female broodstock (RAS), simulate natural spawning stimuli for brood (temperature regulation, photoperiod control, and audio stimulation with male courtship calls), and for the first time with this species, perform invitro fertilization with female eggs and sourced male gametes. As a revolutionary stock enhancement plan for the Florida Keys National Marine Sanctuary, the CFK (College of the Florida Keys) SMART Center looks for better strategies to improve our RAS and increase technician efficiency. After three years of study, the GSMFC grant expanded into integrated multi-tropic aquaculture, highlighting the Eastern Oyster (*Crassostrea virginica*) and the Florida Keys local species of red macro-algae, *Asparogopsis taxiformis.*

Having upgraded the system to incorporate IMTA benefits 1) the outstanding water quality issues with low pH and excess nitrates and 2) reducing the number of gallons necessary to complete daily water changes. *A. taxiformis* has been chosen as the system macroalgae species as the absorbed nitrates and excess nutrients increase our supply, we would sell the supply to local Southern Florida cattle farmers as livestock feed to reduce methane production. However, as there are two lifestyle phases for this species: 1) *Falkenbergia* (found in warmer seasons) and 2) *Asparogopsis taxiformis* (found in cooler seasons), the timing of algae collection must be coordinated with the second life stage cycle of the species for our purposes. No confirmed collection of the species has been gathered. As a placeholder in the system until positive identification of *A. taxiformis*, green macroalgae *Ulva lactuca* and *Chaetomorpha spiralis* have been used to monitor water quality in the GTG system.

Our first attempt with 500 spat of the species, *C. virginica*, remains in a trial phase until water quality concerns have been remediated. *C. virginica* has not been placed into the main GTG system as maintaining system pH is a challenge. Technicians work with the species in trial conditions to stabilize their ambient pH and increase growth rates through feed studies with 1) *Nannochloropsis oculata* & *Isochrysis galbana* 2) concentrated algal paste (Rotigrow plus) and 3) Shellfish Diet 1800.

In conclusion, further study with *C. virginica* will be continued at the College of the Florida Keys Southernmost Aquaculture and Research Training Center. Collection methods for *A. taxiformis* will be further explored during the winter season.

USE OF INSECT MEAL AND ALGAL OIL IN DIETS FOR CHINOOK SALMON *Oncorhynchus tshawytscha*

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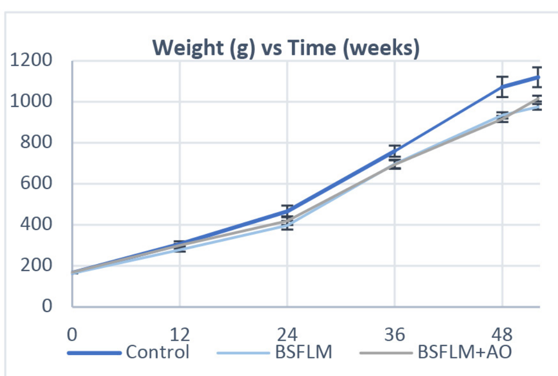
The main objective of the study was to investigate the feasibility of the partial replacement of fish meal and fish oil by black soldier fly larvae meal (*Hermetia illucens*, BSFLM, produced on pre-consumer food waste) with and without supplemental algal oil in Chinook salmon (*Oncorhynchus tshawytscha*) diets. The impacts of the three diets, control (Diet 1), feed with BSFLM (Diet 2), and feed with BSFLM and algal oil (Diet 3), on salmon, including growth and heath, were assessed. These three diets were each fed to four random groups of female Chinook salmon (initial weight 165.0 g/fish), twice daily to apparent satiation for 52 weeks. The fish were weighed and measured every four weeks throughout the duration of the project and the daily feed intake was measured. Samples of seven tissues (gill, spleen, liver, head kidney, trunk kidney, stomach and intestine) were examined for histopathology.

Survival of the fish over the duration of the study was high (98%) and not affected by treatment. At the termination of the study, the fish fed the control diet (no BSFLM or algal oil) had grown significantly faster and had higher final mean weight than the fish fed Diet 2 (87.1% of control) or Diet 3 (90.7% of control). These differences were not statistically significant until 48 weeks on the study. Histological examination revealed some minor, but noticeable differences. In the liver, inflammation was seen in 44% of the BSFL fish, and none (0%) of the control. In the spleen, inflammation was found in 25% of BSFL samples, 17% of BSFL+algal oil samples and 9.1% of Control. The n-3 PUFA content of the muscle was highest in the fish fed the diet with the supplemental algal oil.

In conclusion, the use of BSFL meal is satisfactory as partial replacements for fish meal in diets for Chinook salmon, although with slight reduction on growth. Additionally, there were minor indicators that health could be compromised. The use of algal oil greatly enhanced the n-3 PUFA content of the fish.



STRATEGIES FOR PREVENTING WINTER ULCERS OF THE SKIN IN ATLANTIC SALMON *(Salmo salar L.)* IN NORWAY

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Introduction

Winter ulcers in Atlantic salmon generally lead to reduced welfare and downgraded product quality. Naturally, the winter ulcers outbreak in salmon aquaculture is a significant fish health challenge in northern Norway. An essential measure against winter ulcers is avoiding handling the fish as much as possible. However, due to high salmon lice infestations, the fish must undergo delousing treatments. In the case of non-medicinal delousing treatments (which are more effective), there are unavoidable injuries to the fish skin, where the outcome is usually ulcer outbreaks at low temperatures. The severity of the outcome depends on many factors, where crowding intensities (CI) is a key factor. From our field experience, there is a significant knowledge gap in the cause-and-effect relationships and limited knowledge about the factors associated with this variation. Results from our pilot studies show that sedating the fish during crowding and delousing operations makes fish calmer, reducing the risk of ulcer development. There is little data about which indicators can be used to assess the risk of winter ulcers. This lack of knowledge gives limited room for action to adapt the production plan or implement measures to reduce the risk. The main goal of this study is to identify best practices for crowding and mapping wound risks associated with handling second autumn and winter at sea to reduce the risk of, or extent of, winter ulcer outbreaks in Atlantic salmon. Results from this project will help to shed light on what is today's best practice for crowding and how it should be adapted to a situation with low temperatures and an increased risk of wound development.

Material and Methods

The project is financed by the Norwegian Seafood Research Fund (FHF 901835)[1]. The experiment will be facilitated at LetSea AS at Dønna, Norway. We will use mesoscale cages (n=12) in triplicates. All cages will be treated uniformly, except for crowding methods during the delousing. Combinations of CIs, i.e., grades 1 and 3, according to FISHWELL (**T1** and **T3**) with or without sedation (**S+** and **S-**) during a crowding operation[2], giving us three test groups **T1 S+, T3 S-, T3 S+** and a control group (**T1 S**-). Samples will be collected to investigate the presence of wound bacteria. Camera-based monitoring of wounds at group level will be done.

Results

The project will map possible new indicators for increased winter ulcer risk or "early warning" in case of ulcer outbreaks. Such indicators can initially improve the decision-making basis for crowding methods or adjusting handling procedures before and during delousing. The project will be able to contribute both knowledge and new tools that can improve preventive and mitigating measures to reduce wound problems in the industry, thereby improving fish welfare, profitability, reputation, and sustainability.

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ESTABLISHING AN AQUATIC FEED MILL IN HAWAI‘I: CHALLENGES AND PROSPECTS

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By nature, islands are vulnerable places. Factors such as limited land mass, rapid growth of the human population, and the diversity of people living in Hawai'i make it heavily reliant on imports to meet the food demand. Given its geographical isolation, Hawai'i is also prone to magnified impacts of climate change and pandemics such as COVID-19. Increasing local food production through aquaculture and mariculture is one way to address these issues. With 750 miles of coastline, the Hawai'i islands offer pristine seawater and seafood resources making the aquaculture industry very promising in Hawai'i. To date, there have not been any comprehensive studies that assess the economic potential of using local feed to produce food in Hawai'i. Our study aims to assess the economic feasibility of manufacturing feed utilizing an existing feed mill in Hawai'i. We developed a comprehensive economic model using the Oceanic Institute‘s research feed mill in Hilo, Hawai'i to estimate the cost of producing feed in Hawai'i. We calculated construction cost, fixed cost including annual depreciation, and variable costs. Our preliminary results show that feed ingredients are the second highest cost component in the total production costs. Using two theoretical scenarios, local feed ingredients appear to not have a significant impact in reducing the production cost compared to imported feed. The economic model was presented recently to stakeholders in a hybrid workshop setting. Challenges and opportunities for establishing a feed mill in Hawaii were discussed. This presentation will highlight our findings and the proposed solutions for local feed supply in Hawaii.

AQUACULTURE EXTENSION IN MARYLAND: ASSESSING COMMUNITY KNOWLEDGE, ATTITUDES, AND PERCEPTIONS TOWARDS LAND-BASED RECIRCULATING AQUACULTURE SYSTEMS (RAS)

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The development of recirculating aquaculture systems (RAS) for land-based marine finfish farming in Maryland has encountered obstacles. While one potential facility in Federalsburg, Maryland initially secured land and local government support, the commercial operation faced community opposition during the permitting process. Testimonies presented at town hall meetings highlighted concerns about the impact that land-based RAS would have on local waters, fisheries, and the community. UMD Extension Agent(s) observations of the testimonies provided by Eastern Shore communities revealed varied levels of knowledge regarding aquaculture and RAS. Some of the testimonies demonstrated the public's low awareness of aquaculture practices, such as citing sea lice challenges common to net-pen culture and wrongly claiming that sea lice would occur with salmon raised in RAS. Questions/concerns about facility discharge water were also raised. Faced with these testimonies and the other questions/concerns, the project elected to withdraw all permit and lease applications for the Federalsburg site and, instead, search for an alternative site in Maryland.

Following town hall observations, UMD Extension conducted a Knowledge, Attitudes, and Perceptions (KAP) assessment using online surveys targeting Maryland residents. The survey aimed to identify general familiarity with aquaculture and RAS, understand community attitudes towards RAS, and determine preferred information sources regarding aquaculture and RAS. Data collected from a total of 1,040 respondents provides a baseline for planning Extension programming at UMD and within the USDA-funded SAS^2 project. It will also inform Maryland Sea Grant's future extension efforts.

This presentation will provide an overview of land-based RAS efforts in Maryland, summaries of what was observed at public town halls, preliminary results of the survey data, and a discussion of plans including collaborative efforts with the University of Maine and potentially others.

INSTRUMENTATION AND FIELD SAMPLING TO QUANTIFY INTEGRATED MULTI-TROPHIC AQUACULTURE ENVIRONMENTAL INTERACTIONS

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An experimental plan has been developed to quantify the interactions of an integrated multitrophic aquaculture (IMTA) system with the surrounding environment. The small-scale IMTA system is designed for deployment in the coastal waters of New Hampshire, stocked with 2000 steelhead trout (*Oncorhynchus mykiss*). The fish are split within two containment bays of the floating structure made with high density polyethylene (HDPE) pipe, each with the dimensions of 6 m x 6 m x 3 m. The seafood system also includes 72 m of blue mussel (*Mytilus edulis*) droppers and 48 m of sugar kelp (*Saccharina latissima*) cultivation line that hang from the HDPE flotation pipe. The intent of the mussels and kelp as extractive species is to offset a portion of the dissolved and particulate nutrients from the fed steelhead trout.

To quantify the environmental interactions of the IMTA system with the surrounding environment, a comprehensive measurement plan was initiated utilizing both *in-situ* instrumentation and collection of discrete water and sediment samples. Two solar powered instrumentation packages have been designed to obtain temperature, salinity, dissolved oxygen, chlorophyl, pH, nitrate, fluorescent dissolved organic matter, and current velocities. One sensor suite will be deployed within the fish containment structure with the other at an external location approximately 100 m along the major axis of the M_2 tidal ellipse characteristic of the site. With both flow and concentration values, mass flow rates, both in and out of the IMTA system, can be assessed. The instrumentation system is designed to transmit datasets to shore with cell phone communication. This will enable IMTA evaluation in real-time. Discrete water samples will also be collected to measure total ammonia nitrogen and nitrite, quantify plankton communities, and extract environmental DNA for metagenomic analysis. Sediment samples will be obtained to characterize potential benthic changes. The approach includes installation of a hydrophone mounted to the platform to evaluate changes in the soundscape and monitor presence of marine mammals. The presentation will include examples of preliminary datasets.

SUSTAINABLE DEVELOPMENT THROUGH CO-LOCATION: OFFSHORE AQUACULTURE AND MARINE RENEWABLE ENERGY

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Marine renewable energy (MRE; energy from the waves, tides, currents, and salinity or temperature gradients) has the potential to provide clean energy and reduce greenhouse gas emissions, and while it has generally been thought of as providing power to the grid, it has a unique application in powering at-sea activities, particularly offshore. One such offshore activity is offshore aquaculture, particularly as this is a growing sector with interest in moving activities further offshore. Synergies between these industries arise as MRE can provide power for offshore aquaculture and can also decrease the environmental impact of aquaculture operations by providing power at sea and replacing the reliance on diesel.

This study aims to assess the feasibility for co-locating offshore integrated multi-trophic aquaculture (IMTA) and wave energy off Puerto Rico. IMTA allows the co-farming of fed species (e.g., fish), extractive species (e.g., shellfish), and macroalgae, increasing the sustainability of aquaculture. Using a power source like wave energy can further the sustainability of operations through employing renewable energy. An added benefit of co-location is that for offshore aquaculture, the resources needed to provide power with wave energy may already exist in the location of the aquaculture farm. In Puerto Rico, steps to understand the feasibility of co-locating wave energy and offshore IMTA include outreach and engagement with local stakeholders and communities, a comprehensive spatial analysis to identify potentially suitable areas for co-location (Figure 1), and field work to collect environmental data. The combination of these methods highlighted the potential for co-locating offshore IMTA and wave energy off Puerto Rico as well as important factors to consider for future development of these industries in the region.

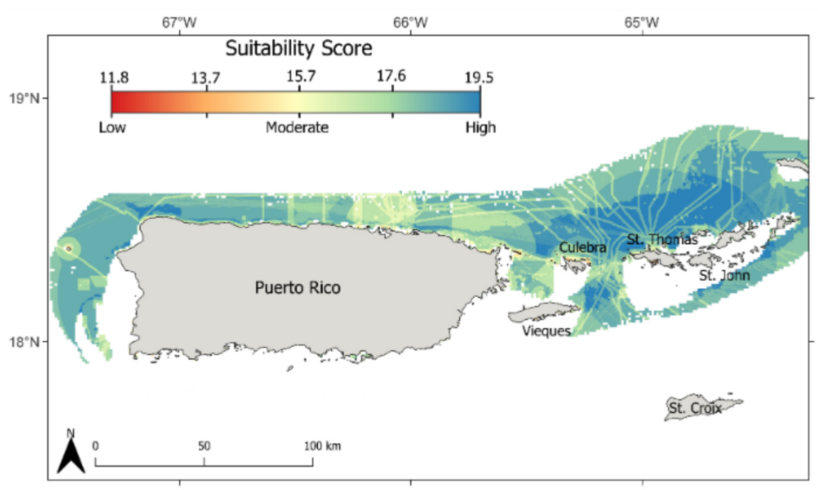

Figure 1. Potential suitability for co-locating offshore integrated multi-trophic aquaculture and wave energy offshore of Puerto Rico. The suitability is shown for areas where the wave resource is sufficient (greater than 5 kW/m) to power wave energy.

In the U.S., similar studies have been carried out to understand how marine energy can power kelp or oyster aquaculture as well as powering onshore and nearshore community-scale aquaculture. These studies also show the possibility of bringing these marine-based industries together for sustainable marine development.

IMPROVING RAINBOW TROUT *Oncorhynchus mykiss* GROWTH PERFORMANCE THROUGH OPTIMIZATION OF DIET-EPIGENETIC INTERACTIONS

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The aquaculture industry has vastly expanded in recent years and accounts for half of seafood consumed globally. With this expansion, sustainable shifts in aquaculture must be made to access nutrients essential to human health in response to a decline in marine resources for aquafeeds. Along with shifts in aquafeed composition, selective breeding programs aid in eliminating mortality rates in fish populations aimed for the marketplace. Rainbow trout are a staple aquaculture species and serve as a non-model organism to investigate toxicology, evolutionary biology, and nutritional programming. Understanding the impacts of nutritional programming in aquaculture species will aid in understanding the effects of broodstock nutrition on offspring growth performance via inherited epigenetic mechanisms while providing information regarding potential mechanisms of maternal effects. Therefore, this project focuses on the interactions between maternal nutrition and genetic selection utilizing rainbow trout, Oncorhynchus mykiss, used within the industry – disease-resistant selected rainbow trout maintained by the National Center for Cool and Cold-Water Aquaculture. The overall project objective includes identifying specific genes and gene pathways in offspring affected by maternal dietary intake of choline supplementation during oogenesis. To accomplish this, global and local DNA methylation patterns were analyzed in trout offspring and compared to global transcriptomic data from corresponding samples. Treatment effects on the methylome and transcriptome were analyzed to identify potential mechanisms altered by maternal choline intake and establish links between epigenetic modifications in the genome and phenotype of the offspring. Results indicate that several metabolic and tissue-specific pathways are under, at least, partial maternal regulation.

MACRONUTRIENT INTAKE EFFECTS ON GENE EXPRESSION OF ANTIOXIDANT AND METABOLISM RELATED GENES IN FRESHWATER PRAWN *Macrobrachium acanthurus*

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Gene expression analysis is a biomolecular tool that helps to understand the relationship between nutrient intake and physiological responses. As an important fishery resource in Mexican cuisine, freshwater prawn Macrobrachium acanthurus contributes to the overall economic growth of the region. However, knowledge of culture conditions of this species is lacking; hence, the aim of this study is to evaluate the effect of different macronutrients intake on the expression of genes related to metabolism and antioxidant function.

Figure 1 summarizes the methodology; briefly, six diets were formulated with 2 protein levels (35% = P35; 40% = P40) and 3 lipid – carbohydrate ratios (2:1, 1:2 and 1:6) and fed to 180 juvenile prawns for 60 days. Figure 2 shows the relative gene expression. Genes related to fatty acid synthesis (FAS) were upregulated with high levels of carbohydrates (L:C ratio 1:6) and with higher protein intake in diet (P40), which suggests that excessive energy is stored as lipid deposits. In contrast, CPT1 which is related to β-oxidation of lipids was downregulated in all treatments. These, combined with the upregulation of hexoquinase (HK) in treatment P35 L:C ratio 1:2 indicates that glycolysis may be the chosen source of energy in these organisms. Gluconeogenesis genes (PEPCK) were downregulated in all treatments; thus, it is believed that carbohydrates are being utilized to fuel the metabolism of prawns instead of lipids or proteins. Gene expression of the antioxidant system revealed that SOD was significantly upregulated in treatment P35 L:C ratio 1:2 which may suggest a favorable effect of this diet, while CAT was upregulated at an L:C ratio 1:2 and in P40 L:C 1:6, suggesting that excess of lipids and high protein and carbohydrate intake could induce oxidative stress caused by reactive oxygen and nitrogen species (ROS and RNS) derived from a macronutrient imbalance in diet.

In conclusion, results suggest that prawns fed the diet with 35% protein and a L:C ratio 1:2 (10% lipids and 20% carbohydrates) favors carbohydrate utilization and show improved antioxidant capacity.

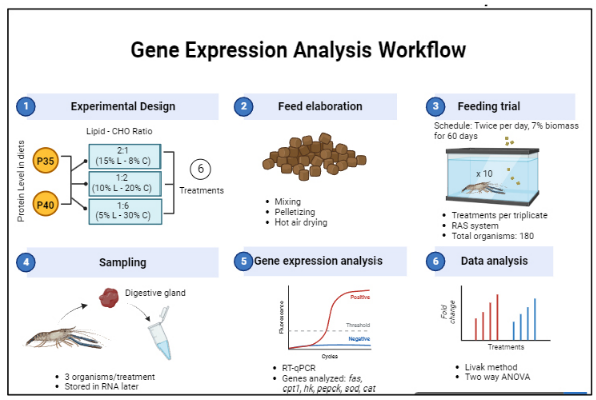

FIGURE 1. *Methodology workflow.*

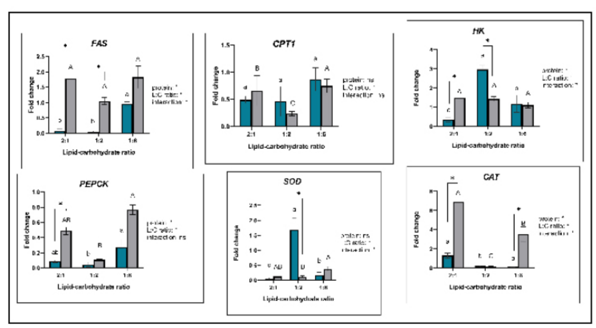

FIGURE 2. *Gene expression of juvenile M. acanthurus fed diets with different macronutrient intake. Data show mean of three replicates ± SD. Lowercase letters indicate significant differences among groups fed diets with 35% protein; capital letters indicate significant differences among groups feds diets with 40% protein (P <0.05).*

PHOTOPERIOD AT EMERGENCE REGULATES EARLY LIFE HISTORY PLASTICITY IN CHINOOK SALMON *Oncorhynchus tshawytscha*

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Human population growth and climate change are causing biological habitats to change at a rapid pace, amplifying concerns that some species will not be able to adapt quickly enough to avoid extinction. Chinook salmon in the Pacific Northwest are particularly vulnerable to the cascade of environmental stressors associated with climate change, especially during the initial freshwater phase of their lifecycle. Early life history trajectory for Chinook salmon is directly related to environmental variation (temperature, photoperiod, flow, food availability) which can shift or alter phenotypic traits expressed by a population, such as timing of juvenile migration downstream (smoltification) and age of male maturation. For example, Fall Chinook salmon in the upper Columbia River Basin generally undergo smoltification as sub-yearlings, however some wild and hatchery reared Fall Chinook have been found to express a successful yearling smolt life history by overwintering in large reservoirs above dams. Some research suggests that this shift to reservoir type yearling smolts represents evolution, an actual genetic change due to the increase in fitness and better downstream survival of this life history type. Alternatively, the shift in life history could simply be a phenotypically plastic response that optimizes life history for the current environmental conditions. To explore this, we raised hatchery-origin Fall Chinook salmon from the Umatilla River (Oregon, USA) in a controlled laboratory experiment designed to describe and define phenotypic plasticity in life history pathways. Fish were split into 3 separate photoperiod groups at ponding: Winter Solstice, Early Spring, and Late Spring, corresponding to the seasonal range of emergence timing within this population. In addition, each photoperiod treatment was split into 2 feeding treatments with replicate tanks to simulate high or low growth. We collected data on fish growth rate, size, maturation status, and seawater survival/adaptability. Our results demonstrate that the early life history of these fish is quite plastic, with smolting occurring at different seasons, sizes and ages depending on environmental conditions. The resulting adaptable life history portfolio may provide this population of Fall Chinook salmon with some baseline capacity to cope with future environmental change.

TEMPORARY RESCUE OF DEAD-END GENE FUNCTION IN RAINBOW TROUT *Oncorhynchus Mykiss* BROODSTOCK

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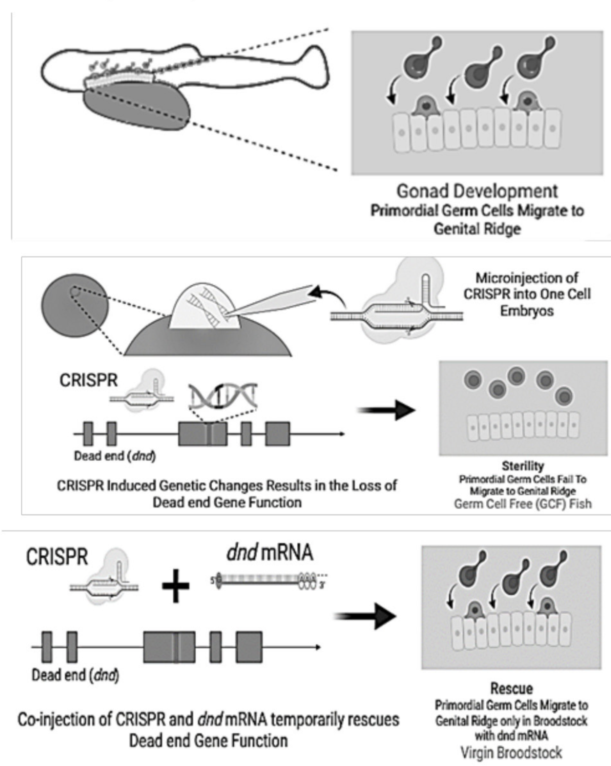
The impacts posed by fish escapement on wild fish populations has been a long-standing environmental concern for the aquaculture industry. A major fear is that fertile escaped fish could negatively impact the genetic integrity of wild fish. Many commercial aquaculture operations rely on the process of triploidization to produce sterile production cohorts, which mitigates genetic risk in the event of an escape. The triploidization process uses thermal, chemical, or pressure shock soon after fertilization to prevent loss of the second polar body during meiosis II, resulting in sterile fish containing three chromosomes. Although triploidization is an effective sterilization technique it is labor and time intensive. Our study explores the use of CRISPR technology to create fertile broodstock that produce all sterile offspring, which could prove valuable for producing inherited sterility in offspring on a commercial scale.

The use of CRISPR technology to ablate germ cells through knockout of the dead end (*dnd)* gene has been verified in several finfish species. However, the approach is not viable on a large scale because it would require gene editing thousands of production fish. Creating fertile broodstock capable of producing all *dnd* knockout sterile offspring could help solve this problem. Our study investigates the effectiveness of rescuing *dnd* knockout-induced sterility in rainbow trout (*O. Mykiss*) by simultaneous co-injection of CRISPR-Cas9 constructs targeting the *dnd* gene, and *dnd* mRNA (Figure 1.). We have been successful in introducing insertion and deletion mutations into the *dnd* gene, and have compelling evidence suggesting that mRNA co-injection can also rescue fertility in the broodstock.

The aquaculture industry is growing rapidly, and adjustments to sterility methodologies is essential for minimizing ecological impact and maximizing production. Our findings could provide valuable solutions to reduce sterilization labor, fish handling, and streamline aquaculture production methods.

FIGURE 1. Detailed graphic displaying overall gonad development, developmental difference between CRISPR technology for *dnd* knockout(sterility) only, vs. *dnd* target plus *dnd* mRNA(rescue)



EVALUATION OF NON-LETHAL CONDITION ASSESSMENT TOOLS FOR THE CAPTIVE AND WILD FRESHWATER WESTERN PEARLSHELL MUSSEL *Margaritifera falcata*

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Native freshwater mussels, benthic and filter-feeding, maintain or improve water quality conditions and support diverse aquatic communities that are beneficial for salmon, lamprey and other native fish. Regrettably the freshwater mussels are some of the most imperiled species in North America. The Western Pearlshell mussel *Margaritifera falcate* WPS, the species of interest for our work, is listed as Near Threatened on the International Union for Conservation of Nature (IUCN) Red List. As more threatened and endangered mussels are moved into refugia it is becoming critical to be able to assess their health and physiological status.

The WPS mussels used in this study were from Abernathy Creek (Longview, WA) and consisted of mussels from three collection years, 2018, 2019 and 2020. Collection years 2018 and 2019 were held in buckets containing sand, gravel and cobble like the substrate where they were found. These buckets, with holes for water circulation, were floating in a shade covered outdoor 10 ft. circular tank supplied with creek water. The mussels from collection year 2020 were held in a trough inside that also contained sand, gravel and cobble and was supplied with creek water. Mussels still residing in Abernathy Creek were also sampled.

Hemolymph was drawn from 10 mussels in each population. The parameters checked in the hemolymph were magnesium, ammonia, alanine aminotransferase (ALT) and aspartate aminotransferase (AST). Increased ammonia and decreased magnesium were shown in previous work at Abernathy to be stress indicators in WPS. The transaminases are considered biomarkers of general stress in aquatic invertebrates. Overall, the parameters were not significantly different between the populations held for different lengths of time in the facility and the mussels in the creek. Only the magnesium was significantly lower ($P<0.05$) in the mussels collected in 2020 and held in the trough inside. Although not significantly different, the other parameters for the mussels held in the inside trough also indicated that population was stressed, possibly due to no cover on the trough and more activity around it. Making the refugia environment as natural as possible will be key to maintaining captive populations.

THE DEVELOPMENT OF TRIPLOIDY INDUCTION METHODS FOR HYBRID STRIPED BASS PRODUCTION IN COMMERCIAL AQUACULTURE

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Sunshine bass are a hybrid produced by crossing White bass females and Striped bass males. These bass hybrids are an important food fish in the United States. The average production cycle for this species can range from 10 to 20 months to reach a marketable size of 0.6 – 1.0 kilometers. As with many commercially produced aquaculture species, controlling reproduction can be important to optimize growth and energy allocation efficiency in this production cycle. Triploidization is an effective method for production of sterile fishes. This project aims to evaluate three triploidy induction methods that have been used successfully with other commercial aquaculture species. Our goal is determining an optimum methodology for triploid production with special attention being placed on maximizing embryo survival and obtaining high triploidy induction in sunshine bass. The three methodologies include thermal shock, hydrostatic pressure shock, and electrical shock. In year one of this study hydrostatic pressure shocks were evaluated for the production of triploid sunshine bass embryos. Three pressures (6000, 7000, and 8000 PSI) and shock durations of 1.5, 2, 3, 4, and 5 minutes were evaluated. All shocks were administered 4 minutes post-fertilization. The produced fry were evaluated for triploidy using a flow cytometer. The initial results yielded very low survival and triploidy percentages. We believe the pressure may have been too intense and the duration too short. We will adjust the pressure shocks by lowering the pressure to 5000 PSI and lengthening the shock duration beyond five minutes. In year two, we will start the evaluation of thermal shocks and electrical shocks.

BUSINESS ECONOMIC ANALYSIS OF WEST COAST BASED URCHIN RANCHING

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Purple sea urchin barrens are causing mass deforestation of kelp in California and Oregon, impacting ecosystem function, fisheries and coastal communities alike. This presents an opportunity to bring together environmental organizations, fishers and aquaculture practitioners to address the issue. Using aquaculture, commercially valueless wild purple urchins can be ranched to enhance their roe production, potentially leading to restoration of kelp forests and a revival of sea urchin fisheries, all while supporting commercial aquaculture activity. Sea urchin ranching is gaining worldwide popularity with greater prevalence of urchin barrens, but an understanding of the feasibility in terms of the economics are required for the nascent industry to advance.

This project seeks to develop an economic model based on an accounting of operating costs of prototype ranching systems for purple sea urchins. Commercially acquired urchins were ranched for 10 weeks in three prototype systems: land-based flow-through tanks, land-based recirculating tanks, and sea-based cages. Basic aquaculture metrics beyond the standard observations of farm staff were measured and recorded by the project team, including gonad index and color. An economic model will be developed by assessing the likely costs of production at commercial scale of each ranching system. A set of microsimulation models will be constructed for each of the prototypes based on collected data from the 10-week trial, which will then be used to investigate a wide range of scenarios about the effects of costs, scale, and markets on the economic and financial feasibility of urchin ranching operations.

Results will advance business management of a sustainable marine aquaculture industry on the West Coast by providing critical information necessary for prospective urchin ranchers to develop business plans. It is anticipated that this project will highlight potential net benefits of commercial aquaculture which will increase communications and trust between environmental groups and fishery associations potentially reducing negative perceptions of aquaculture generally.

THE DEVELOPMENT OF UNI IN PURPLE SEA URCHINS FED A DIET OF VEGETABLES

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An overabundance of the pacific purple sea urchin (Strongylocentrotus purpuratus) along the central coast of California has led to an ecosystem phase shift from kelp forests to urchin barrens. Human intervention in the form of collecting purple urchins from barrens offers some relief to kelp forests, but urchins collected from barrens often do not contain a high yield of high-quality uni. These empty urchins do not have a high market value, and divers do not have an economic incentive to collect them. Urchin ranching, the collection of empty urchins from barrens and raising them in an aquaculture setting, gives divers and aquaculture specialists a way to increase uni production in empty urchins and incentivizes people to help restore kelp forests by collecting purple sea urchins from barrens.

This study aims to determine an effective, sustainable, and accessible diet for the uni development of purple urchins collected from barrens along the central coast of California. Locally collected purple sea urchins were fed an assigned diet for a period of 15 weeks. The five diets included spinach, romaine lettuce, carrots, artichoke, and giant kelp. Uni yield was determined by measuring the gonad somatic index of each urchin to reveal gonad growth relative to body mass. Uni quality was measured in terms of color, firmness, and texture. Objective measurements of color were achieved by photographing and breaking down the color of the uni on a three-dimensional color scale in order to compare it between treatments. Firmness and texture were measured subjectively by a single individual using a 1-4 scale, 1 being exceptional and 4 being unacceptable.

The results from this study will help to establish a feeding plan using diets that are economically and environmentally sustainable. By determining an optimal diet for the uni development of wild-caught purple urchins, this study will encourage urchin ranchers to continue collecting urchins from barrens with the confidence that they can raise them effectively and efficiently.

BIOECONOMICS OF ON-GROWING SPINY LOBSTERS IN FLORIDA

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The commercial spiny lobster fishery is one of Florida's most valuable fisheries. Historically, the fishery caught lobsters under 400 grams as early in the season as possible to meet demand for low-priced frozen lobster tails in the U.S. restaurant market. In recent decades, strong international demand for spiny lobster has resulted in high market prices and international trade. A significant share of spiny lobster landings is now exported live to China, the main market today. However, the market potential may be limited by a seasonal landing pattern, strong seasonal variation in price, and the size of wild-harvested spiny lobster. The current management regime has resulted in the majority of spiny lobsters being harvested around 400 g and within the first few months of the season (i.e., August through October), and price shows strong size and seasonal variation with the preferred market size being >500 g and the highest prices at the end of the season when landings are lowest. Price also varies by grade, and live grade lobsters have higher ex-vessel prices than whole grade lobsters that serve the frozen market. Whole grade lobsters include injured and molting lobsters that are deemed unsuitable for the live export market.

On-growing of wild legal-sized lobsters in tanks prior to export is being explored as a means to grow lobsters to a more profitable size and align supply with peak demand associated with Chinese holidays such as the Lunar New Year in January as well as facilitate rehabilitation of injured or molting lobster. We developed a bioeconomic model that combines production and economic data collected from on-growing experiments to explore the economic feasibility of on-growing wild lobsters in flow-through tanks. We use the model to explore on-growing of wild-caught spiny lobsters under three scenarios: 1) to align supply of lobsters with high demand later in the season, 2) to convert lower grade lobsters to live grade lobsters fit for the live export market, and 3) to grow lobsters to higher value size class (>500 g). Collectively, these analyses are highly informative to understanding opportunities for increasing the value of the spiny lobster fishery in Florida.

EFFECT OF L-ASCORBYL-2-POLYPHOSPHATE (VITAMIN C) ON IMMUNE AND ANTIOXIDANT RESPONSE OF *Litopenaeus vannamei* (BOONE, 1931) BROODSTOCK MALES

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This study evaluates the effect of L-ascorbyl-2-polyphosphate (Vitamin C) on *Litopenaeus vannamei* immune and antioxidant responses, as well as sperm quality of broodstock males. Four diets were formulated: Basal (control group (16 mg/kg of total Vitamin C), and the other three prepared with different vitamin C levels: **A** (322 mg/kg); **B** (628 mg/kg); and **C** (934 mg/kg). Circulant cholesterol, triglyceride (TG), glucose, and total protein were measured. Activities and differential expressions of superoxide dismutase (SOD), catalase (CAT), glutathione peroxidase (GPx) and the immune gene system in the reproductive tract were measured. Sperm quantity and quality were determined. The lowest activity of the antioxidant enzymes was obtained in **B** (628 mg/kg) and the highest one in **C** (934 mg/kg) ($p \leq 0.05$) diets. The immune system genes only showed differences in hemocyanin where the highest expression was obtained in **B** ($p \leq 0.05$) diet. The highest sperm quantity was determined in individuals fed **B** ($p \leq 0.05$) diet, which supplemented with 628 mg/kg Vitamin C benefit *L. vannamei* broodstock males because it guarantees less antioxidant system activity, suggesting a good physiological state.

ASSESSMENT OF THE DIGESTIBILITY OF PROSPECTIVE FEED COMPONENTS TO PRODUCE SUSTAINABLE AQUAFEED IN JUVENILE YELLOWTAIL SNAPPER (*Ocyurus chrysurus*)

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The potential for aquaculture in the carnivorous yellowtail snapper, *Ocyurus chrysurus*, is acknowledged. However, there is a research gap in studying the digestibility of ingredients necessary for formulating well-balanced diets for this species. The pH-stat technique was employed to assess the in vitro protein digestibility of fishmeal (FM), poultry by-product meal (PBM), poultry meal (PM), protiblend (PROT), canola meal (CM), soybean meal (SBM), and wheat gluten (WG). In the in vivo digestibility evaluation, test diets were formulated with a 70:30 ratio of the reference diet and the test ingredients. FM, PBM, and PM demonstrated the highest degree of hydrolysis (DH) in terms of in vitro digestibility. Conversely, PBM showed the lowest apparent digestibility coefficient (ADC) for protein in the in vivo digestibility test. Meanwhile, FM, PM, and CM exhibited higher protein digestibility values. A beta regression analysis between ADC protein, DH, and ash content of the ingredients revealed a strong correlation. The study results suggest that yellowtail snapper effectively digested and absorbed FM, PM, and CM ingredients, particularly those with lower ash content.

INTEGRATIVE ANALYSIS OF THE BIOCHEMICAL ACTIVITY OF DIGESTIVE ENZYMES IN SPOTTED SEATROUT *Cynoscion nebulosus* DURING LARVAL DEVELOPMENT

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The spotted seatrout, *Cynoscion nebulosus*, has significant potential for aquaculture in the Gulf of Mexico. In fish aquaculture, the availability of high-quality fingerlings is the most critical factor for its commercial success. However, the current state of spotted seatrout culture technology is limited to reproductive and larval rearing protocols (to reduce cannibalism). In order to identify physiological biomarkers of the digestive system to optimize feeding strategies (diet design and weaning) during larval development of spotted seatrout. The objective of this study was to assess the activity of digestive key enzymes (pepsin, alkaline protease, trypsin, chymotrypsin, leucine aminopeptidase, alkaline phosphatase, amylase, and bile salt-dependent lipase) in this specie from hatching until day 30. Multivariate analysis identified three digestive stages. The first stage occurred between 1 and 3 days after hatching (DAH); a period of digestive stability showed the highest activity in amylase and bile salt-dependent lipase. The second stage was a period of digestive transition (from 4 to 20 DAH), during which leucine aminopeptidase, chymotrypsin, and alkaline proteases were identified as the predominant enzymes from 4 to 5 DAH. In the third stage, a period of digestive stability, pepsin was the major enzyme that occurred between 25 and 30 DAH. These results indicate that the spotted seatrout larvae have a digestive system adapted to lipids and carbohydrates at the onset of feeding with an immediate transition to protein digestion when exogenous feeding begins.

SPERM QUALITY OF *Litopenaeus vannamei* FED WITH AN EXPERIMENTAL PELLET OR FRESH FOOD IN TWO CULTURE SYSTEMS

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The increase in shrimp production through aquaculture has been carried out thanks to the optimization of processes such as nutrition in the pre-maturation and reproduction phases of shrimp. In this work, the best culture and food system were proved during the prematuration phase to improve the reproductive characteristics of Litopenaeus vannamei males; The biofloc system was compared with clear water and an experimental pellet with a mixture of fresh food. Survival, sperm quality, immune system parameters such as prophenoloxidase (ProFO) and hemocyte count, nutritional condition measured through metabolites in the hemolymph, hepatopancreas and reproductive tract, and oxidant stress biomarkers were measured. In the hepatopancreas and reproductive tract and the relative expression of superoxide dismutase, catalase, glutathione peroxidase, ProFO, α2-macroglobulin and caspase genes in the reproductive tract.

UTILIZATION OF FEED ENZYMES FOR RAINBOW TROUT *Oncorhynchus mykiss* FEEDS

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Feed enzymes have gained favor for use in animal feeds for improving phosphorus utilization, improving energy digestibility, as well as reducing waste loading into the environment. The utility of feed enzymes in aquafeeds has been increasing particularly for warm water species, but information is still limited for cold water, carnivorous species. Phytases are utilized to improve digestion of phosphorus bound as phytate-P in plan-based ingredients. Xylanases are utilized to digest xylan polysaccharide from hemicellulose. Cellulases are utilized to digest cellulose to glucose. Making these components bioavailable to rainbow trout could potentially improve both feed efficiencies as well as reduce fecal waste loading.

An experiment was performed to test the efficacy of phytase, xylanase and a blend of xylanases and cellulases in a plant-based rainbow trout feed compared to a commercial-style trout feed totaling nine diets. The positive control feed contained 45% crude protein and 15% crude fat from a blend of animal and plant sources with a target 0.54% digestible P. The negative control diet was formulated to target the same protein and fat levels but with 0.18% digestible P and 0.38% phytate-P. Phytase (ABVista Quantum Blue) was supplemented 2500 FTU/kg feed in diets 3-9. Diets 4, 5 and 6 were supplemented with graded levels of xylanase (ABVista EconaseXT) at 2000, 4000 and 8000 BXU/kg feed. Diet 7,8 and 9 were supplemented with NSPase blend of cellulase and xylanse (ABVista VistaPre-T) to target xylanase levels of 3500, 7000 and 14000 BXU/kg feed. Feeds were extruded, floating ~4mm pellets with feed enzymes top-coated prior to final oil top-coating. Fish were reared in 15 °C in triplicate tanks of 20 fish weighing on average 26.1 g and fed to apparent satiation for 12 weeks.

Rainbow trout grew less when fed the negative control diet. Supplementation with phytase improved growth to levels attained with the positive control diet. Supplementing with phytase also improved P digestibility in the plant-based diets. Xylanase (EconaseXT) supplementation improved feed conversion ratios for fish fed the plant-based diet. Condition indices were largely unaffected by dietary treatment. Feed nutrient digestibility differed between diets with the positive control diet having higher dry matter, fat, and energy digestibility but lower protein digestibility than the plant-based diet. Fecal particle size differed between the positive control diet which was smaller for all size distributions compared to the plant-based diets. Feed enzyme addition did not greatly influence fecal particle size distributions.

IT'S GETTING HOT IN HERE: AN INVESTIGATION INTO THE ENVIRONMENTAL PLASTICITY OF LARVAL ZEBRAFISH *Danio rerio*

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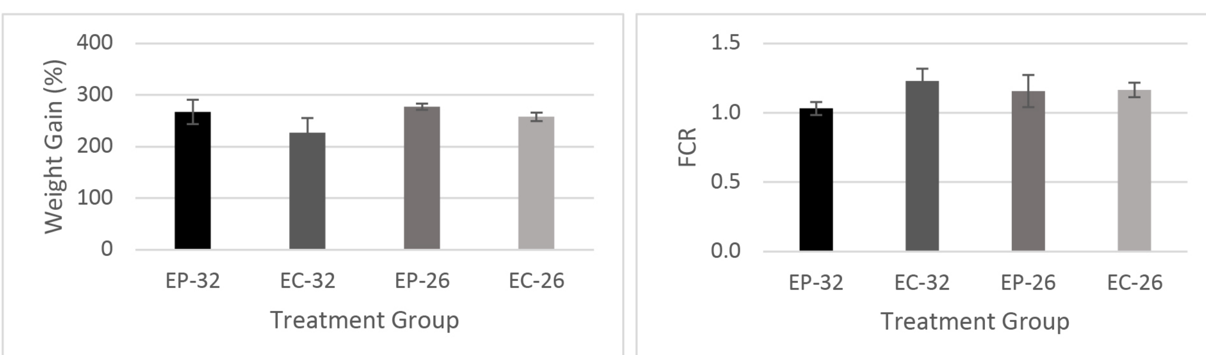
Ectothermic fish can be characterized by a certain degree of environmental plasticity and many of their traits related to behavior, stress response, and social skills can be influenced by early life experiences. These plastic responses provide different species with a coping mechanism to changing environmental conditions with epigenetic alterations in DNA seeming to play a major role. However, the mechanisms behind the induction of the adaptation process and environmental plasticity are not well understood. The main objective of this study was to use zebrafish (*Danio rerio*) as a model to determine if exposure to high temperatures at the larval stage can cause phenotypic plasticity, and how this could affect factors including growth, survival, and food conversion ratio (FCR) when exposed to similar conditions later in life.

Two treatments of zebrafish were randomly distributed into 6 (3L) tanks at 3 days post-hatch (dph), with 120 larvae per tank. This study initially included two treatment groups for the environmental programming: 1) an environmental control (EC) treatment, which remained at the control temperature of 26°C; and 2) an environmental programmed (EP) treatment which was raised to 32°C for a 24hr period between 6-8dph, then returned to 26°C. Both treatments continued with a grow-out period to 35dph at 26°C. At 35pdh, the initial treatment groups were split in half and randomly distributed into four treatments with 11 fish per tank for the environmental challenge. The treatment groups were: 1) both EP and EC raised at 32°C from 35-57dph (EP-32 and EC-32); 2) EC and EP raised at optimal temperature of 26°C from 35-57dph (EP-26 and EC-26). All groups were fed at a restricted feeding rate during the challenge phase equal across all treatments.

During the environmental challenge, the numerical data indicated the EP-32 group tended to have higher individual weight gain compared to the EC-32. The EP-26 group also tended to have higher individual weight gain compared to the EC-26. In addition, the EP-32 group tended to have the lowest FCR, particularly in comparison to EC-32. These preliminary results potentially suggest that brief exposure to high water temperature induced at the larval stage may lead to improved feed utilization and growth in zebrafish when exposed to similar temperatures at a later stage. The statistical and gene expression analyses will be included in the oral presentation.



Figures 1 & 2. Individual weight gain (%) and FCR averages during environmental challenge (35-57dph).

ENSURING THE FUTURE VIABILITY OF CONNECTICUT OYSTERS AND OYSTER FARMS

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Oysters and oyster farming are a highly valued part of Connecticut's maritime economy, environment, and culture. Connecticut has nearly 10,000 acres of protected natural oyster habitat. These beds have served as the primary source of seed for the state's multi-million-dollar oyster industry, have sustained commercial harvest for nearly two centuries, and are among the world's few self-sustaining oyster populations. Yet there are environmental and human-induced impacts to these critical habitats that reduce their function and ability to provide ecosystem services.

In 2018, the state began in a major planning effort to restore its oyster beds. The effort focused on characterizing oyster habitat across the state, compiling environmental and human use data for decision-making, and establishing management, research, outreach, and policy actions to help further facilitate oyster restoration and resulted in the CT Shellfish Restoration Guide (http://shellfish.uconn.edu/natural). While many needs were identified, two primary logistical hurdles existed including: 1) a lack of available workforce and work vessels, 2) limited funding for purchase of mature oysters and oyster shell substrate.

In 2020, it was the pandemic, ironically, that turned the tide in favor of shellfish restoration. Federal and state agencies provided emergency response funding for aquaculture. Funding was used to keep businesses operational while restaurants were closed, specifically to purchase oysters that could not otherwise be sold and shell substrate, and to pay farmers to plant these on natural beds across the state. Researchers are currently investigating optimal oyster and shell planting densities.

In 2021, the Connecticut General Assembly passed Public Act 21-24 aimed to enhance shellfish restoration and support shell recycling. This was an important move with shell substrate being expensive and in short supply. As a result, regulatory guidance was developed, and a shell recycling coordinator was hired to expand the state's modest efforts to recover shell. A survey of the food service sector will further inform the state's plans to incentivize restaurants as well as residents to recycle shell.

It is anticipated that these collective efforts involving a multitude of partner organizations will grow the state's capacity for oyster restoration, result in a net gain in ecosystem services provided by oyster habitats, and ensure the sustainability of the shellfish industry that depends upon them.

ECONOMIC BENEFITS OF LOCAL SEAFOOD IN RESTAURANTS AND RETAIL STORES IN VIRGINIA

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As the fourth largest producer of seafood in the United States, the Virginia Seafood Industry has long been recognized as a vital component of the state's economy, contributing significantly to its economic growth and employment. Recent estimates showed $1.1 billion in total economic output for 2019, supporting over 7,000 jobs. However, these estimates do not reflect the economic contributions from seafood restaurants and retail stores. Restaurants and retail stores are essential in connecting consumers with local seafood products, acting as intermediaries between seafood producers and consumers. Moreover, these establishments often create unique culinary experiences, attract residents and tourists, and fuel Virginia's vibrant food culture. Despite their undeniable importance, the economic contributions of the seafood portion of the sales from these establishments have remained largely unexplored due to difficulties in obtaining primary data. Therefore, we aim to estimate the economic contributions of local seafood sales from restaurants and retail stores in Virginia and generate a more holistic understanding of the Virginia Seafood Industry's overall economic benefits. We plan to purchase datasets of seafood sales in retail stores in Virginia through scanner data of seafood products' bar codes from NielsenIQ, a specialized company in marketing strategy and consumer behaviors. Existing expenditure models from restaurants and retail stores can be found on the IMPLAN modeling software that we will subscribe to perform the economic contribution analysis. Authorities, State agencies, and other entities overseeing restaurants and retail stores, such as the Virginia Department of Taxation, the Virginia Department of Tourism, and restaurant associations, will be consulted for records of the number of commercial licenses or permits held within the state. Data unavailable from secondary sources or consultation with other researchers must be collected through a survey. Seafood distributors will be asked how much Virginia's seafood products stay in the state. In addition, an analysis of restaurant menus published online will be performed to assess the number of entities advertising Virginia seafood products and their prices. After obtaining the necessary data to perform an economic contribution analysis on IMPLAN, the results will be incorporated into the previous model that estimated the contributions from commercial fisheries, aquaculture, seafood processors, and distributors. By combining the contributions of restaurants and retail stores into the economic estimates, we can enhance the accuracy and completeness of the data, enabling a more comprehensive understanding of the Virginia seafood industry's true economic significance. The results of this analysis will include estimates of the economic contributions of local seafood sales from restaurants and retail stores in Virginia to the economy of the Commonwealth, which will be reported as direct, indirect, and induced effects on economic output, the total value added, labor income, other property income, employment, and tax revenue. Additionally, the sectors identified as supported by the Virginia seafood restaurants and retail stores will be ranked to determine which other sectors benefit the most from Virginia seafood business activities.

THE VALUE OF CO-LOCATING AQUACULTURE WITH RENEWABLE ENERGY: PERSPECTIVES OF CALIFORNIA'S COMMERCIAL FISHERMEN

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Globally, the growing need for ocean resources is resulting in an increased demand for ocean space from a number of interest groups (e.g., fisheries, conservation, aquaculture, energy, etc.). While suitable resources exist for these activities individually, the confluence of multiple resource goals operating in the same marine space presents a conflict. Balancing all the needs of these parties is increasingly challenging and may hinder the development of less prioritized sectors (e.g., aquaculture). This exacerbates the existing issue of social acceptance of the aquaculture sector. A possible tactic to help find common ground is co-location of marine activities, which allows for multiple uses at the same time and in the same ocean space. In areas where competition for ocean resources is escalating, co-location can alleviate stress by enabling multiple activities to take place simultaneously, thereby freeing up space for other ocean users. By increasing the value of a region and reducing the trade-offs to stakeholders and the environment, co-location may be able to increase social acceptance of aquaculture. Despite its potential, co-location has remained an understudied tactic in ocean management.

This research will address this research gap by targeting a historically significant stakeholder group in California – commercial fishermen – to (1) provide baseline understanding of the social perceptions of fishermen towards aquaculture and (2) investigate if these perceptions might differ if aquaculture were to be co-located with clean energy, which could limit the loss of fishing grounds. This social perception and behavioral research study will aim to bridge the gap between major ocean users (i.e. fishermen) and agency members involved with aquaculture development, incorporating community engagement and collaboration into state-wide decision-making and contributing to a seafood sector that is socially resilient and sustainable.

SYNTHESIS OF GLOBAL MARINE CO-LOCATION EFFORTS

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The United States is striving to expand its 'blue economy' to meet growing demand for marine resources, including seafood and renewable energy. As a result, there has been a growing competition for ocean space. Co-location, multiple sectors (e.g., aquaculture and renewable energy) operating in the same ocean space at the same time, is one potential tactic that can reduce competition amongst stakeholders. While research into the benefits and tradeoffs associated with co-locating ocean activities is increasing, there is a lack of consistency surrounding the definition of "co-location" and uncertainty surrounding its ability to serve as a tool in sustainable aquaculture development. This research aims to fill that gap by providing a global overview of marine co-location literature, particularly as it relates to aquaculture.

In this study, we synthesized co-location literature published between the years 2000 and 2022 and extracted environmental metrics so that comparisons could be made across regions and oceans sectors. We found that publication of co-location literature was low from 2000 until 2013, before steadily increasing from 2013 until 2017 (***Fig. 1A***). We also highlighted trends in the disciplines and motivations of co-location publications (***Fig. 1B, 1C***). These trends, and others, demonstrate that the study of co-location is growing and may become a useful tool in understanding aquaculture development and siting. Ultimately, this project aims to enhance our understanding of the research gaps, potential benefits, and limitations in sustainable aquaculture development and its space-use dynamics.

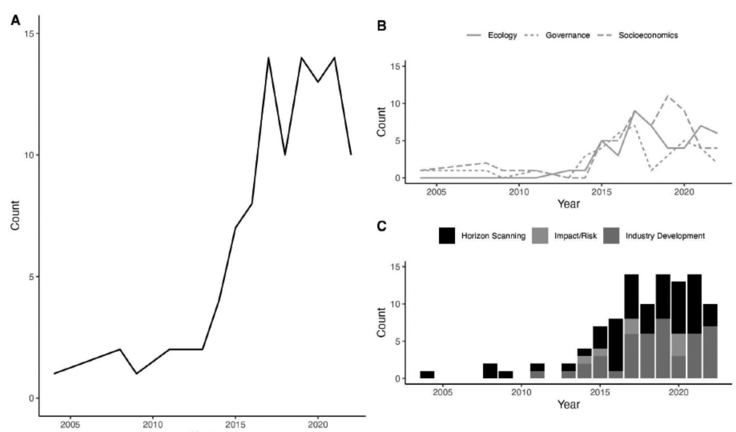

Figure 1. *Shows frequency of publications (years 2000-2022).* ***Pane A*** *reflects the total frequency of co-location publications published over time (m=0.862, R^2=0.763).* ***Pane B*** *reflects the frequency of co-location publications, separated by publication discipline, published over time.* ***Pane C*** *demonstrates the frequency publications, categorized by project motivation.*

EXPLORING THE INFLUENTIAL FACTORS SHAPING CONSUMER BEHAVIOR AND PURCHASE INTENTIONS OF ORGANIC SEAFOOD PRODUCTS

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Enhancing our comprehension of the factors that shape the preferences of U.S. consumers is of utmost importance in fostering the economic viability of organic seafood industry. Therefore, a consumer survey was conducted in 2022 utilizing 'Qualtrics' platform to investigate consumer preferences across ten U.S. Southern states. The survey encompassed approximately 200 participants per state, resulting in a total sample size of 2,129 individuals. Various statistical tools were employed in this analysis, including variance inflation factor, deemed acceptable if its value is below 10, and tolerance limit, considered acceptable if its value is below 0.05. Furthermore, forward and backward stepwise regression methods were utilized with a significance level set at 0.05 to identify influential variables. Subsequently, a multinomial logistic regression model was developed to examine factors impacting consumers' purchasing behavior of organic seafood.

The findings revealed that individuals aged between 30 and 39 strongly preferred purchasing organic seafood. Conversely, older individuals aged 70 and above demonstrated a tendency to make occasional or no purchases of organic seafood. Moreover, individuals belonging to households with a size of 3 to 4 members and an annual family income ranging from $30,001 to $49,999 were more inclined to purchase a greater quantity of organic seafood products. Notably, some survey participants expressed minor reservations regarding the extent to which organic seafood is completely free from chemicals, pesticides, and antibiotics (Figure 1). This dissenting viewpoint suggests a belief that organic seafood may contain trace amounts of such substances. Additionally, occupation emerged as another influential variable, particularly among individuals employed in sales and marketing roles, influencing their purchasing behavior. In summary, this study shed light on key factors such as age, household size, income, concerns about chemical content, and occupational influence, which can guide businesses in catering to the preferences of their target market effectively.

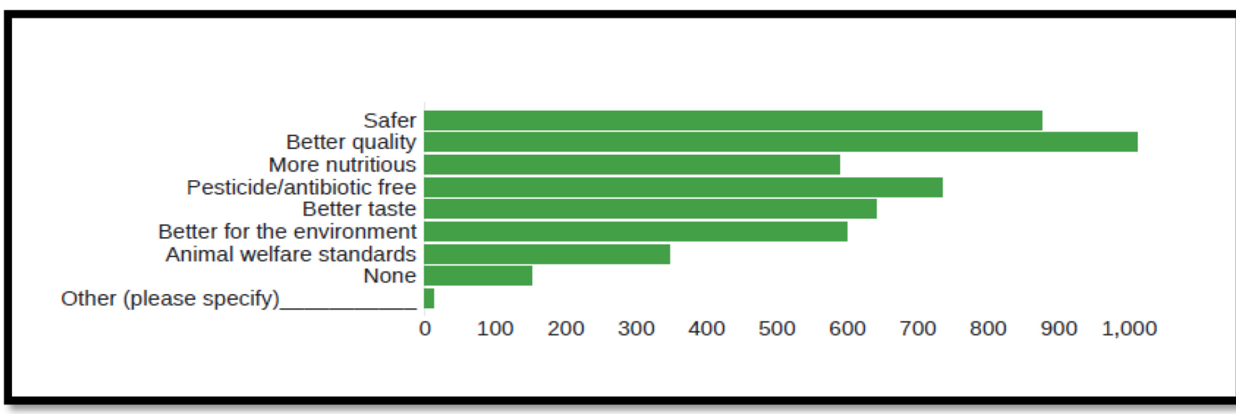

Figure. 1: Reasons for preferring organic seafood over regular food (source: current survey)

CARBON SEQUESTRATION DYNAMICS IN AQUACULTURE PONDS: INFLUENCES OF FISH SPECIES SELECTION, POND AGE, AND FARMING PRACTICES

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Aquaculture ponds, often overlooked in national carbon budgets, present a valuable opportunity for carbon storage. This study explores the carbon absorption rate of pond sediments in relation to fish species selection, pond age, and fish farming management. We employed a standardized soil sampling protocol, using a hand core sediment sampler to collect 200g-300g soil samples from approximately 20 cm depth (methodology adapted from Gilbert et al, 2021)). All samples were collected by the same individual to ensure consistency. Soil analyses were performed at the Oklahoma State University Soil Testing Lab. Channel Catfish (n=4), koi (n=2), and bluegill (n=2) fish-pond soils were sampled. Additionally, a questionnaire captured data on physical and chemical parameters and fish farming management practices.Our results indicated that carbon absorption rates varied significantly among fish species selections. Bluegill fishponds exhibited the highest organic matter (%) and total carbon (%) content in both dry and wet conditions, followed by catfish and koi ponds (Figure 1). Furthermore, carbon absorption rates were assessed in relation to pond age and various management factors (stocking rate, feed, total production). Once again, bluegill fish-ponds showed the highest carbon absorption rates, followed by catfish and koi ponds. This study underscores the potential for optimizing carbon storage in aquaculture ponds and highlights the importance of considering fish species selection, pond age, and fish farming management practices in carbon sequestration strategies. These findings contribute to our understanding of carbon dynamics in aquaculture systems and their relevance in addressing the challenges posed by changing climate patterns.

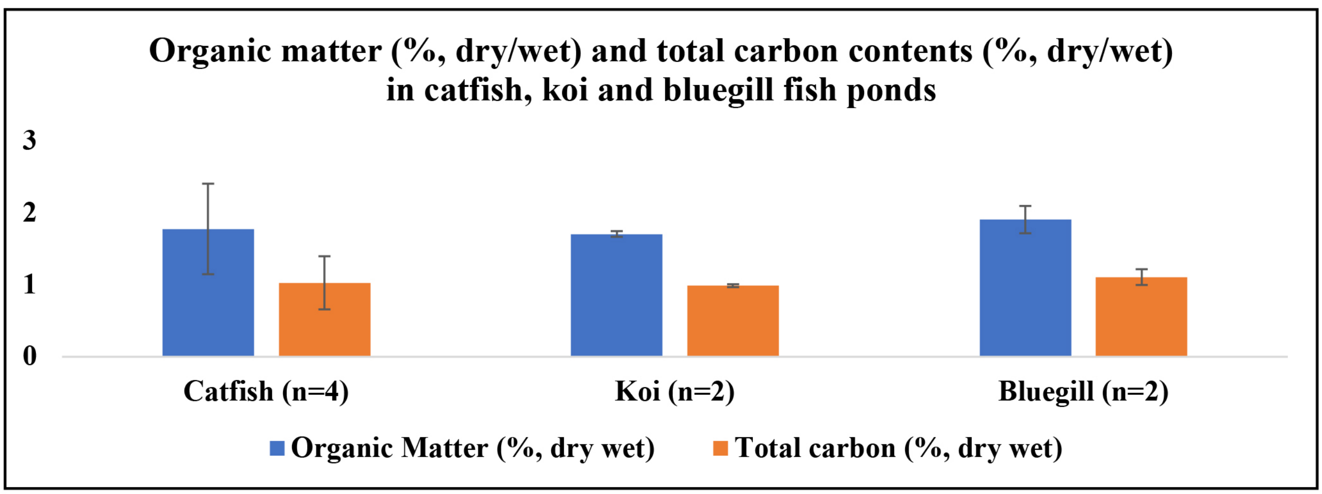

Figure 1: Organic matter (%, dry wet) and total carbon contents (%, dry wet) in catfish, koi and bluegill fish ponds (source: current survey)

ENHANCING CLOWNFISH AQUACULTURE: INNOVATIVE 3D-PRINTED HATCHING APPARATUS

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Achieving consistent hatching success is crucial for the sustainable commercial production of fish, particularly for demersal spawning species like clownfish. The process often involves the delicate task of transferring spawning substrates from broodstock tanks to larval systems, necessitating meticulous care to prevent egg fouling. Traditional methods, while effective, come with challenges in ensuring optimal conditions for each hatch.

Addressing these challenges, we developed a custom-designed 3D-printed hatching apparatus (Figure 1). This innovation streamlines the hatching process for clownfish, a species that can be trained to spawn on removable substrates. The apparatus is specifically tailored to support a standard 6 x 6-inch ceramic tile, commonly used as a spawning substrate in hatcheries.

The design of the hatching stand is key to its functionality. It holds the tile at a precise 60-degree angle, ensuring stability and optimal egg exposure. A critical feature of the design is a channel that positions an air diffuser directly beneath the tile. This arrangement creates an ideal air curtain, facilitating continuous water circulation over the eggs, thereby significantly reducing the risk of fouling, and enhancing viability during incubation.

Moreover, the versatility of this 3D-printed apparatus extends beyond hatching. Variations of the design can be utilized within broodstock tanks to support spawning substrates, mitigating risks associated with tile displacement and simplifying nest removal. By creating a reliable, efficient, and reproducible tool for egg incubation, the probability of successful larval development in each batch is substantially increased.

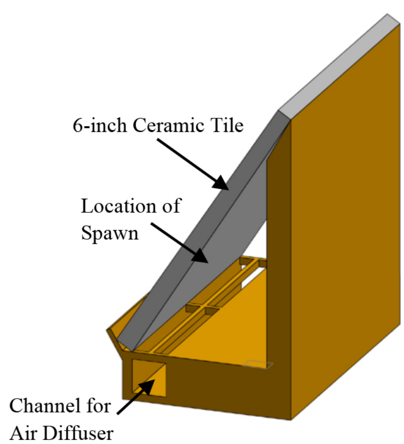

FIGURE 1. Hatching Apparatus (orange), showing the ceramic tile (grey) oriented above the aeration channel.

CORRELATING FATTY ACID PROFILES WITH EGG QUALITY IN MARINE FINFISH FROM PUBLIC AQUARIUMS SPAWNS

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Public aquariums hold untapped potential as catalysts for aquaculture innovation, possessing diverse and biologically rich living collections. This project, a collaboration between leading academic and public aquariums (New England Aquarium, National Aquarium, John G. Shedd Aquarium, Aquarium of the Pacific, and North Carolina Aquariums) aims to utilize living collections to enhance the propagation strategies of marine finfish. Focusing on 14 marine finfish species, many of commercial interest and new to aquaculture, the project seeks to collect and analyze critical spawning data, track egg and larval development, and examine egg quality and larval survival rates.

Each partner aquarium is tasked with collecting eggs from their broodstock, and documenting essential characteristics such as egg volume and quality. A key aspect of this study involves analyzing the fatty acid profiles of each spawn, correlating these data with the observed quality of the resultant spawn. This approach allows for a comprehensive examination of the relationship between diet, egg health, and overall spawn viability. This talk will discuss the current status of data collection on fatty acid profiles and egg quality, and the interconnection between the two examining how feed quality influences them.

The project's outcomes are expected to significantly enhance the scientific understanding and capabilities of these institutions in the early propagation stages of these species. By identifying correlations between egg quality and fatty acid profiles across various species, tailored diets can be developed for these warm water tropical fish, potentially improving propagation success rates. This research not only benefits the partner aquariums but also contributes valuable insights to the broader field of marine aquaculture.

This initiative highlights the importance o ublic aquariums can serve as invaluable resources for aquaculture research and deve ovide practical applications in improving fish rearing practices, particularly in the e presents a significant step towards more efficient and sustainable aquaculture practi esources of public aquariums to enhance our understanding and cultivation of marin

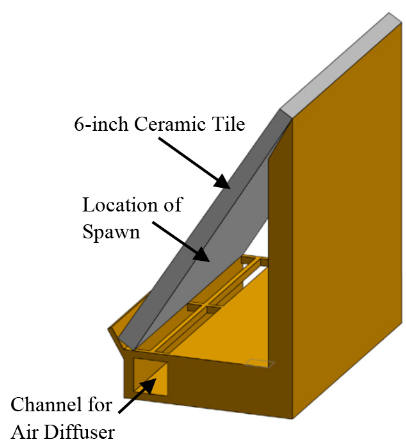

FIGURE 1. Hatching Apparatus (orange), showing the ceramic tile (grey) oriented above the aeration channel.

WHAT NOAA FISHERIES IS DOING TO MANAGE THE POTENTIAL RISKS OF AQUACULTURE ACTIVITIES ON PROTECTED RESOURCES

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Marine aquaculture is a vital sector of the blue economy and further development of this industry is a strategic priority for the Department of Commerce and NOAA Fisheries. As aquaculture production grows, multiple efforts are underway across NOAA Fisheries offices and science centers to address the potential risks of protected resources interactions with aquaculture gear. We aim to develop consistent regulatory approaches to promote aquaculture that conserves protected resources.

This talk will provide context on what NOAA Fisheries is doing to assess, manage, and minimize potential risks to marine protected resources by:

- Describing the regulatory nexus for the management of species and critical habitat protected under the Endangered Species Act and Marine Mammal Protection Act
- Illustrating how we analyze risk in our ESA section 7 consultations
- Highlighting research priorities to further support this topic

Publicizing the mutually beneficial outcome preferred by NOAA Fisheries will also help inform other stakeholders in their efforts to research and develop tools to advance our collective understanding about how to maximize aquaculture production while minimizing potential risks from aquaculture operations.

PRODUCTION OF HYBRID STRIPED BASS AND WATER QUALITY IN SPLIT PONDS COMPARED TO TRADITIONAL EARTHEN PONDS

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The split-pond production system, a modification of the partitioned aquaculture system, is a catfish production intensification strategy used on about 3,000 acres (ca. 1,200 ha) of ponds in the southern U.S. Increased catfish yield results because of improved control of dissolved oxygen and total ammonia concentrations, feeding efficiency, predator control, and harvest. Because hybrid striped bass are fed a higher protein feed than catfish during grow out, pond total ammonia-nitrogen concentration, a prime concern of farmers, can increase and affect hybrid striped bass performance. Hybrid striped bass (*Morone chrysops* x *M. saxatilis*), which is grown in traditional earthen ponds in the U.S., is a promising candidate for the split-pond production system. For the first time, water quality and performance of hybrid striped bass grown to market size in split ponds compared to traditional earthen ponds were evaluated in two 153-155-d studies. Hybrid striped bass (0.55 lb/fish; 250 g/fish) were stocked at 3,000/acre (1,215/ha) in study 1, while in study 2, fish (0.32 lb/fish; 145 g/fish) were stocked at 3,200/acre (1,295/ha). Fish in both studies were fed a 42% crude protein, 12% lipid extruded, floating feed to apparent satiation 6 d/wk. A paddlewheel aerator (4.5 kW/acre; 11.0 kW/ha) in each pond was activated when dissolved oxygen concentration dropped below 40% saturation. The aerator operated only in the split pond fish basin. Total ammonia-nitrogen concentrations in split ponds were significantly lower than in traditional ponds. No significant differences were detected between systems for other water quality variable concentrations. The absence of significant differences in production metrics shows hybrid striped bass perform as well in split ponds and as in traditional ponds when stocked at 3,000-3,200 fish/acre (1,215-1,295 fish/ha).

SIZING CRITERIA FOR BIOFILTER USED IN INCUBATORS SUPPORTING THE PRODUCTION OF TILAPIA FRY

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The tilapia (*oreochromis niloticus*) industry produces 7 million tons of fish worldwide, and only 5% of it is produced in the U.S. There is a demand to significantly improve hatchery water quality in order to stimulate successful hatching in incubator systems that hatch and produce fry. Recirculating aquaculture systems can provide a better outcome for mass production of tilapia, because they allow for more control over the system's environment. RAS facilitates isolation of batches and the year-round growth of fry. This paper addresses the rationale used to size biofilters for this application, based on tilapia's high tolerance for ammonia and pH impact, and egg loading and biofouling behavior. Sizing strategies and criteria for floating beads bio-clarifiers and moving bed reactor systems are discussed. Additionally, this paper provides a developed tilapia-specific equation for sizing biofilters for hatching and fry. Based on BOD_5 of 0.75 ± 0.01 g/g, nitrogen loading of 11.67 ± 0.31%, and protein loading of 73.10 ± 0.42%, the sizing criteria for a PolyGeyser® RAS is determined as a function of the volume of bead media needed for tilapia-specific egg weight and TAN.

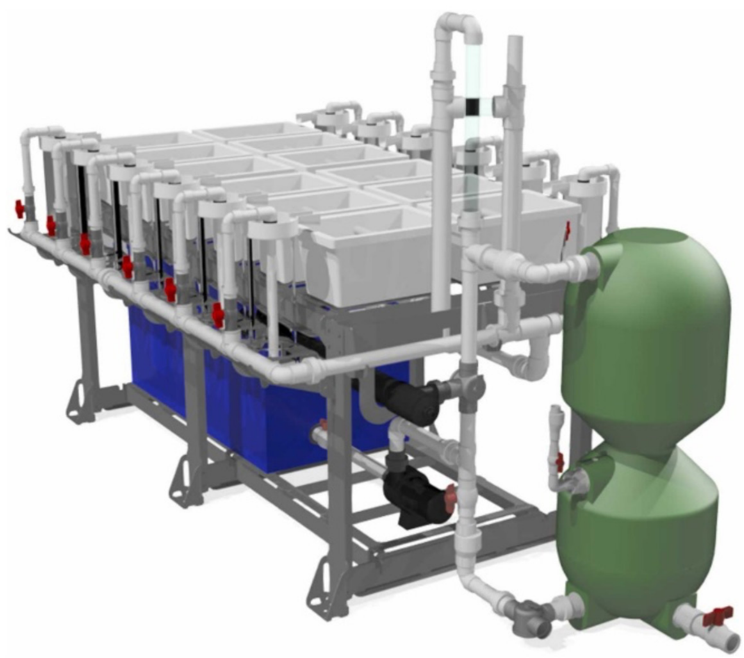

Figure 1: RAS supporting 12 McDonald Jars with a reservoir, recirculation pump, ultraviolet light and static floating bead filter

ENHANCING THE AQUACULTURE POTENTIAL AND STOCKING OF WALLEYE (*Sander vitreus*) THROUGH MANAGEMENT OF FEED NUTRITION

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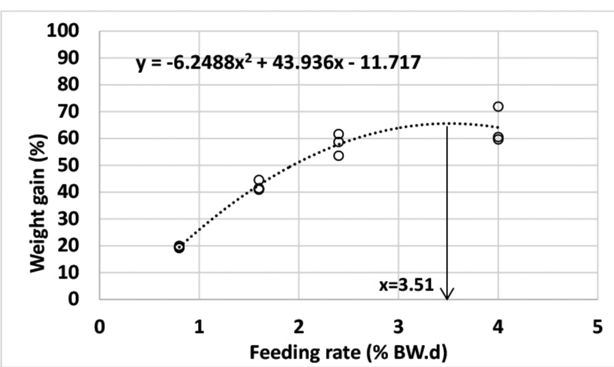
Walleye (*Sander vitreus*) is an ecologically important and highly prized food fish in the Midwest region. With limited commercial harvesting of wild walleye, the primary supply for the region relies on imported walleye. Developing a robust walleye aquaculture industry is crucial to meet the ever-growing market demand. This study aims to establish a cost-effective feeding strategy and formulate a nutritionally balanced feed to enhance walleye aquaculture.

Two feeding trials were conducted on walleye with an initial body weight of 37 ±1.26 g (n=30) within a flow-through water system (19 – 21 °C). In the first trial, walleye were subjected to four feeding rates (0.8%, 1.6%, 2.4%, and 4.0% of body weight per day) for 6 weeks to determine the optimal feeding rate (OFR). The second feeding trial lasted for 9 weeks and aimed to assess the response of walleye to various diets characterized by differing lipid-to-starch ratios: 0.50, 0.65, 0.83, 1.06, and 1.36. Each treatment consisted of three replicates with 20 fish per replication. Fish were fed four times daily (9:00 a.m., 12:00 p.m., 3:00 p.m., and 6:00 p.m.) using automatic feeders. We employed polynomial regression to estimate the optimal feeding rate and the ideal dietary lipid-carbohydrate combination.

Results revealed that the OFR was 3.51% based on weight gain (Figure 1) and 1.35% based on achieving the lowest feed conversion ratio (FCR). Feeding a diet with a lipid-to-starch ratio of 0.99 resulted in the highest weight gain (Figure 2) and a ratio of 1.04 achieved the lowest FCR. Moreover, visceral fat, whole fish lipid content, and lipid retention displayed statistical differences among the various treatments ($P < 0.05$). The findings related to the response of walleye to hypoxia and heat shock stressors are currently under analysis and will be discussed in the presentation. The preliminary findings of this study provide essential baseline data for effective feed management and selection in the context of walleye aquaculture, ultimately promoting its sustainable development.



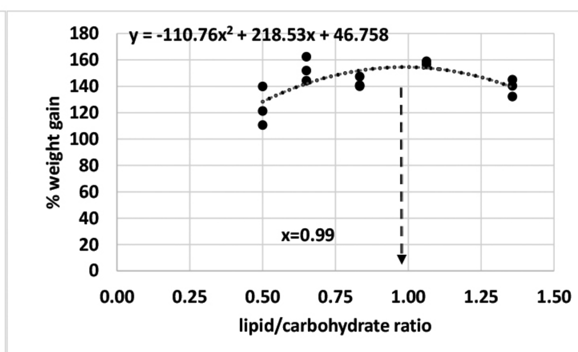


Figure 1: Weight Gain Percentage Based on Feeding Rate

Figure 2: Weight Gain Percentage Based on Lipid-to-Starch Ratio

CULTURE PRACTICES AFFECTING WATER PARAMETERS INSIDE OYSTER GROW-OUT CONTAINERS ON COMMERCIAL SHELLFISH AQUACULTURE OPERATIONS

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Numerous studies have reviewed how different husbandry decisions on oyster farms (e.g. stocking density, biofouling control, and gear type) correlate to oyster performance, but not much is understood about how these decisions affect the water parameters inside oyster grow-out containers. Ambient conditions on leases (monitored directly or through local water monitoring stations) might appear suitable for oyster performance, but different husbandry decisions could potentially affect the environment within the growing containers and cause significant deviation from ambient conditions.

Conditions inside an oyster bag may vary from ambient conditions due to reduced water exchange rates which may be exacerbated by biofouling communities and oyster stocking density. This ongoing project explores if stocking density (measured as percent of bag full with oysters) and total blockage (mesh blockage added to biofouling blockage) affect water parameters (dissolved oxygen, pH, turbidity, and chlorophyll-a) inside oyster grow-out containers at commercial shellfish aquaculture operations. Paired water samples were collected from May through October of 2022 and 2023 from the inside and less than 0.3 meters outside of oyster-growing containers at 22 farms in North Carolina, Florida, and Virginia across various gear types, salinities, and water temperatures. The differential (inside sample – outside sample) was calculated to standardize the results across the different sites.

Preliminary data analysis using a linear model suggests that there is an interaction between stocking density and total blockage on the percent dissolved oxygen (DO) and pH differentials ($p \leq 0.01$ for both). The combined effect of increasing stocking density and total blockage results in a magnified decrease of DO and pH. DO decreases 3.9% for each 10% increase in stocking density and total blockage, while pH decreases 1.6×10^{-3} with these 10% increases. These predictors explain 67% of the variance for DO and 56% for pH. Chlorophyll-a is affected by stocking density ($p \leq 0.01$) and explains 19% of the variance in the results. For each 10% increase in stocking density, chlorophyll-a decreases by 1.13 mg/L. The lowest DO, pH, and chlorophyll-a values were observed in bags with greater than 50% stocking density and 70% blockage (30% DO decrease; 15 mg/L chlorophyll-a decrease; 0.4 pH decrease). There is no relationship between the stocking density and total blockage for turbidity ($p = 0.33$ for the overall model; $R^2 = 0.05$).

Results from this study suggest that farmers can influence the water parameters within their bags through various husbandry decisions. Ambient condition absolute values are not necessarily a good metric to describe what is happening inside grow-out containers. Water parameters within containers can be substantially lower than the outside environment. As predicted climate change could lead to further decreased dissolved oxygen and pH levels, understanding how culture practices might affect conditions within grow-out containers is essential.

ALABAMA-MISSISSIPPI OYSTER COMMUNITY OF PRACTICE

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The purpose of the Alabama-Mississippi Oyster CoP is to:

1) establish a network of interested oyster farmers, wild oyster harvesters, restaurants, management agencies, and other members of the oyster industry to determine common challenges within the oyster community.

2) implement solutions to the challenges facing the oyster industry through sustained Engagement.

3) enhance collaboration within and across the oyster farming and wild harvest sectors by identifying challenges and solution.

4) solve problems collaboratively through sustained engagement with the oyster industry over the long-term.

5) create a list of priority issues, tradeoffs, and decisions to help guide meetings and create innovative solutions.

CONCERNED OYSTERMEN RESTORING ESTUARIES

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The massive disruptions to the oyster industry caused by the covid-19 pandemic creates an opportunity to rethink how oyster habitat can be restored and created. Oyster reef restoration and enhancement projects have focused on replacing or supplementing cultch material in the hopes of gaining a natural spat set. Despite these considerable efforts, oyster reproduction has varied wildly over the last 5 years from Florida to Texas causing nearly catastrophic consequences to the gulf oyster community. The use of aquaculture as a tool for restoration or enhancement has been limited, with any efforts primarily focused on the use of spat on shell. We seek to determine the ecosystem service benefits provided using large, single oysters, obtained from the private commercial aquaculture sector.

The objectives are to:

1. Partner with the Alabama Marine Resources Division (AMRD) and the Mississippi Department of Marine Resources (MDMR) to identify appropriate sites to place oysters.
2. Purchase oysters from farmers in Alabama and Mississippi to provide up to 450,000 3-plus inch farm-raised oysters for enhancement.
3. Monitor the farmed oysters' growth and survival and the ecosystem services they provide.
4. Conduct stakeholder engagement about the program.

Participating oyster farmers are providing oysters to the appropriate state agencies (AMRD and MDMR) for deployment at designated sites. Working in cooperation with the state agencies, oysters stocked will be monitored by Auburn University Shellfish Lab (AUSL) personnel to assess oyster growth and survival, natural recruitments, and estimates of associated ecosystem services.

in addition to the direct support to oyster farmers during the pandemic by paying a net price of up to $0.40 per oyster, this project will also provide critical ecosystem services through improved water quality, increased biodiversity, creation of more diverse habitat and cultural services provided by productive oyster reefs.

STAKEHOLDER PERCEPTIONS OF OYSTER SERVICES: A MIXED METHODS APPROACH TO MAPPING SERVICES TO IMPROVE MANAGEMENT EFFICIENCY

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Oysters are an important species both culturally and economically on Long Island, New York. They provide numerous ecosystem services ranging from filtering and cleaning the water to protecting the coast against storm surges and providing a local and sustainable source of seafood. Because the myriad services oysters provide are difficult to simultaneously optimize, decisions about which ones to prioritize often arise, and stakeholders may end up holding conflicting positions about best management practices. Throughout 21 focus group meetings across a range of stakeholders, people 1) identified what oyster services matter the most to them, and 2) what actors and drivers they saw affecting those services. This allowed us to understand how these services help shape their daily life.

We used Fuzzy Cognitive Modeling (FCM; Figure 1) to produce quantitative modes of stakeholders' views of how ecosystem components are interrelated which may allow managers to envision the impacts of various potential management strategies on specific oyster services. While FCM provides a quantitative structure to understand the relationships among participants and the oyster ecosystem, exploring the emotional connections required an additional qualitative tool. In order to illuminate participant perceptions, a photovoice process followed the FCM mapping session (Figure 2).

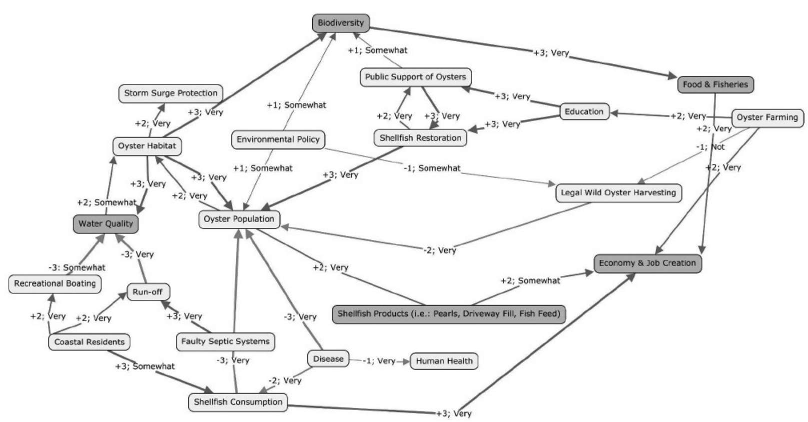

Figure 1 (Left): FCM example; Figure 2 (Right): Photovoice example showing the word "Food & Fisheries" from the FCM.

ADVANCED IMAGING TO UNRAVEL SKELETAL DEFORMITIES IN AQUACULTURED MARINE AQUARIUM FISH

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Deformities in aquacultured fish pose production challenges, particularly in marine aquarium aquaculture. Head, spine, gill, and swim bladder deformities repeatably occur impacting the marketability of fish. To study the extent of the abnormality, a method of preserving and imaging must be developed. We have noticed that previous methods of euthanasia can cause stress, leading to exaggerations in features such as flared operculum, open mouths, and body curvature due to rigor mortis. When investigating the nature of craniofacial deformity, it is vital that the deformed features are not exaggerated during the euthanasia and fixing procedure.

Fine scale imaging via computerized tomography (CT) requires specimens to be positioned well, and ideally with each specimen in the same position for comparison. The easiest way to scan most preserved samples is through embedding in agars or resins. Agar embedding techniques are traditionally utilized on larval fish, embryos, and histological tissue sections to aid in image capture. This work, however, focuses on model species, that differ in size and application to marine aquarium fishes. There has been little to no research or protocols available for emending full fish for craniofacial analysis.

During this study multiple methods of euthanasia, fixing, and agar embedding will be compared to find the best method for image analysis of specimens. Species aquacultured including clownfish (*Amphiprion ocellaris*), royal gramma (*Gramma lorteo*), smallmouth grunt (*Haemulon chrysargyreum)*, glassy sweeper (*Pempheris schomburgkii)*, and the Atlantic lookdown (*Selene vomer*) will be utilized.

Fish representatives with mild (Figure 1A), moderate (Figure 1B), and extreme (Figure 1C) craniofacial deformities will be euthanized in Tricaine methanesulfonate (MS-222) in increments of 50 ppm buffered with 100 ppm sodium bicarbonate and fixed in 10% neutral buffered formalin. This procedure will result in natural, relaxed fish for imaging. The fixed fish will then be embedded in 1-2% agar at temperatures ranging from 30ºC to 50ºC. Method development will determine the best viscosity and temperature to allow ample time to manipulate the specimen and remove bubbles before setting. Consistent, clear, bubble-free embedded specimens can then be scanned to examine the craniofacial features of the fish with increased accuracy.

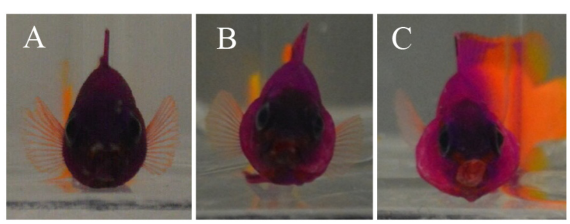

FIGURE 1. Example of mild (A), moderate (B), and extreme (C) craniofacial deformity in Royal Gramma (*Gramma lorteo*).

ASSISTING THE AQUACULTURE AND TOURISM INDUSTRIES OF DELAWARE THROUGH A GLOBAL PANDEMIC

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Consumer demand for seafood significantly declined in response to the sweeping restaurant closures associated with public health and safety guidelines limiting human occupancy resulting from the COVID-19 pandemic. Accordingly, economic output similarly declined, impacting the resiliency of our coastal economies as a nation. In response to the reduction in seafood demand from traditional supply streams such as fish auctions and seafood processors, many seafood producers attempted to shift sales to a direct consumer pathway. However, the transition to direct consumer sales was not easy for seafood producers, nor have the difficulties been evenly spread across supply sectors (i.e. shellfish aquaculture vs. wild harvest fisheries). In response, Delaware Sea Grant (DESG) mobilized an online seafood producer and/or harvester resource page (https://www.deseagrant.org/de-seafood-suppliers) in response to requests to help promote local, sustainable seafood options to the general public. Anecdotal reports from participating members suggest that sales increased in direct relation to online exposure of seafood producers for Atlantic Striped Bass, Black Drum, Black Sea Bass, Blue Crabs, Hard Clams, and Oysters (https://www.foxnews.com/us/commercial-fishermen-seafood-restaurant-closures-struggles).

To further connectivity between seafood suppliers and the public, staff from DESG engaged in a multistage effort to advance direct marketing opportunities, impacting economic opportunities for aquaculturists and commercial fishers in Delaware. The first stage of our plan assisted suppliers of locally produced and harvested seafood options by enhancing direct consumer sales through the development of a network of interested consumers. The second stage of our plan enhanced online marketplace opportunities. The third piece to our strategy focused on marketing and advertising to broaden our potential economic impact through the broader tourism industry. And finally, we worked with our shellfish aquaculture producers to purchase over-grown oysters that were larger than market preferred half-shell oysters for use in a restoration initiative with a non-profit organization, supplementing a transplant fishery for bottom ground lease holders in Delaware Bay. As designed, our efforts expanded outward in space from local to regional scales in a controlled manner, similarly expanding in time to match potential governmental re-openings in the region so that as this plan unfurled, our realized impacts grew in a stepwise fashion.

FIGURE 1. Seafood distribution events helped to connect consumers and suppliers.

OPTIMIZATION OF WATER QUALITY PARAMETERS FOR SURVIVAL AND GROWTH OF EASTERN OYSTER *Crassostrea virginica* LARVAE IN CULTURE

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The Eastern oyster, *Crassostrea virginica,* provides essential ecosystem services and has immense economic value. Various natural and anthropogenic events have led to significant declines in oyster populations, particularly along the east and Gulf coasts of the US. Aquaculture has the potential to fill the gap between supply and demand and contribute to reef restoration. Neither public nor private hatcheries have been able to meet the seed demand for either commercial or restoration purposes due to various natural and anthropogenic events that degrade water quality such as increased temperature, increased loading of nutrients, discharge of pollutants, and changes in freshwater inflow. The objective of this project is to assess the effect of water quality parameters (salinity, temperature, pH, dissolved oxygen (DO), calcium concentration, and alkalinity) on oyster larvae growth and survival. To achieve the proposed objective, water quality data, larval survival, and larval length measurements were taken from larval production tanks at four hatcheries along the Gulf coast.

Eastern oysters were spawned from April-October in 2022 and 2023. During production, larval tanks were monitored daily for salinity, temperature, pH, DO, and weekly for alkalinity and calcium concentration, the latter three of which will be used to estimate aragonite saturation state. Larval performance will be evaluated using growth, percent hatch, and percent survival to harvest. Growth will be calculated using averages of measurements of the shell length on days 2, 4, 6, 8, and 10 until harvesting begins and each day thereafter until larvae are all harvested. Percent hatch will be calculated using the estimated total number of fertilized eggs and the estimated Day 2 larval counts. Percent survival to harvest will be calculated using estimated Day 2 larval count stocked and total harvested larval counts. Water quality will be compared among the hatcheries and associations with larval performance will be assessed.

Preliminary data from Auburn University Shellfish Laboratory (AUSL), a flow-through hatchery, and the University of Southern Mississippi (USM), a recirculating hatchery, in 2022 show that, on average, USM produced larger larvae at a faster rate than AUSL (298 μm in 14 days vs. 239 μm in 18-19 days). AUSL had a slightly higher average percent hatch than USM (51.19% vs. 49.53%), but USM had a higher average percent survival than AUSL (34.93% vs. 26.85%). USM had higher average total alkalinity and average calcium concentration than AUSL (4683.42 μmol/Kg vs. 1789.43 μmol/Kg and 5.92 mmol/Kg vs. 5.85 mmol/Kg, respectively). USM had an average temperature of 25.95 ^{o}C, salinity of 20.67 ppt, pH of 8.47, and DO of 6.95 mg/L. AUSL had an average temperature of 27.65 ^{o}C, salinity of 20.02 ppt, pH of 7.86, and DO of 6.90 mg/L. Further analysis is needed to determine the significance of these findings. When analyzed, this data will improve the understanding of how different water quality parameter combinations affect larval production.

SELECTION OF RAINBOW TROUT *Oncorhynchus mykiss* FAMILIES FOR IMPROVED FEED UTILIZATION EFFICIENCY WITH SOYBEAN-BASED DIETS

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Two experiments were conducted to select rainbow trout families for improved feed utilization efficiency with soybean-based diets. In the first experiment, a total of 1200 fish (32.7±9.4 g, average±SD) belonging to 15 families (CX-118, CX-125, CX-134, CX-135, CX-137, CX-138, CX-141, CX, 143, CX, 144, CX-145, CX-146, CX-147, CX-148, CX-149, and CX-152) of rainbow trout (80 fish/family) were PIT tagged and randomly distributed in four tanks (1 m^3). Fish were reared in this environment for four months and went through two periods of feed deprivation (FD) and two periods of refeeding (RF). During the RF periods fish were fed at satiation with an all-plant extruded diet. After each period, all fish in each tank were anesthetized, PIT tangs were scanned, and weight and lengths were measured. Fish performance was classed as FD-, FD+, RF- and RF+ for fish exhibiting loss (FD) and gain (RF) of weight relatively lower (-) and higher (+) than the population mean and separated into four triplicate groups FD-/RF-, FD+/RF+, FD-/RF+ and FD+/RF-. In the second experiment, another group of 1200 rainbow trout (32.0±6.7 g, average±SD) belonging to the same 15 families were individually PIT tagged and distributed into two groups of 40 fish/tank. The two groups of fish were fed at satiation with two diets, Diet 1 was supplemented with lyophilized powder of spirulina whole cells and Diet 2 was supplemented with lyophilized powder of spirulina whole cells labeled with U-^{15}N. After 18 days of feeding, all fish were scanned, and weight and length were measured. Also, 0.4 mm diameter punches were used to take muscle samples from each fish to analyze for ^{15}N isotopes. Results for the first experiment showed family CX-138 had significantly lower weight loss during FD and family CX-125 had the highest weight loss during this period ($P<0.05$). For the RF period, family CX-148 had the highest WG among all the families. Families CX-125 and CX-146 were in second place with the highest WG compared to other groups and family CX-143 showed the lowest WG during RF. Results for the second experiment showed a similar trend for weight gain (WG %) as the CX-148 family had the highest WG but with no significant differences with the CX-125 group ($P>0.05$). The results for ^{15}N isotope analysis in fish muscle will be presented at the conference. Overall, the results of the present study, so far, have demonstrated that there are substantial genetic-based variations among different families of rainbow trout in utilizing soybean-based diets.

COMPARATIVE FATTY ACID COMPOSITIONS IN *Clarias gariepinus*, *Chrysichthys nigrodigitatus*, *Heterobranchus bidorsalis* AND *Coptodon zillii*

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This study compared fatty acid compositions in *Coptodon zillii, Heterobranchus bidorsalis, Chrysichthys nigrodigitatus, and Clarias gariepinus.* Fish specimens were procured and stored in an ice chest at 4ºC before conveyed for analyses. Saturated, monounsaturated and polyunsaturated fatty acids were determined using the gas chromatography. Results showed no significant difference (P> 0.05) among all species. The PUFA/SFA ratio were above the specified range of 0.4 by FAO, which make them healthier for consumption. From 0.4 in *C. gariepinus,* to 1.95 in *C. nigrodigitatus*, 2.04 in *H. bidorsalis,* and 6.59 in *C. zillii.* Result also shows that these species are rich in PUFAs such as EPA, DHA and LA. Hence the species are safe and healthy for consumption, and can be incorporated into the diet as a food materials containing appreciable measures of healthy fats.

Fish is one of the most nutrient-dense, delectable, and readily digestible foods. A significant portion of the population of the world, especially in developing nations, is very interested in it. It is preferable to hog, beef, and mutton because it is not constrained by culture or religion (Davies and Idowu, 2011). Nearly 80% of individuals in most affluent countries get less than 20% of their animal protein from fish, compared to an estimated 60% of people in many underdeveloped countries who depend on fish for more than 30% of their protein needs. The main elements of lipids are fatty acids. Fish and human diets must include lipids as sources of fatty acids (FA) and energy (Sargent *et al.,* 1999). Saturated, monounsaturated, and polyunsaturated fatty acids are the three main categories of fatty acids.

The omega3 and omega6 polyunsaturated fatty acids have received special attention among the fatty acids (PUFA). Long-chain (LC) n-3 polyunsaturated fatty acids (LC n-3 PUFA), particularly eicosapentaenoic acid (EPA) and docosahexaenoic acid, are abundant in fish lipids (DHA). Humans are unable to produce long chain, n-3 PUFA; they must instead receive them from diet (Alasalvar *et al.,* 2002).

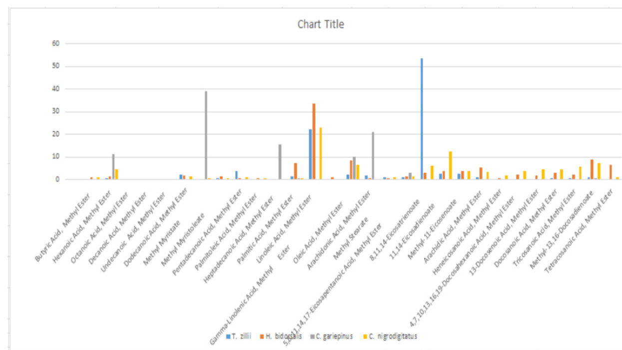

Fig. 1: Fatty acid distribution in *C. zillii, H. bidorsalis, C. nigrodigitatus,* and *C. gariepinus.*

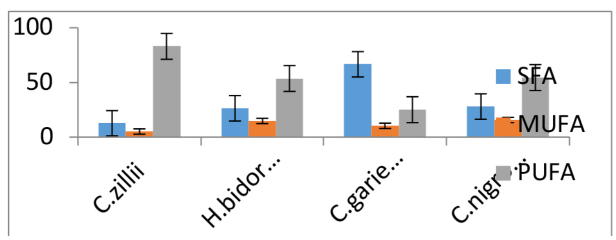

Fig. 2: Quality of Fatty acids in *C. zillii, H. bidorsalis, C. nigrodigitatus,* and *C. gariepinus*

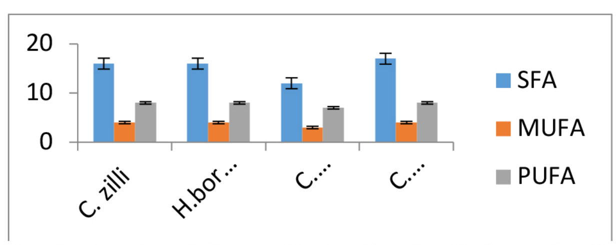

Fig. 3: Quantity of Fatty acids in *C. zillii, H. bidorsalis, C. nigrodigitatus,* and *C. gariepinus*

(Continued on next page)

Major distributions of fatty acid contents found in these species were discovered to be in line with findings in fish species from the majority of freshwater fishes around the world. Health beneficial PUFAs such as EPA, DHA and LA, were recorded in larger quantity across all species. The PUFA/SFA ratio which gives the fat quality of the fish was in good range, with *C. zillii* having the highest and *C. gariepinus* with the least range.

IONIC COPPER CONTROLS MUSSEL AND SNAIL PESTS IN COMMERCIAL FISH FARMS

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Mollusk pests such as zebra mussels, quagga mussels, New Zealand mud snails, ram's horn snails, and apples snails have become a tangible threat to commercial aquaculture, posing severe economic, practical, and regulatory consequences. Copper is among the most reliable tools for combating invasive mollusks, but can be toxic to fish at high doses. Liquid ionic copper has recently been used to successfully control – and even eradicate – mollusk pests including zebra mussels, quagga mussels, and New Zealand mud snails in commercial fish farms without harming the fish. This exciting development has allowed infested hatcheries and rearing facilities to treat for these pests while continuing their operations and distributing produced fish without incurring the substantial losses normally associated with infestations by invasives species, and the treatments historically required to limit them. Several documented case studies relevant to commercial aquaculture will be profiled in this presentation. Acid-stabilized ionic copper was used to eradicate quagga mussels from an entire lake in 2017 without measurable impacts on resident fish or zooplankton populations, and mussels have not been detected there in the 6 years since then. In 2021, a full-lake treatment to eradicate zebra mussels was implemented and measurements taken 3 months post-treatment quantified higher diversity and lake productivity than prior to treatment. In 2020, a state fish hatchery producing rainbow trout *O mykiss* and brown trout *Salmo trutta* was discovered to be infested with New Zealand mud snail *Potamopyrgus antipodarum* and treatments twice per year with acid-stabilized liquid ionic copper have kept the facility free from detections of this invasive species and allowed the hatchery to continue stocking fish into lakes statewide. These and other case studies are evidence that practical efforts to prevent the spread of invasive mollusks can be successfully implemented at full-scale and directly within commercial fish operations, without sacrificing the fish being cultivated. In conclusion, acid-stabilized liquid ionic copper offers an efficient and precise delivery method, is economical, disperses well without mechanical mixing, does not settle out, and is safer for fish than biocides currently employed.

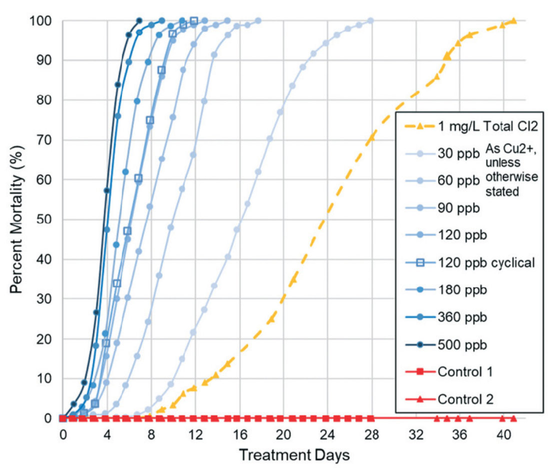

Fig 1: Dose-Mortality of acid-stabilized liquid ionic copper against adult Dreissenid zebra mussels.

AN INTEGRATED ANALYSIS OF TRANSCRIPTOME AND METABOLOME REVEALS THREE BCAAS RELIEVE LIPID ACCUMULATION BY INHIBITING LIPID SYNTHESIS AND PROMOTING LIPID OXIDATION IN THE LIVER OF LARGEMOUTH BASS (*Micropterus salmoides*)

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The intricate and paradoxical relationship between branched-chain amino acids (BCAAs) and lipid metabolism has been focused on the field of nutrition. However, the molecular mechanism mediated by BCAAs in the lipid metabolism of fish is poorly understood. To address this knowledge gap, we characterized the transcriptome and metabolome in the liver of largemouth bass (*Micropterus salmoides*), an extensively cultivated fish with high commercial value. Dietary BCAA supplementation significantly enhanced growth performance, combined with the elevation of essential amino acid levels and the improvement of liver health. Moreover, enzymatic detection and RT–qPCR results showed that BCAAs decreased lipid deposition in the liver. Integrated transcriptomics and metabolomics analysis revealed that the inhibition of lipid synthesis and enhancement of fatty acid degradation may explain the mechanism by which BCAAs relieved lipid accumulation in the liver. The metabolic enzymes *acaca*, *acaa2*, *cpt2*, *acat*, and *aldh9a1*, which were regulated by all three BCAAs, are key targets linking BCAA metabolism and lipid metabolism. Considering that farmed fish suffer from abnormal lipid accumulation in the liver, appropriate BCAA supplementation is an effective nutritional strategy to improve lipid metabolism disorders in aquaculture.

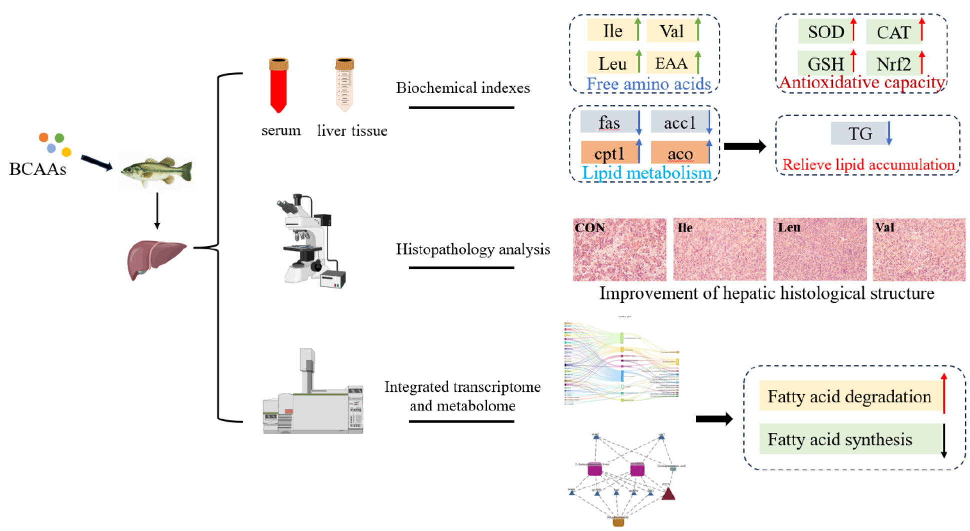
Table 1. Formulation and chemical proximate composition of the experimental diets (% dry matter)

Ingredients	Diets			
	CON	Leu	Val	Ile
Fish meal	31.00	31.00	31.00	31.00
Fermented soybean meal	40.25	40.25	40.25	40.25
Fish oil	4.00	4.00	4.00	4.00
Soybean oil	3.23	3.23	3.23	3.23
Soybean lecithin	1.00	1.00	1.00	1.00
Choline	0.20	0.20	0.20	0.20
Other	19.52	19.52	19.52	19.52
Leucine	0	1.00	0	0
Isoleucine	0	0	1.00	0
Valine	0	0	0	1.00
Alanine	1	0	0	0

(Continued on next page)

Table 2. Growth parameters of largemouth bass (*Micropterus salmoides*) fed the experimental diets (means ± SD, n = 3)

Parameter	Diets				ANOVA
	CON	Leu	Val	Ile	P > *F*
Initial body weight (IBW, g)	6.85±0.07	6.84±0.17	6.75±0.16	6.81±0.13	0.825
Final body weight (FBW,g)	21.41^{a}±0.64	23.15^{b}±0.54	22.75^{b}±0.53	23.11^{b}±0.04	0.008
Weight gain (WG, %)	212.73^{a} ±12.21	238.44^{b}±3.49	237.29^{b}±7.20	239.63^{b}±7.79	0.011
Specific growth rate (SGR, %/d)	2.04^{a}±0.0.07	2.18^{b}±0.02	2.17^{b}±0.04	2.18^{b}±0.04	0.012
Survival rate (SR, %)	98.33±2.89	98.33±2.89	96.67±2.89	100±0.00	0.487
Feed efficiency ratio (FER)	0.89^{a}±0.06	1.10^{b}±0.04	1.02^{ab}±0.11	1.02^{ab}±0.05	0.036
Viscera-somatic index (VSI, %)	6.30±0.19	5.98±0.62	5.65±0.20	5.90±0.27	0.251
Hepato-somatic index (HSI, %)	0.92±0.05	0.93±0.08	0.80±0.09	0.82±0.08	0.139



EFFICACY EVALUATION OF SELECTED IMMERSION ANESTHETIC AGENTS ON *Menippe mercenaria*

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The ethical and humane treatment of animals farmed for human consumption has been a topic of concern among public and scientific stakeholders for decades. These discussions have historically focused on issues pertaining to terrestrial livestock, with little interest directed towards aquacultured species. Recent studies investigating the possibility of sentience in decapod crustaceans has provided a platform for the topic of humane harvest of crustaceans to enter mainstream discourse in both the public and political realms. This has led several countries to implement policies addressing ethical concerns related to decapod slaughter; examples include Norway's ban on slaughter of crustaceans prior to stunning in 2018, bans on boiling lobsters alive in New Zealand, Italy, and Switzerland, as well as the United Kingdom's recognition of decapod crustaceans as sentient creatures in 2021. As dialogue and research in this field continues to expand, efforts to minimize nociception and suffering during the slaughter process are also ongoing.

Humane methods of slaughter typically strive to dispatch animals quickly to minimize pain, suffering, and fear. However, many dispatching methods developed for decapod crustaceans prioritize quality of the product over welfare. Use of substances that diminish an animal's ability to perceive noxious stimuli or lower the individual's ability to experience discomfort are an accepted practice in other food animal industries. Thus, loss of sensibility through use of anesthetics or sedatives is a simple practice that could be incorporated into the harvest process to ensure welfare standards while simultaneously preserving meat quality. The purpose of this study is to identify an ideal drug and method of use that could be implemented prior to slaughter.

A series of pilot trials were conducted using three "anesthetic" compounds to identify the minimum dose required to elicit a sedative or anesthetic response in Florida stone crabs (Fig. 1). Individuals were placed in anesthetic baths and reflex scores were assessed using a modified reflex action mortality predictor (RAMP) that measured voluntary and involuntary responses. Using quantifiable metrics, reflexes were scored on a scale of 0 to 3 with three denoting typical response behaviors, the two intermediary scores being weak responses and zero representing the complete absence of a response. Each reflex was measured every two minutes for a maximum of one hour prior to the subject being transitioned to a recovery tank. Future expansion of this study will consider dosing modifications, evaluation of several physiological responses and increased replication.

Product	Dose	Visual response	Tactile response	Righting reflex	Response to noxious stimuli
Aqui-S 20E	300mg / L	0 @ 20min	0 @ 12min	0 @ 45min	2 @ 5min
$MgCl_2$	66g / L	0 @ 2min	0 @ 2min	1 @ 5min	0 @ 15min
MS -222	4g / L	0 @ 55min	0 @ 55min	0 @ 30min	0 @ 30min

Fig. 1 – RAMP scores of Florida stone crabs immersed in anesthetic baths.

CAN FRESHWATER TREATMENT POTENTIALLY REDUCE ULCER OUTBREAKS IN LAND-BASED SALMON AQUACULTURE?

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Introduction

At low temperatures (<4 °C), ulcer formations cause welfare and economic issues in the production of Atlantic salmon. However, this problem also persists in land-based productions at higher temperatures. Seawater flow-through systems in land-based production of salmon is gaining popularity, which escalates the issues of bacteria-mediated ulcers. This is especially true for smolt; the stage of fish which is more susceptible to bacterial infections. We hypothesize that the ulcer outbreak is related to the relative increase in surface area the fish is exposed to as well as a function of the higher density to water exchange rates in tanks compared to the traditional sea cages. This project aimed to establish a link between starting density, skin health, growth rates, and wound formation in the production of Atlantic Salmon in tanks using seawater.

Material and Methods

The trial was conducted at LetSea's Land facility in Norway. At the start of the trial, the fish were randomly distributed amongst eight trial tanks (2 m^3) at an abundance of fish per tank that reflected 15 kg/m^3 and 20 kg/m^3 (four tanks per group). The tanks were equipped with cyclone feed collecting systems. Water for the trial was derived from the facility's saltwater intake and was treated with UV.

When the first ulcer outbreak was observed, a freshwater treatment was performed. On the day of treatment, 10 fish from each tank were scored for ulcers on the body and fins and for the loss of scales (all scores 0-3 based on Fishwell)[1]. Samples were taken for bacteriology, and PCR on starting and open wounds. After sampling, four tanks were randomly chosen for treatment for three hours (two high- and two low-density). Aqui-S Vet. sedative (final concentration of 4 ml/m^3) was added to all four tanks. The water column was reduced to 20 cm, and 2 m^3 fresh water was added. Salinity was measured, and the fish was kept under observation with continuous measurements of CO_2 and oxygen. After treatment, saltwater supply was turned on, and new samples were taken from the handled fish.

Results and conclusions

Our results show that there were no clear differences in wound formation on the body or fins in tanks between low and high-density groups. It should be noted that body wound scores of 2 and 3 were only presented in high-density tanks. PCRs taken from wounds before and after freshwater treatment showed little difference in CT values between pre-and post-treatment samples. Bacteriology showed positive results pre-treatment but no growth of either *M. viscosa* or *Tenacibaculum sp.* after treatment. No new wound formations were observed 30 days after treatment. The current results suggest that freshwater treatments can potentially reduce marine bacteria-mediated ulcer formations and should be explored further.

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NORTH CAROLINA'S SECRET FLOUNDER PONDS: CREATING A SAFE AVENUE FOR A LOCAL WILD-HARVEST LEGEND

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Since the 1980's commercial fishers in North Carolina, especially in Cedar Island, have created temporary holding ponds for wild caught estuarine southern flounder (*Paralichthys lethostigma*) taken commercially. The goal of these holding ponds, according to local fishers, was originally to hold flounder through the price dips due to flooding of the local market. The North Carolina Division of Marine Fisheries (DMF) was aware of some of these operations in the 1990's and added a LIVE option on Trip Tickets to enable pond operations that had broken into live flounder markets. These operations were all but forgotten by the time regulations were put in place governing coastal aquaculture operations because of employee retirement and turnover.

In 2022, the DMF was made aware of ponds that still existed in the Cedar Island area and needed to be permitted. The DMF's Aquaculture Program coordinated with multiple internal sections and external agencies to develop a method to permit these operations while accounting for several unique risks that are either less concerning, or not present in land-based finfish aquaculture. In doing so, the Aquaculture Program also managed to discover and address a gap between fish dealers and food safety for seafood processors.

As a result, two operations were able to receive a permit for culturing wild-harvest estuarine flounder caught commercially by pound nets (8,000 lbs. and 11,000 lbs., respectively). The unique collaboration between DMF and external agencies may provide a framework for similar challenges in other states, especially as the aquaculture industry develops and grows.

WHERE WE ARE AND WHERE WE'RE GOING – AN UPDATE ON OCEAN RAINFOREST'S WORK IN SOUTHERN CALIFORNIA

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Within the funding framework of the Advanced Research Projects Agency - Energy (ARPA-E) MARINER program through the U.S. Department of Energy, the MacroSystems project team has been asked to demonstrate the economic and social opportunities of offshore cultivation of seaweeds in the U.S. Primed by Ocean Rainforest, Inc. the project is specifically focused on the commercial feasibility of a species named Macrocystis pyrifera, more commonly known as Giant Kelp.

During Phase 1 of the cooperative agreement (2018 – 2019), the MacroSystems team designed a state-of-the-art cultivation structure that minimally impacts existing marine operations and supports ecosystem services in the surrounding environment. In Phase 2 (2020 – 2023), Ocean Rainforest launched a three-year demonstration project in the Santa Barbara Channel to test the durability of the cultivation system. We constructed a hatchery facility and demonstrated the effectiveness of direct seeding Giant kelp for three seasons. We also secured a collection of lines at a nearshore location where biomass growth met/exceeded expectations in 2022. In parallel, Ocean Rainforest won approval from the US Army Corps of Engineers and California Coastal Commission to install an 86-acre demonstration project five miles off the coast – the first federal waters permit exclusively for seaweed aquaculture in the continental US.

With follow-on funding from ARPA-E (i.e., Phase 3 of MacroSystems), Ocean Rainforest installed the demonstration project in April and May 2023 (shown at right). Since then, our team has executed a litany of monitoring surveys in order to remain in compliance with the individual permit, as well as seen preliminary growth of Giant kelp on the system. In January, our team will reseed the farm in preparation for the 2024 harvest.

This presentation will shed light on the results of our first year of operations at the offshore demonstration project, as well as indicate the next keys steps and primary objectives for our work in California. We will also provide additional details with respect to the 2024 seeding effort that – pending weather and winter storms – will be completed early January 2024.

EXPLORING POLYCHAETE MEAL (*Alitta virens*) AS A DIETARY TOOL FOR GUT MICROBIOTA MODULATION IN EUROPEAN SEABASS (*Dicentrarchus labrax*)

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Introduction
Recent research has revealed the significant impact of novel feed ingredients on fish gut microbiota, affecting both the immune status and digestive performance. As a result, analyzing the microbiota modulatory capabilities may be a useful method for assessing the potential functionality of novel ingredients. Therefore, this study aimed to evaluate the effects of dietary polychaete meal (PM) from *Alitta virens* on the autochthonous and allochthonous gut microbiota of European seabass (*Dicentrarchus labrax*).

Materials and methods
Two diets were compared: a control diet with 25% fishmeal (FM) and a diet replacing 10% of fishmeal with PM, in 13-week feeding trial with Juvenile European seabass (*Dicentrarchus labrax*). Homogeneous groups of 40 fish were then distributed into 6 fiberglass tanks of 160-L in a saltwater re-circulation system. Each diet was randomly assigned to triplicate groups of fish, which were fed to apparent satiation three times daily (9h, 12h30, and 16h30) using automatic feeders. At the end of the trial six fish per tank were sacrificed for intestinal microbiota sampling. The intestine digesta was collected by squeezing. The autochthonous intestinal bacteria were collected by scraping the intestinal mucosa. Both digesta and mucosa were pooled into three groups of two fish per tank (n = 9 per dietary treatment). Additionally, 10 g of each feed was collected for analysis of the feed microbiota. All the samples were stored at room temperature until DNA extraction. The feed, digesta, and mucosa-associated microbial communities in fish intestines were analyzed using high-throughput sequencing of the 16S rRNA gene on the Illumina MiSeq platform.

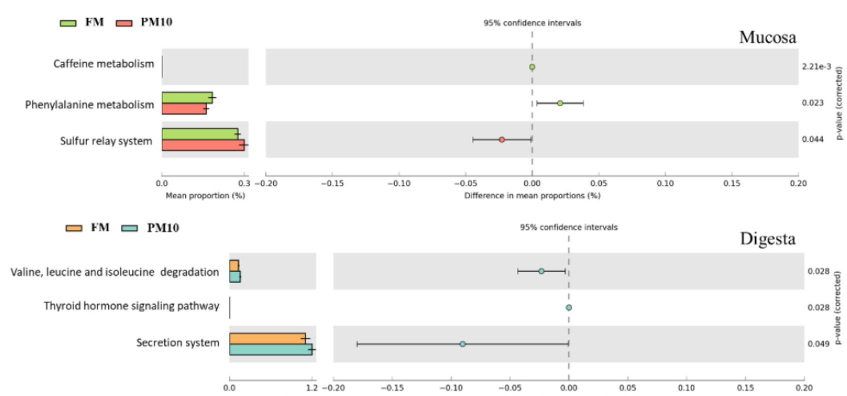

Figure: PICRUSt analysis results of predicted functional pathways in the gut microbiota.

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Results and Discussion

The results of feed microbiota analyses showed that the PM10 feed exhibited a higher microbial diversity than the FM diet. However, these feed-associated microbiota differences were not mirrored in the composition of digesta and mucosal communities. Regardless of the diet, the digesta samples consistently exhibited higher species richness and diversity than the mucosa samples. Overall, digesta samples were characterized by a higher abundance of Firmicutes in PM-fed fish. In contrast, at the gut mucosa level, the relative abundances of *Mycobacterium*, *Taeseokella* and *Clostridium* genera were lower in the group fed the PM10 diet. Significant differences in metabolic pathways were also observed between the FM and PM10 groups in both mucosa and digesta samples. In particular, the mucosal pathways of caffeine metabolism, phenylalanine metabolism, and sulfur relay system were significantly altered by PM inclusion. The same trend was observed in the digesta valine, leucine, and isoleucine degradation and secretion pathways.

Conclusions

These findings highlight the potential of PM as an alternative functional ingredient in aquafeeds with microbiota modulatory properties that should be further explored in the future.

Acknowledgements

This work was subsidized by Project SIDESTREAM, funded through the ERA-NET BLUE BIOECONOMY COFUND by FCT (BLUEBIO/0005/2019). Part of the work was also funded by ATLANTIDA – Platform for the monitoring of the North Atlantic Ocean and tools for the sustainable exploitation of the marine resources” (NORTE-01-0145-FEDER-000040). CIIMAR acknowledges FCT funding (UIDB/04423/2020, UIDP/04423/2020). The authors would also like to thank Tiago Sá and Alexandra Marques for their help during the feeding trial and analytical work.

RESEARCH AND DEMONSTRATION CAPABILITIES AT STATE-OF-THE-ART FACILITY ENABLE HIGHLY UNIQUE AQUACULTURE EDUCATION AND TRAINING PROGRAM

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The University of Wisconsin-Stevens Point Northern Aquaculture Demonstration Facility (UWSP NADF) is a state-of the-art, dynamic facility, showcasing new advances in aquaculture system technology such as sustainable land-based recirculating aquaculture, while also providing traditional aquaculture systems such as flow-through raceways and outdoor ponds for industry-based research projects. The facility's overall mission is to conduct research and advance the discovery, dissemination and application of knowledge for sustainable aquaculture in a northern climate and to promote aquaculture education. One of the facility's main goals is to investigate high-value freshwater fish to support the growing demand for sustainable aquaculture products in the Midwest.

Another crucial focus is to perform industry-applied and commercially scaled research projects while demonstrating effective aquaculture systems, management practices and technologies to various audiences. To support these goals, strong collaborations exist with a variety of groups including the private aquaculture industry, tribal, state and federal hatcheries, other universities, K-12 students, educators and other organizations interested in research, demonstration and educational projects. With a professionally trained staff of dedicated aquaculturists and biologists, the facility maintains a high level of expertise for conducting projects with various cool and coldwater fish at various life stages while being a leader in developing a skilled and experienced workforce for the growing industry.

Availability of a skilled and experienced workforce is currently a major bottleneck to the advancement of aquaculture. UW-Stevens Point was the first accredited university in Wisconsin to offer an aquaculture minor. Furthermore, UWSP NADF offers paid summer internship programs to undergraduates from various universities. This incredible hands-on experience and training enables interns to be placed at UWSP NADF and partnering aquaculture entities such as private, state, federal and tribal facilities. Throughout the program, interns are exposed to a variety of species and systems at commercial or semi-commercial scale research and demonstration applications. For increased training and skill development, through current grant funding, UWSP NADF is offering 6 month paid apprenticeships, where recent graduates are placed with industry partners. Both interns and apprentices directly work with highly experienced facility staff to learn best management practices and techniques for rearing various freshwater fish at all stages of development. Due to the unique skillset achieved, commercial-level application of knowledge and building relationships with industry, job placement for these students has historically been nearly 100 percent immediately following this training program.

LAKE SUPERIOR STATE UNIVERSITY AQUACULTURE CLUB

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The aquaculture club at Lake Superior State University is currently 13 members strong and a proud student subunit of the U.S Aquaculture Society. Our club started back in 2020 with 15 members. We have three deep water culture aquaponic systems, a recirculating aquaculture system, a vertical aeroponics system and zebra fish research tanks. Our aquaponic systems are growing Atlantic salmon, yellow perch, koi, and goldfish. We grow a variety of plants, anything from herbs and house plants to fruiting plants and trees.

The club puts on plant sales every month to have a continuous fundraiser. This schedule allows us time between sales to empty out the grow beds, clean and sanitize, before moving the next set of sprouts into the systems. We hold a yearly tie dye event where community and club members get to tie dye their very own fishman shirt or tote bag. The club has also hosted cooking demonstrations and soap making events.

We hold numerous tours of our facility throughout the year for K-12 groups, campus events, and community outreach. Our goals as a club are to educate the club members and community about aquaculture and aquaponic systems and practices. We also love to tour other aquaculture or aquaponic facilities. These activities allow the club members to gain knowledge about how others run their systems.

The club sends members to different conferences each year. Five members attended the NCRAC/Wisconsin, Minnesota Aquaculture conference in Eau Claire, Wisconsin in February 2023. Those members were able to help with running the sessions and made connections with local industry workers. The members also got the opportunity to visit Jeremiah's Bull Frog Farm before heading back to campus. A week later three members of the club attended the Aquaculture America Conference in New Orlean 2023; presenting their work on shrimp in brackish water aquaculture, heavy metals in aquaponics and growing Eastern White Cedars in aquaponics. The opportunity to go to the Aquaculture America Conference was an eye opening and educational experience. The club looks forward to new members and new experiences each year.

AVOIDING METAL TOXICITY IN CLOSED LOOP AQUAPONICS

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Several fish mortality events in our closed loop aquaponics system appeared to be related to chronic toxicity from heavy metals. We had been operating parallel Koi and Tilapia aquaponics systems for many years. In two separate events we had sudden deaths of a number of fish. In both events, we did not see any evidence of fish stress, such as gasping at the surface or erratic swimming prior to the mortality. Water quality had been monitored on a regular basis using the API freshwater test kits and drinking water test strips. However, most of these kits do not give readings below a pH of 6.0, so any values reported as pH=6 were likely much lower.

Following the mortality events, we analyzed water samples on LSSU's Inductively Coupled Plasma Mass Spectrometry (ICP-MS; Agilent 7800), and found highly elevated levels of some metal ions. In particular, Aluminum, zinc and copper were elevated in the range of both chronic and acute toxicity based on NOAA Screening Quick Reference Tables (SQuiRTs). As we regularly remove water from the system with the solid waste and replace with aged water, we were surprised to observe increased concentrations of these metal ions.

We use aged municipal water sourced from Lake Superior, which has low concentrations of most dissolved ions, and equipment within the aqua systems has few metal components. Further investigation suggested that sources of elevated metals were the commercial Tilapia and Koi food. Additionally, copper pipes may also contribute to elevated Cu and the concentration though Cu concentration varies with residence time of the water in copper pipes. We analyzed all feed samples for metal content and found high levels of aluminum, zinc, and copper. Typically, these metals are not mobilized, so should not pose a risk. However low pH and low oxygen conditions could be a factor in the high levels of these metals. Our results suggest that caution should be taken with closed loop systems and recommend testing water for metals on a regular basis. Although not all aquaculture facilities have access to an ICP-MS, many academic and commercial labs will analyze samples.

We recently restarted the systems with yellow perch, and Atlantic salmon and take regular water samples. We plan to thoroughly flush the source water plumbing to minimize copper leaching from the pipes prior to filling our aging tanks.

We were encouraged to add affordable digital meters to both systems; allowing a real time measure of pH, oxidation reduction potential, temperature, alerts to low pH/oxygen events. We highly encourage constant monitoring of water chemistry in closed loop systems to avoid low pH events and excessive metal accumulation that could lead to metal toxicity.

SOMETHING'S FISHY! THE DIFFICULTIES OF DIAGNOSING PISCINE LACTOCOCCOSIS

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Piscine lactococcosis is a significant emerging threat to wild and cultured fish in the United States. A wide range of hosts are susceptible, including fish from cold, temperate, and warm environments in freshwater or marine systems, as well as humans and other terrestrial animals. The disease in an established issue in European and Asian aquaculture but is rapidly encroaching on ecologically and economically important fish populations in the Americas. Lactococcosis typically presents as a hemorrhagic septicemia causing high mortality rates. Antimicrobial treatment often fails, and development of carrier fish or biofilm formation may lead to recurrent outbreaks. Historically, the disease was attributed to the gram-positive pathogen *Lactococcus garvieae*. However, recent work revealed there are three distinct agents of piscine lactococcosis – *L. garvieae, L. petauri* and *L. formosensis* – which are phenotypically and genetically similar, leading to widespread misdiagnosis. While the three species overlap in host and geographic range, there are relevant differences in host-specific virulence, regional prevalence and antimicrobial susceptibility that impact the success of management interventions. Practical and reliable methods for diagnosis of the specific lactococcosis agents is therefore crucial for implementing appropriate preventative and treatment strategies.

To this end, we compared currently available and recently developed diagnostic methods for their ability to distinguish isolates to the species level, including single and multi-locus gene sequencing, end-point and quantitative PCR (qPCR) assays, matrix-assisted laser desorption/ionization time-of-flight mass spectrometry (MALDI-TOF MS), fatty acid methyl ester analysis (FAME), and API® and Biolog™ systems. Sequencing of the *gyrB* gene was the most accurate and discriminatory single-gene analysis method (Fig. 1). A qPCR assay based on a putative glycosyltransferase gene was also able to specifically distinguish *L. petauri.* Biochemical tests and MALDI-TOF MS showed some species-specific patterns in sugar, fatty acid metabolism or protein profiles, but should be complimented by additional analysis. This work provides direct recommendations for specific diagnosis of piscine lactococcosis for improved disease management.

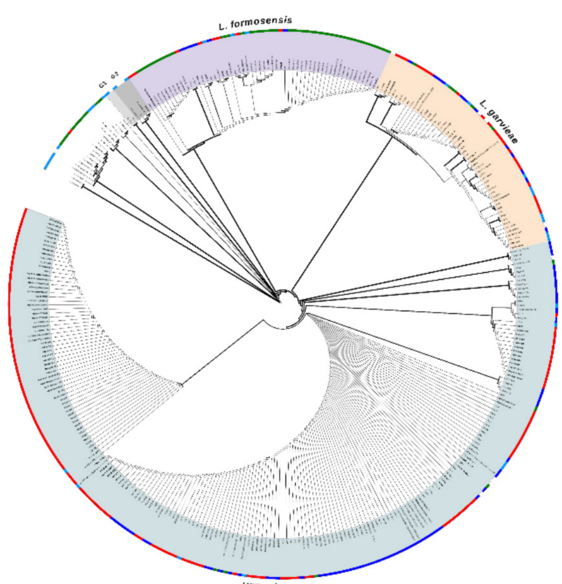

FIGURE 1: Genotyping of *L. formosensis* (purple), *L. garvieae* (orange) and *L. petauri* (teal).

FINTASTIC FLAVOBACTERIA AND WHERE TO FIND THEM: ATYPICAL FLAVOBACTERIAL PATHOGENS IN WESTERN US AQUACULTURE

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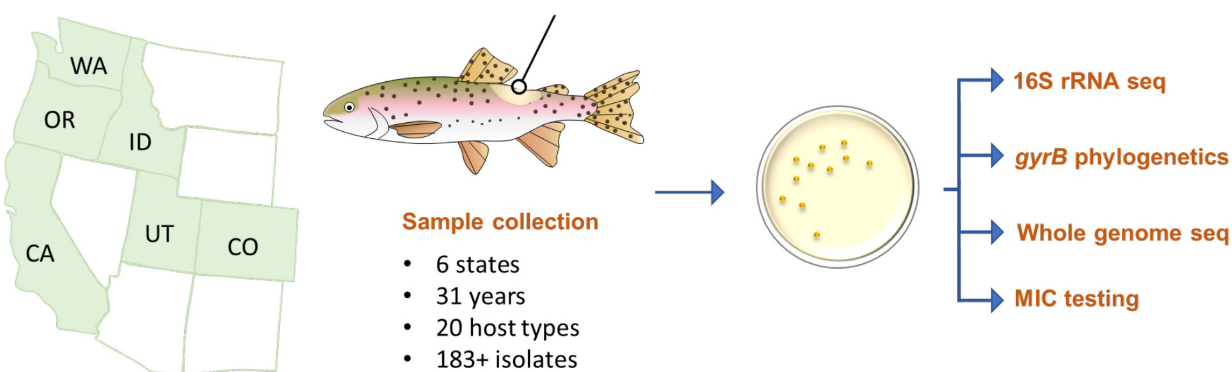
Flavobacterial diseases, caused by bacteria in the order Flavobacteriales, are responsible for devastating losses in farmed and wild fish populations worldwide. The genera *Flavobacterium* (Family Flavobacteriaceae) and *Chryseobacterium* (Weeksellaceae) encompass the most well-known agents of fish disease in the order, but the full extent of piscine-pathogenic species within these diverse groups is unresolved, and likely underappreciated. To identify emerging agents of flavobacterial disease in US aquaculture, 183 presumptive *Flavobacterium* and *Chryseobacterium* isolates were collected from clinically affected fish representing 19 host types, from across six western states. Isolates were characterized by 16S rRNA gene sequencing and phylogenetic analysis using the *gyrB* gene. Whole genome sequences (WGS) and antimicrobial susceptibility profiles were compared between representatives (n = 3) from each major phylogenetic clade. Of the isolates, 52 were identified as *Chryseobacterium* species and 131 as *Flavobacterium*. The majority of *Chryseobacterium* isolates fell into six clades (A-F) consisting of ≥ 5 fish isolates with ≥ 70% bootstrap support, and *Flavobacterium* into nine (A-I). In most cases, whole genome analysis supported *gyrB* clade placement, though approximately half of the isolates selected for WGS fell below digital DNA-DNA Hybridization (dDDH) and Average Nucleotide Identity (ANI) cutoffs for speciation, indicating multiple undescribed species associated with fish disease in the region. Phylogenetic clades showed distinct patterns in antimicrobial susceptibility. Two *Chryseobacterium* clades (F & G), and four *Flavobacterium* clades (B, G-I) had comparably high minimal inhibitory concentrations (MICs) for 11/18 antimicrobials tested. Multiple clades in both genera exhibited MICs surpassing the established *F. psychrophilum* breakpoints for oxytetracycline and florfenicol, indicating potential resistance to two of the three antimicrobials approved for use in finfish aquaculture. Further work to investigate the virulence and antigenic diversity of these genetic groups will improve our understanding of flavobacterial disease, with applications for treatment and vaccination strategies.



SEAFOOD CONSUMER PREFERENCES PRE- AND POST- COVID-19 PANDEMIC: ANALYSIS OF DELIVERY, PACKAGING, AND ADVERTISING DYNAMICS IN THE U.S. SEAFOOD INDUSTRY

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Following the widespread impact of the COVID-19 pandemic, the U.S. seafood industry has faced significant changes in consumer preferences and habits regarding seafood purchases for both restaurant and at-home meals. Amid the economic downturn and subsequent closure of numerous dining establishments, there's a pressing need for businesses to recalibrate their strategies based on detailed consumer insights. This study, covering 20 major cities in the U.S., aims to uncover granular consumer preferences for effective delivery, packaging, and marketing approaches pre- and post-pandemic. Preliminary results indicate an increase in at-home meal consumption from 60% pre-pandemic (2019) to 70% during pandemic (2020) and reverting to 60% post-pandemic (early 2021). Grocery home delivery doubled from 5% in 2019 to 9% in 2020 but normalizing post-pandemic. Notably, consumers using monthly take-out or home delivery services decreased to 7% during pandemic from 10% pre-pandemic but rose up to 17% post-pandemic. To boost purchases of aquatic products like catfish and trout/steelhead, 25% of consumers suggested more dining venues, while advertising strategies could focus on delivery options and recipe availability. Packaging preferences distinctly emphasize the expiration date details. There was a consistent preference for fresh seafood consumption before, during and after pandemic (Figure 1). These study findings hold the potential to equip the U.S. aquaculture sector with valuable insights for adaptive marketing in the post-pandemic phase. Further analysis employing statistical approach will offer more valuable insights to the U.S. aquaculture sector's producers and policy makers for post-pandemic adaptive marketing, providing a comprehensive market analysis that supports businesses in these uncertain times and sets the groundwork for informed future growth.

DIETARY REQUIREMENTS OF CHOLESTEROL FOR JUVENILE CINNAMON RIVER PRAWN *Macrobarchium acanthurus*

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The culture of the cinnamon river prawn *Macrobrachium acanthurus* has been suggested for several years to overcome the possibility of its disappearance caused by several human-related factors. The assessment of nutrient requirements is an important step to develop the culture and cholesterol is an essential nutrient for crustaceans that serves as precursor of sex and molting hormones, adrenal corticoids, and vitamin D. Thus, the present study was aimed to determine the dietary requirements of cholesterol in juvenile *M. acanthurus*.

A 60-days feeding trial was performed with prawns of an initial weight of 0.24 ± 0.08 g (mean ± SD). A basal diet (crude protein, 39 ± 0.6%; crude 8lipid 12 ± 1%; ash 5 ± 0.1%, and moisture, 3 ± 0.3%, mean ± SD) was added with 0.5 (*Chlo-0.5*), 1 (*Chlo-1.0*) and 1.5 (*Chlo-1.5*) g of cholesterol per 100 g of diet. Basal diet without cholesterol addition (*Chol-0*) was used as control. Each diet was fed to triplicated groups of 5 organisms per replicate at a 9% of the total biomass. Obtained data was analyzed with a one-way ANOVA and significant differences were evaluated with a Fisher LSD test (P<0.05).

Data of weight gain (WG) and specific growth rate (SGR) of prawns fed with diets *Chlo-0* and *Chol-0.5* were significantly lower than those observed for the groups of *Chol-1.0* and *Chol-1.5* (TABLE 1). Survival rate was significantly higher in the group *Chlo-1.0*. Higher contents of protein in the muscle were observed when cholesterol increased in the diet, but no significant differences were found. A similar trend was observed in the muscle contents of lipids. The present results indicate that dietary inclusion of cholesterol should be around of 1.0 g per 100 g of diet for juveniles *M. acanthurus*.

TABLE 1. Final weight (FW), weight gain (WG), specific growth rate (SGR) and survival of juvenile *M. acanthurus* fed different levels of cholesterol. Means (± SE) in the same line with different levels were significantly different (P<0.05).

	Treatments			
	Chol-0	*Chol-0.5*	*Chol-1.0*	*Chol-1.5*
FW (g)	0.51 ± 0.1	0.42 ± 0.08	0.50 ± 0.07	0.56 ± 0.1
WG (%)	47 ± 26b	78 ± 4b	124 ± 14a	142 ± 8a
SGR (%/day)	0.6 ± 0.3b	0.9 ± 0.03ab	1.3 ± 0.1ab	1.4 ± 0.05a
Survival (%)	54b	40b	94a	60b

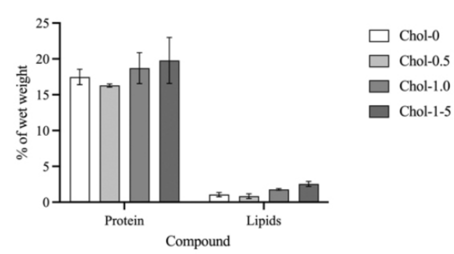

FIGURE 1. Contents of crude protein and lipids in muscle of juvenile *M. acanthurus* fed different levels of cholesterol. No significant differences were observed at this level (P>0.05).

PRODUCTION OF XENOGENIC CATFISH BY TRANSPLANTING BLUE CATFISH *Ictalurus furcatus* AND CHANNEL CATFISH *Ictalurus punctatus* STEM CELLS INTO WHITE CATFISH *Ameiurus catus* TRIPLOID FRY

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Xenogenesis has been identified as a potential alternative for hybrid catfish (channel catfish, *Ictalurus punctatus* ♀ × blue catfish, *I. furcatus* ♂) embryo production. The xenogenesis process can be accomplished by transplanting primordial germ cells, spermatogonial or oogonial stem cells derived from a donor diploid fish into a sterile recipient. Xenogenesis for hybrid catfish embryo production has been accomplished using triploid channel catfish as hosts. However, having a host with a short maturation time and smaller body size than channel catfish would be ideal for rapid commercial application. Hence, the present study was conducted to assess the effectiveness of triploid white catfish (*Ameiurus catus*) as a host species to transplant blue catfish stem cells (BSCs) and channel catfish stem cells (CSCs) to produce xenogeneic broodstock. Triploid white catfish fry were injected with either BSCs or CSCs labeled with PKH26 dye from 0 to 12 days post-hatch (DPH). Then at 45 and 90 DPH, growth performance and survival of recipients were evaluated. Colonization of donor cells was evaluated in recipients using PKH26 dye fluorescence to calculate percent cell and cluster areas. PCR was utilized to determine the percentage xenogens.

No significant differences in body weight and total length of fry were detected among injection day treatments when sampled at 45 and 90 DPH ($P > 0.05$). Overall, survival increased between 0 to 5.5 DPH when white catfish triploids were injected with BSCs or CSCs and highest survival was reported for fry injected between 4.0 to 5.5 DPH. After 5.5 DPH, survival remained high (≥ 81.2%). At both 45 and 90 DPH, cell and cluster area increased for recipients injected from 0 to 5.2 DPH and highest values reported between 4.0 to 5.2 DPH. Thereafter, fluorescent cell and cluster area in the host declined with no further decrease after 10 DPH. At 45 DPH, the highest percentage of xenogens were detected in BSCs and CSCs treatments for fry injected between 4.0 to 5.0 and 3.0 to 5.0 DPH, respectively. At 90 DPH, the greatest mean number of xenogenic individuals detected was for fry injected from 4.0 to 6.0 DPH in both BSCs and CSCs treatments. The current study demonstrated the suitability of white catfish as a host species when stem cells were transplanted between 4.0 to 6.0 DPH, and these findings allow enhanced efficiency of production of xenogenic catfish carrying gametes of either blue or channel catfish.

SOFTSHELL CLAM *Mya arenaria* SURVIVAL, SHELL MORPHOMETRICS, AND SUSCEPTIBILITY TO PREDATION IN RESPONSE TO SIMULATED OCEAN ACIDIFICATION AND WARMING

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The Gulf of Maine and its fisheries, valued at $574 million in 2022, are in the crosshairs of rapid climate change. In particular, ocean acidification (OA) is experimentally demonstrated to impact bivalve survival, growth, and other sublethal endpoints, with the earliest life stages expected to be most sensitive. Maine's third most valuable commercial fishery - the softshell clam, *Mya arenaria* - is already under intense pressure from predation by the invasive European green crab, and OA may be another stressor challenging clam populations as climate change progresses. A pair of experiments were conducted to investigate the responses of *Mya* to anticipated future OA and warming scenarios. The first experiment analyzed *Mya* survival and shell morphometrics in response to 3 pH treatment levels (7.80, 7.50, 7.20) and 2 temperature treatment levels (18°C, 20°C) following exposure between 48 hours post-fertilization and settlement (14 days). The second experiment repeated that analysis with revised pH (7.80, 7.30) and temperature (18°C, 21.5°C) treatment levels, and subsamples of experimental clams were settled under experimental conditions, transferred to floating trays, and further reared under experimental conditions for an additional 2 months until they were large enough to transplant into recruitment boxes on a tidal mudflat in Beals, Maine. Experimental clams were then subjected to a monthlong field trial consisting of pre-deployment pH and temperature treatment levels and a 2-level predator deterrent netting treatment (netting, no netting). At the end of the field trial, experimental clams were analyzed for post-deployment survival and growth. The results of both experiments hint at how early-life stage *Mya* may fare in the future ocean, and the field trial enables an analysis of how stress sustained in early life stages may impact fitness in response to a real-world ecological interaction.

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Becky Holt M.B.A. is an executive producer, brand consultant, and Assistant Director of the FAU Queen Conch Lab. She's spent her career highlighting the good work of mission-forward, international brands and telling the intimate stories of those on the front lines of seafood production and conservation. Prior to the Queen Conch Lab, she was a senior executive at the Global Seafood Alliance – an NGO dedicated to enabling responsible aquaculture and fisheries worldwide. There she managed a membership base comprised of roughly 3,000 seafood companies and professionals and produced seven documentary short films featuring the personal stories of aquaculturists around the world.

Her production experiences in the remote locations of Southeast Asia, Central & South America, and Europe have revealed to her the vast amount of work left to do in understanding where our food comes from and the broad societal and environmental impact misunderstanding leads to. Her films aimed to demystify aquaculture production in the eyes of the public and have been shown at film festivals and industry events worldwide.

As Assistant Director of the Queen Conch Lab, she leads marketing efforts and develops partnerships for community-based queen conch aquaculture projects, toward the vision of a conch farm in every Caribbean country. She works remotely from Southern Maine.

Passionate about career paths that are non-linear, she enjoys relaying how you can go from an undergrad in Oil Painting to travelling the Caribbean in service of saving a threatened species. Every career decision you make is neither "good" nor "bad", it's just leading to "you".

YOUTH ENGAGEMENT IN AQUACULTURE DEVELOPMENT: THE ROLE OF FARMER'S AGE ON AQUACULTURE PRODUCTIVITY, PERFORMANCE, AND EFFICIENCY

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The involvement of youth in aquaculture not only can decrease the unemployment rate but also optimize the development of aquaculture, thereby making a significant contribution to both food security and economic success within the nation. Hence, the present study aims to investigate the extent of youth involvement in aquaculture and analyze the variations in aquaculture productivity, performance, and efficiency based on the age of farmers in Bangladesh. Furthermore, we also examine the connection between the farmers' age and their productivity, profitability, and efficiency levels. To accomplish the aim of this research, data was gathered from a sample of 183 farmers engaged in carp fish production in the five primary aquaculture-producing regions of Bangladesh and data was analyzed using the Stochastic Frontier Analysis. The findings of the study indicate that approximately one-third of the farmers are young in the study areas. The productivity of young farmers was 7.19% higher than middle-aged farmers and 19.46% higher than old-aged farmers. In addition, young farmers seem to be more efficient than aged farmers while farmers aged between 36 and 50 years are most technically efficient. In addition, productivity exhibited an upward trend as the age of farmers grew to a specific threshold (about 40 years). However, after this point, productivity showed a decline with further increases in age. Moreover, it is seen that there is an initial gain in technical efficiency until the age of 45 years, after which there is a subsequent drop in efficiency as age continues to advance. Furthermore, younger fish farmers have a lower yield gap and yield loss in comparison to their older counterparts. For sustainable aquaculture development, the government needs to promote aquaculture entrepreneurship among young people that can provide a continuous flow of income by employing cutting-edge technologies.

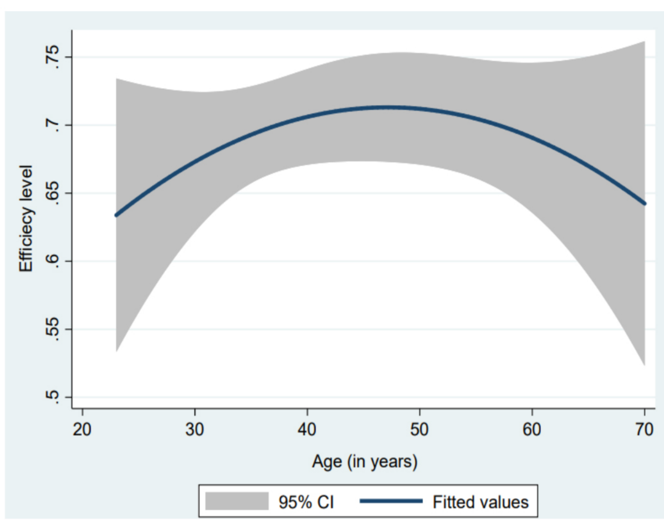

Figure 1: The relationship between farmers' age and efficiency

CAPABILITIES AND LIMITATIONS OF INDUSTRIAL AND CONSUMER-LEVEL 3-D RESIN PRINTING AND PHOTOLITHOGRAPHY FABRICATION OF MICRODEVICES FOR APPLICATIONS IN AQUATIC GERMPLASM REPOSITORIES

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Aquatic germplasm repositories can play a pivotal role in securing the genetic diversity of economically vital aquatic species. However, existing technologies for repository development and operation face challenges in terms of precision, efficiency, and cost-effectiveness, especially for microdevices used in gamete quality evaluation. In this study, we examined the potential of using 3-D stereolithography resin printing of microdevices to address these challenges and evaluated the capabilities and limitations of industrial-grade printers, consumer-level printers, and conventional microfabrication methods such as photolithography. To determine the capabilities of 3-D resin printers and evaluate differences in design versus printed features in a test object, the Integrated Geometry Sampler (IGS) and the Single-piece Sperm Counting Chamber (SSCC) were printed using an industrial 3-D resin printer (Profluidics 285D, CADworks 3D) with a cost of about $25K, high-pixel resolution of 28 μm and rapid printing speed, and a consumer-grade counterpart (Sonic Mighty 8K Phrozen) with a more affordable price around $400-$1000, lower resolution and slower printing speed. The IGS design featured an array of negative and positive features, such as a semi-sphere, cones, and channels with dimensions ranging from 1 mm to 50 μm in width and depth. The SSCC consisted of grid and wall features to facilitate the counting of cells. The 3-D printed parts were compared with polydimethylsiloxane (PDMS) devices cast from a typical photoresist mold. The fabrication quality was evaluated by use of optical profilometry (Keyence, VR-6100) of parameters such as dimensional accuracy and surface morphology, as well as fabrication time and cost. The precision, reliability, and surface quality offered by industrial-grade 3-D resin printing were more than satisfactory for operations requiring features larger than 100 μm due to a very low discrepancy between actual size and mean of measured size in the range of 1 mm to 100 μm. Meanwhile, consumer-grade printers were suitable for microdevices with features larger than 200 μm (Figure 1). These capabilities offer great promise for rapid development and widespread use of standardized microdevices for numerous applications, including gamete evaluation and "laboratory-on-a-chip" applications in support of aquatic germplasm repositories.

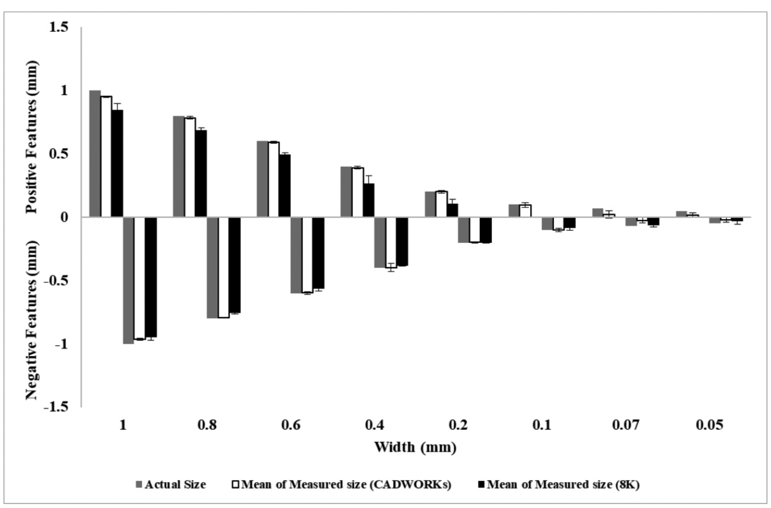

Figure 1. Comparison of positive and negative features of IGS microdevices, including channels with dimensions from 1 mm to 50 µm in width and depth, 3-D printed with clear resin using CADworks and Phrozen 8k printers.

AN OPEN-HARDWARE APPROACH FOR REAL-TIME ELECTRICAL SENSING OF VITRIFICATION TO SUPPORT GERMPLASM REPOSITORY DEVELOPMENT FOR AQUATIC SPECIES

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Development of germplasm repositories for aquatic species is vital for protecting valuable genetic resources. The recovery success of the cells after cryopreservation is highly dependent on freezing and warming conditions due to potential cell damage during the process. In cryopreservation, equilibrium, and non-equilibrium (vitrification) cooling are commonly used methods. Vitrification typically employs ultra-rapid cooling (e.g., >10,000 °C/min) to produce liquid-to-solid phase change into a glass-like state that minimizes ice crystal formation. We seek to enable real-time monitoring of the vitrification process through innovative electrical sensing technologies. Traditional assessment of vitrification has primarily relied on visual observation of sample transparency, which can be subjective and unreliable. Typically, crystalline ice is opaque or translucent, whereas vitrified samples remain transparent. To make this work more accessible, it is based on open fabrication techniques such as resin 3-D printing and printed circuit boards (PCB) to develop custom probes that can be shared by the internet (Figure 1A). These probes can detect electrical impedance signals to monitor phase change (e.g., liquid to solid). Preliminary results (Figure 1B) show an increase in electrical resistance of a 20% dimethyl sulfoxide solution as it undergoes vitrification. These impedance changes reflect formation of ice and validate the feasibility of monitoring vitrification by use of prototype probes fabricated by resin printing of a substrate that could be equipped with electrical circuitry. The impedance increased during cooling reflecting vitrification at the glass transition (T_g) point without a clear release of latent heat (typically seen when cooling more slowly). This approach can offer quantifiable and precise monitoring, enhancing the reproducibility of cryopreservation through vitrification. Open fabrication technologies will enable user communities to fabricate, adapt, and improve such probes, thus contributing to development of germplasm repositories at a community level.

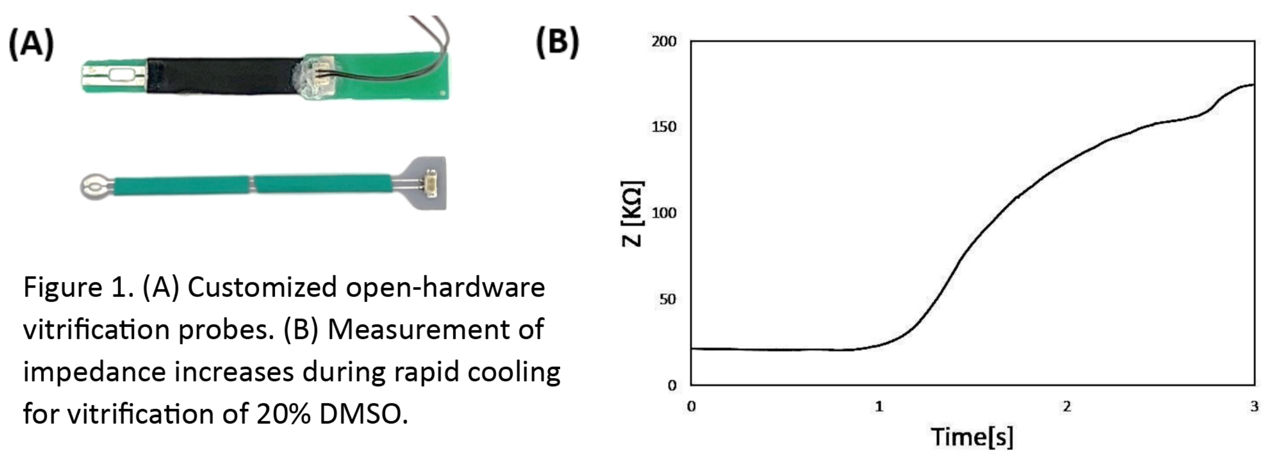

Figure 1. (A) Customized open-hardware vitrification probes. (B) Measurement of impedance increases during rapid cooling for vitrification of 20% DMSO.

INVESTIGATING THE SUPPLEMENTATION OF *Lactococcus lactis* MA5 AS AN AUTOCHTHONOUS PROBIOTIC ON DIETS FOR HYBRID CATFISH *Ictalurus punctatus* × *I. furcatus*: EFFECTS ON GROWTH PERFORMANCE, IMMUNE MODULATION, AND DISEASE RESISTANCE

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The commercial production of hybrid catfish (*Ictalurus punctatus* × *I. furcatus*) in the United States is continuously increasing, now accounting for nearly 60% of the total catfish production, surpassing the production of channel catfish (*I. punctatus*). During this transition, the frequency of disease incidence in hybrid catfish has steadily increased creating cause for concern due to significant economic losses. The utilization of probiotics in aquaculture has been an established practice to improve production yield and animal health in non-ictalurid culture species. However, the use of probiotics has not been commercially adopted in catfish culture due to mixed results related to improved growth and health. *Lactococcus lactis* MA5 was previously identified as a potential autochthonous probiotic from the intestine of overperforming hybrid catfish reared in experimental earthen ponds. In the present study, three graded levels of *L. lactis* MA5 (10^4, 10^6, 10^8 CFU/g of feed) were mixed with a commercial diet and used in a comparative feeding trial for hybrid catfish juveniles (16.1±0.1 g initial weight). In total, 560 fish were equally distributed in 28 tanks and dietary treatments were randomly assigned into each aquarium (36.6 L, 20 fish/tank), operating as a flow-through system (0.5 L/min) with supplemental aeration. Fish were fed at rations of 3-5% body mass, twice daily, for 56 days. Growth performance, survival rate, water quality, and feeding efficiency were monitored throughout the feeding trial. At the end of the study, the head kidney, anterior intestine, and liver were collected for analysis of inflammatory and anti-inflammatory cytokine gene expression; serum samples were tested for superoxide dismutase (SOD) and lysozyme activities; viscerosomatic indices and whole-body proximate composition were also collected. The middle and distal segments of the intestine were sampled for histological examination and analyses are ongoing. At the end of the feeding trial, fish were fed their respective dietary treatments for an additional week, and digesta samples were collected to evaluate the intestinal microbiota. The DNA samples were extracted, and will be subjected to 16S rRNA gene sequencing targeting the V3-V4 region using Illumina MiSeq. No significant differences were observed for growth performance, feeding efficiency, or viscerosomatic indices. However, the serum lysozyme and SOD activity were upregulated in a dose dependent manner. Moreover, the gene expression of immune-related cytokines *IL-1β,* and *IL-6* were upregulated in 10^8 CFU/g, while *TNF-α* was suppressed. A bacterial catfish pathogen, *Aeromonas hydrophila*, was used in an experimental challenge (intraperitoneal injection with 5.3×10^6 CFU/g body mass) to evaluate the disease resistance of the hybrid catfish after the dietary administration of MA5. Notably, the lowest MA5 feeding concentration (10^4 CFU/g) also demonstrated the highest survival rate (72.45%, p=0.001) when compared to the control group (49.5%) 7 days post-challenge. In conclusion, the oral administration of *L. lactis*, MA5 for 56 days as a probiotic can significantly modulate the non-specific immune responses and cytokine mRNA expression, and increase the survival rate of hybrid catfish after *A. hydrophila* infection.

EVALUATING THE EFFECTS OF *Cetobacterium somerae* MSU49, AS FEED SUPPLEMENT FOR HYBRID CATFISH (*Ictalurus punctatus* × *I. furcatus*)

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As one of the most prevalent intestinal bacteria of freshwater fish, *Cetobacterium* spp. is known to be capable of vitamin B12 biosynthesis. In a previous study conducted by our research group, the intestinal microbiota of earthen pond-cultured hybrid catfish (*Ictalurus punctatus* × *I. furcatus*) presented a 28 to 40% relative abundance of bacteria from the genus *Cetobacterium*. Presently, other than vitamin B12 biosynthesis, the metabolism and role of *Cetobacterium* in the intestine of freshwater fish remains unknown, but it is possible that it can be involved in pathogenic bacteria regulation and health promotion. Two *Cetobacterium* spp. were isolated from samples obtained from the previously mentioned study and identified as *Cetobacterium somerae* through whole genome sequence (WGS). The phenotypes of the isolates were evaluated for antibiotic susceptibility, a biochemical panel, and antagonistic inhibition of catfish enteric bacterial pathogens (*Edwardsiella ictaluri*, *E. piscicida*, and *Aeromonas hydrophila*). It was observed that neither isolate had inhibitory properties on all three pathogens *in vitro*, but they are sensitive to regular antibiotics. The identified coding sequences (CDS) of the genome included genes related to amino acid metabolism and vitamin biosynthesis (Vitamins B1, 2, 6, 7, 9, and 12). Lastly, *Cetobacterium somerae* MSU49, was tested as a microorganism to enhance the nutritional profile of protein ingredients (soybean and cottonseed meal) commonly used in catfish feeds through fermentation. A 3×4 factorial design was assigned in this study, aiming to find the optimal fermentation conditions with 3 different temperatures (29, 31, and 33C), and 4 bacteria concentrations (Control, 10^3, 10^4, and 10^5 CFU/g). Anti-nutrition factors, including free gossypol, glycinin, and beta-glycinin were evaluated, and a significant decrease in glycinin (45.4±4.3 µg/g) and beta-glycinin (20.3±6.0 µg/g) levels were observed when ingredients were fermented with 10^3 CFU/mL MSU49 at 33°C for 48 hours compared to control (Glycinin: 65.9±14.3; beta-glycinin: 33.3±3.1 µg/g). Proximate composition and mycotoxin levels of fermented products did not exhibit significant changes. These findings suggests that *Cetobacterium somerae* MSU49 can be a potential microorganism to ferment these plant protein ingredients by providing additional nutrients and reducing anti-nutritional factors.

PRODUCTION ECONOMICS OF BLACK SEA BASS, *Centropristis striata,* IN A RECIRCULATING AQUACULTURE SYSTEM: SENSITIVITY TO GENETICALLY INDUCED GROWTH INCREASES AND ALTERATION OF PROTEIN SOURCES IN AQUAFEEDS

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Based on the University of North Carolina Wilmington's (UNCW) pilot marine fish hatchery and recirculating aquaculture system (RAS) growout facility (Wrightsville Beach, NC), a spreadsheet production economics analysis was conducted for a hypothetical commercial scale RAS growout facility for black sea bass, *Centropristis striata,* in coastal North Carolina, and profitability of alternative production scenarios were explored via sensitivity analysis. Financial performance was measured by assessing farm input costs (e.g. labor, feed, energy), duration of production cycle, time to first harvest, farm gate revenues and returns to owner per production cycle, break-even (BE) prices, discounted payback period, modified internal rate of return (MIRR), and cumulative net present value (NPV). A base case biological growth model was developed through linear regression analysis using empirical growth data from black sea bass raised in RAS at UNCW and at North Carolina State University. Alternative models based on a 12.5% increase per generation in weight-at-age over two generations that might be realized through selective breeding were also investigated.

The benchmark of 75% of the cohort at premium marketable size or larger is reached at 23.9 months for F0 , at 22.8 mos for the F1 generation and 21.7 mos for the F2 generation, at BE prices of \$8.228, \$7.376 and \$7.084, respectively. When F2 generations were fed plant-based aquafeeds, BE drops to \$6.842. The results of this study show that black sea bass can be grown using RAS methods at commercial scale and at competitive prices. Furthermore, implementing genetic selection for improved growth concurrently with plant-based aquafeeds has the potential to significantly improve the economic performance of a black sea bass RAS facility.

Table 1. Summary of Harvest Scenarios includes biomass, average harvest / year, average annual production after first harvest and tank space efficiency for all models created.

Model Iteration	Harvest Biomass per Cohort kgs (lbs)	Average Number of Harvests per Year (after first harvest) (#)	Average Annual Production After First Harvest kg (lbs)
F0 Four- Stage Model #2	16,052 (35,387)	6.02	99,805.5 (220,035)
F1 Four-Stage Model	16,052 (35,387)	6.79	109,027.02 (240,363.43)
F2 Four-Stage Model #2	16,080 (35,450)	7.33	117,919 (259,967)

Table 2. Commercial base case cumulative net present value (CNPV), Modified Internal Rate of Return (MIRR), Discounted Payback Period (DPP), and breakeven price (BE) for base case generation (F0) and two generations of selective breeding (F1 and F2).

Generation	NPV (\$)	MIRR (%)	DPP (mos.)	BE (\$)
F0	\$432,141.95	7.556	12	\$8.236
F1	\$2,253,800.08	11.664	7	\$7.376
F2	\$3,053,031.52	12.862	6	\$7.084

NORTHEAST BIVALVE HATCHERY HEALTH CONSORTIUM

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The goal of the "Northeast Bivalve Hatchery Health Consortium (NEBHHC): Managing Larval Mortalities in Northeast Hatcheries" is to support the growth of the bivalve shellfish industry in the USA by providing access to diagnostic tools helping hatcheries ensure reliable production of bivalve seed. The objectives for this consortium are to: (1) identify the causes of bivalve hatchery larval mortalities and crashes in the Northeast US through an integrated, collaborative, and proactive approach to sample collection and analysis; and (2) develop strategies and protocols to manage and minimize larval crashes in hatcheries.

During the 2024 and 2025 hatchery seasons, we will be working with commercial and public/research hatcheries wishing to participate in the project to collect algae, water, and larvae from a variety of larval runs, including "good" (successful performance) and "bad" (lower performance or crashes). Hatcheries will also provide data relevant to larval performance. All individual hatchery information collected will remain confidential. We will provide all supplies for the sample collections, cover shipping fees, and cover the cost of disease diagnosis. The goal of this presentation is to inform others of this work and strengthen our experimental plan and enlist hatcheries and other stakeholders (e.g., researchers, extension specialists) to participate in the NEBHHC. Members of the NEBHHC coordinating team, include pathologists, ecologists, hatchery managers, and extension specialists, connections made will answer questions and gather feedback from stakeholders on how to address this critical issue of larval crashes.

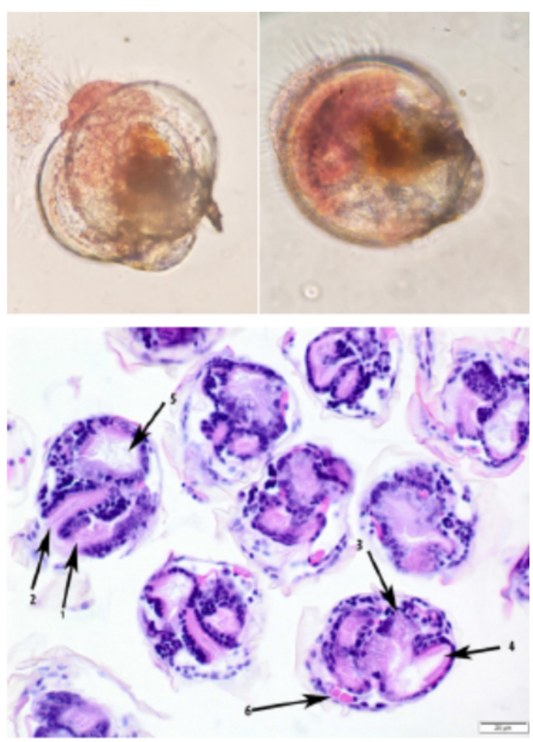

Figure 1. Photos by R. Smolowitz

A NEW ELECTRONIC DATA SYSTEM FOR SHELLFISH IN WASHINGTON STATE

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Modern and simple data reporting for Washington shellfish producers is on the horizon. State agencies required to collect harvest data are coordinating with shellfish trade associations, non-regulatory agencies, and the Pacific Shellfish Institute to develop a new electronic data system. The system will consolidate multi-agency reporting and improve consistency. This is a “win-win” for shellfish managers, farmers, and harvesters. Accurate and reliable harvest production reporting is critical to conduct economic analyses that support the productivity and economic sustainability of shellfish aquaculture. Accurate information has been lacking for decades, hindering U.S. aquaculture growth and programs to aid economic relief following catastrophic events like natural disasters and the COVID-19 pandemic. Production data are also vital for consumer and market evaluations, and prospective investments in the shellfish producing sector. Data is also needed for outreach programs that educate the public and policy makers. Production information is an important component of telling the story of shellfish as a natural resource. Volumes and value demonstrate the significance of shellfish like oysters, mussels and clams to our coastal communities and U.S. seafood production. This effort is funded in part by NOAA National Sea Grant under #NA21OAR4170088. The team has carefully considered confidentiality and is seeking widespread buy-in from stakeholders.

RHODE ISLAND SEA GRANT'S EFFORTS TO SUPPORT AND INFORM THE SEAFOOD SECTOR DURING THE PANDEMIC

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When the COVID-19 pandemic threatened to interrupt and debilitate the Rhode Island seafood sector, the state, Rhode Island Sea Grant, and a host of partners worked with the industry to develop lifelines to encourage stability and a customer base. While the seafood sector was hit hard, food insecure people in the state also suffered. The need and demand for healthy, sustained food sources in the state has always been present and the pandemic exacerbated the needs, with one in four households in Rhode Island lacking adequate food (see Status Report on Hunger, 2021). Utilizing and leveraging these well-defined and well-managed channels, with partners that have been leaders in these efforts, RISG worked with the existing seafood distribution channels to provide awareness, handling, and preparation experience for oysters, to encourage opportunities for oysters to be used in the future.

Also, since the COVID-19 pandemic disrupted seafood supply chains across the country, fishermen were forced to seek out and develop new ways to market catch. Dockside sales of finfish represented one of these new markets in Rhode Island, complementing long-standing efforts to strengthen connections between local seafood harvesters and consumers. In April 2020, with support from RISG, the RIDEM created a new emergency authorization for fishermen to sell finfish directly to consumers from their vessels at the dock.

RISG also purchased thermometers for the fishing industry help them determine COVID-19 infections which allowed healthy individuals to return to work safely in the confined quarters of fishing boats. The Rhode Island Sea Grant Legal Program (RISGLP) also provided rapid response to state fishermen by working with stakeholders to clarify legal issues associated with the DSDL program, in particular, clarifying issues related to the interaction of the DSDL program with RIDOH food business licensing requirements.

The aquaculture industry was also hit had by COVID-19. RISG responded by: a) conducting an industry survey of impacts to assess need and appropriate and rapid RISG responses; b) link growers with free small business support and guidance through Venture Café and District Hall Providence; c) host a series of webinars on funding support and how to navigate federal/state grants and support for growers; d) distributing a weekly eNewsletter to growers featuring resources, deadlines, events, and support for the industry; and e) directly purchasing local RI oysters to distribute to food insecure communities to help build a future market to this local, sustainable product.

FROM REFUGE TO RELEASE: UPGRADING METHODS AND FACILITIES FOR ADVANCED FISH PROPAGATION OF DELTA SMELT

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In this presentation, we detail the transformative journey of our laboratory, which has transitioned from maintaining a refuge population of delta smelt (Hypomesus transpacificus) primarily for research purposes to establishing a large-scale propagation program. This significant shift aims to address the urgent conservation needs of the delta smelt, a species critically indicative of the health of its native aquatic ecosystems. Initially, our focus was on preserving a genetically diverse refuge population, employing controlled breeding and maintaining stable environmental conditions to facilitate in-depth studies on the species' biology and ecology.

However, the alarming decline of wild delta smelt populations has driven us to expand our role and capabilities significantly. Collaborating with various agencies and university laboratories, we have led the evolution of our conservation strategy to meet these challenges. The transition to a large-scale propagation program involves substantial facility upgrades and methodological enhancements. We have adopted advanced breeding technologies, developed new genetic management strategies, and implemented new health management protocols. These enhancements aim to ensure the production of robust, genetically diverse delta smelt populations, aligning with our goal of producing 125,000 adults per year by 2025. This presentation will explore the key aspects of this shift, focusing on our collaborative efforts and the new approaches we have adopted in response to the critical conservation needs of the delta smelt.

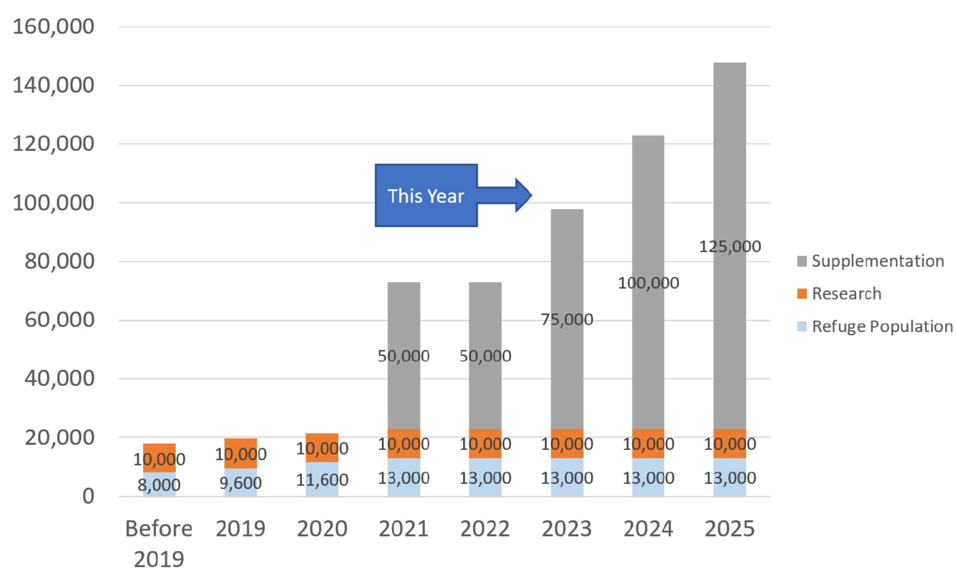

Figure 1. Change of the production goal over the years at the UC Davis Fish Conservation and Culture Laboratory.

EARLY LIFE CYCLE AND EFFECTS OF MICROALGAL DIETS ON LARVAL DEVELOPMENT OF WARTY SEA CUCUMBER, *Apostichopus parvimensis*

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The high commercial value (up to $300–500/kg dried) and the increasing demand for sea cucumbers has promoted over-exploitation in the wild, which has resulted in the collapse of natural stocks and is likely negatively impacting vulnerable benthic ecosystems. Overfishing is encouraging the development of aquaculture technologies for sea cucumbers to meet the market demand and to create new economic opportunities. Warty sea cucumber (WSC) *Apostichopus parvimensis* is one commercial species along the Pacific coast of the U.S. Wild populations of WSC have reached levels of concern due to overfishing, and it is now listed on the International Union for the Conservation of Nature Red List of Threatened Species.

Adult WSCs were collected off the coast of San Diego and held under ambient conditions in flow through seawater tanks. Spawning induction trials were conducted at the end of the natural spawning season. Larval stages and survival rates were recorded, and the effects of single and multiple combinations of microalgae species were evaluated in relation to larval performance. The spawning rate (spawned/total) was 0-55.6 %, and the fertilization rate was 85.15±1.71 %. The gastrula stage was reached between 36 h and 3 days post-fertilization (dpf), and early, mid and late auricularia stages were reached at 3, 8, 12 dpf with a mean length of 581.15±98.34, 862.72±84.84, and 663.86±59.94 µm, respectively. Late auricularia larvae became non-feeding doliolaria at 15 dpf with a reduced mean length to 441.01±16.92 µm, and reached the pentactula stage at a mean length of 483.00±11.39 µm at 17 dpf. The survival rate decreased to 24.17±2.89 % at 19 dpf, at which time the doliolaria and pentactula stages accounted for 28.07 % and 8.77 % of the survivors, respectively. During the first 7 days of culture larval mortality was 50%. The survival rate of larvae fed with different diets was not significantly different, but larvae developed faster when fed with *Rhodomonas* sp., and a mixture of *Rhodomonas* sp.+ *Tisochrysis lutea* than other diet groups. The results of this study will help establish hatchery production protocols for *A. parvimensis* and aid in the further development of the aquaculture of this species.

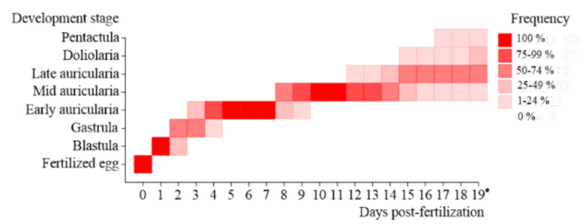

Figure 1. Frequency chart depicting the larval development progression of WSC at 20 °C.

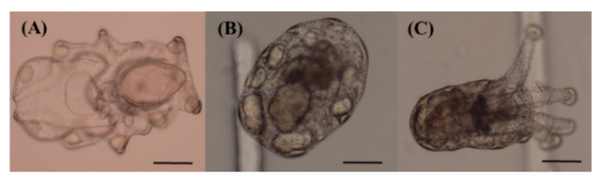

Figure 2. Larval development of WSC at 20 °C. A: Late auricularia. B: Doliolaria. C: Pentactula. Scale bar 100 µm.

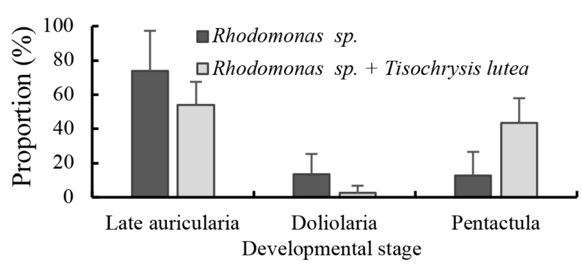

Figure 3. Proportion of late auricularia, doliolaria and pentactula in the diet group of *Rhodomonas* sp. and *Rhodomonas* sp.+*Tisochrysis lutea*.

PERFORMANCE AND WATER REMEDIATION CAPACITY OF DULSE *Devaleraea mollis* AND SEA LETTUCE *Ulva lactuca* CULTURED IN THE EFFLUENTS FROM WHITE SEABASS (*Atractoscion nobilis)* IN A LAND-BASED INTEGRATED MULTI-TROPHIC AQUACULTURE (IMTA) SYSTEM

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Nitrogenous compounds such as ammonia, nitrate, and dissolved organic nitrogen are the main waste components of marine fish aquaculture effluents. These compounds are also regarded as primary nitrogen sources for seaweeds, and are a limiting factor for the growth of seaweeds. In order to understand how dulse (*Devaleraea mollis*) and sea lettuce (*Ulva lactuca*) affect and are affected by marine fish effluent, we developed a land-based integrated multi-trophic aquaculture (IMTA) system to co-culture *D. mollis* and *U. lactuca* with white seabass (*Atractoscion nobilis*). *A. nobilis* has numerous aquaculture characteristics desirable for commercialization and decades of research have brought it to a commercial ready state.

In this IMTA system, the sand-filtered seawater flowed through the *A. nobilis* culture tanks (700 L each), and then entered *D. mollis* and *U. lactuca* cultivating tanks (700 L each) by gravity. This experiment was conducted from March through to July in ambient seawater with three replicates. The initial stocking densities of *A. nobilis*, *D. mollis* and *U. lactuca* were 30 kgWW/m^3, 4 kgWW/m^2 and 1 kgWW/m^2 with densities reset monthly and weekly, respectively. The temperature was 13-21°C during experimental period. *Devaleraea mollis* tanks were shaded at 60% to decrease ectocarpus growth. The seawater exchange rate was 63vol./day.

Atractoscion nobilis grew 0.88g/day, with an average weight gain of 68.84g (from 118.76 g to 187.60g). The average total ammonia nitrogen (TAN) of 0.07 mg/L (peaking at 0.25 mg/L) from effluents of *A. nobilis* tanks (no or low TAN detected in ambient seawater) resulted in the productivity of 24.53 gDW/m^2/d for *U. lactuca* and 13.58 gDW/m^2/d for *D. mollis* with the average specific growth rate (*SGR*) of 20.95±13.09%/d and 3.16±2.27%/d, respectively. The average TAN removal efficiency was 32.15% by *U. lactuca,* and 13.19% by *D. mollis*, and for nitrate, nitrite, and phosphate, the average removal rate was 56.54%, 13.88% and 7.9% by *U. lactuca*, and 41.53%, 10.83% and 15.06% by *D. mollis*. The pH in effluents of *D. mollis* and *U. lactuca* tanks increased to 7.77-8.32 from values of 7.71-8.08 in effluents from *A. nobilis* tanks. The results of nutritional quality of the seaweeds (e.g., nitrogen, carbon, lipid) are pending. Our results show that *A. nobilis* can supply nutrient-enriched effluents to co-cultivated *D. mollis* and *U. lactuca* in IMTA systems to increase seaweed growth and productivity. Additionally, *D. mollis* and *U. lactuca* can efficiently remove nutrients and increase pH values before effluents are discharged into coastal regions. In future studies, harvested *D. mollis* and *U. lactuca* will be fed to other co-cultured invertebrates (e.g., abalone, sea urchins) in this IMTA system to diversity seafood production and increase system efficiency even further.

A LITERATURE REVIEW OF TILAPIA/ LETTUCE AQUAPONICS – PRODUCTION STATUS, VARIETIES, AND RESEARCH GAPS

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Aquaponics has received considerable attention in recent years as a bio-integrated model for sustainable food production. Tilapia and lettuce are the most commonly used combination among aquaponics producers, hobbyists and educators. Therefore, the goal of this literature review was to aggregate the knowledge on the current status of tilapia/ lettuce production, fish densities, systems configuration, common lettuce varieties, and identify research gaps. Among the forty reviewed publications, 72.5% were using Nile tilapia, 17.5% were using red, 2.5% were using red Mozambique, 5% were using rocky mountain strain and 5% of the articles stated that they used tilapia without reporting the species. Throughout the reviewed publications, tilapia initial density used ranged from 0.34 to 28.4 kg/m^3, which depended on the purpose of the study, experimental size and design. Nile and red tilapia final yields were in the range of 12.58 to 28.50 and 9.81 to 50.45 kg/m^3, respectively. For the hydroponic unit, 55% of the publications used deep water culture (DWC), 35% used nutrient film technique (NFT), and only 10% used media bed (MB). Culture period was up to 8 months, but these long culture periods used staggered fish production. Harvest schedules were determined based on target lettuce size and experimental design (~4-5 weeks). Basil, cucumber and cherry tomato were used in aquaponic systems to optimize efficiency. Some of the gaps this review identified includes fish culture data (i.e., fish initial weight, density, duration, and/ or yield), which were not completely presented in multiple articles. The optimum ratio between fish feeding rate and plant growing area (57 g of feed/day/m^2) was originally calculated at the University of Virgin Island and published in 1988 using Bibb lettuce. This ratio has been used by farmers and researchers as a rule of thumb for years. However, this recommended ratio did not take into account other factors such as fish species, protein content of the diet, plant species/ variety, plant density, biological filtration, and air flow in the grow bed. Hence, the current review is suggesting that fish to plant ratio and fish density needs to be re-evaluated. As there is a thermal preference mismatch between tilapia and lettuce, there is a need to evaluate the optimum temperature for both to obtain the highest growth performance. Nowadays, it is recognized that the genetic quality of farmed stocks must be routinely improved and protected. Therefore, feeding frequency, feeding amount and stocking densities in aquaponic systems should be continuously revaluated with the improved strains of tilapia as well as heat tolerant varieties of lettuce.

IMPLEMENTATION OF FIL FUNDED PROJECTS IN ASIA REGION: ROLE AND IMPACTS ON AQUACULTURE AND FISHERIES DEVELOPMENT IN BANGLADESH AND CAMBODIA

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In Asia region, during the 1st Phase (September 2018 – September 2023) of the Feed the Future Innovation Lab for Fish (FIL) under Mississippi State University (MSU), USA financially and technically supported and implemented 7 aquaculture and fisheries research projects in Bangladesh and Cambodia. Both Bangladesh and Cambodia are the two naturally resourceful agro-based nations in Asia. In particularly Bangladesh is one of the leading countries in Asia-Pacific region for aquaculture development to support human nutrition, income generation of rural fish farmers and country's economic growth. The country is currently ranked in the 5th position being a producer of 2.8 percent of the total global aquaculture production. On the other hand, although aquaculture in Cambodia, is one of the flourishing sub-sectors, but till remained far behind to other neighbouring countries viz. Vietnam and Thailand including Bangladesh, but aquaculture plays as well an important role in food security and livelihoods of the people. Government of Bangladesh and Cambodia are extremely supportive to develop aquaculture and fisheries. Meanwhile, FIL came forward to implement successfully 5 projects in Bangladesh to the areas viz. i) Cryogenic sperm banking of major carps; ii) Carp genetic improvement; iii) Harnessing machine learning to aquaculture production and value chains; iv) Foodborne pathogens at aquaculture value chains; v) Strategies for inclusive aquaculture value chains. At the same time, FIL implemented in Cambodia 2 successful projects viz. i) Development of Bighead catfish culture; ii) Sustainability of fisheries for resilience of Cambodian fishing communities. Successful implementation of these research projects had already shown a great impact at the end of the activity period in September, 2023, while a number of evolved aquaculture and fisheries technologies have been innovated, tested at farmer's field, disseminated and used for maximizing human nutrition and poverty alleviation of hundreds and thousands of vulnerable rural communities (mostly youth and women communities) in these two Asia region countries, which had certainly contributed to the missions of the Feed the Future Strategy and/or resilience programming.

In this paper, an attempt has been made to address successful implementation of FIL funded 7 projects in Asia region along with the role and impact on aquaculture and fisheries development in Bangladesh and Cambodia are also highlighted.

GROWTH, PHOTOSYNTHESIS, TOXINS (OA AND DTX), AND GENES OF THE DINOFLAGELLATE ALGAE *Prorocentrum lima* UNDER NUTRIENT DEFICIENCY

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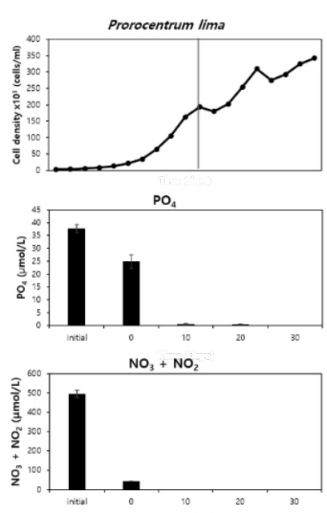
Prorocentrum lima is known to having toxins such as okadaic acid, DTX-1 and DTX-2, causing diarrheal shellfish poisoning (DSP). Toxins within these algae can affect organisms at other trophic levels such as shellfish and humans through the food chain. This species has a high growth rate (up to 0.5 d^{-1}) and requires large amounts of nutrients. The expression level of the toxin increases in nutrient deficient environment. This study is to observe changes in growth, photosynthetic efficiency, pigment (Chl *a, b* and carotenoids), toxin (OA and DTX), and gene expression under nutrient depletion. The *P. lima* cells were cultivated at 20 °C and 100 µmol m^{-2} s^{-1} in f/2 medium. The first sampling of cell and seawater was conducted approximately 3 hours after replacing the medium. The f/2 addition was stopped when the cell concentration reached about 200,000 cells/ml. After the nutrient addition was stopped, the sampling was conducted at a 10-day interval for 30 days. During the exponential growth period, *P. lima* took up more than 90% of the nitrate and nitrite in the medium within 3 hours. On day 10, nitrate and nitrite concentration was depleted, and phosphate also became limited, < 0.5 µmol/l (Fig. 1). Interestingly, even after the supply of nutrients was stopped, the cell density was continuously increased for how many days, and the cell concentration reached about 350,000 cells/ml (Fig. 1). During the experiment, *P. lima* showed the specific growth rate (SGR) of 0.06 d^{-1}, with the highest value was 0.12 d^{-1} during the exponential growth phase. Chl *a* and carotenoids (pg $cell^{-1}$) showed no significant effect of nutrient deficiency. However, Chl *b* was higher on the 10th day compared to other days. The results of photosynthetic efficiency, toxins and gene expression will also be presented.

This research was supported by a grant (20163MFDS641) from Ministry of Food and Drug Safety in 2023.

FIGURE 1. Cell density of *Prorocentrum lima* and nutrients concentration (phosphate, and nitrate and nitrite) in medium.



CONSUMER PREFERENCES FOR HEMP-FED AQUACULTURE

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Increasing consumption of seafood in the U.S. and globally has prompted growing attention to the environmental and safety concerns associated with the commercial fishing industry. Farm-raised fish are a resource-efficient source of animal protein that consumers may substitute as a generally safer, sustainable alternative to wild-caught fish. However, it is important for the aquaculture industry to continuously innovate to maintain the most efficient and environmentally conscious production methods.

Hemp grain production in the U.S. has created a new possible source of dietary nutrients and energy for farm-raised fish as a complementary substitute for fish meal, which is costly and environmentally taxing. However, it is unclear whether consumers will be averse to consuming hemp-fed fish. The objective of this study is to survey U.S. consumers to determine demand sensitivity to hemp-fed labels on fish products, and respective willingness to pay for these products. Moreover, our survey oversamples underrepresented minority groups because Native Americans tend to consume significantly more fish than other groups. The results of this survey will be informative to stakeholders in the hemp and aquaculture industries, as well as processors that may collect a premium from labeling products as hemp-fed.

DIAGNOSIS OF *Vibrio* spp IN POSLARVAS OF WHITE SHRIMP (*Litopenaeus vannamei*) COLLECTED IN TRANSPORT TANKS, IN THE NORTHWEST OF MEXICO

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Shrimp farming is an extremely important sector in food production worldwide, considering that the biggest problem they face are disease outbreaks. Various infections are attributed to the Vibrio genus, which cause significant mortality from the first days of cultivation, eventually eliminating up to 100% of the population. Within this genus there are specific species and strains that contain one or more extrachromosomal plasmids capable of encoding a potent binary toxin (PirAB) that causes Acute Hepatopancreatic Necrosis Disease. The objective of this study was to determine the presence of toxigenic *Vibrio parahaemolyticus in* postlarvae of white shrimp collected in transport tanks of larval production laboratories, using bacteriological and molecular methods.

Samples were collected from a total of 26 containers, 12 corresponding to Sonora (LA, LC, LE) and 14 to Sinaloa (LB, LD, LF) between the months of April and July 2022 and February 2023.

Six of which tested positive for toxigenic *V. parahaemolyticus*, corresponding to two laboratories. By the bacteriological method, 21 positive cases of toxigenic *V. parahaemolyticus* (green colonies, sucrose fermenters) were obtained. Using real-time PCR (IQ REAL AHPND/EMS Toxin 1 GeneReach) it was confirmed that six of the above cases were positive for the PirAB toxin. The partial region of the 16s rRNA of the positive bacterial strains was sequenced. In the BLAST system they were analyzed using the online algorithm and compared with the database reported in NCBI. Lab A presented *V. campbellii* and *V. parahaemolyticus* while Lab B presented *V. campbellii*.

The *V. parahaemolyticus* strain was known to be the main encoder of the binary toxin PirAB (Tran *et al*., 2013). The plasmid encoding the binary toxin can be transferred between clades with high similarity. Horizontal gene transfer promotes the conversion of non-pathogenic strains into strains that increase the spread of AHPND (Han *et al*., 2015; Restrepo *et al*., 2018). This results in *V. campbellii* being reported as toxigenic strains carrying the binary toxin.

It was possible to diagnose the presence of the PirAB toxin in strains of the genus *Vibrio*, obtaining characteristics of typical colonies in TCBS and CRHOMagar media. Furthermore, the molecular identification used has high affinity with *V. parahaemolyticus* and *V. campbellii*.

Tabla 1. Resultados de los análisis.

Lab	Case	Bacterio logy	PCR	Species
LA	C3	+	+	*V. campbellii*
	C6	+	+	*V. parahaemolyticus*
	15	+	+	*V. campbellii*
LB	C2	+	+	*V. campbellii*

FOOD AND FEEDING HABITS OF THE CICHLIDAE IN TAGWAI RESERVOIR, NIGER STATE, NIGERIA

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Four hundred and seventeen (417) samples comprising of one hundred and eighty-six *Sarotherodon galilaeus* and two hundred and thirty-one (231) *Coptodon zillii* were collected on monthly basis for four (4) months (March, 2021 to June, 2021) from the catches of local fishermen operating on Tagwai Reservoir, in Niger State, Nigeria. The fresh samples were transported in ice - chest box to the Biology Department laboratory of Ibrahim Babangida University (IBB), Lapai, Niger State, where analyses were carried out. Eight (8) different types of items that constituted plant and animal materials were found as food in the stomachs of each of *S. galilaeus* and *C. zillii*. This included detritus, sand, algae, plant material, nematode, plankton, seed and unidentified material. Plant material was highest (30.30%) followed by detritus (17.32%) then algae (16.01%) and lowest was nematode and unidentified material each with 2.16%. Feeding intensity of both species of fish was high due to low percentage of empty stomachs recorded during the period of study. 157 stomachs of *S. galilaeus* out of 186 examined had food while 181 stomachs of *C. zillii* out of 231 examined had food. *S. galilaeus* and *C. zillii* are omnivore and herbivore respectively based on their feeding habits. Diet overlap or similarity showed moderate level of association in diet and less competition for food between the two species. There is need to examine other aspects of biology, such as growth, fecundity, age of these fishes in the reservoir. This study can be used as baseline information for carrying out similar study in other water bodies.

COMPARATIVE GROWTH ASSESSMENT OF AFRICAN CATFISH (*Clarias gariepinus*) FED SWEET POTATO (*Ipomea batata*) LEAF MEAL AND RICE BRAN AS ALTERNATIVE FEED MEAL

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The study compared growth performance of *Clarias gariepinus* fingerlings fed sweet potato leaf meal and rice bran as alternative feed meal. Five diets, that contain 0%, 25%, 50%, 75% and 100% inclusion levels were formulated and designated as SPM_1 SPM_2 SPM_3 SPM_4 SPM_5 and RBM_1 RBM_2 RBM_3 RBM_4 RBM_5. Highest initial weight in $SPLM_3$ (50%) differ significantly ($p>0.05$) from $SPLM_1$ (0%) while RBM4 (75%) can be compared to RBM_1 (0%). Final weight and body weight gain follow similar trend with $SPLM_2$ (50%) recorded highest, which differ significantly ($p>0.05$) with other diets. Decrease of SPLM inclusion level increase fish weight. Highest SGR in $SPLM_2$ (25%) can be compared favorably with $SPLM_1$ (0%) and other diets while RBM_2 (25%) differ significantly ($p>0.05$) with RBM_1 (0%). Diet $SPLM_5$ (100%) can be compared with other diets in SGR with RBM3 (50%) that differ significantly ($p>0.05$) with only RBM1 (0%). Highest FE in $SPLM_1$ (0%) can be compared favorably with $SPLM_3$ (50%) and $SPLM_4$ (75%) in feed acceptability. RBM_5 (100%), which is highest differ significantly ($p>0.05$) with RBM_1 (0%). Apart from RBM4 (75%) other diets were accepted by the fish. It is therefore recommended that 25% inclusion level of SPM should be used in the diet of *C. gariepinus* for better performance than even 75% inclusion of rice bran, study on lower inclusion level of SPM need to be carried out, this type of study need to carried out on other cultured species of fish such as *Heterobranchus* (catfish) and even Tilapia, study on the use of other processing methods of sweet potato leaf and rice bran for feed formulation should be carried out and this type of study need to be carried out in other culture system.

IMPACTS OF BLENDING VARIOUS PROTEIN AND OIL SOURCES ON THE GUT MICROBIOTA OF RAINBOW TROUT, *Oncorhynchus mykiss* RAISED AT VARIED TEMPERATURE REGIMENS

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Aquaculture sustainability depends on several factors, such as fish nutrition, water temperature, and the type of farmed fish. A crucial component in promoting aquaculture sustainability is the replacement of fishmeal (FM) and fish oil (FO) with alternative nutrient sources. Recently, there has been an increased focus on assessing the effects of innovative feed formulations on the fish gut microbiome. It is relatively uncommon for studies to examine the combined effects of diet and temperature on rainbow trout's gut microbiota.

Therefore, we evaluated the impact of substituting animal-based diets with plant-based diets on the composition and metabolic profiles of gut microbiota in rainbow trout (Oncorhynchus mykiss) raised at 14°C, 18°C, or 20°C. The contents of transient fish guts were analyzed using 16S rRNA gene and shotgun sequencing methods.

The results showed Firmicutes, Fusobacteria, Proteobacteria, Spirochaetes, and Desulfobacteria (Fig. 1) as dominant phyla for most treatments. Temperature significantly influenced microbial composition with Fusobacteria disappearing at 14°C (Fig.2). However, diets did not substantially impact bacterial diversity or composition, although plant ingredients led to minor increased Firmicutes and Bacillae. Fusobacteriaceae were significantly higher in fishguts fed fishmeal-based diet. In response to plant-based protein and 100% vegetable oil blend, genes related to fatty acid metabolism and lysine degradation were increased. At KEGG level 3, fish reared at 14°C showed a significantly increase in pathways linked to pentose and glucuronate interconversions, lysine biosynthesis, glycerolipid metabolism, and glycolysis compared to 18°C or 20°C.

Through this study, insight has been provided into the relationship between diet, temperature, and gut microbiome in rainbow trout, which will facilitate improved aquaculture practices through targeted feed formulations.

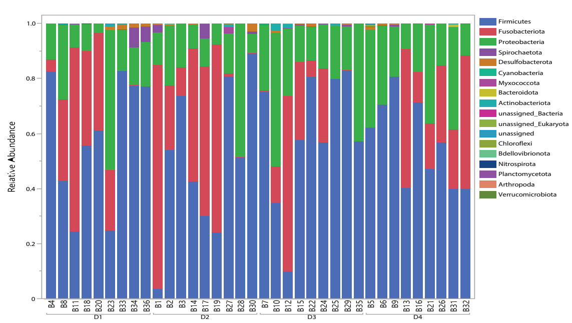

Fig.1 Relative abundance of bacterial phyla in individual fish grouped according to diets.

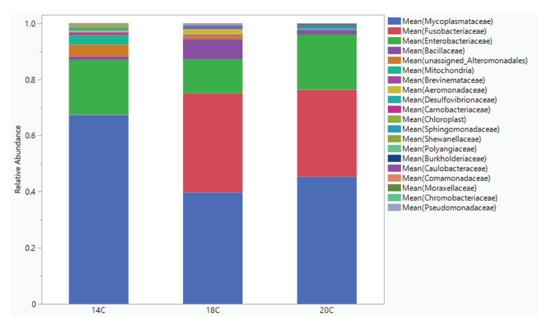

Fig.2 Relative abundance of bacterial family in fish grouped according to temperatures.

DIETARY TRYPTOPHAN SUPPLEMENTATION INCREASES LYSOZYME ACTIVITY IN CHANNEL CATFISH, *Ictalurus punctatus,* IN STRESSED, UNSTRESSED AND DISEASED CONDITIONS

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The US catfish aquaculture industry faces numerous reoccurring challenges, including fish losses from environmental stressors and infectious diseases. The consequence of prolonged stress within an aquaculture setting is a general decrease in production efficiency, especially decreased growth and disease resistance. Over time, stress modulation and disease treatment have been limited to the use of chemical drugs. However, there has been a growing focus on safer alternatives because these chemical drugs are known to have various adverse effects on the environment and human health. In this experiment, therefore, we wanted to investigate if tryptophan as a nutraceutical could modulate farming stress and increase immune responses against virulent *Aeromonas hydrophila* (vAh; ML09-119). We had four different experimental groups of channel catfish (*Ictalurus punctatus*): (1) control fish fed with control feed, (2) control fish fed with tryptophan-treated feed; (3) stressed fish fed with control feed; and (4) stressed fish fed with tryptophan-treated feed. After five weeks of feeding, we challenged the catfish with vAh and kept the fish in the challenged condition for 72 hours. We collected fish blood samples and extracted serum for sera lysozyme activity analysis before and after the disease challenge. Based on our preliminary data, tryptophan increased the lysozyme activity in both stressed and unstressed groups before and after the disease challenge. An increased lysozyme activity could infer an overall improvement in the innate immune response of fish under different rearing conditions. If proven, this finding may change the farming practices of catfish and reduce the usage of chemical treatments while maximizing profits and protecting the environment.

CONCENTRATION OF HEAVY METALS IN *Parachanna obscura* AND ITS IMPLICATION TO HUMAN HEALTH IN NIGERIA

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Heavy metal pollution is a growing environmental concern that can have serious health consequences for humans and wildlife. Fish are particularly vulnerable to heavy metal contamination as they can accumulate toxins in their tissues over time. This has led to increased interest in the assessment of heavy metals in fish tissues as a means of monitoring ecosystem health and human exposure risks. This study assessed the heavy metal concentrations in African Snakehead (*Parachanna obscura*) from Alape River, Igbokoda in Ilaje Local Government Area of Ondo State, South Western, Nigeria. The heavy metal concentrations were in the gills, intestine, and trunk of the fish. Results shows higher concentrations of heavy metals were generally found in the gills and intestine over the months. Iron recorded the highest metal found in the fish organs and Cadmium the lowest. The hierarchy of the measured concentration level (mg/kg) of the metals was as follows: Fe (2.43mg/kg) > Ni (1.14 mg/kg) > Mn (0.45 mg/kg) > Cu (0.31 mg/kg) > Pb (0.06 mg/kg) > Cd (0.05mg/kg). The range values for Nickel were beyond the permissible limits of WHO. The fish show negative allometric growth as 'b' values were less than 3. The condition factor (K) values for all samples of *Parachanna obscura* ranged between 1.13 and 3.78 with total mean value of 1.96±0.24. Continued monitoring of heavy metal levels in fish tissues is necessary to identify trends and assess the effectiveness of mitigation measures in reducing contamination levels. The findings suggest that African Snakehead *Parachanna obscura* from Alape River can be consumed safely without posing significant health risks.

PRELIMINARY RESULTS FOR THE LARVICULTURE OF THE OHIO RIVER PRAWN *Macrobrachium ohione*

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There are five species of freshwater caridean prawns that are native to the United States and have potential for aquaculture. None are currently farmed in controlled conditions due to difficulties of their management during the larval rearing phase. The majority of experimentation with these species occurred in the 1970s to the 1990s and then subsequently were abandoned with the rising popularity of the giant river prawn *Macrobrachium rosenbergii*. Nevertheless, rising interests in sustainable aquaculture have provided the opportunity to explore the aquaculture of native species. Thus, the objective of this work was to carry out the larviculture of the Ohio river prawn *Macrobrachium ohione*. Adult specimens of the Ohio river prawn were obtained from the Atchafalaya river system near Berwick, Louisiana and Butte La Rose, Louisiana, and were then transported to the Aquaculture Research Center of Lincoln University of Missouri. Berried females were separated into tanks of freshwater. Larvae were separated into 25 gallon tanks and were gradually acclimated to brackishwater with a salinity of 10, pH of ~8.5, dissolved oxygen of ~5 mg/L, and a temperature of 28° celsius. Larvae were fed with *Artemia* nauplii. The larviculture lasted 65 days. No post-larvae were obtained. It is noteworthy that survival was ~85% until day 45 of the pilot larviculture. This is promising when considering that there was no use of inert feed and little water maintenance, indicating the hardiness of this species. We believe that we were able to reach an advance stage before metamorphosis. The use of inert feed and more adequate rearing conditions will facilitate metamorphosis of this species, which has yet to be done in a controlled setting.

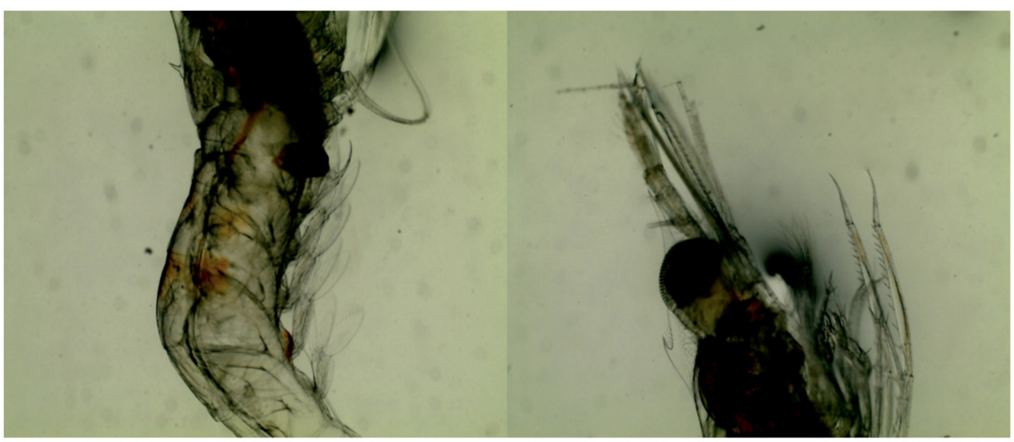

Figure 1. *Macrobrachium ohione* larvae analogous to zoea stage IX of the *Macrobrachium rosenbergii*.

SEAWEED FOOD SAFETY: COMPARING COMPLIANCE WITH PREVENTIVE CONTROLS FOR HUMAN FOODS AND SEAFOOD HACCP

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With increased interest in seaweed production, there is a need for profitable markets for seaweed products. The food market is seen as one of the most profitable, but there are a myriad of food safety regulations in the United States. These regulations govern the processing and marketing of food products to protect public health and prevent the occurrence of foodborne illness. While some resources already exist on the hazards associated with seaweed products (produced by Connecticut Sea Grant, Alaska Sea Grant, Food and Agricultural Organization of the United Nations and others), there is little guidance on the regulatory requirements for producing seaweed products in the US.

With funding from the National Seaweed Hub, the National Sea Grant Law Center worked with New York Sea Grant and Connecticut Sea Grant to create a guide to help the emerging seaweed industry understand the prevailing regulatory requirements surrounding the production of seaweeds as food. There are currently two regulations that are being used to regulate seaweeds at either the federal or state level: 1) the Preventive Controls for Human Foods (PCHF) regulation under the Food Safety and Modernization Act; and 2) the Seafood HACCP regulation. The guide provides an overview of the PCHF regulation and its application to seaweed operations, a comparison of the PCHF and Seafood HACCP regulations, and a checklist for operations transitioning from Seafood HACCP to PCHF. The guide will help readers understand the similarities and/or differences between the two regulations and determine how their operations will be regulated under the federal framework.

A LARGE - SCALE INDOOR MASS CULTURE PROGRAM FOR THE ALGA, *Dunaliella salina* FOR ACHIEVING HIGHEST PRODUCTION OF BETA CAROTENE

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Mass culture of alga in round tank of 500 liter capacity with internal illumination tubes were used for the study. These tanks had 5 tubes each having a length of 120 cm. in each tube 200 light emitting diodes of white light were placed which had illumination control. Three 60 watt flood LED (red) lights were also placed on the roof of the tank. The resultant illumination was 170μmol/m^{-2}.The illuminations for the tanks was fixed for 16 hours daily with low illumination during start and shut down time of a cycle. The tanks were filled with 0.5M Sea water and a marine micro-algae *Dunaliella salina* was used as an organism in this study. The tanks were fed with 10% CO_2 and 90% N2 mixture of gas for a period of 30 minutes a day with a flow rate of 3 L/min, for every hour 1.25minutes was set for dosing with micro-bubbles through a ceramic diffuser. The tanks were fed with three different modified *D. salina* media, Nitrate based media, Ammonia based media and fish paste based media for making highest biomass during the period of 10 days. The highest biomass was recorded in fish paste based media with a 18.76x10^6 cells/ml, a count of 15.2x 10^6 cells/ml in nitrate based media and 14.89x10^6 cells/ml in ammonia media. The total wet biomass generated were in the range of 1.97g/L, 1.6g/L, 1.56g/L for the three media respectively.

FEED TECHNOLOGY AND NUTRITION ON BROODSTOCK DEVELOPMENT AND BREEDING OF AQUACULTURE SPECIES

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Food quality and quantity affect fish reproduction. Adequate protein is essential for egg development, spawning, formation of follicles, ovarian tissues, growth and development of embryo. Feed should be formulated to meet the nutritional needs of the reproducing fish which is the key factor of attaining desired brood and seed quality. The brood stock diet should be cheap, low cost, with low conversion efficiency and high conversion ratio with less wastage and will improve the reproductive potential and yield maximum production of fry, high larval survival and fry growth ultimately increasing the profit. A sustainable and cost effective technology for brood stock development and mass production of fry and fingerlings will be the key factor for developing aquaculture industry. A full and comprehensive understanding of reproductive mechanism, such as, gonadal maturation, fertilization success and larval quality is absolutely essential for developing a sustainable and cost effective technology for brood stock development and mass production of fry and fingerlings, the basis for fish and shrimp culture industry. This emphasizes the importance of the role of nutrition on reproduction of fishes. Dietary protein significantly affects fertility, gonad maturation, fecundity, hatching and viability of fish eggs and larval growth. Egg size and composition are useful indicators of seed production in terms of hatchability and larval quality. Larger fish egg size will eventually result in larger fry at hatching. Larger fries possess the advantage of better survival and growth through more efficient prey capture and tolerance to survival. The hatchery produced fish are better in captivity and survive longer and attain maximum growth in the minimum duration of culture. Thus nutrition plays a major role in the reproductive performance and production of quality eggs and larvae which in turn enormously enhances gross fish production and improves fish culture trade globally.

ROLE OF FRESH WATER FREE LIVING PROTOZOANS AS BIOINDICATORS AND BIOREMEDIATION TOOLS IN VEMBANADU LAKE, KERALA, INDIA, AN IMPORTANT RAMSAR SITE

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The use of free living protozoan communities has benefited in perfectly characterizing and monitoring the prevailing environmental conditions of aquatic habitats and a particular community of organism may be useful as an environmental indicator due to many reasons. Vembanad Lake and its adjacent kohl lands has acclaimed international recognition as a Ramsar site.In the present study, 19 species of free-living protozoans have been identified and characterised from this lake . A total of 15 testacid rhizopods belonging to 2 orders, 6 families and 9 genera were recorded. And the ciliates of 3 orders, 3 families were recorded. Among the testaceous rhizopods 1species from Arcellidae family, 5 from Centropyxidae, 1 species from Nebelidae, 6 from Difflugidae belonging to the Class Lobosea and 2 species from the Class Filosea belonging to Cyphoderiidae and Euglyphidae families were identified. Some of these free-living forms have given certain insights of the prevailing ecological conditions of this lake thus acting as perfect Bioindicators. *Euglypha tuberculata* reported in the present study is a species of wide tolerance and survives in diverse habitats. Similarly *Cryptodifflugia oviformis* which was reported for the first time in India in this study prefers dryer environments. Due to its small size, this species mainly feeds on bacteria and yeasts, their high abundance explains active decomposition process in the area.The diversity of the free-living ciliates in the study area included species belonging to 3 genera namely Euplotes, Tachysoma and Coleps and they were pollution indicators possessing the property of heavy metal uptake.The water quality analysis and heavy metal analysis also proved the waters of the lake polluted with heavy metal concentrations. These freshwater free living protozoans serve as good bioindicators reflecting the natural ecological conditions prevailing in the Vembanad Lake. They can also be effective bioremediation tools that can be applied to solve the heavy metal pollution crisis of the lake.

EVALUATION OF DIETARY BLACK SOLDIER FLY LARVAE MEALS AND LAURIC ACID IN PRACTICAL DIETS FOR LARGEMOUTH BASS *Micropterus nigricans*

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A potential ingredient for the use in aquafeeds is lauric acid (hereafter C12), which is predominantly found in coconut oil and has been shown to have virucidal and bactericidal properties. Enrichment of black soldier fly larvae with C12 is possible by using coconut in feeding substrates. The use of black soldier fly larvae has also been shown to have microbial benefits when included in diets.

A growth trial is being conducted to evaluate the effects that C12 and enriched black soldier fly larvae has on the production performance of largemouth bass (LMB) a growth trial is being conducted. A set of seven isonitrogenous and isolipidic diets were formulated with varying levels of two black soldier fly meals (BSFM; one control and another C12 enriched) and different sources of purified C12. A control diet devoid of C12 was formulated and modified to originate six additional diets containing different concentrations of C12. Diets containing different levels of the BSFM had final C12 concentrations of 1.5%, 2.8%, and 4.5%, and those formulated with the purified source contained 1.6%, 3.5%, and 6.3% C12.

The trial is being conducted in an indoor recirculating aquaculture system comprised of 28, 110-L glass aquaria. Groups of 15 (5.0 g initial weight) LMB were stocked in each aquarium and are being fed twice daily at fixed rates which are adjusted at every two weeks by assessing biomass and survival in each aquarium. Each experimental diet was randomly assorted and assigned to four groups.

During the first three weeks of the experiment the results thus far have indicated LMB responded well to dietary BSFM, but growth and feed efficiency tended to reduce as the dietary level of C12 increased (Table 1). When in excess, dietary C12 might have detrimental effects on the production performance of LMB. Results on whole-body proximate composition, fatty acid profiles, and nutrient retention will be presented. Our current findings indicate that BSFM is well utilized by LMB but the concentration of C12 might affect production performance.

Table 1 Results of LMB C12 and BSFM Trial

Enriched Black soldier fly Diets (%C12)						
Variable	NCTL (0)	D2 (1.5)	D3 (2.8)	D4 (4.5)	P value	R²
FW (g)	12.2	12.4	12.9	11.5	0.4805	0.0362
%WG	146	133	136	128	0.0088	0.3977
FE	0.9	0.8	0.8	0.8	0.0051	0.4394
Purified lauric acid Diets (%C12)						
Variable	NCTL	D5 (1.6)	D6 (3.5)	D7 (6.3)	P value	R²
FW (g)	12.2	12	11.8	10.5	0.0092	0.3941
%WG	146	141	130	109	0.0031	0.4764
FE	0.9	0.8	0.8	0.7	0.0028	0.4838

FW= final weight (g), % WG= percent weight gain, FE= feed efficiency

Mi FRESH FISH: A FISHERIES' CONSUMER EDUCATION MARKETING CAMPAIGN

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Consumer awareness and education is needed in the U.S. to provide aquaculture social license — the social acceptance for a business to operate. Industry relief funding for COVID-19 provided an unique and exciting opportunity for Michigan fish producers to address consumer awareness. Funded by the reallocation of CARES Act II funds, the Mi Fresh Fish marketing campaign worked collaboratively with the Michigan Fish Producers Association, Michigan Aquaculture Association, Michigan Sea Grant, and Monte Consulting to uplift and increase awareness about fish raised, caught, or processed by local Michigan businesses.

The one-year Mi Fresh Fish marketing campaign (www.mifreshfish.org) was designed to be an evergreen project, expected to continue its impact after the end of the allocated funding. The collaboration produced a brand name, logo, consumer survey data, adaptable ads (including print social media, and video), a website, two videos about Michigan producers, a mobile aquaculture demonstration tank, more than 20 print marketing assets, a public Mi Fresh Fish Expo held on the front lawn of the Michigan capital, and a celebration webinar to summarize the project.

Within 8 months, Michigan Google ads landed more than 91 M views and 641,000 clicks to the website and Michigan social media ads had over 1.3 M views and 60,000 clicks to the website. Additionally, there has been a 50% increase in searches surrounding Michigan Fresh Fish since the start of the campaign. With over 500 people attending the Mi Fresh Fish Expo, qualitative impacts of the Mi Fresh Fish marketing campaign are still ongoing. The ensuing relationship and awareness building has opened pathways to new conversations and productive educational opportunities. This presentation will highlight the Mi Fresh Fish marketing campaign impacts, benefits, challenges, and lessons learned, and will provide a scope of work or overview of the Expo to discuss costs if an Expo is to be replicated in the future. Samples of the educational marketing assets will also be available for attendees.

INVESTIGATION OF EMACIATION DISEASE OUTBREAK CAUSED BY *Enteromyxum Leei* IN OLIVE FLOUNDER FARMS ON JEJU ISLAND, SOUTH KOREA

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Olive flounder farming in South Korea was initiated in the mid-1980s on Jeju Island, which offers turbulent marine conditions and underground seawater temperatures of around 17°C throughout most of the year, providing an ideal environment olive flounder aquaculture. As of 2022, Jeju Island contributed approximately 51% of national flounder production in South Korea, yielding 23,337 metric tons valued at $261,870,000. Nevertheless, with the growth of the olive flounder aquaculture industry, there has been an increase in disease caused economic loss. In recent years, *Enteromyxum leei* (*E. leei*) infection has caused emaciation symptoms and mass mortality in olive flounder. *E. leei* proliferates within the intestine during digestion, penetrates the intestinal wall in substantial quantities, impairs intestinal function, obstructs digestion, and hinders nutrient absorption. The situation exacerbates when bacterial diseases coincide with *E. leei* infestations.

The objectives of this study were to identify the seasonal incidence patterns, affected fish sizes, and the relationship between of *E. leei* infestations and bacterial diseases. We conducted a total of 1,164 disease examinations for four years, from 2017 to 2020. The results revealed a total of 165 cases of *E. leei* infection, indicating an incidence rate of 14.2%. Seasonally, 40 cases occurred in November, 29 cases in October, and 26 cases in December, primarily in the autumn and early winter. A total of 23 cases transpired during the six months from March to August, affirming its seasonality. The incidence of *E. leei* infection varied by the size of the fish, with a 1.2% infection rate for juvenile fish less than 20 cm, a 13.7% infection rate for fish between 21 and 30 cm, a 25.2% infection rate for fish sized between 31 and 40 cm, and a relatively lower incidence rate of 7.6% observed for fish over 40 cm. Co-infections of bacterial diseases among the fish infected with *E. leei* were as follows: 51.5% for *Vibriosis*, 10.9% for *Tenacibaculosis*, 23.6% for *Streptococcosis*, and 19.4% for *Edwardsiellosis*. In comparison to the incidence of bacterial diseases, the rate of co-infection with *E. leei* was significantly higher for *Edwardsiellosis* and *Vibriosis*. In conclusion, this study highlights the significant impact of *Enteromyxum leei* infestations on olive flounder aquaculture in Jeju Island, South Korea, revealing seasonal incidence patterns, size-dependent infection rates, and the association with bacterial diseases, underscoring the need for effective management strategies to mitigate economic losses in the industry.

DEVELOPING A LOW-WATER EXCHANGE LAND-BASED AQUACULTURE SYSTEM FOR OLIVE FLOUNDER (*Paralichthys olivaceus*)

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Flow-through aquaculture systems greatly demand water resources because of the large volumes of high-quality source water required to rear fish and the discharge of wastewater into the aquatic environment. In particular, the discharge of untreated aquaculture wastewater can lead to physicochemical and biological degradation of the receiving waters. Despite advances in feed quality and feeding practices, the treatment of wastewater from flow-through aquaculture facilities has lagged considerably.

In this study, a novel low-water exchange aquaculture system was developed to reduce the excessive water exchange rate and solve persistent water quality problems in the traditional flow-through aquaculture systems. The improved aquaculture system was designed to reduce the water exchange rate from 24 cycles per day to 8–9 cycles by including a CO_2 vacuum degassing tower equipped with a degassing media. In addition, this system recovered approximately 70 % to 80 % of the heat discharged from the aquaculture tank from the inflow water through a heat exchanger. The insufficient heat source (20 % to 30 %) was supplied using a heat pump to control the optimal water temperature of the aquaculture tank. Thus, productivity could be maximized. This system consists of a solids (50 μm) treatment unit, Ag-NPs impregnated filtration + CO_2 vacuum degassing tower, heat exchange device, heat pump, and influent filtration and disinfection system (ultraviolet device).

The aquaculture system developed in this study was established using mass balance relations. The aquaculture system can be operated with only 30–45 % of the flow rates used in traditional flow-through systems. The system saves energy and maintains total ammonia nitrogen (TAN) and CO_2 concentrations in each aquaculture tank below 2 mg/L and 7 mg/L, respectively. This system is expected to reduce the mortality rate of farmed fish by improving the efficiency of water treatment devices. The next step would be to evaluate the maximum load of TAN and CO_2 generated when cultivating *Paralichthys olivaceus* in the traditional and modified flow-through aquaculture systems and perform experimental and numerical analysis to investigate whether such a system could be incorporated effectively in the aquaculture industry.

DEVELOPING MACROALGAE FEED INGREDIENTS FOR MARINE FISH FEEDS

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The demand for fishmeal and fish oil in aquaculture feeds has increased dramatically in recent years. Alternative protein and oil sources are needed if further development of the aquaculture industry is to be sustained. Terrestrial plant ingredients can replace a portion of the fishmeal used in feeds for a number of species. Complete replacement, however, is seldom achieved. Macroalgae may prove a more appropriate feed ingredient than terrestrial plants products for marine fish feeds as macroalgae contains many essential nutrients from the marine environment that are limiting in terrestrial plants. Additionally, there appears to be health benefits associated with the use of some macroalgae species for some marine fish species.

Our recent studies at NOAA have explored the potential of using domestically cultured macroalgae as ingredients in marine fish feeds. Macroalgae species tested to date include the red macroalgae Pacific dulse *Palmaria mollis* and Turkish towel *Chondracanthus exasperates*, the green macroalgae *Ulva spp*., and sugar kelp *Saccharina latissima*. We additionally produced kelp protein concentrates from sugar kelp via chemical and thermal methods and evaluated these ingredients. Using sablefish *Anoplopoma fimbria* as a model cold water marine species, we evaluated the effects of these novel ingredient on fish growth, feed intake, feed efficiency, whole body nutrient composition, liver histomorphology, and gut microbiome. Results will be presented with some species showing positive trends and some species demonstrating negative effects. Of particular interest, the addition of Turkish towel to sablefish feeds improved fish liver health and increased fish survival when exposed to the pathogen atypical *Aeromonas salmonicida*.

Results from our research indicate some macroalgae species may be promising alternative feed ingredients for cold water marine fish. Further research is needed to explore reasons behind observed decreases in feed intake, feed efficiency, and protein retention with some species. Future research directed towards improving the performance of kelp protein concentrates in marine fish feeds and the development of screening methods to identify new promising macroalgae species will be discussed.

THE MARINE ALGAE INDUSTRIALIZATION CONSORTIUM (MAGIC): DEVELOPMENT OF MARINE MICROALGAE FOR THE SUSTAINABLE PRODUCTION OF FOOD, FEED, AND FUEL

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The Marine Algae Industrialization Consortium (MAGIC) was originally formed to address pressing challenges in the commercialization of microalgae as a source of biofuel with the major goal to (1) Model the sustainable supply of 1 million metric tonnes ash free dry weight (AFDW) cultivated algal biomass and (2) Demonstrate valuable co-products produced along with biofuel intermediates to increase value of algal biomass by 30%. To achieve these goals, the project demonstrated and validated high-value co-products to drive down the cost of biofuel by increasing the value of algae "co-products" towards increasing the selling price of total algae biomass as one of the key drivers of economics and adoption. This was accomplished through five core, interdependent tasks including: (1) strain selection to identify and deliver strains for mass culture, (2) mass culture using a hybrid cultivation system and following key operating parameters for downstream applications to provide algae feedstock, (3) recovery and conversion to evaluate two alternative methods to separate dry algae biomass into oil and residuals for downstream testing, (4) product assessment to determine biofuel, aquafeed or poultry feed product efficacy using algae biomass fractions as well as to provide critical performance data for valuation and (5) commercialization to use technoeconomic and life cycle assessments (TEA/LCA) as iterative design and assessment tools including consideration of target markets, competitors, and distribution channels to guide product assessment, development and valuation. Here we provide a summary of this multi-institutional, multi-year, multi-disciplinary project that successfully demonstrated all of the components of an end-to-end process from mass microalgae cultivation and dewatering, to recovery and conversion of algae biomass components, to final product demonstration and process valuation; the combined results provide essential data and a framework for future commercialization of algae based bioproducts.

FIELD TRIALS OF MIDORI AND MYAGI PACIFIC OYSTER LINEAGES IN 4 ESTUARIES ALONG THE CALIFORNIA CURRRENT

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The Molluscan Broodstock Program (MBP) has been breeding *Crassostrea gigas* since 1996, and oyster growers across the California Current use its primary "Miyagi" lineage extensively. Recently, the MBP imported a new lineage of *C. gigas* from Southern Japan (the "Midori") for its potential resilience to thermal stress and disease. The introduction of the Midori lineage has garnered significant interest from industry members seeking to enhance their operations using this more robust lineage. This has led to wide-spread cultivation of the Midori lineage; however, few studies have sought to directly compare seed performance of the two lineages at large multi-estuary scales. Here we report on a series of farm trials in Yaquina Bay, OR; Humboldt Bay, CA; Tomales Bay, CA; and Morro Bay, CA. Our findings highlight the increased robustness of the Midori lineages when reared in stable SEAPA type oyster gear. These findings however do not hold when oysters are raised in tipping gear where mortality rates between lineages was not significantly different. Together our data provide a broad evaluation of the new Midori lineage of *C.gigas* and provides insights into how each lineage responds in key characteristics (survival, shell shape, meat weight) across a broad geographic region.

OYSTER ENHANCEMENT FOR NEW HAMPSHIRE OYSTER GROWERS AND ESTUARIES

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The National Sea Grant Program funded a project to provide relief to aquaculture operations in New Hampshire due to COVID-19 impacts. Ten NH oyster farmers participated in oyster population and ecosystem service enhancement studies using up to 10,000 unmarketable (too large, misshapen) oysters sold to NHSG at market price. The purchased oysters were then moved by the farmers, to pre-selected non-producing areas of their farm license areas to create State permitted experimental oyster reefs. Funds supported the initial condition of the oysters (fall 2020) and ensuing assessments (spring & fall 2021) of ecosystem impacts in terms of recruiting young oysters and the growth and survival of the adult oysters were conducted by NHSG personnel, farmers and UNH researchers. Measurements of average shell growth (% increase), % mortality and recruitment of young oysters showed experimental oysters exhibited growth trends, mortality and evidence of recruitment that varied by site but were in ranges consistent with previous studies of farmed oyster beds in the experimental areas. Growth ranged from 4-46% (average = 19.8%), mortality ranged from 0-25% (average = 9.1%), and evidence of recruitment occurred at 9 of the 10 farms (Table 1). The study suggests that construction of "restoration areas" on farm or other sites can sustain oysters in the short and long-term because natural recruitment is an important factor affecting restoration success.

Photographs of restoration sites, field observations, and data discussed above indicate that even in the first year at least two important ecosystem services were provided by oysters on the restoration areas: habitat provision and water filtration. Habitat provision for macroalgal communities was evident, dominated by *Gracilaria* and including *Ulva* and *Ascophyllum* that were mostly attached to the oysters. Animals were also observed, including mud crabs (xanthids), green crabs, hermit crabs, ribbed mussels, blue mussels and hard clams. Thus, as expected, these small, constructed reefs provided important habitat for a wide diversity of organisms. The growth data was evidence of filter feeding associated water filtration of food and other suspended particles, which along with environmental condition data can be used to quantify bioextraction of nitrogen and other dimensions of estuarine health by farmed oysters and oysters in wild and restoration reefs.

Table 1. Growth and mortaily measurements of experimental reef oysters at 10 NH oyster farms

	Growth	Mortality		
	Fall 2020-21	Fall 2020	Spring 2021	Fall 2021
	% increase	%	%	%
Range	4-46	0.6-17.6	0.7-25	0-19.7
Average± sd	19.8±16.6	10.5±5.9	10.8±8.7	6.5±5.9

THE ADDITION OF PREBIOTICS AND A FERMENTED SOYBEAN MEAL MAY IMPROVE THE GROWTH AND HEALTH OF LARGEMOUTH BASS (*Micropterus salmoides*) WITH THE ASSISTANCE OF A PALATANT TO IMPROVE DIET ACCEPTANCE

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Developing a Largemouth bass diet that is sustainable and acceptable to the fish is an ongoing process. Fish meal reduction accompanied by increased plant protein sources such as soybean meal in diets can present challenges such as increased anti-nutritional factors (ANFs) and reduced palatability. Soybean meal (dehulled, solvent-extracted, 48% protein) is a high-quality plant protein source with a fairly balanced amino acid profile. However, diets with high levels of this meal are not always accepted by fish, which reduces feed intake and growth. The addition of a prebiotic and/or fermented soybean meal with an improved nutrient profile and reduced ANFs can improve digestion, absorption, and health factors. Prebiotics and fermented soy can both improve gut microflora, gene expression, and immune function. The addition of a palatant can increase the acceptability of soy diets to the fish. For this study we developed diets with soybean meal, fermented soybean meal, soybean+prebiotic, fermented soy+prebiotic, soybean+palatant, fermented soy+palatant, soybean+palatant+prebiotic, and fermented soy+palatant+prebiotic. The fish are being fed twice a day to apparent satiation for 8 weeks. Four-week results are shown in Table 1. At harvest, we will collect tissues for gene expression, microflora analysis, digestive enzyme activity, and proximate analysis.

Table 1. The survival and weight data collected at four weeks of feeding.

Diet Name	Survival (%)	Total Weight (g)	Average Weight (g)	Total Weight Gain (g)	Average Weight Gain (g)	Weight Gain (%)
Control	97.5	200.3a	10.3	118.5a	6.1a	145.0a
Soybean	100.0	196.8ab	9.8	115.2ab	5.8ab	141.2ab
Soybean+Prebiotic	100.0	198.6ab	9.9	116.6ab	5.8ab	142.2ab
Fermented Soy	100.0	188.0ab	9.4	106.0ab	5.3ab	129.4ab
FermSoy+Prebiotic	100.0	188.8ab	9.4	106.8ab	5.3ab	130.2ab
Soybean+Palatant	99.0	194.6ab	9.8	112.8ab	5.7ab	137.9ab
FermSoy+Palatant	100.0	197.0ab	9.9	115.8ab	5.8ab	142.6ab
Soy+Pal+Pre	100.0	190.8ab	9.5	109.2ab	5.5ab	133.9ab
FermSoy+Pal+Pre	97.5	182.0b	9.4	100.3b	5.2b	122.7b
p-value	0.22	0.03	0.07	0.03	0.05	0.04

SPLIT-ROOT HYDROPONICS: INVESTIGATING CHERRY TOMATO RESILIENCE TO SALINITY STRESS

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Salinity stress limits plant growth and development and presents a significant obstacle to global food production. A split-root hydroponic system was used to evaluate the salinity tolerance of cherry tomatoes (*Solanum lycopersium* var. cerasiforme). The objective was to establish a salinity threshold that would increase both crop performance and plant resistance to salinity stress. Three salinity levels: 0 parts per thousand (ppt), 4.5 ppt, and 9 ppt and two root conditions: homogeneous and heterogeneous were used. The split-root system was adopted to expose one side of the root system to saline water and the other side to freshwater conditions.

A randomized complete block design was used, with three replications and a total of 36 experimental units. The size index (plant height, widest width, and perpendicular width), stomatal conductance, photosynthesis rate, fruit production, and chlorophyll content were among the growth and physiological characteristics that were measured. EC, pH, DO, and salinity levels of the treatments were also monitored weekly. Dry shoot and dry root weights were measured, and leaf tissue analysis was done at end of the experiment. The results showed that tomato fruit yield significantly decreased ($p<0.05$) with increasing salinity levels and that both the shoot dry and the root dry weight was greater in homogeneous mixtures, with the exception of salinity level of 9 ppt. The salinity tolerance threshold was exceeded in the 9 ppt homogeneous treatment, resulting in lower dry root and shoot dry weights compared to the 9 ppt heterogenous treatment.

The stomatal conductance decreased throughout the day with increasing salinity levels as the increased salt stress triggered stomata closures in the tomato leaves, reduction in the CO2 intake and reduction in the plant photosynthetic rate. Salinity also increased the EC of the solutions and the foliar analysis results showed reduction in the nutrient uptake and foliar nutrient concentration in the 4 ppt and 9 ppt treatments. The results show that utilizing the split-root technique can increase cherry tomato salinity tolerance. Future research will concentrate on using different tomato cultivars, using shrimp water effluent, and investigating the implications for the timing of salinity stress on the cherry tomatoes.

VETERINARY AQUACULTURE OUTREACH IN THE NORTH CENTRAL REGION

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In 2021, USDA-NIFA North Central Regional Aquaculture Center (NCRAC) funded a synergistic research and Extension project entitled "Improving fish health in the NCR by integrating extension with the development of alternative disease prevention methods" to Michigan State University (MSU; Chairperson Dr. Loch), Ohio State University (OSU; Mr. Smith), and University of Minnesota (UMN; Dr. Phelps). MSU is leading the research on identifying flavobacterial variants and creating and evaluating the vaccine. UMN is working with MSU veterinarian Dr. Kebus to develop a host of farmer-focused deliverables. The project aims to develop practical and usable fish health applications for producers and fish health professionals and as such will be the focus of this presentation.

From January to September 2023, Dr. Kebus has:
- visited 28 fish farms/hatcheries in the NCR,
- had over 144 consultations with farmers, veterinarians, and consults,
- gave over 23 presentations to a total over more than 755 attendees,
- joined 13 committees of aquaculture-related professional associations.

The team has also developed, implemented, and evaluated the results of a regional fish health semi-structured survey. The survey was conducted by Dr. Kebus via phone, e-mail, and in-person. The results identified pressing fish health concerns for NCR aquaculture producers. The results of the survey are helping to identify activities to focus on within this NCRAC project, but it will also serve as the foundation of continued fish health monitoring, research, and Extension within the region in the future.

The team is currently working to develop generalizable forms which can be used by farmers to identify where there may be risk on the farm in relation to aquatic animal health. These forms will guide producers to previously developed best management practices, fish health related materials, and training opportunities, as appropriate. Farmer focused educational documents will be developed should there be any gaps identified in the literature.

As part of the synergistic activities of the project, while on farms, Dr. Kebus is, as appropriate, collecting and submitting moribund salmonids to the MSU-Aquatic Animal Health Laboratory if they have clinical signs of bacterial coldwater disease and rainbow trout (*Oncorhynchus mykiss*) fry syndrome (both caused by *Flavobacterium psychrophilum*). The extension components of this project are helping the researchers by providing them the opportunity to examine and bacteriologically analyze these fish to develop an effective autogenous vaccine.

STRESS AND GROWTH RESPONSE OF PURE, PALMETTO, AND SUNSHINE STRIPED BASS *Morone saxatilis* AT DIFFERENT TEMPERATURES

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Striped bass (SB; *Morone saxatilis*) and their hybrids (HSB) are currently cultured in freshwater ponds throughout the southern US as a food and gamefish. The industry currently ranks 4th in domestic finfish production where HSB rather than pure SB are more often produced because they are thought to have accelerated growth rates and a greater stress tolerance. No studies to date, however, have conducted direct comparisons of HSB to SB over a range of conditions with controlled genetic crosses. In this effort, families of SB and HSB were spawned using domestic and wild broodstock, PIT tagged, and grown together ("common garden") to market size (~1 kg) in recirculating aquaculture systems. Fish were genotyped for parentage and stocked into 2 recirculating systems (three x 1,500 L tanks; 15 fish/tank) connected at the sumps. Each tank received 1 wild Texas SB, 2 domesticated SB, 3 wild sunshine HSB (Texas male), 3 domestic sunshine HSB (domestic male), and 6 domestic palmetto HSB (domestic female) allowing for comparisons among multiple half-sibling families. Systems were maintained at 18 °C for a two-week acclimation period post stocking before all fish were netted from tanks, immediately transferred to a bath of Aquacalm™ (metomidate hydrochloride) and bled to determine baseline plasma cortisol levels. Fish were returned to tanks and then raised at 18, 24, and 30 °C for one month at each respective temperature. The fish were fed daily to satiation and amounts recorded to calculate FCR while visually observing behavior among crosses. After the 18 and 24 °C, rearing periods, the fish in all tanks were subjected to a 1-minute net chasing stressor and then three tanks were bled one hour post stressor to measure peak cortisol concentrations. After the final month at 30 °C, the fish in all tanks were chased, bled, measured, and survival monitored for an additional week. Survival (>90%) and % weight gain (~26%) were similar for SB and HSB crosses. Plasma cortisol levels and additional growth data will be presented but these results indicate no differences in performance among purebred and HSB in simulated commercial conditions.

EFFECT OF MULTI-STRAIN PROBIOTICS ON THE GROWTH, BLOOD BIOCHEMISTRY, AND ENZYME ACTIVITIES OF *Clarias batrachus*

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In the aquaculture industry, probiotics serve as biofriendly agents that contribute to better growth and health of fish. This study was designed to evaluate the effects of multistrain probiotics (MSP) on growth, whole-body composition, digestive and antioxidant enzymes, hematology, blood biochemistry, and physiological stress parameters in *Clarias batrachus* fingerlings. Five experimental diets were prepared with supplementation of MSP (*Bacillus subtilis*, *Bacillus licheniformis,* and *Enterococcus faecalis*) powder at 0.5, 1.0, 1.5, and 2.0 g/kg, labeled T_0, T_1, T_2, $T_{3,}$ and T_4 diets, respectively. Healthy fish were acclimatized and distributed in 15 aquaria (89 × 58 × 61 cm) in triplicate with an initial weight of 10.13±0.01g. Fish were provided with experimental diets for 90 days @ 5% body weight. After completing the feeding trial, fish were dissected to collect liver (antioxidant enzymes), intestine (digestive enzymes), whole body fish (proximate analysis), and blood (hematology, blood biochemistry, and physiological stress parameters) for analysis. The findings of the current study showed improvements (P<0.05) in the growth performance observed in MSP-enriched groups in comparison to the control. Whole body composition and stress parameters (glucose and cortisol) were not affected by MSP supplementation in diets. Digestive enzyme (amylase, protease, and lipase) and antioxidant enzyme (glutathione peroxidase, superoxide dismutase, catalase, and malondialdehyde) activities in the MSP-supplemented groups were enhanced significantly (P<0.05). Hematological parameters such as white blood cells, red blood cells, hemoglobin, and hematocrit were also significantly increased in response to MSP supplementation in diets. Moreover, an increasing trend in blood biochemistry was observed in the activities of alanine phosphatase, while a decrease in alanine aminotransferase and aspartate aminotransferase was observed. In conclusion, MSP supplementation up to 2.0 g/kg significantly enhanced growth performance, hematology, serum biochemistry, and digestive and antioxidant enzyme activities in *C. batrachus*.

RESILIENCE CAPACITY AND SUSTAINABILITY OF PRAWN FARMING IN BANGLADESH

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Promoting environmentally friendly prawn farming is essential for maintaining natural resources, creating a healthy atmosphere, and guaranteeing the food security of millions of people worldwide. This study aimed to evaluate the resilience capacity and sustainability of prawn farmering in climate-vulnerable areas of Bangladesh. A total of 200 prawn farmers were randomly selected from Bagerhat and Khulna districts and data were gathered through direct interviews. The SAFA (Sustainability Assessment of Food and Agriculture) framework and the USAID resilience capacity model were employed to analyze the farmers' sustainability and resilience capacity, respectively. It is found that the resilience capacity across eight dimensions was notably insufficient. Particularly, the majority struggle in handling marketing risk, political uncertainties, and environmental hazards. Merely 15.08% of farms shows moderate capability in managing these risks, encompassing political and environmental challenges. The comprehensive resilience index value stood at 0.430, indicating a notably low score. This signifies farmers' weaknesses in cooperation, business strategy, and diversity fundamentals, reflecting a limited ability to safeguard their farms against salinity and unforeseen threats. Nevertheless, farmers exhibit strength in power dynamics fundamentals. In four sustainability metrics, local farmers score well in terms of social well-being, with 80% performing at best and good levels. However, there are challenges in other areas like environmental integrity, economic resilience, and governance. For instance, their performance in long-term profitability in prawn farming, sustainable business practices, environmental conservation, water management, and economic resilience is moderate at best. Moreover, the absence of written records for business purposes and limited awareness about crucial environmental factors like natural forest conservation and endangered species pose significant concerns. Therefore, resilience capability, environmental integrity, and governance need to be improved for the long-term sustainability of prawn farming.

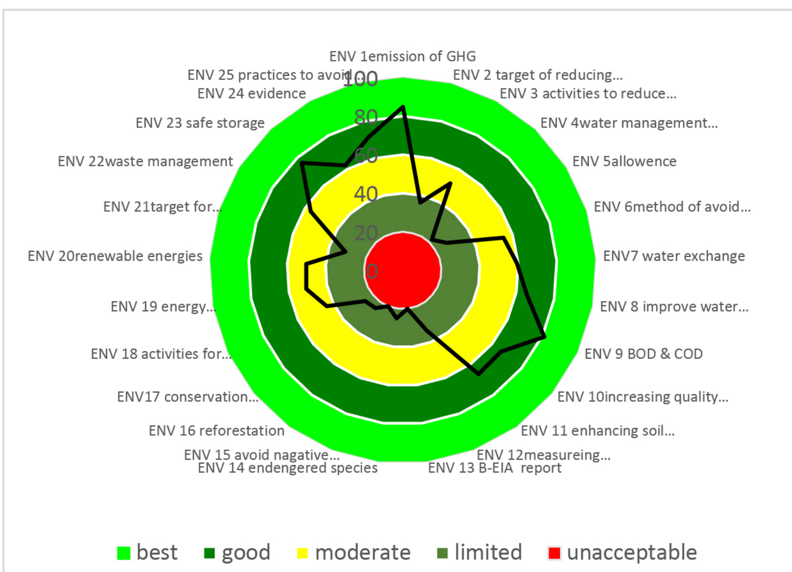

Fig 1: SAFA radar chart for the environmental integrity dimensions

CANNABIS FOR SHRIMP: DIGESTIBILITY OF HEMPSEED MEALS BY *Litopenaeus vannamei*

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Efforts to optimize plant-based diets continue to be a key area in aquaculture nutrition research. Among traditional and novel protein feedstuffs with potential for use in aquafeeds is industrial hemp. Hempseed meal (HSM) is rich in protein and lipids and might complement other protein sources in feeds for farmed aquatic animals. Nevertheless, information on the nutritional value of HSM for aquatic animals remains limited.

A digestibility trial was conducted to assess the nutritional value of two commercially available HSMs for Pacific white shrimp (*Litopenaeus vannamei*). Four experimental diets were formulated by blending equal portions of a reference diet (REF; 35% crude protein, 10% lipid) mixture with each of three test ingredients: HSM-P30 (35% CP and 20% lipid), HSM-P50 (45% CP and 23% lipid), and conventional soybean meal (CSBM) at a 70:30 ratio (dry matter basis). Each experimental diet was randomly assigned to four groups of twelve shrimp (10±1.0 g/shrimp) stocked in 16, 110-L glass aquaria operating as a recirculating aquaculture system. Water quality parameters were maintained within acceptable ranges for the shrimp. Shrimp in each aquarium were fed four times daily. Fecal matter was collected four times throughout the day, discarding the first collection to reduce the effect of coprophagy and intake of other material other than feed, overnight. To determine the apparent digestibility coefficients (ADCs) for crude protein, energy, and amino acids ~ 0.3% yttrium trioxide (Y_2O_3) was used in diet as an indicator.

Based on our results (Table 1), the CSBM and HSM-P50 diets displayed higher ADC for crude protein compared to REF and HSM-P30, while lower ADC for energy was observed in both HSM diets compared to REF and CSBM ($P<0.05$). For the test ingredients, higher ADC for crude protein was found in CSBM and HSM-P50 compared to HSM-P30. The highest ADC for energy was found in CSBM, followed by HSM-P50 and HSM-P30 ($P<0.05$). The test ingredients also differed in terms of amino acid availability, which will be presented. Based on our findings, the HSM proteins are well digested by the Pacific white shrimp, while the lower ADCs for energy in both HSMs compared to CSBM might be due to higher fiber content in the former. Overall, our results indicate that HSM can be a good complementary source of nutrients and energy in shrimp feeds.

Table 1. ADCs for Digestibility Diets and Test Ingredients (%, dry matter basis). Means in a column with different letters were significantly different ($P < 0.05$)

	ADCs for Digestibility Diets				
Parameters	REF	CSBM	HSM-P30	HSM-P50	Pr > F
Crude Protein	86.5 ± 0.3[b]	89.8 ± 0.3[a]	85.1 ± 0.4[c]	88.6±0.1[a]	< 0.001
Energy	80.0 ± 0.5[a]	81.1 ± 0.2[a]	66.8 ± 0.6[c]	76.5±0.1[b]	< 0.001

	ADCs for Test Ingredients			
Parameters	CSBM	HSM-P30	HSM-P50	Pr > F
Crude Protein	95.2 ± 0.6[a]	81.9 ± 1.3[b]	92.6 ± 0.3[a]	< 0.001
Energy	84.0 ± 0.8[a]	40.7 ± 1.7[c]	75.9 ± 0.2[b]	< 0.001

CANNABIS FOR SHRIMP: RESPONSES OF PACIFIC WHITE SHRIMP *Litopenaeus vannamei* TO DIETARY HEMPSEED MEALS

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Efforts to optimize plant-based diets continue to be a key area in aquaculture nutrition research. Among traditional and novel protein feedstuffs with potential for use in aquafeeds is industrial hemp. Hempseed meal (HSM) is rich in protein and lipids and might complement other protein sources in feeds for farmed aquatic animals. Yet, information on the nutritional value of HSM for aquatic animals remains limited.

A 7-week feeding trial was conducted to assess the nutritional value of two HSMs (P30 and P50) in practical diets for Pacific white shrimp grown in a recirculating aquaculture system. A conventional soybean meal-based diet (CSBM-C) was formulated to contain 35% crude protein and 10% lipid and was used as the control for HSM inclusion. Five additional diets were formulated to include P30 and P50 at 10% and 20% partially replacing CSBM digestible protein, with one extra P50 diet being formulated without supplemental methionine and lysine. An additional diet (FM-35) formulated to contain 35% fish meal was used as a standard reference for the plant-based formulations. Fifteen hand-sorted shrimp (~ 1.0 g/shrimp) were stocked into each of 35, 110-L glass aquaria and randomly assigned one experimental diet (n=5). Shrimp in each aquarium were fed four times daily based on an expected growth rate of 1.5g/shrimp/week. Water quality parameters were maintained within acceptable ranges for the species. At the conclusion of the feeding trial, data on production performance and whole-body composition was gathered.

After seven weeks of feeding, shrimp survival ranged from 60 to 96.7%, with the lowest survival being observed in the CSBM treatment. Shrimp fed FM-35, P30, and P50_10 diets grew at a rate of 1.6-1.7 g/week, and displayed the lowest FCRs among all groups ($P<0.05$). Based on the responses of groups fed the P50_20 diets, supplementation of methionine and lysine was unnecessary in these formulations. Additional results on nutrient retention efficiency, whole-body fatty acid, and cannabinoid contents will be presented. Our findings in this study indicate that both HSM products evaluated are good complementary sources of nutrients and energy in plant-based diets for Pacific white shrimp.

Table 1. Performance metrics of shrimp fed the experimental diets for 7 weeks.

Parameters	IW (g)	FW (g)	WG (g/week)	WG (% of initial)	FCR	Survival (%)
FM 35	1.2 ± 0.1	12.9 ± 0.2^{a}	1.7 ± 0.03^{a}	1025.4 ± 34.2^{ab}	1.3 ± 0.1^{b}	90.0 ± 4.9^{ab}
CSBM	1.2 ± 0.1	10.7 ± 0.2^{bc}	1.4 ± 0.04^{bc}	819.8 ± 65.7^{b}	2.1 ± 0.1^{a}	60.0 ± 4.9^{c}
P30_10	1.2 ± 0.1	12.9 ± 0.2^{a}	1.7 ± 0.04^{a}	1039.3 ± 63.5^{a}	1.2 ± 0.04^{b}	95.0 ± 2.0^{a}
P30_20	1.1 ± 0.04	12.6 ± 0.2^{a}	1.6 ± 0.03^{a}	1057.4 ± 49.1^{a}	1.3 ± 0.04^{b}	93.3 ± 3.1^{ab}
P50_10	1.0 ± 0.1	11.9 ± 0.2^{ab}	1.6 ± 0.03^{ab}	1050.26 ± 50.2^{a}	1.3 ± 0.1^{b}	96.7 ± 3.3^{a}
P50_20	1.1 ± 0.1	9.9 ± 0.7^{c}	1.3 ± 0.1^{c}	813.8 ± 24.4^{b}	1.9 ± 0.2^{a}	80.0 ± 6.8^{b}
P50_20-AA	1.2 ± 0.1	11.1 ± 0.2	1.4 ± 0.02	868.0 ± 48.2	1.5 ± 0.03	88.3 ± 2.1
Pr > F	0.4643	<0.0001	<0.0001	0.0017	<0.0001	<0.0001
Pr > t (D6 vs D7)	-	0.1147	0.114	0.3455	0.1072	0.2732

IW= Initial mean weight; FW= Final mean weight; WG= Mean weight gain; FCR= Feed conversion ratio
Means in a column with different letters were significantly different ($P<0.05$). T-test for D6 versus D7 in a column with different letters were significantly different ($P<0.05$).

CONSUMERS' WILLINGNESS TO PAY FOR SAFER FISH IN BANGLADESH

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Bangladesh is the 5th largest aquaculture-producing country in the world and the aquaculture industry is more focused on quantity than quality. It might result in several health issues and deter customers from eating fish. It is critical to evaluate the consumers' knowledge, attitudes, and preferences for the quality of fish. Therefore, the main objective of the study is to estimate consumers' willingness to pay (WTP) for safer fish and determine the factors influencing their WTP for safer fish. This study used a conjoint choice experiment analysis to determine the willingness to pay for three main aquaculture species in Bangladesh namely, Tilapia, Pangas, and Rohu. Additionally, the study explored potential constraints consumers face in consuming safer fish. Primary data has been collected from 600 consumers through a questionnaire survey from Dhaka, Mymensingh, Rajshahi, Jashore, Bogura, and Chittagong districts in Bangladesh. Descriptive statistics and conditional logit models have been used as analytical tools. It is found that the consumers in Bangladesh consume fish for 4 days or more within a week; and among the three species, they spend more on Rohu fish which is 34.83% of their total expenditure for fish. The preliminary results showed that production environment, gill color, other visible attributes, contamination of microbial, heavy metal and antibiotics, selling condition, certification from authority, inspection by BFSA (Bangladesh Food Safety Authority), age, and income are significant variables that play vital roles in consumers' choices for three different species of fish. This study suggested that stakeholders and policymakers should pay attention to the quality of the fish more specifically on the safer quality attributes and the inspection of them which will encourage the consumers to consume more fish for their protein intake and that may help the fish farmers to earn more and may help to reduce health issues in Bangladesh.

EVALUATION OF DIFFERENT SEEDSTRINGS FOR THE *Pyropia* NURSERY

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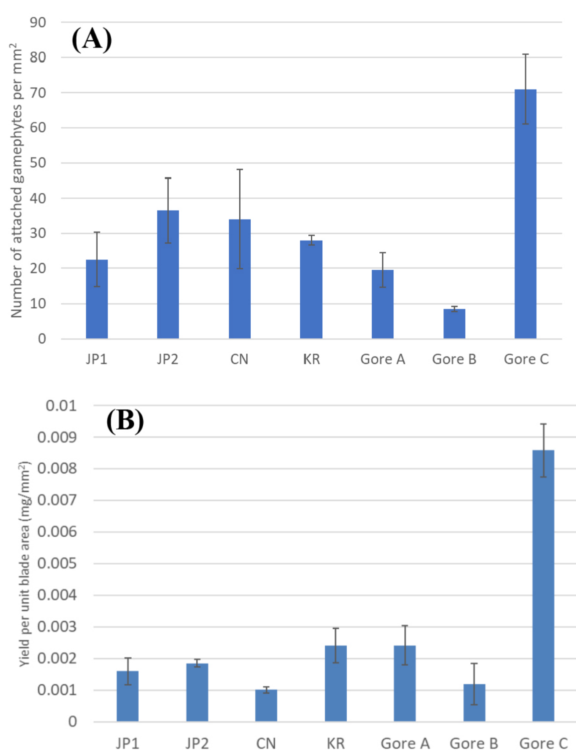
Seedstring cultivation is a fundamental method for *Pyropia yezoensis* aquaculture, as it provides an artificial substrate for the attachment of *P. yezoensis* conchospores and growth of the macroscopic blade gametophytes. This method has been widely used in the *P. yezoensis* aquaculture in Asia due to its convenience for *Pyropia* management and harvest. However, the composition and types of seedstrings vary in different countries. Little is known about the effect of different seedstrings in terms of spore attachment and early development of the gametophytes in *P. yezoensis*. In this study, four types of commercially available seedstrings from Korea (KR), China (CN) and Japan (JP1 and 2) and three new seedstring types developed by W.L. Gore & Associates Inc. (Gore A, B and C) were compared. The comparisons were conducted in three aspects: seeding density, growth rate and biomass yield. Our results show that, for both conchospore and archeospore seeding, the Gore C seedstring had the highest seeding density and yield among all seedstrings while the Gore B had the lowest. For conchospore seeding, the Gore A and B seedstrings had the highest growth rate at the early stages of gametophytes too. In the case of archeospore seeding, the difference between Gore A and other seedstrings was not significant. The CN and KR seedstring showed lower growth rates than the other seedstring types in the case of conchospore seeding. A comprehensive evaluation shows that the Gore C seedstring type, had the best performance among all seven seedstrings under laboratory conditions (Fig. 1). Future studies are needed to test the performance of the seedstrings on *Pyropia* farms.

FIGURE 1. The number of blades (A) and biomass yield (B) per unit area (mm^2)



GENETIC PARAMETERS FOR GROWTH TRAITS IN GULF OF MEXICO EASTERN OYSTER FAMILIES REARED IN HIGH AND LOW SALINITY ENVIRONMENTS

Heather King*, William Walton, Huiping Yang, Leslie Sturmer, Christopher Hollenbeck, John Scarpa, Brian Callam, Jim Stoeckel, Scott Rikard, Megan Gima, Jason Stannard, Kelly Lucas, Andrea Tarnecki, Eric Saillant

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The eastern oyster (*Crassostrea virginica)* supports large markets throughout the eastern United States. In recent decades, wild stocks have observed major declines across the species' range including in the Gulf of Mexico (Gulf). In 2019, the SALT consortium initiated a breeding program to support the developing industry in the Gulf with oysters bred for improved performance in different salinity environments. In September of 2020, the first generation was produced using 102 males and 102 females collected from 17 natural reefs between San Antonio Bay (Texas), and Cedar Key (Florida).Families were bred according to a 2 x 2 factorial crossing design, pooled for common garden culture, and deployed at 7 growout sites in April 2021. At the end of the growout period, four sites were selected that represented high (AH) and low (MB, USM, LSU) salinity environments based on salinity conditions recorded during the growout period. The 204 founders and 6,414 offspring were assayed at 192 Single Nucleotide Polymorphism markers and the obtained genotypes were used to assign offspring to parent pairs using a likelihood ratio approach. Genetic parameters were estimated using animal mixed models in ASREML v.4.2. Estimates of heritability at low salinity ranged between 0.63 ± 0.06 and 0.84 ± 0.05 and were significantly higher than the estimate obtained at the high-salinity site (0.38 ± 0.08). Estimates of dominance variance did not differ significantly from zero. Genotype x environment correlations for growth rate ranged from 0.62 to 0.99 and were highest between low salinity sites (Table 2).

FIGURE 1. **Map of growout sites used for assessment of genetic parameter.**

Left to right: GILA (Grand Isle, LA), DIMS (Deer Island, MS), MBAL (Mobile Bay, AL), AHFL (Alligator Harbor, FL).

TABLE 1. **Genetic correlations of ln height between harvest sites.**

	LSU	**AH**	**MB**
AH	0.71 ± 0.09		
MB	0.79 ± 0.06	0.73 ± 0.09	
USM	0.76 ± 0.06	0.62 ± 0.11	0.99 ± 0.01

Low salinity sites are USM (Deer Island), LSU (Grand Isle), MB (Mobile Bay) and the high salinity site AH (Alligator Harbor).

PARTICLE DEPOSITION MODELING: AN IMPROVEMENT USING FLUME-BASED OBSERVATIONS FOR RED DRUM *Sciaenops ocellatus*

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Environmental modeling of ocean net-pen aquaculture is driven by predicting how solid materials fall through the water column to the seafloor. Model parameters of sequential ocean flow vectors and the mapping of the benthos all contribute to calculating where the falling solids stop moving and interact with the seafloor. One crucial model input parameter is the velocity at which fecal materials fall through the water column by gravity. Salmon fecal settling velocities, density, and shape factor drag coefficient have been investigated on multiple occasions and are the default values in major net pen models since salmon producers are the primary model consumers. It is anticipated that net pen aquaculture will expand into the Gulf of Mexico cultivating warmer water species than salmon such as red drum (*Sciaenops ocellatus*). We are investigating red drum fecal settling velocities and mass fractions using various feed types and fish sizes to better understand if and how settlement behaviors are different from salmon. To do so, we have constructed a flume apparatus capable of measuring the range of fecal settling velocities and the mass fraction that falls at the different velocities.

SELECTION RESPONSE OF GULF OF MEXICO EASTERN OYSTER (*Crassostrea virginica*) BRED FOR PERFORMANCE IN LOW SALINITY ENVIRONMENTS

Heather King*, Huiping Yang, Leslie Sturmer, Christopher Hollenbeck, John Scarpa, Jim Stoeckel, Scott Rikard, Megan Gima, Jason Stannard, Kelly Lucas, Brynna Buckmaster, Sumi Akter, Andrea Tarnecki, Eric Saillant

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The decline of natural reefs of the eastern oyster *(Crassostrea virginica*) in the northern Gulf of Mexico (Gulf) has stimulated the development of aquaculture to support the market demand and restoration programs. Gulf habitats feature diverse salinity environments that may require oysters bred for habitat-specific optimal genetic characteristics. Here, we report the performance of eastern oyster bred in low-salinity environments after one generation of selection.

Selective breeding employed a common-garden approach where families were pooled at fertilization for communal rearing and molecular pedigrees were used a posteriori to determine parentage and estimate breeding values in a walk-back selection process. The F1 generation pool was bred in 2020 and included 202 full and half-sib families that were deployed on three low salinity sites for growth challenge. Breeding values (BV) for height were estimated at harvest size in fall 2021. Parents with highest BVs were bred in 2022 to generate 102 full sibs and 51 half sib families with a selection differential of +3.10 mm (5.7%). A control pool was also generated using 25 full sib families with BV's averaging +0.089 mm. The F2 generation (selected and controls) was reared at the Grand Bay Oyster Park and Mobile Bay site, where growth and survival were monitored via bi-monthly sampling. Selected oysters had significantly greater survival at peak mortality (Fig. 1) and shell height 10-months post deployment (Fig. 2) than control oysters at both sites, indicating positive response on growth and correlated increase in survival.

FIGURE 1. **Interval mortality in selected and control groups at two culture sites. Error bars denote standard error over replicate bags. GB, Grand Bay; MB, Mobile Bay; sel, selected; ctr, control.**

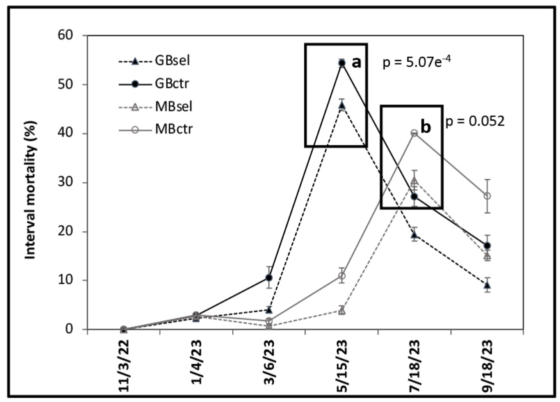
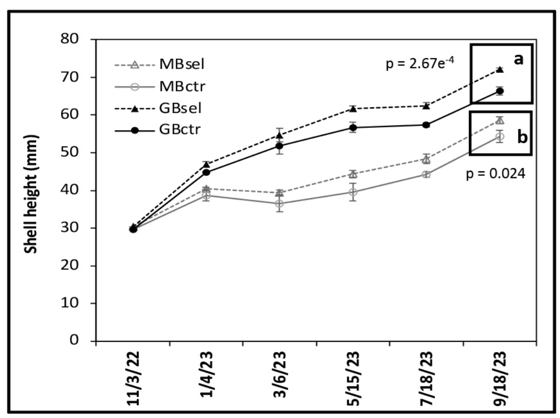


FIGURE 2. **Average shell height of selected and control groups at two culture sites. Error bars denote standard deviation based on replicate bags. See Figure 1 for acronym.**



ENHANCING AQUACULTURE OPERATIONS THROUGH DATA-DRIVEN DECISION-MAKING - THE ROLE OF STARTUPS IN ADDRESSING AQUACULTURE’S PRESENT AND FUTURE CHALLENGES

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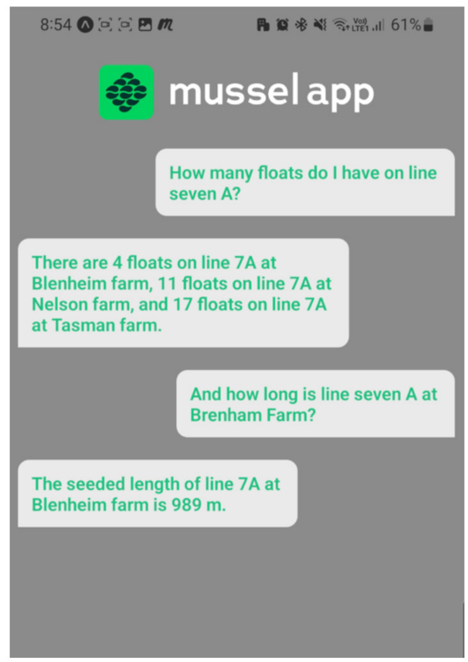
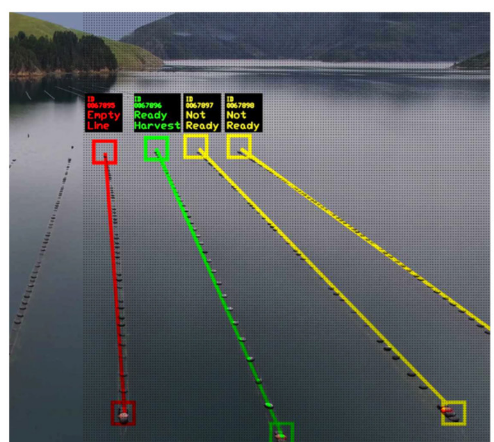
In this presentation, we explore the critical role of data collection and analysis in aquaculture, particularly under the challenges posed by the availability of workforce and climate changes. With the need for efficient operations and stock high mortality rates, the focus is on how startups, like New Zealand’s Mussel App, are helping to improve aquaculture management. We present the journey of Mussel App in simplifying the complex lives of skippers and operational managers, emphasising the importance of data-driven decision-making for improving operational efficiency and stock survival rates. The presentation will illustrate the successes and challenges faced by startups, present New Zealand’s aquaculture ecosystem and demonstrate the startup’s significant contributions to enhancing sustainability and productivity in the aquaculture industry.



AI Farm Assistant – “Alexa” for farm



Digital twin – live computer visualisation of farm

COMMUNITY BUILDING: A SOCIAL APPROACH TO SUPPORTING SUCCESS IN THE ORNAMENTAL AQUARIUM TRADE THROUGH THE MARINE AQUARIUM SOCIETIES OF NORTH AMERICA

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The Marine Aquarium Societies of North America (MASNA) is a non-profit organization founded on the principle of elevating the knowledge of the aquarium keeping community with the goal of fostering a positive and successful experience. A well-informed and educated community of aquarists has the ability to reduce unnecessary losses, choose sustainably sourced fish, corals, and other invertebrates, whether from wild fisheries or aquaculture producers, as well as advocate for ocean resource conservation. With education as a foundational component, the annual Marine Aquarium Conference of North America (MACNA) is held in the Fall of each year at popular destination cities throughout the North America. Through instructive speaker sessions, a poster session, scholarships, and awards, MACNA is an educational platform unlike the majority of aquarium trade shows which tend to focus on sales of live animals and aquarium equipment. The history of the organization as well as its future will be discussed.

ENHANCEMENT OF COMMERCIALLY AVAILABLE MICROPARTICULATE FEEDS USING THREE AMINO ACIDS: AN INVESTIGATION INTO FIRST FEEDING OF *Betta splendens*

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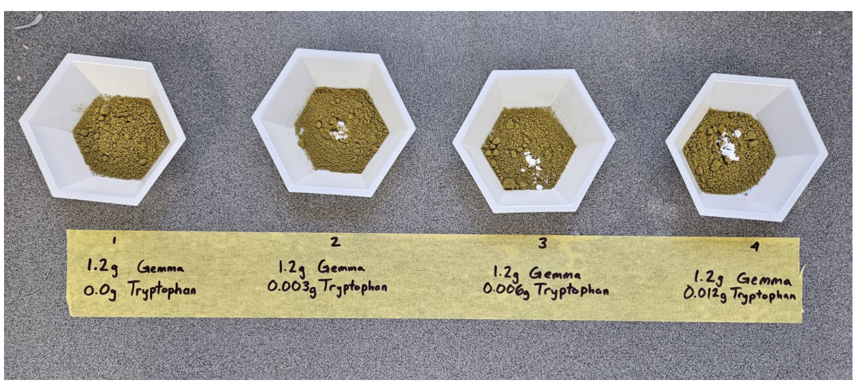
Artemia spp. are a common live feed in aquaculture. While feeding *Artemia* cysts can be convenient due to the long shelf life and the short time necessary for hatching and preparation, other issues remain. Cost and availability can vary significantly based on supply or lack thereof; this variability causes fluctuations in production expenses. In recent years, microparticulate feeds have gained popularity due to availability, cost, enhanced nutritional profiles, and incremental size ranges appropriate for a variety of mouth gape sizes. However, concerns persist regarding larval feeding rates in delicate nursery systems. Aside from degrading water quality, uneaten feeds represent wasted money. Microparticulate feeds need to be recognized by larvae and effectively ingested to provide a cost advantage over *Artemia* nauplii. Poor feeding performance with microparticulate feeds may be due to the absence of visual or olfactory cues inherent to live prey organisms. To better characterize larval feeding incidence of microparticulate diets, a series of trials were conducted with the freshwater ornamental species *Betta splendens*, evaluating three feed attractants (alanine, betaine, and tryptophan). Feed attractants were top-dressed onto commercially available microparticulate diets at three concentrations (0.25%, 0.5%, 1.0%) and fed over the course of a 14-day experiment. At the end of the experimental period survival, standard length, and weight were recorded. Samples were also preserved for analysis of digestive enzymes and RNA /DNA ratios as a proxy for larval quality. Results from these experiments will provide insights into the efficacy of amino acid use as feed attractants in larviculture scenarios. Subsequent economic analyses will be performed to determine cost effectiveness at current price points of *Artemia*, microparticulate feeds, and amino acids given realized gains in survival and growth. This information will ultimately be used to revise and optimize larval production protocols for *B. splendens*.



A COMPARATIVE STUDY OF OKRA *(Abelmoschus esculentus)* GROWN IN FLOOD-AND-DRAIN AND DEEP-WATER CULTURE AQUAPONICS SYSTEMS: AND THE EFFECT OF PLANT DENSITY ON GROWTH AND PERFORMANCE

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Aquaponic growing systems integrate aquaculture and hydroponic techniques through a symbiotic relationship between fish, plants, and nitrifying bacteria, resulting in the ability to produce plants and fish in a single system. These systems have been shown to be advantageous for certain crops as they require less space, water resources, and provide a controlled growing environment.

In summer 2023, Okra *(Abelmoschus esculentus)* was grown for 12 weeks in a greenhouse utilizing two kinds of aquaponic growing systems: six deep-water culture systems using floating rafts, and six flood-and-drain systems with expanded clay substrate. A plant density treatment was also included in the study for each growing system: high density (18 plants) or low density (12 plants) in a 2 x 2 factorial design. Nile tilapia *(Oreochromis niloticus)* were stocked at equal densities (40 equally sized fish) per system and fed to satiation with a commercial diet (32% protein, 6% lipids) daily. Data on fruit production, leaf, stem and stalk growth, and root development was collected along with mineral analysis data on the fruits, leaves, stems, stalks, and roots to determine the effect of the culture system and plant density on the performance of Okra in aquaponic systems.

Preliminary analysis of the data indicates that fruit production and growth of Okra appears to be superior in flood-and-drain systems with clay substrate relative to Okra grown in deep-water culture systems. It also appears that density did not affect the growth and performance of Okra in either culture system.

AN OVERVIEW OF ACTIVITIES AND PROGRAMMING FOR UAPB'S USAS STUDENT SUBUNIT FOR 2023

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The US Aquaculture Society student subunit, along with the American Fisheries Society student subunit, collectively make up the Aquaculture and Fisheries Club (AFC) within the Aquaculture and Fisheries Center of Excellence at the University of Arkansas at Pine Bluff. Currently, the club has 26 members consisting of graduate and undergraduate students. Both student subunits worked jointly to organize several informational, educational, and social events for its members and the campus community. The main goals of these events were to provide learning opportunities for aquaculture and fisheries students from researchers and industry professionals and to promote collaboration and team building within the organization. In 2023, the USAS student subunit hosted four guest speakers from the aquaculture and natural fisheries fields in collaboration with the AFC. The student subunit also organized a workshop on developing and delivering professional presentations for its student members. The club members also participated in several community and campus service events. These included "The Wetlands and Wildlife Festival" hosted by the Delta Rivers Nature Center, "Aquatic Science Day" hosted by the Aquaculture and Fisheries Center of Excellence, and several other campus recruitment events, where club members gave tours of the campus and the aquaculture and fisheries facilities. Finally, the club organized a social event consisting of a fish fry and tailgate party to celebrate UAPB's final home football game. All the events and activities hosted by the club were well-attended, and in addition to, student members, faculty members, university administrators, and local community leaders also attended most of these events.

"WHAT'S IN THE WATER?" THE STUDY OF SHRIMP POND MICROBIOMES AND THEIR RELATIONSHIP TO DISEASE OUTBREAKS

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Studies have suggested that the shrimp microbiota is related to the rearing water microbiome which is linked to disease outbreak. We at Keeton Industries have initiated a long-term study of the microbiomes of shrimp ponds to understand the population dynamics in healthy and diseased environments. We plan on using this information for probiotic management to improve water quality and shrimp health.

Previously, we reported the results of colony isolations from ponds that were either positive or negative for White Feces Syndrome (WFS). We established a method that allowed us to collect the microbiome on filters and purify DNA of quality for PCR detection of *Vibrio* species, and genes associated with WFS.

In this study, we made colony counts (see Table) and isolations from 5 new ponds located in India with different intensity of WFS and the PCR studies were repeated. Results will be compared to the previous year and reported. In addition, Targeted Amplicon sequencing results will be reported for Samples A2 and A4.

Pond	Infection WFS	TSA	HiChrome	TCBS	MacConkey
A1	Infected	$1.5X10^{7}$	NA	$2X10^{5}$	TNTC
A2	Severe	$3.2X10^{4}$	$9.2X10^{1}$	$3X10^{3}$	0
A3	Severe	$3.1X10^{5}$	$1.4X10^{3}$	$2.4X10^{4}$	0
A4	Starting	$5.6X10^{3}$	$9.1X10^{1}$	NA	0
A5	Starting	$9X10^{3}$	$<10^{1}$	$2.3X10^{1}$	2
B1	Uninfected	$5.4X10^{4}$	$6.6X10^{1}$	$2.6X10^{3}$	0
B2	Uninfected	NA	$5.8X10^{1}$	$3.5X10^{2}$	3
B3	Uninfected	$5X10^{4}$	$2.5X10^{1}$	$2.9X10^{3}$	$1.5X10^{1}$

AN ARCHIPELAGO, NOT JUST ISLANDS: DEVELOPING REPOSITORY SYSTEMS FOR SAFEGUARDING THE GENETIC RESOURCES OF AQUATIC INVERTEBRATES

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Safeguarding of the genetic resources of economically important agricultural species has developed into multi-billion-dollar global industries driven by collecting, evaluating, storing, and distributing cryopreserved germplasm maintained in repositories. These efforts have combined public research innovation with commercial development and provide a wide variety of approaches, platforms, and technologies from which to build new global genetic resource industries. Overall, the value of germplasm repositories and the urgent need to develop them is being realized by the broader scientific community, especially for established, minor, and emerging invertebrate biomedical models. Beyond the actions of individual entities, development of repository systems for protection of resources would be most productive at the levels of communities and community networks to facilitate the translation from research to application, enabling efficient use of material, and to improve generalizability. Germplasm repository systems that are generalizable across a variety of organisms would support development of new repositories and provide a way to address multi-taxa challenges. An islands-to-archipelago model could be useful for building repository systems to protect the genetic resources of aquatic invertebrates. In this, parallel and cross-cutting efforts would occur simultaneously for multiple organisms. Thus, instead of developing a new "island language" for each organism, communities would work together to create languages compatible with others on neighboring islands to form an "archipelago" (Figure 1). This would include development of communities, technologies, and community-level cryopreservation pathways. Model organism communities face similar problems in protecting genetic resources – rapid expansion of genetic lines followed by deep regret for the lack of maintenance and protection pathways. By recognizing an archipelago rather than separate islands, invertebrate research communities can address problems before they occur. Furthermore, by including established repository concepts in development of new pathways, we can leverage existing resources and information to bring much-needed generalization, scalability, and application to minor and emerging model organism communities.

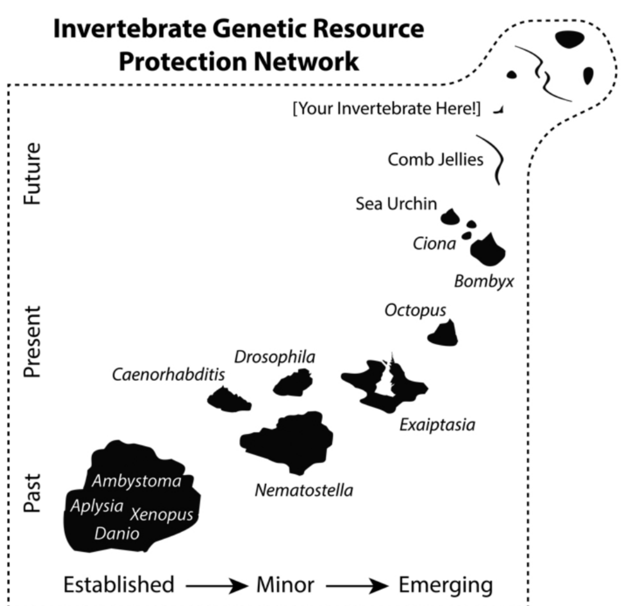

Figure 1. An island-to-archipelago model for development of approaches to safeguarding the genetic resources of multiple invertebrate organisms across their research communities.

GREEN SEA URCHIN *Strongylocentrotus droebachiensis* FROM THE HATCHERY TO THE NEW ENGLAND FARMERS: A UNIVERSITY OF MAINE – CENTER FOR COOPERATIVE AQUACULTURE OVERVIEW

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The green sea urchin *Strongylocentrotus droebachiensis* is native of the Gulf of Maine and supports a fishery that back in the early 90s has its peaked landings with about 39 million of pounds with a value of about 23.5 million. The fisheries has declining since then and in 2022 was worth 2.7 million in 2022 with about 834,580 pound at landing.

The University of Maine – Center for Cooperative Aquaculture Research (UMaine-CCAR) developed a pilot-scale hatchery in 2006 providing juvenile urchins (5-10 mm diameter test) for trials as a sole crop or in a combination with oysters, scallops or seaweed to growers. The research done at UMaine-CCAR evaluates wild broodstock management, better practices for phytoplankton production, hatchery techniques including infrastructure, and best husbandry practices during early developmental larval stages, and settlement systems development.

The UMaine-CCAR has been providing sea urchin juveniles to growers along the Gulf of Maine, and the farmers are developing systems combining their main crops (oysters, scallops, and seaweed) with sea urchins that will provide an extra income using the infrastructure already established and/or experimenting with the sea urchins as way to mitigate and control biofouling, especially for the oyster and scallops gear.

The future direction for the UMaine-CCAR hatchery includes to be a reliable source of sea urchin juveniles for growers and scientists for the Northeastern region and beyond, workforce training for sea urchin hatcheries, support for existing and new growers that want to introduce the green sea urchin as a new species to their farms.

DEVELOPMENT OF FLUORESCENCE *in-situ* HYBDRIZIATION FOR DETECTION OF *Enterocytozoon hepatopenaei* IN FORMALIN-FIXED / PARAFFIN EMBEDDED *Pennaeus vannamei* TISSUE

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Enterocytozoon hepatopeneaei (EHP) is a microsporidial pathogen of farmed shrimp including *Penaeus vannamei, P. monodon,* and *P. stylirostris*. The fungus causes the disease Hepatopancreatic Microsporidiosis (HPM) which is listed as an emerging disease by the World Organization for Animal Health (WOAH, Paris, France). Currently, methods for detecting or confirming EHP infection are primarily based on Hematoxylin and Eosin (H&E) histology, PCR-based diagnosis targeting the 18S rRNA gene and the spore wall protein gene, as well as *in-situ* hybridization (ISH) using a DIG-labelled 18S rRNA gene probe. We report the use of fluorescence *in-situ* hybridization (FISH) as a new diagnostic method for EHP detection. Due to the use of direct FISH procedures, this protocol is approximately 30% faster than the traditional ISH method.

To determine the feasibility of the newly developed FISH method for EHP detection, sections of Davidson's-fixed, paraffin-embedded shrimp tissue from an experimental EHP challenge study of *P. vannamei* was used. Specific-Pathogen-Free (SPF) tissue was used as a negative control, and a known EHP-infected tissue with at least Grade 3 infection level was used as a positive control. EHP detection was carried out using H&E histology, ISH using the 18S rRNA gene probe, and the newly developed FISH protocol. The FISH probes (EHP510 F/R) were labeled at the 5' end with an Alexa Fluor 594 fluorophore (IDT). EverBrite TrueBlack® Hardset Mounting Medium with DAPI (Biotium) was used to provide a nuclear counterstain and reduce autofluorescence in tissue sections.

The EHP positive block was confirmed for the presence of EHP infection by traditional pathological analysis and ISH. The new FISH protocol was successful in detecting EHP in the hepatopancreas of the shrimp (see Figure 1). This new method will not only reduce turnaround times in EHP diagnosis, but also allow for detection of multiple pathogens in a single tissue section and the visualization of spatial relationships between pathogens in coinfections.

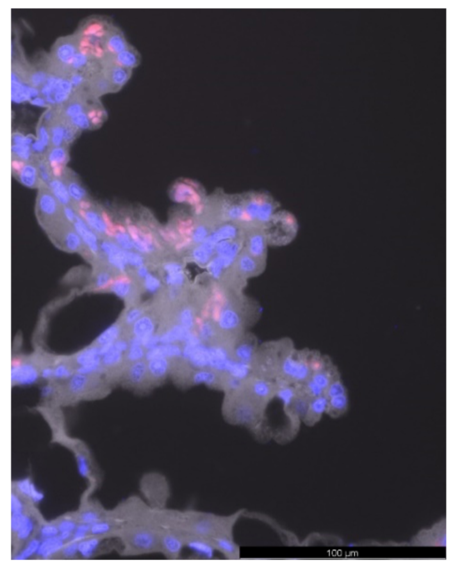

Figure 1 - Detection of EHP using fluorescence *in situ* hybridization (FISH) and EHP-specific probe targeting the 18S rRNA gene. The light red signal indicates EHP infected cells in the hepatopancreas tubule section, and blue signals indicate nuclei in the hepatopancreas tubule epithelial cells. Microscopy was performed at the University of Arizona - UArizona Imaging Cores - Optical, RRID:SCR_023355.

ENVIRONMENTAL HYPOXIA IN ECOLOGICALLY IMPORTANT ESTUARIES AND ITS EFFECTS ON NATIVE FISH SPECIES DURING EARLY DEVELOPMENT

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Estuaries like those in the Gulf of Mexico and the Indian River Lagoon (IRL) host some of the most species-diverse ecosystems in North America. However, the distribution and intensity of hypoxia (low dissolved oxygen, DO) is increasing due to eutrophication, 'dead zones', and algal blooms. Effects of coastal hypoxia is well-studied in adult fish, yet gaps of information remain in terms of fish early life stages, including potential consequences to early development, hatching success, and ultimately recruitment of economically important native species, including the Florida Pompano (*Trachinotus carolinus)* and Red Drum (*Sciaenops ocellatus*). To test the effects of hypoxia, fertilized eggs were incubated in two treatments of severe and moderate hypoxia (20 and 50% DO saturation, 1.4 mg/L and 3.3 mg/L, respectively) and one treatment of normoxia (100% DO saturation, 7 mg/L) in a recirculating aquaculture system (Fig.1). Treatments were run in triplicates (n=3). Eggs and larvae were sampled at 24- and 48-hours post-fertilization to assess embryonic and larval development, survival, and fatty acid lipids use. Lipids were extracted from each sample and separated into neutral (used for energetic purposes) and polar (used for membranous development) fatty acids. The concentration of these fatty acids informs us of the potential effects of severe hypoxia on energy demand and membrane permeability (i.e., homeostatis mechanism). Changes in hatch success, survival, and overall development will be presented. This project enhances the understanding of marine ecosystem function where hypoxic zones are prevalent in areas like in the IRL, and the Gulf of Mexico. Investigating the potential impacts of hypoxia on early larval stages improves conservation and management strategies for recruitment of these species.

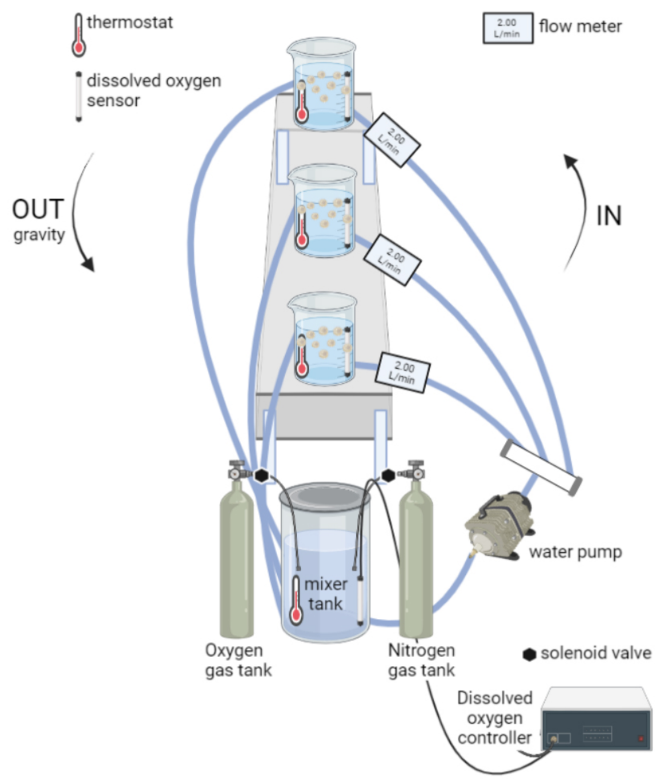

Figure 1: Recirculating design for dissolved oxygen exposure using compressed nitrogen and a source of oxygen to control the percent saturation of dissolved oxygen within each treatment. Design shown for only one treatment.

UTILIZATION OF ALGAL TURF SCRUBBER BIOMASS IN SEA URCHIN *Lytechinus variegatus* DIET

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The sea urchin, *Lytechinus variegatus*, inhabits the eastern coast of the United States, ranging through the Gulf of Mexico from NC, USA to the northern coast of Brazil. *L. variegatus* are one of the most widely used model systems and have been cultured for aquaculture production. The Algal Turf Scrubber (ATS) uses attached algae to efficiently remove inorganic nutrients from water, producing harvestable algal biomass. ATS biomass typically has a high ash content, which has been difficult to utilize in fish and crustacean aquaculture feeds. However, the high ash content present in many sea urchin diets allows ATS biomass to be utilized as a potential option in sustainable feed for *L. variegatus*. The present study was conducted to assess ATS biomass as a fishmeal and ash replacement in nutritionally complete diets. The biomass was harvested from two ATS systems, one receiving treated wastewater effluent and the other incorporated into a hydroponics system. Successful incorporation of this biomass into *L. variegatus* diets improves the sustainability of the feed by using a biomass grown solely on waste inorganic nutrients (i.e. nitrogen and phosphorus).

Juvenile *L. variegatus* were collected from Port St. Joe (29.8119° N, 85.3030° W), FL and transported to Aquaponics Research Laboratory in Savannah, Georgia USA. The closed recirculating aquaculture system used in this study consisted of thirty-two 0.6-liter polyethylene tanks. One hundred and twenty *L. variegatus* were randomly distributed and initial weights and diameters were recorded. Initial average weight (g) was 23.96 and diameter (mm) was 59.94. Thirty tanks contained four individuals per tank and six dietary treatments (n=5) were assigned. Six nutritionally complete diets were formulated as follows: (I) full fish meal control, (II) ten percent Fish Meal Replacement (FMR) with Wastewater Treatment Algae (WWTP), (III) twenty percent FMR WWTP, (IV) ten percent FMR Aquaponics Algae (AP), (V) twenty percent FMR AP, and (VI) fifty percent FMR AP. *L. variegatus* were fed to slight excess daily. Water quality was checked for nitrate and ammonia levels once every four weeks. A one-way ANOVA was performed based on dietary treatments.

After twelve weeks there were no significant differences between final weights of the different treatments. One-hundred percent survival occurred across all individuals. Final average weight (g) was 31.92 and diameter (mm) was 67.76. We saw an average of 7.96 (g) increase across individuals during the twelve weeks.

Subsequent to receiving samples back for analysis, additional data will be presented on: final test weight (g), lantern weight (g), and proximate composition of the gonad.

Results indicate that fishmeal protein and ash can be replaced by ATS algae for both WWTP and aquaponics algae in *L. variegatus* diets.

USE OF DIFFERENT PHOTOPERIODS OF ARTIFICIAL GREEN LIGHTING (LED) IN BIOFLOC SYSTEM ON THE GROWTH AND OXIDATIVE STRESS OF *Penaeus vannamei*

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Several parameters influence the establishment of a BFT system and farmed animals' performance. Aquaculture production systems with shrimp exposed to plenty of natural light may perform better than systems with low light levels due to the growth of photosynthetic microorganisms. Furthermore, the presence of light also positively influences the abundance of microorganisms, reflecting in the better performance of cultured shrimp. This research aimed to assess the impact of different green light photoperiods from LED lamps on water quality, microorganism community, antioxidant capacity (ACAP), lipid peroxidation (TBARS), and growth performance of the Pacific white shrimp *P. vannamei* in the BFT system. The study was conducted in the Shrimp Production Laboratory of the Institute of Oceanography of the Federal University of Rio Grande – FURG, Brazil. Trial was performed in 150L indoors tanks, using *P. vannamei* larvae with an initial weight of 0.48 g at a stocking density of 500 shrimp m-^{3}. The experiment lasting 61 days and was designed with four treatments (four replicates), with different photoperiods using LED green light: 1) 16h LI/8h DA, 2) 12h LI/12h DA (control), 3) 8h LI/16h DA and 4) 4h LI /20h DA.

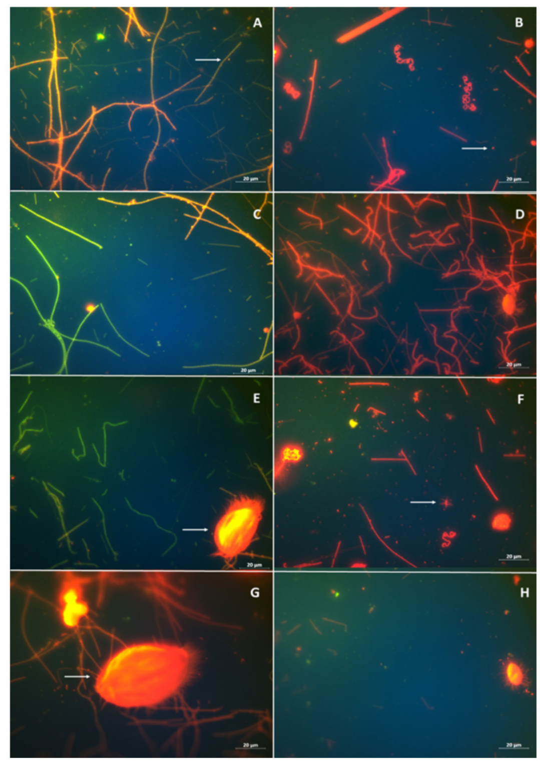

Fig. 1. Abundance of bacteria in the microbial floc Magnification of 1000x by epifluorescence microscope (image: Wellica G. Reis).

No significant differences were found in the water quality parameters, however, there were significant differences in the bacterial abundance of free coccoids, free filamentous, attached filamentous, vibrios, and bacilli ($p < 0.05$) and in protozoa, such as flagellates, ciliates, rotifers, nematodes, and amoebae ($p < 0.05$, Fig 1). There were also significant differences in lipid peroxidation (TBARS) with lower lipid peroxidation in the 12h LI/12h DA, 8h LI/16h DA, and 4h LI/20h DA treatments and higher antioxidant capacity (ACAP) in the hepatopancreas and muscle tissues in the 8h LI/16h treatment DA ($p < 0.05$). In addition, shrimp from treatment 8h LI/16h DA showed a higher final weight than the control treatment 12h LI/12h DA ($p < 0.05$).

The different photoperiods positively influenced the antioxidant capacity and oxidative damage (lipid peroxidation) and zootechnical performance. Results suggest that the photoperiod of 8 hours of green light and 16 hours of darkness can be recommended for rearing *P. vannamei* in biofloc system.

EFFECTS OF DEXTRAN SULFATE AND HEPARIN ON SHRIMP IMMUNITY

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Shrimp aquaculture suffers from white spot syndrome virus (WSSV) outbreaks and acute hepatopancreatic necrosis disease (AHPND). Currently, pond management is the key to preventing WSSV and AHPND, as there is no effective agent to prevent or cure these diseases. Sulfated polysaccharides are known to be part of the infective mechanism of many pathogens and essential to host immune responses. This work investigates the protective effects of dextran sulfate and heparin against WSSV and *Vibrio parahaemolyticus*, causing AHPND, in white shrimp *Litopenaeus vannamei*. After feeding shrimp with either 1%(w/w) dextran sulfate or 0.1%(w/w) heparin, proPO activity in the white shrimp and the expression levels of *proPO1*, *proPO2*, *lyso2*, *pen3* and *alf1* significantly increased. Both sulfated sugars showed a protective effect against WSSV. In addition, the microbiota of shrimp fed with dextran sulfate and heparin was reported. The dominant phyla in all samples was *Proteobacteria*. There was no significant differentiation among most of the alpha diversity indices. However, the effects of sulfated polysaccharide feeding by times on alpha diversity were observed on Day 3 and Day 14.

SPILLOVER EFFECTS OF NEIGHBORING SALMON FARMS TREATMENTS: THE ROLE OF SPATIAL PRODUCTION SITE DISTRIBUTION ON SEA LICE INFESTATION. KARMØY ZONE CASE

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Norwegian salmon farming is carried out in open sea cages, which makes the interaction between farming sites and the marine environment unavoidable. In order to keep the sea lice infestations under the regulatory threshold imposed by the government, several treatments are performed, such as mechanical removal, medicine via feeding, bath treatments, and cleaner fish use (Fig. 1). This study investigates the spillover effects of neighbouring farm treatments on the farm compliance in being below the regulatory threshold. We employ spatial panel dynamic models to analyse the relationship between the proximity of farms and the incidence of sea lice infestations, focusing on the Karmøy zone in Norway.

The research identifies varying patterns of sea lice distribution across farms. Figure 1 illustrates the correlation between the types and frequencies of treatments and the levels of sea lice, establishing a baseline understanding of the infestation dynamics. The study then extends this analysis to consider the distance between farms as an additional influential factor. The inclusion of Moran's I test for assessing spatial autocorrelation further quantifies the spatial relationships and dependencies among the variables, reinforcing the study's focus on the spatial dynamics of sea lice infestation. However, the spillover effects from neighbouring farms treatments seem insignificant in our model.

In summary, this study provides insights into how the spacing between salmon farms might influence sea lice levels, considering the treatment practices and their effectiveness. The findings contribute to a better understanding of the complex dynamics of sea lice infestations in salmon aquaculture and underscore the importance of considering farm distribution in infestation management strategies.

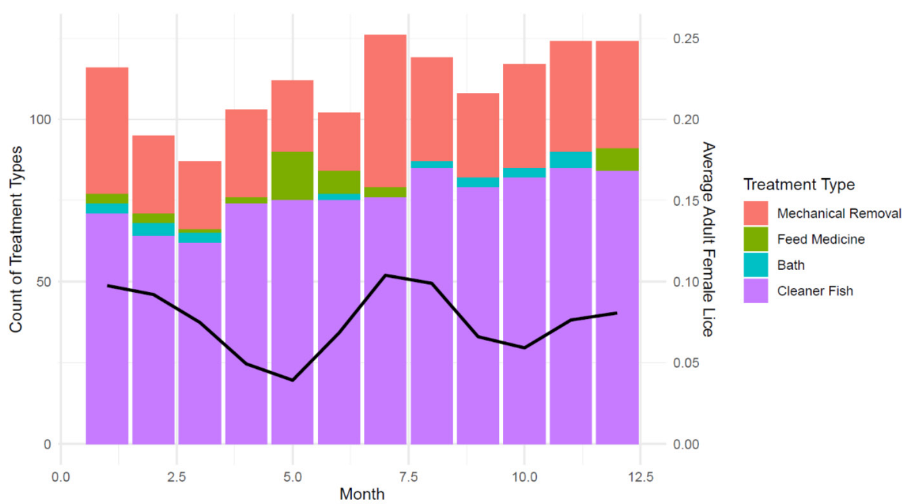

Figure 1 Count of treatment types and adult female lice, Zone 3, 2019

COST AND IMPACT OF OFF-FLAVOR ON US CATFISH FARMS

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Off-flavor has been a persistent problem in the U.S. catfish industry. The economic effects of off-flavor incidence are felt at the farm, processor, and market levels. This study quantified the cost of catfish off-flavor at the farm level. A survey of catfish producers carried out in 2022 (n=54) revealed that 85% of the foodfish production area was following management practices for curbing off-flavor. From producer responses, the average annual off-flavor prevalence and the associated processing plant sample rejection rate was 27%, with the highest rates being in the summer months (45%). The average duration of harvest delays was 23 days/year with the highest in winter months (36 days). Forty-three percent of the surveyed area were using only diuron products while 35% of the area employed diuron and copper sulfate for managing off-flavor, making diuron a popular choice algicide (78% of the area) for off-flavor management. Direct annual cost associated with off-flavor management on catfish farms amounted to \$39.9 million (\$2,325/ha or \$0.272/kg). This accounted for about 10% of the total cost of producing market-sized catfish in 2022. Cost of holding and maintaining fish during the off-flavor period accounted for majority (94%) of the annual direct costs. Other contributing cost components include labor spending on off-flavor treatment, sampling, and transport; cost of treatment supplies; sampling supplies, sampling transportation, and interest on operating expenses. Cost of production was sensitive to changes in the prevalence and duration of off-flavor events. Total industry economic loss from off-flavor was estimated at \$74 million in 2022. The study details the continued significance of off-flavor in US catfish farming and sheds light on the associated economic effects.

ECONOMIC CONTRIBUTION OF US AQUACULTURE FARMS

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US aquaculture is comprised of a multitude of sectors that are diverse in terms of species raised as well as geographic distribution. The industry is comprised of major sectors such as foodfish, mollusks, crustaceans, sportfish, baitfish, ornamentals, and other miscellaneous categories. This diverse nature in terms of species raised and geographic distribution along with the lack of farm data leads to difficulties in quantifying the true economic contribution of US aquaculture. Based on primary farm-level information generated from recent farm surveys, industry spending patterns along with revenues generated by these sectors were compiled to generate economic impact estimation for 2022. An analysis-by-part approach in IMPLAN was used for quantifying the economic contribution which allowed for segmenting the contribution of major sectors while quantifying the national contribution of US aquaculture. The methodology also allowed for segmenting the contribution of the US marine and freshwater aquaculture sectors. Funding from the NOAA National Sea Grant allowed for this very first effort to quantify the economic contribution of US aquaculture. This study will lay a platform for subsequent economic impact research as well as allow for detailing the impact of macroeconomic shocks such as the COVID-19 pandemic on US aquaculture.

ESTIMATING THE TRUE ECONOMIC IMPACT OF DISEASES: THE CASE OF EDWARDSIELLOSIS

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Quantifying the economic loss associated with any aquatic diseases is often confounded due to coinfections and/or comorbidity. Most estimations of economic losses from diseases include calculating revenue losses or the value of lost production. The lack of accounting for true costs results in spurious extrapolations of estimated loss values. The proper economic analytical method would be to estimate the loss of "profits" due to disease which includes a detailed estimation of cost and returns in the presence and absence of disease. Edwardsiellosis of catfish caused by *E. ictaluri* and *E. piscicida* remains one of the most significant diseases in U.S. catfish aquaculture. Economic losses related to this disease are currently unknown. This work sheds light on the losses associated with *E. ictaluri* and *E. piscicida* in catfish aquaculture. The robust economic approach employed is grounded in farm-level production data and long-term disease trends in the industry. Direct farm-level economic losses from Edwardsiellosis ranged from -$3,485/ha to -$13,320/ha causing industrywide economic losses of -$5.2 to -$17.6 million/year. The lost revenue due to Edwardsiellosis ranged from -$8.4 to -$24.8 million/year causing a negative economic impact of -$15.5 to -$45.9 million per year. The economic losses and negative impacts of Edwardsiellosis are relatively greater on the foodfish sector compared to the fingerling sector. This work provides a platform for a more accurate estimation of the true economic impacts of diseases for aquaculture sectors for which commercial farm data is available.

WHOLE INSECT LARVAL MEAL AS A FUNCTIONAL FEED INGREDIENT TO IMPROVE THE SOYBEAN MEAL BASED DIETS UTILIZATION IN ATLANTIC SALMON, *Salmo salar*

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Alternative aquafeed options have been explored to improve efficiency and lower production and environmental costs. Soybean meal (SBM) is a major ingredient in aquafeed industry and high inclusion of SBM exhibit soybean induced enteritis in carnivore fish including Atlantic salmon (*Salmo salar*). Black soldier fly (*Hermetia illucens*) larvae (BSFL) have emerged as a sustainable and viable alternative, demonstrating considerable potential in aquafeed formulations. Previous studies have showcased the positive impacts of BSFL on survival rates, antioxidant capacity, and immune responses in various fish species. Using black soldier fly meal as a complementary ingredient to SBM based diets has been shown to improve performance of rainbow trout in terms of growth performance and health. Therefore, our goal was to evaluate the effects of whole black soldier fly larval meal (WBLM) as complementary feed ingredient in soybean meal based diets on growth performance and gut health in Atlantic salmon.

Seven experimental diets were isonitrogenous (42% crude protein) and isolipidic (20% lipid): fish meal based diet (FM), low level SBM based diets (LS), SBM+5% and 10% WBLM (LS-WB5 and LS-WB10) and high level SBM based diets (HS), SBM+5% and 10% WBLM (HS-WB5 and HS-WB10). A total of 630 Atlantic salmon (15 g) were distributed in 21 tanks (triplicates) in recirculatory aquaculture system.

Results revealed that supplementation of WBLM in soybean meal based diets improved the growth performance of salmon. WBLM exhibited significant positive effects in low level of soybean meal based diets whereas high inclusion (10%) of WBLM in high soy bean meal (40%) based diet exhibited negative effects on growth performance of fish. Feed utilization parameters were significantly affected by the dietary treatment. Supplementation of WBLM in high soybean meal based diets improved the feed efficiency compared to non-supplemented groups. The histology of distal intestine was negatively impacted by the high inclusion of soybean meal in salmon, however inclusion of WBLM in soy diets mitigated the gut inflammation in salmon. Gene expression pattern related to gut inflammation is being analyzed. Genes associated to growth performance, gut barrier integrity and acute inflammatory-related cytokines and chemokines, NF-kB and TNF-α-related genes, and regulators of B and T lymphocytes function are being analyzed.

Conclusively, inclusion of whole insect larval meal in soybean based diets improved the production performance and mitigate the gut inflammation in Atlantic salmon for sustainable salmonids production.

ADVANCING AQUACULTRUE EDUCATION THROUGH COLLABORATION BETWEEN WESTERN AND INDIGENOUS KNOWLEDGE

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Advancing sustainable aquaculture requires collaboration between indigenous knowledge keepers and western scientists. The University of Maine's AquEOUS fellowship program aims to integrate indigenous and western science through applied aquaculture research.

The AquEOUS fellowship program hosted its first cohort of undergraduate students in the summer of 2023. Six students from across the nation participated in the 10-week fellowship with research experience areas focused on sea run fisheries restoration and management, shellfish restoration, environmental DNA to monitor river health and restoration, and the developemnt of an indigenous youth aquaponics program. This poster will detail this programs goals and objectives, highlight the student experience, and feature future program expectations.

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ECOSYSTEM SERVICE EVALUATION OF KELP FARMS VERSUS NATURAL KELPS BEDS IN KODIAK ALASKA

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Seaweed farming is a rapidly growing industry in Alaska. In 2022, Alaska produced 536,000 pounds of kelp which was nearly double the production of kelp in 2021. An important question for both scientists and industry is to better understand the ecosystem interaction of kelp farms in the nearshore environment. Discussions with industry and collaborators have identified that there is a need to quantify the ecosystem services, specifically habitat provisioning of kelp aquaculture for commercial or ecologically-important species. In fall of 2022, the Alaska Fisheries Science Center initiated a small-scale study in Kodiak, Alaska to assess juvenile and adult fish habitat use of kelp farms. We asked a cascading set of basic questions 1) What is the species composition within a kelp farm versus a natural kelp bed, 2) How does the population change over the course of the grow-out season and, 3) What happens to the population post-harvest? We are using a three pronged approach to assess the habitat provisioning of local kelp farms and natural kelp beds through: visual surveys via go-pro cameras; e-DNA collection and analysis; and juvenile fish collection via Standard Monitoring Units for Recruitment of Fishes (SMURFs). We present here our methods and preliminary results of our study.

ADVANCEMENT OF PACIFIC OYSTER RESEARCH CAPACITY IN ALASKA THROUGH RESEARCH HATCHERY DEVELOPMENT AND FIELD TESTING

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The oyster industry is well poised for expansion in Alaska; however, major bottlenecks in industry growth include restricted production of oysters at early life stages, and a lack of selected broodstock for seed production. To date, the only consistent supply of oyster seed for Alaska farmers has originated from out-of-state sources. Likewise, the genetic groups used in these hatcheries have been selected for increased performance in Oregon, Washington, and California, where the climate and nearshore oceanography differ from those found in Alaska. To address these bottlenecks, researchers at NOAA-AFSC based in Juneau and Kodiak, AK are collaborating with federal and industry partners to enhance selective breeding efforts in Alaska, investigate novel gear configurations, and develop the first research oyster hatchery in the state. Specific projects include efforts with the USDA-ARS Pacific Oyster Genomic Selection Project (Newport, OR) and Pacific Hybreed (Manchester, WA) to investigate field performance for genetic groups of interest. The research hatchery that is being developed in Juneau, AK will serve as a research hub for advancing rearing technology and techniques to increase capacity to grow the early life stages of oysters and develop broodstock for both in-state and out-of-state production. This collaborative approach to breeding and hatchery research leverages expertise and capabilities of researchers across the US Pacific coast to resolve barriers to industry growth.

COLUMNARIS DISEASE IS CAUSED BY *Flavobacterium columnare* AND THREE NEWLY DESCRIBED *Flavobacterium* SPP.

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Flavobacterium columnare is the causative agent of columnaris disease in freshwater fish. Four discrete genetic groups exist within the species and research has demonstrated associated host and virulence differences. Previous research has suggested that the species designation may require revisions; therefore, the present study determined the taxonomic status of the four genetic groups of *F. columnare* using polyphasic and phylogenomic approaches. A polyphasic approach was taken to confirm previous phylogenetic relationships and to compare phenotypic, biochemical, and chemotaxonomic properties or representative isolates from the four genetic groups. The research followed the proposed minimal standards for describing new taxa of the family *Flavobacteriaceae* by Bernardet et al. Phylogenetic analyses of 16S rRNA and *gyrB* genes using different methodologies demonstrated the four genetic groups formed well-supported and distinct clades within the genus *Flavobacterium*. The average nucleotide identity (ANI) and digital DNA-DNA hybridization (GGDC) values between *F. columnare* ATCC 23463^{T}, genetic group 2 isolate AL-02-36^{T}, genetic group 3 isolate 90-106^{T}, and genetic group 4 isolate Costa Rica 04-02-TN^{T} were less than 90.84% and 42.7%, respectively. Chemotaxonomic, MALDI-TOF characterization and ANI/GGDC calculations afforded differentiation between the genetic groups, indicating each group is a discrete species. The names *F. covae* sp. nov., *F. davisii* sp. nov., and *F. oreochromis* sp. nov. were proposed to represent genetic groups 2, 3, and 4, respectively, and recently validated. Since these pathogens (collectively referred to as columnaris causing bacteria, CCB) are globally distributed and have significant impacts on wild and cultured fish species, recognition of the four species will advance and improve research to define host-pathogen-environment relationships, epidemiology, and develop effective control and prevention measures in aquaculture. Such research needs to target the correct bacterial species and research findings can be properly interpreted by correct and consistent taxonomic assignment.

Flavobacterium covae IS THE PREDOMINANT SPECIES OF COLUMNARIS-CAUSING BACTERIA IMPACTING THE CHANNEL CATFISH *Ictalurus punctatus* INDUSTRY IN THE SOUTHEASTERN USA

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Columnaris disease is a leading cause of disease related losses in the catfish industry in the Southeastern USA. The term 'columnaris causing bacteria' (CCB) has been coined in reference to the four described species that cause columnaris disease, *Flavobacterium columnare*, *F. covae*, *F. davisii*, and *F. oreochromis*. Historically, *F. columnare, F. covae,* and *F. davisii* have been isolated from columnaris disease cases in the catfish industry; however, there is a lack of knowledge of which CCB species are most prevalent in farm-raised catfish. The current research objectives were (1) sample columnaris disease cases from the US catfish industry and identify species of CCB involved, and (2) determine the virulence of the four CCB species in channel catfish in controlled laboratory challenges. Bacterial isolates or swabs of external lesions from catfish were collected from 259 columnaris disease cases in Mississippi and Alabama from 2015-2019. DNA extracted from the samples were analyzed using a CCB-specific multiplex PCR to identify the CCB identified in each diagnostic case. Results demonstrated that *F. covae* is the predominant species of CCB impacting the US catfish industry, present in 94.2% (n = 244) of diagnostic case submissions. Challenge experiments demonstrated *F. covae* and *F. oreochromis* were highly virulent to channel catfish while *F. columnare* and *F. davisii* were on average less virulent. Collectively, these results demonstrate *F. covae* is the predominant CCB in the US catfish industry and research aimed at developing new prevention and control strategies should target this bacterial species. The methods described herein can be used to continue monitoring the prevalence of CCB in the catfish industry and can be easily applied to other industries to identify which *Flavobacterium* species have the greatest impact.

CONTROLLED LABORATORY CHALLENGE DEMONSTRATES MODERATE ADDITIVE GENETIC VARIATION IN RESISTANCE TO TILAPIA LAKE VIRUS IN NILE TILAPIA

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Tilapia lake virus (TiLV) is a lethal virus impacting farmed tilapia (*Oreochromis* spp.). The virus was identified in 2014 and its emergence has resulted in substantial economic losses to the global tilapia industry. Given the lack of treatment options currently available, selective breeding for increased disease resistance may be a viable option for reducing the impact of this pathogen. Therefore, this study was initiated to phenotype Nile tilapia (*O. niloticus*) families for resistance to TiLV and determine its additive genetic variation and heritability. Fish from the eleventh generation of the Spring Genetics Nile tilapia breeding program with nucleus operations in Homestead, Florida, US, were used for this study. A total of 142 full-sib families (mean weight, 142.3 g) were included in the challenge with on average 17 fish per family (range, 4 to 20). All fish were challenged at the USDA-ARS AAHRU with TiLV via intraperitoneal injection with a viral dose corresponding to 2.25×10^4 $TCID_{50}$ $fish^{-1}$ and placed into a single 5,550 L tank. Mortality data on each individual fish was collected for 21 days post challenge and a univariate animal linear model was used for quantitative genetic analyses. The accumulated mortality at the end of the experiment was 74.5%. The results revealed high variation in the mean survival of the families challenged with TiLV (range, 0% to 95%). The additive genetic effect for survival to TiLV was significantly different from zero ($P < 0.001$; log-likelihood ratio) and the estimated heritability was $h^2 = 0.29 \pm 0.1$. The results demonstrated moderate additive genetic variation in resistance to TiLV and suggest promise in genetic improvement of tilapia for resistance to this virus by selective breeding. Genomic analyses are pending to evaluate the potential for genomic or marker assisted selection. In the next generation, families will be produced by assortative mating (high and low estimated breeding values) and challenged to confirm the heritability of resistance to TiLV. The end goal is the production of a high performing strain of tilapia with disease resistance for the global tilapia industry.

FOUNDING THE AQUACULTURE COLLECTIVE: THE VIRGINIA INSTITUTE OF MARINE SCIENCE STUDENT SUBUNIT OF THE UNITED STATES AQUACULTURE SOCIETY

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The Aquaculture Collective (AquaCo) at the Virginia Institute of Marine Science (VIMS) aims to expand educational, professional, and social opportunities to students of all levels interested in aquaculture through events rooted in discussion, skill development, and connection. In addition to providing opportunities to students at W&M and VIMS, AquaCo will broadcast to and interact with external communities that are less exposed to aquaculture. Broadly, the subunit aspires to increase awareness and accessibility of aquaculture and the USAS by building upon the reinvigorated aquaculture initiative at VIMS. While USAS has formally recognized AquaCo as a student subunit of USAS, the organization is currently traversing the recognition processes at VIMS and W&M.

The organization is unique to VIMS, W&M, and possibly USAS in being the first aquaculture-focused organization *and* the first student-led organization that will incorporate both undergraduate and graduate students into its membership. The two campuses are located twenty-five minutes apart, and logistical issues have historically been an issue for interaction between the campuses. This organization aims to overcome this challenge by funding travel between both campuses and holding events, such as chapter meetings, at both campuses.

AquaCo's three-part mission: 1) Educationally, AquaCo plans to leverage the resources from USAS and VIMS to provide an organized forum for students to learn about various regional and international aquaculture. There will be an emphasis on 'learning by doing' and 'learning by teaching.' 2) Professionally, AquaCo will promote the development of new skills and abilities and provide networking opportunities through participation in USAS and WAS events. There will be a focus on improving communication skills through a 'boots on the ground' approach to outreach in less-resourced communities. 3) Socially, the organization will serve as a relaxed setting for students to bond over productive conversations about aquaculture. We will welcome all people of all backgrounds to participate in fostering long-lasting relationships built around aquaculture.

In this presentation, I will highlight how we plan to achieve our mission and provide an overview of the VIMS and W&M facilities where this will occur.

ASSESSING THE EFFECTS OF HUSBANDRY DECISIONS ON MORTALITY, GROWTH, AND TIME-TO-MARKET IN OFF-BOTTOM OYSTER AQUACULTURE

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Off-bottom oyster aquaculture is a labor-limited industry with slim profit margins. Production inefficiencies can amplify the economic strain on a company. Therefore, any technique that improves production and reduces operational costs has tremendous potential to increase the economic sustainability of shellfish aquaculture. While previous studies have highlighted the benefits of low stocking densities (which presumably increases water flow and food availability), less is known about the effects of densities that trigger the practice of splitting, or thinning into lower densities. This project addresses this gap by investigating the effects of splitting oysters at three different triggering densities (25%, 50%, and 75%) on growth metrics, yield, and time-to-market.

In April 2023, 27 FlipFarm baskets were stocked with ~25 mm oysters at 10% of total basket volume and deployed across three lines on the VIMS Research Farm in the York River, Chesapeake Bay (9 baskets per line). Baskets were haphazardly assigned one of three thinning densities, and regularly observed for growth, split once a treatment level reached the trigger volume, and restocked at 10% by size class (creating additional baskets). To date, the 25% treatment has been split three times, the 50% treatment split twice, and the 75% treatment split once. Preliminary data show oysters in the 50% treatment grew faster than the 25% treatment over the second half of the sampling period (Fig 1). The cumulative mortality of these treatments has not differed. Anticipated splits in the coming months will provide further insights into yield, time-to-market, and estimated labor-related cost-benefit scenarios.

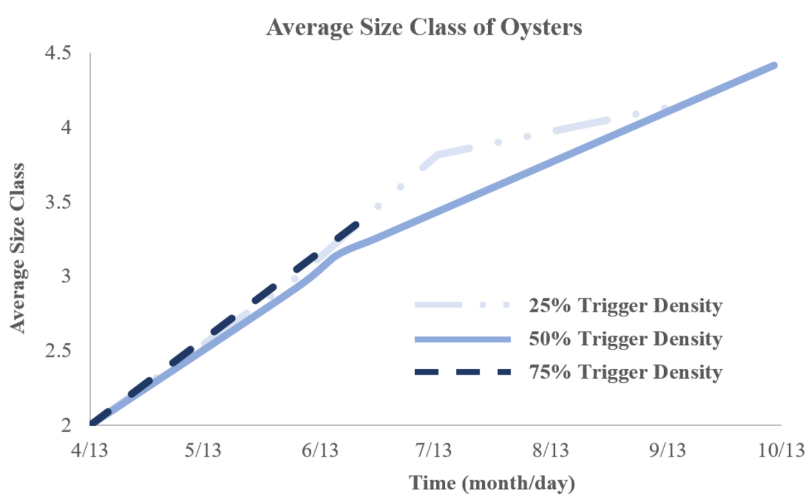

Figure 1: The average size class of oysters for 25% trigger density (dashed and dotted line), 50% trigger density (solid line), and 75% trigger density (dashed line). Values for size classes represent the hole size of the mechanical sorter: 2 = 22mm. 3 > 22mm. 4 = 32mm. 5 = 44mm. and 6 > 44mm.

THE KENTUCKY STATE UNIVERSITY (KSU) UNITED STATES AQUACULTURE SOCIETY STUDENT SUBUNIT: EDUCATION, COMMUNITY, PROFESSIONAL DEVELOPMENT, AND COLLABORATION WITH KSU'S TILAPIA CAPACITY BUILDILNG PROJECT TO CREATE EXTENSION RESOURCES

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The KSU United States Aquaculture Society (USAS) Subunit had a productive year (2022-2023). Subunit activities included online and in-person guest speaker presentations from Kentucky (KSU Drone Specialist) and New York (East Hampton Shellfish Hatchery Director). Members assisted each other with their research projects, visited two local zoos for education and recreation, and provided Extension service to local fish farmers (Figure 1). Field trips included Kentucky fish farms and other aquaculture centers to aquire field experience and apply knowledge and skills gained at KSU's School of Aquaculture and Aquatic Sciences. The subunit engaged in professional development by participation at Conferences of the World Aquaculture Society, Kentucky Academy of Science (KAS), and Women of the Water Conference 2023 (Figure 1). The subunit supported seven members' oral and poster presentations at the KAS Conference 2023, and one member, Oluwafemi Adebayo, received the USAS Student Travel Award at Aquaculture 2023. The subunit contributed substantially to creating educational videos on whole fish and fillet processing and cooking to develop Extension resources as part of the human nutrition component of KSU's Tilapia Extension Project: 'Expanding Aquaculture and Healthy Food Choices to Reduce Economic and Health Disparities Affecting Minority and Limited-Resource Stakeholders'. This collaborative work accomplished through the KSU Tilapia Project has been presented at conferences, and the videos and information were posted on various social media platforms and posts to maximize dissemination (Figure 1). Lastly, election was held for new executives to take charge of the subunit activities, to ensure continuity, and to plan and to implement activities to fulfill objectives as stated in the KSU USAS Subunit Bylaws.

Figure 1. Subunit members collected fish at the largest Largemouth Bass Farm in Kentucky, presented at conferences, and contributed to human nutrition video production.

COMPARISON OF HEMOLYMPH COLLECTED WITH COMMERCIAL AND LAB-MADE ANTICOAGULANT

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Shrimp, as well as other invertebrate species, have extremely quick hemolymph clotting times. A non-clotted sample is optimal to effectively measure most hematological parameters. Syringes are typically coated with some form of anticoagulant prior to hemolymph collection to delay or prevent clotting long enough to allow time for such analysis to be conducted. During a recent experiment we used a commercially available anticoagulant, containing dipotassium ethylenediamine tetraacetate, that had been successfully used to collect hemolymph from other invertebrates for *Litopenaeus vannamei;* however, the hemolymph clotted too fast to be used for the intended analysis. To preserve the remaining samples, a solution of lab-made anticoagulant, containing sodium citrate, was used in place of the commercial anticoagulant. There were observable differences between the hemolymph collected with the two anticoagulants, including sample clotting time and sample hue. The hemolymph collected with the commercial anticoagulant clotted within seconds and had a cloudy, slightly purple color, while the lab-made anticoagulant did not clot and was clear in appearance. Due to the increased clotting and the cloudy appearance of the hemolymph when using the commercial anticoagulant, it was difficult to obtain differential hemocyte counts using a hemocytometer. When using the hemolymph collected with the lab-made anticoagulant the samples were clear and the different cell types were easily distinguished under the microscope. Measuring phagocytic capacity of hemolymph collected with the commercial anticoagulant was also challenging. The sample was too thick and the unadhered hemocytes did not wash off the slides, creating a dense mound that became saturated with dye when staining, making it difficult to visualize the phagocytizing hemocytes. When using the lab-made anticoagulant, the unadhered hemocytes were readily washed away, and staining was even. This allowed for easier visualization of phagocytic activity. Due to these observable differences, the use of the commercially available anticoagulant initially used is not advocated for the collection of hemolymph from *L. vannamei*. Although this product may work well as an anticoagulant for some invertebrate species we recommend the use of sodium citrate for *L. vannamei*.

THE ENVIRONMENTAL EFFECTIVENESS OF SEA LICE REGULATION: COMPLIANCE AND CONSEQUENCES FOR FARMED AND WILD SALMON

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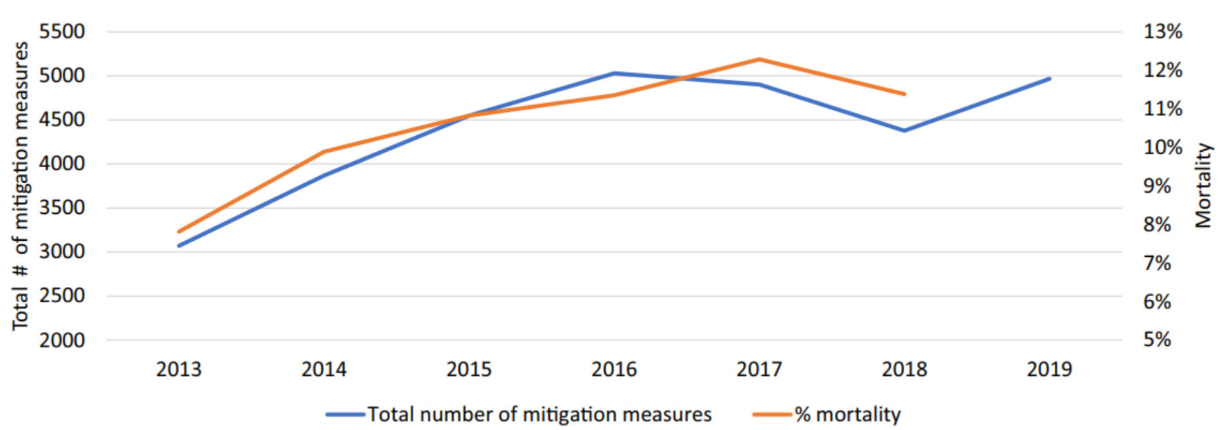
Protecting the health and survival of wild salmon populations is a main objective of sea-lice regulation for salmonid farming. This study has evaluated the environmental effectiveness of sea-lice regulation setting strict thresholds for the average number of lice per farmed fish in Norway. From an environmental perspective, the success of such regulation does not depend on the average number of lice per salmon in the net pens, but on the degree to which compliance contributes to lessening the mortality risk for surrounding wild salmonid populations—and thus, ultimately, the wild salmon population survival. Since the 1970s, the proportion of wild Atlantic salmon returning to Norwegian rivers has been almost halved, while Norwegian salmon farming has undergone massive industrialization and expansion. As the proliferation of sea lice may be an important part of the explanation for the decline in wild salmon, Norway has enacted increasingly stricter regulatory thresholds for the average number of lice per farmed fish at production sites.

This study shows that practicing a stricter lice threshold reduces the average number of lice per fish within farming sites. Thus, the strict regulation has had positive effects on lice-levels at production sites. However, more frequent de-lousing measures to ensure compliance leads to farmed-salmon welfare problems and higher mortality rates in the net pens (Fig. 1). Furthermore, the analysis shows that the environmental effectiveness of the regulation has been limited or absent: successful compliance with stricter thresholds has not lessened the sea-lice infestation pressure on surrounding, wild salmonid populations. The environmental effectiveness of such regulation is thus limited. This raises the important question of whether a regulatory regime focused on minimizing the average number of sea lice per farmed fish may do more harm than good, unless accompanied by a broader set of regulatory instruments targeting other variables that affect sea-lice infestations in the wild salmon habitat.

Fig. 1: Number of de-lousing actions and farmed fish mortality.



FEED THE FUTURE INNOVATION LAB FOR FISH: SETTING THE TABLE FOR GLOBAL IMPACT

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The Feed the Future Innovation Lab for Fish, funded by the U.S. Agency for International Development (USAID), aims to reduce poverty and improve nutrition, food security, and livelihoods in partner countries by supporting research on sustainable aquatic food systems. The Fish Innovation Lab is managed by the Mississippi State University Global Center for Aquatic Health and Food Security. It is one of 21 Feed the Future Innovation Labs, which are leveraging the expertise of U.S. universities and partner country research institutions to tackle some of the world's greatest challenges in agriculture and food security.

From 2018-2023, the Fish Innovation Lab supported 24 activities focused on applied research and sustainability of aquaculture and fisheries, 15 of which were in African countries: Ghana, Kenya, Nigeria, and Zambia. The lab also had eight activities in Bangladesh and Cambodia, as well as one activity that focused on Peru, the Philippines, Madagascar, and the Pacific Islands region. The Fish Innovation Lab's program areas included improving productivity, mitigating risk, and improving human outcomes. Additionally, the Fish Innovation Lab had four cross-cutting themes, which were incorporated into each funded activity and guided the lab's work overall: mainstreaming gender equity and youth inclusion, advancing human and institutional capacity development, strengthening resilience, and advancing nutrition.

The Mississippi State University Global Center for Aquatic Health and Food Security was awarded a five-year extension in fall of 2023 to continue management of the Fish Innovation Lab to address global food security challenges through aquatic food systems. Target countries for the Fish Innovation Lab in 2023-2028 will be Bangladesh, Kenya, Nigeria, and Zambia, with the potential for work in other Feed the Future countries. The Fish Innovation Lab has revised its program areas to focus on 1) climate-smart aquatic system innovations, 2) nutrition and food systems, and 3) inclusive access to improved inputs. The cross-cutting themes for all activities will be capacity development, gender equity and social inclusion, and resilience. Linking together U.S. universities and institutions with in-country partner universities and institutions is pivotal in fostering innovative solutions to the critical issue of food insecurity. The Fish Innovation Lab anticipates releasing a Request for Proposals in 2024.

To learn more about the activities of the Fish Innovation Lab and for information on funding opportunities, visit our website at www.fishinnovationlab.msstate.edu and subscribe to our newsletter at https://rb.gy/j17i6.

GROWTH RATE OF EASTERN WHITE CEDAR IN AQUAPONICS VERSUS SOIL

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Silviculture and aquaponics are novel topics that have been intriguing scientists and foresters alike. In theory, by combining the two disciplines, pre-existing fish hatcheries could add on an aquaponics system to reduce excess nutrients: thereby reducing eutrophication in local waterways while growing saplings for multiple purposes. The nutrient waste will potentially grow saplings faster than in conventional agriculture, giving them a competitive advantage. These saplings could be used for forest restoration purposes or landscaping, thus increasing the number of native trees in landscaping, and restoring natural habitats.

In a preliminary study conducted last year, Eastern White Cedar saplings were successfully sprouted from seed, using only damp paper towels and a grow light. Seedlings were transferred into a deep water culture system (DWC) and grown for approximately 8 months before being transferred to soil. The saplings thrived in the deep water culture system and are now successfully thriving in soil. However, there was a large variation in size of saplings, possibly because half of the sprouts were transferred into the DWC system later than the other half. Two of these saplings were transplanted in front of the Native American Center on campus at Lake Superior State University in September 2023.

The study was continued in February 2023, this time with consistent planting schedules and control groups, to compare stem growth rates between aquaponically grown and soil grown saplings. The aquaponics saplings were grown in a DWC with no added media, leaving the roots floating. Whereas the soil grown saplings were in 10 inch pots with Black Gold soil. Soil and water chemistry and stem height were recorded every two weeks. Both sample groups received the same environmental conditions. Preliminary results show a higher survival rate in aquaponics compared to soil. Overall, combining silviculture with aquaculture has potential benefits for protecting the aquatic environment and creating a new field of aquaponics.

VITAMIN E REQUIREMENT OF PACIFIC WHITE SHRIMP *Penaeus vannamei* POST-LARVAE

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The Pacific white shrimp is the most economically valuable shrimp species among crustacean aquaculture species. The fast growth, disease resistance, and tolerance for a wide range of water temperature and salinity are the key characteristics of the shrimp species cultures. Vitamin E, as an essential micro-nutrient, plays important roles in various physiological and biochemical processes. Vitamin E maintains and enhances the growth, innate immunity and antioxidant capacity of fish and shrimp. Thus, this study was conducted to determine the dietary vitamin E requirement for Pacific white shrimp post-larvae.

The basal diet (E0) was prepared using soybean meal, fish meal and fish oil (protein, 32.5%; lipid, 9.20%). Four other diets were prepared by adding vitamin E (DL-α-tocopherol acetate) of 40, 80, 120 and 160 mg/kg to the basal diet (designated as E40, E80, E120 and E160, respectively). Each diet was randomly assigned in quadruplicate groups of each 50 shrimp (3.95 ± 0.21 mg) and fed to the shrimp for 34 days.

The growth performance and feed utilization efficiency (FCR, PER) were significantly increased by vitamin E supplementation. The survival was the lowest in E0 group (65%), but no significant difference was found. Relative mRNA expression levels of insulin-like growth factor-binding protein, amylase, chymotrypsin and superoxide dismutase genes were significantly increased in shrimp fed vitamin E supplemented diets than in shrimp fed E0 diet. Shrimp fed E80, E120 and E160 diets had significantly higher resistance to ammonia than shrimp fed E0 diet. Broken line regression analysis indicated that the optimum vitamin E level of the shrimp post-larvae would be 60.5 mg/kg diet.

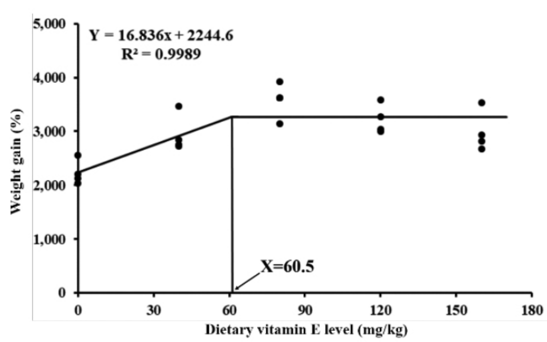

Figure 1. Estimation of optimum dietary vitamin E requirement based on the weight gain (%) of Pacific white shrimp post-larvae.

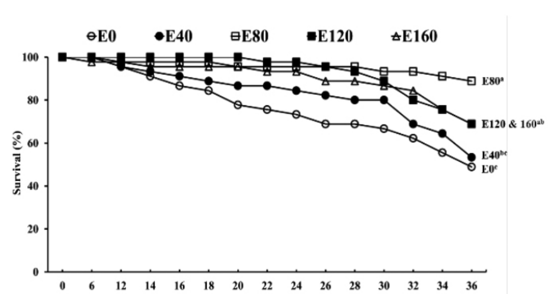

Figure 2. The survival of Pacific white shrimp postlarvae challenged ammonia for 36 hours at the end of 34 days feeding trial.

PYRIDOXINE REQUIREMENT OF PACIFIC WHITE SHRIMP *Penaeus vannamei*

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Pyridoxine acts as a coenzyme in many reactions involved in the nutrient metabolism. It is an essential nutrient to maintain and enhance the growth performance, immunity and antioxidant capacity of aquatic animals including fish and shrimp. This study was designed to determine the optimal level pyridoxine in diet for Pacific white shrimp.

A control (Con) diet was formulated to have a low crude protein level (33%) without pyridoxine supplementation. A negative control (Con-) diet was formulated with 0.4% tetracycline hydrochloride for the evaluation of the effects of pyridoxine synthesis by intestinal microorganism in the shrimp. Six other diets were prepared by adding pyridoxine at 25, 50, 75, 100, 125 and 150 mg/kg to Con diet (designated as P25, P50, P75, P100, P125 and P150, respectively). Each diet was randomly assigned quadruplicate groups of each 20 shrimp (0.38±0.00 g) and fed for 45 days.

The growth performance was significantly increased by pyridoxine supplementation in diets. The dietary pyridoxine improved the innate immunity and antioxidant capacity of shrimp. The highest activities of trypsin, chymotrypsin, lipase and amylase were observed in shrimp fed P75 diet. Cell membrane thickness was significantly increased in all the pyridoxine supplemented groups, except for P25 and P150, than in Con group. Gene expression was significantly upregulated in cystathionine-β-synthase, cystathionine-γ-lyase, pyridoxal kinase and crustin up to P75 group. The broken line regression analysis indicated that the optimum pyridoxine level of a low protein diet seems to be 75.7 mg/kg diet based on

Table 1. Growth performance, feed utilization and survival of *Litopenaeus vannamei* fed the experimental diets for 45 days.

Diet	FBW	PER	Survival
Con	5.28±0.25[cd]	1.64±0.05[cd]	96.3±4.8
Con⁻	5.04±0.27[d]	1.59±0.05[d]	96.3±2.5
P25	5.81±0.22[bc]	1.74±0.04[bcd]	98.8±2.5
P50	6.20±0.33[ab]	1.87±0.07[abc]	97.5±5.0
P75	6.74±0.18[a]	1.96±0.05[a]	98.8±2.5
P100	6.44±0.10[ab]	1.88±0.10[ab]	97.5±5.0
P125	6.10±0.39[ab]	1.84±0.12[abc]	97.5±5.0
P150	5.81±0.35[bc]	1.78±0.08[cd]	98.8±2.5
Pr >*F*[*]			
ANOVA	0.00	0.00	0.40
Linear	0.02	0.00	0.34
Quadratic	0.00	0.00	0.94

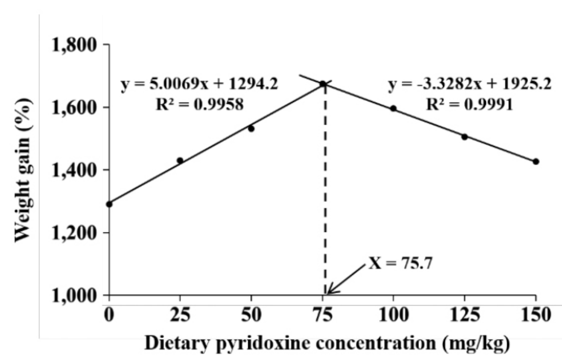

Figure 1. Estimation of optimum dietary pyridoxine requirement based on the weight gain (%) of *Litopenaeus vannamei*

INFLUENCE OF *Sargassum horneri* EXTRACT ON THE GERMINATION OF SALTMARSH PLANTS *Suaeda maritima* AND *Salicornia herbacea*

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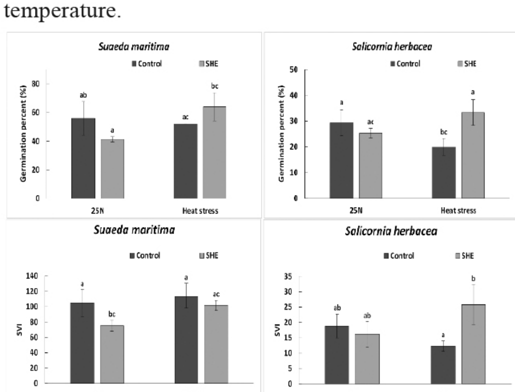
Sargassum horneri blooms have been a major issue in East China Sea, the Yellow Sea and Korea since 2015, causing significant damages to seaweed farms in Korea and China. Due to the economic and ecological risks induced by the extensive growth of *S. horneri*, efforts have been made to utilize the massive biomass of *S. horneri* by extracting useful bioactive compounds. *S. horneri* extract's efficacies such as anti-oxidant, anti-inflammatory, and anti-tumor activities have been demonstrated by several studies. *Suaeda maritima* and *Salicornia herbacea* are major species of saltmarsh plant, widely distributed in Korea, and they have been proposed as good candidates to be used in saltmarsh afforestation. Thus, we examined how *Sargassum horneri* extract (SHE) affects the germination and seedling growth of *Su. maritima* and *Sa. herbacea* for 18 days, both at optimal and elevated temperatures.

In the group exposed to SHE treatment, seeds were placed within Petri dishes containing filter papers soaked with approximately 5 - 7 ml of a 0.5% SHE solution diluted with deionized water (DW). In contrast, the control group had filter papers moistened only with DW. The Petri dishes were maintained at a temperature of 25°C, while, for the heat stress condition, an identical set of experimental trials was conducted at 30°C. The light was set at an intensity of 20 μmol photons m^{-2} s^{-1}, and the photoperiod followed a 12:12 (L:D).

We observed a clear enhancement in thermal tolerance in *Sa. herbacea* due to the application of SHE. In the presence of both heat stress and SHE treatment, the germination percentage (GP) and seedling vigor index (SVI) of *Sa. herbacea* were 33.3% and 25.8, respectively (Figure 1). These values were significantly higher compared to those of the untreated group, which recorded 20% for GP and 12.3 for the SVI ($P<0.05$). However, in the case of the *Su. maritima* experiment, there was no observed improvement in thermal tolerance induced by SHE treatment. These findings suggest that the application of *Sargassum horneri* extract can enhance thermal tolerance in *Sa. herbacea*, and the effect of SHE for thermal tolerance improvement may be species specific.

Figure 1. Germination percent (Above) and Seedling vigor index (Below) of *Suaeda maritima* and *Salicornia herbacea* seeds in optimal and heat stressed temperature.



GENERATION OF MAVS GENE KNOCKOUT ZEBRAFISH AND THE CONSEQUENCES OF THIS MUTATION DURING VHSV INFECTION

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The MAVS (Mitochondrial Antiviral Signaling) pathway is an important component of the innate immune system that plays a critical role in defending the host against viral infections. This pathway is primarily responsible for detecting the presence of viral RNA or other viral components and initiating an antiviral immune response. In teleost, Mavs-related studies are rare. In this study, we generated *mavs* knockout zebrafish (*mavs*$^{(-/-)}$) with 11 bp deletion at the target site using CRISPR/Cas9-mediated technique. To elucidate the function of Mavs in viral infection, we injected viral hemorrhagic septicemia virus (VHSV) into wild-type (WT) and *mavs*$^{(-/-)}$ larvae (4 days post fertilization (dpf)) and adult fish, then we evaluated the mortality percentage and VHSV copy number. Our results exhibited that the *mavs* gene began to be expressed from 2 cell stages and *in situ* hybridization revealed its unique expression site in the kidney, liver, and intestine. According to the qPCR results, the liver of adult zebrafish has the greatest *mavs* expression, followed by the intestine. The successful *mavs* mutant was created utilizing a CRISPR/Cas9-mediated technique, which resulted in a 67 bp shortened protein with an early stop codon. Furthermore, in 7dpf larvae downstream gene analysis, interferon regulatory factor 3 (*irf3*), *irf7*, *ifn-φ1*, *tnf-α1*, and *il-6* were found to be increased in *mavs*$^{(-/-)}$ compared to WT. The VHSV injection (300 $TCID_{50}$/larva) caused death at 60 hours post-injection (hpi) in both types of larvae, and the mortality percentage was higher in *mavs*$^{(-/-)}$ compared to WT throughout the experiment. Furthermore, at 24 and 48 hpi, the viral copy number was considerably higher in *mavs*$^{(-/-)}$ compared to WT. Further, the mortality of *mavs*$^{(-/-)}$ and WT adult fish infected with 5×10^6 $TCID_{50}$/ml VHSV began at 6 dpi and 8 dpi and reached 100% and ~73% at the end of the experiment, respectively. The mean viral copy numbers from five individual zebrafish in each group at various time points revealed notable discrepancies in VHSV copy numbers between the groups on days beyond the first. Throughout this period, the VHSV copy number in WT fish remained significantly lower than that in *mavs*$^{(-/-)}$ mutants. In summary, our study, which utilized the deletion of *mavs* in zebrafish, provides compelling evidence that Mavs plays a critical role in immune regulation during viral infections.

SELECTIVE BREEDING TO IMPROVE RESISTANCE TO COLUMNARIS DISEASE IN RAINBOW TROUT

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A line of rainbow trout with improved resistance to *Flavobacterium psychrophilum*, the causative agent of bacterial cold water disease (BCWD), was developed over five generations of selective breeding. As a result of selection, mean survival following laboratory *F. psychrophilum* challenge in the resistant (ARS-Fp-R) and contemporary control (ARS-Fp-C) and susceptible (ARS-Fp-S) lines was 84.9, 50.5, and 22.0%, respectively, and the genetic trend for survival in the ARS-Fp-R line was +10.1 percentage points per generation. Importantly, improved survival in the ARS-Fp-R line based on laboratory challenges translated to improved resistance to BCWD in production-scale field challenges where fish were naturally exposed to the pathogen.

Preliminary laboratory challenges of families from the three genetic lines with *F. columnare*, the causative agent of columnaris disease, suggested that: 1) survival following *F. columnare* challenge is heritable; and 2) resistance to *F. psychrophilum* and *F. columnare* has a positive (favorable) genetic correlation in this population. As a result, selection to improve survival following *F. columnare* challenge became the sole breeding objective. Fifth-generation families (n = 100) from the ARS-Fp-R line served as the base population, and selection is currently being practiced to develop double-resistant (ARS-Fp/Fc-R), randomly-mated control (ARS-Fp-R), and susceptible (ARS-Fc-S) lines over five subsequent generations of selection.

Contrary to expectations, no upward selection response and only modest downward selection response was observed through the first two generations; mean survival following *F. columnare* challenge of second-generation families was 19.2, 19.7, and 6.2% for the ARS-Fp/Fc-R, ARS-Fp-R, and ARS-Fc-S lines, respectively. Whereas typical family variation in survival was observed each generation (i.e., ranges of 27 – 98%, 9 – 89%, and 1 – 62% survival in the base, first, and second generations, respectively), mid-parent breeding values were not predictive of progeny survival in the subsequent generation (within-line correlations ≤ 0.06).

Compared to the BCWD challenge (injection-based, flow-through challenge model), increased variation (~1.4-fold) in survival across replicates (challenge tanks) within a family was observed for the columnaris challenge (immersion-based, flow-through challenge model), suggesting reduced accuracy of the survival phenotype due to unknown non-genetic effects. Efforts are currently underway to develop and evaluate the utility of a mixed-family (common garden) recirculation-based columnaris challenge model to improve accuracy of the survival phenotype and resulting breeding value estimates.

MODELING EMBRYO SURVIVAL: GENETIC AND ENVIRONMENTAL INFLUENCES ON EYE-UP RATE IN A NORTH AMERICAN ATLANTIC SALMON SELECTIVE BREEDING PROGRAM

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Selective breeding programs improve target traits but can also unintentionally change genetically correlated traits in the selected strain. The U.S. Department of Agriculture–Agricultural Research Service National Cold Water Marine Aquaculture Center (NCWMAC) in Franklin, Maine maintains a North American Atlantic salmon selective breeding program focused on improving commercially important traits (e.g., growth rate and sea lice resistance). However, the program has experienced a significant decline in the percent of eyed embryos over its 14 years of operation, leading to concerns that reproductive performance was being unintentionally changed by selection for the target traits. The aims of this study were to 1) model eye up success as a heritable trait utilizing the recorded pedigree and 2) correlate eye-up rate with environmental conditions experienced by the broodstock.

Counts of eyed embryos were analyzed with a maternal trait model containing a spawn year effect to determine the strength of genetic and environmental influences on the eyed embryo rate. To investigate the environmental influences in more detail, water quality parameters in the broodstock rearing system observed over the same 14 year time period were correlated with the estimated spawn year effect percentage of eyed embryos to determine environmental factors. The direct genetic effect had a small heritability (0.059 ± 0.009) as did the maternal genetic effect (0.039 ± 0.013). Comparatively, the maternal environmental effect accounted for a moderate amount of the phenotypic variance (0.165 ± 0.012). The spawn year effect was statistically significant ($p < 0.01$), and the values were negatively correlated with yearly un-ionized ammonia (mg/L, -0.56, p = 0.04,), nitrate concentrations (mg/L r= -0.65, p=0.01) and temperature (°C, r = -0.61, p = 0.02).

Overall, the results indicated that the decrease in eyed embryos over time was not caused by genetic selection but instead due to increases in water temperature and/or nitrogenous waste concentrations in the broodstock rearing system.

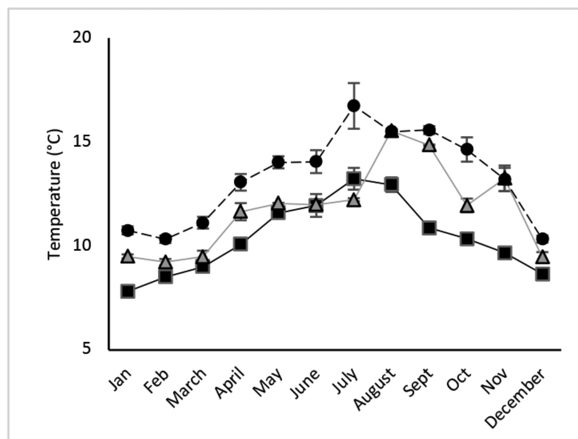

Figure 1: Temperature every 6 years black line with squares (2009), gray line with triangles (2015), dash lines with circles (2021). Points indicates averages error bars SEM

Table 1: Correlation table for eye-up rates correlated with un-ionized ammonia, nitrite and temperature

	Parameters	r	p-value
Eye-Up	Un-ionized ammonia (mg/L)	-0.56	0.04
Eye-Up	Nitrite (mg/L)	-0.65	0.01
Eye-Up	Temperature (C)	-0.61	0.02

SWIMMING UPSTREAM: BREAKING THE BARRIERS TO GENDER EQUALITY IN AQUACULUTRE

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While women are gaining footholds in aquaculture there are specific steps that can be taken to insure continued presence of women in leadership roles.

1) At conferences
    a. insure rooms for breastfeeding and pumping
    b. provide resources for childcare at the conference city
    c. makes sure all panels include at least one woman (preferably 50%)
2) In private industry
    a. Provide parental benefits that extend for at least 3 months
    b. Work to provide childcare resources at or as close to the workplace as possible
    c. Work to move women into leadership and mentor roles

EXAMINING THE SOCIAL ACCEPTABILITY OF AQUACULTURE ON FLORIDA'S GULF COAST

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The United States' seafood systems are likely to transition to more farmed production in the decades ahead, mirroring trends seen around the world. Given the shortage of arable land and limited freshwater resources, much of this growth is likely to come from marine aquaculture. Despite its promise, there is considerable social resistance to marine aquaculture, which is stalling development and creating rifts in communities. Part of the challenge is that social acceptance in aquaculture is complex and poorly understood, largely due to limited data. The Florida Gulf Coast is an ideal place to examine these dynamics because there has been increasing interest and attention paid to offshore aquaculture development in the region, and ongoing controversy about a proposed offshore pilot finfish farm. Focusing on communities along the Gulf coast of Florida between Tampa and the Florida Keys, this research uses semi-structured interviews with target stakeholder groups including local government, environmental non-governmental organizations, seafood buyers, commercial and recreational fishermen, aquatic farmers, and academia/extension as well as focus groups with the general public to better understand social acceptance of aquaculture in Florida. These interviews and focus groups examine awareness of aquaculture (broadly and specific to participant communities), the strengths of U.S. aquaculture, barriers to acceptance, and distinctions in acceptance (e.g., by species or gear type). Preliminary results suggest that aquaculture, notably offshore aquaculture, is far less controversial than has been portrayed in the media or public comments on permit applications. This study will provide researchers, farmers and decision-makers with a better understanding of the social acceptability of aquaculture, which could inform and improve aquaculture development throughout the U.S.

LIVELIHOOD DIVERSIFICATION AND TRANSITIONS IN SHELLFISH AQUACULTURE ON THE EAST COAST OF THE U.S.

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Shellfish aquaculture is the largest sector of aquaculture in the United States, but it is an anomaly in the agrifood economy because it is primarily comprised of small-scale farms. It is also a relatively new industry compared to land-based farming. The ubiquity of small farms and shellfish aquaculture's recent rise in commercial seafood production in the U.S. make it an interesting focus for the study of livelihood diversification. Further, aquaculture is often touted by decision-makers as an additional or alternative livelihood option for fishers, though there is very little research on whether fishers in the U.S. are adopting aquaculture, and what fishers or farmers think of this livelihood pathway. This study uses semi-structured interviews with shellfish farmers and fishers in different communities on the east coast to understand their perspectives on aquaculture as a livelihood diversification option, and if they decided to diversify or transition into aquaculture, why they chose to do so. The findings from this research indicate that, despite some technical similarities between shellfish fishing and farming, fishers and farmers do not see aquaculture as a logical or straightforward transition from fishing, a view driven largely by the perception of sociocultural differences in fishing and farming communities, and the non-material benefits these industries offer. As shellfish aquaculture continues to expand across the U.S., research trying to understand why individuals pursue this profession will be of increasing importance to inform regulations and management systems.

MICROENCAPSULATED BLEND OF CITRIC ACID, SORBIC ACID, THYMOL, AND VANILLIN STIMULATES IN-FIELD PERFORMANCES OF CHANNEL CATFISH *Ictalurus punctatus*

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At the global level, infectious diseases have a major economic impact on aquaculture species associated with poor growth performance, mortalities and treatment costs. In recent years, there has been increasing interest in alternative natural ingredients for the development of novel functional feed to tackle these matters: organic acids, as well as botanicals and their chemically derived equivalents, nature-identical compounds, have been used as antimicrobials and additives improving feed efficiency and growth whilst exerting immunomodulatory support. This trial aims to evaluate the effects of a microencapsulated functional additive (MFA), AviPlus®Aqua, a blend of citric acid, sorbic acid, thymol, and vanillin on growth and feed efficiency of channel catfish (*Ictalurus punctatus*) in grow-out farming conditions. The trial was set in a commercial farm located in Alabama, with four In-Pond Raceway System (IPRS). The raceways, each 115 m^2, were located in the same four hectares pond, sharing the same water with paddlewheels providing water movement and aeration. Each raceway was stocked with ~8,400 fingerlings (mean weight 38 g). Diets were formulated and manufactured in Alabama (28.0% protein, 2.5% crude fat and 7.0% crude fibre). Two diets, control and test diet, were tested in duplicates and both had the same formulation, but test diet included 0,15% of MFA AviPlus®Aqua applied with oil coating. Trial duration was 270 days (~9 months) and at the end of the trial all fish were harvested, weighted and survival and Feed Conversion Rate (FCR) were estimated. Final body weight (FBW) differed highly with test diet recording higher growth compared to control (+37.5%), however survival showed no differences resulted in 92% aggregated for all treatments. Consequently, harvested biomass differed between treatments (+28.2%). FCR was influenced by the test additive too: diet with AviPlus®Aqua recorded 1.67 against 2.08 of control group (-19.4%). The results obtained in this farm trial supports the benefits observed in other fish species in the use of botanical-based functional feed, improving the overall health condition allowing the animals to use energy on growth raising efficiency in the utilisation of the feed. The data therefore support the use of AviPlus®Aqua as a beneficial and feasible tool to improve the performance of channel catfish during the grow out months.

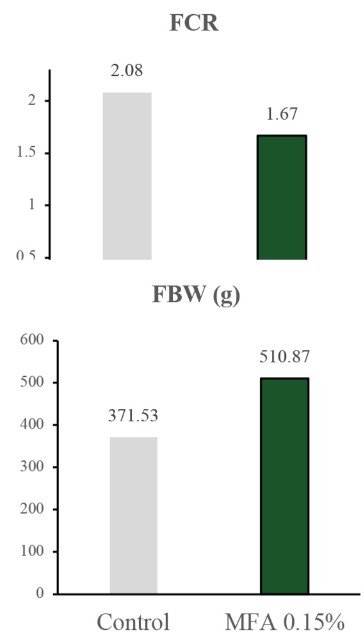

Fig. 1 – Aggregated 9 months results of field data – zootechnical parameters.

RESPONSES OF PURPLE MUD CRAB *Scylla tranquebarica* TO VARIOUS SACCHARIDE SOLUTIONS AND THE SACCHARIDE-COATED PELLETED FEEDS

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Mud crabs (*Scylla* spp.) are economically important portunid species for aquaculture in many countries across the Indo-Pacific region. However, there is still no commercial species-specific formulated feed available for mud crabs, and mud crabs generally reject pelleted feed and the commercial formulated feeds available for other farmed aquatic species. Therefore, diets attractability and palatability are important criteria to develop formulated feed for mud crabs. To identify the suitable chemoattractant for attracting mud crabs to the feed, and also feeding stimulant to promote feed ingestion in mud crabs, the present study examined the *S. tranquebarica* appetitive response towards the solutions of various saccharides (galactose, glucose, sucrose, maltose, fructose, mannose) at 1.0 M, 0.1 M, and 0.01 M in Experiment I, and also its feeding response towards the pelleted feeds, coated with the selected highly stimulative saccharides (galactose, glucose, sucrose or fructose) in Experiment II. In Experiment I, all saccharides tested were stimulative to the *S. tranquebarica*. At 1.0 M, galactose, glucose, and sucrose were the most stimulative saccharides, although they were not as stimulative as the marsh clam extract (positive control). The stimulative effects of galactose and glucose were not significantly reduced when they were tested at 0.1 M. In Experiment II, the pelleted feeds coated with the selected saccharides at 0.1 M were more attractive (higher mean score) to the *S. tranquebarica* than the control feed (without saccharide coating), but only the mean scores of galactose and sucrose were significantly higher than that of the control feed. Nevertheless, no true ingestion on any of the pelleted feeds was observed, presumably due to the non-ideal dietary inclusion method used. Based on these results, it was concluded that all the saccharides tested were potent chemoattractants to the *S. tranquebarica*. However, additional study is needed to further confirm that these saccharides are also feeding stimulants to the mud crab. Additional research is also required to refine the formulation and application method of these saccharides as a practical chemoattractant or feeding stimulant in the farming of *Scylla* mud crabs.

PROPAGATION FOR RECOVERY AND RESTORATION: A REVIEW OF TWENTY PRIORITY PROGRAMS

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As extinction risk of imperiled aquatic species continues to increase due to impacts of climate change, habitat degradation, and invasive species, the utility of restoration aquaculture will continue to expand. The propagation of aquatic species for the express purpose of recovering threatened or endangered species or restoring unlisted, imperiled populations are priority activities conducted by the United States Fish and Wildlife Service (Service). Developing ecosystem-level benchmarks of success for these programs and continually adapting to their outcomes is critical to ensure sustained contributions to conservation.

Framework analysis-based reviews were conducted to evaluate twenty species propagation programs. For each program, the authors reviewed details associated with recovery or restoration planning; captive propagation; post-release monitoring and evaluation; and adaptive management. Secondarily, gaps in information required to evaluate each category or assess the overall conservation contribution of the program were highlighted.

To elucidate patterns in outcomes among programs, qualitative content analyses were conducted on each report based on the 15 elements described in Lorenzen et al. (2010). Passages in the Executive Summary, and Recommendations and Conclusions sections were coded into one of the 15 element categories and assigned a score of positive (existing program component), neutral (background information), or negative (identified program deficiency). The resulting scores were consolidated by species program and element category into an aggregate matrix to represent overall programmatic status. This analysis showed that propagation programs for recovery of ESA listed species tend to have robust data associated with recovery planning and post-release monitoring and evaluation, while many restoration programs lack the requisite authority structure to ensure consistent application of these activities. A strength of many of the propagation programs that were evaluated is Service leadership related to implementation of genetic principles in broodstock management and population monitoring.

The trends identified in this synthesis can be used to reform existing conservation aquaculture programs to ensure alignment with species recovery and restoration goals. Also, as more species require captive propagation, programmatic development will be strengthened through consideration of these priority propagation framework analyses and this synthesis.

RISK ASSESSMENT FOR SUPER-INTENSIVE RECIRCULATING SHRIMP AQUACULTURE SYSTEMS

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The rapid expansion of shrimp aquaculture in recent decades has made shrimp a readily available and affordable seafood option. In 2021, global shrimp production reached 10.5 million metric tonnes, with nearly 70% originating from aquaculture. Despite its remarkable success, the conventional pond-based shrimp farming industry faces growing environmental and economic sustainability concerns, particularly due to its vulnerability to diseases. Super-intensive recirculating shrimp aquaculture systems (RAS) offer a promising solution to address the rising global shrimp demand while mitigating environmental and disease impacts. However, these systems also present unique challenges and risks that require careful consideration to ensure their long-term viability and profitability. This paper introduces a simplified model to evaluate the financial feasibility of a hypothetical RAS shrimp farm under various risk scenarios and explores the influence of uncertain economic and biological factors on the profitability of RAS shrimp aquaculture. Profitability is assessed using the probability distribution of the net present value of aquaculture production, and we examine the impact of risks in market price, environmental stressor, disease outbreak, system failure, and biological growth on profitability. Our findings contribute to a deeper understanding of the risk profiles associated with RAS shrimp aquaculture and provide valuable insights for investors and farmers to optimize their production strategies.

DEVELOPMENT OF GENETIC BREEDING TO IMPROVE THE EASTERN OYSTERS' GROWTH AND SURVIVAL IN MARYLAND LOW-SALINITY WATERS

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The primary aquaculture regions in Maryland are situated in the upper and middle Chesapeake Bay, characterized by low-salinity waters with an average annual salinity of around 12 ppt. This environmental factor has led to a monoculture in Maryland's aquaculture - the eastern oyster, as most other popular seafood species require higher salinity levels. While oysters can survive in low-salinity conditions, their growth rate is significantly reduced compared to those in higher-salinity environments. Notably, during years of high rainfall, acute low salinity events have caused substantial mortality in both wild and farmed oysters. Consequently, enhancing growth and survival rates of oysters in low-salinity waters has been a key breeding goal in Maryland.

The Patuxent Environmental and Aquatic Research Laboratory initiated an oyster genetic breeding program in 2019, in response to significant losses in Maryland's oyster aquaculture due to two consecutive years of abnormally low salinity. This program consists of two objectives, one is to develop superior oyster lines, including diploids, triploids, and tetraploids, better adapted to Maryland's low-salinity waters, with improved survival and growth rates. Given their growth advantage, triploid oysters have been widely adopted by Maryland growers to mitigate the slow growth caused by low salinity. Enhancing the low-salinity tolerance of diploids and tetraploids that are fundamental in producing triploid seeds for commercial use, is anticipated to improve overall performance of the commercial triploid seed. The other objective is to develop genomic selection (GS) or marker-assisted selection (MAS) method, which expected to facilitate rapid genetic enhancements in wild populations, significantly shortening the breeding cycle.

For the first objective, three low-salinity diploid lines were developed from 2020 to 2023. All the parents of these lines were survivors from laboratory acute low-salinity challenge experiments (2 - 3 ppt), among which one line's parents also incorporated a disease-resistant line. Three triploid lines were produced from Maryland wild stock using chemical induction in 2020, which will be used for a tetraploid creation by crossing with the established low-salinity diploids. The selected low-salinity diploid lines exhibited higher survival rates compared to both wild oysters and triploids in laboratory tests. In a three-year field test, one of the three triploid lines demonstrated accelerated growth compared to the control triploids (from industry) and the other two triploid lines. For the second objective, a multi-trait genomic-best-linear-unbiased-prediction model was identified for shell height, and a Bayes B model was established for survival, both selected for their higher accuracy in cross-validation compared to other models. A genome-wide association analysis identified 30 significant SNPs across the genome for the survival trait, suggesting the potential for marker-assisted selection in this trait. Future efforts will focus on tetraploid production, continuous genetic improvement, and validation of GS models or genetic markers.

AN INTRODUCTION TO FLAVOBACTERIAL DISEASES AND MANAGEMENT: SOME PRACTICAL GUIDANCE FOR PRODUCERS

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Flavobacterial diseases in fish are caused by both well-known and recently described species within the families *Flavobacteriaceae* and *Weeksellaceae*. Globally, these Gram-Negative bacteria cause substantial losses in farmed and wild fish populations, where outbreaks can be relatively difficult to effectively prevent and control despite over a century of scientific research. Herein, an introduction to the fish-pathogenic flavobacteria will be provided, which will then be followed by a discussion of some practical, science-informed guidance that can be used to reduce the risk of flavobacterial disease outbreaks in farmed and hatchery-reared fishes.

EVALUATING THE SUPPLEMENTATION OF SOY LECITHIN FOR THE PRODUCTION PERFORMANCE AND PHYSIOLOGICAL RESPONSES OF CHANNEL CATFISH *(Ictalurus punctatus)*

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Soy lecithin is a valuable co-product of soy oil extraction with high content of phospholipids, which can be used as a feed additive for aquafeeds. The supplementation of phospholipids in aquafeeds may have to meet the essential requirements for physiological and metabolic function. The supplementation of soy lecithin can influence stress, improve the growth performance, and survival of several aquatic species, including channel catfish, *Ictalurus punctatus*. The present study is evaluating incremental doses of soy lecithin (0, 0.5, 1.0, 1.5, and 2%) in catfish diets to determine the optimal supplementation level in a plant based experimental feed. The fish were stocked in a recirculating aquaculture system and subjected to a feeding trial for12 weeks, and this feeding trial is currently ongoing. At the end of the study production parameters will be collected and fish will be challenged by air exposure and stress markers (plasma cortisol, blood glucose, plasma osmolality, and lactate), and hematocrit will be measured. The remaining fish will be subjected to a bacterial challenge (*Edwardsiella ictaluri*), to evaluate disease resistance and survival. The survival after bacterial challenge will be evaluated using the Kaplan-Meier survival test.

Table 1. Preliminary growth performance of channel catfish with the inclusion of (0, 0.5, 1, 1.5, and 2%) soy lecithin during six weeks. Data are presented as average ± standard deviation.

Variables	Treatments				
	Control	0.5%	1%	1.5%	2%
Initial weight (g)	4.42 ± 0.1	4.37 ± 0.18	4.38 ± 0.12	4.39 ± 0.07	4.48 ± 0
Final weight (g)	18.11 ± 0.93	18.3 ± 0.7	18.32 ± 2.58	17.75 ± 2.58	18.4 ± 1.09
Weight gain (%)	310.25 ± 26.97	319.5 ± 9.04	318.16 ± 21.93	304.22 ± 58.3	310.25 ± 26.97
Survival (%)	100	100	100	100	100
Feed efficiency	0.62 ± 1.11	0.60 ± 2.27	0.59 ± 1.51	0.57 ± 10.98	0.61 ± 3.67

GENDER ANALYSIS FOR AQUACULTURE DEVELOPMENT: A CASE STUDY FROM MAINE AND NEW HAMPSHIRE OYSTER FARMING INDUSTRY

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New England is a leader in sustainable aquaculture practices and, in comparison with other parts of the United States, has high numbers of woman-operated leases for shellfish cultivation. There is a small, but emerging body of literature focused on gender equity for the region's aquaculture industry. However, the existing policies have not acknowledged or accommodated the diversity of participants entering the industry. Without demographic information such as gender incorporated into fishery and aquaculture datasets, we lack a comprehensive understanding of resource management, distribution of benefits, and equitable engagement in the industry. We surveyed a subset of oyster farmers in Maine and New Hampshire to allow for a gender analysis of barriers and opportunities to working in the industry for example in funding opportunities, training programs, social networks, and gear. We also implemented a photovoice case study, a participatory action research methodology, with four women oyster farmers to share stories about their experiences as oyster producers and to understand the role of social networks in how women start and build businesses on the water. Investigating aquaculture development through a gender lens can provide insights to inform more socially equitable management and policy decisions for aquaculture expansion.

Our findings provide a baseline of data shedding light on the role of gender in oyster farming in Maine and New Hampshire to foster equal economic opportunities for working on the water and growing local, sustainable seafood. More broadly, our findings contribute to emerging research applying gender and social-ecological systems analyses to understand how gender dynamics impact barriers and opportunities for aquaculture producers in the United States

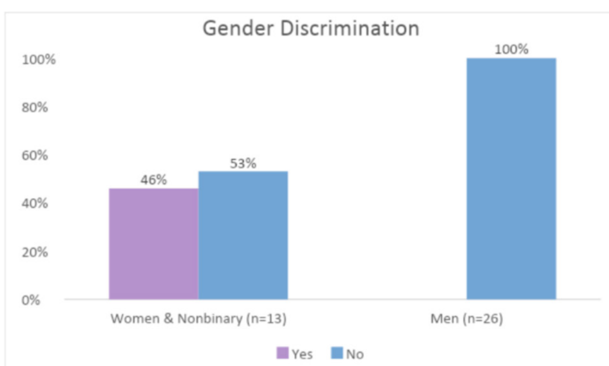

Figure 1. Survey respondents reporting differential treatment at work in the oyster aquaculture industry in ME and NH by gender. Women and non-binary identifying (n=13), men identifying (n=26). Relationship between gender and differential treatment is statistically significant (p<0.001).

OYSTER FARMING THROUGH A GENDER LENS: A PHOTOVOICE CASE STUDY

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New England maintains the highest numbers of women operated oyster farms in the country. However, aquaculture policy has not kept up with the diversity and innovation of the sector. Although women make up half the workforce in the seafood sector globally, their contributions are largely left out of management decisions. In the United States, data on gender are not currently collected, for example as part of the state aquaculture permitting process. To shed light on women's participation in the industry, this research conducted a photovoice case study with four women who own and operate oyster farms in Maine and New Hampshire. Photovoice is a photography and visual storytelling methodology that is commonly used to engage and empower women while also expanding their community networks. The methodology involves a training photo documentation period including written narratives, semi-structured interviews, a focus group, and a final public exhibit. Furthermore, the photovoice methodology is increasingly used as a tool to address the social-ecological issues in fisheries and aquaculture

Our findings provide a baseline of data on the role of gender in oyster farming in Maine and New Hampshire to foster equal economic opportunities for working on the water and growing local, sustainable seafood. Integrating gender analysis in aquaculture development is critical to ensure equal access and opportunity for women to a viable business, a social support system, and the ability to produce food with positive impacts on ecosystem biodiversity, water quality, and a small or neutral carbon footprint. More broadly, our findings contribute to emerging research applying gender and social-ecological systems analyses to understand how gender dynamics impact barriers and opportunities for aquaculture producers in the United States.

Figure 1. "Boat Problems and Triumphs" by Alicia Gaiero (Lord, 2022).

ENVISIONING OUR AQUACULTURE FUTURE: A DESCRIPTION OF OCEAN ERA'S PROPOSED OFFSHORE FISH AND SEAWEED FARM (O'AHU, HI)

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Development of a domestic offshore aquaculture industry remains nearly stagnant. Only Maine and Hawai'i have food fish farms in their coastal waters. As an isolated Island State, Hawai'i is almost completely reliant on transocean imports for nearly everything, staple foods, fossil fuels (for energy and transporation), building materials and consumer goods. With an eye to make our home more self-sufficient, while nurturing our incredible ocean resources, Ocean Era will be applying for the requisite State and Federal permits to install and operate an open ocean fish and seaweed farm off O'ahu's south coast.

The Nation's first open ocean fish farm (HOARP, later Hukilau Foods) was operated from 1999 - 2014, close to our proposed location. We propose to raise a variety of marine finfish that will serve our local seafood market, as well as be exported to the Continental US. The fish species that will be included in the permit application include Nenue (*Kyphosus vaiginesis*), Moi (*Polydactylus sexfilis*), and Kanpachi (*Seriola rivoliana*). Since the waters offshore of O'ahu at our prosed site are too nutrient poor to support seaweed growth, the seaweed lines will be added to the system after two or three cages are stocked with fish. *Caulerpa lentilifera, Halymenia hawaiiana* and *Gracilaria parvispora* are the types of seaweed under consideration for production.

DEVELOPMENT OF A NOVEL METHOD FOR STERILITY INDUCTION IN FISH AND SHELLFISH AQUACULTURE

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Reproductively sterile fish and shellfish are widely used in aquaculture to reduce ecological concerns associated with aquaculture, improve growth rates and product quality, and allow producers to protect their genetically-selected lines (i.e., intellectual property) from unauthorized propagation. However, current approaches for sterility induction are generally viewed as insufficient. Ploidy manipulation, specifically triploidy, is the most common method employed for sterilization of fish and shellfish. Triploidy induction entails exposing early embryos to a "shock" (e.g., hydrostatic pressure, low/high temperature exposure) to induce retention of a full extra set of chromosomes per cell, changing the ploidy of the individual from diploid (2n) to triploid (3n). Triploid animals generally exhibit reduced survivorship and environmental resilience, which can make them difficult to farm and is of particular concern in light of climate change. Moreover, triploidy methods are underdeveloped for many species and are not always fully effective. Therefore, new approaches for sterility induction are needed.

We are researching an alternative approach for sterility induction that seeks to eliminate the germ cells (i.e., the future gametes) altogether, preventing any possible reproductive development. This novel approach is based on gene silencing technology, which uses "morpholinos" to temporarily silence a gene(s) that is essential to germ cell identity and development. After serving their role, morpholinos degrade and do not introduce any modifications to the DNA (i.e., non-GMO). In order to make this technology scalable for commercial aquaculture, morpholinos were conjugated to a carrier, Vivo, that allows for transport of the morpholinos across the chorion in a bath immersion-style treatment suited for large batches of eggs, circumventing the need to microinject individual eggs/embryos.

Sablefish (*Anoplopoma fimbria*) and Pacific oyster (*Crassostrea gigas*) are being used as model finfish and shellfish aquaculture species, respectively, for this research. In sablefish, proof-of-concept has been achieved. By temporarily silencing a gene known as *dead end* (*dnd*) via immersion of sablefish eggs with a *dnd*-morpholino-Vivo construct, gonads of some resulting fish were completely devoid of germ cells and did not show any signs of reproductive development. Our future work with sablefish aims to optimize this method to attain higher rates of sterility induction and to evaluate the performance of the sterile sablefish in an aquaculture setting relative to untreated and triploid fish.

Since shellfish do not possess the *dnd* gene, our research has sought to identify a gene that plays a similar role in germ cell identity/development. Through single-cell RNA sequencing (scRNA-Seq), a cutting-edge approach that uses high-throughput sequencing to identify genes expressed in individual cells, several candidate germ-cell specific genes have been identified in Pacific oysters. These will be the targets for future trials aimed at silencing their expression to potentially induce sterility. Ultimately, we plan to expand this technology to other aquaculture species.

EVALUATION OF SPLIT-ROOT SYSTEM IN SHRIMP EFFLUENT-BASED SALINE AQUAPONICS FOR MANAGING SALINITY STRESS IN RED KALE ('KX-1') *Brassica napus* L. var Pabularia

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The split-root technique is a promising system for cultivating plants under saline conditions, facilitating the production of salt-sensitive vegetables in saline aquaponics. While saline aquaponics typically uses salt-tolerant plants due to high salinity levels, these plants have not yet reached consumer acceptance. Integrating high-value vegetables like red kale could significantly enhance economic feasibility. Split-root enables a plant to have more than one root zone environment, which is crucial for nutrient and water uptake under salinity stress. The system allows direct use of shrimp aquaculture effluents at high salinity levels, without dilution, avoiding reduced nutrient concentrations for plants.

Despite its potential, there is a lack of studies on split-root application in Deep Water Culture (DWC), a prevalent aquaponics system. Thus, a study was conducted to evaluate the split-root system in managing salinity stress in red kale within a DWC aquaponics setup based on shrimp effluent. The experiment encompassed a completely randomized design with three treatments: Hydroponics at 0 parts per thousand (ppt), Saline Hydroponics at 10 ppt, and Shrimp effluent at 10 ppt. Two split-root conditions, homogeneous and heterogeneous, were used to create different root environments.

The results of the ANOVA showed significant interactions ($p<0.05$) among the conditions and salinity levels for size index, biomass accumulation, and plant height. Heterogeneous conditions demonstrated higher performance at 10 ppt salinity compared to homogeneous conditions and there were no significant differences ($p>0.05$) between the saline hydroponics and the shrimp effluent treatments. However, in photosynthesis measurements and tissue analysis, no interactions were found between conditions, but there were significant differences among the salinity levels. Hydroponics (0 ppt) was significantly different ($p<0.05$) from the rest of the treatments under both the homogenous and heterogenous conditions, whereas saline hydroponics and shrimp effluent did not show significant differences ($p>0.05$). The study highlights the effect of the split-root heterogeneous condition in managing salinity stress in red kale, offering valuable insights into optimizing plant growth under saline conditions while showing potential opportunities for further research.

CIRCULAR AND CYCLICAL MATING SYSTEMS TO MINIMIZE INBREEDING ACCUMULATION IN CLOSED POPULATIONS

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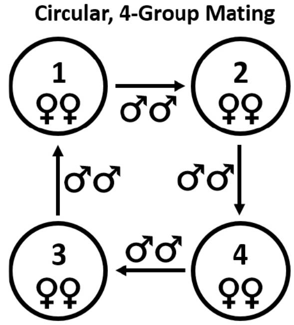
One objective in most aquaculture breeding programs is to maintain as much genetic variation as possible from one generation to the next by avoiding mating of closely related individuals. This is especially true for conservation aquaculture, when wild populations are to be enhanced with hatchery reared animals. However, no mating system can actually prevent the accumulation of inbreeding in a closed population over an extended number of generations. As the quantitative geneticists Kimura and Crow stated in their 1963 article *On the maximum avoidance of inbreeding*, “a system that avoids mating of relatives for as long as possible does so at the expense of a more rapid final approach to homozygosis.” However, some strategies are available to minimize loss of genetic variation over time. When they are applied correctly, the result is a mathematical increase in the effective number of reproducing individuals.

Most of the mating systems that have been developed for minimizing inbreeding in small populations involve subdividing the population into a number of groups, and then maintaining distinct breeding groups in subsequent generations. The simplest of these systems is referred to as Circular Mating, wherein individuals within each group are allowed to reproduce, and in the subsequent generation the male offspring from each group are transferred to mate with female offspring from an ‘adjacent’ group. When broodstock numbers are low, inbreeding accumulation rates are somewhat high in earlier generations but they tend to level off over time and actually remain at levels somewhat lower than those attained by other mating systems.

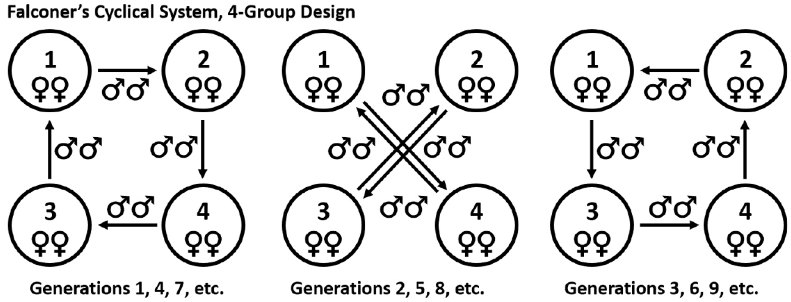
Cyclical mating systems are superior for minimizing inbreeding in earlier generations. They also rely on exchanging males between groups but the exchange patterns vary, cyclically, over generations. In cyclical mating systems, inbreeding levels among groups can bounce up and down from generation to generation, but the long-term trend still results in accumulation.

Circular, 4-Group Mating



Same transfer pattern each generation.

Falconer’s Cyclical System, 4-Group Design



DEVELOPMENT OF RIFAMPICIN AND NOVOBIOCIN RESISTANT *Aeromonas salmonicida* STRAINS AND THEIR POTENTIAL AS LIVE ATTENUATED VACCINE CANDIDATES

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Aeromonas salmonicida, the causative agent of furunculosis, poses a significant threat to a diverse range of hosts in both fresh and marine fish. Currently, there are no commercial vaccines available to treat furunculosis in non-salmonid fish. Limited vaccine options exist to prevent furunculosis in sablefish specifically. This problem is evident as sablefish aquaculture has intensified in the Pacific Northwest, furunculosis continues to cause high mortality rates during production. The primary objective of this study is to develop a live-attenuated vaccine suitable for immersion administration, aiming to effectively treat furunculosis in sablefish for commercial aquaculture production. Attenuated strains of A. salmonicida were generated using rifampicin and novobiocin through successive passages on TSA with escalating concentrations of the antibiotics, reaching up to 400 mg/ml for both rifampicin and novobiocin. Attenuation of *A. salmonicida* strains was confirmed through in vivo challenges in sablefish and rainbow trout. Overall, the proposed live-attenuated vaccine to prevent furunculosis in sablefish and rainbow trout could become an asset to sustainable aquaculture management if proven effective.

EFFECT OF BIOFLOC SYSTEM ON WATER QUALITY AND GROWTH OF IMC IN INDORE TANK

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Biofloc technology is a technique of enhancing water quality in aquaculture through balancing carbon and nitrogen in the system. The technology has recently gained attention as a sustainable method to control water quality, with the added value of producing proteinaceous feed *in- situ*. The present study was conducted to compare the effects of *in-situ* produced biofloc and externally added biofloc on the growth and production of IMC under different stocking densities in light limited Indore tank.

Experiments were carried out in twenty seven cemented tanks (1000 L each) for a period of 90 days. The experimental design included *in-situ* biofloc, externally added biofloc and control treatments conducted at three different stocking densities (STD) 25, 50 and 75 no. fish per m^3 of tank respectively with each experiment replicated thrice.

IMC of individual average weight 15± 1.6 g was reared in all treatments. In *in-situ* biofloc treatment, low protein (20%) commercial fish feed was added initially. Further, organic carbon in the form of wheat flour was added daily to maintain the C:N ratio at 10 . The amount of feed and extra carbohydrate required in biofloc process varies with time as biomass density varies with time. Around 60% extra carbohydrate to be applied in a typical *in-situ* biofloc tank.

In externally added biofloc treatment, 50% of fish feed and 50% wet floc was added. The biofloc was produced in a 25 m^3 cemented tank using aquaculture effluent from a nearby carp culture pond and maintaining the best C:N ratio of 10. In control treatment, high protein (30%) commercial fish feed was added. In all the treatments, TAN concentration was kept below 1 mg L^{-1} through 50% water exchange whenever required (Table-1). Feeding rate, water quality parameter and fish growth parameter were determined following standard methodology. TSS and BOD levels were more in *in-situ* biofloc treatment as compared to the control and externally added biofloc treatments.

Table:1 Details of water exchange in different treatments.

STD (no/m^3)	Treatments	Number of water exchanges	Days of water exchange
25	Control	4	30, 42, 60, 72
	In-situ Biofloc	3	53, 65, 86
	Externally added	2	63, 85
50	Control	4	23, 50, 65, 83
	In-situ Biofloc	3	31, 62, 77
	Externally added	2	42, 76
75	Control	5	20, 32, 47, 62, 77
	In-situ Biofloc	4	44, 59, 71, 83
	Externally added	3	43, 67, 88

The harvested weight of fish in externally added and *in-situ* biofloc treatment with STD 25 no./m^3 were found to be significantly higher among all the treatments ($p < 0.05$). The results achieved in the study confirmed the trends of decrease in growth for IMC species with increased stocking densities. During the 90 days culture period net fish yield was highest (4306 ± 59.60 kg ha^{-1}) in externally added biofloc tank with highest stocking density (STD 75 no/m^3). Fish survival was 100% in all the treatments. The FCR values in *in-situ* biofloc treatment and externally added biofloc treatment were less compared to the control treatment.
Table:1 Details of water exchange in different treatments.

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DEVELOPMENT OF A PCR-BASED DIAGNOSTIC ASSAY FOR WHITE SPOT SYNDROME VIRUS (WSSV) IN FORMULATED AQUAFEED

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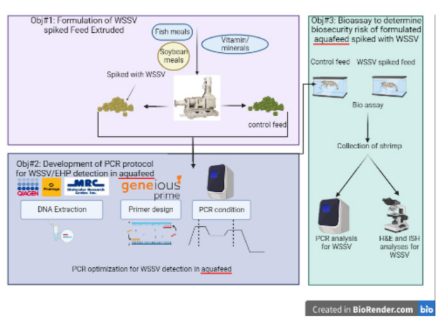
Formulated aquafeed holds promise as a safer alternative to fresh feed, offering numerous advantages in large-scale farming of crustacean and fin fish. However, the current limitations of PCR-based detection methods hinder their broad application for testing a diverse range of aquafeed and feed ingredients. In response to this challenge, our objective is to develop a robust and validated PCR-based diagnostic assay for detecting WSSV in aquafeed. This assay will play a pivotal role in facilitating disease-free certifications of formulated aquafeeds, thereby ensuring the health and well-being of farmed aquatic animals.

Experimental shrimp feeds were produced by incorporating WSSV-infected tissue containing a viral load of 3.07 x 10^7 copies/mg of tissue into a commercial-type shrimp feed formulation prior to extrusion. In order to find an optimal method of DNA isolation from aquafeed, total genomic DNA was isolated using four different methods. The viral polymerase gene was selected as a target gene to develop a PCR protocol for WSSV detections since the polymerase gene plays an important role in WSSV replication. Four sets of primers/probes (corresponding to three conventional PCR protocols and one real-time PCR protocol) targeting the polymerase gene of WSSV were developed. The specificity and limit of detection of the newly developed PCR protocols were determined. Diagnosis sensitivity (Dse) and Diagnosis specificity (Dsp) of the PCR methods were determined using known WSSV-spiked feed.

The newly developed primers and probes detected only WSSV in the specificity test. To determine the limit of detection (LOD), three independent assays were conducted for each primer pair. The LOD was 100 copies/reaction and 10 copies/reaction for conventional PCR and real-time PCR assays, respectively.

The PCR assay using WSSV polymerase as a target gene for PCR amplification has a high sensitivity and specificity in detecting WSSV in formulated aquafeed. Since polymerase is a critical gene in viral replication, a lack of amplification of polymerase would indicate that aquafeed does not contain infectious WSSV. The WSSV detection method described here can provide an effective means of determining the infectivity of aquafeed products. By providing a means to evaluate the infectivity of aquafeed products, we empower industry stakeholders to make more informed choices, reduce waste, and optimize the utilization of resources, ultimately benefiting both the environment and economic sustainability.



ASSESSING WOMEN'S INVOLVEMENT AND THEIR KNOWLEDGE, ATTITUDE AND PRACTICES (KAP) ON SAFE FISH PRODUCTION

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Aquaculture is the fastest growing sector that is meeting the global protein requirements as well as creating a stable earning source for many people. However, women's contribution in aquaculture is immensely unrecognized, especially for safe fish production. Therefore, this study investigates women's contribution to aquaculture and their knowledge, attitude, and practices (KAP) on safe fish production in Mymensingh district of Bangladesh considering 120 randomly selected women. This study was conducted on polyculture fish production system. The KAP index was estimated to assess KAP level, and the Tobit model was used to determine the factors influencing KAP level of women. In addition, Structural Equation Model (SEM) was employed to determine the causal relationship among knowledge, attitude, and practice on safe fish production. Preliminary results revealed that, women had significant contribution in fish production activities which was about 19.18% in terms of total person-days in a year. Among different fish farming activities, women contributed significantly (81.61%) to feed application during the culture period. Based on the KAP index, women's level of knowledge and attitude on safe fish production were acceptable and good respectively, but practice level were not satisfactory. Furthermore, experience, training, farm ownership, and connection with pharmaceutical companies had statistically significant positive effects on the KAP level. On the contrary, education had insignificant effects on their KAP level. The results of SEM analysis found a significant positive association between women's knowledge with practice and attitude level. Considering the findings, increasing level of knowledge of women can improve attitude and practice towards safer fish production. Hence, the government and NGOs should pay special attention to improving safe fish production knowledge, attitudes, and practices of women to recognize women's contribution and enhance nutrition security for millions of fish-dependent households.

EFFECTS OF REDUCED ALTERNATE DAY FEEDING ON THE GROWOUT OF DOMESTIC STRIPED BASS *Morone saxatilis* IN RECIRCULATING AQUACULTURE

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Striped bass (*Morone saxatilis*) is an emerging new cultivar in the U.S. due to its ability to grow rapidly up to 1.3 - 2.3 kg (3 - 5 pounds) within a 24-month production cycle. The feasibility of cultivating this species has increased with successful domestication and many years of selective breeding for improved growth characteristics. Our previous research suggests that feeding striped bass every other day (3x/week) instead of daily (5x/week) to satiation may improve feed efficiency while having little impact on growth performance, particularly at larger body sizes of around 475 g. Here, we tested if feeding fish on alternate day at a reduced feeding rate could improve feed conversion efficiency and the amount of feed required to grow fish to market size relative to daily fed fish. We investigated the effects of feeding daily (7x/week) vs. alternate day (3-4x/week) on striped bass growout. Fish (500 g) were fed daily (2% BW/day) throughout 253 days. Fish on the alternate day feeding regime were fed at the following rates relative to daily fed fish: 50% for 0-89 days and 75% for 90-253 days. Alternate day fish were subsequently shifted to daily feeding at 100% rate to that of the daily fed group until reaching 2 kg body size.

The mean weight (0.95 ± 0.008 kg) and length (41.26 ± 0.10 cm) of the daily fed fish were significantly higher than that of alternate day fed fish weight (0.72 ± 0.006 kg) and length (39.55 ± 0.09 cm) by day 89. This significant difference in growth continued throughout the course of the study. After 253 days, the daily fed fish (1.97 ± 0.01 kg) were 22.8% larger than alternate day fed fish (1.52 ± 0.02 kg; $p< 0.001$). The alternate day fed fish caught up (compensatory growth) to daily fed fish sizes within 2.5 months (1.91 ± 0.03 kg) after being shifted to daily feeding. The overall feed conversion ratio (FCR) did not differ between feeding regimes (FCR 1.61). However, similar to our previous study, the FCR changed with fish age although at greater body size. FCR was 9.1% better in daily fed fish after the first 89 days (FCR 1.49 fed vs. 1.64 alt) and 5.8% after 187 days (FCR 1.47 fed vs. 1.56 alt). Interestingly, at 253 days the FCR shifted and was 17% better in alternate day fed fish (FCR 2.0 fed vs. 1.66 alt). The FCR during the compensatory growth phase of alternate day fed fish was 2.4, making the overall plus the catchup period FCR 1.79. These data show that overall feed conversion does not differ between daily and alternate day fed striped bass but there is a negative effect on growth performance in alternate day fed fish. However, a shift to daily feeding can ameliorate the delayed growth response of alternate day feeding with extended growout time. The FCR of alternate day fed fish at 1.5 kg was notably better than daily fed fish when approaching sizes of 2 kg. More work is needed to fully understand the age effects on FCR in striped bass. These results show that 0.5 kg BW striped bass fed daily grew very rapidly to 2 kg (6 g/day) while fish fed under the current alternated day regime grew 4.6 g/day. Increasing the initial rate of feed on alternate days, where fish growth rates declined the most (0-89 days), is likely required to produce fish of comparable size as daily fed fish while providing potential for improved feed conversion.

MARINE MAMMAL ENTANGLEMENTS IN THE UNITED STATES: A NATIONAL OVERVIEW UNDER NOAA'S MARINE MAMMAL HEALTH AND RESPONSE PROGRAM

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Entanglement in, and ingestion of, active, lost, or discarded fishing gear and marine debris is a global problem affecting many species, including marine mammals. All species of marine mammals can become entangled. Entanglement injuries can result in death from infection, starvation, amputation, blood loss, strangulation, or drowning/asphyxiation. Death can be immediate or take weeks, months, even years.

U.S. marine mammal entanglement response networks, administered by NOAA Fisheries' Marine Mammal Health and Stranding Response Program, were established to safely and effectively respond to reports of entangled marine mammals under NOAA Fisheries' jurisdiction. The networks are separated by taxonomic group and required skill set: large whales (baleen and sperm whales), small cetaceans (dolphins, porpoises, and small toothed whales), and pinnipeds (seals, fur seals, and sea lions). These response operations depend on the collaborative skills of many state and federal agencies, non-profit organizations, coastal communities, and other individuals working together.

While the removal of some or all of the entangling material by response teams increases the likelihood of that individual animal surviving, entanglement response of individual animals is not a sustainable solution for the long term. Preventing marine mammal entanglement is a critical goal for NOAA and our partners.

Analyzing materials removed from entangled animals provides information that may lead to actions to reduce the risk of future entanglements. This ultimately aids in the conservation and management of many species, including those listed as threatened or endangered under the Endangered Species Act. While fishing gear and marine debris account for the majority of marine mammal entanglements in the United States, the origin of the gear cannot be determined in many cases. Entanglement networks have documented cases in which marine mammals have become entangled in aquaculture gear. As aquaculture increases in scale, expands into new habitats, and gear types continue to be developed, there is potential for increasing marine mammal entanglements in aquaculture gear.

THE EFFECTS OF FOOD LEVEL AND STOCKING DENSITY ON GROWTH AND SURVIVAL OF YELLOWFIN TUNA *Thunnus albacares* AND PACIFIC BLUFIN TUNA *Thunnus orientalis* LARVAE

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A comparative study investigating the effects of food level and stocking density on growth and survival of larvae was conducted with yellowfin tuna (YFT) *Thunnus albacares* at the Achotines Laboratory, Inter-American Tropical Tuna Commission (IATTC), Republic of Panama, and Pacific bluefin tuna (PBF) *Thunnus orientalis* at Oshima Station, Kindai University, Japan, in May and July of 2023.

Larvae of each species were tested during the first 10 days of feeding (DOF) under replicated combination treatments of low and high food levels (500 rotifers/L and 5000 rotifers/L), and low and high initial stocking densities (5 larvae/L and 15 larvae/L). The replicated treatments were: High Food: Low Density (HF:LD); Low Food: Low Density (LF:LD); High Food: High Density (HF:HD); and Low Food: High Density (LF:HD).

Larvae were sampled on 1 DOF, 6 DOF and 11 DOF, and measurements of standard length (SL), and dry weight (WT) were obtained. On the last day of the experiment, all individual larvae from each tank were manually counted and an estimation of expected survival rate and standardized biomass of each treatment cohort were made.

With YFT larvae, both food level and density significantly affected growth in SL and WT (ANOVA, $P < 0.01$). With PBF larvae, however, only food level significantly affected final SL and WT (ANOVA, $P < 0.01$), and density only affected growth significantly when interacting with food level ($P = 0.016$). At all treatment levels except the LF:HD level, specific growth rate (SGR) in dry weight was higher for YFT compared to PBF and ranged from 28-33%/d, while SGR for PBF ranged from 27-30%/d. In the LF:HD treatment, SGR in dry weight was nearly the same for both species (23-24%/d). Survival rates on DOF 11 were higher for YFT compared to PBF over all treatments, and ranged from 5-22%, including a surprisingly-high level of 20% at the LF:LD treatment. For YFT, there were statistically significant differences in final survival among treatments (ANOVA, $P< 0.05$), and stocking density significantly affected final survival. Over all treatments, mean survival at DOF 11 for PBF ranged from 4-14%, and no significant differences in survival were detected among food treatments, although food level had a stronger effect than density on survival. With both species, only food level had a significant effect on standardized biomass of the cohort (ANOVA, $P < 0.05$).

Food level strongly affects growth of both species, with stocking density exhibiting a pronounced effect on YFT survival. YFT exhibit surprisingly strong survival and growth under low density conditions. Both species show high potential as candidate species for marine aquaculture.

EFFECTS OF ENVIRONMETAL MANIPULATIONS ON THE SURVIVAL, GROWTH, AND FEEDING INCIDENCE OF LARVAL *Neocirrhites armatus*

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The flame hawkfish (*Neocirrhites armatus*) is a marine ornamental fish endemic to the Indo-Pacific and is popular in the aquarium trade due to its bright coloration, small size, and behavior. Captive rearing of hawkfish is of great interest but is limited by broodstock spawning and defined larviculture protocols. Fertilized embryos yield altricial larvae lacking functional eyes, mouth, and digestive tract, and are thus dependent on endogenous yolk reserves until first feeding. The transition stage from endogenous to exogenous feeding is defined by mass larval mortality due in part to lack of appropriate nutrition. Mortality can be reduced through manipulations of environmental conditions that increase prey capture and promote growth and survival. These conditions are species-specific, and development of such protocols will facilitate culture efforts and promote commercialization of the flame hawkfish.

Initial larval rearing experiments with *N. armatus* evaluated the effects of algae density, algae species, copepod species, copepod density, and prey type on the survival, growth, and feeding incidence from 0 – 5 days post hatch (DPH). The greatest survival and feeding incidence for algal density was 150,000 cells mL^{-1} of *Tisochrysis lutea*. The comparison of algal species showed a significant increase in survival using *Nannochloropsis oculata* over *T. lutea*, with no significant difference in feeding incidence (Figure 1). Larvae fed on *Parvocalanus crassirostris* showed no significant difference in survival and feeding incidence over those fed *Oithona colcarva*. Using these results, rotifers were introduced at first feeding in comparison and alongside copepods as a 50/50 mix. This experiment indicated that larvae cannot consume rotifers at first feeding and still do not ingest them at 5 DPH, resulting in the highest survival and feeding incidence in the copepod only treatment. The prey density experiment compared densities ranging from 1.25 – 5.0 nauplii/mL per day. While initial feeding incidence was significantly greater in the 5.0 copepods mL^{-1} treatment, there was significantly higher survival in the 1.25 and 2.5 copepods mL^{-1} treatments, with significantly greater growth in the 2.5 and 5.0 copepods mL^{-1} treatments. The development of early larviculture protocols for *N. armatus* will provide critical information necessary for commercialization of this species.

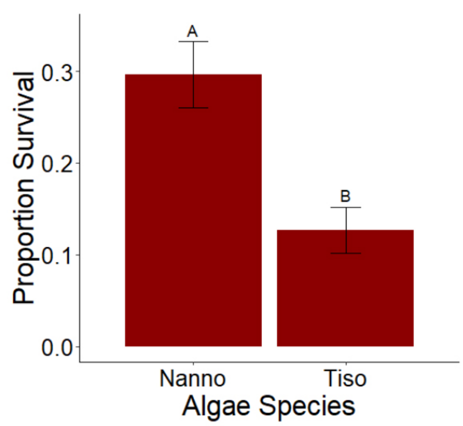

Figure 1. Mean survival (±SEp, n = 5) of *N. armatus* larvae at 3 DPH in response to algal species *T. lutea* and *N. oculata*. Letters above denote significance between treatments ($P \leq 0.05$).

LARVAL DEVELOPMENT OF *Dascyllus auripinnis* AND EFFECTS OF FEED ATTRACTANTS ON SURVIVAL, GROWTH, AND FEEDING INCIDENCE

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The golden domino damselfish (*Dascyllus auripinnis*) is known for its distinct coloration among damselfishes and is popular among collectors in the aquarium trade. Development of culture techniques for the golden domino damselfish will help producers profit from market demand as well as provide insight into the rearing protocols for other damselfish species. The golden domino damselfish was successfully raised at the Tropical Aquaculture Laboratory (TAL) in June of 2023. A broodstock pair has been established at TAL and spawns every 7-10 days on ceramic tiles. Eggs hatch after approximately 72 hours of incubation at 27°C. A larval rearing trial was conducted to culture *D. auripinnis* through metamorphosis to the juvenile stage. A spawn of approximately 10,000 embryos were hatched into a 144 L glass aquarium. Live *Nannochloropsis oculata* was used as greenwater and larvae were fed enriched rotifers (*Brachionus plicatilis*) twice daily beginning at 3 days post-hatch (DPH). A total of seventeen fish were settled as juveniles with a resulting survival rate of approximately 0.0017%. Larvae metamorphosis occurred at 42 DPH and was identified by complete pigmentation alongside a change in behavior and association with provided substrate.

Commercialization of ornamental aquaculture species continues to be limited by mass larval mortality in early larval stages. Such mortality can be associated with poor feeding success and insufficient larval nutrition. The addition of appetite stimulants, or feed attractants, is theorized to increase consumption of feeds by promoting the hormones in fish associated with appetite. An improvement in feeding success should in turn lead to better survival and growth of larvae. This approach has been relatively unexplored in marine species and can be used alongside live feeds, such as copepods. To assess the ability of feed attractants to increase ingestion of live feeds, *D. auripinnis* larvae were used in a series of feeding trials. Appropriate dosages of three feed attractants, tryptophan, betaine, and alanine, were determined in first-feeding trials. These initial dosage experiments compared the survival of 3 DPH larvae against a control without feed attractant, after five hours of exposure to the following dosages of each feed attractant: 10^{-4} M, 10^{-6} M, and 10^{-8} M. A dosage of 10^{-4} M tryptophan resulted in equivalent survival compared to the control. A dosage of 10^{-8} M betaine resulted in significantly higher survival than the control treatment. A dosage of 10^{-6} M of alanine was equivalent in survival to the control. These dosages will be used in a final 7-day comparison trial of each feed attractant against a control without feed attractant to determine long-term effects on survival and growth.

DESIGN AND INTEGRATION OF RAS AIRLIFTS

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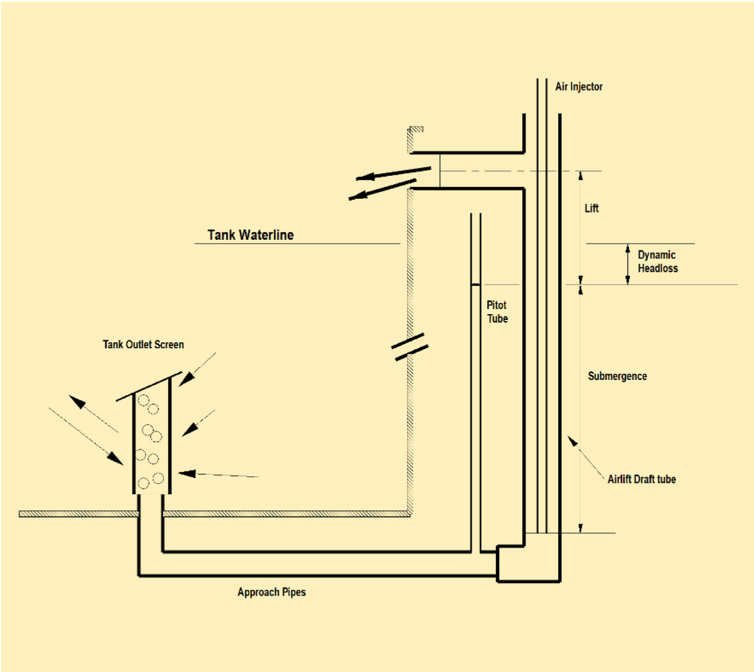
Airlifts are used to reduce the energy cost associated with RAS circulation, aeration, and carbon dioxide stripping. They are generally powered by air from centralized blowers and facilitate the isolation of blocks of tanks providing barrier to the spread of disease.

The benefits are only realized when the RAS system is correctly designed to facilitate low lift circulation typically without the use of a centrifugal water pumps. The Lift to Submergence ratio (S/L) is key to the design and airlift operational efficiencies. The lift is the height the water must be lifted above the hydrostatic head where the air is injected. The hydrostatic head is easily observed by a pitot tube placed just before air injection. L/S ratios in the range of 20-25 percent are considered ideal for RAS applications. The Gas to Liquid ratio (G/L) defines how much air must be injected (in liters per minute) to move a given flow (in liters per minute). This is the prime operational parameter defining air lift performance once the L/S ratio has been set. With L/S ratios in the 20-25% range, operational G/Ls tend to range close to 1.3.

Interim airlift design guidelines were generated in 2005 and have been refined by practice over the last 20 years. These design rules facilitate the design of airlifted RAS in a rational manner and are based on empirical design constants. Safety factors of about two, are inherent in the criteria. Oxygen and carbon dioxide stripping rates have been estimated. Airlifts are compatible with a number of treatment devices. The criteria have proven robust in commercial practice.



ASSESING THE CAPACITY OF RED ALGAE *(Gracilaria vermiculophylla)* AND AMERICAN OYSTERS *(Crassostrea virginica)* TO SEQUESTER AMMONIA FROM SHRIMP *(Litopenaeus vannamei)* IN A LAND-BASED IMTA SYSTEM

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Growing shrimp with extractive species is gaining momentum as an effort to reduce effluent waste in shrimp aquaculture. At University of New Hampshire's Coastal Marine Laboratory, oysters and red algae were incorporated into a shrimp recirculating aquaculture system to determine their effectiveness in reducing ammonia waste. This is a critical step in reducing negative impacts to ecosystems surrounding shrimp aquaculture operations, while producing valuable biproducts.

An aquatic habitat system (AHAB) was used, which consisted of 36 individual 9L tanks vertically stacked into 9 columns and 4 rows, each column making up an isolated system. A 4-week trial was conducted comparing three treatment types: 1) shrimp grown with oysters and red algae, 2) shrimp grown with only red algae, and 3) shrimp grown with red algae as well as aeration to re-suspend waste particles. No additional biofilters or mechanical filters were used.

A second one-week trial was conducted to compare shrimp grown with different ratios of shrimp to seaweed biomass. Shrimp were grown with the same ratio as the first trial, a shrimp: seaweed ratio of 1:2, as well as an increased ratio of 1:4 and 1:6. Water samples for both trials were collected once a day before feeding, and once a week before feeding and at regular intervals up to five hours after feeding. Biomass data was also collected once a week throughout the experiment. Results for both trials were analyzed by measuring ammonia concentrations in water samples and will be shared.

ACUTE THERMAL STRESS IMPACTS SPERM QUALITY IN BLUE CATFISH *Ictalurus furcatus*

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Sperm of many aquaculture species are often inadequate in quality/quantity and result in low fertility and offspring viability. This is particularly true for fish that do not release milt via manual-stripping, such as with the commercially important blue catfish (*Ictalurus furcatus*), which, is mated with female channel catfish (*I. punctatus*) to produce a hybrid that accounts for more than 50% of US catfish production. Pond aquaculture systems are prevalent in the catfish industry, where temperatures can reach upwards of 36°C in warmer months, and daily fluctuations of 3-6°C are common. These extreme conditions will likely be intensified by the effects of global climate change. In fishes, most studies have focused on how environmental factors influence sires before mating. However, sperm themselves experience fluctuating environments, and potential environmentally and genetically induced changes to sperm have implications on offspring traits. This study investigated how thermal stress impacts sperm quality and whether thermal stress-induced changes in sperm negatively impact offspring performance.

Blue catfish sperm from 8 males were placed into temperature blocks at 4°C (control), 32°C (pond temperature towards the end of spawning), and 36°C (pond heatwave). After 0-90 min of temperature exposure, sperm cell health (viability) was assessed. Sperm were activated and kinematics analyzed using Computer Assisted Sperm Analyses software. Sperm exposed to the thermal environments were then used for *in vitro* fertilization trials, where eggs from three females were fertilized with 9 males (3 females × 3 males each nested in female × 3 temperature exposures × 3 replicates = 81 experimental units). Hatching success was determined. Additionally, fry deformity rate, body weight, and survival were recorded at 30 days post-hatch.

Sperm viability decreased over the thermal gradient, with the lowest viability at 36°C after 30, 60, and 90 min of exposure (Fig. 1A). Sperm motility also declined over the thermal gradient (Fig. 1B). Offspring performance data from fertilization trials are currently being analyzed. Data will help predict paternity outcomes in response to environmental thermal stressors.

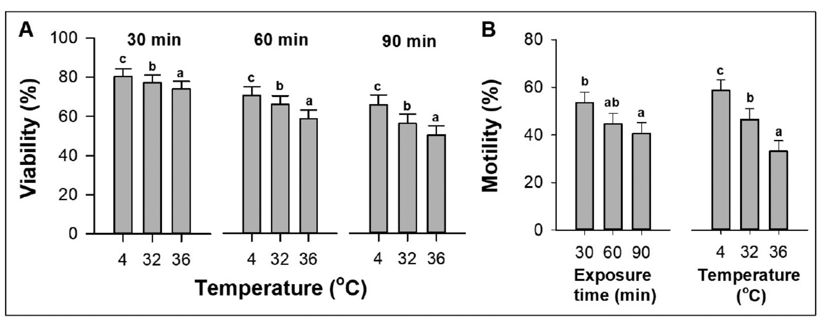

Fig 1. Impact of acute thermal stress on sperm viability and motility in blue catfish.

ALTASEADS CONSERVANCY: A KELP SEEDBANK FOR AQUACULTURE AND CONSERVATION

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Kelp populations have climate change pressuring their survival, biotic and abiotic stressors like sea urchin predation, and rising sea water temperatures are two of the most impacting factors threatening kelp forests in the western coast of the U.S. Kelp forests are a biodiverse-rich habitat which serve as feeding and breeding grounds for many ecological, and economically important species. We have formed a non-profit organization, AltaSeads Conservancy, with a mission to safeguard kelp populations in *ex-situ* temperature-controlled chambers. Our focus and goal are to create an open repository of well-studied strains available for restorationists, researchers, and farmers. Currently we hold 600 hundred individual strains of *Macrocystis pyrifera,* Giant kelp, in our collection; as well as over 400 individuals from species such as *Egregia menziesii*, *Undaria pinnafitida*, *Costaria costata, etc* (12 species to date); which includes a collection of species spanning over 30 years. And we are to receive an import of 1350 individuals of *Nereocystis luetkeana*, bull kelp during Winter 2023. We are also reaching out to colleagues to send us kelp reproductive tissue so we may isolate new strains into our collection.

Recent trials have shown the feasibility of using gametophytes for seeding seedstring lines for kelp farming. Using this approach, it is possible to select for specific traits of interest like thermal tolerance, higher sugar content, faster growth, etc. We are interested in implementing these protocols for restoration purposes, following guidelines from regulatory authorities to avoid negatively impacting local populations.

Lastly, our organization is also engaged in outreach and education activities, having received visits from over 400 K-12 school students, and over 2,000 general public at our facilities located in the AltaSea at the Port of Los Angeles Campus in the year 2023.

A PRELIMINARY STUDY OF OPTIMUM DIETARY PROTEIN REQUIREMENT OF BURBOT *Lota lota maculosa*

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Burbot *Lota lota maculosa*, a freshwater species similar to cod, has the potential for diversifying aquaculture. However, limited information exists on the dietary protein requirement of this fish species. For this reason, a 10-week feeding trial was conducted to evaluate the optimal dietary protein requirement of sub-adult burbot.

Two-hundred and sixty-four fish (141 ± 2.80 g) were randomly distributed in twenty-four 60-L closed recirculating circular tanks (11 fish/tank). Six experimental diets with increasing crude protein levels (38, 43, 48, 53, 57, and 61 %) were formulated and designated as CP38, CP43, CP48, CP53, CP57, and CP61, respectively. Four tanks were used for each diet, and the fish were hand-fed to apparent satiation twice daily.

The weight gain and specific growth rate of experimental fish increased with increasing dietary protein up to 53% (CP53) and then decreased with further increases in dietary protein. The CP38 group exhibited the lowest feed conversion efficiency, and the protein efficiency ratio and protein productive value increased up to CP53 and decreased with higher protein levels. Dietary protein levels significantly influenced fillet nutrient composition ($P < 0.05$) but had no significant effect on body indices (K-value, fillet yield, HSI, and VSI) ($P > 0.05$). Dietary protein level did not affect serum glucose content. Fish fed CP43, CP48, and CP53 diets showed the highest activities of serum glutamic-pyruvic transaminase, alkaline phosphatase, and glutamic-oxaloacetic transaminase, respectively. While the expression of insulin-like growth factor 1 (igf1) did not exhibit any defined trend ($P = 0.158$), the levels of myoblast determination protein 1 (myod; $P = 0.035$) and myosin heavy chain (myhc; $P < 0.001$) were significantly influenced by the graded protein levels. Conclusively, based on a second-order polynomial regression analysis of weight gain, the optimum dietary protein level for sub-adult burbot was estimated to be 49.5% (Figure 1).

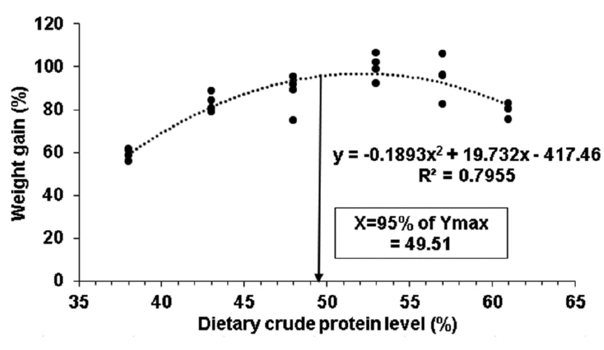

Figure 1. Optimum dietary protein level for burbot *Lota lota maculosa*

Campylobacter, SEABIRDS, AND OFF-BOTTOM OYSTER AQUACULTURE

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Campylobacteriosis, caused by bacteria in the genus *Campylobacter*, is the most common source of human bacterial gastroenteritis worldwide. A department of health investigation traced a 2021 outbreak in Rhode Island to the consumption of raw oysters. Indigenous to the gastrointestinal tract of birds, indirect transfer of *Campylobacter* to oysters during bird interactions with commercial oyster farming gear may be responsible. Due to these concerns, oyster farmers must maintain an operational plan describing mitigation strategies to minimize risks associated with bird interactions. However, data on *Campylobacter* transfer from seabirds to oysters is lacking. Goals of this study include 1) test the effectiveness of a non-lethal bird deterrent, 2) enumerate *Campylobacter* in seabird species found in the northern Gulf of Mexico, and 3) survey oysters for *Campylobacter* and describe the similarity between isolated strains from oysters and seabirds.

Six experimental floating cages were deployed at a farm site in coastal Alabama, three equipped with bird deterrents (zip ties) and three controls. Cameras monitored the efficacy of the deterrents. *Campylobacter* incidence in seabird fecal matter was determined using a selective and differential media. An enrichment procedure was used to detect *Campylobacter* in oysters.

Deterrents decreased bird interactions with gear 8-fold (Fig. 1). Approximately 7.5% of bird feces were positive for *Campylobacter* (Table 1). Sequencing of the 16S rDNA identified the isolates as *C. lari* subsp. *concheus*. This species has not been confirmed as a human pathogen.

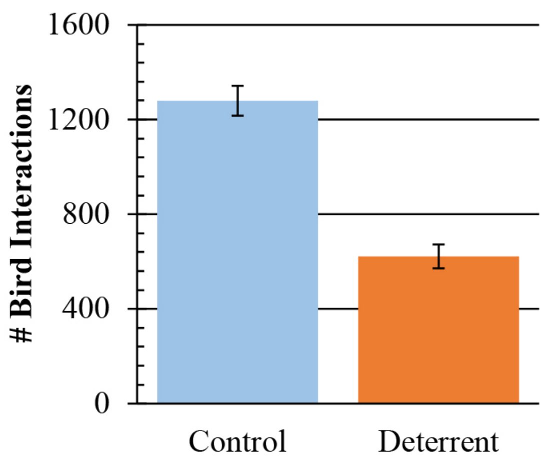

Figure 1. Seabird interactions with oyster cages. $P < 0.05$

Table 1. *Campylobacter* prevalence in seabirds.

	# Sampled	# Positive	% Positive
Caspian Tern	6	0	0
Common Tern	10	1	10
Sandwich Tern	21	0	0
Least Tern	13	1	7.69
Royal Tern	55	4	7.27
Brown Pelican	40	5	12.5
Laughing Gull	2	0	0
Total	**147**	**11**	**7.48**

MAINE SHELLFISH AND SEAWEED AQUACULTURE APPRENTICESHIP: A PARTNERSHIP BETWEEN INDUSTRY AND THE COMMUNITY COLLEGE SYSTEM

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Workforce shortage in Maine's aquaculture industry has been an obstacle to growth for many businesses and could stunt the industry's tremendous growth potential. To address this, the Gulf of Maine Research Institute (GMRI), The Maine Aquaculture Association (MAA), and Educate Maine partnered on The Maine Aquaculture Workforce Development Strategy- a forward thinking strategic roadmap for Maine to achieve a cohesive and comprehensive workforce training pipeline that meets the needs of today's industry and anticipates future workforce needs as the industry evolves. Considerable progress has been made towards implementing the Strategy since it was published in 2020. The first-generation Maine Aquaculture Occupational Standards were created by MAA in partnership with GMRI and Educate Maine to help standardize workforce training programs. Using the Occupation Standards as building blocks and with funding from USDA NIFA, the first Shellfish and Seaweed Aquaculture Apprenticeship was registered with the Maine Department of Labor. This program includes 2,000 hours On-the-Job Training (OJT) as well as 144 hours Related Technical Instruction (RTI). Apprentices receive their OJT hours while employed for an aquaculture business and their RTI hours are provided by Southern Maine Community College (SMCC). All training provided by SMCC was reviewed and approved by an industry steering committee. This program is still in its pilot year and currently has 6 apprentices at 5 aquaculture farms (4 oyster farms, 1 mussel/kelp farm). Overall feedback has been very positive from both the apprentices and the aquaculture businesses. During this session we'll talk about the process of creating the program and what we've we hope the future of this program will be.

CONCURRENT INFECTIONS OF *Flavobacterium psychrophilum* AND *Flavobacterium columnare* IN RAINBOW TROUT FINGERLINGS *Oncorhynchus mykiss*

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Flavobacterium psychrophilum and *Flavobacterium columnare* are the etiological agents of bacterial coldwater disease (BCWD) and columnaris disease, respectively. Trends such as intensification of farming practices, wide-spread development of antibiotic resistance, and climate change have increased the overlap of these two diseases, resulting in combined infections that may exacerbate losses while further complicating treatment strategies. Few studies have attempted to elucidate concurrent infections in salmonids, as such, the goal of our present research - as part of an overarching study on mitigation of *F. psychrophilum* and *F. columnare* through probiotic treatment - is to better understand the effects of dual infection by BCWD and columnaris disease on rainbow trout survival. In a preliminary experiment, 360 fingerling rainbow trout (1.8g) were challenged for one hour using an immersion bath containing a pre-determined "High", "Mid", and "Low" dose of either *F. pyschrophilum* (CSF-259-93), *F. columnare* (051-10-S5), or a 1:1 mixture of the two bacteria. The presence of pathogens will be determined by streaking of the spleen and kidney on TYES agar and subsequent identification of bacterial colonies. Provided the results of this prechallenge are positive, further investigations will include a comprehensive analysis of the presence of *F. psychrophilum* and *F. columnare* using real-time quantitative polymerase chain reaction (qPCR) as well as through ELISA to measure IgM antibodies post challenge. The outcomes of these studies are crucial for clarifying the virulence of bacterial co-infections compared to single-pathogen infections, providing valuable insights into effective treatment strategies for managing concurrent infections in rainbow trout aquaculture.

GONADAL SEX DIFFERENTIATION IN SACRAMENTO PIKEMINNOW *Ptychocheilus grandis* THROUGH HISTOLOGICAL SAMPLING

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Sacramento Pikeminnow (*Ptychocheilus grandis)* are a large (up to 1.4m) piscivorous cyprinid native to the Sacramento-San Joaquin basin in California. They were introduced in the upper mainstem of the Eel River, CA in 1979. Over time, it has become one of the most prevalent fish species within the Eel River ecosystem, raising concerns due to its predation and competitive interactions with juvenile salmonids and other native fishes. Because of this, there have been many suppression efforts to eradicate the Sacramento Pikeminnow populations in the Eel River, but none of them have been successful in reducing their populations in a meaningful way. Despite the Sacramento Pikeminnow being as abundant as they are, there is very little information on their life history and especially on their reproduction. The overall goal of the present study is to create Trojan YY supermales as a novel strategy to mitigate Sacramento Pikeminnow populations. The specific objective of this study is to determine when juvenile Sacramento Pikeminnow gonads start to differentiate. With this information, we will know when to start feeding them hormones to manipulate their sex.

Sacramento Pikeminnow collected from the Eel River of all ages and sizes were dissected and had their gonads removed. Small gonads that were unidentifiable under a microscope were kept for histology. These unidentifiable samples were usually collected from fish that ranged in size from >10-20 cm. The tissues were embedded with paraffin wax, and then stained with Hematoxylin and Eosin dye.

Preliminary results show that fish smaller than 15 cm have undeveloped gonadal structures. Hormonal sex reversal should be applied during this period of sexual differentiation. Our future study will be feeding estradiol to fish smaller than 15 cm to produce an XY female that would be crossed with an XY male for the end production of YY fish.

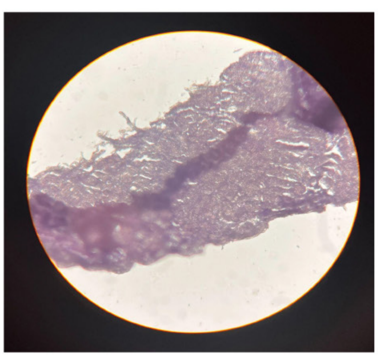

Figure 1: Male testes from a 23.6 cm Sacramento Pikeminnow

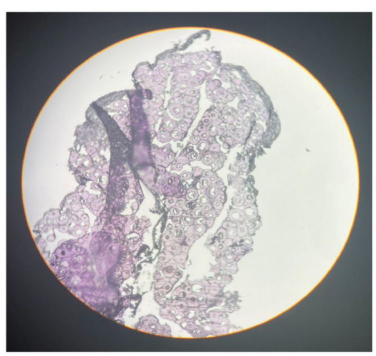

Figure 2: Female ovaries from a 39.9 cm Sacramento Pikeminnow

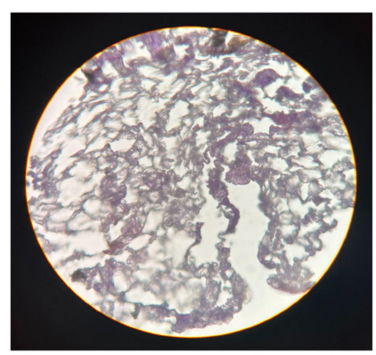

Figure 3: Undifferentiated gonads from a 14.3 cm Sacramento Pikeminnow

USING ALGAL TURF TECHNOLOGY TO REMOVE EXCESS NUTRIENTS AND EVALUATE BIOMASS POTENTIAL

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Algal Turf technology is a biosystem that uptakes excess amounts of carbon, nitrogen, and phosphorus, from wastewater sources. This system also produces cleaner recycled water, 0_2, and algal biomass. These systems if implemented in agriculture settings can decrease the nutrients in the wastewater improving the water quality of the water allowing it to be reused for irrigation of agriculture farms or industry. The produced algae biomass also has the potential to be used as biodiesel, bioethanol, or biofertilizer. Unfortunately, there is limited information and training available for farmers to apply algal turf technology to their farms. This project focuses on implementing an Algal Turf system to analyze the potential of the biomass produced and how the system improves the water quality by focusing on flowrate of the wastewater and biomass yield. Preliminary results indicate that they system with the highest flow rate has the most biomass yield and the most nutrient removal with phosphorus removal being the most significant. We will analyze the quality of the algal biomass for related studies such as biofertilizers, animal feed and bioenergy. To then train, educate and have farmers utilize these systems in Delaware in order to improve the farms wastewater quality.

THE IMPACT OF THE PRIME MINISTER MATSYA SAMPADA YOJANA (PMMSY) PROJECT ON THE FISHERIES SECTOR OF INDIA

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Owing to the richness in aquatic resources in terms of fresh water, brackish water and long coastline, India is considered to be the most significant aquaculture hub of the world along with China. The prestigious programme of India named Pradhan Mantri Matsya Sampada Yojana (PMMSY) with a total outlay of approx.2.7 billion USD. The project envisaged to upgrade and transform the status of India from a "carp hub" to a place with more diversified programmes in aquaculture for doubling the aquafarmers' income. The major objectives of the programme are to maximize the potential of fisheries in a sustainable, responsible and inclusive way, use of land and water resources efficiently to increase fish production and productivity and to modernize and strengthen the value chain, including post-harvest management and quality improvement. The programme clearly envisioned the absolute welfare of the stakeholder communities including fishers, fish farmers and other allied workers footed in the sector. Through the project, India could emerge as a leading shrimp producer in the world with a series of developmental projects including PMMSY. The country looks forward to enhance the aquaculture productivity from 3 tonnes per ha to 5 tonnes per ha which will augment the total export earnings to approx. 13 billion USD. The sector is expected to create 0.6 million additional employment opportunities per year which will make the sector more prosperous. Five Mega Integrated Aqua Parks are envisaged during the period, creating a new dimension in the sector with improved product quality, improvised cold chains, enhanced product diversification and commendable recreation. In the coming years it is proposed to form thousands of SHGs bringing at least 90 million women under this umbrella. For implementing the various programmes under PMMSY, National Fisheries Development Board (NFDB) and various State Governments played a pivotal role for ensuring the success to the grass root level.

REPLACEMENT OF LIVE FOOD (ROTIFERS AND *Artemia*) BY A COMMERCIALLY FORMULATED DIET IN MARINE FLORIDA POMPANO (*Trachinotus carolinus*) LARVAE

Sahar Mejri[1], David Bradshaw[2], Ben Panitz[1], Carlie Perricone[1], Christopher Robinson[1], Nicole Kirchoff[3], Alyson Chin[1], Fernando Paredes[1], Ethan Weber[1], Avery Davis[4], Marty Riche[1], and Paul S. Wills[1]

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Commercial production of marine fish juveniles still relies on the supply of live food, such as rotifers and *Artemia*. Pelleted diet substitution for live prey is important for reducing production costs and for sustaining a high and constant quality juveniles production in commercial hatcheries. The objective of this research is to test the potential of a novel commercial compound diet (INVE feed, INVE Aquaculture, Belgium) to replace and eliminate the use of rotifers and/or *Artemia* for live feeding of Florida Pompano. INVE Natura pRo (<100um & 100/250 um) and ExL (200/400 um & 300/600 um) are designed to reduce the need to use rotifers and *Artemia* by at least 50%. A study conducted by INVE in seabream (*Sparus aurata*) using these feeds found increases in survival, wet weight, robustness, and decreases in malformations. To reach this objective, Florida Pompano eggs were supplied by Proaquatix (Vero Beach, FL). Eggs from the same batch were stocked at 26,000 eggs/liter in 16–110-gallon (416 L- filled to 330 liters) tanks at Live Advantage Bait LLC (LAB) and 30,000 eggs/liter in 16–200-gallon (757 L) tanks at Proaquatix. Hatching success was estimated at each farm (~72% at LAB and ~96% at Proaquatix). A control group and 3 live feed replacement treatments (50% replacement for rotifers and *Artemia*, 80% replacement for rotifers and *Artemia* and 80% for *Artemia* only) were tested in quadruplicate. Pre-trial eggs and larvae at 8, 18, 27 and 31 days post hatch (DPH) were sampled from each tank for fatty acid (FA), biometric, and microbiome analysis. The preliminary results showed that at 18 DPH (last day before introducing Otohime), the control treatment showed the highest weight gain followed by the 50% for rotifers and *Artemia* treatment (11.23 ± 2.25 mg and 7.39 ± 1.33 mg, respectively). At 29 DPH, the control also showed the highest weight gain, but within the standard deviation of the replacement treatments. At 18 and 29 DPH the control had the highest length, within the standard deviation of the replacement treatments with the largest difference in the 80% for *Artemia* only treatment (6.02 ± 1.21 vs. 4.71 ± 2.06 at 18DPH and 19.9 ± 1.13 vs. 18.13 ± 1.99 at 29DPH, respectively. Fatty acid results showed a relatively similar profiles toward the end of the experiment between all treatments, but highest DHA content in the 80% for *Artemia* treatment at 18 DPH, with 4.92 ± 1.32% of total FAs in the control and 14.88 ± 2.86% of total FAs in the 80% for *Artemia* (**Figure 1**). We find the preliminary results very promising to replace live feeds by formulated diets, which will help sustain the production of stable high quality Florida pompano fingerlings. However, it is important to keep in mind that further nutrition experiments, to accurately determine larvae requirements is paramount, which will constitute a platform for formulating appropriate diet for larvae fish.

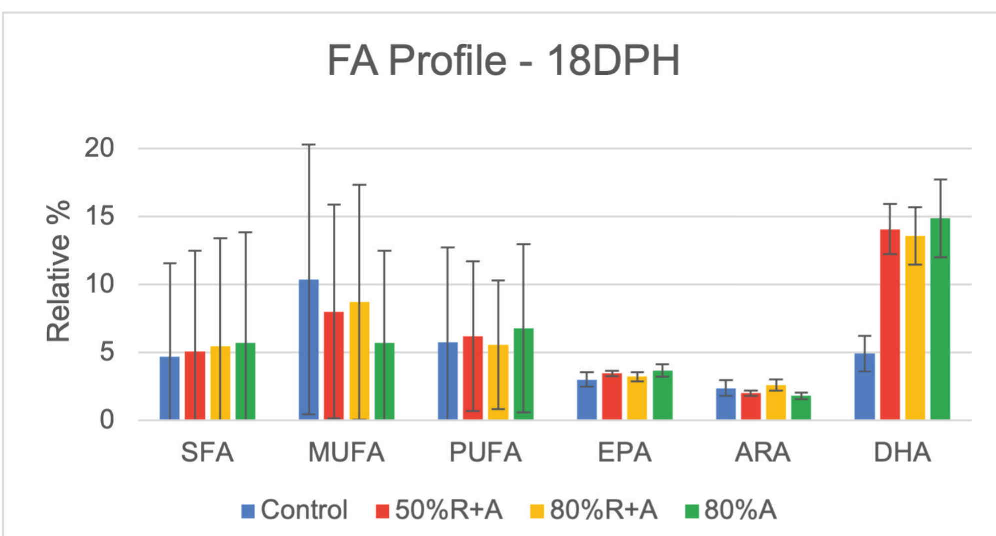

Figure 1. Fatty acid profile of Florida Pompano larvae sampled at Proaquatix at 18 days post hatch. Bars and error bars represent relative percentage mean and standard deviation of 4 tank replicates for each diet treatment which is represented by color. The largest difference is in the relative DHA content with 4.92 ± 1.32 in the control and 14.88 ± 2.86 in the 80% for *Artemia*.

EFFECTS OF WEANING AGE ON LARVAL RED DRUM *Sciaenops ocellatus* GROWTH AND SURVIVAL IN RECIRCULATING TANKS

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The timing of co-feeding (CF) live prey and microparticulate diet (MD) can affect growth and survival of larval marine fishes. The effects on growth and survival of larval red drum for CF beginning on day 8, 14, and 20 (CF 8, CF 14, and CF 20, respectively) were tested. CF periods lasted for 12 days for CF 8 and CF 14 and 10 days for CF 20. The larvae were stocked at 15/L and cultured from 2 to 30 days post hatch (dph) in 520 L tanks with re-circulating filtration and environmental control. The larvae were fed semi-continuously with automatic feeders. Standard length and wet weight were determined several times between 8 and 30 dph, and survival was determined at 30 dph. Cost per fish was calculated from costs of rotifers, artemia, MD, and larval culture husbandry for each CF period. There was a significant interaction between the day CF was initiated and fish age for standard length and wet weight (Length: $F_{3,1057} = 3.84$, $P < 0.008$; Wet weight: $F_{4,792} = 3.63$, $P < 0.0061$). Growth was faster for CF 8 between 15 and 21 dph than the other groups, growth accelerated in CF 14 after 21 dph to meet the length and weight of CF 8, while the slowest growth occurred in CF 20. Survival was significantly affected by the day CF was initiated with mean survival (± standard deviation) for CF 8, CF 14, and CF 20 of 0.301±0.087, 0.362 ±0.070, and 0.476±0.028, respectively. Survival in CF 14 was not significantly different from CF 8 nor CF 20, but survival of CF 20 was significantly greater than CF 8. Growth of larvae was reduced in CF 20 possibly because of increased survival or benefits of MD not realized when fed at earlier ages. Cost per fish decreased with each successive CF period but opportunity costs to grow CF 20 fish for additional days, to reach the same size as the other CF schedules, was not determined. Changes in artemia supply and demand could increase the cost of CF 20 and MD amounts used during CF might be reduced with future investigations to reduce costs. This study demonstrated how weaning using different CF schedules affects culture performance and costs for larval red drum, and the results can be used to determine costs under different facility specific situations and goals.

CONSIDERING THE SOCIAL IMPACT OF AQUACULTURE

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For aquaculture development to be truly sustainable, understanding the way in which an individual operation or entire industry fits within local communities is critical. The social impacts of aquaculture – including the "socio- suite": socio-cultural, socio-economic, socio-environmental, and socio-political – are neither well qualified nor well quantified, but there are many of ways to consider them. How does aquaculture integrate into local economies? How does aquaculture contribute to local heritage or identities? What are some of the less readily quantifiable ways that aquaculture influences communities? This "speed talk" introduces a range of frameworks used to understand the social impact of aquaculture, drawing largely on participatory approaches.

SHELLFISH AND SEAWEED AQUACULTURE ECOSYSTEM SERVICES HORIZON SCAN: PROJECT UPDATE

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Shellfish and seaweed aquaculture are increasingly recognized for their role in ecosystem services production, and a growing body of peer-reviewed science documents their connections to all categories of ecosystem services: cultural, provisioning, regulating, and supporting. This project aims to assess the state of the science and utilize the knowledge of experts throughout the United States to identify key next steps for advancing the field of bivalve shellfish and seaweed aquaculture ecosystems services research. Framed as a horizon scan, this project seeks to identify not only research gaps and needs, but potential areas where policy or management has yet to operationalize well-documented aquaculture-associated benefits and services.

In 2023, research scientists, industry leaders, resource managers, extension personnel, and others well-versed in aquaculture ecosystem services were invited to contribute to this aquaculture ecosystem service horizon scan. Synthesized findings of that information call will be presented to introduce an initial prioritization and discussion of related research and management needs. This presentation will be one of several opportunities for project participants and others to provide feedback on this synthesis.

TRYPTOPHAN MODULATES PHYSIOLOGICAL PROCESSES IN CHANNEL CATFISH, *Ictalurus punctatus* IN STRESSED AND DISEASE CONDITIONS

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Physiological changes in fish in response to stress are generally interpreted as an indication of the severity of a stressor as well as a reflection of the capacity of a species of fish to manage a particular level of stress. In farmed fish, an increased level of continuous stress culminates into eventual decrease in disease resistance as well as reduced growth rate. Biologists are well familiar with these physiological responses of fish to stress various investigations on using nutraceuticals in modulating physiological stress responses are ongoing. In this study, we tried to observe the effects of tryptophan, an essential amino acid, in modulating physiological processes in Channel catfish, *Ictalurus punctatus,* raised in stressed and a diseased conditions with virulent *Aeromonas hydrophila* (vAh). In particular, we have checked levels of blood glucose and hematocrit, before and after the disease challenge with virulent *Aeromonas hydrophila* (vAh; ML09-119). We had 4 different experimental groups: (1) control fish fed with control feed, (2) control fish fed with tryptophan-treated feed; (3) stressed fish fed with control feed; and (4) stressed fish fed with tryptophan-treated feed. After five weeks of feeding, we challenged the catfish with vAh and kept the fish in the challenged condition for 72 hours. Our preliminary results showed that catfish fed with tryptophan-fed feed had considerably improved levels of blood glucose and hemtocrit, both in the stressed and diseased conditions. Further research is being conducted to optimize the concentration of Tryptophan in the feed in order to ascertain the potential immunomodulating properties of this essential amino acid.

SEQUENCING ALL THE FISHES IN THE DEEP BLUE SEA: IMPACTS OF SAMPLE STORAGE TIME, TEMPERATURE, AND BUFFER TYPE ON DNA QUALITY VALIDATED THROUGH LONG READ SEQUENCING AND ASSEMBLY

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There are over 1.6 million species of animals and 435 thousand species of plants on Earth. Long-read sequencing technology is enabling biologists to digitally archive the genomes of these organisms to understand fundamental basic questions in evolution, bolster conservation strategies in the midst of massive extinctions, and improve food production through crop and livestock genomics. One of the primary challenges however, is obtaining samples from field sites and preserving them in a way that ensures high quality DNA for long read sequencing. Here we demonstrate the impacts of storage time (0 days, 7 days, 21 days, and 42 days), storage temperature (4 Celsius, 22 Celsius), and storage buffers (95% EtOH and RNAlater) on the preservation of fish blood across ten species of fish. We show that high quality DNA as measured by yield, purity, and fragment size can be obtained from samples stored at 95% EtOH at 4 Celcius for up to 6 weeks and RNAlater at room temperature for up to 3 weeks. We compare these storage impacts on sequencing read length, genome assembly quality, and methylation variation. We compare the impact of storage metrics on sequencing read length, quality and yield across 10 species of fishes sequenced using the gold standard 'snap frozen' method and demonstrate the feasibility of using this new storage method. We validate by doing deep sequencing on three fish and compare assembly metrics. Here we show 95% ethanol protects against degradation for fish blood (22°C, ≤6 weeks). Using Nanopore, we assemble high quality reference genomes from three fish and two plant species (contig N50: 6.5-13.8Mb; BUSCO completeness: 94.4-99.2%; QV: 43.8 for *M. esculenta*).

Table 1. Sequencing and assembly results of fish and plant samples from extended storage conditions Species: *M. californiensis* (Mcal), *G. nigericans* (Gnig), *K. azureus* (Kazu), *M. esculenta* (Mesc), *S. bicolor* (Sbic)

	storage			sequencing					Assembly				
Species	Stored	°C	Weeks	N50_s	N50_d	Long	Q_avg	cov(x)	N50	contig	C(%)	QV_n	QV_hyb
Mcal	ET	22	6	3.4	9.8	176.5	18.7	58	6.5	1761	98.7		
Gnig	ET	22	6	3.5	15.2	139.4	17.9	37.8	9.7	1441	98.5		
Kazu	LN	-80	0	16.9	54.4	418.9	20.1	28.4	21.8	641	98.8		
Kazu	ET	22	6	15.8	20.5	183.4	19.1	33.9	13.8	792	98.6		
Kazu	RN	22	6	13.7	15.1	225.5	19	11.2	5.1	795	98.7		
Mesc	LN	-80	0	21.6	38.7	367.8	19.2	52.8	16.5	460	99.0	47.5	49.3
Mesc	ET	4	3	13.9	24.1	296.2	17.8	58.0	10.4	638	99.2	43.8	44.6
Mesc	RN	22	3	1.9	6.2	392.3	17.2	37.3	0.4	18881	99.0	32.1	32.5
Sbic	ET	4	3	9.1	18.9	394.9	19.4	54.8	8.7	845	94.4		

METAANALYSIS OF USING DUCKWEED (*Lemnaceae*) IN FISH FEEDS

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One of the primary sustainability challenges in aquaculture is replacing fish meal with plant based ingredients in aquafeeds. Plants are not optimal however due to low protein content and antinutritional factors which can cause gut dysbiosis. Duckweed (Lemnaceae) is a family of aquatic plants with high protein content and has been used successfully for various types of animal feeds. In this systematic review and meta-analysis of 58 papers, we summarize the extent by which duckweed has been used in fish production including the species of fish tested, the grow out stage of fish, and method of application. Duckweed studies spanned a total of 18 species of fish (16 freshwater and 2 marine) that collectively are valued at 263 billion USD annually, and comprise 28% of total aquaculture production by mass. The average experiment length was 72 days (S.D. 42) at the fingerling life stage. Duckweed was fed to fish through live grazing, dried, and pelleted forms with 20% inclusion as the most common formulation. The Lemna spp. were the most commonly used for feeds, dominated by L. minor, L. gibba, and unknown Lemna species. Spirodela polyrhiza was the second most common. Duckweed inclusion levels between 15-30% was associated with positive outcomes on fish growth and feed conversion ratio without any negative impact on survival rates. Most duckweed species, especially from Wollfiella have not been tested as a fish feed, but should be explored whereas most studies focused on freshwater fishes rather than marine.

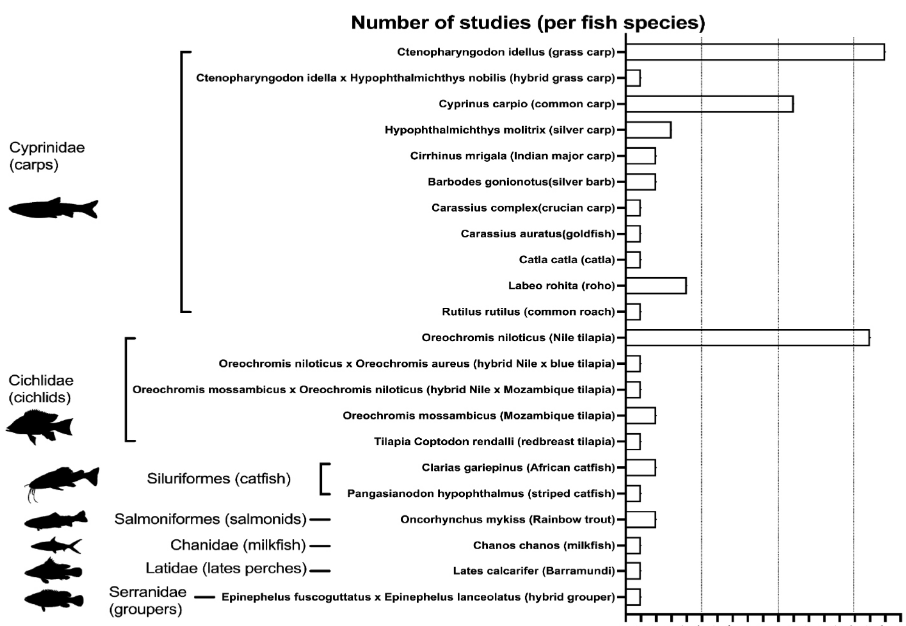

Figure. Duckweed fish feed experiments conducted across 18 species and 4 hybrid species of fish.

MORTALITY OF STRESS-REARED CHANNEL CATFISH, *Ictalurus punctatus,* FED TRYPTOPHAN AND CHALLENGED WITH VIRULENT *Aeromonas hydrophila*

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In the US catfish industry, infectious diseases cause significant revenue and financial loss, with millions of fish affected annually. Chronic stress and suboptimal rearing conditions increase disease susceptibility, causing millions in lost revenue. Historically, chemicals and drugs have been used to treat bacterial diseases. Nevertheless, these treatments are becoming more restricted since they present numerous side effects on the environment and health safety. Tryptophan is an essential amino acid for fish, and previous studies have shown that tryptophan could improve the immune response in fish. In this research, we wanted to investigate if tryptophan could increase the immunity and disease resistance in catfish, *Ictalurus punctatus,* raised in an aquaculture setting. We had five different groups for the experiment: (1) control group; (2) stressed group; (3) stressed group challenged with virulent *Aeromonas hydrophila* (vAh; ML09-119); (4) stressed group treated with tryptophan; and (5) stressed group treated with tryptophan and challenged with vAh. After 72 hours post-infection, we observed a significant reduction in the mortality rate in the stressed group treated with tryptophan and challenged with vAh compared to the stress group not treated with tryptophan and challenged with vAh. Based on this preliminary study, we can infer that tryptophan has a considerable effect in reducing fish susceptibility to mortality caused by bacterial disease in the face of environmental stressors. The results from this study could have a significant impact on farming practices in the catfish industry.

INVESTIGATIONS ON THE SUPPORTING SCENARIO FOR SMALL-SCALE SHELLFISH AQUACULTURE AND ITS CONTRIBUTION TO FOOD SECURITY IN THE USA

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The aquaculture industry evolved from rather environmentally harmful past practices to the current high-tech management focused on increasing production concomitantly with sustainability while surpassing wild fisheries as a world contributor to seafood supply. Small-scale aquaculture (SSA), as the name implies, is still far behind other forms of aquaculture in global documentation and proper support. According to the FAO, jointly small-scale fisheries and aquaculture produce more than 50% of the global seafood, and aquaculture continues to grow as a source of seafood, but in both sectors, the recognition of contribution from these activities is often unacknowledged and unquantified. Arguably, one of the most sustainable farmed species group that also attract the investment of small farmers as a family-operated business is suspension-feeding bivalves. Bivalves are in the spotlight for scalability, but criticism about the species perception as a luxury item pushes for an analysis of bivalves as a possible contributor to seafood security.

Focusing on the food security aspect possibly provided by the small-scale shellfish farming industry, we provide an overview of shellfish aquaculture in the international, and in more detail, national context, based on a recognized framework and plan of action from FAO's International Year of Artisanal Fisheries and Aquaculture and key indicators (KI) for the analysis of the status of small-scale shellfish aquaculture (SSSA; Fig.1). Our analysis show that basic data and supporting structure for SSSA are often missing from databases and gets overlooked in national contexts. As a result, SSSA reports and long-standing sustainability are uncertain and these highlight the need for acknowledgement and assistance in practice.

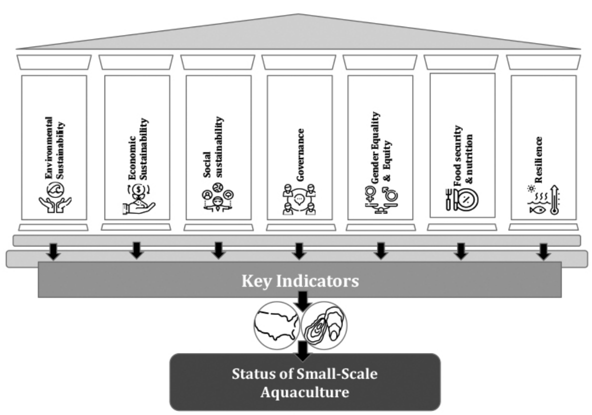

Figure 1: Study overview based upon FAO's IYAFA pillars (Figure made with icons by Freepik; Parzival'1997; noomtah; and imaginationlol from www.flaticon.com).

PANDEMIC PERSPECTIVES ON FISH FARMING AND FISH EATING FROM AMERICA'S DAIRYLAND

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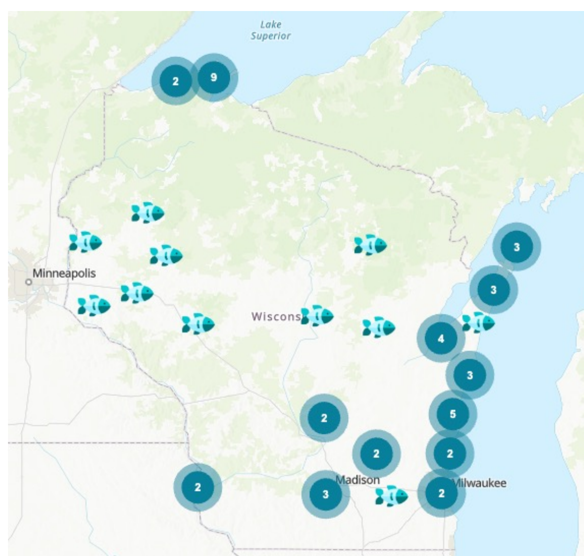
Wisconsin might be known for its cows, but it is also the fabled epicenter of the Friday night fish fry. During the darkest days of the Covid-19 pandemic, restaurants hosting this Friday tradition necessarily shuttered their doors. Yet, after about two months of reconfiguring their businesses, the majority of the state's food-fish farmers reported mild to no consequences related to the lack of restaurant sales. In fact, fee fishing operations reported increases in their revenue as families sought outdoor activities throughout the summer of 2020.

There were and continue to be some tough pandemic-related consequences for fish producers in Wisconsin. Supply chain challenges are among the numerous vulnerabilities the pandemic exposed. Larval shrimp destined for Bloomer, Wis., died in the mail. Fish pellets are harder to come by and they rot when packaged too quickly. The lack of small-scale fish processing facilities prompted one aquaponic producer to donate tilapia to a raptor center. Meanwhile, an already dwindling workforce became even thinner. We know these things and more because NOAA Sea Grant's Covid response funding enabled Wisconsin Sea Grant to hire a food-fish outreach coordinator to reboot its Eat Wisconsin Fish initiative.

This presentation covers what Wisconsin Sea Grant learned about the heartland's seafood supply with respect to the pandemic by talking to fish producers and others. It also showcases pandemic-era outreach and communication efforts including updates to the Eat Wisconsin Fish website, online cooking demonstrations, social media activities and the inception of The Fish Dish podcast.

A map of Wisconsin indicating commercial fisheries, fish farms, fish markets and places to learn about fish-production. 2023, Credit: Josephine Hunt



SECRETED PROTEASES INFLUENCE *Flavobacterium columnare*'s VIRULENCE IN ZEBRAFISH AND RAINBOW TROUT

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Flavobacterium columnare, a Gram-negative fish pathogen belonging to the phylum *Bacteroidota*, causes columnaris disease in numerous commercially important freshwater fish species in the U.S. and globally. Columnaris disease negatively impacts all U.S. finfish aquaculture industries, leading to substantial financial ramifications estimated at $50 million annually. Due to the ectopic nature of the disease, it is highly contagious and deadly, especially in aquaculture, where fish population density is high allowing for greater disease transmission. Since there are unknown virulence factors contributing to columnaris disease pathogenesis, there are currently no effective prevention measures. While it is known that the secretion of extracellular proteins, including proteases, aggravates *F. columnare* infection, identification of the secreted virulence factors remains incomplete. A new protein secretion system, known as the type IX secretion system (T9SS), was shown to be required for *F. columnare* virulence. This T9SS secretes many soluble and cell-surface associated proteins, all of which are potential virulence factors. Thirty-five of the T9SS-secreted proteins were identified as predicted proteases, but their role in columnaris disease pathogenesis is largely unexplored.

Proteases are commonly recognized as crucial virulence factors among various pathogens, and they add to the complexity of *F. columnare*'s pathogenic mechanisms. The genome of *F. columnare* harbors numerous protease-encoding genes, potentially involved in nutrient acquisition and degrading fish tissues to promote virulence. In prior studies, our investigation into the *F. columnare* T9SS-deficient mutant strains (Δ*gldN* and Δ*porV*) unveiled a notable defect in proteolytic activity. In this study, we have undertaken a comprehensive exploration of individual protease functions by constructing a library of combinatorial protease mutants. We constructed a series of gene deletion mutants, each lacking either individual or multiple (up to ten) protease-encoding genes, and assessed them for proteolytic activity and any associated growth defects. Additionally, we used zebrafish and rainbow trout as model species to evaluate the pathogenic potential of these protease-deletion mutants through immersion challenges. While the majority of mutants retained their virulence, mirroring the wild-type strain, certain single or multi-deletion mutants displayed proteolysis defective phenotype and decreased infectivity. Specifically, a mutant devoid of ten proteases and another lacking the tail-specific protease (TspA) exhibited reduced virulence in rainbow trout fry trials compared to the wild-type strain, emphasizing the role of proteases in *F. columnare* virulence. Overall, our findings underscore the impact of secreted proteases on the pathogenesis of columnaris disease and their role as pivotal elements of *F. columnare*'s arsenal of virulence factors. These proteases could potentially serve as valuable targets for future vaccine development efforts.

PURIFIED BREWERS' YEAST–DERIVED FUNCTIONAL FEED ADDITIVES ALLEVIATE SOYBEAN MEAL-INDUCED ENTERITIS IN ATLANTIC SALMON PARR

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The inclusion of high levels of soybean meal and other plant ingredients have been shown to trigger inflammatory response and induce dysbiosis in the distal intestine of Atlantic salmon. Functional feed additives (FFAs) such as brewers' yeast (*Saccharomyces cerevisiae*) may confer immunomodulatory effects in fish. In this experiment, we investigated the ability of two brewers' yeast FFAs from Leiber GmBH to modulate the known pathological effects of high SBM in Atlantic salmon parr. Product A (β-glucan) contains cell wall extracts rich in β-1,3 and -1,6-glucans while product B (yeast extract) is made of soluble dried cell extracts rich in amino acids, glutamic acids, nucleotides and peptides.

A total of 450 salmon parr (ca. 24 g) were randomly assigned into 15 experimental units and fed one of 5 experimental diets: 1] Neg_ctrl (0% SBM), 2] Pos_ctrl (30% SBM), PβG (30% SBM + 0.02% β-glucan), SDYE_1 (30% SBM + 1% yeast extract) and SDYE_2.5 (30 % SBM + 2.5% yeast extract), with each treatment replicated three times. Fish were fed between 1% - 2% of body weight per day with feeding rate adjusted following periodic batch weighing. At the end of the experiment, samples of skin and distal intestine samples were collected for light microscopy, scanning and transmission electron microscope, gene expression, and microbiome analysis following relevant protocols.

The results from this experiment showed that the high SBM treatment (Pos_ctrl) induced extensive signs of enteritis with significantly wider lamina propria (Table 1) and higher density of goblet cells in the epithelium than the Neg_ctrl diet (Fig 1). These negative physiological changes were not observed in the yeast treated groups, evidencing a protective role against enteritis. However, there was no significant difference among the treatments in zootechnical performance (weight gain, SGR and FCR; data not shown).

On-going analyses include 1] electron microscopy to establish the physical modulations induced by the treatments at the ultrastructural levels, 2] the transcriptional responses of enteritis biomarkers, immunological and barrier-regulating genes and, 3] metabarcoding analysis using full-length 16S sequencing (SMRT, PacBIO®) to obtain high resolution data on microbial diversity and taxa relative abundance.

Figure 1: Goblet cell density per 400 μm² of mucosal fold. Different superscripts represent significantly different means of goblet cell count between the treatments.

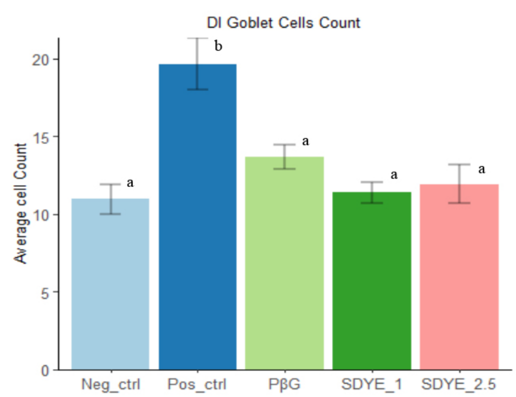

Table 1: Growth performance of fish subjected to experimental diets after 56 days of feeding.

	Neg_ctrl	Pos_ctrl	PβG	SDYE_1	SDYE_2.5	P-Value
Mucosal fold length (μm)	295 ± 161	261 ± 97	303 ± 116	317 ± 110	284 ± 96	0.2030
Lamina Propria width (μm)	**18.5 ± 1^a**	**32.5 ± 2^b**	**19.4 ± 9^a**	**15.9 ± 8^a**	**19.9 ± 8^a**	**<0.001**

Values are mean ± standard deviation. Different superscripts indicate statistically significant difference among the groups.

THE IMPACT OF FINANCING ON FARM SUCCESS: A RISK ANALYSIS FOR AQUACULTURE

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In many economic models, we assume firms are unconstrained by credit. However, this assumption does not hold across all industries or regions of production. A notable example is the aquaculture sector, one of the fastest-growing food production industries, where firms often struggle to secure financing due to limited collateral. This lack of credit access potentially forces firms to operate below their optimal production levels, increasing their risk of closure.

Aquaculture, like other food production sectors, faces inherent risks due to its susceptibility to environmental factors and market volatility. These risks may exacerbate the consequences of operating far from optimal production levels. This project explores the theoretical and simulated impacts of credit constraints on prospective aquaculture firms.

Our theoretical model, depicted in Figure 1, compares three scenarios: K) typical firm capital accumulation with access to credit, $\hat{K}$) capital accumulation when larger firms are more resilient to external shocks, and $\check{K}$) capital accumulation under credit constraints. The model indicates that the most significant differences in optimal capital accumulation time-paths occur in the early years of a firm's existence, suggesting this to be the most critical period for firm survival.

To quantify our model, we employed a Monte-Carlo simulation for a prospective clam aquaculture firm. Preliminary results, illustrated in Figure 2, corroborate our theoretical findings. Firms with access to credit, able to acquire capital more rapidly, exhibit a higher survival rate. This trend is consistent across various initial endowments (shown on the horizontal axis). Overall, our results show the importance of access to credit for aquaculture firms, particularly new and small firms.

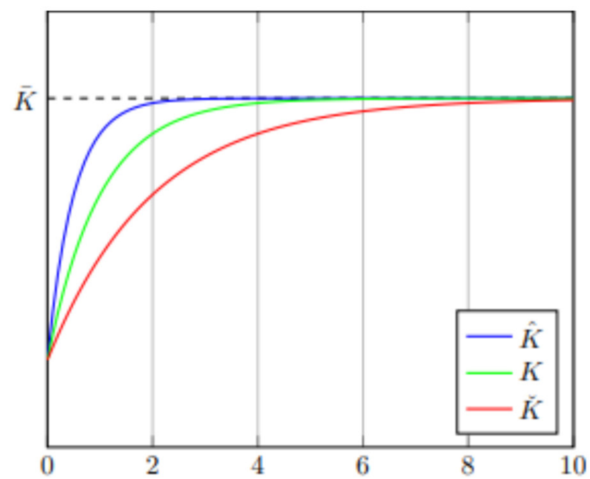

Figure 1: Optimal Capital Accumulation

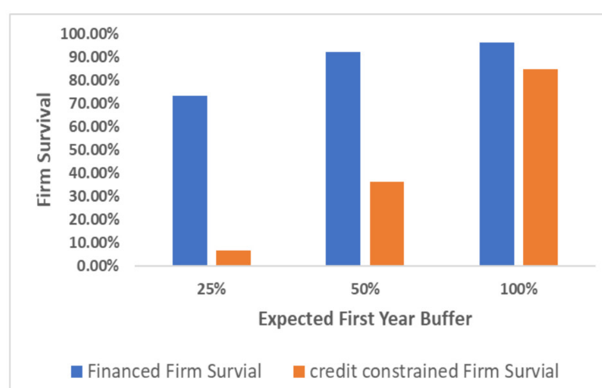

Figure 2: Simulated Firm Survival Rate

NET PEN PLACEMENT WITHIN A SALMON AQUACULTURE FARM AFFECTS SALMON LICE *Lepeophtheirus salmonis* INFESTATION RATES

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Salmon lice (*Lepeophtherius salmonis*) infestations cause major disruptions in marine Atlantic salmon (*Salmo salar*) farming operations. Effective mitigation of these pests is reliant on monitoring for epizootics and pre-emptive treatment of lice populations before they become self-propagating. Farms typically consist of multiple salmon-rearing cages (net pens) arranged in a grid. Initially, planktonic lice infest individual net pens, but as the population grows, all the net pens in a farm become affected. Subsequently, monitoring and treatment requirements are often gauged at the farm level. Studies that focus on elucidating the infection dynamics of salmon lice often concentrate on a regional scale, incorporating multiple farms for analysis, but have rarely examined the dynamics that occur within a farm. In this study, the interactive effects that occur between net pens and the environment at a farm scale were investigated. Specifically, this study examined whether increased environmental exposure differentially affected lice abundance and aggregation in the net pens of a farm. Through weekly sampling of lice burdens, we compared exposed net pens, which inhabit the corners of the grid arrangement, and those that are buffered from exposure by adjacent net pens. We followed the establishment and eventual epizootic infestation of salmon lice on a farm over a summer growing season until the infestation required treatment. We found that exposed net pens had consistently higher overall abundances and indicators of aggregation. We also found that egg-bearing female lice numbers fluctuate between these net pen groups before exponential growth in the overall lice population of the farm. These results have important implications for the adoption of better monitoring strategies, more informed experimental designs, and further understanding of self-propagating infestations in salmon lice.

IMPROVING LOW SALINITY PERFORMANCE OF PACIFIC WHITE SHRIMP *Litopenaeus vannamei* USING A GENOMIC APPROACH

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Global aquaculture production of shrimp has increased drastically over the last two decades with production increasing from ~1.3 million MT in 2001 to ~7.5 million MT by 2021. Despite the global increase in farmed shrimp production, US shrimp aquaculture production has remained relatively low over this same period (<3,000 MT in most years with a maximum of ~6,000 MT in 2003). The lack of growth in US shrimp aquaculture can be attributed to many factors, including low costs of imported products relative to US products, permitting issues and regulations, and land use conflicts. However, there is one sector of the industry that has shown signs of growth: inland farms. It is estimated that there are ~100 inland shrimp farms in operation in the US (including startups and "backyard" farms) and these farms produce >400 MT/year. Some of these use outdoor ponds/tanks and have access to low-saline groundwater, but a majority of inland farms are indoors, utilize recirculating aquaculture systems (RAS), and rely on seawater made from natural or synthetic sea salts.

Inland farming is attractive for several reasons, including minimizing the introduction and spread of pathogens (i.e. increased biosecurity), potential for year-round production, farms can be closer to major markets allowing for direct marketing to consumers and food service industry, and locating farms away from sensitive coastal areas. Inland farming does have inherent challenges though, most notably high capital and operational costs. Reducing capital costs industry-wide will be difficult, as most inland farms will require costly infrastructure, and solutions for capital reduction may be region specific. Thus, to support the continued growth of inland shrimp farming, efforts are needed to reduce production/operational costs.

This project focused on the genetics of *Litopenaeus vannamei* growth and survival under normal and reduced salinity conditions. The impacts of reducing salinity on the performance of selectively bred *L. vannamei* will be reported, so that inland farmers can weigh the economic benefits of reducing salinity (i.e. reducing input costs) against the impacts on shrimp performance. In addition, valuable genetic parameter estimates will be provided which will allow breeders to estimate trade-offs in genetic gain if selection and farming occur at different salinities and, ultimately, determine if developing separate lines for high and low/reduced salinity is warranted. Lastly, the benefits of using a genomic selection approach in shrimp will be presented.

ISOLATION AND CHARACTERIZATION OF PHAGE AHFM11 AGAINST HYPERVIRULENT *Aeromonas hydrophila* AND ITS USE IN AQUACULTURE AS A THERAPEUTANT

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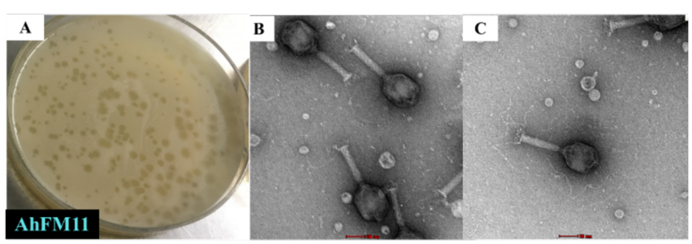
Phages infecting hypervirulent *Aeromonas hydrophila* (vAh) had not been isolated anywhere in the world; however, phages have been isolated against motile *Aeromonas* septicemia (MAS) with only few of them having been characterized. This study aimed at developing therapeutic phage against hypervirulent *Aeromonas hydrophila* infection in aquaculture systems.

A total of 110 water samples were collected aseptically. A novel phage AhFM11 specific to hypervirulent *A. hydrophila* was isolated and shows lytic activity against reference *A. hydrophila* (ATCC 35654). Soft agar overlay method was used to determine titer and found to be 1.58 x 10^{10} pfu/mL. Host range of the AhFM11 phage was performed for 131 *Aeromonas* spp. and 10 non *Aeromonas*. The results indicated that AhFM11 had a broad host range, infecting 65 *Aeromonas* species. Also, it was found that this phage did not harbor any antibiotic resistance genes. This is the first report of phage against hypervirulent *A. hydrophil*a.

Transmission electron microscopy (TEM) revealed that phage AhFM11 belongs to the family of Myoviridae (Figure 1). One-step growth curve of AhFM11 shown that the phage has an average burst size of 276 ± 15 PFU per infected cell, adsorption rate of 97.3% and found to be stable in different environmental conditions. The AhFM11 genome comprised of 176,963 bp with an average G/C content of 41.5% (NCBI accession No. MZ450807.1). The novel bacteriophage-based strategies therapeutic approach (injection, oral feed and immersion) to prevent and treat *A. hydrophila* infection were studied. Therapeutic application in injection, immersion and feed impregnated phages showed 100%, 95.11% and 93.11% survival than the challenged untreated fishes. These findings support that phage AhFM11 can be used to treat/control *A. hydrophila* infection in cultured fishes and has immense value as a potential alternative to antibiotics.

FIGURE 1. *A. hydrophila* phage (AhFM11) isolation and its TEM images.



A. Plaque formation on *A. hydrophila* in TSA soft agar plates. **B**. Negatively stained (2% uranyl acetate) TEM image exhibiting numerous phages (Bar = 200 nm). **C.** TEM image of phage exhibiting icosahedral head along with sheathed tail tube and its fibers which belongs to Myoviridae family (Bar = 100 nm).

HISTOLOGICAL AND PHYSIOLOGICAL CHARACTERIZATION OF DIGESTIVE SYSTEM ONTOGENY IN AN ORNAMENTAL WRASSE *Halichoeres melanurus*

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Marine ornamental aquaculture often relies on the production of live feeds that are considerably costly to produce, which poses a constraint to the growth of the marine ornamental aquaculture industry. Introducing microdiets during larval development may help reduce the amount of live feeds needed and therefore greatly reduce the cost and labor involved. However, the digestive tract of marine larvae is rudimentary in early stages, making the digestion and assimilation of microdiets difficult. A 25-day trial was conducted to characterize the digestive tract ontogeny of *Halichoeres melanurus,* an ornamental wrasse species not yet commercially cultured, to give insight into potential feeding and weaning protocols. Larval *H. melanurus* were raised on live feeds, including *Parvocalanus crassirostris* copepods, *Brachionus plicatilis* rotifers, and *Artemia* sp. nauplii from 3 to 25 days post-hatch (DPH). Larvae (n=10 per time point) were sampled 12 times throughout the trial to analyze growth, digestive enzyme activity, and digestive tract development. The activities of lipase and trypsin were quantified using standard microplate assays. Histology was used to visualize morphological changes in the digestive system at each sampling time point. Trypsin (Figure 1A) and lipase (Figure 1B) activities were detectable from 3 DPH and increased more dramatically after 15 DPH, indicating the maturation of the digestive tract. The digestive tract remained agastric and was characterized by a unique pouch-like organ, named the oesogaster, located posterior to the esophagus and anterior to the intestine. Further studies will be conducted to elucidate the function of the oesogaster, which has been found in other species of wrasse. Overall, these data help us better understand the digestive capabilities of *H. melanurus* throughout development and will guide future feeding and weaning protocols.

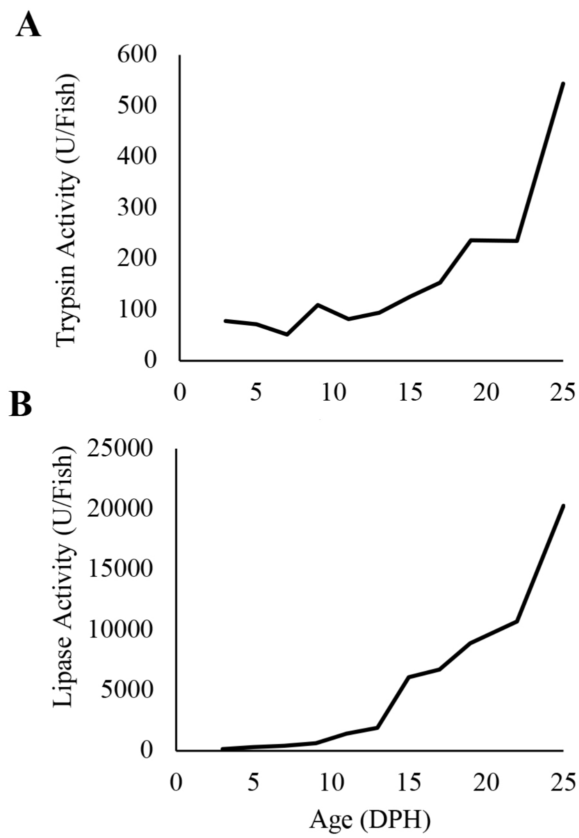

Figure 1. Digestive enzyme activity of larval *H. melanurus* from 3-25 DPH fed exclusively live feeds (A – Trypsin, B – Lipase). Data points represent enzyme activity per fish from a pooled sample of 10 fish, thus error bars are absent.

REDUCING THE RELIANCE ON LIVE FEEDS DURING LARVIULTURE OF *Amphiprion ocellaris*

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Clownfish (*Amphiprion ocellaris*) have been one of the most significant marine ornamental commodities for decades and have recently emerged as an important model organism for ecology and evolution research. These fish have been cultured commercially for decades, however bottlenecks during larviculture continue to affect survival and appearance of juvenile fish. Additionally, clownfish larviculture is heavily reliant on live feeds, such as rotifers and *Artemia* nauplii, which increases the complexity and cost of raising this species. This study aimed to utilize the digestive physiology of clownfish to inform subsequent weaning and dietetics experiments to reduce the overall use of live feeds. A previous study examined *A. ocellaris* larval digestive physiology from 0-15 days post-hatch (DPH) and found that the digestive tract of *A. ocellaris* matures around 7 DPH, indicated by the presence of a functional stomach. First, larvae were weaned from rotifers to *Artemia* nauplii at three time points (3, 5, and 7 DPH) during a 15-day trial. This trial found that larvae can be transitioned to *Artemia* nauplii as early as 5 DPH (Figure 1A). A second 25-day weaning trial aimed to transition larvae from live feeds to a commercial microdiet (MD) as early as possible. Digestive ontogeny data were used to introduce MD at three time points surrounding stomach development (5, 8, and 11 DPH). Larval survival was greatest when MD was introduced at 5 DPH (Figure 1B), therefore *A. ocellaris* larviculture may not require the use of *Artemia* nauplii prior to MD introduction. A dietetics trial is currently underway, where the effects of three types of commercially available MDs on larval growth, survival, and pigmentation are being examined. Overall, these data will help reduce the overall reliance on rotifers and *Artemia* nauplii, which will result in more cost-efficient and streamlined larval culture protocols for *A. ocellaris.*

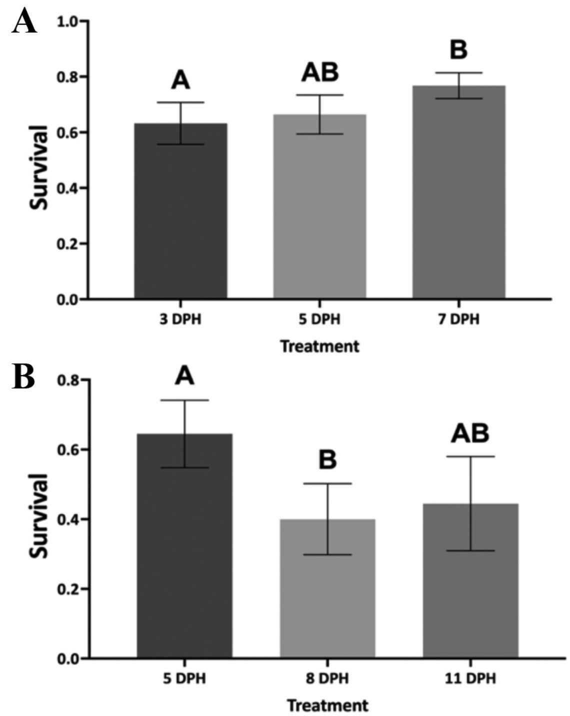

Figure 1. Proportional survival (±SEM) of *A. ocellaris* at 15 DPH (A) and 25 DPH (B) after exposure to different weaning regimes. Different letters above bars indicate statistical significance.

OPT REAL-TIME PASSIVE ACOUSTIC MONITORING (PAM) SYSTEM PROPOSAL

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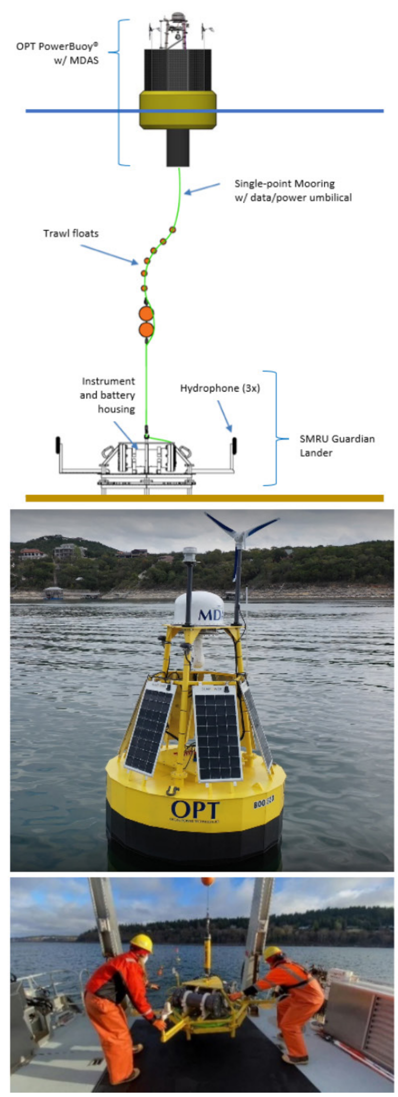
Abstract:
Offshore wind companies continue to create wind farms off coastlines which may be harmful to sea life. Due to the migration of large marine mammals through these waters, a Passive Acoustic Monitoring (PAM) system capable of real-time and long term detections is needed for their protection.

Proposed Solution:
Ocean Power Technologies, Inc. (OPT) has combined with industry experts in marine mammal behavior, data analysis, signal processing, and maritime systems to develop a PAM system for marine mammal protection. Our solution involves integration of OPTs commercially available PowerBuoys® with a specialized seafloor lander system equipped with hydrophones. The system can detect and localize large marine mammal activity. The data captured is processed in real-time and, through high-bandwidth Satellite Communications (SATCOM), is sent to a shore-based station equipped with monitoring software. An external marine science company provides PAM Operators for final validation of detections. Validated detections will be relayed via a cloud analytics system for notifications to ocean users. The system is also capable of long-term passive monitoring of areas of interests with integrated onboard data storage.



Representative system configuration illustrating key system components. Final hardware and mooring configurations subject to change.

Deployment Strategy:
Phase 1: System Integration, optimization, and deployment planning, considering prior in-ocean demonstration data, marine mammal targets, and METOCEAN characteristics of the deployment location(s).

Phase 2: Deployment of the PAM systems up to one year of autonomous real-time monitoring and detection of large marine mammals. The system is scalable, allowing for a network of PAM systems to monitor a large area.

PAM System Hardware: OPT's PowerBuoy® paired with a specialized seafloor lander, featuring three hydrophones. Each PowerBuoy® has a solar panel array and wind power generation. Energy is stored in on-board high-capacity batteries, with proven reliability. Acoustic data is digitized and processed in real-time using a specific processor running monitoring software. The system can detect a range of marine mammals, optimized for large marine mammals. A single point umbilical mooring system is used to minimize entanglement risks.

AQUACULTURE: IT IS TIME TO FOCUS ON THE QUALITY

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The world's population is rising and the subsequent demand for high protein sources of food is rising with it. A push for healthier sources of protein is also an increasing demand. Hence, aquaculture is rising in prevalence and importance in today's society with the increase in fish consumption and the limitations imposed by normal fishing methods. Aquaculture offers a solution to these issues by providing high protein foods that require less space to farm, a lesser time to harvest, and a lower cost to produce, and it is lesser detrimental to the environment. However, current aquaculture techniques involve the use of chemicals in order to reduce disease and mortality within the crops, caused by crowding, handling, transportation etc. In order to provide solutions to the problems of farming and the needs of the people without the use of potentially harmful substances many researchers are looking in to the use of nutraceuticals (functional food) in order to decrease stress responses, increase immune responses, increase growth, and increase the nutritional value of farmed aquatic animals – both fish and shellfish. In this presentation, I will highlight all these issues and suggest solutions.

RESPONSIBLE CATFISH IS NEXT ON THE US MENU! THE SCOPE EXTENSION PROJECT OF THE AQUACULTURE STEWARDSHIP COUNCIL

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The Aquaculture Stewardship Council (ASC) is the world's leading certification scheme for farmed seafood. In 2022, the total global production of ASC certified seafood amounted to 1.55% of the global aquaculture production. Our findings show that ASC can meaningfully address most of the industry's global challenges. We demonstrate this through alignment with a significant proportion (49%, or 82/169) of all Sustainable Development Goal targets; with more than 80% of those considered to be 'well' or 'very well' addressed. Compliance with the ASC Standards helps to reduce farm's environmental footprint, conserve natural resources and contribute to worker's well being.

During our stakeholder survey in 2022, it was shown that stakeholders recognise key benefits delivered through ASC: the logo provides assurance that ASC delivers a good product, ASC serves as a catalyst for improved production processes and opens doors to new customers and markets. 84% of respondents find these benefits to be very valuable and 80% of the respondents believe ASC is achieving its mission. ASC is the most recognised certification scheme for farmed seafood. Consumer awareness of our ASC label is significantly higher than similar programmes in many key markets.

Looking forward, there is interest for expanding our scope to multiple catfish species, namely: *Clarias gariepinus; Heterobranchus bidoralis; Ictalurus punctatus; Hybrid of Heterobranchus longifilis X Clarias gariepinus*. According to the FAO, the genus *Clarias spp.* accounts for 2.3% of the total fish production in 2020 and it is a fish species with a remarkable potential for the development of freshwater aquaculture. Catfish also has a high commercial interest especially in North America and Asia. Catfish and its hybrids are therefore gaining importance worldwide.

All these species seem to have competitive profit margins for large-scale production which is leading farmers to opt for more intensive aquaculture practices with associated social and environmental risk as well as risks for the fish welfare. These risks will be covered by the implementation of the ASC Farm Standard with species-specific indicators. Thus, the ASC sees an urgent need to include these species in the portfolio to actively address major concerns and issues.

Our goal is to involve relevant stakeholders in the content development, especially regarding metric setting. The catfish industry is an important contributor of the US economy; therefore, the inclusion of American catfish farmers is fundamental in this project. Farmers also benefit from this as ASC certification allows them to drive additional revenue and income though access to global and local market demand. This is the next step to bring responsible catfish on our consumers' tables!

CONSUMER PREFERENCE OF DRY CATFISH (Clarias gariepinus, Burchell 1822) PRESERVED WITH SWEET ORANGE PEEL (Citrus sinensis-L Osbeck, 1757)

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Study confirmed that people consume more dried fish than fresh fish in Nigeria, and mostly fresh water river dry fish. This study tends to compare the consumer preference of dry Catfish (*clarias gariepinus* Burchell, 1822). Preserved with Sweet Orange Peel (*Citrus sinensis* L. Osbeck*)* either smoked with fire wood or with gas oven. The fish were gutted, washed throughly with water to remove external dirt, and transferred into a basket for proper draining of water. The fresh fish were dipped in 150ml of sweet orange peels extract for 30 minutes, and divided into three groups the fish were marinated with spices and placed randomly on the rack of smoking klin. The fish were prepared and smoked using dry fire wood in a traditional smoking klin for a period of 2hrs, and the other part smoked with oven gas. The dried fish was Prepared into pepper soup sample and a trained panel of judges was used to assess the acceptability make comments through a questionnaire. The smoked catfish were allowed to cool at room temperature and samples were taken from each batch respectively for proximate analysis. The result of proximate analyses of samples showed that the moisture content of the smoked fish with charcoal is lower (10.04 %) than that of oven gas sample (14.80 %). The crude protein, fat, ash, crude fibre and nitrogen free extract of the smoked fish with charcoal sample were 55.34, 13.29,3.88,14.22 and 13.27, respectively compared to 52.80,13.47,3.46, 13.29 and 16.68 observed in the oven gas fish, respectively. The mean score of organoleptic evaluation showed that both processed fish products in terms of organoleptic assessment, smoked fish with firewood or charcoal had better flavour, taste, texture and general acceptability than the smoked fish with oven gas as revealed by the panellists with better reduction in moisture content and higher protein content observed in fish subjected to smoking. The role of orange peel prolonged the shelf life of fish and can be used as antimicrobial and antioxidant activity. It is concluded that smoking with charcoal or dried wood is better and more accepted than fish smoked with oven gas in the processing of catfish (*Clarias gariepinus*).

UNOBSERVED MORTALITY OCCURS EARLY IN LARVAL WALLEYE CULTURE

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One of the most persistent challenges in walleye larviculture is the high rate of unobserved mortality occurring within the first 30 days post-hatch. Walleye larviculture is characterized by high mortality rates, but oftentimes only a fraction of the total mortality in walleye larviculture is observed. Unobserved mortality is frequently attributed to a high rate of cannibalism at the early life stage. Additionally, dead fry decompose quickly at this stage, which may also contribute towards unaccounted mortality. Despite cannibalism and fry decomposition being frequently identified as causes of unobserved mortality, there is little empirical evidence available that assesses the causes and timeframe of unobserved mortality in walleye larviculture. To further investigate the quantity of unobserved mortality rates, fish survival was determined after three different time periods in the treatment tanks. Larval fry were stocked at low densities of 4-6 fry per liter and raised at optimal conditions for walleye including turbid water, 24-hour feeding, dim lighting and spray bars. In the treatments fry were reared for 8, 15 and 30 days. Tanks were cleaned daily, and dead fry were enumerated to account for observed mortality. At the end of the study period, the tanks were drained and all fry were hand counted. A high rate of unobserved mortality occurred in all treatments. Unobserved mortality averaged 37.62%, 41.15%, and 24.60% of all mortalities from the treatments, respectively.

AN OPEN-SOURCE METHOD FOR DEWATERING MICROALGAE CULTURES FOR USE IN LIVE FEED PRODUCTION

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Microalgae culturing is an essential contributor to aquaculture and other industries in biotechnology. These cultures are used in the Roger Williams University Aquaculture and Aquarium Science Lab (RWU AASL) and Luther Hx. Blount Shellfish Hatchery to sustain filter-feeding organisms, as well as provide adequate shading in larval tanks during the culturing process. Microalgae production is a costly and time-consuming process, so it is essential to optimize growth and storage methods. Using microfiltration (MF) and ultrafiltration (UF), the total volume of liquid the microalgae cells are suspended in can be significantly reduced, creating a dewatered, cell-dense output that can be stored and fed when necessary. Utilization of MF and UF is preferable for cell viability compared to other methods of dewatering. There are several different components that affect the efficiency of these filtration processes and this project details ideal methods for dewatering microalgae using a single-pump small-scale crossflow filtration system.

To fully capture the changes occurring to the algae population during filtering, a mathematical model was developed. This model aims to test the effects of parameters such as flow rate, culture volume, and pressure on cell count and viability. Modeling also simulated the impacts of shear stress within the MF or UF system on the microalgal cells, as high stress dramatically reduces cell viability. Simulated parameters must be repeatedly tested to ensure the most viable biomass concentration. Upon dewatering, the decrease in culture volume and increase in cell density of the retentate allows for the compact storage of microalgae (Figure 1).

Establishing best practices for microalgae filtration fosters the creation of a time and cost-efficient method of feeding the organisms grown in the RWU AASL and Hatchery. This will also provide a convenient method for acquiring concentrated microalgae for use in commercial hatcheries or other industry locations.

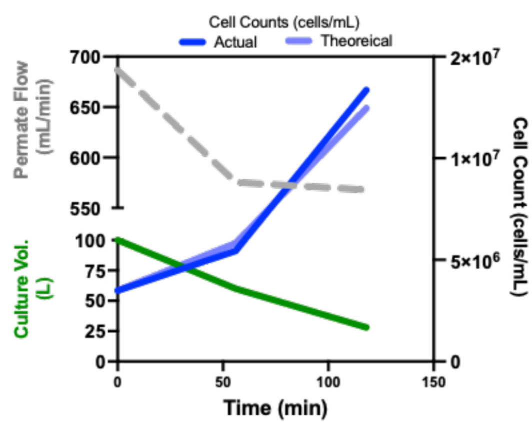

FIGURE 1. Relationships between permeate flow rate, culture volume, and cell density. Cell counts do not differentiate between viable and non-viable cells.

CREATING WORKFORCE PATHWAYS BY EDUCATING YOUTH THROUGH AQUACULTURE

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Aquaculture is the fastest growing sectors of food production worldwide and is vitally important to obtaining sustainable food security in the future. However, in the United States aquaculture continues to grow at a sluggish pace and is often misunderstood or completely unknown to many U.S. consumers.

In an effort to increase awareness for the next generation of seafood consumers and create defined pathways into the aquaculture workforce many extension educators and academics are creating K-12 aquaculture programs and working closely with K-12 schools to help integrate aquaculture curriculums into classrooms. A model initiated in Michigan that consists of three core initiatives geared toward creating a new aquaculture work force and an educated consumer base has arisen. The core tenants of this program include 1) K-12 Teacher trainings and assistance with teacher networking 2) K-12 curriculum development and a high school aquaculture competition and 3) Post-secondary programs identified and/or created.

The efforts that have been taking place in Michigan and the Midwest are centered around the Youth Education in Aquaculture Initiative (http://ncrac-yea.org/), an effort funded through a variety of funding partners including the North Central Regional Aquaculture Center, Michigan Sea Grant and the Center for Great Lakes Literacy. This program was started by Lake Superior State University Professor Dr. Barbara Evans, and is now co run by Dr. Evans and Elliot Nelson with Michigan Sea Grant. Through this effort a network of schools is being created to allow for cross school collaboration. In addition teacher trainings and curriculum resources are being compiled and offered. The keystone of the program is the Aquaculture Challenge, a competitive high school competition aimed towards engaging high schools in an integrative STEM and business competition. In addition new post-secondary programs have been created and are now seeing graduates who come through the high school programs and enter into post-secondary programs. This session will focus on these efforts and how they are leading to a clear and defined pathways into the aquaculture workforce.

Youth Education
in Aquaculture

EVALUATION OF DIETS CONTAINING SORGHUM AT DIFFERENT LEVELS OF THERMAL ENERGY ON GROWTH PERFORMANCE OF THE PACIFIC WHITE SHRIMP, *Litopenaeus vannamei*

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Sorghum, which is one of the most sustainable cereals can be used as a potential source of carbohydrate in animal feeds. This study aims to evaluate the growth performance of white shrimp juveniles fed diets containing sorghum and whole wheat when processed at different levels of thermal energy input. Six diets containing sorghum and whole wheat at different levels of process energy inputs (low, medium, and high) were formulated and extruded under controlled conditions using a Wenger X-20 single screw extruder. In this study, these treatments were assigned amongst 40 tanks with six replicates per treatment diet. Additionally, a commercial diet was also included as a reference but utilized four replicates. Shrimp juveniles (initial weight 0.82g) were randomly stocked at a density of 15 shrimps per tank and were maintained in a semi-closed recirculating system. They were fed four times per day using a standard ration over the 42-day growth trial. After six weeks, there were no significant differences in final weight, weight gain, survival rate, and FCR among treatments. However, the results showed that thermal energy input during extruding did not have a noticeable impact on shrimp growth or whole-body energy. These findings indicate that grain sorghum can serve as a carbohydrate source to replace whole wheat in shrimp diets.

Table 1. Growth performance of juvenile Pacific white shrimp (0.82g) fed diets with different levels of thermal energy input of sorghum and wheat within a 6-week experimental period.

Growth Parameters	Final Biomass (g)	Final Weight (g)	Weight Gain (g)	Weight Gain (%)	TGC	FCR	Survival (%)
Commercial	105.66	8.46	7.65	938.63	2.16	1.59	83.33
Wheat_HT	110.08	9.10	8.27	1007.93	2.34	1.52	81.11
Wheat_MT	116.26	8.94	8.13	994.82	2.30	1.46	86.67
Whear_LT	114.15	9.02	8.20	999.47	2.32	1.47	84.44
Sorghum_LT	111.13	8.79	7.96	962.84	2.25	1.49	84.44
Sorghum_MT	110.27	8.84	8.02	975.77	2.27	1.51	83.33
Sorghum_HT	111.12	9.26	8.44	1035.73	2.39	1.44	80.00
PSE	5.16	0.23	0.23	41.81	0.07	0.06	3.88
P-value	0.89	0.42	0.43	0.79	0.16	0.74	0.91

EFFECTS OF DIFFERENT SOYBEAN LEVELS AS MAIN PROTEIN SOURCE ON GROWTH PERFORMANCE AND FEED UTILIZATION EFFICIENCY OF PACIFIC WHITE SHRIMP (*Litopenaeus vannamei*)

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With low oligosaccharide (LO-SBM) and fermented soybean (FerSBM) meals serving as the primary protein source, this study sought to assess the effects of varying replacement percentages of solvent-extracted soybean meal on the growth and feed utilization efficiency of Pacific white shrimp. For eight weeks, a green water recirculation system was used with the stocking density of 30 shrimp tank^{-1} (~38 shrimp m^{-2}) The initial weight of the shrimp was 0.29 ± 0.01 g (Mean ± Standard Deviation). Nine different experimental diets were examined. Solvent extracted soybean meal was the primary source of protein of the basal diet, which was replaced with four levels of replacement (40 %, 60 %, 80 %, and 100 %) of each of LO-SBM and FerSBM. All growth metrics in the trial showed no significant differences among diets ($p>0.05$). Except for phosphorus retention ($p<0.001$), we observed no significant contrast concerning feeding utilization efficiency ($p>0.05$). The results revealed that, in the context of natural productivity, the tested soybean ingredients at various levels had no detrimental effects on the growth response or feed utilization of Pacific white shrimp. Furthermore, given the trial's conditions, a high replacement rate did not correspond to improved performance. The outcome showed the potential of replacing the solvent extracted soybean meal with new variety low oligosaccharide and fermented soybean meals when needed. This research expands upon earlier studies wherein shrimp given LO-SBM and FerSBM shown superior performance compared to those fed diet containing soy protein concentrate, expeller-pressed soybean meal, and animal-based ingredient. Overall, both low oligosaccharide or fermented soybean meal supported good growth of the shrimp and are suitable protein sources.

Growth Performance	Basal	LO-SBM 40 %	LO-SBM 60 %	LO-SBM 80 %	LO-SBM 100 %	FerSBM 40 %	FerSBM 60 %	FerSBM 80 %	FerSBM 100 %	p-value
SR (%)	96.68	100.00	100.00	100.83	98.33	99.18	100.83	97.50	97.50	0.250
FW (g)	20.38	20.38	20.70	19.92	20.87	19.49	19.91	19.46	19.75	0.178
WG (%)	6,948.17	6,807.97	6,866.09	6,735.23	7,065.39	6,575.86	6,607.91	6,451.02	6,432.96	0.169
FCR	1.05	1.01	1.00	1.04	1.01	1.06	1.02	1.10	1.06	0.053
ANPR (%)	51.03	52.67	52.48	51.18	50.37	50.52	50.84	50.95	51.16	0.944
NPR (%)	23.42^{bcd}	25.95^{ab}	24.07^{abc}	27.03^{a}	24.02^{abcd}	22.33^{cd}	22.46^{cd}	21.73^{cd}	20.80^{d}	<0.001

EFFECTS OF DIFFERENT SOYBEAN INGREDIENTS AS MAIN PROTEIN SOURCE ON GROWTH PERFORMANCE, FEED UTILIZATION EFFICIENCY, INTESTINAL HISTOLOGY, AND PHYSIOLOGICAL GENE EXPRESSION OF PACIFIC WHITE SHRIMP (*Litopenaeus vannamei*) IN BIOFLOC SYSTEM

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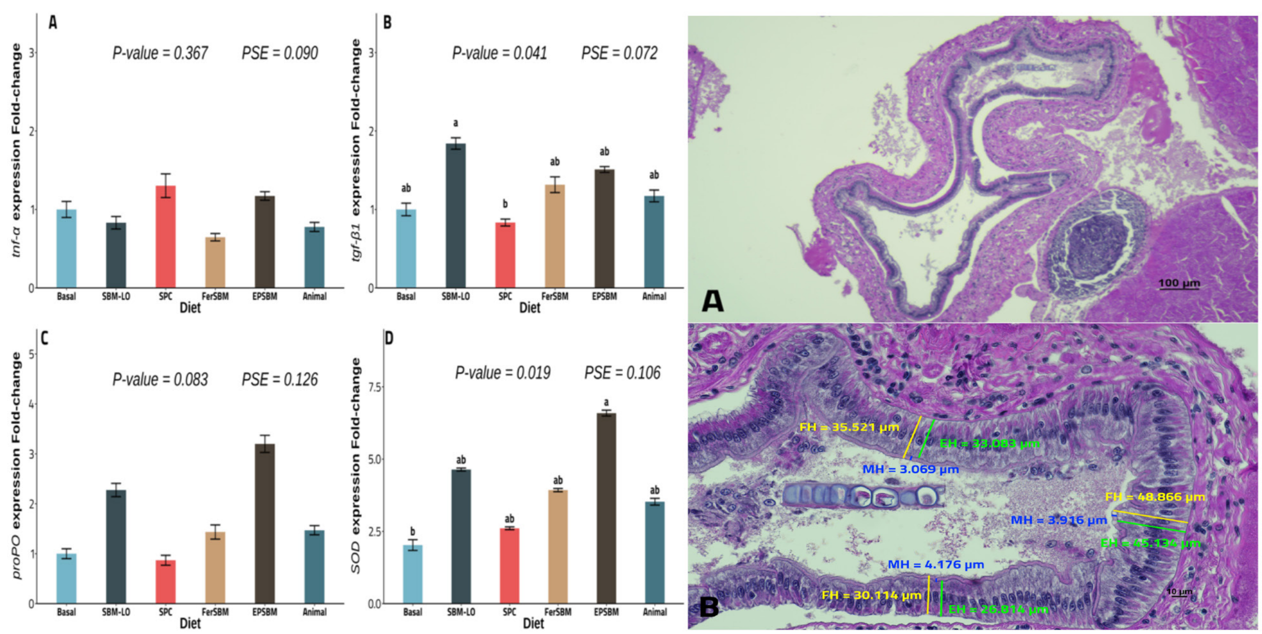
The purpose of this study was to assess the effect of replacing solvent extracted soybean meal with more advance soy-based proteins on growth performance, feed utilization efficiency, intestine histology, and gene expression when reared under intensive biofloc culture conditions. The study was carried out at stocking density of 30 shrimp $tank^{-1}$ (~166 shrimp m^{-2}) at an initial weight of 1.18 ± 0.001 g. Shrimp were fed over eight weeks using four replicate tanks, with six experimental diets including solvent extracted, low oligosaccharide, fermented, expeller-pressed soybean meal, soy protein concentrate, and an animal-based diet with 50% fishmeal and 50% meal as protein source. The trial findings demonstrated substantial differences between shrimp groups, particularly those received animal-based and plant-based diets, for all growth parameters ($p<0.05$), except for survival rate ($p>0.05$). With respect to feed utilization efficiency, we observed interesting trends with significant higher in phosphorus retention and apparent net protein retention for all diets except for that of soy protein concentrate ($p<0.05$). Concerning histology, no significant impact of the tested ingredients on histomorphology could be seen ($p>0.05$). While shrimp fed SPC and basal diets signified noticeable down regulation for the expression of *tgf-β1* and *sod* ($p<0.05$). Based on these findings, additional study on diverse processed soybean sources under bacterial-driven conditions is needed to get greater insight into combining multiple soybean constituents for an improve dietary matrix for shrimp farming.



EFFECTS OF HIGH PROTEIN DISTILLERS DRIED GRAINS WITH YEAST AS PRIMAY PROTEIN SOURCE ON GROWTH PERFORMANCE, FEED UTILIZATION EFFICIENCY, HAEMOLYMPH PARATEMETERS, AND PHYSIOLOGICAL GENE EXPRESSION OF PACIFIC WHITE SHRIMP (*Litopenaeus vannamei*)

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The purpose of this study was to determine the effect of replacing fish meal, soybean meal, and con protein concentrate in an equal ratio with high protein distiller's dried grains with yeast (HP50Y) on Pacific white shrimp growth, feed utilization efficiency, haemolymph parameters, and physiological gene expression. For eight weeks, a green water recirculation system was employed with a stocking density of 30 shrimp tank^{-1} (~38 shrimp m^{-2}) and an initial weight of 0.22 ± 0.007 g (Mean Standard Deviation). Six distinct experimental diets were investigated. The primary protein sources in the basal diet were systematically replaced (0-25% diet) with high protein distillers dried grains with yeast. In the study, no significant changes in shrimp growth indicators were found between shrimp reared on the various diets ($p>0.05$). We found no significant differences in feed utilization efficiency ($p>0.05$) except for net phosphorus retention ($p<0.001$). While physiological gene expression analysis is being investigated, the haemolymph index exhibited a similar pattern with no statistically significant outcome ($p>0.05$). The results showed that, in the setting of natural productivity, different replacement levels did not impair the growth response, feed consumption, and haemolymph indicators of Pacific white shrimp when appropriately balanced with other protein sources. The results demonstrated the feasibility of replacing the primary protein source with high protein DDGS with yeast in practical feed applications. Overall, the use of high protein DDGS with yeast in shrimp feed formulation resulted in a good growth rate with no negative effects found.

Growth Performance	Basal	DDGS 5%	DDGS 10%	DDGS 15%	DDGS 20%	DDGS 25%	p-value
SR (%)	98.35	98.35	99.18	98.35	96.68	100.00	0.270
FW (g)	18.53	18.46	18.56	18.15	17.86	17.86	0.201
WG (%)	8,481	8,464	8,480	8,334	8,273	8,149	0.804
FCR	1.09	1.08	1.09	1.11	1.13	1.12	0.372
ANPR (%)	44.86	43.72	46.07	45.82	44.07	44.68	0.784
NPR (%)	23.53^{ab}	21.24^{b}	24.90^{ab}	27.40^{a}	26.26^{a}	24.35^{ab}	0.012

pH IN THE DIGESTIVE TRACT OF THE PYGMY OCTOPUS, *Paroctopus digueti*

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The digestive tract pH of the pygmy octopus (Paroctopus digueti) was evaluated. Octopuses were acclimated to captivity in fed and fasted treatments. The pH of all organs of the digestive tract was measured. Food intake (214.9 ± 157.6 mg) and transit time (8h) were evaluated. The pH of the digestive tract regions was acidic. No difference was found in the pH of fed and fasted octopuses.

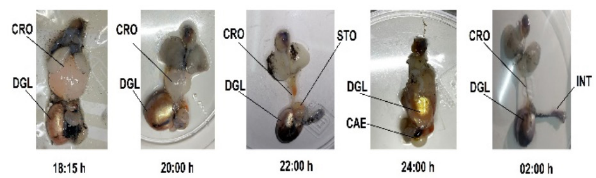

Fig. 1. Transit of food in P. diguetti digestive tract.

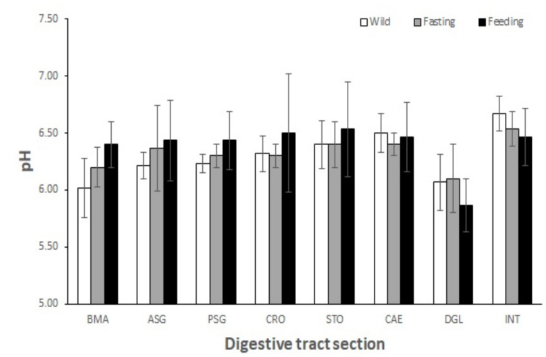

Fig. 2. Internal pH in P.digueti digestive tract organs.

Adult octopuses obtained from the wild (mean ± SD) (42.1 ± 15.1 g), and those acclimated to captivity in a fed (25.4 ± 9.0 g, n=15) or fasted (23.1 ± 6.1 g, n=15) state, were studied. The pH of the internal part of the buccal mass (BMA), anterior salivary glands (ASG), posterior salivary glands (PSG), crop (CRO), stomach (STO), caecum (CAE), digestive gland (DGL) and intestine (INT) was measured. Food intake (dry weight) per octopus was 53.8 ± 35.1 mg to 214.9 ± 157.6 mg at 15 min and 8 hours, respectively. The apparent food transit time was approximately 8 h for the appearance of feces in the posterior intestine (Fig. 1). The pH of the digestive tract regions was lower than pH 7.0. No difference was found when comparing fasting (6.41 ± 0.22) and feeding octopus (6.41 ± 0.23). DGL had the lowest pH (6.04 ± 0.12 in the wild and 5.97 ± 0.17 in feeding octopuses). The apparent transit of food over 8 h agrees with transit time in *O. maya* and *O. mimus* (Gallardo et al., 2017). The acidic pH of the digestive tract of *P. digueti*, is in agreement with the pH in *O. maya* (Vidal et al., 2014), *O. bimaculatus* (López-Peraza et al., 2014); and *O. vulgaris* (Sykes et al., 2020). Also, according to Linares et al. (2015), the pH in the DGL is the more acidic, although, in our study, we found values above pH 5.0 and not between pHs 3 and 4. All the above information is essential to understand the digestive physiology of the pygmy octopus. Attention must be paid to the fact that the physiological pH values of this species indicate the conditions of action of their digestive enzymes (fasting or feeding). In conclusion, the pygmy octopus has an acidic pH in its digestive tract in fasting and fed conditions.

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EMPOWERING WOMEN IN KENYAN AQUACULTURE: A CALL FOR SUSTAINABLE GROWTH

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Rio Fish, a pioneering force in the Kenyan aquaculture sector, presents an insightful exploration at Aquaculture America 2024. Focused on fostering the growth of women-led enterprises in aquaculture.

The presentation unveils the innovative strategies and success stories of Rio Fish in transforming the aquaculture landscape.

Despite challenges, Rio Fish has propelled women entrepreneurs in aquaculture, fostering economic growth and community resilience.

This presentation serves as a call to action, seeking elusive financing to support the expansion of women-led aquaculture ventures. By showcasing the success stories and potential of Kenyan aquaculture, Rio Fish aims to inspire collaboration and investment, ultimately contributing to the thriving and sustainable development of women enterprises in the aquaculture landscape.

EVALUATION OF THE MUCOSAL HEALTH OF ATLANTIC SALMON *Salmo salar* FED TWO DIETARY YEAST ADDITIVES

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The Atlantic salmon (*Salmo salar*) is a prominent species in aquaculture, and optimizing its growth and health is of paramount importance to the aquaculture industry. Brewer's yeast is a known source of essential nutrients and bioactive substances such as β-glucans, mannan-oligosaccharides, and nucleotides which can potentially enhance the growth and overall health of aquatic species. This study investigates the impact of incorporating two distinct commercial brewer's yeast additives, an autolysed brewer's yeast (ABY) and a soluble dried yeast extract (SDYE), manufactured by Leiber GmbH into the diet of Atlantic salmon juveniles on their performance and mucosal health.

A 9-week feeding trial was conducted in a cold freshwater indoor recirculatory aquaculture system (RAS) with Atlantic salmon juveniles (37.08g) at the University of Plymouth. Three isonitrogenous and isocaloric diets were formulated to meet the known nutrient requirements of Atlantic salmon (Table 1). The control diet (T1) had no brewer's yeast additive while the other two diets, T2 and T3, were supplemented with 0.25g/100g of autolysed brewer's yeast or soluble dried yeast extract, respectively. The fish (20 fish/70L tank) were fed one of the three diets (n = 3 tanks) at 1% of body weight per day. Water quality parameters were monitored throughout the trial. At the end of the feeding trial, skin and intestinal samples were taken for intestinal assessments using light and electron microscopy, expression of immunoregulatory genes, haematology, and 16S rRNA metabarcoding.

The result of the skin histology revealed that there was a significant enhancement ($p<0.05$) of goblet cell abundance through dietary supplementation in the fish fed T2 (18.22±2.48 /200µm) compared to the T1 (14.56±2.85 /200µm) and T3 (14.44±2.66 /200µm) groups.

Ongoing analysis of histological parameters of the intestinal samples, expression of key immunoregulatory genes, haematology, and a 16S rRNA metabarcoding analysis of intestinal samples.

Table 1: Experimental diets (g/100g)

INGREDIENTS (G/100G)	T1	T2	T3
Corn Gluten Meal	22.00	22.00	22.00
Sunflower meal	15.94	15.78	15.78
Fishmeal	7.00	7.00	7.00
Soybean meal	15.00	15.00	15.00
Wheat Gluten Meal	13.82	13.82	13.82
Vegetable oil	12.08	12.08	12.08
Fish oil	9.00	9.00	9.00
Lysine	2.00	2.00	2.00
Threonine	0.17	0.17	0.17
DL methionine	0.32	0.32	0.32
Arginine	1.36	1.36	1.36
CMC	0.50	0.50	0.50
Mineral premix	0.50	0.50	0.50
Histidine	0.31	0.31	0.31
ABY	-	0.25	-
SDYE	-	-	0.25

INVESTIGATION OF THE MICROBIAL SAFETY OF EASTERN OYSTERS *Crassostrea virginica* FROM SALLY COVE IN REHOBOTH BAY, DELAWARE

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The Eastern oyster (*Crassostrea virginica*) is a popular seafood choice in the USA, consumed raw by nearly 20 million Americans. These oysters filter approximately five liters of water per hour while accumulating various contaminants from seawater within their bodies. Pathogenic bacteria have been detected in various seafood, including oysters, and have led to numerous reported foodborne illnesses. Sally Cove in Rehoboth Bay (Longitude: Latitude; 075˚ 07.631' W: 38˚ 38.932' N) is one of the principal habitats and aquaculture sites for oysters along the Atlantic coast in Delaware, where oysters are produced through suspended and bottom cultures for both commercial and ecological purposes. However, agricultural practices and human activities in Delaware elevate the risk of microbial contamination within the Delaware Inland Bays, which were previously reported to have contained high levels of bacteria. The objective of this study was to detect and compare the presence of ten pathogenic bacteria in seawater and oysters from the suspended and bottom oyster cultures in Sally Cove in Rehoboth Bay, Delaware. For comparison, a site without oysters (Sally Cove control) within Sally Cove was selected as a control.

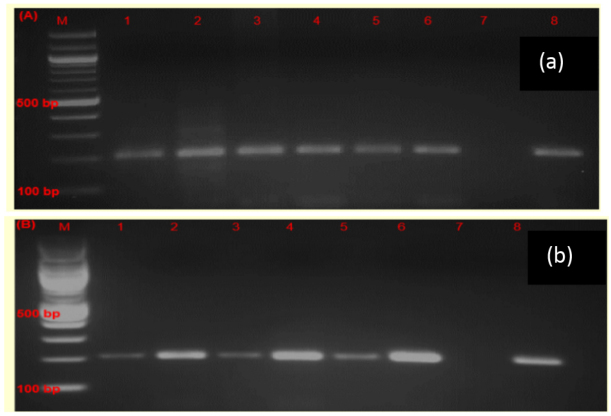

Figure 1(a-b). Presence of *Vibrio parahaemolyticus* in seawater and oysters, sampled in (a) July and (b) August, from Sally Cove and control site.

Note: M- 100 bp ladder, 1- Bottom culture seawater from Sally Cove, 2- Suspended culture seawater from Sally Cove, 3- Bottom seawater from the control site, 4- Suspended seawater from the control site, 5- Bottom culture oyster from Sally Cove, 6- Suspended culture oyster from Sally Cove, 7- Negative control, 8- Positive control.

Triplicates of seawater (8.0 L) and oysters were sampled from suspended (0.10 m) and bottom (1.80 m) cultures once across four months, from July through October 2023. Seawater was centrifuged to obtain the sediment containing environmental DNA (eDNA) while the oysters were washed and shucked, and their intervalvular fluid and tissues were homogenized and pre-enriched in buffered peptone water or tryptic soy broth for culturing. Bacteria were detected using polymerase chain reaction (PCR) and gel electrophoresis with bacteria-specific primers **(Figure 1)**. Preliminary findings revealed the presence of *Vibrio parahaemolyticus, Escherichia coli*, *Listeria monocytogenes*, and *Clostridium* species in seawater and oysters sampled in July and August from both suspended and bottom cultures at Sally Cove and the control site. In conclusion, consuming raw oysters from Sally Cove during summer may pose risks of contamination of these pathogenic bacteria.

NORWEGIAN SEAFOOD TRADE: THE ROLE OF SEAFOOD TRADERS

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Norwegian seafood trade has experienced considerable growth over the past 15 years, led by the success of the salmon aquaculture industry. With the aim of continued growth in production, maintaining and growing the demand for seafood is crucial to maintain the value of Norwegian seafood.

This paper investigates the role of seafood traders in Norwegian seafood export.

Seafood traders are defined as exporting firms that trade in both wild and aquaculture products. These are dealers/merchants of a wide portfolio of seafood, different from pure aquaculture or wild seafood exporters.

We hypothesize that seafood traders mplay an especially important role in the growth of the industry in global markets. They might facilitate substitution between aquaculture and wild seafood products; integrating aquaculture and wild seafood in the market. They might also help introduce new seafood products to new customers by utilizing their existing customer network in other seafood products.

To investigate the role of seafood traders we leverage data on customs declarations for Norwegian seafood exports. Our results show that seafood traders are a minority of exporting firms, but they are large firms and account for a majority of exports. Seafood traders typically operate in higher valued species, such as salmon and fresh white fish. We also find that seafood traders achieve a higher export price (10% premium) than comparable specialist traders. Looking at the growth of new seafood products to new markets we find that exporting firms that introduce new seafood products to markets tend to already export a different seafood product to the same market. This suggests they utilize their existing customer network to introduce new products. We also find that seafood traders introduce more new products than the specialist traders. All in all, our results suggest that seafood traders that export a wide portfolio of both wild fish a aquaculture products play an important role in both integrating different products in the market, and spreading new products to new markets.

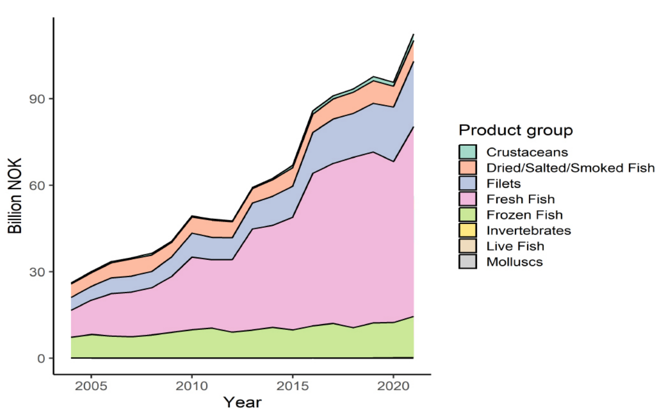

FIGURE 1. Value of Norwegian Seafood

MOLECULAR PROFILING, GROWTH PERFORMANCE AND SELECTION TRAITS FOR DIFFERENT STRAINS OF *Clarias gariepinus* BURCHELL IN MAJOR NIGERIAN FRESH WATER BODIES

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The African mud catfish (*Clarias gariepinus*) is well known for its nutritional and economic importance and it's the most important cultured fish species in Nigeria. Its sustainable production is being threatened by inbreeding depression occasioned by the use and reuse of imported frys and fingerlings from exotic homogenous stocks. Knowledge of genetic variation of this important fish species is needed to improve its efficiency of breeding and for possible identification. Morphological, genetic, and molecular studies were carried out to determine the residual genetic variability and assess the possibility of improving the fish quality through selective breeding of local strains.

Growth performance was examined by heterosis performance on Specific growth rate (SGR), Hatchability, survival, and mean growth over a period of 26 weeks through reciprocal crossings of different strains, while the molecular analysis examined the selection traits through protein profiling using Sodium deodosulphate polyacrylamide gel electrophoresis (SDS-PAGE) analysis, and genetic differentiation using random amplified polymorphic DNA (RAPD) assay and microsatellite analysis. Morphological comparisons revealed morphometric homogeneity between *C. gariepinus* fish population in River Benue and River Niger and their tributaries which clustered into five considerably distinct populations.

The growth performance analysis shows significant difference in mean weight gain, specific growth rates and survival rate ($P<0.05$). Sokoto sourced strains (SKT) gave the best growth of 595.00±4.33g, closely followed by its reciprocal hybrid with South African strains (SA ♀ X SKT ♂) 554.00±6.22g, while the New Bussa strain had the lowest growth value (70.00±2.07g) at the grow-out level. The cross between the Dutch and Yola strains gave the highest positive mean heterosis of 28.54% ($P<0.05$).

The DNA-RAPD analysis recorded an overall low polymorphism among and within the local and exotic populations of *C. gariepinus* in Nigerian freshwater bodies and their reciprocals (19.35%). However, considerably higher levels of polymorphism were detected between the Lokoja Ganija strains (29.67%) and Yola strains (12.09%). The nine microsatellite loci used to screen the wild *C. gariepinus* strains and their crosses germplasm revealed polymorphic information content (PIC) values that ranged from 0.077±0.231 to 0.395±0.399 with the local strains showing slightly higher allelic diversity than the three exotic strains. This study demonstrated that the seven local strains population of Nigerian *C. gariepinus* species screened contained higher allelic and gene diversity as compared to the cultured exotic populations. It therefore identified and recommends the Sokoto and Yola strains (for growth performance) and Lokoja, Sokoto and New Bussa strains (for genetic variability) as possible founder stocks and viable substitute to the much-touted exotic strains for the catfish aquaculture industry in Nigeria.

AQUACULTURE ROBOTICS RESEARCH AT SINTEF OCEAN– AUTONOMY, NAVIGATION, AND MOTION PLANNING DEDICATED TO IMPROVE EFFICIENCY, SAFETY AND FISH WELFARE

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Research on aquaculture robotics at SINTEF Ocean targets the development of dedicated solutions for the aquaculture industry and aims to address the industry's challenges related to navigating and manoeuvring in dynamically changing environments, performing intervention and inspection operations, and increasing the level of autonomy. With an interdisciplinary focus, we are linking the fields of technology and biology and perform fundamental and applied research on the modelling of UUVs, aquaculture structures, fish behaviour and environmental disturbances, and on advanced control strategies for the autonomous navigation of unmanned underwater and surface vehicles operating in dynamically changing environments.

Through variety of projects, we have developed methods and robotic solutions for autonomous operations in fish farms (to name few of them: CHANGE, ResiFarm, NetClean 24/7, RACE-Fish Machine Interaction, CageReporter and Artifex). Some of our developments include autonomous net following, framework for navigation inside net pens, robust low-level control methods and motion planning systems including obstacle avoidance. We own and use a variety of robotic systems including aerial, surface, and underwater vehicles. In addition we contribute to the development of new, dedicated robotic systems suitable for operating in both traditional sea-based fish farms and new production technologies. SINTEF Ocean owns four research licenses for farmed Atlantic salmon (*Salmo salar)* and we can therefore test and demonstrate our developed methods in realistic environments (Figs. 1 and 2).

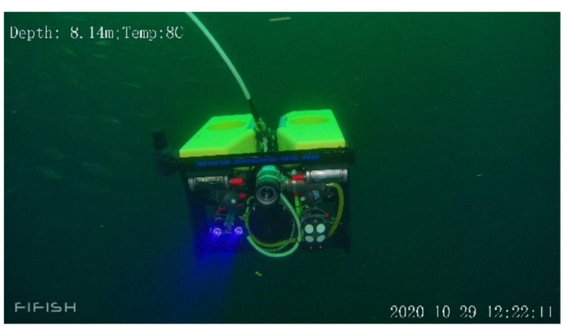

Figure 1: The ROV equipped with a laser.

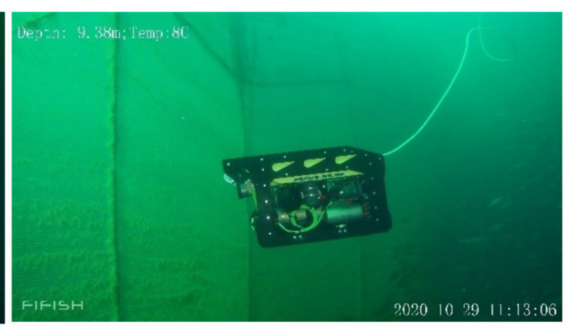

Figure 2: The ROV during net following.

IMPACT OF LOW WATER TEMPERATURE ON GROWTH, FEED CONSUMPTION, AND FEED EFFICIENCY OF JUVENILE LARGEMOUTH BASS *Micropterus nigricans*

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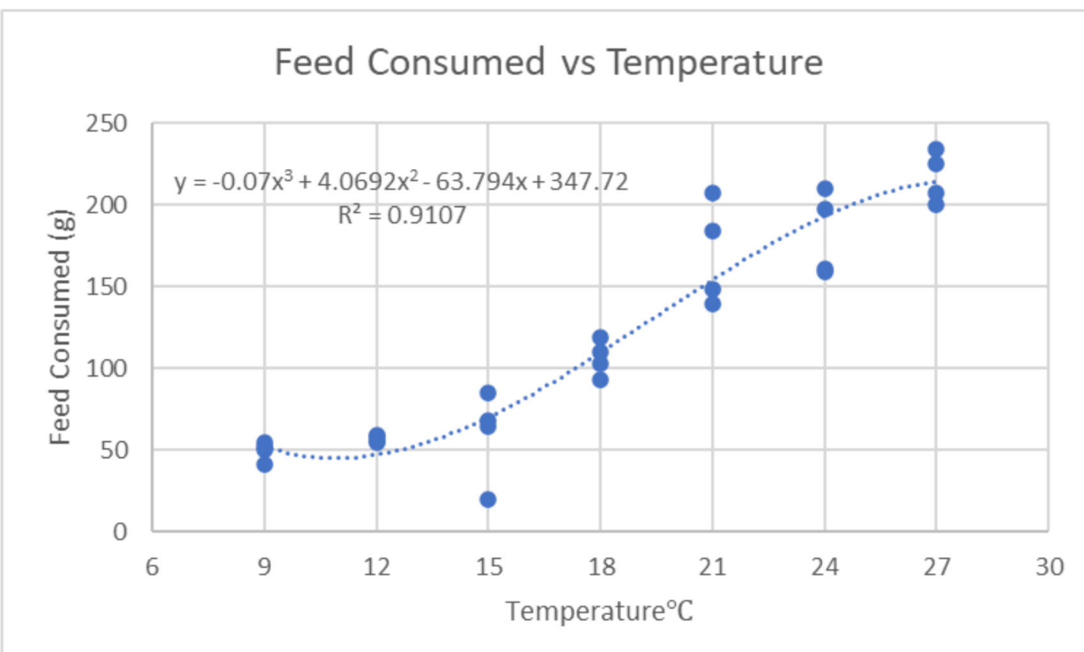
Growth of Largemouth Bass (LMB) as a food fish in Kentucky is constrained by a modest growing season. This study examines growth, feed consumption, and feed efficiency of LMB at temperatures occurring in the spring or fall in temperate regions. Data generated will be instrumental in developing a practical feeding protocol for Largemouth Bass to take advantage of growth potential throughout the year.

The study is being conducted over a 9-week study at the Aquaculture Research Center of Kentucky State University. Seven individual recirculating systems with each system comprised of four replicate aquarium tanks were randomly assigned a temperature treatment (9, 12, 15, 18, 21, 24, and 27°C). Prior to stocking the experiment, individual Largemouth Bass (LMB) were injected with a Passive Integrated Transponder (PIT tag). Each tank was stocked with 10 feed-trained juvenile LMB (56.2 ± 0.8 g) and fed once daily by hand to apparent satiation with slow-sinking 6.5mm commercial trout feed (45% protein, 20% fat). Water quality is monitored to maintain conditions suitable for growth. The weight, length, and tag number for each fish will be recorded at the end of the study. Significant differences will be determined with One-Way ANOVA, and relationships described with regression analysis. The ongoing analysis of weekly feed consumption measurement reveals an excellent fit between feed intake and water temperature. Full results from the study will be presented.



EX-ANTE COST-BENEFIT ANALYSIS OF SMART SUSTAINABLE SHELLFISH AQUACULTURE MANAGEMENT (S^3AM) TECHNOLOGY

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Despite the cost advantages associated with shell on bottom-culture oyster farming, several challenges persist in the industry. One major issue is the difficulty faced by growers in identifying suitable underwater areas within submerged leases for oyster seed deployment. Often, seed deployment happens randomly, resulting in significant seed wastage when they land on unsuitable substrates like mud or silt instead of the desired substrate.

To address this problem, a promising solution in development—an underwater drone equipped with remote sensing capabilities designed to measure water quality and map the lease ground. The technology is intended to reduce input waste and optimize oyster farming practices. To assess the feasibility of implementing this technology for oyster growers, a preliminary economic analysis was conducted. using data gathered from a farm survey conducted in 2018 in the state of Maryland. The analysis involved simulating the performance of 100,000 farms, assuming a triangular distribution for input and capital costs. The Net Present value from this analysis indicated that the S3AM technology could potentially be more profitable for larger farms (figure 3) as compared to smaller ones (figure 1). Here we considered a farm that produces 200 bushels/year as small, 2000 bushels/year as medium and 6000 bushels/year as a large farm.

We will further perform analysis to measure other financial performance measures such as break-even price and yield above total and variable cost, and investment analysis under various production scenarios to fully evaluate its potential benefits and cost effectiveness under various production scenarios.

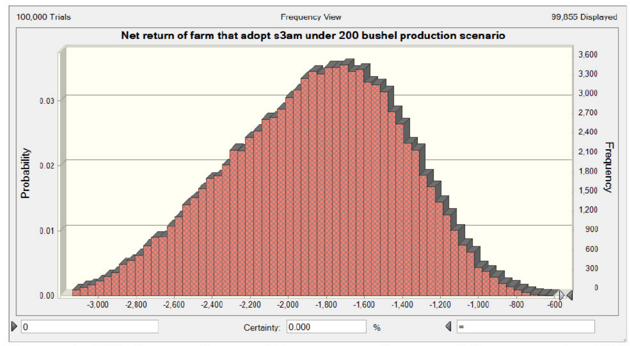

Figure 1. 0% chance for positive return for small farms under S^3AM

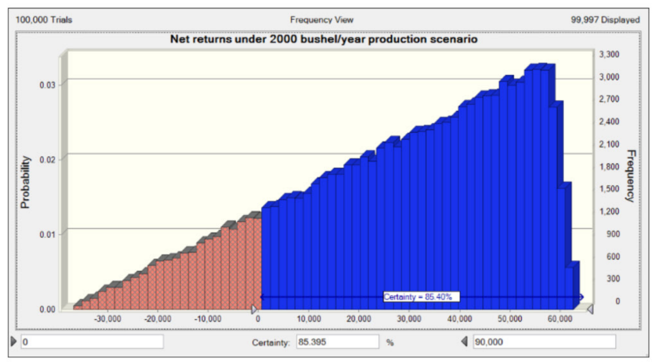

Figure 2. 85% chance of positive return for medium farms under S^3AM

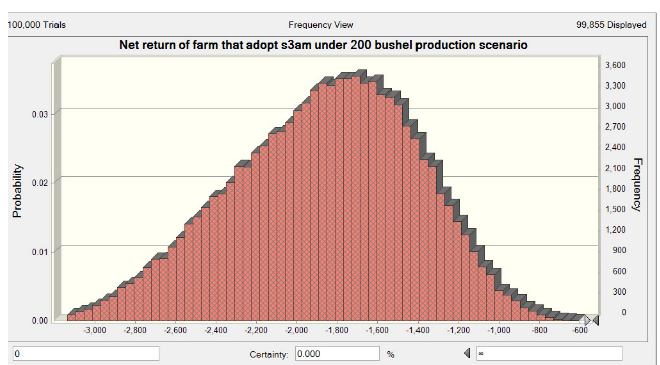

Figure 3. 100% chance of positive return for large farms under S^3AM

UTILIZING AN AQUACULTURE INDUSTRY COLLABORATIVE TO INCREASE HAWAI‘I’S RESILIENCE AND FOOD SECURITY

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Hawai‘i’s food system is highly dependent on imports—between 85-90% of Hawai‘i’s food is imported. The COVID-19 pandemic underscored Hawaii’s fragility, reliance on imports, and lack of food security as supply chain disruptions and consumer panic purchasing resulted in empty grocery shelves during the pandemic’s early months. As such, public opinion is shifting towards a more food secure Hawai‘i and locally grown agriculture and aquaculture efforts are finding more support in the state legislature and community.

In 2021, the University of Hawai‘i Sea Grant College Program established a Hawai‘i Aquaculture Collaborative (HAC) whose membership consists of 100+ industry leaders representing Hawai‘i’s diverse aquaculture subsectors including Hawaiian fishpond practitioners, land-based freshwater producers, land-based seawater producers, open ocean producers, processors, consultants, an accelerator/incubator, and an industry association. An additional 20+ support partners include K-12 and post-secondary schools, researchers, government agencies, legislators, and other aquaculture stakeholders across the state. The HAC is tasked with identifying industry-related priorities and developing/implementing initiatives and solutions to advance those priorities. Support partners are being engaged to leverage their strengths and resources to support these industry-driven initiatives.

Collaborative activities conducted to date include: 1) engaging policymakers and government agencies on industry priorities through written communication and meetings; 2) developing and distributing an Aqua+Culture video, which premiered at a 150-person event titled “What’s the Catch? Cultivating Hawaii’s Seafood Future” in June 2022 and was distributed through a local television station, Hawaiian Airlines inflight programming, and social media; 3) a monthly collaboration with the Natural Energy Laboratory of Hawai‘i Authority to offer a virtual Tech and Research Brown Bags seminar; and 5) creating the Collaborative’s website (hiaquacollab.org), which catalogues events, actions, membership, and employment opportunities; and 6) conducting an inventory of aquaculture training programs in Hawai‘i.

IMPACT OF ADVANCED SOYBEAN VARIANTS ON CALIFORNIA YELLOWTIAL *Seriola dorsalis*: GROWTH PERFORMANCE, INTESTINAL MORPHOLOGY AND HEALTH

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California yellowtail (CYT) *Seriola dorsalis*, renowned for its rapid growth, desirable texture, and flavor, holds substantial potential for aquaculture production. Species of this genera have a well-established production history in Japan, Australia, and China. It also has a robust market presence in the United States, making it an appealing candidate for commercial aquaculture. The utilization of soy protein in CYT diets has demonstrated success, with a significant reduction in fishmeal levels. Despite this level of soy protein inclusion, concerns about potential intestinal inflammation related to varying soybean meal levels in fishmeal replacement have emerged. Various soy improvement strategies, including fractionation, enzymatic treatment, heat treatment, and microbial fermentation, have been consistently investigated to mitigate the negative impact of soybean meal on the nutrition and immune systems of various fish species. While advanced soy variants have proven beneficial, the effects are species-dependent and may contribute to improved alternative diet formulation if beneficial to CYT.

This study aimed to optimize soybean meal inclusion levels by incorporating advanced soybean meal variants in the CYT diet. Six isonitrogenous and isolipidic diets, featuring high protein low oligosaccharide soybean meal (Bright Day, Benson Hill, St Louis, MO) and an enzyme-treated soybean meal (HP 300, Hamlet Protein Inc., Findlay, OH) at sequential inclusion levels (0, 50, 100%) replacing solvent-extracted soybean, were formulated for an eight-week feeding trial in a recirculation system. The study compares these formulations against a soy-free animal protein-based diet. At the end of the trial, fish were sampled for growth performance, body proximate composition, intestinal morphology, and immune response from gut samples.

After eight weeks of dietary treatment, the results showed consistent FCR (P=0.775), weight gain (P=0.242), and high survival rate (99.4 ± 0.54%) among dietary treatments (P>0.05). Histological evaluations of the intestine revealed no significant gut inflammation, and gene expression analysis of immune and digestive markers *apn* (P=0.687), *mga* (P=0.397), *gpx1* (P=0.279), *atpase* (p=0.590), *il1β* (P=0.659) shows no significant differences, affirming the health of CYT on the formulated diets. These findings indicate that the inclusion of advanced soybean meal products, replacing up to 20% of fishmeal, does not negatively affect CYT's growth, intestinal morphology, or immune gene expression. Advanced soybean meal products can be incorporated into CYT diets, limiting fishmeal inclusion to 10% and replacing up to 100% of commercial SE soybean meal without compromising intestinal integrity.

This has positive implications for the commercial production of CYT and future research.

OPTIMIZATION OF GROWTH AND IMMUNITY OF CHANNEL CATFISH *Ictalurus punctatus* THROUGH DIETARY SUPPLEMENTATION BY A HUMIC SUBSTANCE OR A PROTEASE COMPLEX

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Commercial humic substances (HS) and a protease complex (PC) have previously been shown to improve resistance to columnaris disease and demonstrate growth potential in juvenile channel catfish. Although additives enhance fish health, some also have the potential to improve feed efficiency through enhanced digestibility of alternative protein sources. However, it is believed that the duration and period of application may interact with growth or immune enhancement. A feeding trial was designed to optimize the inclusion of HS or PC in a low-protein commercial catfish diet, employing varying feeding regimens to assess their impacts on growth performance and health.

An 8-week feeding study was conducted in thirty-six recirculating tanks. Channel catfish fingerlings (2.01±0.94g) were fed a control diet (commercial catfish feed, CTL; 28%) or supplemented diets (PC or HS; 28%). The control diet was fed in four replicates on a satiation schedule for 8 weeks. The treatment diets were administered through four feeding regimens also in four replicates each: 1) every day for 8 weeks, 2) for the first 4 weeks, 3) for the final 4 weeks, and 4) every other week. Fish were fed the control diet when the supplemented diets were not fed. Following the feeding trial, catfish were sampled for growth performance, blood, and organs for baseline health indicators. Individual additives regimen groups were compared with the control.

The trial demonstrated a high survival rate (98.4±0.05%) across all treatment groups. Growth results indicated an improved growth pattern in the supplemented diets compared to the basal-fed group. Continuous supplementation of HS or PC significantly reduced FCR compared to the CTL group after 8 weeks (P=0.004; P<0.001). Similarly, supplementing PC or HS during the last 4 weeks contributed to a lower FCR than the control (P=0.046; P<0.001) and was indifferent to continuous feeding of any additives. Regarding the percent weight gain (WG%), tank biomass gain (TBG), and thermal growth coefficient (TGC), continuous supplementation of PC or HS also offered the best performance. Feeding PC for the final four weeks significantly improved TBG and higher percent weight gain (WG%) than the control group. In addition, continuous PC treatment enhanced sera lysozyme compared to the control (P=0.041). While no significant trend was observed in sera lysozyme for different HS regimens, skin mucus lysozyme was significantly improved after offering HS in the last four weeks compared to the control (P=0.032). These findings demonstrated that continuous supplementation of PC or HS in commercial catfish diets best improves growth and enhances the non-specific immune response, indicating immunostimulation properties linked with these additives.

MULTIPLE, LOW-DOSE COPPER TREATMENTS STABILIZE BACTERIAL COMMUNITIES IN CHANNEL CATFISH PONDS

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The parasite *Bolbophorus damnificus* can infect catfish and, in severe cases, cause high fish mortality. Since no approved treatments are available for infected fish, disease control methods focus on reducing populations of the two snail intermediate host species, *Planorbella trivolvis* and *Biompharlaria havanensis.* Copper sulfate application to the pond perimeter is one commonly used method to control snail numbers. Multiple low dose copper treatments are preferred over a single, high dose application to minimize negative effects to algal blooms and fish health, while still effective in reducing snail numbers. The effects of this treatment strategy on pond water bacterial communities have not been assessed and is an additional consideration, given the important roles bacteria have in nutrient cycling and fish health. To evaluate the effect of multiple low-dose copper sulfate treatments on catfish pond microbiota, twelve ponds received four weekly treatments of copper sulfate. Four ponds each were treated with copper sulfate pentahydrate dosages (0.0, 0.5, 1.0, or 1.5 mg/L $CuSO_4$*$5H_2O$). Water samples were obtained before each weekly treatment and two weeks, four weeks, and 8 weeks after the final treatment, resulting in seven timepoints for each pond. DNA was extracted and subjected to 16S rRNA gene sequencing on an Illumina MiSeq. Copper sulfate dose and time had significant effects on bacterial community diversity ($p<0.05$). Higher copper sulfate doses minimized shifts in alpha diversity across timepoints; Shannon entropy ranges were 2.26, 1.60, and 1.32 for low, medium, and high $CuSO_4$ doses, respectively. Similarly, beta diversity was more volatile across sampling timepoints in control ponds compared to those receiving copper sulfate treatments. Analysis of relative abundance data suggested the stabilizing effect of copper sulfate was no longer apparent after 8 weeks. Low dose copper sulfate treatments appear to have minimal, short-term effects on pond bacterial communities.

BIOACCUMULATION OF POTENTIALLY TOXIC METALS IN WATER, SEDIMENT, SILVER CATFISH (*Chrysichthys nigrodigitatus*) AND TILAPIA (*Tilapia zillii*) HARVESTED FROM MAJIDUN AND IGBEDE RIVERS, LAGOS STATE NIGERIA

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In the last decades, aquatic contamination by heavy metals has become a global crisis. Potential toxic metals (PTMs) in aquatic system are produced from natural and anthropogenic sources and the degree of contamination in fish is dependent on the sampling site, pollution types as well as mode of feeding of the fish The concentration of PTMs such as such as manganese (Mn), iron (Fe), copper (Cu) , zinc (Zn), cobalt (Co), chromium (Cr), cadmium (Cd) , lead (Pb) and nickel (Ni) in silver Catfish (*Chrysichthys Nigrodigitatus*) , Tilapia (*Tilapia Zilli*), water and sediment collected from Majidun and Igbede rivers were investigated and analyzed using buck scientific model 210 atomic absorption spectrophotometer (AAS) . Iron (Fe) was the most abundant in all the samples analyzed with the highest level of mean concentration recorded in the sediment with a value of 0.56 µg/g as against 0.20 µg/g, 0.19 mg/L 0.18 µg/g recorded for Tilapia, water and Silver Catfish (*Chrysichthys Nigrodigitatus*) collected from Majidun river and a similar trend was noted for all the samples from Igbede river with the sediment recording a value of 215.8 µg/g. The high value obtained in the sediment may be associated with the natural abundance of iron in Nigeria soil as well as been a major depository of heavy metal. The accumulation of heavy metals in the samples analyzed for Igbede river were in the order of magnitude Fe >Mn>Zn > Cu compare to Majidun river with an order magnitude of Fe > Zn >Mn >Cu, Fe > Mn > Zn >Cu > Co >Ni, Fe > Mn > Zn > Cu and Fe > Zn > Mn > Cu for water, sediment, Tilapia and Silver Catfish (*Chrysichthys nigrodigitatus*) respectively. Pb, Cd, Ni, Co and Cr were not detected in the analyzed samples from both river except for Igbede tilapia that recorded 1.7 µg/g of Ni and sediment of Majidun river that had a low concentration of Ni and Co respectively. The accumulation of iron and zinc by the fishes from both the surrounding water, sediments and their diet were relatively low and are below permissible limits of Food and Agriculture Organization (FAO) and Lagos State Environmental Protection Agency (LASEPA) for daily intake which implies that both *Chrysichthys Nigrodigitatus* and *Tilapia Zilli* the analyzed in both Majidun and Igbede River are safe for human consumption.

SEA CUCUMBER *Neostichopus grammatus* DENSITY AND FREQUENCY OF TANK CLEANING AFFECT THE GROWTH OF ABALONE *Haliotis midae* IN INTEGRATED MULTI-TROPHIC AQUACULTURE

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The integrated multitrophic aquaculture (IMTA) of sea cucumber and abalone has been proposed as a potential bioremediation tool that stimulates increased abalone growth. This study aimed to assess the role of sea cucumber stocking density and frequency of tank cleaning in IMTA on abalone growth, water, and sludge bioremediation. The study was conducted for 16 weeks and was made of four treatments and four replicates; abalone cocultured with sea cucumber (low density) with tanks cleaned once a week (L1); abalone cocultured with sea cucumber (low density) with tanks cleaned twice a week (L2); abalone cocultured with sea cucumber (high density) with tanks cleaned once a week (H1) and abalone cocultured with sea cucumber (high density) with tanks cleaned twice a week (H2). Rearing water nitrite was significantly lower (p = 0.001) at high stocking density of sea cucumbers, but sludge was unaffected. Tanks cleaned once weekly had higher sludge organic matter (p = 0.015) and sludge sulphur content (p = 0.020) and lower sludge carbon (p= 0.003) and nitrogen content (p =0.049).

At the end of the experiment, the stocking density of sea cucumber and frequency of tank cleaning affected abalone mean weight [p = 0.047; p = 0.011, respectively] without a significant interaction (p = 0.517). Abalone in H1 had a higher mean weight and shell length than abalone in L2 and H2 but was similar to those in L1. The stocking density and frequency of cleaning used in this study had no effect on the growth of sea cucumbers [p = 0.150; p = 0.470), respectively].

This study has shown that in an abalone-sea cucumber IMTA system, the stocking density of sea cucumber and the frequency at which tanks are cleaned influence abalone growth and bioremediation of the rearing water. The tank cleaning frequency alone affects the tank sludge quality; tanks need not be washed too frequently as, in addition to causing animal stress, cleaning markedly increased carbon and nitrogen level of tank sludge. Both these effects are likely to negatively impact abalone growth.

GROWTH PERFORMANCE AND mRNA EXPRESSION OF INTESTINAL AMINO ACID TRANSPORTERS IN TILAPIA *O. niloticus* FED DIFFERENT DIETARY PROTEINS

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Feeding trial was conducted to compare the growth performance, amino acid profile, nutrient digestibility and hepatic and intestinal morphologies of (*O. niloticus*) fed formulated diets containing either fishmeal (FM), soybean meal (SBM), or protein-enriched copra meal PECM® as the main protein source. The diets were fed to fish with an initial weight of 28.86±1.7 g for 118 days in an indoor RAS. The mRNA expression of peptide amino acid transporters *slc15a1a* and neutral amino acid transporter *slc6a19* were also examined in the anterior, mid and posterior intestine of tilapia.

Results showed that PECM® -fed fish exhibited 50% slower specific growth rate and reduced body condition factor than FM or SBM-fed fish (Table 1). Although a decrease is also noticeable in other growth parameters measured, these did not vary significantly among the three diets including feed conversion and protein efficiency ($p<0.05$). Overall protein digestibility of diets was high (90.90±2.98%) and unaffected by plant ingredients. No diet-related histopathology was detected in the intestine and liver.

It was hypothesized that the amino acid transporters which are responsible for the absorption of digested proteins in the intestine of fish shall be influenced by dietary changes. Results showed that *slc15a1a* and *slc6a19* responded differently to the dietary treatments. A spatial expression in the intestinal length was also observed. The mRNA expression might be associated with the amino acid profile of each dietary protein source.

This study helps in the evaluation of the potential of PECM® as an alternative source of protein for aquafeed and contribute in the understanding of the absorption mechanisms of amino acid transporters in the intestine of tilapia.

Table 1 Growth performance, feed utilization, and morphometric indices of Nile tilapia fed either a fishmeal (D1), soybean meal (D2), or PECM®-based (D3) diet for 118 days. Values are presented as mean ± SEM (n = 3).

	Diets[1]			
Parameters	D1	D2	D3	p-value
Final body weight (g)	120.2 ± 17.9	103.7 ± 24.4	56.5 ± 13.6	0.126
Final standard length (cm)	14.3 ± 1.0	13.9 ± 1.2	11.8 ± 1.0	0.264
Weight gain (g)	88.6 ± 17.5	77.1 ± 21.1	28.17 ± 9.84	0.092
Specific growth rate (%-day^{-1})	1.13 ± 0.15^{a}	1.13 ± 0.09^{a}	0.57 ± 0.13^{b}	0.028
Total feed intake (g-fish^{-1})	256.4 ± 9.6	229.1 ± 68.6	140.6 ± 14.1	0.192
Feed conversion efficiency	0.35 ± 0.08	0.34 ± 0.02	0.19 ± 0.06	0.175
Protein efficiency ratio	1.11 ± 0.25	1.06 ± 0.08	0.75 ± 0.22	0.427
Hepatosomatic index (%)	1.88 ± 0.05	2.16 ± 0.32	2.16 ± 0.20	0.604
Condition factor	3.96 ± 0.27	3.67 ± 0.12	3.17 ± 0.07	0.0503
Viscerosomatic index (%)	10.05 ± 1.11	10.56 ± 0.92	12.06 ± 0.92	0.385
Relative intestinal length	5.72 ± 0.86	4.84 ± 0.52	5.23 ± 0.17	0.599
Survival (%)	14.2 ± 5.2	11.4 ± 5.3	17.9 ± 3.8	0.653

Note: Means within each row not sharing a common letter superscript are significantly different ($p < 0.05$).

ASSESSING TWINE SELECTION AND GROWTH OF BULL KELP *Nereocystis luetkeana* FROM NURSERY TO OPEN WATER CULTIVATION IN HUMBOLDT BAY, CA

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Seaweed farming is the fastest-growing aquaculture industry in the U.S. Bull Kelp (*Nereocystis luetkeana),* valued for its commercial, cultural, and ecological significance in the Pacific Northwest, has drawn considerable interest. Cal Poly Humboldt established a one-acre seaweed farm in Humboldt Bay, CA. This study aimed to 1) assess twine efficiency in nursery cultivation of Bull Kelp sporophytes, 2) evaluate growth at varying depths on the farm using different cultivation systems, and 3) analyze heavy metal and nutrient profiles of harvested biomass for human consumption safety.

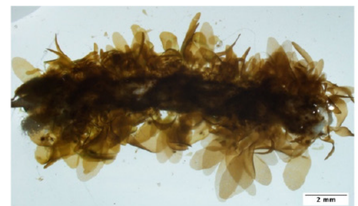

Fig 1. Juvenile kelp sporophytes on Kuremono twine at 7 weeks in nursery

The nursery consisted of eight 24-L tanks held in a flow-through recirculating system. Each tank incubated five 10-inch spools wrapped in different twine types, including Hemp (Hem) 1mm, Kuremono Kuraraay vinolyn (Kur) 1mm, Korean- polypropylene (PP)/ polyethylene (PE) (Kor) 1.5mm, Gortex-polyester/ fluoropolymer (Gor), and Powers-Nylon 1.2mm (Nyl). Sporophytes were nursed for six months, and the quality was assessed based on % coverage, blade coloration, blade consistency, and unwanted growth.

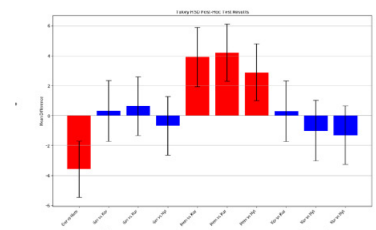

Fig 2. Tukey HSD Post-Hoc Test Results for Spool Quality among Twine Types.

Preliminary analyses using Shapiro-Wilk and Levene's tests revealed non-normal data distribution and heterogeneous variances. The Kruskal-Wallis test confirmed significant variations in spool quality among different twine types. Dunn's post-hoc test highlighted Kur as superior ($p = 0.02$; Kur vs Gortex) and 0.03 (Kur vs Korean). One-way ANOVA and Tukey HSD post-hoc test confirmed spool quality variations across twine types (Fig. 2, 3).

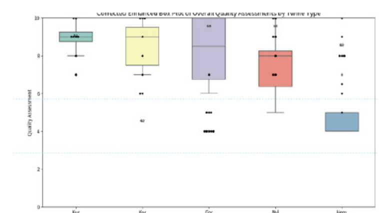

Fig 3. Corrected Enhanced Box Plot of Overall Quality Assessments by Twine Type.

Results from this study contributed to a comprehensive understanding of Bull Kelp cultivation on long lines in California.

ENHANCING AQUACULTURE SUSTAINABILITY: THE IMPACT OF WHITE MELON SEED INCLUSION ON FEED CHARACTERISTICS AND DIGESTIBILITY IN JUVENILE NILE TILAPIA *Oreochromis niloticus* DIETS

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The aquaculture industry faces significant challenges due to the high cost of fish feeds, primarily driven by the increasing demand for fishmeal. This study explores the viability of using white melon seeds as an alternative to fishmeal in the diets of juvenile Nile tilapia (*Oreochromis niloticus*). White melon seeds, recognized for their high protein content, align well with the dietary protein requirements of juvenile Nile tilapia (32-38%) and offer a promising solution to reduce aquaculture feed costs while maintaining nutritional adequacy. This study investigates the use of white melon seeds as an alternative ingredient to replace fishmeal partially or fully in juvenile Nile tilapia (*Oreochromis niloticus*) diets. The research focused on assessing the effects of white melon seed on the physical characteristics and digestibility of juvenile Nile tilapia feed.

Experiments involved formulating three different diets with white melon seed inclusion levels at 3.75%, 7.5%, and 15%, compared against a commercial feed (38%). These diets were tested over eight hours for floatability, expansion ratio, and bulk density. The results showed that all white melon seed-inclusive diets maintained high levels of floatability (>82%), with significant variations in physical properties observed across different inclusion levels. The apparent digestibility of protein, ash, and dry matter in these diets was also evaluated, demonstrating high digestibility rates (>90%) for all components, except for ash which was 88% in diet 1.

The results indicated that incorporating white melon seed into fish diets presents a promising approach to improving feed characteristics and reducing costs in aquaculture. The study highlights the potential benefits of white melon seed as a sustainable feed ingredient, contributing to the economic viability and environmental sustainability of fish farming practices.

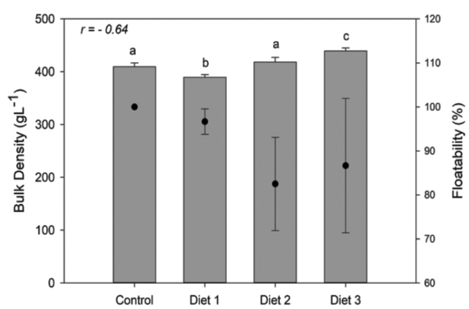

Figure 1. Comparing experimental diets: Average bulk density & floatability

Table 1. Assessing Apparent Digestibility Coefficients (%) in *Oreochromis niloticus*: Control vs Three Melon seed Diets.

VARIABLE	TEST DIETS			
	CONTROL	DIET 1	DIET 2	DIET 3
Crude protein	99.17 ± 0.41	98.85 ± 1.19	98.9 ± 0.49	99.40 ± 0.14
Ash	94.78 ± 2.21	87.82 ± 18.52	95.20 ± 1.66	96.97 ± 1.17
Dry matter	98.72 ± 0.46	97.43 ± 2.30	96.96 ± 1.43	98.15 ± 0.56
NFE	81.92±6.40	75.30±7.54	70.34±11.66	70.00±8.12

INTENSIVE AERATION LEADS TO NITROGEN OXIDATION IN EARTHEN CATFISH PONDS

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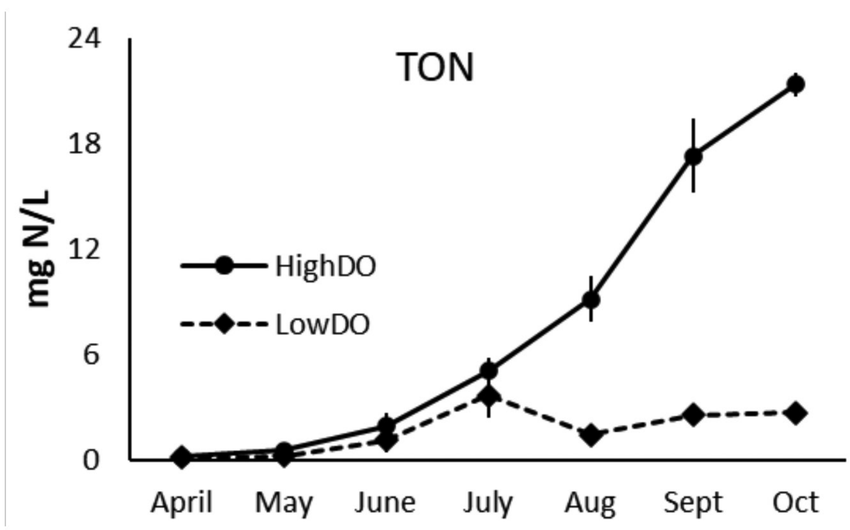
The commercial catfish industry has been increasing fish stocking density coupled with increased aeration and feeding rates. Long regarded as photoautotrophic systems, intensive earthen production systems may achieve feeding rates that surpass the nitrogen assimilatory capacity of the phytoplankton population. Hybrid catfish (7,500, *Ictalurus punctatus* x *I. furcatus*) were stocked in 0.25-acre (0.10-ha) earthen ponds equipped with three 2-hp (1.5 kW) paddlewheel aerators. Dissolved oxygen concentration of each pond was measured by a monitoring system and energized aerators to maintain the minimum dissolved oxygen at either 3.5 mg O_2/L (HighDO) or 1.5 mg O_2/L (LowDO). Water quality was measured weekly and feeding rates reached 660 ± 48 and 439 lbs/acre/day for the HighDO and LowDO treatments, respectively. Fish grew significantly smaller in LowDO ponds (0.74 ± 0.02 lbs) than HighDO ponds (1.00 ± 0.03 lbs) but did not have different survival (95% average). Production reached 29,400 ± 1200 lbs/acre in HighDO ponds but only 20,700 ± 800 lbs/acre in the LowDO ponds. Total ammonia concentration was not different between treatments but was higher in August and September in LowDO ponds. Total oxidized nitrogen (TON, NO_2^--N + NO_3^--N) was significantly higher from August through October in HighDO ponds, largely driven by the concentration of nitrate. The increased aeration and oxygen present in ponds managed with higher dissolved oxygen concentration allowed excess ammonia to be oxidized to nitrite and ultimately nitrate, leaving the water suitable for catfish production.



INCREASING THE ACCESSIBILITY OF STATE MARINE AQUACULTURE POLICY DATA THROUGH THE DEVELOPMENT OF AN INTERACTIVE ONLINE DASHBOARD

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The vast majority of marine aquaculture in the U.S. occurs in state waters and, thus, is regulated and managed at the state level, with considerable variation in how individual states manage the industry. Even within the management frameworks of individual states, there is a diverse patchwork of policies, regulations, and agencies that govern the marine aquaculture industry. This complex mosaic of state policies can be confusing for prospective farmers but also offers a tremendous opportunity for cross-state learning, exchange, and coordination among aquaculture managers and policy makers. In 2022, the National Sea Grant Law Center (NSGLC) at the University of Mississippi School of Law and project partners at Florida State University (FSU) received funding from the Builder's Initiative to develop a living database and a framework for standardizing state-level marine aquaculture policy data. The database, which launched in the Fall 2023, is accessible through an online dashboard hosted via Tableau Public and linked from the NSGLC's website. This work builds on a 2019 project funded by NOAA Sea Grant where the FSU researchers assessed aspects of marine aquaculture policy for the 23 marine states in the U.S., categorizing and synthesizing 16 attributes of aquaculture and marine aquaculture legislation, policies, regulatory frameworks, and management. With the additional funding, the NSGLC and FSU team conducted research to expand the dataset with 26 additional attributes, for a total of 42 attributes.

The resulting database provides the first systematic overview of the state-level marine aquaculture policy landscape in the U.S. The interactive dashboard provides a powerful new tool for federal and state aquaculture managers, academic researchers, and industry members to learn about, explore, and compare state aquaculture policy regimes. Increasing access to these data will help users identify inconsistencies among states and potential policy models for adoption to address gaps.

The database will be maintained and updated annually by the NSGLC in partnership with the State Marine Aquaculture Coordination Network (SMACN). SMACN is a professional network that brings together state aquaculture managers and Sea Grant extension personnel to discuss best practices for marine aquaculture management and an avenue for interstate information exchange.

This presentation will provide an overview of the research and development process, followed by a walk through and demonstration of the functionality of the interactive dashboard.

ADDRESSING THE NEEDS OF AQUACULTURE COMMUNITY THROUGH LEGAL RESEARCH AND EXTENSION

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The National Sea Grant Law Center's mission is to encourage a well-informed constituency by providing legal information and analysis to the Sea Grant Community, policy-makers, and the general public through a variety of products and services. Sea Grant is a leader in developing innovative technologies for all sectors of the seafood industry, including aquaculture, seafood processing and food safety. Research and extension efforts are focused on ensuring a safe and sustainable supply of seafood products for current and future generations. The National Sea Grant Law Center supports Sea Grant's mission by providing legal research, outreach, and education on aquaculture issues such as leasing and permitting, marketing and direct sales, and food safety. On specific projects, the National Sea Grant Law Center also works directly with relevant state regulators on its research, outreach, and education activities.

The presentation will provide an overview of the National Sea Grant Law Center at the University of Mississippi School of Law and the legal research and extension services provided to the aquaculture community through the Sea Grant network. This presentation will also share details for several ongoing projects related to seaweed food safety, state aquaculture policies, and direct seafood sales.

EVALUATING THE INFLUENCE OF DIETARY IMMUNOSTIMULANTS ON GROWTH IN NILE TILAPIA (*Oreochromis niloticus*) AND ROMAINE LETTUCE (*Lactuca sativa*) IN A BIOFLOC-INTEGRATED AQUAPONICS SYSTEM

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The integration of hydroponic systems and biofloc-based aquaculture as a resents an opportunity for resource-efficient and sustainable systems with a focus on nutrient recycling and water conservation. This study examined the effects of immunostimulants as dietary supplements on Nile tilapia and romaine lettuce growth within this integrated system. In the fish biofloc system, juvenile Nile tilapia (9.99 ± 0.55 g) were provided with a protease complex (PC) and a humic substance (HS) as immunostimulants in addition to a standard commercial feed (control-Basal) for 60 days. Growth measurements and feed adjustments were performed bi-weekly. The hydroponics system with romaine lettuce consisted of 9 feeding troughs with 15 plants per trough. Weekly water replacement from biofloc settling chambers into feeding troughs was carried out. Plant growth parameters and destructive measurements of lettuce growth were conducted at the end of the 28-day trial. The water quality parameters of both systems were kept at acceptable ranges.

The study revealed that there were no significant differences in fish growth parameters, including percent weight gain (P=0.231), survival (P=0.272), and feed conversion ratio (FCR; P=0.317) among the dietary treatment groups. Likewise, lettuce growth metrics, such as size indices (P=0.276) and leaf number (P=0.084), did not exhibit significant variations across treatment groups. However, the perpendicular width of the PC-treated plants was significantly higher than the control treatment (P=0.010). Notably, the PC-treated water led to higher leaf greenness, as measured by SPAD (P=0.002). Regarding foliar tissue analysis, essential macronutrients met the required plant nutrient levels, and Mg (P=0.011) and Ca2+ (P=0.0006) in control plants displayed significantly higher levels than in PC and HS-treated plants. The micronutrients were also in the required levels (0.05-100ppm), but B in HS-treated plants was higher (P=0.004) than in the other treatments. However, there was a deficiency of copper (Cu) and iron (Fe) in the leaves of plants in all treatments so they should be supplemented into the water.

In conclusion, this study suggests that the inclusion of dietary protease complex (PC) or humic substance (HS) did not substantially impact Nile tilapia growth under the conditions of this experiment. However, PC-treated water demonstrated the potential to enhance romaine lettuce quality and growth. To optimize the biofloc effluents, it is advisable to supplement copper (Cu) and iron (Fe). The results of this trial indicate that utilizing aquaculture effluent as a water and nutrient supplement can lead to favorable outcomes in both the quantity and quality of lettuce production, making it a promising practice for producers.

STREAM – A SATELLITE-BASED WATER-QUALITY MONITORING SYSTEM FOR EFFECTIVE ASSESSMENT OF AQUACULTURE OPERATIONS

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Coastal resources are prone to intertwined effects of climate variability and anthropogenic stressors. With their massive societal and economic benefits through fisheries, aquaculture, and recreation, it is imperative for decision-making entities to integrate the highest-quality data and observations into decision support systems, thereby enhancing coastal management and monitoring. To further enrich existing observational capabilities, we have developed an expedited data processing system that ingests, processes, and displays water quality (WQ) maps (i.e., chlorophyll-a, Secchi, total suspended solids) from high-resolution imagery (10 – 30 m) of Landsat and Sentinel-2 missions. This web-based platform, STREAM (a satellite-based analysis tool for rapid evaluation of aquatic environments), offers globally validated WQ products developed using a processing engine that relies on a machine-learning model. For its interface, we harness various tools and capabilities that have already been developed as part of NASA's near-real-time data processing systems (e.g., Fire Information for Resource Management System). It allows end-users to visualize WQ maps, identify pixel values, and view time-series plots for a given pixel or a region. STREAM will enable low-latency (< 6 hours) detection of anomalous WQ conditions for robust and timely decision-making. The system is currently live and supports processing at select regions.

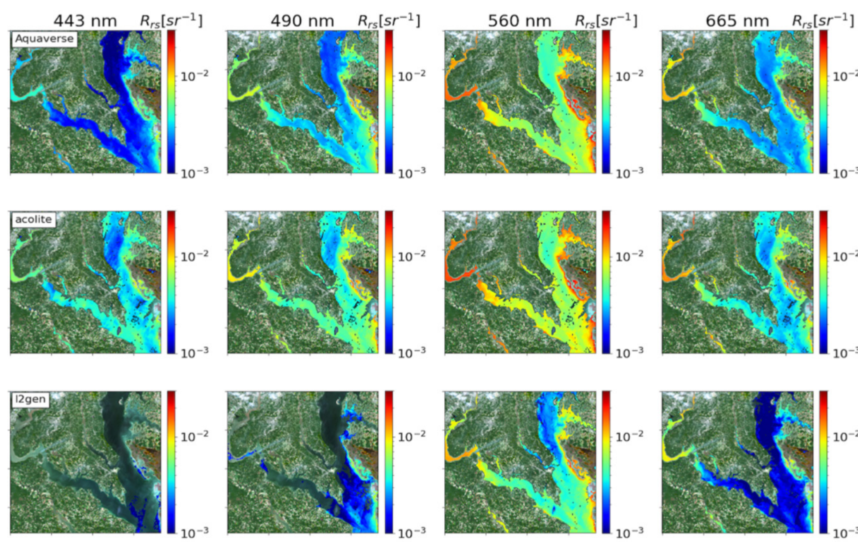

Figure 1. Chesapeake Bay on Sep 29th, 2021. Our (20-meter) Sentinel-2 reflectance products (top row, generated from our processing engine termed Aquaverse) are compared with equivalent products from other processors. Reflectance products are supplied to our machine-learning model to generate chlorophyll-a, Secchi, and TSS maps.

EVALUATING THE EFFECTS OF DIFFERENT SOYBEAN MEAL SOURCES ON FEED UTILIZATION AND GROWTH PERFORMANCE IN A CONTROLLED ENCLOSED ENVIRONMENT FOR CHANNEL CATFISH *Ictalurus punctatus*

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Soybean meal is among the most widely utilized plant-based ingredients in formulating feed for aquatic species. Its nutritional profile, characterized by high protein content and a favorable amino acids composition, makes it an excellent substitute for animal-based proteins.

This study aimed to assess the effects of various sources of soybean meal protein, encompassing four experimental diets. The trial was conducted in a clear water recirculating system, with a stocking density of 20 fish fry per tank and an initial weight of 2.14 ± 0.03 g (Mean ± SEM) for a duration of 10 weeks period. The experimental diets included a basal diet comprising 56.4% soybean meal and 8% poultry meal as the primary protein sources. Three test diets were then developed replacing soybean meal with either corn fermented protein (CFP-GT33), enzyme treated soy (HP300) or a high protein low oligosaccharide variety (Bright Day). Additionally, a commercial 32% protein catfish feed was included as a reference. All growth data collected during the trial, except for the survival rate ($p > 0.05$), showed significant differences among treatments ($p < 0.001$). Furthermore, we appreciated that the use of the Bright Day treatment exhibited good tissue development and a performance for channel catfish.

Considering the results of this study, we can highlight that the use of soybean meal protein is a feasible alternative for animal-based diets. Histological and gene sequencing studies in channel catfish will validate the dietary matrix and the interaction of their components with the physiological growth of the fish.

USING FISHERIES TECHNIQUES TO ESTIMATE THE AGE AND GROWTH OF HYBRID CATFISH *Ictalurus punctatus* FEMALE × *I. furcatus* MALE IN WEST ALABAMA COMMERCIAL PONDS

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In West Alabama, catfish producers routinely face the challenge of fish that exceed market size (aka “Big Fish”) in their commercial ponds. These fish are skilled at evading seine nets during harvest and can increase in size significantly before subsequent harvests occur. This is problematic for catfish producers because processing plants prefer catfish within the 0.45 – 1.81 kg range, and farmers are paid a premium price for catfish of this size. Depending on the market and processing plant, a catfish producer can receive little-to-no monetary value for an oversized catfish. Due to their larger size and growth potential, hybrid catfish (*Ictalurus punctatus* ♀ × *I. furcatus* ♂) can become a more significant issue than channel catfish if they evade harvest. In this study, 1,005 hybrid catfish were collected from twelve recently harvested commercial ponds from seven commercial catfish farms in West Alabama from December 2021 to August 2022 with an electroshocking boat. The objectives of this study were to describe and quantify the age structure and growth of hybrid catfish that evade capture and remain in commercial ponds following harvest and grow beyond acceptable market size as defined by catfish processing plants (i.e., Big Fish). Length (mm), weight (kg), and sex were recorded, and lapilli otoliths were removed to estimate the total length and weight at age, with the successful aging of 1,001 fish. Results of this study indicate that hybrid catfish exceeded the premium size threshold at age 2.72 years and should be harvested after one production cycle. Additionally, from age 2 to 3, the average hybrid catfish can gain 2.9 kg, growing from 0.4 kg to 3.3 kg. Growth was significant based on sex; males overall were predicted to weigh more than females based on the weight-at-age model. By age 4, there were significant differences in mean weight (p = 0.009), males were predicted to weigh 9.73 kg, and females were predicted to weigh 8.10 kg. Taking length into consideration, males had a higher L_{∞} at 1,301 mm compared to 1,131 mm for females.

COMPARING NILE TILAPIA (*Oreochromis niloticus*) AND HYBRID STRIPED BASS (HSB: *Morone saxatlilis X M. chrysops*) FOR BUTTER (REX) AND GREENLEAF (MUIR) LETTUCE PRODUCTION IN A SMALL-SCALE, DEEPWATER, AIRLIFT DRIVEN AQUAPONICS SYSTEM

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Nile tilapia (NT) (*Oreochromis niloticus)* are often used in aquaponic systems as a nutrient source for plants due to their hardy nature and ability to grow well under varying conditions. In relation to other fish species, however, tilapia do not always command a high market value, potentially reducing the sustainability of any aquaponics business. In conjunction with a local aquaponics business, we compared lettuce production between two 9,500-L airlift driven, deepwater aquaponic systems to determine fish species' impacts over a seven-month period. In system one, NT were raised in combination with Greenleaf and Butter lettuce. In the second system hybrid striped bass (HSB) (*Morone saxatilis x M. chrysops*) were raised in combination with the same two types of lettuce. Fish were stocked at typical recirculating aquaculture system (RAS) production densities for each species (NT = 139/m^3: HSB = 76/m^3). Lettuce plants were grown in rock wool media and floated in foam boards at a density of two plants/ft^2 with a total growing space of 108 ft^2/raceway. Other than fish feed, chelated iron, sodium bicarbonate and topping off system water, no inputs were added to either system. Standard RAS/aquaponic water quality measurements were made to monitor overall health of the fish and the systems. Fish were sampled monthly to measure growth and adjust feed rations. An equal number of plant boards were harvested across both systems upon first maturity to make plant production comparisons. Results of plant and fish production, water quality and system recommendations will be presented.

HEPATOPANCREATIC MICROSPORIDIOSIS IN THE AMERICAS

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Hepatopancreatic microsporidiosis caused by *Enterocytozoon hepatopenaei* (EHP) is currently one of the main diseases of concern affecting the international shrimp farming industry. Originally limited to some countries in Asia, EHP or a closely related species has also been documented in Venezuela in 2016.

This disease is relevant not only because it causes mortality, but also because it contributes to slow growth and can make the shrimp more susceptible to other, secondary infections. Although direct transmission from shrimp to shrimp is a known fact (i.e., via cannibalism or ingestion of spores shed in the feces), there is limited information regarding alternative modes of transmission or the existence of potential vectors or reservoirs. EHP was originally discovered in *Penaeus monodon*, but *Penaeus* (*Litopenaeus*) *vannamei* and crayfish (*Procambarus clarkii*) are also very susceptible. Additionally, it has been shown experimentally that the infection can be passed from *Penaeus* (*L.*) *vannamei* onto *Penaeus* (*L.*) *stylirostris*.

There are indications that hepatopancreatic microsporidiosis is spreading in the Americas. During 2023, our laboratory confirmed the presence of microsporidian infections affecting the hepatopancreas of shrimp in other countries aside from Venezuela. We do not know yet how closely related this microsporidian is to EHP. However, conventional H&E histology has revealed the presence of lesions diagnostic of the disease, and it is similar enough to be detected by current EHP PCR and qPCR protocols. The parasite is also recognized by a gene probe designed for detection of EHP by *in situ* hybridization assays. Ongoing research comparing genomic sequences will reveal the level of relatedness with EHP.

Hepatopancreatic microsporidiosis is a high-risk disease. Since current molecular methods are adequate at detecting the parasite, avoidance by exclusion should be implemented whenever possible to avoid further spread in this continent.

EFFECTS OF DIETARY CARBOHYDRATE SOURCE IN FLORIDA POMPANO (*Trachinotus carolinus*) GROWTH AND NUTRITIONAL PHYSIOLOGY

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Utilization of carbohydrates has reported beneficial effects when supplemented to aquafeed formulas. Carbohydrates are a well-known source of body energy, high-quality binding ingredient and economical component for aquafeed. When inadequate or insufficient carbohydrates are presented in the diet, other energy-yielding nutrients, such as proteins and lipids are catabolized to produce energy. Thus, inadequate dietary carbohydrate source could result in reduced growth performance, high feed conversion ratio, fatty liver deposition and mortality. On the other hand, an appropriate carbohydrate source could lead to cost reduction of formulated diets, lessen ammonia excretion, improve protein consumption, and increase farm profitability. This protein sparing effect of carbohydrates is becoming of great interest in aquaculture. Currently, little is known about carbohydrate metabolism in Florida pompano, *Trachinotus carolinus*. Thus, the objective of this research was to determine the effects of different carbohydrate sources on Florida pompano growth. To this end, five isonitrogenous, isolipidic and isocaloric diets were formulated using different carbohydrate sources namely whole wheat grain flour, wheat starch, whole corn grain flour, corn starch and dextrinized corn starch. At the end of the 10-week growth trial, fish were assessed for growth performance, feed utilization, body composition, hepatic enzyme activity, gene expression and gut microbiome variations.

Overall, the results indicated that whole wheat grain flour is the more adequate dietary carbohydrate source based on production performance, physio-biochemical and molecular approaches. These data are critical when formulating a complete commercial feed for sustainable and profitable culturing of Florida pompano.

NUTRITIONAL EFFECTS OF BLACK SOLDIER FLY LARVAE PROTEIN INCLUSION IN DIETS OF JUVENILE RED DRUM (*Sciaenops ocellatus*)

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Fish meal holds outstanding nutritional value, and it is a principal component of most fish diets. However, aquafeed production reliance on fish meal is questionable due to economic, environmental and sustainability reasons. During the last decade in the USA and globally, insects have emerged as an alternative to terrestrial plants, marine and animal protein sources in aquaculture. Insects are rich in protein and lipids, and contrary to plants, they are devoid of anti-nutritional components and indigestible non-starch polysaccharides. Black soldier fly larvae (BSFL), maggot meal, mealworm larvae, adult Orthoptera (grasshoppers and crickets), and silkworm pupae have been the focus of investigation for their nutritional attributes, ease of rearing and high biomass production. BSFL has shown to provide a well-balanced amino acid profile, strengthening its potential as a promising fish meal substitute to include into aquafeed diets. For these reasons, the objective of the current study was to determine the appropriate dietary inclusion level of black soldier fly meal (BSFM) based on the growth performance of Red drum. The results suggested that 50% BSFM inclusion level is appropriate plus it seems as a forthcoming and promising low-cost, sustainable and nutritious replacement of fish meal protein when formulating commercial diets for Red drum. These efforts are geared toward developing complete commercial diets for sustainable farming of US aquaculture fish species.

EVALUATION OF CARBON DIOXIDE REMOVAL(CDR) POTENTIAL OF SEAWEED AQUACULTURE AND BLOOMS

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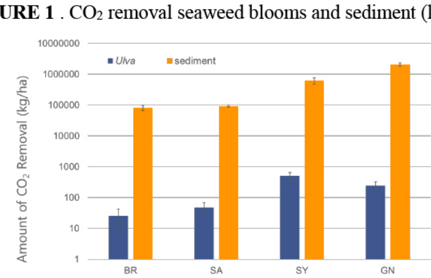
Researches on carbon absorption in marine ecosystems continue increasing worldwide, and marine ecosystems are able to absorb 26% of the world's carbon emissions every year. Seaweeds use carbon dioxide as substrate for photosynthesis to generates oxygen into the air and carbohydrates accumulated in their tissue which supports for their growth. Therefore, their capacity of collecting (or sequestrating) carbon dioxide can be counted in an annual carbon absorption amount. Blue carbon stores more carbon in sediments than green carbon in vegetation. Carbon stored in sediments is known to decompose very slowly and last for hundreds or even thousands of years. However, there have been no studies on carbon sequestration capacity of sediments around seaweed ecosystems. We estimated the carbon sequestration potential of seaweed aquaculture and blooms, and nearby sediments. We measured the tissue carbon content and organic carbon in different depths of sediments at six tidal flat (BR, SA, GN, SY, WJ) and seaweed aquaculture (JD) and marine forests (PH) in South Korea. Seaweed samples were collected from each site, dried, and ground for carbon analysis. Sediments were collected using a corer, separated into 5 cm intervals and homogenized at each depth. Total carbon and organic carbon contents, and sediment size were analyzed for the sediments. The amount of carbon dioxide removal by tidal flats seaweed was 0.025-0.51 tCO_2/ha, and the sediment removed 82-2,110 tCO_2/ha. The potential carbon dioxide sequestration by sediment in seaweed aquaculture area was 243-351 tCO_2/ha. As the paradigm of climate change policy shifts from land-based to marine sector due to acceleration and expansion of climate change effects, it is critical to evaluate carbon reduction potential of algae clusters and surrounding sediments.

FIGURE 1 . CO_2 removal seaweed blooms and sediment (kg/ha)



THE OREGON AQUACULTURE EXPLORER: AN INTEGRATIVE GEOSPATIAL PLATFORM SUPPORTING AQUACULTURE INVESTMENT, EDUCATION, PERMITTING, AND FINANCIAL PLANNING

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The Aquaculture Explorer, an integrated geospatial platform, was designed to facilitate the development of the aquaculture sector in the state of Oregon. The authors developed the tool in partnership with Oregon State University, state agencies, and the aquaculture industry. The platform has three components: 1) a site selection portal with geographic and demographic information in a GIS setting; 2) a financial planning tool that estimates costs and returns based on site selection; and, 3) an estuarine planning tool to support shellfish regulation and permitting. The platform is designed to help aspiring farmers locate aquaculture farm sites with critical attributes regarding land, water, markets, and utilities. In addition to private producer use, regulators and permitting agencies can use the tool to visualize protected habitat issues and multiple use conflicts.

The financial tools are designed to help investors evaluate business operations and adjust financial projections. The tool currently accommodates three species/systems models: striped bass in pond systems, tilapia in Recirculating Aquaculture Systems (RAS), and sturgeon in RAS. Currently, the authors are at work on a model for a co-culture system with dulse seaweed and purple sea urchins, as well as an aquaponics system model. Each model has unique bio-economics, drawing from significant background research and data on their diverse production attributes. After using the tool to select a site and a species, the user can then complete a farm profile the incudes production volumes, area of operation, and the costs associated with startup, operating, transportation, and financing. Users can toggle each variable to adjust assumptions and projections. The model provides financial performance for an average year as well as a ten-year projection.

The mapping tool provides 69 different data layers to assist in site evaluation. Users can include their distance from major markets, feed suppliers, and processing locations. The mapping tool also provides data on wells and springs, water body data, protected habitat and resources, elevation, and sources of solar and geothermal energy, among others. The estuarine data layers can help shellfish growers evaluate estuary sites that are consistent with regulatory requirements. The Explorer generates summary site reports for growers to evaluate regulatory considerations.

The Aquaculture Explorer Platform is a unique approach to support aquaculture development. It is now being integrated in undergraduate and graduate aquaculture classes to help train the state's new aquaculturists. We expect the Oregon Aquaculture Explorer Platform will be a vital tool to facilitate development, provide a common language, and facilitate dialogue between public entities and private growers.

HARMONY AND HAZARDS: A COMPARITIVE STUDY OF *Vibrio* spp. In *Crassostrea Virginica* AS PROTECTORS AND POTENTIAL PERILS IN COASTAL ENVIRONMENTS

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Crassostrea virginica plays a crucial role in maintaining our ecosystem and food chain, acting as a natural filter for water by removing sediments, bacteria, and nutrients. However, *C. virginica* can also host microorganisms like *Vibrio* spp. some of which pose risks to human health.

In this regard, *V. vulnificus* and *V. parahaemolyticus* can cause infections, while *V. coralliilyticus* and *V. tubiashii* harm shellfish. To identify Vibrio in both oysters and seawater, we employed 16S rRNA-specific primers and used PCR and RT-PCR to confirm specific types such as *V. vulnificus* and *V. parahaemolyticus*. Our results revealed the presence of *V. parahaemolyticus* and *V. coralliilyticus*, with *V. parahaemolyticus* being the predominant species. Importantly, the levels of Vibrio for both oyster larvae and human health were recorded 3.36 cfu / g in *C. virginica* and 200 cfu / mL in seawater. While Vibrio the concentrations of human-pathogenic Vibrio recorded 91.6 cfu / g in *C. virginica* and 120.33 cfu / mL in seawater during our studies.

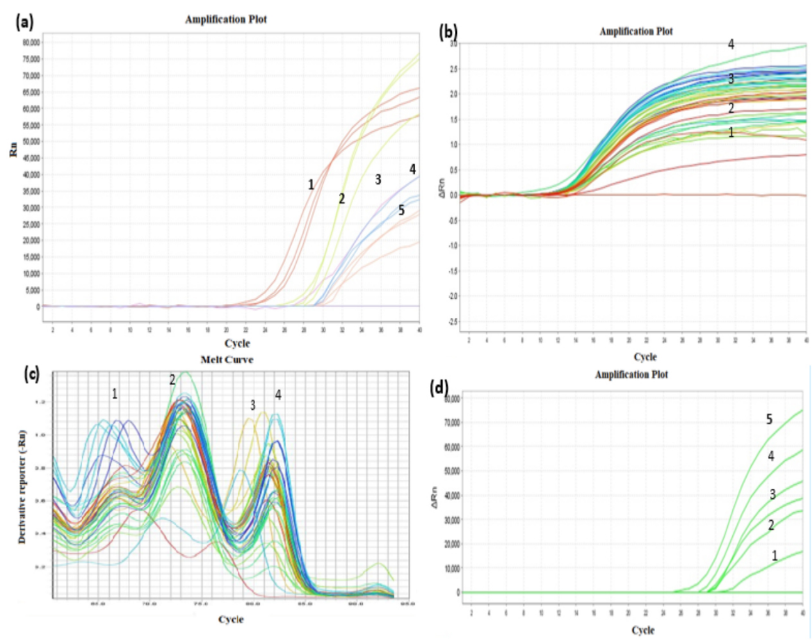

Figure 1 (a-d). The confirmation of the targeted *Vibrio* using specific primers using SYBER Green. (a) demonstrates the amplification plot on the concentration of the plasmids (1: 100 ng, 2: 10ng, 2: 100 pg, 4: 10 pg, 5: 1 pg). (b) amplification plot on the reproducibility of the detection method using the multiplex technique. (c) the melt curve analysis for the detection of different targeted Vibrio (1: *V. parahaemolyticus* 2: *V. vulnificus* 3: *V. coralliilyticus,* and 4: *V. Tubiashi.* (d) Amplification plot on different concentration of the *V. tubiashi.*

THE INTESTINAL MICROBIOTA OF FARMED AND WILD BROOK TROUT (*Salvelinus fontinalis*): ASSESSING VARIATIONS LINKED TO DIET THROUGH 16S RRNA GENE METABARCODING

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Given the increasing significance of aquaculture in animal protein production, several researchers started to investigate the gut microbiota of several aquatic organisms. In this context, our study aimed to characterize the core intestinal microbiota of the brook trout (*Salvelinus fontinalis*), a fish species that can be found both in farmed and natural environments in Italy, where it is considered an invasive species.

This salmonid species is of economic and environmental importance to several countries, including Italy. In this research, we conducted an analysis of the microbiota present in farmed and wild *S. fontinalis* with a specific focus on distinguishing between the intestinal wall and the contents of the middle section of the intestine.

A total of 66 individuals, all aged 2+ years, were included in the study, comprising 46 wild individuals and 20 farmed brook trout from two different years. We employed a 16S metabarcoding approach, targeting the V3–V4 hypervariable regions of the 16S rRNA, to obtain microbiota data. Our findings revealed that the core microbiota in these fish species mainly consisted of *Proteobacteria* (both *Alpha*- and *Gammaproteobacteria*), Actinobacteria, Firmicutes (comprising *Bacilli* and *Clostridia*), and *Fusobacteria* exclusively in farmed specimens. The presence of *Fusobacteria* in farmed individuals is likely linked to their fishmeal-based diet.

Furthermore, our analysis of alpha and beta diversity demonstrated discernible differences between wild and farmed fish. Notably, we identified statistically significant differences in microbiota composition between the intestinal walls and contents of wild fish, whereas no variations were observed in the farmed fish.

This study represents the first examination of intestinal microbiota in *S. fontinalis*, encompassing both farmed and wild individuals. Future research endeavours may explore the comparative aspects of our data with those pertaining to other fish species, as well as delve into the analysis of different portions of the brook trout intestine.

OCCURRENCE OF MICROPLASTICS IN AQUACULTURE SYSTEMS: SOURCES, ECOLOGICAL RISKS, EFFECTS, AND MITIGATION APPROACHES

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The intensification of microplastic pollution in aquatic ecosystems has become the focus of global attention. Sources of microplastics in aquatic environment include terrestrial inputs, tourism, shipping, aquaculture, fishing, and atmospheric. The small size range of microplastics (<10 µm) facilitates their accumulation at various trophic levels through ingestion. Indeed, microplastics have been detected in various organisms.

The ingestion of microplastics can lead to various negative physiological effects, including immunotoxicity, reproductive toxicity, and behavioural changes. In addition, microplastics sever as carriers of various pollutants, resistance genes, and microorganisms. As the issue of microplastic pollution gains global attention, there is a growing focus on researching microplastics in aquaculture. To ensure environmental safety, economic efficiency, and food safety, it is imperative to gain a thorough understanding of microplastic pollution in aquaculture.

This contribute provides an overview of the sources and effects of microplastics in aquaculture. Microplastics in aquaculture originate from external environmental inputs and aquaculture processes. They have the potential to release harmful additives, absorb pollutants in the aquaculture environment, degrade the quality of the aquaculture setting, and lead to toxicological effects. These factors can impact the behaviour, growth, and reproduction of aquaculture products, ultimately diminishing the economic benefits of aquaculture. Moreover, the presence of microplastics in aquaculture products may also pose health risks to consumers.

Efforts to combat microplastic pollution in aquaculture will be also discussed. Ecological interception and purification are recognized as effective methods for mitigating this issue.

Additionally, enhancing aquaculture management practices and improving fishing gear and packaging are practical solutions. Proactive measures include the development of new portable microplastic monitoring systems and remote sensing technology, which hold promising applications. Encouragement is given to strengthen the oversight of microplastic pollution in aquaculture through talent exchange and the enhancement of relevant laws and regulations.

RESILTROUT "RESILIENT AQUACULTURE TO GLOBAL CHANGES: RESEARCH SUPPORTING THE ITALIAN TROUT FARMS" PROGRAM

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The Istituto Zooprofilattico Sperimentale of Piemonte, Liguria and Valle d'Aosta have recently awarded the "RESILTROUT – Resilient Aquaculture to Global Changes: Research Supporting the Italian Trout Farms" Program (2022-2026), funded by the Italian Ministry of Agriculture, Food Sovereignty, and Forestry.

This Program primarily targets the freshwater aquaculture sector, specifically trout farming, which holds historical and production significance in Italy. The overarching objective of the RESILTROUT Program is to bolster the competitiveness of Italian aquaculture production by capitalizing on research and technological advancements. This entails integrating both research and production sectors to ensure long-term sustainability across environmental, economic, and social dimensions throughout the entire aquaculture sector. Moreover, RESILTROUT aims to foster stable collaboration among several stakeholders within the aquaculture value chain. This overarching goal will be pursued through the attainment of specific objectives, aligned with the environmental goals outlined in the European Regulation n. 852/2020:

- objective 1: achieving environmentally friendly and sustainable businesses to address the environmental goal of "mitigating climate change";
- objective 2: selecting resilient trout strains in alignment with the environmental goal of "adapting to climate change";
- objective 3: implementing water recirculation systems, promoting the sustainable use and protection of water and marine resources;
- objective 4: reusing wastewater sludge and implementing measures for energy and resource efficiency, contributing to the environmental goal of "transitioning to a circular economy";
- objective 5: Reducing pharmaceutical contamination in water and sediments, aligning with the environmental goal of "preventing and reducing pollution";
- objective 6: Producing sterile brown trout strains and perform a statistical model to assess the timeline for introducing such strains to ensure the absence of hybridization with the native marble trout. This objective is tied to the environmental goal of "protecting and restoring biodiversity and ecosystems";
- objective 7: Promoting innovation and ensuring the fish welfare.

The small companies (Azienda Agricola Canali Cavour; Troticoltura delle Sorgenti) and the Università Cattolica of Sacro Cuore (Piacenza, Italy) actively participate in the RESILTROUT activities as beneficiary entities.

SUPERTROUT – “TO BE OR NOT TO BE *Lactococcus petauri*”

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SUPERTROUT is a European project aimed at improving sustainability and performance of aquaculture farming system mainly through the breeding for lactococcosis resistance in rainbow trout and the development of an orally administered recombinant protein vaccine.

Among infectious diseases, lactococcosis, sustained by *Lactococcus garvieae*, a warm water pathogen, is a major re-emerging bacterial disease, seriously affecting the sustainability of aquaculture industry worldwide. Lactococcosis is a septicaemic disease characterized by high mortality and great economic loss. The severity of the symptoms could vary according to the pathogenicity of the bacterial strain, fish species and size, and abiotic parameters such as water temperature and for this reason it is enhanced by global warming.

In the context of SUPERTROUT, genomes comparison and the characterization of *L. garvieae* strains, collected along the time in natural outbreaks recorded in Italy, Greece, Spain, and Turkey allowed to re-allocate different strains, previously classified *L. garvieae*, as *Lactococcus petauri*, a recently described novel species of the genus *Lactococcus*. *L. petauri* has been previously reported in California and Brazil and from our data, it appears widely spread in the Mediterranean area, with the only exception of Italy in which all the analyzed strains were *L. garvieae*. *L. garvieae* was routinary diagnosed using biochemical test, specific PCR targeting 16S and MALDI-TOF, but due to the high genetic similarity level, these methods failed to discriminate between the two species. Results obtained led us to develop new molecular and discriminating diagnostic tool such as a PCR based on ITS 16S-23S rRNA and to study differences in terms of pathogenesis (based on capsule genes cluster and hemolysins genes) and antimicrobial resistance.

Strains characterization associated to reverse vaccinology is particularly important to develop vaccines specifically targeting *L. petauri*, considering that actually only *L. garvieae* vaccines are available and to apply the appropriate antimicrobial treatment in field.

HYDRODYNAMIC-MODULATED LARVAL DEVELOPMENT AND POTENTIAL FOR JUVENILE CO-CULTURE WITH CORALS IN THREE SYMPATRIC SEA URCHIN SPECIES

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Echinoderms have been labelled as a boom-and-bust phylum. A Caribbean-wide population bust of the long-spined sea urchin *Diadema antillarum* in the early 1980s is the most extensive mass-mortality event reported for any marine animal. This die-off was a major contributor to coral reef decline throughout the region. Meanwhile, the variegated sea urchin *Lytechnius variegatus*, which shares part of its range with *D. antillarum*, has exhibited protracted population booms in seagrass leading to hectares of bare area in formerly dense meadows.

Larval biology (e.g., morphology and developmental rate) can mediate recruitment potential and is likely to influence urchin demographics. The desire to understand larval development also stems from the potential to produce small juvenile animals for use in co-culture with sexually propagated corals as a part of reef restoration programs. Finally, there is interest in directly stocking some species of cultured urchins to coral reefs to replace ecological function lost following the *D. antillarum* die-off.

This presentation will describe experiments on larval and juvenile *D. antillarum*, *L. variegatus*, and *Tripneustes ventricosus*, a coral reef-associated species that is of interest for coral co-culture as well as ecological restoration. Turbulent shear levels driven by water velocity were found to affect larval development and settlement rates to differing degrees among the three species. A subsequent experiment found that, while juveniles of all three urchin species reduced benthic algal cover relative to a negative control, intraspecific differences existed in the algal communities curated and in effectiveness for coral co-culture.

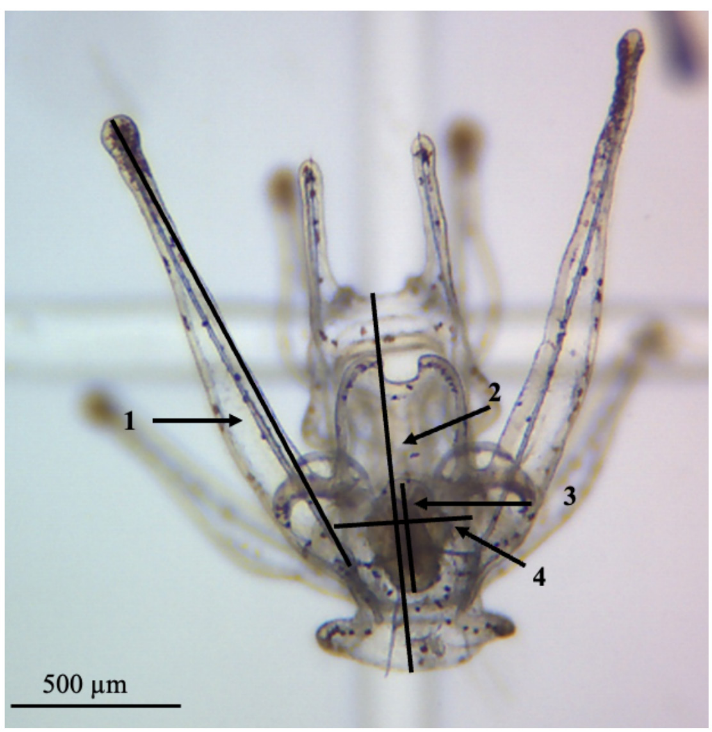

Figure 1: Ventral view of *L. variegatus* larvae showing post-oral arm length (1), body length (2), stomach length (3), and body width (4).

AUTOMATING OYSTER AQUACULTURE WITH THE SUN

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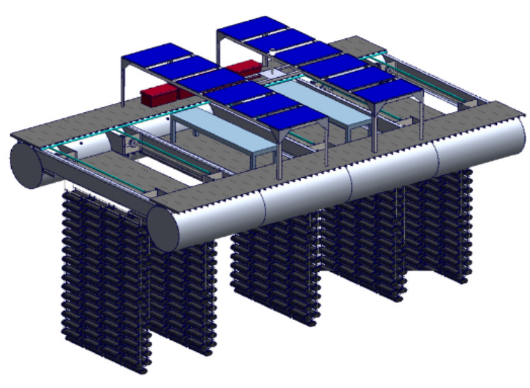
Oyster aquaculture technology has been relatively static in an industry needing to grow to meet global protein demand and advance restoration. Oyster aquaculture is very labor intensive, often growing less than a half million oysters per acre depending on gear types and site location. Floating and off-bottom gear is typically positioned in the near-shore environment or in the upper few feet of the water column, limiting overall growth and increasing conflicts with land-owners and other stakeholders.

The Solar Oyster Production System (SOPS) has been developed to take advantage of offshore space that is typically not used by other oyster aquaculture systems. The SOPS supports a series of cages in up to twenty feet of water and utilizes solar power to mechanically rotate the cage array through the water column and above the water, providing desiccation/air exposure and the opportunity for mechanized washing, which minimizes overall labor inputs. The rotation sequence can be programmed to meet the needs of the grower. The mooring system and robust design of the platform allows location of the SOPs in higher-energy environments, with integrated anti-poaching technology that allows units to be placed further offshore, potentially minimizing stakeholder conflict. SOPS can grow spat-on-shell oysters for restoration or from seed for market oysters. Approximately 150,000 oysters from seed can be grown on one 40' x 25' SOPS prototype (see below).

In the Chesapeake Bay watershed, nitrogen and phosphorus credits for oysters harvested from aquaculture operations can be traded on the nutrient credit market. Use of the SOPS for 1 acre of high-density oyster aquaculture may remove nutrients equivalent to treating stormwater runoff from over 100 acres of impervious surface.

A SOPS prototype was launched in October 2021 and loaded with spat-on-shell oysters in coordination with the Chesapeake Bay Foundation. For two years, growth was successful and the diploid oysters were deposited on a reef at the entrance to the Baltimore Harbor in early November 2022. Triploid seed oysters were grown to gauge the effectiveness of the technology. In 2024, SOPS will be deployed to the lower Chesapeake Bay to gauge its effectiveness on an active oyster aquaculture farm.



CREATING A NON-LETHAL SAMPLING METHOD FOR OFF-FLAVOR COMPOUNDS BY COMPARING GEOSMIN CONCENTRATIONS IN BLOOD AND MUSCLE TISSUE OF ATLANTIC SALMON, *Salmo salar*

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Geosmin (trans-1, 10-dimethyl-trans-9-decalol) and 2-methylisoborneol (2-MIB) are off-flavor compounds found naturally in water and soils but also in recirculating aquaculture systems (RAS). The off-flavoring caused by geosmin and 2-MIB can be described as earthy and musty, which can be off-putting to potential consumers of farm-raised fish. The human sensory threshold for geosmin and 2-MIB is variable among individuals, however, it is generally accepted that humans can taste geosmin at 0.044 to 0.5 µg/kg and 2-MIB > 0.9 µg/kg respectively (Lindholm-Lehto 2018). These off-flavor compounds are produced as secondary metabolites from actinomycetes, mycobacteria and a variety of other bacterium. Lipophilic compounds like geosmin and 2-MIB can be detected in system water but are known to accumulate in lipid-rich fish tissues. The goal of this research study is to develop a method to analyze geosmin and 2-MIB concentrations through blood analysis instead of using muscle tissue. We aim to compare concentration of geosmin within muscle, organ tissues, and blood in Atlantic Salmon, *Salmo salar*, to better understand the mechanisms of transport and accumulation of off-flavoring compounds in the body of Atlantic Salmon with the overall goal of validating a non-lethal method for analyzing geosmin and 2-MIB through blood sampling.

COMPARISON OF TOTAL AMMONIA NITROGEN MEASUREMENTS OF CATFISH POND WATER BETWEEN TRADITIONAL FIELD METHODS AND A LABORATORY METHOD

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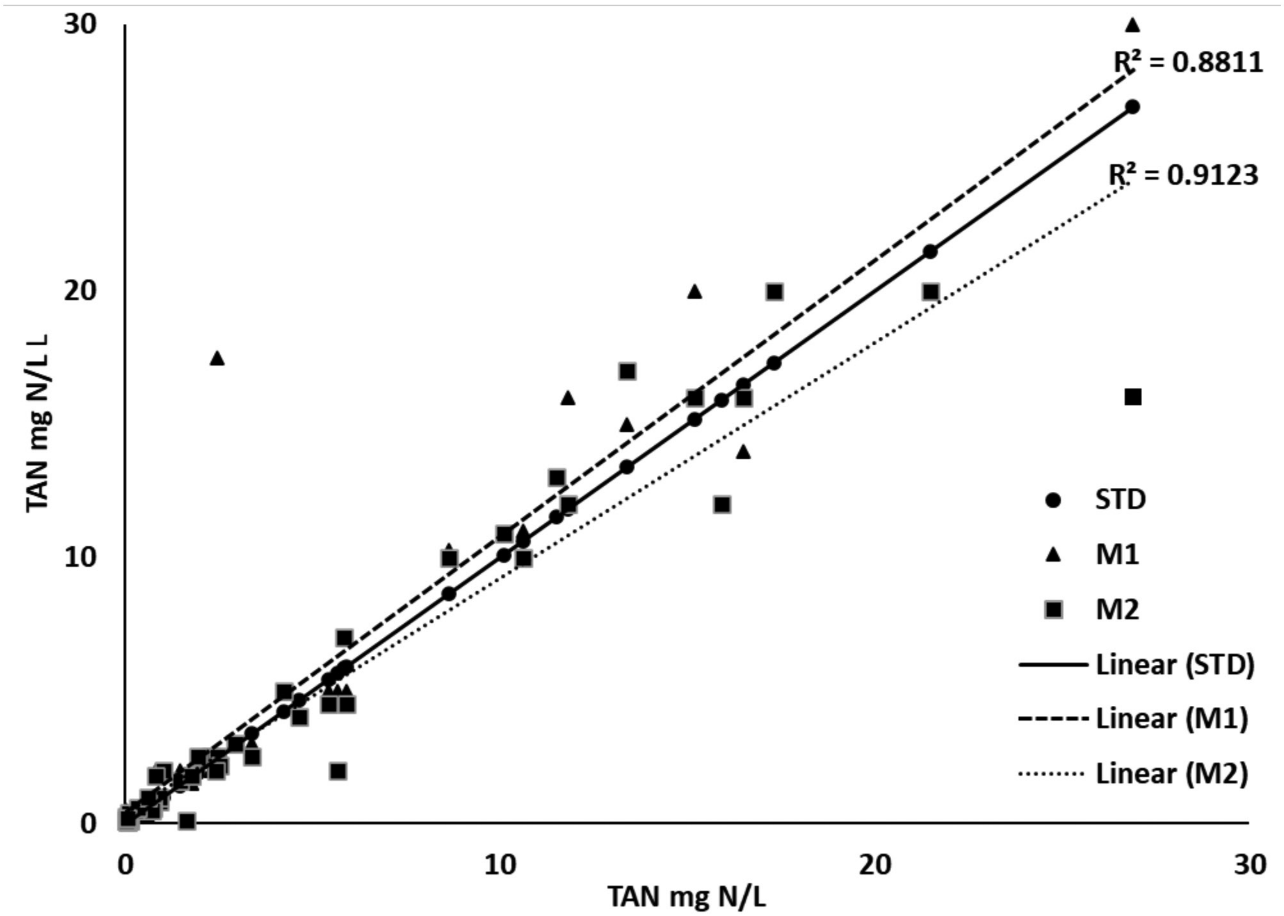
Traditionally, commercial catfish farmers use field kits to measure total ammonia nitrogen (TAN) of unfiltered pond water, but the impact of filtering and total ammonia concentration on their accuracy is unknown. Commonly used field ammonia analysis kits were evaluated by comparison to a laboratory method of 53 water samples obtained from commercial catfish farms and research ponds in Mississippi. Unfiltered samples were analyzed by two salicylate chemical reaction-based field kit methods (M1 and M2) and compared to a filtered laboratory salicylate method (STD) read by a spectrophotometer. Total ammonia concentrations obtained from the field kits (M1 and M2) are closely correlated with the standard laboratory method up to 10 mg N/L TAN. When TAN values are higher than 10mg/L, field kit methods begin to diverge, and return either slightly lower or higher values compared to the standard method. Unfiltered water analyzed with field ammonia test kits are very reliable up to 10 mg N/L, but higher concentrations begin to lose precision and may no longer be appropriate, depending on the application.



EFFECTS OF BLACK SOLDIER FLY PROTEIN ON HISTOMORPHOLOGY OF INTESTINE AND LIVER IN JUVENILE RED DRUM (*Sciaenops ocellatus*)

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Fish meal is recognized for its excellent nutritional content and is a key element in many fish diets, however it takes up a larger part of overall cost compared to other ingredients. Additionally, fish meal market variability for aquafeed production confirms the need for an alternative protein source. Thus, it has been reported that incorporating Black soldier fish meal (BSFM) is a viable option to substitute fish meal for aquafeed production practices. Histological analysis of intestines in Red drum provides insights into the efficiency of nutritional absorption, immunity response and digestion processes. Similarly, histological liver analysis provides characteristics on lipid storage and lipid metabolism within the tissue. Thus, histological analysis is crucial to help identify potential impacts of experimental diets on the health and function of the liver and intestine when including BSFM as a fish meal substitute. Therefore, the objective of the study was to investigate the impact of BSFM on the liver and intestine morphology of Red drum. To this end, five experimental diets were formulated to meet nutritional requirements for Red drum. One control diet containing 100% fish meal and four with increasing BSFM protein levels to substitute fish meal (25%, 50%, 75%, 100%). A total of 400 fish were evenly distributed into 20 fiberglass tanks with a photoperiod of 12 hours light and 12 hours darkness. All experimental diets were randomly assigned to each tank with four replicates per treatment during an 8-week feeding trial. Our preliminary results suggest that fish fed with diets containing 50% BSFM protein inclusion presented increased muscle and villus thickness, with slight rise in goblet cells in intestine. Fish fed with 50% BSFM diet in the liver presented minimal changes in lipid deposition compared to the control. Fish fed with diet levels above 50% BSFM, presented noticeable signs of hyper-vacuolization and inflammatory responses in the liver.

THE VELELLA EPSILON PROJECT: PIONEERING OFFSHORE AQUACULTURE IN THE SOUTHEASTERN GULF OF MEXICO; CHAPTER 6 – FINALIZING PROJECT PERMITTING AND PREPARING FOR DEPLOYMENT: ACT III

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The Velella Epsilon Project is an extension of previous projects (Velella Beta-test and Velella Gamma Project) which demonstrated small-scale, offshore, marine fish culture in the waters of Kona, Hawaii. The Velella Epsilon (VE) Project will adapt these technologies to Gulf of Mexico (GOM) waters, while pursuing two simultaneous efforts: (a) permitting and deployment of a research-scale, demonstration net pen in Federal waters, and in tandem, (b) navigating the commercial permitting process to obtain a commercial offshore aquaculture permit in Florida waters, while documenting this effort in a Manual for Aquaculture Permitting Pathway (MAPP).

The VE Project focuses on a small, pilot-scale (single net pen) aquaculture system where up to 20,000 red drum (redfish; *Sciaenops ocellatus*) fingerlings would be reared for approximately 12 months in Federal waters approximately 40 nautical miles west-southwest of Sarasota, Florida. We expect to yield approximately 17,000 fish (85% survival rate) with a final fish size of approximately of 3.0 pounds (lbs.)/fish. An estimated final maximum harvest weight of 51,000 lbs. whole weight is anticipated. These fish will be landed in Florida, marketed, and sold to state- and Federally licensed dealers, in accordance with state/Federal laws.

The VE Project will lay the groundwork for wider acceptance of commercial aquaculture in the GOM region by: (1) Serving as a platform for the promotion of rational aquaculture policies and demystification of the industry, by providing a working net pen example to politicians, constituents, journalists, and other influencers of policy or public perceptions, as well as the local community; (2) Increasing public awareness of, and receptivity towards, offshore aquaculture and the need to culture more seafood in U.S. waters, by providing public tours of the offshore operation, including (possibly) snorkeling inside the net pen, and fee fishing; (3) Serving as a demonstration platform for data collection of water quality, potential benthic impacts, and marine mammal and fish stock interactions resulting from offshore aquaculture in the GOM; and (4) Providing local recreational, charter, and commercial fishing communities with evidence of the benefits of aquaculture, through the fish attraction device (FAD) effects of the project, and by documentation of fish aggregation and fishing boat activity around the VE Project.

Chapter 6 – Finalizing Project Permitting and Preparing For Deployment: Act III - will walk us through the sixth year's experiences and achievements of finalizing the permitting process (via a permit modification) while collaborating with net pen manufacturers and engineering firms to evaluate a demonstration size net pen system that is representative of, and scalable to, a commercial farm scale system. A review of significant advancements performed with the MAPP development, as well as evaluations of potential commercial siting analyses, will be discussed.

TRIANGULATING MARKET POTENTIAL FOR FOOD-FISH AQUACULTURE IN MINNESOTA WITH CONJOINT AND PARTIAL BUDGETING ANALYSES

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In 2017, Minnesota Sea Grant hosted a workshop to discuss whether an environmentally responsible and sustainable food-fish aquaculture industry could be established in Minnesota. The group identified two categories of research needed, one of which was "marketing and understanding consumer perceptions and demand" (Moen et al., 2017, p. 43). In response to their needs, a NOAA-funded study "Determining market potential for food-fish aquaculture in Minnesota" was initiated in late 2020.

The study approaches the objective from demand and supply side analyses to triangulate the market feasibility. The market data for locally farm-raised seafood products do not exist in Minnesota, as the industry has yet to recover from an environmental controversy in the late 1980s surrounding commercial salmonid aquaculture efforts in abandoned mine pits. Thus, demand side assessment relies on conjoint analysis using data collected from a consumer survey. Supply side assessment consists of partial budgeting analysis, relying on producer-validated enterprise budgets. Estimates of the premium consumers are willing to pay for Minnesota farm-raised seafood products will be compared with the break-even prices estimated from the partial budgeting analysis to determine market feasibility of a food-fish aquaculture in Minnesota. Of species of interest for Minnesota aquaculture, the analysis will focus on yellow perch and walleye. The consumer valuation will be estimated for shrimp as well.

Two pilot consumer surveys conducted in 2022 show that many Minnesotans are now open to consuming farm-raised seafood products, with more favorable perceptions of farm-raised seafood products over those of commercially harvested products in terms of long-term health impacts, environmental impacts, and food safety risk (Table 1).

Table 1. Comparative perceptions between farm-raised and commercially harvested seafood

Farm raised is…	Long-term health impacts (positive & negative)	Environmental impacts (positive & negative)	Food safety risk
much better than **commercially harvested**	17%	13%	14%
somewhat better than **commercially harvested**	26%	19%	20%
About the same	20%	27%	29%
somewhat worse than **commercially harvested**	12%	14%	14%
much worse than **commercially harvested**	8%	7%	6%
I am not sure	17%	20%	18%

Findings from a pilot study, sample size = 330

GLOBAL ECOLOGY AND DISTRIBUTIONAL POTENTIAL OF TWO OYSTER AQUACULTURE PESTS: OSHV-1 AND *Perkinsus marinus*

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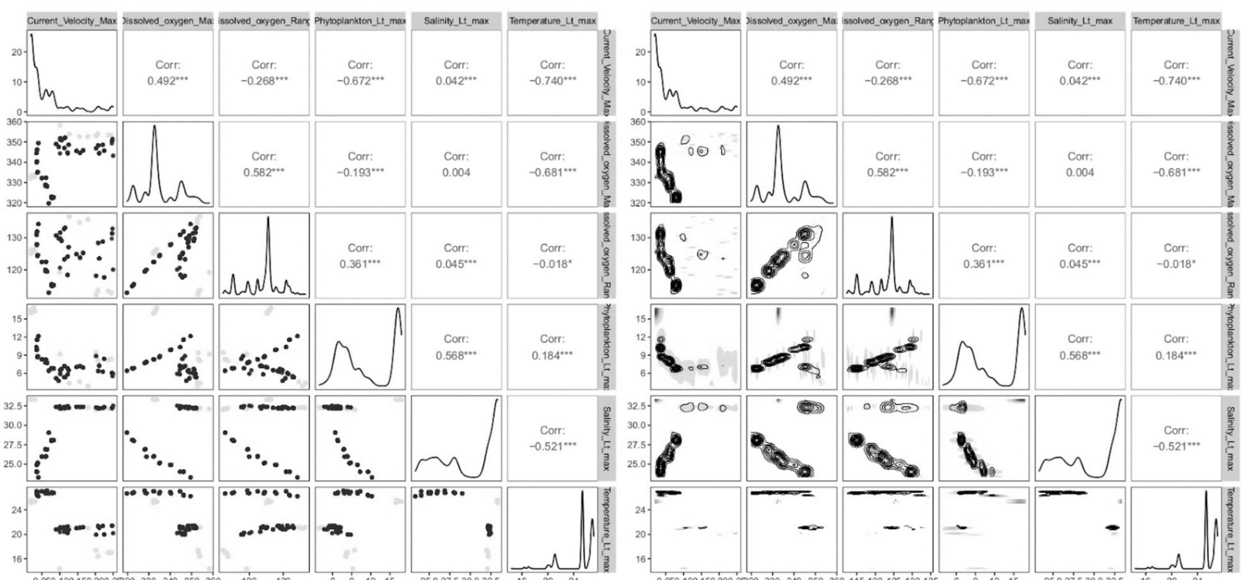
Oyster aquaculture is an expensive enterprise that requires considerable infrastructure and investment. As such, infection by pathogens and pests can have important economic consequences. Part of the challenge of avoiding such infections and mitigating their effects is a function of biosecurity and local-scale infection control. However, another important dimension may be awareness of the global-scale distributional potential of the pathogens and pests. This aspect of oyster aquaculture remains largely unaddressed. We assembled testing data from oyster aquaculture initiatives around the world and tested for environmental bias in the distribution of positive test results in assays for OSHV-1 and *Perkinsus marinus* among the distribution of all tests conducted. A universal result confirmed that an ecological niche of the pathogens exists that is distinct from that of oysters. We then explored the implications of these niche dimensions for the geographic distributional potential worldwide with intriguing and suggestive indications of distributional limitation for each of the two pathogens. We are now improving these models by (1) incorporating additional testing data, (2) adding data reflecting environmental conditions on adjacent terrestrial areas, and (3) making the environmental data specific to the time of testing rather than longer-term averages. Such broad-scale ecological and geographic studies can complement the local-scale biosecurity measures that are currently in place.



Exploration of environmental correlates of occurrences of *Perkinsus marinus*, showing positive (black) and negative (light blue) test results in 15 bivariate environmental spaces, based on points (left) and density kernels (right).

CHARACTERIZING GENETIC X ENVIRONMENT INTERACTIONS OF ATLANTIC SALMON *Salmo salar* SELECTED FOR GROWTH IN NETPENS THROUGH EVALUATIONS IN RECIRCULATING AQUACULTURE SYSTEMS

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Growth performance of fish in any production system is affected by environment and genetics. The St. John River (SJR) strain of Atlantic salmon *Salmo salar* has been selected for growth in net pens at the National Cold Water Marine Aquaculture Center (NCWMAC), Franklin, ME for five generations while the Gaspe strain was previously selected for growth in tanks for two generations. It was previously shown the Gaspe strain outperformed the SJR strain in a recirculating aquaculture system (RAS). With RAS Atlantic salmon facilities coming to the U.S., we sought to investigate whether the selected SJR strain would perform as well or better than the Gaspe strain across a range of RAS environments. Approximately 1,000 eyed eggs (2,000 eggs total) from both strains were shipped separately to The Conservation Fund's Freshwater Institute (TCFFI; Shepherdstown, WV) and an additional 2,000 eggs the Northern Aquaculture Demonstration Facility (NADF; Bayfield, WI). Eyed eggs were also maintained and grown at the NCWMAC. All studies were conducted under experimental RAS conditions. Once the fish reached ~50 g/fish, they were pit tagged, weighed, and combined into tanks at each location until they reached approximately 4 kg/fish.

Results from FCFFI showed the SJR strain weighed 4.6 kg/fish while the Gaspe strain weighed 3.6 kg/fish at harvest. Similarly, at the NAD, the SJR strain weighed 4.8 kg/fish while the Gaspe strain weighed 2.6 kg/fish. SJR strain fish at the NCWMAC weighed 2.7 kg/fish while the Gaspe strain fish weighed 1.8 kg/fish at the most recent sampling. A complete profile of growth, fillet characteristics, mortality, and maturity will be presented. The results of the study clearly show the growth superiority of the SJR strain when compared to the Gaspe strain when reared in RAS.

CHALLENGES, OPPORTUNITIES, AND PROFITABILITY OF SMALL AND MEDIUM OFF-BOTTOM OYSTER FARMS: ANALYSIS AND A SPREADSHEET-BASED TOOL

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I analyze costs, break-even prices, and profits for beginning small-to-medium off-bottom oyster farm operations ranging from as few as 27,000 oysters planted on 0.5 acre to as many as 1.28 million oysters planted on four acres. An Excel spreadsheet-based tool was developed as part of this work to allow users to estimate cost and profit under alternative assumptions and scenarios. For the purpose of analysis, I use Southeast Louisiana, USA, as the representative location of farm operations.

Results are meant to represent an operation under a range of reasonable assumptions on production, environmental conditions, and markets likely to hold during the first five years of operation. Results are provided in two forms: "Full Accounting" results that include all relevant costs (explicit costs and opportunity costs), consistent with economic theory and practice; and "Partial Accounting" results that exclude owner labor costs and depreciation on boat, motor, and vehicle. The latter results are included because they are deemed by some in the industry to be the type of analysis on which growers actually make decisions. Because these latter results ignore certain major cost components, their results appear much more favorable.

Under reasonable assumptions of a farm start-up period and moderate crop losses due to periodic adverse environmental conditions, the five-year average break-even price under Full Accounting is estimated to range from $2.57 per oyster for 40,000 oysters planted on half an acre to $0.52 per oyster for 960,000 oysters planted on four acres. Average annual profit under Full Accounting is estimated to be negative for production levels at or below 480,000 oysters planted on two acres, and positive at production levels at or above 720,000 oysters planted on three acres. Sensitivity analysis indicates that none of the production levels considered are fully robust to the variety of conditions that an oyster farm in this region is likely to face.

Farming for the high-end half-shell oyster market is dependent upon a small set of buyers willing to pay high prices. I estimate that there are a very limited number of establishments in the region that feature off-bottom half-shell oysters. Prices received by growers vary widely. Although prices at or above $1 per oyster have been observed, the average price is in the $0.40-0.59 per oyster range. Data from some states indicate that nearly half of farmed oysters end up in lower-value markets where prices are below $0.25 per oyster. Some farms are located distant from markets and do not have access to an established distributor, requiring them to market and deliver oysters directly, which can yield higher prices, but also requires added effort that can erode much of the gains associated with higher prices. There is also currently a shortage of hatchery-reared seed across the entire US Gulf Coast. Farm gear and infrastructure are susceptible to storms. It has not been demonstrated that gear can be sunk and retrieved cost-effectively or relocated in time to avoid damage and loss of both gear and crop.

MEASURES OF MATTER FOR MARINE LIFE - ARCHITECTURE SUPPORTING AQUACULTURE RESEARCH LABORATORIES, AQUACULTURE TANK FARMS, AQUARIUM ROOMS

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Coastal marine laboratories or aquaculture production grow out facilities housing marine life require special architecture and infrastructure considerations for success. A balance between the scientists'/growers' goals and the planning professional's expertise will build alignment with the environmental conditions of unpredictable coastline seawater dynamics. Environmental effects of materiality corrosion, high-wave surges, heavy rain flooding, and high-wind damage from storm events are just a few of the sustainability consideration challenges. It is here that vulnerability aligns with the resilience related investments and the broader vision to ensure long-term viability.

Enduring Building Design and Construction Measures of Matter provide
stable marine life health
predictable fresh seawater quality + quantity
long lasting sustainable corrosion resistance materiality
alignment with coastal conditions and the natural environment

These buildings all offer unique and innovative design and construction approaches to:
Mitigation of weather disruptions by way of flood proofing strategies and types of construction
Dimensional open floor areas for moving large gear in/out of wide doors with heavy equipment
Accessible systems for routine maintenance and removal of fouling with cleanouts at 10'-12'
PVC high pressure 150 psi seawater supply piping with multi-headed quick disconnects
Redundant seawater supply and discharge for cleaning while actively supporting marine life
Drains to collect and move spent seawater by way of trench or area drains
Discharge direct to water source with proper permits, filtering, and chemical treatment
Water Quality testing at fresh seawater source and at point of delivery to holding tanks
Water Quantity alignment with marine life holding tank sizing and the delivery system as well as alignment with recirculating systems and water holding tank sizes planned for weekly purging
Corrosion resistant re-circulating seawater supply and discharge systems; and building materiality
Temperature alignment of seawater source and tank with water piping and thermometers
Oxygen ozone generators and polishers, tank air pumps, and skimmers to control oxygen content
Condensation barriers for all surfaces and for seawater piping and tanks
Turbidity Control at point of intake to avoid prop wash in navigable waters and seek proper depth
Water Pressure control to allow survival of small nutrients
Overhead sub-structure to carry power reels, air system, and water supply
Filtration to reduce fouling while allowing sea creature food sources to sift through and in
Power generators for uninterrupted animal life quality during weather disaster events
Building Climate control systems easy to repair + re-place or with automated controls
Emergency alarm systems for seawater systems failure notification

UPDATE: THE ROLE OF SEA URCHIN AQUACULTURE IN A MISSION TO RESTORE SEVEN ICONIC REEFS IN THE FLORIDA KEYS

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Severe coral reef degradation throughout Florida's Coral Reef has resulted in >75% coral cover loss since the 1980s and actively threatens the identity, culture, and economy of this region. This reality has spurred the development and rapid expansion of in-water coral propagation and outplanting activities intended to restore live coral cover; unfortunately, restoration has been unable to keep up with the rate of ecosystem decline as evidenced by widespread coral bleaching and mortality earlier this year. Overcoming this immense problem requires an adaptive approach involving novel ecological intervention strategies.

Mission: Iconic Reefs is a bold collaborative endeavor initiated by the National Oceanic and Atmospheric Administration attempting scalable restoration of seven iconic coral reef sites in the Florida Keys National Marine Sanctuary through use of the best available science. A critical aspect of this effort involves re-establishing missing functional herbivory to prevent competitive overgrowth of corals by fast growing benthic algae. This presentation will provide updates regarding development of intensive aquaculture methods for the Caribbean long-spined sea urchin *Diadema antillarum*, a formerly abundant keystone reef herbivore. Notably, improved capacity to aquaculture this species has enabled experimental population enhancement to degraded reefs and prompted the need for a scalable hatchery-to-reef pipeline. Near-future juvenile grow-out investigations to occur in both in-water and land-based enclosures will also be discussed.

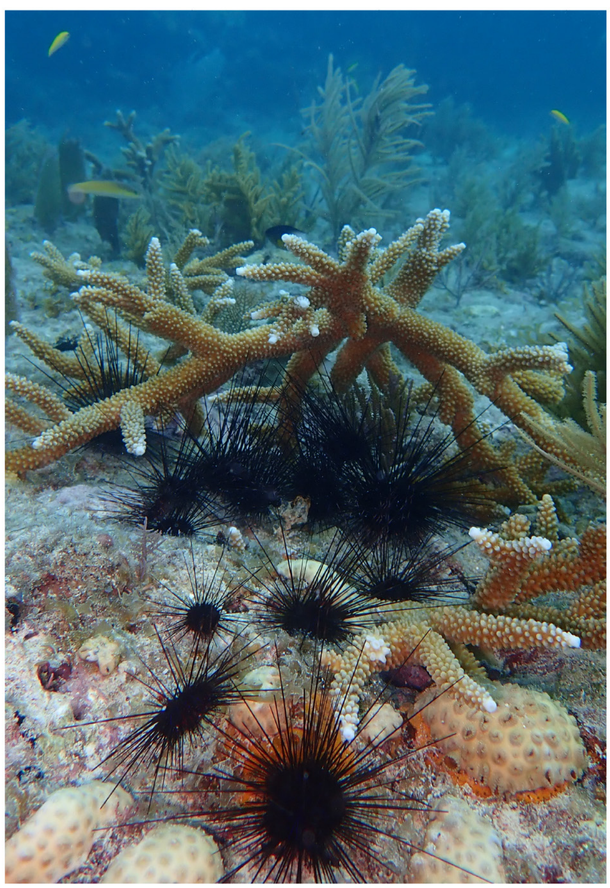

Figure 1: Captive-reared *Diadema antillarum* restocked to a restored reef-site in the Florida Keys.

USE OF DIFFERENT FERTILIZATION STRATEGIES FOR THE SYNBIOTIC SYSTEM ON WATER QUALITY, MICROBIAL COMPOSITION AND GROWTH OF *Penaeus vannamei* IN THE NURSERY PHASE

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Synbiotic system is characterized using vegetable bran (e.g., wheat and rice bran) processed by probiotic microorganisms (e.g., *Bacillus* and yeasts) as a supplementary organic carbon source for the system fertilization. Vegetable bran, as they are rich in carbohydrates and fiber, need to be broken down into more labile forms so that their absorption by microorganisms is enhanced. This can be achieved through processing by fermentation and/or microbial respiration by probiotic microorganisms. Considering the lack of consensus among the use of different strategies and the periods in which they can be used, these topics still need to be elucidated for better fertilization management in this system. Therefore, the aim of this study was to evaluate the effect of fermentation (F; phase without aeration) and respiration (R; phase with aeration) processes and different processing times of synbiotic system fertilizer on the nursery phase and compare with biofloc technology system.

A nursery phase trial (stocking density: 2400 shrimp m^{-3}) was carried out for 48 days testing the following treatments: CW: clear water (control); BFT: biofloc system; F12: fermentation for 12 hours; F12+R12: fermentation for 12 hours + respiration for 12 hours; F24: fermentation for 24 hours; F24+R24: fermentation for 24h + respiration for 24h; R12: respiration for 12 hours; R24: respiration for 24 hours. The fertilizer was composed of rice bran, a commercial probiotic blend (*Bacillus subtilis* and *Bacillus licheniformis*), sodium bicarbonate, molasses, and water.

Treatments F12+R12 and R24 had a faster control of TAN. A dominance by amoeba was observed in the treatments BFT, F12, F12+R12 and F24. Treatments F12+R12, F12 and F24+R24 showed a higher abundance of ciliates than treatments CW, BFT, F24 and R12 at the end of the experimental time. The abundance of vibrio at the end of the experimental time was higher in the F24+R24 treatment than in the other treatments. At the end of the experimental time, treatments F12, F12+R12, F24 and R12 had a lower FCR than CW treatment. Yield was higher in F12, F12+R12, R12 and R24 than in CW treatment. Our findings indicate that the reduction of fertilizer processing time can be considered for the synbiotic system fertilization, optimizing the management of the system. Therefore, we consider 12 hours of fermentation and 12 of respiration (F12+R12) the best fertilization strategy, as it provided a reduction in FCR, increased yield and produces significant effects on plankton composition.

Acknowledgements: The authors are grateful for the financial support provided by the National Council for Scientific and Technological Development (CNPq), Coordination for the Improvement of Higher-Level Personnel (CAPES) and Foundation for Research Support of the State of Rio Grande do Sul (FAPERGS).

PLANKTON COMMUNITY IN *Penaeus vannamei* NURSERIES WITH SYNBIOTIC SYSTEM UNDER DIFFERENT FREQUENCIES OF ADJUSTMENT ON Ca:Mg:K RATIO IN LOW SALINITY WATER

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The culture of *Penaeus vannamei* is a reality in several regions of the world far from the coast. However, one of the main barriers to overcome for the success of this culture is the imbalance among the major ions in low salinity water. One of the alternatives to solve this problem is ionic supplementation in water through the salt addition. This supplementation can be carried out so that the water maintains a Ca:Mg:K ratio close to 1:3:1, which is found in seawater. In addition to the importance of the major ions for osmoregulation and metabolism in shrimp, these minerals also play a fundamental role in water quality and can influence the primary productivity of the system. These ions are considered important macronutrients for the phytoplankton and can affect the entire microbial loop. It is a fact the importance of major ions on variables that can influence planktonic community structure of an aquaculture environment. However, the variation in the concentration of these ions throughout a culture and the imbalance in the Ca:Mg:K ratio of water shows that the effect of the adjustment frequency of this ratio must be studied. Thus, the aim of this study was to evaluate plankton communities in *Penaeus vannamei* nurseries under different frequencies of adjustment on Ca:Mg:K ratio in low salinity water and with a synbiotic system.

A nursery culture was carried out for 40 days, using 2000 shrimp m^{-3}. Following treatments were established: 1IA (Ca:Mg:K ratio adjustment to 1:3:1 on day 1); 2IA (Ca:Mg:K ratio adjustment to 1:3:1 on day 1 and day 20); 3IA (Ca:Mg:K ratio adjustment to 1:3:1 on day 1, day 10, and day 20); SW (seawater - salinity of 31 g L^{-1}); and SWD (seawater diluted to a salinity of 2.3 g L^{-1}). Rice bran processed by probiotic microorganisms was used as an organic carbon source.

Treatments did not have a significant effect on phytoplankton and zooplankton composition. However, plankton composition was significantly different over the experimental course. A reduced abundance of Cyanophyta was observed compared to traditional aquaculture systems. This can be explained by the probiotic bacteria addition to the system, along with fertilization, which may have limited the growth of this harmful algae. Throughout the experiment, zooplankton community had a dominance by protozoan microorganisms, such as amoebae and ciliates. The presence of copepods and rotifers was also observed throughout the experimental time. This proves that the use of the synbiotic system provides conditions for the microbial loop development, mimicking a natural environment. Different adjustment frequencies in the water Ca:Mg:K ratio do not significantly change plankton composition in *P. vannamei* intensive nurseries using low salinity water and synbiotic system. Temporal variation in plankton composition probably occurred due to fertilization of the system with an organic carbon source. The use of the synbiotic system proved to be efficient in microbial loop development, providing the growth of a high load of microorganisms that can influence water quality and shrimp growth in low salinity water.

COMPARING AEROBIC AND ANAEROBIC MINERALIZATION OF SLUDGE FROM CLEAR-WATER AND HYBRID BRACKISH-WATER RAS

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Water reuse is a key feature of inland, brackish-water, recirculating aquaculture systems (RAS) and mineralization of thickened waste may play a role in reducing water discharge. In clear-water systems solids filtration is robust, hybrid systems in comparison, operate with less filtration. By allowing the collected sludge to remain in contact with an external water body, the process of mineralization or decomposition of solids, can release nutrients and minerals important for plants used in brackish-water aquaponics. It is unclear how the waste from the two system types might differ and what the effects of aerobic versus anaerobic environments may have on mineralization of the material. This trial compared aerobic and anaerobic mineralization of marine shrimp sludge from two system types over a four-week period to determine changes in concentrations of dissolved nitrogenous compounds, phosphate and mineral content over time.

Sludge was collected from separate clear-water (CW) and hybrid (HY) shrimp RAS settling chambers. A 28-day trial examined each water type in aerobic (AE) and anaerobic (AN) conditions. The two water types and two oxygen levels created four treatments: CW-AE, CW-AN, HY-AE, HY-AN. Each treatment was randomly assigned to four replicate, 18-L containers. The water in each container was analyzed weekly for total ammonia nitrogen (TAN), nitrite-nitrogen (NO_2-N), nitrate-nitrogen (NO_3-N), phosphate (PO_4) and alkalinity (ALK). Additional water samples were collected weekly and filtered, then sent to an independent lab for inductively coupled plasma mass spectrometry (ICP-MS) for elemental analysis.

The concentrations of ALK, TAN and PO_4 tended to be higher overall and NO_3-N tended to be lower overall in anaerobic treatments. Because the denitrification process reduces NO_3 and produces alkalinity, these results indicate that denitrification was occurring in the anaerobic treatments. Plants generally prefer uptake of NO_3 over ammonia and use less energy to do so; however, both compounds can be assimilated into plant tissues. The CW-AE treatment showed a gradual increase in PO_4 concentration that may continue past the duration of this project. However, the anaerobic treatments generated far more PO_4 than the aerobic treatments in the four weeks of this trial. The difference (initial – final) in elemental concentrations showed an increase of dissolved Ca and decrease of Mn and Fe concentrations in aerobic systems. There was an overall decrease in all treatments of Na, Mg, Ca, K and Sr concentrations, and an overall increase in all treatments of S, Li, Ni, Si, P and Br concentrations. After only two weeks, mineralization had yielded the highest TAN, NO_3 and PO_4 concentrations, suggesting that different compounds could be generated depending on the amount of time the material was processed. Results of this study indicate that system type may not be very impactful with regard to waste mineralization. However, aerobic versus anaerobic mineralization environments, and perhaps time, can make large impacts on what compounds become dissolved in the water. This information may be used by producers to select for particular compounds best suited to the needs of their particular aquaponics plants.

BUSINESS AND ECONOMIC PLANNING FOR SEAWEED AQUACULTURE SYSTEMS IN THE UNITED STATES

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This presentation will provide an overview of a project funded under the NOAA Sea Grant funding opportunity titled, “Addressing Economics and Market Needs of the U.S. Aquaculture Industry.” Kelp, *Saccharina spp*. are the most common seaweed species cultivated in the United States. Kelp farming, as well as the farming of various other seaweeds, is a significant and growing industry in the US as seaweeds, especially kelp, can be used for food, medicinal products, additives and bioremediation. With any new industry, barriers to its development and expansion always emerge. One of the greatest barriers is the lack of economic/financial information on the cultivation of domestic kelp. There is a need to better understand the realistic economic and financial parameters associated with kelp aquaculture in order for farmers, investors and lenders to make more informed decisions regarding investment in this type of venture.

Project objectives include: (1) Develop business planning and management tools for kelp aquaculture systems, which improve the economic and financial viability of this industry; (2) Increase access to capital among existing and prospective seaweed farmers via an emphasis on improved industry knowledge for investors/financers/potential market entrants: (3) Conduct a comprehensive economic assessment of the ecosystem services provided by seaweed aquaculture; and (4) Develop outreach and education activities through SG extension for industry, regulators and financial institutions to support the development of a seaweed aquaculture industry. ***This presentation will share business planning and management tools developed to date.***

DEVELOPING A SUSTAINABLE BLACK SOLDIER FLY PROTEIN INDUSTRY FOR FISH FEEDS

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Insect husbandry is an economically promising and environmentally responsible means to produce quality ingredients for fish feeds. Among all insects, one the best candidates for this role is the black soldier fly (*Hermetia illucens*) which has already been tested on many species of fish. This insect is prolific, and its life cycle sufficiently well understood for a controllable husbandry. The black soldier fly (BSF) larvae grow very fast (2,000X gain in about 20 days) eating a wide variety of food waste materials and show excellent food conversion efficiency. Very important for any animal growing industry, the BSF larvae cultures tolerate the highest known biomass density (in kg per volume of growth facility), and have the highest biomass yield, relative to any other farmed animal. Close to 100 million tons of surplus organics is available each year in the US alone. If all this waste material is steered toward farmed insects it would result in more protein than the global production of fish meal. Recent advances in the BSF science and industry created an opportunity for rapid expansion of BSF protein as a reliable commodity. We review features that will heavily influence the contribution of the BSF protein industry to the evolution of fish farming. These are: requirements and solutions for high product quality; relationship between technological advances and production costs; and ecological impacts of the BSF industry.

With regards to product quality, we will discuss the importance of the BSF feed materials. The sourcing, composition and the pre-processing of the larvae feed have become key requirements for obtaining quality protein. We will also discuss how novel fermentation technologies led to an industry that is now safe from spreading food-borne pathogens. The quality and consistency of the products (proteins and fats) are discussed, as well as other valuable byproducts of this industry (fertilizers and BSF-derived polymers). Selection processes, novel genetic lines, larvae immunization for increased fish health and the monitoring of insect pathogens are promising research directions to the benefit of this industry.

At the technology level, four types of processes control product quality and the economic efficiency of the BSF protein industry. These are: the husbandry protocols, the biomass drying method, the defatting choice and the technologies used for mass transfer. We compare outcomes of the various technological choices that are presently implemented in the BSF industry and what should be expected with regards to performance for fish feeds. The introduction of automation in large factories led to sizable BSF factories with improved economics. This is excellent news for urban areas that must manage large volumes of perishable food waste. For example, a one million people city, or a food pre-processing industry servicing one million consumers, will produce over 250 mt of food waste daily. On the other hand, economic analyses have indicated that minimalist dimensions to make a BSF protein factory sustainable begin at sizes as low as 40-80 mt of food waste per day. Great prospects now exist for mutually beneficial symbiosis between cities as little as 300,000 inhabitants and sustainable BSF factories.

Finally, the future of the BSF protein industry also depends on its environmental footprint. It was shown that BSF protein has the lowest consumption of freshwater relative to other methods of producing feed-grade protein, and also the lowest GHG footprint relative to other methods of recycling food waste. For all these reasons, the BSF protein industry is only at the cusp of its potential as a global commodity and predicted to grow at an accelerated pace in the next decade.

OPTIMIZING COLONIZATION AND PROLIFERATION OF BLUE CATFISH (*Ictalurus furcatus)* DONOR STEM CELLS FOR THE CREATION OF XENOGENIC CATFISH; DETERMINING THE OPTIMAL DONOR STEM CELL QUANTITY

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The United States catfish industry is playing a significant role in advancing the national aquaculture industry, coinciding with a cultural shift towards increased consumption of farmed fish. The hybrid catfish (♀ channel catfish, *Ictalurus punctatus*, × ♂ blue catfish, *I. furcatus*) accounts for ~70% of the catfish market due to its superior performance compared to its parent species. To continue advancing the hybrid catfish industry, efforts are being made to advance reproduction techniques such as xenogenesis. Xenogenesis has successfully enabled the production of hybrid catfish embryo by transplanting undifferentiated stem cells derived from donor diploid blue catfish fish into a triploid channel catfish. However, a critical aspect is establishing the ideal quantity of donor cells for transplantation, a factor pivotal for boosting both colonization and proliferation efficiency. Thus, the present study is focused on identifying the optimal quantity of blue catfish stem cells for transplantation to produce xenogeneic catfish. Triploid channel catfish fry were injected with either 80,000 or 100,000 blue catfish stem cells labeled with PKH26 dye from 4-, 5-, and 6-days post-hatch (DPH). Then at 45 and 90 DPH, total length (TL), weight (BW), and survival of recipients were evaluated. Colonization of donor cells in recipients was evaluated using PKH26 dye fluorescence by calculating the percent cell (<150 μm^2) and cluster areas (>150 μm^2) and PCR was used to determine the percentage of xenogens from gonadal tissues.

Quantity of stem cell injected had no overall significant impact on survival ($p>0.05$) of recipient fish at both sampling periods, but TL ($p<0.05$) and BW ($p<0.05$) were significantly different at times which can be explained by stocking density variation. At both sampling intervals, no significant difference was seen for percent cell area fluorescing ($p>0.05$), but cluster area was found to be significantly higher in individuals injected with 100,000 stem cells ($p=0.001$ & 0.003). PCR analysis showed, 83.7% and 79.3% of xenogens were detected when recipients were injected 80,000 and 100,000 cells, respectively. Overall, introduction of 100,000 cells/fry led to better proliferation and colonization of blue catfish donor cells in channel catfish hosts. These findings will further enhance the efficiency and feasibility of germ cell transplantation for commercial-scale hybrid catfish production.

LAURIC ACID-ENRICHED BLACK SOLDIER FLY MEAL AND ITS EFFECTS ON PACIFIC WHITE SHRIMP *Litopenaeus vannamei* IMMUNE RESPONSE

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The Pacific white shrimp (*Litopenaeus vannamei*) is the most widely produced shrimp species worldwide, reaching a global production of over 4 million metric tons in 2019. However, the intensification of shrimp production increased its susceptibility to disease outbreaks. Considering that the utilization of antibiotics has fallen out of favor due to numerous reasons, developing cost-effective feed additives which can not only inhibit pathogens but also enhance the immune response and increase the resistance of shrimp to various pathogens has considerable potential. Lauric acid (LA), a 12-carbon saturated fatty acid, which is the most prominent fatty acid in the lipid of black soldier fly larvae (BSFL), has antimicrobial and immune-boosting properties. Thus, it was anticipated that growing BSFL on substrates that have elevated levels of LA would further concentrate this fatty acid in the insects and resulting meal, which could naturally enhance the immunity of shrimp if provided as a dietary supplement. Therefore, the main objectives of the present study were a) evaluate the use of substrates high in LA in enriching BSFL with LA; b) evaluate the effects of incremental levels of dietary LA in both purified form and in BSFL on shrimp's growth performance and immune response. BSFL were produced in triplicate containers containing 7 kg of substrate and approximately 10,000 small BSFL. A control substrate (Gainesville House Fly Diet, 300 g kg^{-1} of alfalfa meal, 500 g kg^{-1} of wheat bran, 200 g kg^{-1} of cornmeal) and an experimental substate consisting of a 70/30 mixture of control substrate and fresh coconut shavings were utilized. After 7 days of growing on the respective substrate, larvae were harvested, purged, processed, and analyzed for proximate and fatty acid compositions. The proximate analysis showed an increase up to 87% in the lipid content of the LA-enriched BSFL meal. In addition, the LA concentration of larvae produced with LA-rich substrate was 31% higher in comparison to BSFL reared on the control substrate. To evaluate the effects of LA on shrimp responses, 420 shrimp juveniles (~1.2 g initial weight) were equally distributed in 35 aquaria (110-L) operating as a recirculating system and offered the experimental diets four times a day to apparent satiation for 56 days. The treatments consisted of diets containing LA from a purified commercial source (0.6, 1.0, and 1.6%), and LA from regular BSFL meal, a 50/50 mixture of regular BSFL meal and LA-enriched BSFL, and LA-enriched BSFL (providing LA at 0.9, 1.5, and 2.3%, respectively). At the end of the feeding trial, hemolymph samples were collected and total hemocyte count (THC), phenol oxidase (PO) and lysozyme (LZ) activities were determined. Although no differences were found for PO and LZ activities, a significantly higher THC was observed in shrimp fed diets containing 0.6% purified LA and 1.5% of LA from LA-enriched BSFL meal. Our results show that it is possible to concentrate the levels of this fatty acid in BSFL and resulting meal, and that LA promoted an increase in the number of shrimp defense cells, which could potentially increase their resistance against pathogens. Further studies are needed to evaluate the putative immune-boosting capacity of LA under stress and bacterial challenges.

EVALUATION OF *Moringa Oleifera* SEEDS TO TREAT BACKWASH AQUACULTURE DISCHARGE

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Solid management is one of the most critical yet problematic issues in recirculating aquaculture systems (RAS). Dewatering or thickening solids is often needed to reduce the sludge volume by about 50 to 100 times to minimize the handling and disposal costs. Coagulation–flocculation process is commonly employed in municipal water treatment facilities to remove solids. However, most of the conventional metal-based or synthetic coagulants may not be ideal for RAS due to potential toxicity and incompatibility with downstream sludge processing methods. Therefore, a natural coagulant extracted from *Moringa oleifera* (MO) seed protein is proposed.

The aquaculture waste collected from the backwashed beadfilter discharge was collected from a Delta Smelt (*Hypomesus transpacificus*) hatchery in Byron, California, USA. The coagulation study was conducted using a jar test with the following conditions: flash mix at 200 rpm for 30 s, slow mix at 40 rpm for 15 min, and settling for 30 min. At the end of the settling period, samples were taken at 8 cm above the bottom (marked on the jar) using a pipette, and water quality was tested. The preliminary result showed that raw MO seed (Figure 1) was able to successfully remove the total suspended solids from the aquaculture waste.

Nonetheless, to increase the economic viability of the proposed method, defatted MO seed cake, a byproduct from MO oil industry, may be used in place of the raw seed. Further study is designed to explore different pretreatments of oil expression and to investigate the protein extractability and coagulant performance of the resulting MO seed cake. The oil from MO seeds is extracted using either thermomechanical (hot or cold press), solvent (hexane or ethanol), or the combination of the two. The protein is extracted by mixing the defatted samples with NaCl solution. The protein solubility is calculated by comparing the soluble protein (measured using BCA protein assay) with the initial protein in the samples (measured using combustion method). Finally, the coagulation efficiency is performed using jar test.

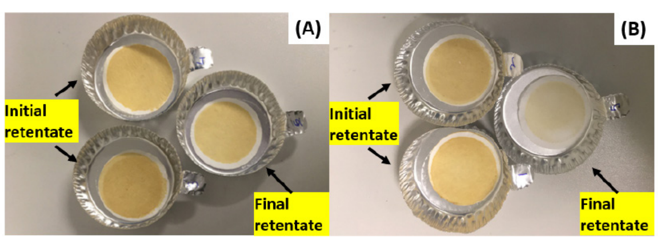

Figure 1. Initial and final retentate of aquaculture discharge sample with (A) no treatment and (B) with raw MO seed coagulant.

COMPARATIVE CASE STUDY OF SMALL-SCALE FISH PROCESSING FOR LOCAL SEAFOOD SUPPLY

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This study investigated the viability of utilizing a shared-use commercial kitchen and on-farm kitchen to support small-scale local fish processing to supply seafood to local food systems. A case study of each facility type is assessed for feasibility and economic viability for fish farmers. Assumptions made are processing production scale I = 2,500 lbs, scale II = 5,000 lbs and scale II = 10,000 lbs of tilapia and rainbow trout per year and selling at 10% and 15% markups.

We conducted a sensitivity analysis on raw product pricing, commercial kitchen rental rates, and on-farm setup costs to assess inherent uncertainty and potential outcomes for each scenario. The main outcome measure is a profitability index which measures profitability of an investment using ratio of present value of expected cash inflows to initial investment cost. A profitability index value greater than 1 indicates positive profitability. In Table 1, the financial analysis suggests that farmers interested in processing tilapia can utilize rental commercial kitchens for processing from 2,500 lbs to 10,000 lbs per year and selling at a minimum of 10% markup. If a farmer can set up an on-farm kitchen and process at least 10,000 lbs per year, selling at a minimum of 10% markup makes the best economically viable venture. Processing rainbow trout utilizing shared-use a commercial kitchen to process from 2,500 lbs to 10,000 lbs per year is profitable, and similarly having an own on-farm kitchen facility to process at least 10,000 lbs per year is also the best economical venture.

By incorporating uncertainties in raw product prices, commercial kitchen rental cost, and on-farm kitchen setup costs, we found that these variations do not change the overall positive profitability index of 1.10 for processing tilapia or rainbow trout in commercial kitchens. However, breakeven prices and selling prices do exhibit sensitivity to these fluctuations. Moreover, the profitability index, payback period, and net present values remain stable for Scale II and Scale III production levels, even when accounting for a 20% increase in on-farm setup cost.

Table 1: Metrics for Processing Fish Using Local Facilities

	Scale I	Scale II	Scale III
TILAPIA			
Commercial Kitchen			
Selling Price (15% markup)	$24.43	$19.57	$17.26
Profitability Index	1.15	1.15	1.15
Selling Price (10% markup)	$23.38	$18.72	$16.51
Profitability Index	1.10	1.10	1.10
On-farm kitchen			
Selling Price (15% markup)	$19.35	$16.48	$14.88
Profitability Index	0.73	0.95	1.39
Selling Price (10% markup)	$18.51	$15.76	$14.24
Profitability Index	0.62	0.78	1.07
TROUT			
Commercial Kitchen			
Selling Price (15% markup)	$16.94	$14.01	$12.61
Profitability Index	1.15	1.15	1.15
Selling Price (10% markup)	$16.20	$13.40	$12.06
Profitability Index	1.10	1.10	1.10
On-farm kitchen			
Selling Price (15% markup)	$13.88	$12.14	$11.18
Profitability Index	0.79	1.07	1.64
Selling Price (10% markup)	$13.28	$11.61	$10.69
Profitability Index	0.66	0.86	1.23

CHALLENGES AND OPPORTUNITIES FOR CONTINUE DEVELOPING THE AQUACULTURE EXTENSION PROGRAM AT OHIO

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The Aquaculture extension program at the Ohio State University has been in place for over twenty-five years, with the goals of increasing the number of aquaculture producers, aquaculture production, and enhancing the sustainability of the aquaculture industry in Ohio.

As a newcomer to Ohio, I have been tasked to strengthen this program. One of the first features from the Ohio's aquaculture industry is the diversity of species used, which range from freshwater shrimp to marine shrimp, from baitfish to tilapia, rainbow trout, yellow perch, and walleye, among others. The extension program requires to have the input of fish farmers, the Ohio Aquaculture Association, Faculty, Staff, and the community in general, to be able to have a foreseeable impact. This presentation will focus on challenges and opportunities that have been identified during the first six months of extension field work with aquaculture producers in Ohio.

FROM POND TO PLATE: ASSESSING FISH PRODUCERS' KNOW-HOW AND CONSUMERS' WILLINGNESS TO PAY FOR SAFER FISH IN BANGLADESH

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This study examines the fish producers' food safety knowledge, attitudes, and practices (KAP). Also, it reveals the consumers' willingness to pay (WTP) for a safer fish species, rohu, produced under controlled feed management using no antibiotics. Two hundred forty fish producers from 8 upazilas of 4 districts, which accounted for 29% of total inland (pond) fish production, were selected for the KAP study. It is found that the producers have excellent knowledge, attitudes, and behavior towards safe fish production. Structural equation modeling (SEM) assessed the relationship among food safety KAP. Despite having sufficient knowledge of safe fish production, the producers do not necessarily put it into practice. However, producers' attitude towards safe fish production positively and significantly impacts their practices. Therefore, targeted learning and communication strategies are necessary to improve safe practices.

Data on consumers' willingness to pay (WTP) was collected from 94 fish consumers in Mymensingh and Narayanganj districts using experimental auction sessions in April 2023. The respondents included 25% female and 75% male consumers from different income groups. Participants bid on two fish sets: control fish purchased from the neighborhood wet market and safer/trial fish cultured in real farm settings. The initial session provided the participants with little information regarding the production methods. The bid for trial rohu was significantly higher, on average, 21%, than for the control fish due to its superior visible characteristics.

TABLE 1. The WTP per kg. of safer rohu

Participant		Appearance Alone			Information treatment		
		Bid Price (Tk.)		% Price premium (t-value)	Bid Price (Tk.)		% Price premium (t-value)
		Control (SE)	Trial (SE)		Control (SE)	Trial (SE)	
Male	High (24)	253 (6.75)	288 (7.44)	14 (11.63^{***})	249 (7.35)	295 (6.96)	18 (9.56^{***})
Male	Middle (24)	248 (5.72)	301 (9.57)	22 (6.56^{***})	238 (4.82)	315 (9.59)	33 (8.17^{***})
Male	Low (23)	255 (5.75)	313 (6.61)	22 (7.59^{***})	244 (5.29)	326 (4.53)	33 (13.04^{***})
Female (23)		243 (7.64)	310 (7.48)	27 (7.36^{***})	215 (7.35)	335 (6.96)	56 (9.56^{***})
Average (94)		250 (4.00)	303 (3.24)	21 (14.05^{***})	237 (4.19)	317 (3.24)	34 (16.88^{***})
Mean difference		53			80		

Source: Authors estimation from auction data

POPULATION CHARACTERISTICS ASSESSMENT ON BLUE CRABS (*Callinectes sapidus*) AND VIRUS IDENTIFICATION OF *Callinectes sapidus* Reovirus 1 (CsRV1) USING PCR ANALYSIS IN DELAWARE INLAND BAYS

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The blue crab (*Callinectes sapidus)* population in the Delaware Inland Bays, particularly Rehoboth Bay, holds significant economic and ecological importance. *Callinectes sapidus* is a key contributor to the seafood industry in Maryland and Delaware. This ongoing study focuses on areas associated with oyster aquaculture and pilot oyster reefs. The primary objective is to evaluate the blue crab population and identify a potential pathogenic virus affecting them. The study specifically targets *Callinectes sapidus* reovirus 1 (CsRV1), analyzed in the lab using PCR (polymerase chain reaction) and qPCR (quantitative polymerase chain reaction) methods. Notably, no prior research has comprehensively examined the *Callinectes sapidus* population and CsRV1 within the Delaware Inland Bays. CsRV1 primarily affects the gills, impacting the respiratory system, and is associated with elevated mortality rates in aquaculture settings. Infected crabs exhibit symptoms such as lethargy, behavioral changes, and respiratory distress in natural habitats. Study sites were selected based on distinct characteristics, including areas with oyster aquaculture, artificial reefs, and control sites. The research involved deploying 18 traps across six sites, each with two large commercial cages and one small lobster pot. The summer and fall of 2022, the research team collected data from over 1,000 blue crabs. Our findings indicate stable populations of adult females at natural control sites throughout the season, with an increase in adult male abundance during the cooler months at aquaculture and reef sites. In 2023, CsRV1 was identified in the lab using PCR and qPCR techniques.

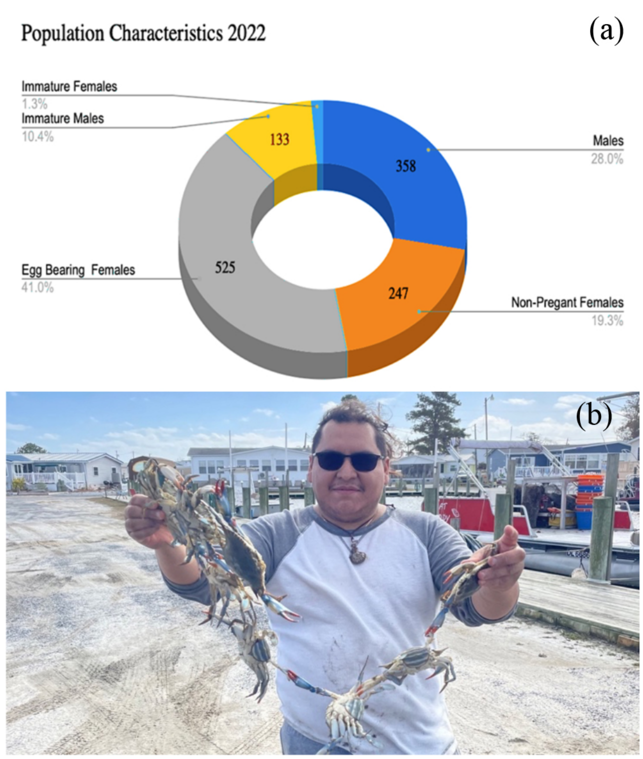

Figure 1 a-b. (a) *Callinectes Sapidus* population characteristics in Rehoboth Bay, DE, during the 2022 sampling season. Out of 1147 individuals around 525 females were egg-bearing. Roughly 787,500,000 eggs have been accounted for and released into Rehoboth Bay**. (b)** A picture of me processing blue crabs at our release and study site to minimize recapture likelihood.

AMPHIBIOUS WAGON DEVICE FOR EQUIPMENT TRANSPORT IN LOWER LAGUNA MADRE

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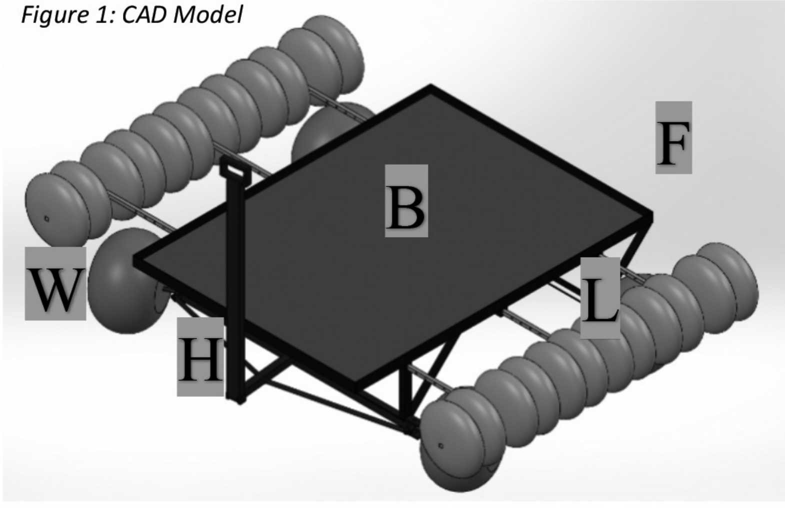
Texas was the last US coastal state to implement Cultivated Oyster Mariculture (COM). Several implementation issues hamper COM in the very shallow Lower Laguna Madre (LLM) of South Texas where much of the state's seagrass beds are located. Along South Padre Island's west coast exists an extensive area of shallow sandy bottom waters that is mostly devoid of seagrass and bordered by extensive tidal flats approximately 1 km wide closer to the island. Shallow water oyster grow-out trials are being conducted in this area at UTRGV's Experimental Field Station to minimize seagrass impact. The aim of this engineering project was to develop a device that would assist in equipment transport to the LLM field site across the periodically submerged tidal flats. The terrain is challenging where vehicles may get stuck or damage the sensitive tidal flat ecosystem. Standard beach wagons are not suitable as their tires sink into the sediment. Currently equipment is carried on foot, which is physically demanding and inefficient. The proposed amphibious wagon device must be practical and efficient for the research team. It must also utilize accessible materials and be affordable for other potential users such as economically disadvantaged oyster farmers and local fishermen.

The team investigated similar products on the market, and established design specifications. A morphological chart was used to compare many solutions for integral device components and were mixed and matched to find the most optimized solution. Material selection was important due to the corrosive salt-water sandy environment, having to be lightweight but strong enough to withstand the load capacity of the research equipment and possibly an average person's weight for an emergency to be carried out of the field. A finite element analysis (FEA) was conducted to analyze the frame's high stress and deformation points. Stress calculations were done by hand to verify the simulations. Archimedes' Principle was used to calculate the buoyancy force needed to float the combined weight of the load and device.

Figure 1 shows a CAD model created on SolidWorks. The device is composed of several major components: Frame (F), floats (L), wheels (W), handle-steering mechanism (H), and base plate (B). The frame holds all the components together and takes the bulk stress of the load.

Figure 1: CAD Model



A COMPUTER VISION TOOL FOR PRECISE AND RAPID FISH FILLET COLOR CATEGORIZATION

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Fish fillet color plays a crucial role in customer acceptance. Traditional visual fillet color assessments are often labor-intensive, subjective, and lack standardization. Colorimeters have been used for meat and fillet color assessments; however, their accuracy leaves room for improvement as they provide point color measurement and fail to capture the non-uniformity of fillets. Recent computer vision technologies have shown promise in accurately assessing fillet color, but their application is often limited to algorithm optimization. This study describes a portable computer vision tool for the rapid and precise color profiling of fish fillets. The tool consists of a single-board computer integrated with a red-green-blue (RGB) camera, facilitating data acquisition, onboard image processing, and data visualization. An automated algorithm was developed and optimized for resource-constrained edge devices to segment fish fillets and color palettes on the SalmoFan™ Lineal scale in the field of view of the camera. Various color difference metrics, such as Delta E (CIELAB 1976, 1994, and 2000), and hue angle were employed to assess the visual disparities in color between color palettes on the SalmoFan™ Lineal scale and the fillet. The minimum Delta E and difference of the hue angle were used to rate fillet color on SalmoFan™ scale ranging from 20 to 34. The performance of the tool was validated on 60 fillet portions (2 species × 5 fish/species × 2 fillet/fish × 3 Portions/fillet) obtained from 10 fish (species: Atlantic Salmon and Rainbow Trout) cultured in Recirculating Aquaculture System. The obtained fillet color values were compared with the visual ratings provided by three experts. An evaluation of the performance and accuracy of the developed digital tool for fish fillet color categorization will be presented.

THE U.S. GEOLOGICAL SURVEY (USGS) NATIONAL WATER AVAILABILITY AND USE ASSESSMENT PROGRAM: ESTIMATING AQUACULTURE WATER USE

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The U.S. Geological Survey (USGS) National Water Availability and Use Assessment Program is updating approaches for providing estimates of water use with nationally consistent models and improved water use data collection techniques. Models are being developed to estimate water withdrawal and consumptive use for 8 categories of use (public supply, domestic, irrigation, thermoelectric power, self-supplied industrial, mining, livestock, and aquaculture). The work presented here is focused on estimating water use for aquaculture. Understanding and estimating water use for the aquaculture industry in the US can help answer important questions used to inform decision makers tasked with ensuring the long-term success of aquaculture and support water management decisions. The aquaculture industry in the continental United States used about 7,550 million gallons per day of fresh water in 2015, and as demands for freshwater increase, understanding aquaculture water use will continue to be important for sustaining the aquaculture industry and our nation's water resources. Historically, water use has been estimated for aquaculture using linear equations and proprietary data sources that have limited the USGS's ability to provide current and complete water use estimates to the public. New techniques for estimating and assessing water use for aquaculture are in development with a focus on methods that can predict water use independent of the proprietary data used in previous studies and improve the spatial and temporal resolution of aquaculture water use estimates. The aquaculture water use estimation model aims to address the critical question of how the aquaculture industry uses water. These new models will be used to estimate historical and future freshwater demands for aquaculture and how variability in land-use, climate, and socioeconomic factors impact water use. The aquaculture water use model will utilize limited available facility-level and water-use data such as animal types and counts, facility locations and characteristics, and water withdrawal and return data.

SHORT TERM EFFECTS OF ELEVATED NITRITE AND NITRATE ON PACIFIC WHITE SHRIMP (*Litopenaeus vannamei*) SURVIVAL

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Animal density in indoor shrimp production is continuing to increase as producers seek to maximize production from their aquaculture systems. Increasing animal density and therefore feeding rates, results in faster accumulation of nitrogenous waste in systems with limited water exchange. Pacific white shrimp (*Litopenaeus vannamei*) are considered to be resilient to most forms of nitrogenous waste and have higher tolerances than many other aquatic species. Although shrimp may be tolerant to elevated levels of ammonia, nitrite, or nitrate individually, there is little information on the combined effects of these nitrogenous wastes on shrimp, particularly nitrite and nitrate. This study was designed to evaluate shrimp survival when subjected to elevated levels of both nitrite and nitrate.

In this experiment 36 64-L tanks were stocked with 10 shrimp each at a salinity of 15 ppt. Three different concentrations of nitrite-N (0, 10, 20 ppm) and four different concentrations of nitrate-N (0, 200, 400, 600 ppm) were used, resulting in a total of 12 treatments with three replicates each. The treatments were labeled based on the targeted amount of nitrite and nitrate in mg/L: 0/0, 0/200, 0/400, 0/600, 10/0, 10/200, 10/400, 10/600, 20/0, 20/200, 20/400. 20/600. The experiment was conducted for 11 days, at which point the total number of surviving shrimp were counted.

When examined individually, nitrite had a significant impact on survival at both the 10 and 20 ppm levels. By itself, nitrate levels of 600 ppm significantly decreased shrimp survival. Furthermore, the interaction between the two compounds was found to have a significant negative impact on shrimp survival. Combined levels of nitrite over 15 mg/L and nitrate over 400 mg/L showed mortality rates approaching 50%. This has important implications for shrimp producers, as many producers maintain high levels of nitrate and frequently experience fluctuations in nitrite levels. It seems that the two compounds should not only be considered as individually toxic, but in combination as well.

A SURVEY-BASED APPROACH TO CHARACTERIZING THE U.S. SHRIMP FARMING INDUSTRY

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Currently, the U.S. shrimp farming industry is poorly understood. With the unique opportunities for growing high-quality shrimp in the U.S., a better understanding of the status and the research needs of the industry may help drive forward progress in this sector. More specifically, if issues such as the number of farms, quantity of shrimp produced, production techniques used, and problems or limitations shrimp farms are facing were better understood, this information could be used by universities and government agencies to assist farmers in developing and growing their businesses.

For this project, we created, disseminated, and compiled the results of a survey of U.S. shrimp farmers to gather data to describe the U.S. shrimp farming industry. First, a candidate participant list was compiled through internet searches, existing lists from Kentucky State University (KSU) extension activities, and other sources. We then developed and pilot-tested a multi-modal survey tool (written – U.S. Mail, electronic – Survey Monkey online, and voice – through phone calls). We developed promotional materials, advertised the survey in industry newsletters, and contacted potential participants to garner support. Once we received responses, the data was compiled, cleaned, coded, validated, and analyzed.

After at least two attempts to contact everyone on our list, there were 31 refusals and 36 responses to our survey (a response rate of 54%). The majority of farmers had been growing shrimp for between 1 and 5 years (42%), while 26% had been farming for 5 to 10 years, 13% had been growing shrimp for 10 to 20 years, 13% more than 20 years, and only 7% for less than one year. Most farmers grew shrimp for food production (90%), although 20 and 23% grew broodstock and post larvae, respectively. Forty percent of respondents stated that their operation was not profitable over the last 12 months, although just as many stated they were somewhat or moderately profitable. The majority (63%) stated that they expected to be somewhat to very profitable in the next five years. Half of the farmers used a biofloc system, 26% used a hybrid system, and very few used flow through or clear-water RAS. 70% used swimming pools or above-ground raceways, and 60% had their systems in a closed, insulated building. 72% said that consistent availability was extremely important regarding post-larvae and 68% said post-larvae hardiness was extremely important. Other question topics included water quality issues, filtration and water treatment, biosecurity, disease problems, marketing aspects, and extension needs. The survey results demonstrate that the U.S. shrimp farming industry has a diverse set of objectives, concerns, and needs. These data will be used to guide research, extension, and policy objectives in the coming years, with the intention of helping grow the industry. Thank you to our funding source, APHIS-NAHMS, and thank you to the participants who shared information with us.

EARLY-LIFE FECAL TRANSPLANTATION FROM HIGH MUSCLE YIELD RAINBOW TROUT TO LOW MUSCLE YIELD RECIPIENTS ACCELERATES SOMATIC GROWTH THROUGH RESPIRATORY AND MITOCHONDRIAL EFFICIENCY MODULATION

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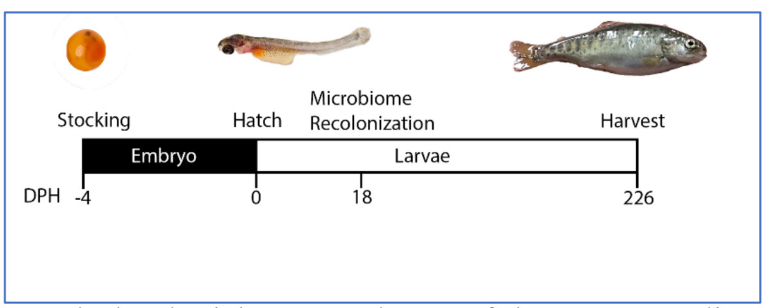
Background: Previous studies conducted in our lab revealed microbial assemblages to vary significantly between high (ARS-FY-H) and low-fillet-yield (ARS-FY-L) genetic lines in adult rainbow trout. We hypothesized that a high ARS-FY-H donor microbiome can accelerate somatic growth in microbiome-depleted rainbow trout larvae of the ARS-FY-L line. Germ-depleted larvae of low ARS-FY-L line trout reared in sterile environments were exposed to high or low-fillet yield-derived microbiomes starting at first feeding for 27 weeks.

Results: Despite weight-normalized diets, somatic mass was significantly increased in larvae receiving high fillet yield microbiome cocktails at 27 weeks post-hatch. RNA-seq from fish tails reveals enrichment in NADH dehydrogenase activity, oxygen carrier, hemoglobin complex, gas transport, and respiratory pathways in high fillet-yield recolonized larvae. Transcriptome interrogation suggests a relationship between electron transport chain inputs and body weight assimilation, mediated by the gut microbiome.

Conclusion: These findings suggest that microbiome payload originating from high fillet yield adult donors primarily accelerates juvenile somatic mass assimilation through respiratory and mitochondrial input modulation. Further microbiome studies are warranted to assess how increasing beneficial microbial taxa could be a basis for formulating appropriate pre-, pro-, or post-biotics in the form of feed additives and lead to fecal transplantation protocols for accelerated feed conversion and fillet yield in aquaculture.



CHALLENGES AND NEW OPPORTUNITIES FOR MASSACHUSETTS SHELLFISH GROWERS DURING THE PANDEMIC

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Woods Hole Oceanographic Institution Sea Grant and partners proposed to support the aquaculture industry with challenges they experienced as a result of the COVID-19 pandemic using Sea Grant rapid response funding. Due to pandemic-related restaurant closures the market demand for oysters on the half-shell due fell dramatically early in the pandemic, which led to exploration of alternative markets for oysters. Specifically, the lack of oyster shucking capacity was addressed through technology that allowed the quality protein in the shucked meats to become more available. While value added products were explored with industry in oyster stuffing and smoked oyster spreads, the bulk of the oyster meats were frozen in pint (1 lb) containers for food bank distribution with good success. Seventy-six oyster growers, 15 dealers and 4 processors participated in this portion of the project.

A second portion of the project focused on expanding market opportunities for shellfish growers to work with municipalities on shellfish enhancement projects. Massachusetts has robust recreational shellfish harvest with management at the local town level. The Sea Grant funding allowed four towns to work more closely with their community of growers to purchase overstock oysters and relay them to hard hit recreational fishery areas. Over fifty growers participated in this portion of the project forging lasting relationships to help manage shellfish resources locally.

ILLUMINATION AND SYSTEM DECOUPLING: THE IMPACT ON NUTRIENT DYNAMICS AND PRODUCT YIELD IN AQUAPONICS

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Over 23 million American households reside in food deserts, predominantly affecting marginalized communities in urban areas. Aquaponics holds promise as a sustainable solution, empowering local residents to cultivate fresh fish and vegetables. However, limited technical knowledge, system instability, and poor product quality pose barriers for novice users. This study explores how design choices influence system stability, user-friendliness, and product quality. We conducted a two-factorial experiment examining the impact of algal biofloc and system decoupling. Expert researchers managed three replicates, while novice users in four Alabama high schools operate four additional replicates, evaluating aquaponics' performance in novice user's hands.

Nitrification is crucial for aquaponic system stability and product quality. Improving nitrifying bacteria performance potentially enhances system reliability. In our study, most systems maintained stable nitrification with minimal ammonia levels. However, when fish were introduced, decoupled systems experienced a brief ammonia spike due to increased organic load and insufficient nitrifier abundance. In contrast, coupled systems benefited from the higher organic load, boosting nitrification and nitrate levels, while decoupled systems saw a decrease in nitrate levels due to the dilution effect.

Algae-coupled systems outperformed bacteria-coupled systems in terms of achieving the highest fish growth, confirming the findings of prior research that even a small amount of algae in fish diets can enhance both fish growth and nutritional value. Furthermore, despite lower nitrate levels in algae-coupled systems compared to bacteria-only coupled systems, they obtained superior tomato biomass production. This may suggest that in algae-coupled systems, plants were able to absorb nitrate efficiently even though a lower amount of nitrate was available.

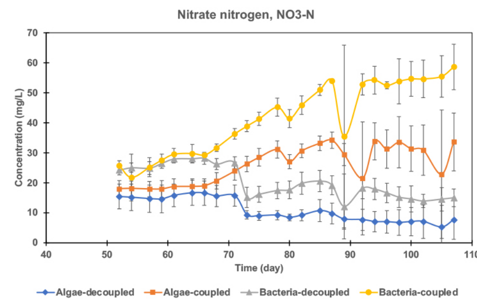

Figure 1. Nitrogen concentration as nitrate during the initial fifty days following fish stocking among four treatments including a) bacteria-coupled, b) algae-coupled, c) bacteria-decoupled, d) algae-decoupled

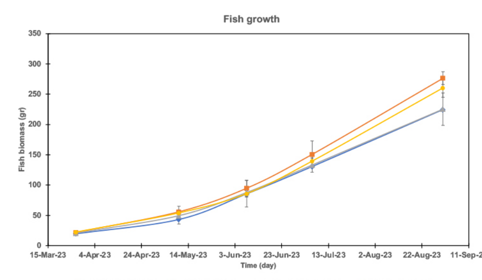

Figure 2. Fish growth among four treatments over a five-month period: a) bacteria-coupled, b) algae-coupled, c) bacteria-decoupled, d) algae-decoupled

ADVANCING AQUACULTURE THROUGH PUBLIC AQUARIUM COLLABORATION AND INNOVATION

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This project aims to increase the knowledge base of early-stage propagation and rearing of aquaculture species by leveraging the unique resources of public aquariums. Specifically, we seek to utilize public aquariums' biological resources to foster aquaculture development. Through partnering two academic institutions with seven aquariums, the initiative focuses on developing and expanding broodstock systems for marine finfish species at public aquariums, many of commercial interest.

Our approach includes engaging aquariums in the collection of eggs from species spawning in their exhibits, thereby aiding in the expansion of dedicated broodstock systems. An important aspect of the project is enhancing the understanding of egg quality from eggs spawned on exhibit or in broodstock systems. By facilitating access to known spawning individuals and eggs, the project aims to jumpstart the development of new species for aquaculture.

This initiative highlights the potential of public aquariums as catalysts for aquaculture innovation. AZA has recently established a cooperative network for larval rearing and broodstock development. This project underscores the importance of collaborative efforts in bridging the gap between conservation-oriented research and commercial aquaculture applications, positioning public aquariums to help drive innovations in aquaculture species and contribute knowledge to new food fish culture species.

In this presentation, we will discuss how the cooperative model has been developed for Association of Zoos and Aquariums (AZA) member aquariums. This innovative model represents a significant shift in how public aquariums contribute to aquaculture, emphasizing collaborative breeding and rearing of marine species. We will explore the potential of public aquariums in developing new species for aquaculture, detailing how their unique environments and resources can be harnessed for sustainable aquaculture. Our work showcases the transformational role of public aquariums in advancing aquaculture.

CRACKING THE CODE: DEVELOPING AN OPEN-SOURCE EGG IDENTIFICATION CATALOG FOR PUBLIC AQUARIUM AQUACULTURE

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Public aquariums offer an immense biodiversity in their living exbibits. A critical aspect of accessing the aquaculture potential of living marine collections has been the challenge of identification fish eggs from multispecies exhibits, particularly those from broadcast spawners. This presentation highlights the development and application of an innovative solution to this issue: an Open-Source Marine Fish Egg Catalog.

Initially spearheaded by Roger Williams University and the New England Aquarium in 2010, this project leverages DNA barcoding and photo-documentation techniques to create a comprehensive catalog of marine fish eggs. This initiative gained momentum in 2021 with the support of an Association of Zoos and Aquariums (AZA) Conservation grant.

The process involves collecting, photo-documenting, and DNA barcoding eggs from marine fishes spawning in aquarium habitats. This approach has proved invaluable in environments where collecting fertilized eggs yields a high volume of specimens from various species, posing significant challenges in species identification and resource allocation for rearing. The DNA barcoding provides precise species identification linked with individual egg photos, facilitating the collection of morphometric data. To date, we have collected, photographed, and sequenced the DNA barcode gene (COI) of 238 fertilized fish egg samples, leading to the identification of 39 species across 13 families represented in the catalog.

This catalog serves as a vital resource for aquarium aquaculture professionals, enhancing our ability to strategically select and prioritize fish species for research and conservation efforts. The presentation will cover the tools and techniques employed in building this catalog, the practical applications of this open-sourced resource, and its implications for advancing our understanding and conservation of marine biodiversity.

BALANCING ACT: THE IMPACT OF TRADE POLICY ON AQUACULTURE, BIODIVERSITY, AND CONSERVATION

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The marine aquarium trade is a global industry that links exporting and importing countries through a complex network of suppliers and buyers. Annually, about 20-30 million specimens are traded across international boundaries, encompassing around 2000 marine fish species, 544 Scleractinia coral species, and approximately 500 non-coral invertebrate species. A species of particular concern within the trade is the Banggai cardinalfish (*Pterapogon kauderni*), listed under the Endangered Species Act (ESA). Recent policy developments, such as NOAA's proposed 4d rules, threaten to impose stringent restrictions on the import and export of aquacultured fishes, affecting both source and non-source countries.

The global supply of these marine organisms is heavily influenced by socioeconomic and environmental factors, including market access, compliance with CITES quotas, country-specific regulations, and consumer demand. The trade in corals has been traditionally dominated by 10 to 15 exporting countries, with Indonesia, Australia, and Pacific Island nations exporting the greatest volume. Yet the likely increase in highly restrictive export rules and import restrictions through the ESA poses a significant challenge to sustainable trade: policymakers risk shifting aquaculture practices away from biodiverse-rich source countries, whose biodiversity has supported the growth of a billion-dollar industry, to importing nations. This shift potentially contravenes international biodiversity conventions by reducing the biological stewardship and conservation incentives in source countries.

Shifting aquaculture activities risks losing biodiversity management and local conservation efforts. This presentation will discuss maintaining a balance in policy to support biodiversity conservation, illustrated through case studies on the Banggai cardinalfish and Scleractinia coral trade, highlighting the impacts of restrictive policies on ecosystems and economies.

Advances in aquaculture technology are crucial for sustainable practices, yet their effectiveness depends on policies that consider global trade dynamics and the role of source countries in biodiversity. The talk will emphasize policies that integrate environmental protection with sustainable aquaculture and biodiversity conservation. We'll conclude with policy recommendations to support the marine aquarium trade and global biodiversity, focusing on source countries' roles in conservation.

CONTINUED DEVELOPMENT OF INNOVATIVE HATCHERY TECHNOLOGY FOR BLACK GROUER *Mycteroperca bonaci* INCLUDING INTEGRATED MULTI-TOPHIC AQUACULTURE (IMTA) WITH OYSTERS *Crassostrea virginica* AND SEAWEED *Asparagopsis taxiformis*

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Commercial landings of the black grouper (*Mycteroperca bonaci*) from the southwestern Atlantic and Caribbean waters have declined by as much as 94% since 1990 (Figure 1). However, the species remains economically important in the region and in high demand both commercially and recreationally. Therefore, the development of aquaculture technology for this species is important, not only to reduce fishing pressure and supply the seafood demand, but also to potentially contribute to wild stock populations through stock enhancement. Therefore, with support from GSMFC in February 2020, the College of the Florida Keys started the pioneering process of domestication of *M. bonaci* using innovative technology and strategies intended to reduce complications often associated with broodstock collection and maturation for this taxon.

More recently, the project has explored the incorporation of integrated multi-trophic aquaculture (IMTA) using bivalves and seaweed to stabilize water quality in the grouper recirculating aquaculture systems and reduce the labor associated with frequent water quality monitoring and water changes. The focus of this presentation is to provide an update on the progress towards these goals and objectives.

EFFECTIVENESS OF PREDATORY *Halobacteriovorax* BACTERIA TO ATTACK AND KILL HUMAN PATHOGENIC STRAINS OF *Vibrio parahaemolyticus*

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Halobacteriovorax (*HBx*) are Gram-negative predatory bacteria that invade and kill other Gram-negative marine-associated bacteria. We showed broad specificity of four *HBx* strains toward 23 well-characterized strains of human pathogenic *V. parahaemolyticus* (*Vp*). Host specificity was not affected by *Vp* sequence type or serotype, the presence of *Vp* hemolysins (*tdh* and/or *trh*), or the geographic locations from which the vibrios or the *HBx* were obtained. Two of the more rapidly growing *HBx* were selected for use as potential treatments to reduce *Vp* in naturally contaminated market oysters obtained from a commercial harvesting site in the Delaware Bay.

The 23 strains of clinically-derived *Vp* were kindly provided by the US FDA and represented strains obtained from Atlantic, Pacific, Gulf, and Hawaiian coasts of the US. Two of the *HBx* strains were isolated from the Atlantic coast. The others were from the Gulf of Mexico and the Hawaiian coast. Host specificity assays of the four strains were performed in each of the 23 *Vp* strains using a double agar plaque assay technique. Plates were incubated at 26°C for up to 7 days and plaque presence or absence was evaluated as well as plaque sizes. The *Vp* strains consisted of 6 different sequence types (ST) including pandemic strains ST3 and ST36, as well as 12 *Vp* serotypes. Strains were also selected based on the presence or absence of the well-known *Vp* hemolysins *tdh* and/or *trh*.

Results showed that all four *HBx* predated upon at least 21 of the 23 strains of *Vp* with a mixture of *HBx* strains H4 and G3 capable of infecting and killing all 23 *Vp* strains. *HBx* strains originally isolated from the Atlantic, Gulf, and Hawaiian coasts were capable of killing *Vp* obtained from distant locations. *HBx* also attacked most of the *Vp* without regard to hemolysin presence or

absence. *HBx* strains H4 and G3 produced the largest plaques, suggesting faster growth or infection rates, therefore, they were selected as potential biocontrol agents to reduce *Vp* levels in market oysters.

Over the summer, tank studies on naturally contaminated oysters were performed to compare the levels of *Vp* present in the gills and digestive tissues of *HBx*-treated and untreated (negative control) oysters over a 3-day period. Results were inconclusive due to the presence of other *Vp* predators present at higher-than-expected levels in the oysters. These included bacteriophages, high levels of suspected *Pseudoalteromonas* spp., and some background levels of *HBx.* 16S rRNA sequencing is underway to identify these predators. Studies on oysters are continuing.

FIGURE 1. Micrograph of small *HBx* attacking larger *Vp*

IT'S NOT THE SIZE THAT MATTERS: STOCKING LARGER CHANNEL CATFISH *Ictalurus punctatus* FINGERLINGS DOES NOT PROTECT AGAINST PROLIFERATIVE GILL DISEASE

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Proliferative gill disease (PGD) is the leading parasitic disease in US catfish aquaculture. The causative agent, *Henneguya ictaluri*, is a myxozoan that most commonly infects fingerling sized catfish and can have devastating impacts on the industry at multiple levels. Management of PGD primarily includes selectively stocking low-risk ponds, based on a species-specific molecular assay performed on pond water samples. This study aimed to evaluate the potential of stocking larger fingerlings to improve survival while also investigating the influence of parasite burden and fish size on three metrics of gill condition. Two industry-relevant sizes of fingerlings (small: ~12 cm, large: ~20 cm) were stocked into 19 cages located in ponds with known PGD outbreaks. After one week, the fish were removed from the ponds. Water samples were also collected at stocking and removal. At time of removal, mortalities were recorded, and all survivors were euthanized for gill collection. Gill wet mounts were evaluated for percent gill damage, number of lesions, and number of presporogonic plasmodia. There was no significant difference in mortality rates between the large and small fingerlings. Generalized linear regression showed no interaction between parasite burden in the pond water or gill tissues and fingerling size. In all regressions, only parasite burden in the pond water or gill tissues was a significant predictor of any gill condition metrics. Results from this study suggest that stocking of larger fingerlings provides no appreciable protection from PGD mortality or sub-lethal gill damage.

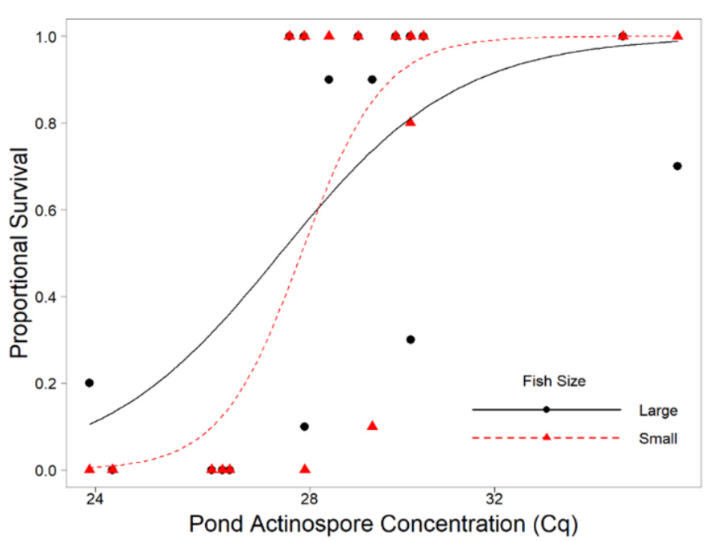

Figure 1. Dose-response curve of fish survival based on pond water parasite burden (qPCR Cq) and two sizes of fingerlings.

NOVEL WAVE ENERGY CONVERTER FOR OFFSHORE AQUACULTURE

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Current offshore aquaculture systems rely on diesel generators to supply the bulk of the power necessary for feed barges, pumps, monitoring sensors, communications, and aeration systems. These generators are detrimental to the ocean environment and local marine life due to noise pollution, carbon emissions, and potential for fuel spills. Fuel, generator leasing, and maintenance also represent a significant portion of the operating costs of offshore farms. Restrictions on unattended generators have also presented complications for permitting efforts within U.S. waters.

Offshore aquaculture stakeholders have begun preliminary investigations into the use of marine renewable energy but have not identified the optimal solution. Recent advancements in aquaculture technology, specifically floating and submersible fish pens, have allowed these systems to be placed in deeper water with more potential wave action, leading to an opportunity for co-deployment with ocean renewable energy.

To address these needs, Triton Systems, Inc. (TSI) is developing a Wave Energy Converter (WEC) to provide supplemental power to offshore aquaculture systems. The TSI WEC (Figure 1) is a self-contained floating buoy that interfaces with aquaculture farm components through a proprietary compliant tether to transmit power and data between systems. This structural tether allows the WEC to leverage the farm's existing mooring system, removing the need for an independent anchoring system and simplifying or eliminating the need for additional permits.

Triton and its partners are currently conducting outreach with stakeholders within the global and domestic US aquaculture markets to understand the energy requirements of typical offshore aquauculture installations. The results from this outreach will be used to develop an intitial WEC system design, which will then be evaluted through stakeholder review, laboratory testing, and open-water deployments in relevant environments.

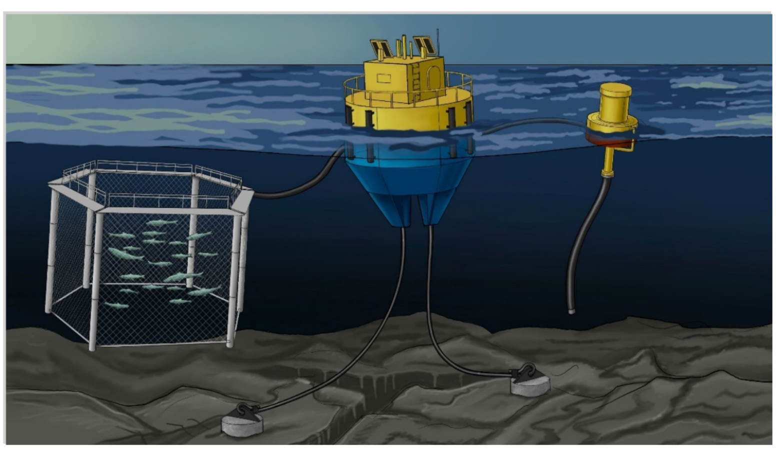

FIGURE 1: Offshore aquaculture installation with submerged fish pen (left), feed barge (middle), and TSI WEC (right)

USING AQUACULTURE TO ADDRESS A FOOD SECURITY MULTIDISCIPLINARY COLLABORATION MODEL

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Food security challenges require comprehensive solutions, and it makes sense to work in multidisciplinary collaborative teams. This is easier said than done. Bringing together engineers, biologists, and entrepreneurs to work efficiently on the same problem can be challenging due to different idiosyncrasies, communication styles, and disciplinary perspectives. In this paper, the coauthors share their road to collaboration. Dr. Rampersad, expert on food security, Dr. Robles, expert entrepreneurs, and Dr. Vargas, expert in product innovation now have an efficient collaboration system where students from different disciplines work seamlessly on the same challenges, in this case aquaculture, but the origins of this collaboration were trying.

At the beginning, 6 years ago, the faculty team decided to collaborate, soon they faced multiple challenges, ranging from differences in technical language, having unrealistic expectations, communication gaps, and lack of understanding other's roles, among others. In this paper we recount these challenges, problems generated, and how these were addressed (and not necessarily solved!). This paper can serve as a practical guide for others to solve (or more accurately, improve) some of their multidisciplinary collaboration challenges. It can also serve as inspiration to readers feeling frustrated with their collaborations. The coauthors team has not solved all of their problems and issues; everyday they face new ones, but they have found principles by which to address any upcoming situation, and it all starts with respect and acknowledgement of the other.

As defined by Thomas Aquinas, nothing moves without motivation, and the coauthors motivation has been that the food security challenges (e.g. oyster farming, prawns farming among other projects), demand a sustainable and comprehensive solution with team of experts in different areas ideally working together. The coauthors realized that each challenge is one problem, and hence, required one team, hence, the mantra of their collaboration has been "we are one team".

Fig1. Engineers, Researchers and Potential Oyster Farmer doing field work in the Lower Laguna Madre

EXAMINING THE POTENTIAL BENEFITS OF RAS AQUACULTURE FOR US PRODUCTION

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Between 1990 and 2021 annual global aquaculture production increased 629% reaching 126 million metric tons (including edible plants) in 2021. Asia, and particularly China, has dominated world aquaculture production, accounting for roughly 91.5% of total global production in 2021 with China alone accounting for 57.8% of global production. Production growth rates for North America and Europe have lagged the rest of the world since the 1950s and led to large decreases in share of global production for these continents. In 1950, Europe and North America were both major participants in global aquaculture production and accounted for 34.9% and 10.1% of production by quantity, respectively, by 2021, those shares had decreased to 2.85% and 0.86% of production by quantity, respectively (FAO, 2023).

Generally, developed countries have not participated in the Blue Revolution with a few exceptions. The United States is a prime example of a developed country that was once at the forefront of aquaculture production and now functions mainly as a consumer with regards to the Blue Revolution. In 1970 the United States (US) was the world's third largest aquaculture producer by quantity, in 2021 it was only the World's 19^{th} largest producer (FAO, 2023). Restrictive and costly regulations (Abate et al., 2016; Boldt et al., 2022; Engle et al., 2019; Engle and Stone, 2013; Guillen et al., 2019; Knapp and Rubino, 2016; Nielsen, 2011, Van Senten et al., 2018;), higher labor costs and limited access to labor (Bostock et al., 2016; Engle et al., 2019; Iversen et al., 2020), and negative perceptions of aquaculture (Froehlich et al., 2017; Papacek, 2018; Knapp and Rubino, 2016) have all been identified as potential reasons for the lack of aquaculture growth in the US and other developed countries.

The trend of the Blue Revolution occurring almost exclusively in developing countries combined with stringent regulations and other impediments to aquaculture production growth in developed countries raises the question: Is there a path for the US and other developed nations to grow large-scale domestic aquaculture industries, or will they continue to function mainly as consumers in the Blue Revolution with limited production? This paper discusses the potential for the US to grow its aquaculture industry through RAS-based production. We examine how RAS-based production has the potential to avoid several impediments to aquaculture growth in the US that have plagued other production strategies and benefits available to growers provided by the high level of production control associated with RAS. Additionally, we will show how RAS-based aquaculture could allow the US to benefit from its competitive advantage in capital and knowledge-intensive industries.

DEVELOPMENT OF A REGION-SCALE SHELLFISH HARVEST NUTRIENT CALCULATOR

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Bivalve shellfish aquaculture can provide a variety of ecosystem services beyond food production. Shellfish assimilate nutrients into their tissue and shell, and these nutrients are removed from a waterbody when animals are harvested. In some coastal environments where excess nutrients are causing water quality problems, this service provided by shellfish farms has been formally incorporated into nutrient management programs, and in a few cases farmers have even received payments for nutrient removal services.

Resource managers and industry members have indicated a need for a simple tool, backed by robust science, to predict nutrient removal by harvest of cultivated shellfish. We have synthesized available literature for eastern oyster farms across the US Northeast region (North Carolina to Maine), and applied methodology used by the Chesapeake Bay Program to calculate nutrient removal at harvest. Variability in oyster tissue and shell nutrient content was low, and an assessment of farm location, ploidy, and cultivation practice (with vs. without gear) suggested that a single average value could reasonably be applied across all farms. Evaluation of variation in animal size and weight across these same factors is ongoing and will determine the number of farm input factors needed in the final tool. The harvest nutrient calculator tool will be freely available online, and a preview of the tool will be provided in this presentation. Data gaps will be identified, and data needs for the creation of similar tools for other species and other regions will be discussed.

NEW JERSEY SHELLFISH AQUACULTURE EXCHANGE — A CROSS-CUTTING APPROACH TO HABITAT RESTORATION AND RESILIENCY

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The COVID-19 pandemic had an unprecedented impact on economies around the world and severely disrupted food supply chains. Relying heavily on sales to restaurants, New Jersey oyster farmers were particularly hard hit, reporting lost sales exceeding 90% in the second quarter of 2020. Farmers were forced to pivot to direct sale opportunities. In addition to the direct loss of revenues, the lost sales led to crop management challenges as oysters destined for spring markets remained on farms, out growing premium market size, taking up limited farm space and precluding gear cycling. While no longer suitable for prime markets, the large oysters were ideal for habitat restoration purposes. A program was developed to purchase these unsold oysters for habitat restoration. Seventy-six thousand farm raised oysters were purchased and planted on four New Jersey oyster enhancement areas in fall 2020 and a model shellfish exchange program fostering the direct planting of farm-raised oysters was developed. The model shellfish exchange program paved the way for subsequent restoration efforts employing farm-raised oysters and provided ecological and economic uplift. A secondary project objective was the development of a directory of New Jersey shellfish farms designed to connect consumers to New Jersey shellfish farms and their products and educate them about the methods and benefits of shellfish aquaculture. Both efforts supported market diversification of shellfish farm businesses, not only better enabling farms to weather the COVID-19 "storm", but also creating a path supporting long-term resilience and sustainability of New Jersey's shellfish aquaculture sector.

DEVELOPING A STREAMLINED SPME METHOD FOR ANALYSIS OF OFF-FLAVOR COMPOUNDS IN FISH TISSUE USING FARM RAISED TILAPIA

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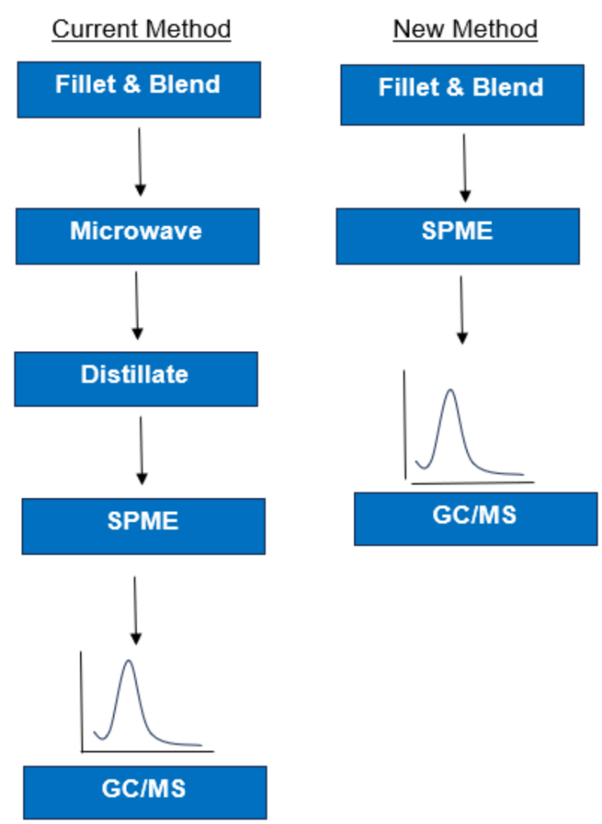
Geosmin and 2-methylisoborneol are naturally occurring compounds that are often responsible for the off-flavor in fish. These compounds, while not causing adverse health effects, still create a musty taste in fish which leads to customer dissatisfaction and distrust in the aquaculture industry. The current method for extracting these compounds from fish involves microwave distillation and then SPME using GC/MS. Microwave distillation does come with challenges as the lack of uniformity of heat can lead to reproducibility issues. There are also scaling issues and potential safety hazards with microwave distillation. Thus, the focus in the development of alternative extraction methods was to remove microwave distillate ion from consideration.

To eliminate microwave distillation in the extraction procedure several solvents were tested, and organic solvents were promising in extracting 2-methylisoborneol and inorganic solvents were adequate in extracting Geosmin. Other factors that were considered were different extraction parameters that affect semi-volatile compounds including temperature and length of time in which the sample was exposed to the fiber.

A main challenge has been to obtain sufficient recovery without co-eluting interfering compounds or destroying the compound of interest. 5 mg/kg to 200 mg/kg range of samples were tested for 2-methylisoborneol with acceptable recoveries.

This is currently a work in progress with the method development but are confident that microwave distillation will not be required in extraction of these off-flavor compounds in fish tissue.

TABLE 1. Broad overview comparison of the steps of the current fish tissue extraction method with the new proposed method.



MORPHOMETRIC AND MERISTIC VARIATION OF CICHLIDS IN ZOBE RESERVOIR, KATSINA STATE, NIGERIA

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Morphomeristic methods are ancient methods of fish taxonomy and is still in use globally. Tilapia are diverse species with high similarities that needs proper identification, hence, the needs for detailed analysis of morpho-meristics traits. This study investigates the similarities and differences among the Cichlids species in Zobe reservoir using morphometric characteristics and meristic counts. A total of 100 fish samples that belongs to the Cichlidae family were obtained from Zobe reservoir and identified using field guide. Out of the fish collected, 72 were used for the morphomeristic analysis (18 per species identified) using 24 morphometric characteristics and 6 meristic counts. Morphometric and meristic data were normalized and analyzed using Principal Component Analysis and Canonical Discriminant Analysis with PAST Software. Four species, *Oreochromis niloticus, Oreochromis mossambicus, Coptodon zilli* and *Sarotherodon galilaeus* belonging to three genera were identified in the study area. The Principal Component Analysis (PCA) resolved 3 components which accounted for 83.32% of the total between species variation but still showed high level of overlaps among the species. The overlap was for *Oreochromis niloticus, Oreochromis mossambicus* and *Sarotherodon galilaeus*. 1st and 2nd Canonical Discriminant Analysis (CDA) accounts for 92.34 % and 95.0% in morphometric and meristic counts of among-group total variability respectively. The Discriminant analysis for morphometric data showed partial speciation and overlaps between the species, while meristic counts revealed complete speciation in gill rakers, lateral line scales, number of dorsal and anal rays. Morphomeristic identification of cichlids should be based on meristic counts especially gill rakers, lateral line scale, dorsal and anal rays. Therefore, field guide with meristic counts should be always employed.

Table 1: Discriminant Function Coefficient of Variables from Morphometric parameters

Variables	Function 1	Function 2	Function 3
SL	0.057	0.124	0.087
BD	**0.707**	-0.238	0.159
HL	0.516	-2.754	**1.079**
SnL	-12.551	**81.28**	-13.356
ED	-13.762	**71.331**	-17.484
PrOb	**13.997**	-79.409	13.142
AFL	0.305	**0.631**	0.586
PvFL	-0.116	-0.243	-0.096
PFL	**1.547**	-3.1329	-0.969
DFL	-0.6633	**2.1467**	1.5685
CPL	-4.2817	-0.953	-2.341
CPD	-1.168	0.049	-1.489
PDL	0.203	1.358	**1.558**
PAL	-1.2664	0.441	-0.967
LLW	**4.632**	-2.586	1.136
LJW	**3.840**	-0.421	1.212
CD	-6.956	1.401	**2.537**
LLL	0.762	**2.229**	-1.902
ULL	**1.799**	-3.085	0.263
PSL	3.841	**5.068**	4.472
LDS	-5.631	-1.235	-1.876
TAS	-4.535	-4.589	-1.061
Eigenvalue	24.46	9.24	2.77
% Variance	67.18	25.36	7.46

Table 2: Discriminant Function Coefficient of Variables from Meristic counts.

Variables	Function 1	Function 2	Function 3
DS	-1.275	-1.647	-1.603
DR	**0.796**	-0.208	0.119
AS	0	0	0
AR	**2.827**	1.708	0.415
LLS	-0.393	0.164	**0.453**
GR	0.0127	**0.209**	0.0216
Eigenvalue	13.55	7.32	1.07
% Variance	61.75	33.35	4.89

DIETARY INCLUSION OF YUCCA EXTRACT AND BACILLUS SUBTILIS; A WAY TO MODULATE AMMONIA DISCHARGE, GROWTH PERFORMANCE, IMMUNITY AND CYTOKINES GENE EXPRESSION OF NILE TILAPIA (*Oreochromis niloticus*)

Mohamed Elsayed Salem, Doaa M. Elsisy, Sara O. Makled, Heba Mohamed Abdel-Ghany

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The Nile tilapia (*Oreochromis niloticus*) is one of the most popular species worldwide. Nevertheless, intensive aquaculture systems is the most common fish farming systems generate a high amount of ammonia, a major metabolic waste product of fish, owing to fish waste and feed residue decomposition, increased organic matter deposition at the bottom of ponds, and a shortage of dissolved oxygen. On the other hand, plant extracts *Yucca schidigera* has been proven to be a potent, cost-effective agent for controlling ammonia. The inclusion of dietary *Bacillus subtilis* stimulates the immune system, promotes growth performance, and modifies the intestinal flora. Thus, evaluating the effect of using yucca and/or Bacillus bacteria on growth performance, immune status, and water quality of cultured Nile tilapia is the main objective of the current study.

Three diets were prepared to contain 0.2 g kg^{-1} of Yucca extract (Y), 1 g kg^{-1} of *Bacillus subtilis* (B), or a combination of Yucca extract and *B. subtilis* (0.2 and 1 g kg^{-1}) (YB), and the fourth diet (control) was left without an additive (CON). Nile tilapia (*Oreochromis niloticus*) fingerlings (13.54±0.32 g) were fed the test diets for 65 days.

As for the un-ionized ammonia (NH_3), CON gave a significantly higher value than the rest of the treatments; YB yields the lowest value of all. The highest growth performance and feed utilization were observed in the B treatment, followed by the YB treatment, while the control and Y treatments gave lower results. PA; PO; RB and ACH50 were showed the highest levels for YB-treatment with significant differences from the rest treatments; the lowest level was obtained for control (Table 2). LSZ lowest value was reported for YB-treatment which differs significantly from other treatments; the lowest value was for the control. The highest activity of SOD, GPx and GH were observed for YB- treatment, while the lowest activity was for the control (Table 1). Control showed the highest MDA result while the lowest result was reported for YB-treatment. The highest activity of Il-8 and Il-1 cytokines activity were observed for B-treatment followed by YB- treatment and control which possess the lowest activity. YB-treatment gave the maximum mean value of Tnf cytokine followed by B-treatment Salem 490 REV

Table 1. Effect of the experimental diets on the antioxidant parameters of Nile tilapia

	CON	Y	B	YB
MDA (U mg^{-1})	4.07±0.15^a	3.27±0.15^b	2.40±0.10^c	1.03±0.15^d
SOD (U mg^{-1})	16.63±0.55^c	24.17± 0.25^b	25.30± 0.66^b	31.63±1.19^a
GPx (μmol mg^{-1})	0.230± 0.03^c	0.33±0.02^c	0.63±0.06^b	1.77±0.15^a
GSH	0.184±0.001^d	0.333±0.001^c	0.764±0.002^b	1.823±0.002^a
TAC	0.25±0.04^d	0.60±0.10^c	1.33±0.15^b	2.27±0.14^a

Data are presented as mean values ± standard deviation of the mean. Data in the same row with different superscripts significantly differ ($P < 0.05$). malondialdehyde (MDA) superoxide dismutase (SOD), glutathione peroxidase (GPx) reduced glutathione (GSH), total antioxidant capacity (TAC).

Table 2. Effect of the experimental diets on the immunological parameters of Nile

	CON	Y	B	YB
PA	3.93±0.47^d	6.67±0.59^c	9.60±0.36^b	12.27±0.25^a
PO	0.67±0.15^d	2.10±0.26^c	2.7667±0.15^b	3.93±0.35^a
RB	4.10±0.36^d	4.77± 0.15^c	5.53±0.15^b	7.77±0.21^a
ACH50	34.40±0.62^d	37.60±0.35^c	42.83±0.21^b	45.33±0.58^a
LSZ	82.67±1.53^d	87.00±1.00^c	114.67±2.08^a	95.00±1.00^b

Data are presented as mean values ± standard deviation of the mean. Data in the same row with different superscripts significantly differ ($P < 0.05$). Respiratory burst (RB), Phagocytic activity (PA), Alternative complement activity (ACH50), Lysozyme (LSZ).

Table 3. Effect of the experimental diets on cytokines

	CON	Y	B	YB
Il-8	1.20± 0.17^c	6.43± 0.05^b	8.23± 0.21^a	7.93± 0.15^a
Il-1	1.17± 0.15^d	2.85± 0.05^c	4.58± 0.07^a	3.14± 0.05^b
TNF	0.53±0.03^c	2.67±0.15^b	3.48±0.030^a	3.69±0.09^a

Data are presented as mean values ± standard deviation of the mean. Data in the same row with different superscripts significantly differ ($P < 0.05$). Interleukin 8 (IL-8), Interleukin 1 (IL-1), and tumour necrosis factor (TNF).

SCREENING OF POTENTIAL PATHOGENIC AND PROBIOTIC BACTERIA FROM BIVALVE SHELLFISHES

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Disease control is critical for effective hatchery production of bivalve shellfish. Bacterial infections, particularly those associated with *Vibrio* and *Aeromonas*, cause rapid larval mortality, with severe consequences for hatcheries and farmers who rely on them. This study aims to screen and identify potentially pathogenic and probiotic bacteria in bivalve shellfish facilities.

A total of 122 bacterial isolates from water, algae, and larval samples were identified using 16S rRNA sequencing and screened for their antimicrobial activity against shellfish pathogens, hemolytic activity, and biofilm formation. Among the 20 genera identified, *Vibrio* (34%), *Pseudoalteromonas* (23%), and *Alteromonas* (18%) are the most abundant.

The pathogenicity of the selected potential pathogenic and probiotic isolates was tested with oysters and clam larvae, and adult oyster hemocytes. Results showed that potential probiotic isolates are generally safe while some potential pathogens (Clam15, DEN12, CH1, CH7, CH3, CH30, CH4, CH6) showed host-specific pathogenicity to either clam or oyster larvae. Results from the high-throughput screening assay using oyster hemocytes were concordant with the results of the more labor-intensive larval assays. Further work is being done to optimize the high-throughput screening pipeline.

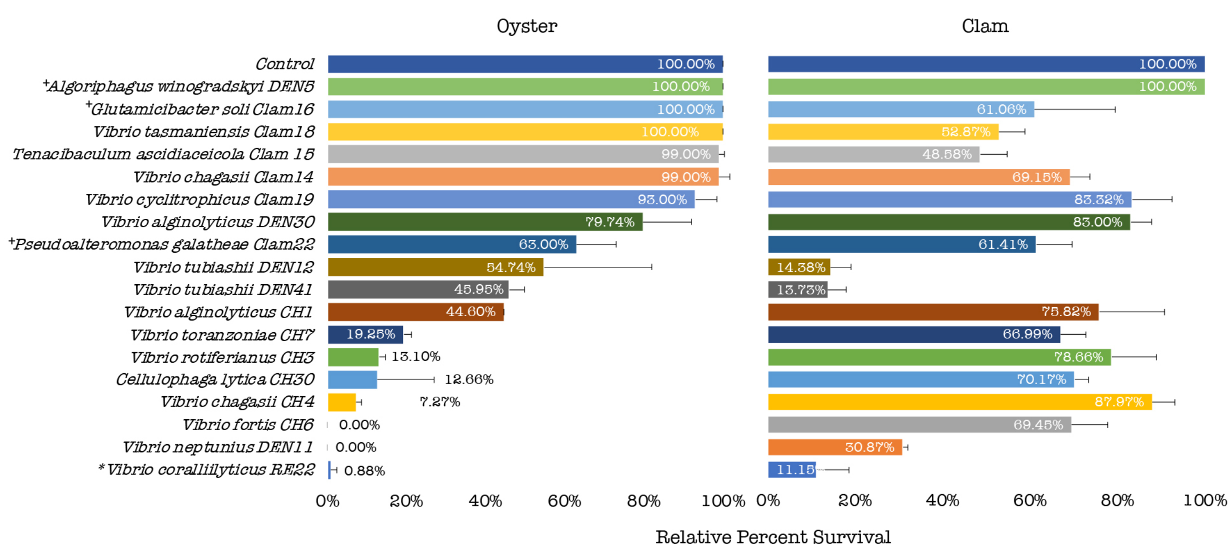

FIGURE 1. Relative percent survival of oyster and clam larvae after 15-28 h exposure to selected potential pathogenic and probiotic isolates at 10^5 CFU/mL. +Potential probiotic isolates; *Pathogen (Control).

Note: 50% mortality threshold was used to identify isolates with larval-killing potential.

THE EFFECTS OF LOW DISSOLVED OXYGEN IN GREENWATER SYSTEMS OF THE PACIFIC WHITE SHRIMP *Litopenaeus vannamei*

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Low dissolved oxygen concentrations are often considered as a factor influencing the performance of *Litopenaeus vannamei* in aquaculture. Different studies with dissolved oxygen as a primary limiting factor, have indicated this is a stressor factor that can influence growth, tail flip speed, immune response, metabolic rates, and gene expression, but most research has been conducted in long period of hypoxia settings using water mixed with gaseous nitrogen and sodium sulfite to preserve hypoxia level. Hence, there is a gap in our understanding of its effect in natural diurnal cycles and its impacts under natural production environments. Therefore, this study aimed to create low dissolved oxygen conditions in a green water system and its effect on survival rate, growth performance, apparent net protein retention, and metabolic enzymes in hemolymph. Additionally, tissues of gill and hepatopancreas were collected to search for inflammatory gene expression. Two trials were conducted at Claude Peteet Mariculture Center in Gulf Shores, AL. The first trial consisted of three levels of air supply (Low= 0.25, medium =0.35, high= 0.7 cubic feet per second (cfs)). It was set up with 12 tanks (750L) stocked at 35 shrimp/m^2 and initial weight (1.99 ± 0.06g) maintaining an equal flow rate. The second trial consisted of two levels of aeration (Low= 0.25 and high= 0.7cfs) stocked at 30 shrimp/m^2 and initial weight (4.30 ± 0.24g). Feed inputs were estimated with expected growth of 2 g week^{-1} for the first trial and 3 g week^{-1} for the second trial. Results showed that hypoxia environments were achieved in green water, constraining aeration levels (Figure 1). The levels of metabolic enzymes of the hemolymph, such as Alanine aminotransferase and Alkaline phosphatase, were not significantly different among treatments in the first trial. Moreover, low dissolved oxygen concentration happened more frequently in higher biomass conditions, resulting in an increment 9% of low dissolved oxygen occurrences in the second trial, significantly affecting survival (P=0.003) and growth (P=0.048). Therefore, growth performance is influenced by a reduction in density because of dissolved oxygen concentrations.

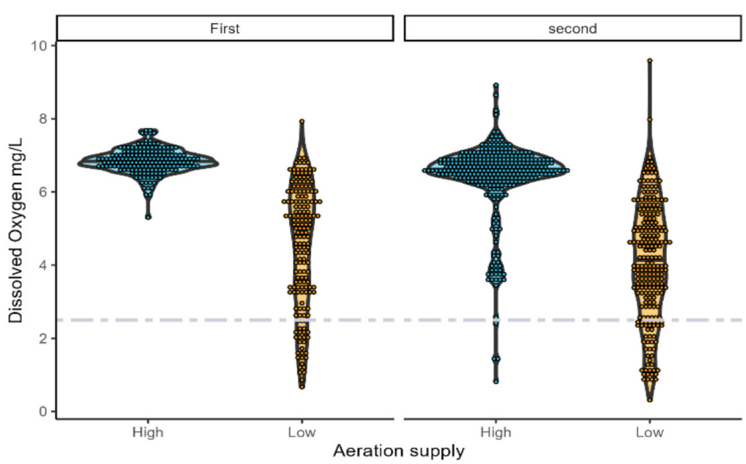

Figure 1 Average of morning readings for both trials.

'SEA'ING FURTHER' - CLOSING KNOWLEDGE GAPS AND IMPROVING SUSTAINABILITY ACROSS THE AQUACULTURE FEED SUPPLY CHAIN

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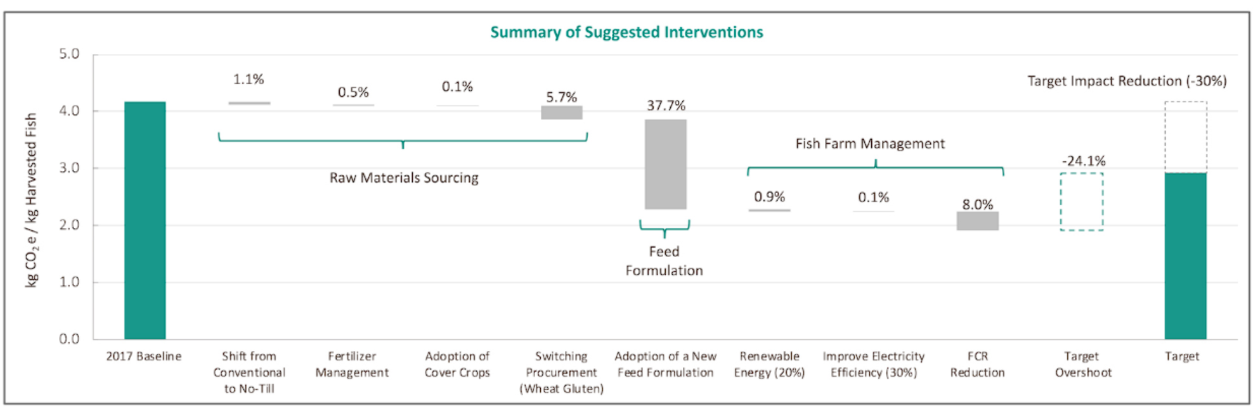
Aquafeeds are the costliest resource and biggest contributor to environmental impacts associated with aquaculture operations. As the commercial aquaculture industry expands, environmental monitoring programs and sustainability initiatives are essential to ensure social, economic, and ecological impacts are minimized. Cargill Aqua Nutrition (CQN), one of the largest global aquafeed manufacturers, has recently established the SeaFurther Sustainability program (also referred to as "the program" in this report). The program's goal is to assist their aquaculture farm customers in reducing carbon emissions along their respective aquafeed supply chains by 30% by 2030. The program utilizes Life Cycle Assessment (LCA) methodologies which have been useful in providing reliable, numerical values for carbon footprint comparisons.

The goal of this capstone project is to advance CQN's greenhouse gas mitigation efforts by implementing the program in North America via public-private collaboration. First, I obtained an understanding of the LCA methodologies behind the program and CQN North America's existing system processes on reporting. Currently, I am in the process of working with CQN North America to collect data required for LCA model calculations. This allows me to create a living database for each respective customer's supply chain. Lastly, I will create reduction roadmaps and provide insights to the program's customers on how they can lower their carbon footprint (Figure 1). Continued program development will include a landscape analysis to identify the next environmental impact category priorities among CQN North America and their customers.

Figure 1. Baseline carbon footprint and a list of potential interventions in raw material sourcing, feed formulation, and fish farm management to achieve a 30% target reduction.



PVA-MIR-11881, A NOVEL MIRNA, WITH POTENTIAL THERAPEUTIC PROPERTIES AGAINST WSSV INFECTION IN SHRIMP

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The Pacific white shrimp (*Litopenaeus vannamei*) aquaculture is particularly vulnerable to serious losses associated with the outbreak of white spot and the lack of effective treatment measures for the disease (WSD) caused by the white spot syndrome virus (WSSV). MiRNA, a class of small non-coding RNA, plays a crucial role in RNA interference in response to viral infection. However, the information about shrimp miRNAs regulating viral genes is still limited. As a result, the goal of this work is to find shrimp miRNAs that target WSSV genes and have a therapeutic impact against WSSV infection. First, we investigated miRNA expression data from our in-house RNA sequencing database of unchallenged and 24h-WSSV-challenged shrimp hemocytes and found 1,239 differentially expressed unannotated short RNAs (DEUs). Pva-small RNA-11881 was identified as a potential DEU because it is the most down-regulated DEU and the second biggest node with the most target WSSV gene connections. The sequences of Pva-pre-mir-11881, a possible precursor miRNA of the unannotated Pva-small RNA-11881, were found in the *P. vannamei* genome, confirming the presence of mature miRNA. As a result, we named it Pva-mir-11881. The potential use of Pva-mir-11881 against WSSV infection in shrimp was investigated. Pva-mir-11818 has shown the ability to knock down *WSSV004*, a critical early viral gene, and *WSSV419*, a WSSV nucleocapsid protein. Furthermore, injecting shrimp with the recombinant Pva-pre-mir-11881 resulted in a considerable knockdown of WSSV004, WSSV419, and *WSSV164* and enhanced anti-melanization activity in hemolymph. Nevertheless, injecting Pva-pre-mir-11881 with WSSV can improve cell homeostasis by modulating program cell death, such as lowering apoptosis and necrosis. When compared to the control group, introducing Pva-pre-mir-11881 can lower the WSSV copy number and increase the survival rate when infected with WSSV. In summary, Pva-mir-11881, a new shrimp miRNA, could play a significant role in WSSV gene regulation, and Pva-pre-mir-11881 might be used as an RNA therapeutic against WSSV infection in shrimp aquaculture.

PRODUCTION AND CHARACTERIZATION OF FISH VISCERA SILAGE AND ITS EVALUATION AS A FEED INGREDIENT ON THE PRODUCTIVE PERFORMANCE OF TAMBAQUI

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The objective of this study was to explore the utilization of tambaqui (*Colossoma macropomum*) viscera in silage (VS), as a novel feed ingredient, to bring additional revenue to the entire fish farming industry. Different silage processes were evaluated, and the best ingreident was the fermented silage. It was manufactured with 79.8% ground tambaqui viscera (w/w), 15% sugar cane molasses, 5% expired whole yogurt (as a source of lactic acid bacteria), and 0.25% sorbic acid as an antifungal agent. A comprehensive assessment of VS nutrient composition, fatty acid and amino acid profiles, as well as the apparent digestibility coefficients (ADC) of nutrients and energy for juvenile tambaqui, was performed to select the best silage method. Following the characterization of VS, five experimental diets were formulated with graded levels of VS inclusion (0%, 5%, 10%, 15%, and 20%) to assess the physical quality of the feed, and the production performance of tambaqui during a comparative feeding trial. Juvenile tambaqui (~22.6 g initial weight) were randomly distributed among 20 fiberglass tanks (700 L; 21 fish/tank), and fish were fed four times daily until apparent satiation for 13-week period. The silage presents 45.8% dry matter, 24% lipids, and 24% crude protein, and leucine and lysine were found in high concentrations when compared to other essential amino acids. Fish viscera silage contained levels 5.4 mg of eicosapentaenoic acid/g of lipids to 1.7 mg of docosahexaenoic acid/g of lipids. The ADC for protein, lipids, and gross energy were 88.3%, 94.5%, and 85.1%, respectively. Pellets containing higher levels of VS exhibited reduced rates of expansion and floatability. Nevertheless, fish in all experimental groups displayed similar growth, achieving a remarkable 500% increase in weight relative to their initial weight. The average apparent feed conversion rate was 1.43, the protein efficiency rate was 2.28%, and the relative growth rate reached 1.79% per day. Fish fed 20% VS showed an increase in plasma cholesterol levels; however, it remained within the range for healthy tambaqui. Incorporating viscera silage into the diets of juvenile tambaqui led to a decrease in the activity of the alanine aminotransferase enzyme, which confirms normal liver functions. The production cost of the diets averaged US$ 0.94/kg and did not significantly impact the economic efficiency indicators. Converting fish viscera into silage results in an energy-rich ingredient suitable for aquafeeds, and readily digestible by juvenile tambaqui. In conclusion, it is feasible to incorporate up to 20% of fermented viscera silage into the diets of juvenile tambaqui without adversely affecting their growth and overall health.

BLACK SOLDIER FLY LARVAE (*Hermetia illucens*) EXOSKELETON AS A POTENTIAL SOURCE OF CHITIN IN DIETS FOR CHANNEL CATFISH (*Ictalurus punctatus*)

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Chitin, a biopolymer found in the exoskeletons of black soldier fly larvae (BSFL), has demonstrated immunostimulating activity in various fish species, and may serve as a potential prebiotic to improve growth performance, gut health, and immune responses for aquaculture. Therefore, this study was conducted to assess the inclusion of chitin from the exoskeleton of BSFL, and purified chitin from shrimp, in the diets of channel catfish juveniles. The basal experimental diet was formulated to meet the nutritional requirements of channel catfish juveniles (37% crude protein and 19.7 MJ de gross energy per kg). The exoskeleton of BSFL served as a rich source of chitin (BSFL-Chitin), containing 28.9% chitin. Additionally, shrimp-extracted chitin (Pure-Chitin) also was evaluated for comparison. Both chitin sources were supplemented to the basal diet at 500 and 1000 mg/kg. The feeding trial used 1,000 channel catfish juveniles (1.82 ± 0.12 g), randomly distributed into 25 experimental units at a density of 40 fish per aquarium (110 L). The fish were fed for 60 days based on biomass (8%), which was adjusted every 5 days according to the growth rate. The recirculating aquaculture system included a biological and a mechanical filter, and water quality parameters were assessed thrice a week. The resulting data were subjected to analyzed two-way ANOVA, as a 2 × 3 factorial with 2 sources of chitin at 3 graded levels. The experimental catfish exhibited a 12-fold increase from their initial weight with a feed efficiency of ~0.86. However, the different sources and concentrations of chitin did not significantly impact production performance parameters, as fish fed all the dietary treatments exhibited similar growth. Fish fed the BSFL-Chitin 500 diet had lower viscera weights ($P<0.05$). The hepatosomatic index (1.4%), and intraperitoneal fat ratio (4.1%) were not affected by the inclusion of chitin in the diets of channel catfish. Digesta samples were collected to profile the intestinal microbiota by sequencing 16S rRNA using Illumina MiSeq. In addition, fish fed the various diets will be subjected to a bacterial challenge using *Edwarsiella ictaluri*. Blood and serum parameters are currently being evaluated.

PERSEVERANCE IN CAPTIVE REARING OF THE SONORA SUCKER *Catostomus insignis*: MANAGING FOR SURVIVAL FIRST

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Stocking is an important tool used by fisheries biologists for conservation and management, but knowledge on how to spawn and rear the desired species is essential to a stocking operation. While many fish species have existing culture techniques, there has been little success in determining the requirements for the survival and reproduction of Sonora suckers (*Catostomus insignis*) in captivity. This presentation aims to share some early challenges encountered with rearing Sonora suckers. We initially collected 49 Sonora suckers from the Salt River Project canals near Mesa, AZ in January 2023 to investigate techniques for spawning and rearing. Post collection, the fish contracted a bacterial infection, *Aeromonas hydrophilia*. Outbreaks of this bacterial infection are often related to stress. We attempted to manage stress through the improvement of several environmental factors, including flow and filtration. Additionally, the infected fish were given Oxytetracycline, an antibiotic, through medicated baths, intramuscular injections, and medicated feed. Our presentation explores the effects of environmental changes and medical interventions on the rate of mortality in Sonora suckers.

EVALUATING COMMERCIAL DIETS FOR THE PRODUCTION OF JUVENILE FRESHWATER PLAIN POKETBOOK MUSSELS *Lampsilis cardium*

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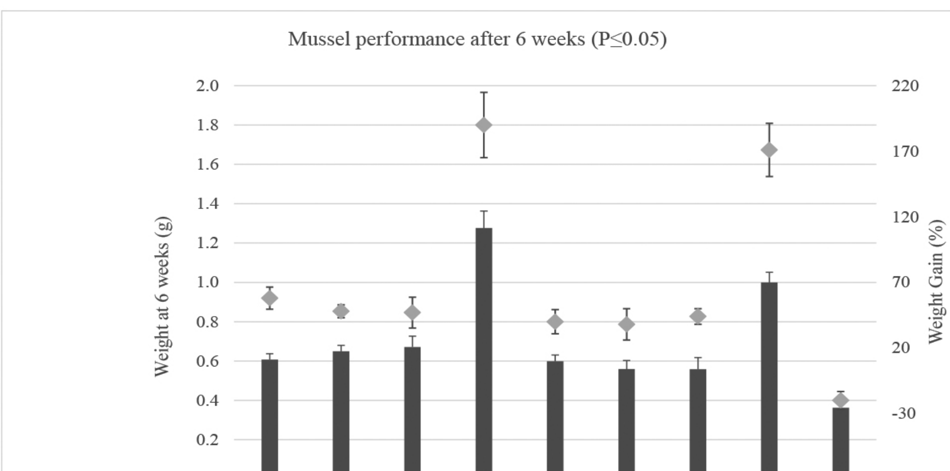
Lampsilis cardium (Rafinesque 1820) is a relatively widespread species that inhabits numerous drainages of the Mississippi, Ohio, and Missouri rivers in central North America. Freshwater mussels play a key role in ecosystems, providing several valuable services, such as water filtering, nutrient cycling, habitat provisioning and mediation of food resources, as well as improving water quality and substrate stability. The use of microalgae for freshwater mussel aquaculture has increased due to the increasing need for alternative feed sources. As dietary nutrient deposition by freshwater mussels is not well understood it is imperative to understand what their dietary nutrient requirements are for conservation efforts as well as their role in ecology of the many rivers, and streams they inhabit.

A 90-day trial is underway to examine commercial aquaculture feeds that are readily available to grow freshwater mussels in a hatchery setting and determine if additives enhance their growth and survival. The trial is being conducted in a static aquaculture system that holds 36, 9L tanks with 20 juvenile mussels per tank. The tanks are filled with 50ml of sand, halfway with bio media, and have an air stone in them for aeration. One third of the system's water flushes every 8hrs. The mussels are fed once daily one of nine treatments. Eight treatments are fed algae or algae with additives. These eight treatments are broken up between paste and freeze-dried algae, six of which have different additives including worm casings, probiotics, and live algae replacement in their formulations. The mussels are sampled for growth and length every two weeks, during this time feed rations are adjusted.

The current results (figure) indicate that treatments 4 and 8 outperformed all remaining treatments in terms of current mussel weight and weight gain (P<0.05). Updated results on production performance will be presented. Based on the current findings, one of the additives evaluated is driving the higher performance observed in treatments 4 and 8.



	T1	T2	T3	T4	T5	T6	T7	T8	Negative Control
■ Weight at 6 weeks (g)	0.608	0.65	0.671	1.276	0.599	0.56	0.559	1	0.363
◆ Weight Gain (% of initial)	58.00	48.00	47.00	190.00	40.00	38.00	44.00	171.00	-20.00

CONNECTING SEA GRANT, THE NATIONAL CENTERS FOR COASTAL OCEAN SCIENCES, AND COASTAL-OCEAN COMMUNITIES TO IMPROVE SUSTAINABLE AQUACULTURE SITING AND DEVELOPMENT PROCESSES

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As emphasis on increasing aquaculture production in the U.S. continues, it is necessary to ensure that sustainability is at the core of all efforts. Sustainable aquaculture development includes both human and environmental needs that can make planning challenging to navigate. Development is especially complex in marine ecosystems with diverse, interested parties who have varying degrees of overlapping spatial needs. The National Centers for Coastal Ocean Sciences (NCCOS) have developed resources for aquaculture farm siting and development that begin to address the complex needs of interested parties utilizing coastal-ocean spaces. The key to successful usage and continual development of the NCCOS planning resources is a science-based, community-led approach, which will ideally result in the identification of optimal locations for aquaculture development. Because many local groups overlap with aquaculture areas in coastal-ocean environments, it is important to deliberately connect and build capacity among users through conversations centered around aquaculture tools to improve sustainable aquaculture development.

Aiming to build capacity between the Sea Grant Network, NCCOS, and other coastal-ocean groups involved with aquaculture development, we are hosting six collaborative, regionally tailored workshops across the nation over the course of four years: beginning with the Mid-Atlantic (Fall 2022), Gulf of Mexico (Winter 2023), California (Fall 2023), Pacific Northwest (Summer 2024), Pacific Islands (Early Winter 2025), and New England (Spring 2025). Through this project we aim to 1) extend the engagement of NCCOS aquaculture planning resources, 2) increase connections and collaborations with diverse interested parties, and 3) advance aquaculture siting conversations more broadly with summary pathway reports citing key themes and findings after the conclusion of each workshop. After the first three workshops in the Mid-Atlantic (Fall 2022), Gulf of Mexico (Winter 2023), and California (Fall 2023), we have begun to identify differences with respect to aquaculture siting tool use and perspectives among the regions and various interested groups. Prior workshop findings will partially inform the framework of the remaining three workshops and final pathway report.

SPATIAL MODELING FOR AQUACULTURE OPPORTUNITY AREA IDENTIFICATION IN ALASKA STATE WATERS

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On June 1, 2023 NOAA announced the beginning of a process to identify Aquaculture Opportunity Areas (AOAs) in Alaska state waters focusing on sustainable invertebrates (shellfish, sea cucumber, etc.) and seaweed aquaculture. NOAA's National Centers for Coastal Ocean Science (NCCOS) is working with our federal and state partners to conduct spatial modeling in support of this effort. NCCOS employed a combination of spatial mapping approaches, scientific review, and public input gathered through a recently published Request for Information (RFI) to narrow down the study areas that will be the focus of the spatial analysis. Following study area selection, NCCOS is using best available spatial data and Indigenous Knowledge to account for key environmental, economic, social, and cultural considerations to support the identification of areas of high suitability for aquaculture within Alaska state waters. In this presentation, NCCOS will provide updates on our progress to-date to develop a spatial model to support the identification of an AOA in Alaska state waters, including continued opportunities for stakeholder input into the process.

INTEGRATING INFORMATION ON BENEFICIAL SERVICES PROVIDED BY SHELLFISH AQUACULTURE INTO THE AQUACULTURE PERMITTING AND REVIEW PROCESS

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Shellfish aquaculture operations can provide a variety of beneficial environmental services. Cultured shellfish have been increasingly incorporated into nutrient management strategies due to their ability to assimilate nutrients into their tissue and shell. Shellfish aquaculture gear also creates complex structure, and a variety of recreationally and commercially important fish species have been observed exhibiting habitat-related behaviors such as foraging, shelter seeking, and reproduction around aquaculture gear. Other environmental, economic, and social benefits associated with shellfish aquaculture have also been documented.

Despite the growing body of evidence that aquaculture can consistently provide beneficial services, the current aquaculture permitting framework largely focuses on possible adverse effects to various environmental and socioeconomic factors. Engagement with resource managers suggests this is likely because adverse effects are often easier to quantify and document than beneficial effects, and variability in aquaculture production practices can limit manager’s ability to make defensible assumptions on the types and extent of beneficial effects a proposed operation may provide. In addition, not all aspects of the current aquaculture review/permitting framework allow for, or easily lend themselves to, a synergistic evaluation of adverse and beneficial effects during the aquaculture review/permitting process.

We will discuss the results from initial outreach with resource managers to share information on existing regionally relevant research and literature related to nutrient and habitat provisioning from shellfish aquaculture and data gaps, and the existing regulatory mechanisms and the types of tools/end-products that may support greater consideration of beneficial services associated with shellfish aquaculture in the aquaculture permitting and review process.

TOWARDS SUSTAINABLE AQUAFEEDS: EVALUATING DEFATTED MICROALGAL CO-PRODUCT FOR REPLACING FISH MEAL IN AQUACULTURE DIETS FOR RAINBOW TROUT (*Oncorhynchus mykiss*)

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Globally, aquaculture is a rapidly growing food sector due to increasing demand for seafood. However, using marine-derived forage fish like anchovies and sardines for fishmeal (FM) and fish oil (FO) in aquafeeds, especially for salmonids—the most significant users—has raised sustainability concerns. These concerns have led to the exploration of sustainable alternative aquafeed ingredients. Microalgae represent a more environmentally sustainable alternative because they can be produced in large quantities on controlled nonarable land, contain high protein and long-chain fatty acid profiles, and typically do not compete with human food products. We report our recent study to develop aquaculture feed formulae using defatted co-product biomass left over after commercially raising microalga, *Nannochloropsis* sp., to produce a nutraceutical.

Data from our recent experiments show comparable growth, filet composition, feed conversion, and survival of rainbow trout fed a diet entirely replacing FM with *Nannochloropsis* sp. co-product. We first determined the nutrient digestibility of the co-product. We then conducted a 64-day nutritional feeding experiment to determine the optimal level of FM replacement for growth and filet fatty acid composition. We finally used the Cruz Aquafeed Sustainability Tool to determine the diets' economic conversion ratio (ECR; feed cost per kg of fish produced). The digestibility study showed that the raw *Nannochloropsis* sp. co-product diet had higher protein and energy values. The growth study results showed that trout fed 100% FM replacing the diet with the raw co-product did not significantly differ from fish fed the reference diet in feed conversion ratio, growth, and survival rates. The analysis of the ECR results showed no significant differences between the diets. Thus, utilizing *Nannochloropsis* sp. co-product in trout feed can completely replace FM while maintaining rainbow trout's growth performance, flesh composition, and cost viability at levels similar to the fish fed diet.

TABLE 1. Experimental Diet Set-up

Digestibility Experiment	Growth Experiment
4 replicate tanks/diet	4 replicate tanks/diet
Reference diet	Reference diet (Na 0)
Enzyme diet	*Nannochloropsis* replaces 33% of FM (N33)
Raw co-product diet	*Nannochloropsis* replaces 66% of FM (N66)
Extrusion diet	*Nannochloropsis* replaces 100% of FM (N100)

TABLE 2. Initial weight, final weight, weight gain, feed conversion ratio (FCR), specific growth rate (SGR), protein efficiency ratio (PER), and survival rate of rainbow trout fed experimental diets.

	Diet				
	N0	N33	N66	N100	*P* value
Initial weight (g)	40.94 ± 0.83	39.7 ± 0.39	40 ± 0.43	41.21 ± 1.02	0.42
Final weight (g)	117.17 ± 3.3	110.78 ± 1.42	113.29 ± 1.81	113.99 ± 1.96	0.30
Weight gain (g)	76.23 ± 2.84	71.08 ± 1.26	73.3 ± 1.72	72.77 ± 1.08	0.31
FCR	0.93 ± 0.04	1.01 ± 0.01	0.97 ± 0.02	0.98 ± 0.02	0.26
SGR	0.95 ± 0.05	0.9 ± 0.03	0.93 ± 0.04	0.88 ± 0.03	0.49
PER	2.24 ± 0.08	2.08 ± 0.03	2.08 ± 0.04	2.08 ± 0.05	0.17
%Survival rate	100	100	100	100	

LESSONS LEARNED FROM EXPERIMENTAL BIOASSAYS INVOLVING *Enterocytozoon hepatopenaei*: IMPLICATIONS IN DEVELOPING FUNCTIONAL FEEDS AND EHP RESISTANT LINES OF SHRIMP

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The microsporidian parasite *Enterocytozoon hepatopenaei* (EHP) has spread from its initial geographical origin, Thailand, to other major shrimp producing countries around the world and continues to impact the production of penaeid shrimp and other commercially important crustaceans. As the economic losses due to EHP spread continues to accrue, many aquafeed and other aquaculture companies from around the world are working on to develop preventative and therapeutic measures to contain the disease. Over the past few years, numerous EHP bioassays have been conducted in the Aquaculture Pathology Laboratory at the University of Arizona to develop therapeutics, preventative diets, and EHP-resistant *Peneus vannamei* lines. Collectively, these experiments have provided valuable insights into: (a) the challenges associated with early-stage EHP infections, (b) how EHP infections spread with low prevalence, (c) short-term effect of EHP on growth of shrimp, (d) observation time needed to gain meaningful data on the reduction in parasite load following a therapeutic treatment, as measured by PCR-based diagnosis and histopathology (e) population size, number of tanks, and the size of tanks to be considered before designing an experimental bioassay for therapeutic development, and screening of genetic lines for EHP resistance.

DEVELOPING AN AQUACULTURE LITERATE PUBLIC THROUGH YOUTH AND ADULT ENGAGEMENT

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Aquaculture producers and extension agents consider lack of consumer awareness about aquaculture a barrier to the development of the industry in the Midwest region of the United States. Though consumers may have heard the word aquaculture, according to our recent survey of aquaculture extension professionals, most can neither define it nor explain it to others. This information corroborated data from our recent survey of attendants at the Minnesota State Fair in 2022, where we learned that though most consumers surveyed did not have a negative view of aquaculture, they had little understanding of where their seafood comes from. Interestingly, these same consumers indicated that seafood origin was an important factor in their seafood choices and that they were willing to pay extra for "local" products. All of this information suggests that a critical component of supporting a sustainable aquaculture industry in the Midwest region is engagement and education around aquaculture and the potential for its products to be sustainable, healthy, and to benefit local economies. Consequently, a goal of a number of our aquaculture focused projects are to engage youth and adults in age appropriate, effective, and science based interventions about aquaculture to develop consumers who can make informed decisions at the seafood counter.

To help address our goal, we have completed a review of currently available aquaculture resources through both a comprehensive assessment of web material and a survey to aquaculture extension professionals. We are in the process of compiling this material and designing a web interface to provide these resources to aquaculture interested communities. Based on our comprehensive review, we are designing and delivering age appropriate, engaging, youth and adult material aimed at creating more aquaculture literature consumers. Through a collaboration with Spark-Y, a nonprofit youth focused organization in Minneapolis, we have developed a cooking demo and lesson plan, seafood cookbook, and fish filet and cooking demonstration videos to engage kids and families in preparing seafood at home. In addition, we are engaging adults in aquaculture by teaching them how to filet and cook fish, sharing aquaculture produced products at venues such as state fairs and seafood celebrations, and developing farm tours for legislators. Creating a more seafood literate public will not only benefit the aquaculture industry but also empower consumers to make better food decisions to benefit their own health and the environment.

BUILDING PARTNERSHIPS AND SOCIAL LICENSE THROUGH AQUACULTURE ENGAGEMENT IN THE GREAT LAKES REGION

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States bordering the Great Lakes from Minnesota to New York include some of the largest and most valuable natural freshwater ecosystems in the United States. Despite the abundance of freshwater, aquaculture production in the Great Lakes region has not kept pace with increases in consumer demand for fish and seafood, and lags the progress made in US coastal states.

One of the barriers to aquaculture growth in the Great Lakes region is a lack of understanding by the public about what aquaculture is and what the local industry requires to succeed. Coupling this lack of aquaculture knowledge with the desire to maintain natural freshwater systems and economically, culturally and socially important fisheries, the social license supporting aquaculture expansion in the Great Lakes region is tepid at best. Over the last ten years there has been increased interest and efforts to expand aquaculture in the Great Lakes region. Funding from NOAA through the National Sea Grant Office, funds from the USDA through the North Central and Northeastern Regional Aquaculture Centers, and other funding has expanded education, outreach and research activities to support an environmentally responsible and sustainable aquaculture industry in the Great Lakes region. A number of these initiatives attempt to increase the understanding of, and social license for aquaculture, either directly or indirectly. This short presentation will summarize a number of these efforts, and how they attempt to increases social license for aquaculture. Some examples include:

- Formation of the Great Lakes Aquaculture Collaborative that provides education, outreach and research to both the industry and seafood consumers.
- The development and implementation of "Eat Local Fish" type websites that benefit producers and target consumers to increase their knowledge of aquaculture, how the products are grown and where local products can be purchased.
- Working in partnership with the aquaculture industry, state agencies and academia to solve common issues/problems using aquaculture as a tool.
- Engaging the public directly in the development of state aquaculture plans, participation in aquaculture surveys, and soliciting input for market studies, which all increase the publics' overall exposure to, and understanding of, aquaculture.
- Working closely with decision makers to demonstrate the benefits of aquaculture, and informing them on what efforts they can take to build a more sustainable aquaculture industry in the Great Lakes region.

All of the above examples have multiple objectives, but in combination build the foundation for a more positive perception and understanding of aquaculture that increases social license when considering expansion of aquaculture in the Great Lakes region.

ONGOING DEVELOPMENT OF CRYOPRESERVATION TOOLS AND PROTOCOLS TO IMPROVE UTAH FISHERIES

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Utah Division of Wildlife Resources (UDWR) has developed a cryopreservation program for the long-term storage of fish milt. Utilizing a mobile freezing lab, UDWR has successfully cryopreserved Rainbow Trout *Oncorhynchus mykiss* and Muskellunge *Esox masquinongy* milt, each achieving post-thaw motility >50%. The goals of the program are to supplement statewide spawning efforts, conserve imperiled populations, and create disease-resistant crosses. Efforts are ongoing to increase fertilization rate of eggs using cryopreserved milt, expand the number of species which can be cryopreserved, and create a milt cryobank. This presentation will discuss the development of cryopreservation technology in Utah and the ongoing work of UDWR to improve and expand the program.

HOW TO ASSESS VALUE IN A SITE? WEIGHING UNRELATED PROS AND CONS IN SITE SELECTION

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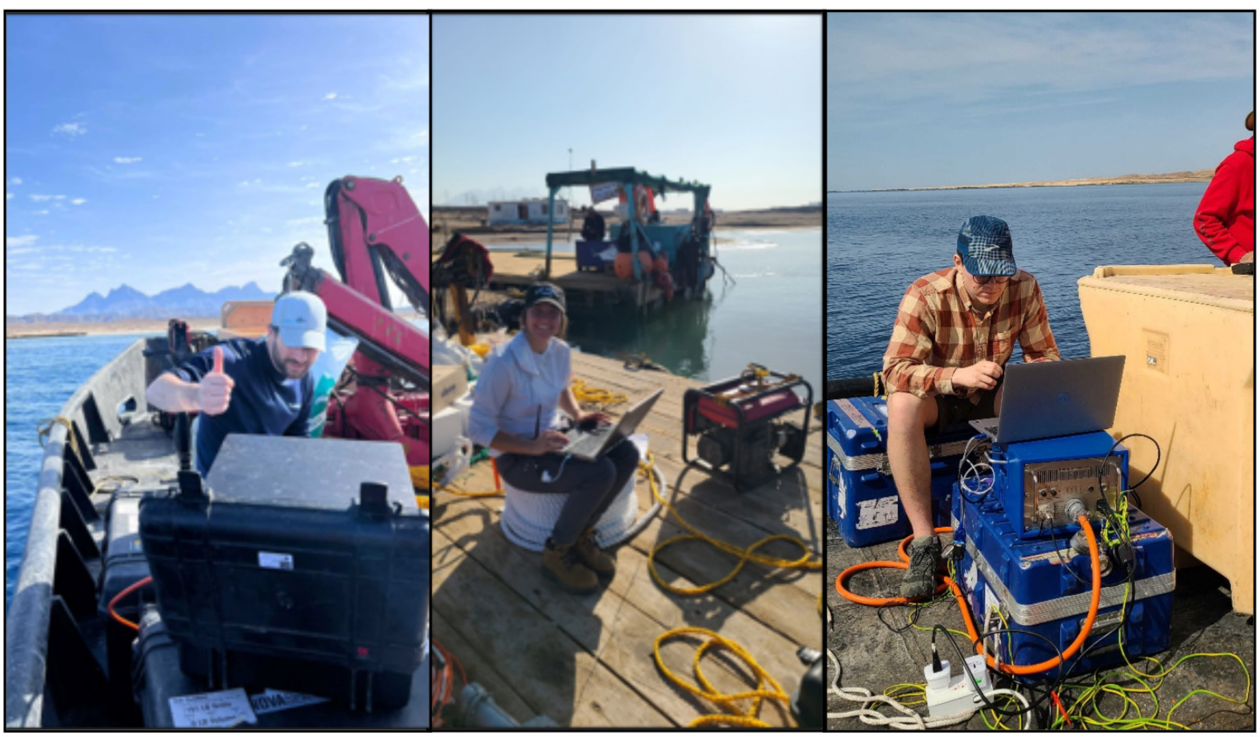
Innovasea has been providing site selection studies for over 15 years to established and entrepreneurial farmers and has developed an optimal process to evaluate sites wholistically. No site is perfect, and it can be challenging to determine which site is best suited for a project when different locations have different advantages and disadvantages which may be hard to compare.

Weighing the pros and cons of the different site limitations requires both experience and analysis techniques. What is preferrable; a good water source for a nursery or a low energy offshore grow out environment? A site that is easy to obtain permits for or a site with warmer water? These types of questions are hard to answer since the factors being discussed are not easily translatable.

This presentation will review some methods that can be used to create data, evaluate sites, and support decision making through analysis. These techniques enable farmers to make data-driven decisions as opposed to relying on "gut feelings".



EARLY PATHOGEN DETECTION THROUGH WATER SAMPLING OF AQUACULTURE SYSTEMS

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Parasites in the genera *Cryptocaryon* and *Neobenedenia*, and subclass Scuticociliatia infect the skin, gills, and sometimes deeper tissues of marine fish, and they are among the most common pathogens in public aquaria and aquaculture. This ciliate *Cryptocaryon irritans* causes marine "white spot" disease, and has a complex life cycle that results in rapidly escalating infections and major subsequent mortality events. As part of the life cycle, there is a free-swimming stage which suggests that there should be a detectable amount of the organisms in the water column prior to major infection. The skin fluke *Neobenedenia* spp. is a monogenean capsalidae that attaches to and infests a broad range of aquarium fish. This parasite hatches from an egg stage and can remain in a free-swimming stage, for a few days before finding a suitable host. Members of the Scuticociliatia are free-living, opportunistic parasites that feed and reproduce once attached to a host causing visible ulcerations of the skin.

Currently, clinical diagnosis of these parasites is based on physical detection, and their presence is not often noticed until disease symptoms have developed. Cytologic detection methods such as microscopic examination of skin mucus, gill biopsies, sediment, substrate, or filtrate samples are crude, "needle-in-a-haystack" tools, having very low sensitivity. These organisms can be present in subclinical concentrations, where the presence of the organism is not recognized.

This study aimed at developing a TaqMan multiplex qPCR assay to not only detect the parasite, but also correlate abundance with disease, thus allowing use of the test to determine threshold levels of each parasite in the water column. This information can then be used to initiate treatment before major infection events take place. These methods also be adapted for other targets, such as bacterial or viral pathogens.

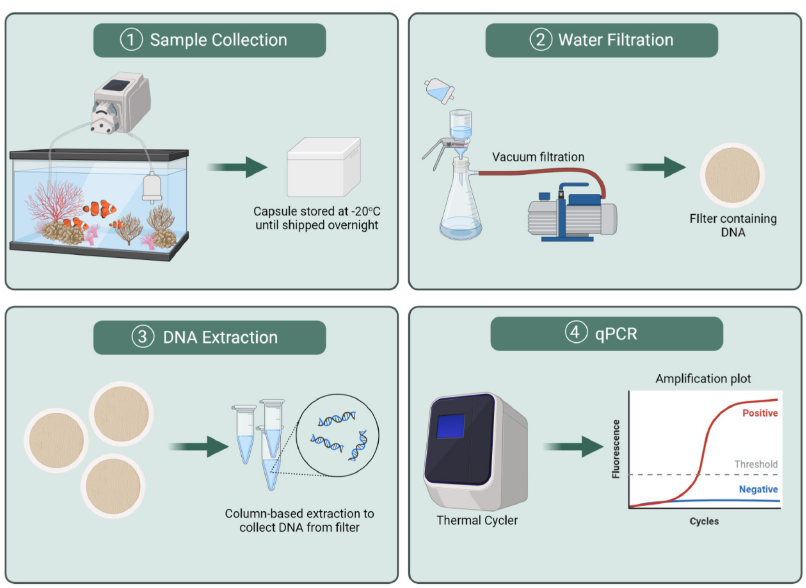

Figure 1. Diagnostic workflow.

EXPERIMENTAL PERACETIC ACID (PAA) USE IN A NORTH CAROLINA TROUT RACEWAY

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Peracetic acid (PAA)s a colorless liquid with a strong vinegar-like odor that in low doses is used as a water disinfectant in many industries including recirculating aquaculture systems (RAS) in Europe. In February 2023, Evonik Corporation received EPA approval for the sale of VigorOx ® Trident as a biocide to combat specific waterborne fish pathogens in US aquaculture systems.

Disease outbreaks occur periodically in trout raceways during the spring and summer months in western North Carolina. A usual approach to combat this is through the use of Formalin. For the first time in the US, PAA was tested in a series of commercial trout raceways. Weekly eye and gill samples were collected to monitor any fish health changes; PAA concentration and water quality parameters were also regularly monitored.

After an Ich outbreak, it was determined that the method used to introduce the PAA into the water was not ensuring even distribution throughout the water column of the raceways. This led to a modification of the PAA dosing system. Due to this problem, we plan to repeat this study in 2024 to obtain more conclusive results. The results and lessons of this study will be discussed.

ASSESSING THE EFFECT OF TEMPERATURE ON FEED CONSUMPTION, FEED EFFICIENCY, AND GROWTH RATE IN LARGEMOUTH BASS *Micropterus nigricans*

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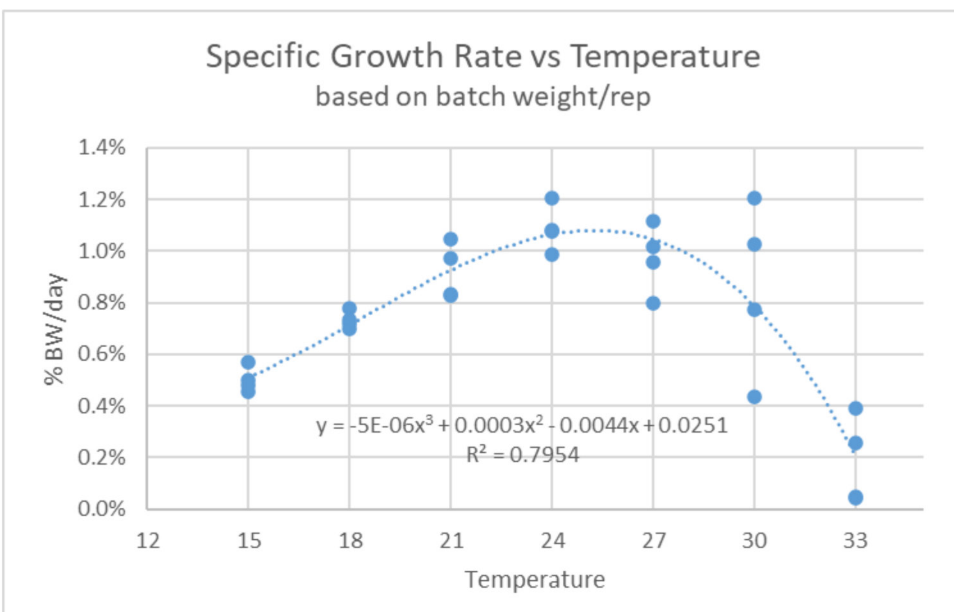
Obtaining growth of largemouth bass (LMB) to a market size of 570 g by the end of the second season is a challenge for producers in Kentucky. Development of practical feeding protocols to take full advantage of growth potential throughout the production season will be useful. This 9-week study examined the influence of water temperature on growth, condition factor, feed consumption, feed efficiency for feed trained largemouth bass (LMB) fingerlings.

Seven individual recirculating systems with four replicate aquarium tanks per system were randomly assigned a temperature treatment (15, 18, 21, 24, 27, 30, and 33°C). Prior to the experiment, individual LMB were injected with a Passive Integrated Transponder (PIT tag). Each tank was stocked with 6 feed-trained fingerling LMB (68.6 ± 1.4 g) and fed once daily by hand to apparent satiation with slow-sinking commercial trout feed (45% protein, 20% fat). Water quality was monitored to maintain conditions suitable for growth. Weight, length, and tag number for each fish was recorded at the end of the study. Significant differences will be determined with One-Way ANOVA, and relationships described with regression analysis.

As expected, feed consumption and growth among treatments increased to a maximum and then decreased with increasing temperature. Regression analysis yields a maximum SGR at 25.1°C with an R^2 of 0.79 and a maximum total feed consumed at 26.8°C with an R^2 of 0.72. Regression equation maximum for feed efficiency was 24.1°C with an R^2 of 0.73. There was no significant difference in survival among treatments. Tag specific data will be reported in the presentation.



DIRECT MARKETING AND SELLING FARM RAISED FISH TO U.S. CONSUMERS: INSIGHTS FROM CASE STUDY INTERVIEWS OF FARMERS

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U.S. aquaculture has the potential to ease demand on overexploited capture fisheries and reduce the seafood trade deficit by providing consumers with a domestic source of healthy farm-raised protein. However, US farmers generally, and North Central Region (NCR) farmers specifically, face challenges such as competition and price with both imported and domestically produced seafood products when it comes to marketing and selling their farm-raised products. Due to the relatively high cost of production in the US compared to other countries as well as differences in variable production cost between regions and subsectors within the US aquaculture industry, some farmers have opted to directly market and sell at least a portion of their farm's annual production into niche markets. This will allow then to reduce competition and get a better price than they would if they sold at the farm gate to fish haulers or processors.

To learn more about how aquaculture producers directly market aquaculture products in the NCR and beyond, case study interviews were conducted with small to medium-scale farmers who had first-hand experience with marketing and selling directly to consumers or intermediate buyers within the supply chain. There were twelve respondents in total, and aquaculture businesses have been in operation from 5–30 years, with an average number of years of 11.5. Farmers reported direct marketing and/or selling their products at farmers' markets, online and from the farm, and to intermediate buyers which included grocery stores and restaurants. Just over half of the farmers interviewed, 58.3%, were marketing and selling through more than one market channel. Farmers are using a variety of strategies for finding new customers and promoting their products and services from cold calls and in-person visits to utilizing modern technology such as business websites and social media platforms. Almost seventy seven percent (66.7%) of farmers interviewed are using internet options such as Facebook, Instagram, Twitter, and websites to find new customers. Farmers marketing to intermediate buyers are more likely to only use the internet for market research and identifying potential customers. Most of their new customer contacts are made by making phone calls, visiting businesses, and word of mouth. Marketing strategies vary based on many factors such as species, product form, and target customers, but in general, farmers are tailoring their marketing strategies to find customers that value their products.

INVESTIGATING THE GENO- AND SEROTYPIC DIVERSITY OF *Flavobacterium psychrophilum* INFECTING CAPTIVE-REARED SALMONIDS OF THE NORTH CENTRAL REGION OF THE USA

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Flavobacterium psychrophilum, causative agent of bacterial coldwater disease (BCWD) and rainbow trout fry syndrome, is a top contributor to disease-associated losses in salmonid (Family *Salmonidae*) aquaculture around the world. In the USA, BCWD outbreaks are a perennial problem, including within aquaculture facilities and hatcheries of the North Central Region (NCR). Although a range of BCWD prevention and control measures are available, their efficacy is often inconsistent at best. One possible factor contributing to these inconsistencies is the intraspecific geno- and sero-diversity of *F. psychrophilum* that has become increasingly apparent in some regions of the USA and abroad. Unfortunately, most of the specific *F. psychrophilum* geno- and sero-variants responsible for losses in NCR trout and salmon farms have not been identified, a matter with likely implications for vaccine development and efficacy. To this end and as part of a larger study aiming to enhance the health of US farmed fishes, efforts to isolate, identify, and characterize the predominating *F. psychrophilum* variants in NCR trout and salmon facilities are underway. Thus far, moribund salmonids from seven facilities in seven NCR states e.g., Michigan (MI), Ohio (OH), Iowa (IA), Wisconsin (WI), Minnesota (MN), Missouri (MO), and South Dakota (SD) have been collected, clinically examined, and bacteriologically analyzed. Examined fish (n=161) presented with a range of gross disease signs consistent with BCWD, including fin erosion, external ulceration, exophthalmia, visceral hemorrhage and/or pallor, and splenic swelling and enlargement. Cultures for flavobacterial isolation (n=651) were prepared on FPM-A medium and inoculated with tissues from the gills, brain, kidney, spleen, and representative external lesions. As a result, 183 yellow-pigmented bacterial isolates were recovered, 121 of which were identified as *F. psychrophilum* via *F. psychrophilum*-specific endpoint PCR analyses. Overall, *F. psychrophilum* was detected in ~33% of the examined fish and from six of the seven facilities. As additional facilities in the NCR are being sampled, genotyping via multi locus sequence typing is underway. Likewise, molecular serotyping has been completed for a subset of the recovered *F. psychrophilum* isolates, revealing some interesting trends, including host species to serotype associations and that some facilities were affected by a single molecular serotype and others by two or more serotypes. After identifying the predominating *F. psychrophilum* variants in the sampled NCR facilities, lab and field-based experiments will test the protective efficacy of various autogenous bacterin preparations, with the aim of producing efficacious, site-specific bacterins capable of enhancing fish health and productivity throughout the region. The findings from the study are expected to be of interest not only to fish health specialists but also to stakeholders in the aquaculture sector seeking effective strategies to mitigate the impacts of BCWD in the NCR.

EVALUATION OF HEMP SEED PROTEIN CONCENTRATE ON HEALTH INDICES AND AS A PARTIAL FISH MEAL REPLACEMENT IN STRIPED BASS *Morone Saxatilis* DIETS

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Nutrition research into fish meal replacements have increased sustainability, but additional alternatives are needed if aquaculture is to continue to expand. Hemp seed meal has been discussed as an alternative to fish meal due to its similar nutritional qualities and sustainable global production. This study evaluated five hemp seed protein concentrate inclusion levels for their effect on health indices and as an alternative to fish meal through growth and digestibility trials with striped bass (*Morone saxatilis*). A seven-week growth trial was conducted within a recirculating aquaculture system using a total of two control diets (commercial and experimental) and five experimental hemp seed protein concentrate replacement diets (10%, 20%, 30%, 40%, 50% fish meal replacement). Each diet was randomly assigned to four tanks with each tank containing four fish. At the end of the growth trial, no significant difference was found within final weight, percent weight gain, thermal growth coefficient, survival, intraperitoneal fat ratio, and muscle ratio across the diets. Condition factor and hepatosomatic index were found to be significant, but all treatments performed well based on condition factor and higher inclusion levels did not indicate a larger liver which was found at the 10% replacement level. Apparent protein digestibility of menhaden fish meal (83.9) was not significantly different from hemp seed protein concentrate (83.3). These findings indicate that in striped bass diets, hemp protein concentrate is well tolerated up to 33.2% of the total diet which corresponded to a 50% replacement of fish meal with hemp seed protein concentrate.

Final weight (FW), percent weight gain (WG), thermal growth coefficient (TCG), percent survival, condition factor (K), hepatosomatic index (HSI), intraperitoneal fat ratio (IPF), and muscle ratio (MR) of striped bass (Morone saxatilis) fed commercial and experimental diets for 7 weeks in a feeding trial.[1]

Growth Metrics	Commercial Control[2]	Control	10%[3]	20%[3]	30%[3]	40%[3]	50%[3]	P-value
FW (g)	43.35 ± 8.6	39.54 ± 5.6	47.81 ± 11.5	44.07 ± 6.8	45.16 ± 9.4	42.39 ± 10.8	45.18 ± 6.5	0.90
WG (%)	95.14 ± 39.7	80.95 ± 20.9	104.95 ± 50.8	104.31 ± 20.6	83.71 ± 43.3	91.43 ± 56.3	94.84 ± 31.3	0.97
TGC	6.88 ± 2.8	5.78 ± 1.6	7.97 ± 3.8	7.36 ± 1.8	6.68 ± 3.2	6.47 ± 3.7	7.15 ± 2.2	0.96
Survival (%)	100	100	100	100	100	100	100	N.A.
K	$1.06 \pm 0.1^{a,b}$	1.15 ± 0.1^{b}	$1.05 \pm 0.1^{a,b}$	$1.13 \pm 0.1^{a,b}$	1.16 ± 0.1^{b}	1.03 ± 0.1^{a}	$1.09^{a,b}$	0.00
HSI (%)	$1.55 \pm 0.1^{a,b}$	1.38 ± 0.1^{a}	1.81 ± 0.3^{b}	1.45 ± 0.2^{a}	1.40 ± 0.3^{a}	$1.5 \pm 0.23^{a,b}$	$1.62 \pm 0.2^{a,b}$	0.00
IPF (%)	5.55 ± 1.1	5.09 ± 0.5	4.80 ± 1.2	5.66 ± 0.9	5.54 ± 0.9	5.44 ± 1.0	4.98 ± 0.8	0.43
MR (%)	38.8 ± 1.1	39.99 ± 1.2	37.85 ± 0.9	39.32 ± 0.9	38.85 ± 2.0	39.15 ± 1.2	39.12 ± 1.3	0.07

[1]Means of four replicates groups ± standard deviation (n=4). Letters within the same row with different letters are significantly different (P<0.05). [2]Purina AquaMax Sport Fish MVP, Purina Animal Nutrition, LLC (crude protein 43%, crude lipid 12%). [3]Values represent percent fish meal replacement in the control diet with hemp seed protein concentrate.

IRON NANOPARTICLES AND ORGANIC ACID SUPPLEMENTATION IN THE DIET OF CHANNEL CATFISH, *Ictalurus punctatus*

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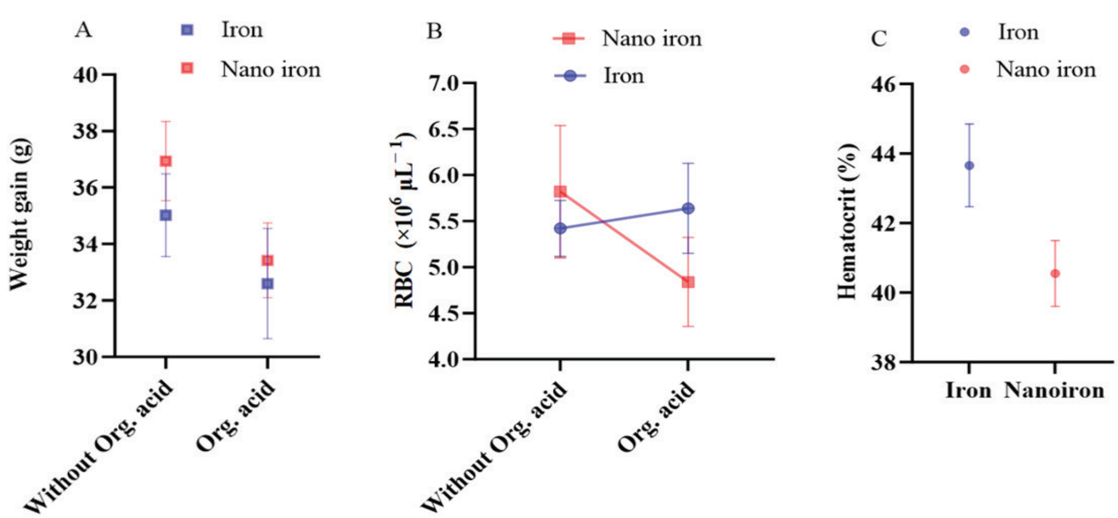
Microminerals are essential nutrients required for normal metabolism, of which iron is one involved in several biochemical processes, such as oxygen transport, electron transfer, and energy metabolism. The application of mineral nanoparticles has been gaining traction in animal nutrition due to their increased surface area which may enhance bioavailability, thereby improving micronutrient uptake. Idiopathic catfish anemia is an ongoing disease first reported in 1983, and catfish producers have provided iron-supplemented feeds to mitigate this disease. The present study evaluated the supplementation of iron nanoparticles and the organic acid (calcium propionate) on channel catfish growth performance, blood chemistry, and health parameters. A feeding trial was carried out for 9 weeks to evaluate two factors, the source of iron (bulk and nanoparticles) and the supplementation of organic acid (with and without calcium propionate). The iron was included at 1000 mg/kg of feed and the calcium propionate at 0.25% of dry weight. The growth performance, hematological parameters, and viscerosomatic indices have been analyzed. The organic acid decreased the weight gain of fish independent of the iron source (Figure 1A). An interaction was observed, where RBC decreased significantly when the nano iron was combined with the calcium propionate (Figure 1B). Significant differences also were observed in hematocrit between fish fed the bulk iron (43.7 ± 3.6%) and nano iron (40.6 ± 2.3%) (Figure 1C).

Overall, iron in bulk form and iron nanoparticles affected the blood hematocrit. However, dietary calcium propionate negatively affects the weight gain and RBC of channel catfish. Samples from the intestinal microbiota, the whole-body proximate composition, and the immune parameters of the plasma are currently being analyzed and will be presented.

Figure 1. Weight gain (A), red blood cell count (RBC) (B), and hematocrit (C) of channel catfish fingerlings fed with iron (bulk iron and nano iron) and with or without calcium propionate for 9 weeks.



ESTABLISHING A FEEDING PROTOCOL TO IMPROVE THE PERFORMANCE AND FILLET QUALITY OF RAINBOW TROUT (*Oncorhynchus mykiss*) FED SOY-BASED DIETS FOR 7 MONTHS

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Among the alternative ingredients, plant proteins (PP) are the most commonly used in aquafeed. However, PP contain anti-nutritional factors and imbalanced nutrient composition which adversely affect the performance, health, and fillet quality of fish. The feed additives can improve the growth and health of fish. The goal of the study was to assess the impact of the PP diets (~30% soy) supplemented with the additive mixture (A) on the growth and fillet quality of rainbow trout and establish a feeding protocol based on muscle fibre recruitment pattern to maximize PP utilization.

In a seven-month feeding trial, 2,000 fish (2.22 g) were divided into four groups with 5 replicates (100 fish/tank), fed isonitrogenous (42% crude protein) and isolipidic (20% lipid) diets: control (30% FM), plant protein (PP), PP+A1 (krill meal, taurine, and organic selenium), and PP+A2 (proline, hydroxyproline, and vitamin C).

Results indicate that FM, PP+A1, and PP+A2 groups exhibited significantly higher ($p < 0.05$) weight gain compared to the PP group. Additionally, the additive mixtures (PP+A1 and PP+A2) maintained fillet quality, showing significantly increased ($p < 0.05$) hardness and chewiness compared to the FM and PP groups during 90 days of storage at -20°C. Muscle histology revealed four growth phases based on muscle fiber recruitment (Figure 1 and 2): hyperplasia (2.2 - 15 g), hypertrophy (15 - 50 g), hyperplasia (50 - 150 g), and hypertrophy (150 - 350 g). Conclusively, supplementing additive mixture in PP-diet can mitigate their negative effects in rainbow trout. Based on identified muscle recruitment pattern in growth phases offer valuable insights for precision nutrition in future feeding trials.

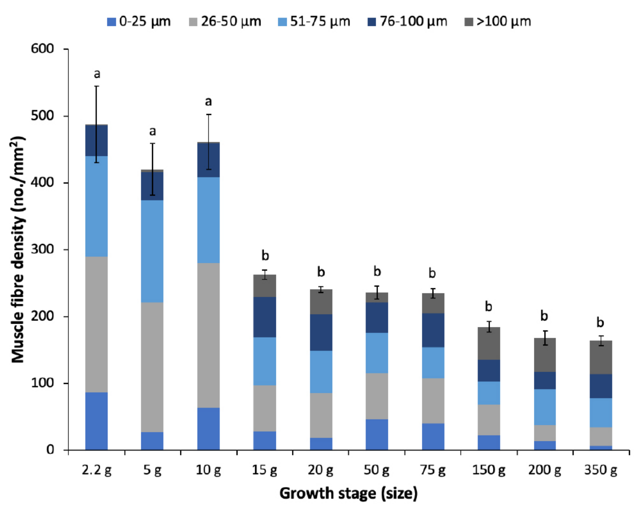

Figure 1: Muscle fibre recruitment in rainbow trout

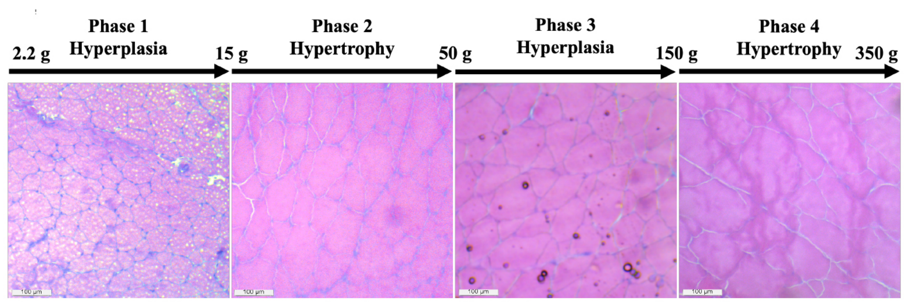

Figure 2: Different growth phases of rainbow trout based on muscle fibre recruitment pattern during seven months of feeding trial

A NOVEL FEEDING STRAGEY BASED ON MUSCLE FIBRE RECRUITMENT TO MAXIMIZE THE PERFORMANCE OF RAINBOW TROUT (*Oncorhynchus mykiss*)

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The growth of fish is a consequence of two events, namely hyperplasia (increase in muscle fibre number) and hypertrophy (increase in muscle fibre size). In our previous study, we identified four phases of growth based on the muscle fibre recruitment pattern in rainbow trout. These phases are- hyperplasia (2.2 - 15 g), hypertrophy (15 - 50 g), hyperplasia (50 - 150 g), and hypertrophy (150 - 350 g). Based on these growth phases, the aim of this study was to determine the least cost feeding strategy for the nutritional programming of rainbow trout to maximize growth, feed utilization, and fillet quality.

In a six-month feeding trial, 1400 fish (5.8 g) were distributed into seven treatments in triplicates (70 fish/tank), fed isonitrogenous (42% crude protein) and isolipidic (20% lipid) diets according to the feeding protocol depicted in Figure 1. Briefly, T1, T4, and T7 fed fish meal (FM), plant protein (PP), and additive mixture (AF, krill meal, taurine, and organic selenium) supplemented diets throughout the feeding trial, respectively, whereas the other four treatments were subjected to diet switching during the end of each growth phase.

Both FM (T1) and AF (T7) individually or in any combinations (T5 and T6) showed higher ($p<0.05$) weight gain than other groups in the last phase (PHASE 4) (Figure 1). The feed conversion ratio (FCR) of T2 and T4 was higher than other groups; however, no difference in FCR was found among other groups. Muscle fibre recruitment pattern, the expression of myogenic genes, and fillet quality are being analyzed. Conclusively, during hyperplasia, the high-quality protein-demanding phase, AF performs better than FM. The application of targeted nutrition to different growth phases shows promising results to maximize growth and reduce the feed cost. Overall, this novel feeding strategy will reduce the cost of fish production.

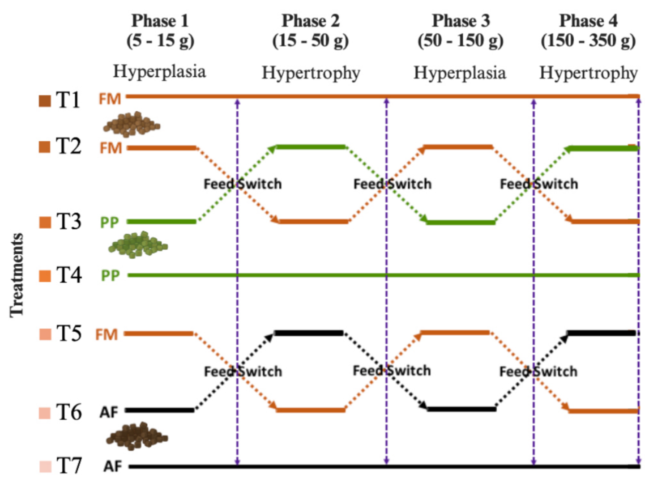

Figure 1: Overview of the feeding protocol

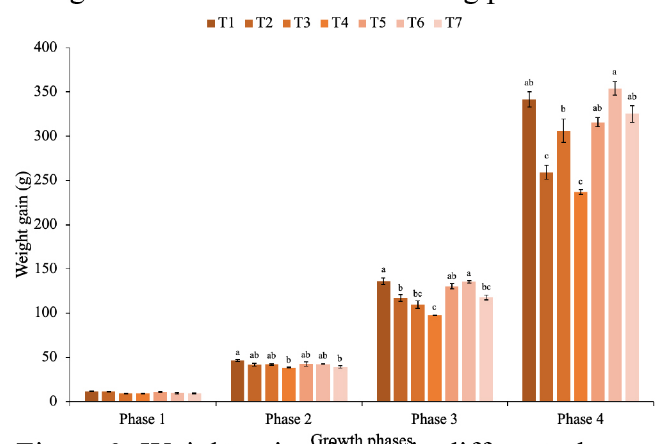

Figure 2: Weight gain of trout in different phases

EARLY STAGES OF IMPLEMENTATION OF GENOMIC SELECTION IN THE EASTERN OYSTER, CRASSOSTREA VIRGINICA, IN A MID-ATLANTIC BREEDING PROGRAM

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Advances made through family breeding at the Aquaculture Genetics and Breeding Technology Center at the Virginia Institute of Marine Science have yielded substantial gains in economically-important traits for the eastern oyster, *Crassostrea virginica,* including improvements in survival, growth rate and meat yield. Shape characteristics, such as fan shape and cup depth are monitored and included in a multi-trait selection index. Genetic gains from family breeding are transferred to the commercial industry through yearly production of two licensed family-based broodstock lines. The lines are derived from top families for improved performance in low salinity, low disease-pressure environments and moderate salinity, high disease pressure environments.

Pedigree-based breeding has limitations, however, utilizing estimated breeding values (EBV) calculated as an average value for the family as a whole, thereby possibly under- or over-estimating the breeding potential of individuals. It also relies on assumed genetic relationships based on believed coancestry. In contrast, genomic selection calculates more accurate breeding values and relationships through genotyping. Through combined efforts of the East Coast Oyster Breeding Consortium members, a 66K SNP array has been developed specifically for east coast oyster populations. ABC has utilized this tool to genotype over 4,700 oysters, (531 parents, 3073 progeny) from 4 years of family production and testing. In spring 2023, genomic selection was used for the first time to calculate genomic estimated breeding values (GEBV) on broodstock candidates, initially selected based on high EBV. The spread of GEBVs within families indicated a high degree of genetic gain is possible using genomic selection over pedigree-based approaches. To test this, spawns were executed to create 57 high salinity, 57 low salinity and 5 low-ranked GEBV families. Field trials of these families, to be assessed in fall 2024, will be the first step in validation of realized gains associated with genomic selection.

FROM CONFLICT TO COLLABORATION: EXPLORING THE SOCIAL AND ECOLOGICAL DIMENSIONS OF RECIRCULATING AQUACULTURE DEVELOPMENT THROUGH A MIXED METHODS APPROACH

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Recirculating aquaculture systems are increasingly seen as an important component of aquaculture sectors around the world. In the United States, efforts to increase the nation's aquaculture output have inspired RAS proposals in several states. These proposed developments have been met with varied levels of support from key stakeholders and the public. Addressing these social challenges requires analyzing the development conflicts and building an understanding of public perception surrounding RAS with solutions in mind. The challenge is to account for the context specificity surrounding aquaculture development, which includes taking into consideration the species, size of the operation, and impacts to local and regional social-ecological systems. To this end, we propose a three-tiered approach to researching public perception of RAS development starting with qualitative assessments of local perceptions, followed by empirical exploration of drivers of support at a regional scale, and ending with a decision support tool for community and industry stakeholders. At present, each stage of the recommended approach is being explore via research towards understanding public perceptions of RAS development in Maine, U.S. We intend to share the benefits of our three-tiered approach, to share results to date, and future research directions.

First , stakeholder interviews (n = 71) across 3 proposed U.S. RAS facilities including sites in Maine, California, and Florida have been completed and analyzed to explore the discourse surrounding the ensuing conflicts and drivers of Social License to Operate(SLO) – tacit approval from relevant stakeholders. Using an inductive grounded theory approach, we have completed three rounds of coding to arrive at themes that capture both SLO perceptions and the spatial scales (local, regional, national, global) used to frame social-ecological risk/benefit perceptions (e.g., impacts to jobs, local trails, ways of life, etc.). Findings from this assessment will inform survey design to analyze public perception of risks and benefits, industry values, trust, and SLO for RAS developers. Here we plan to empirically explore the relationships between the variables above and the (SLO) framework. This effort is currently underway with the of survey deployment in Fall 2024. Last, using the findings from both local and regionally oriented research, the development of a decision support tool for RAS development site selection can help decision makers address these urgent challenges. This spatial analysis and decision support tool will be based on not only conventional RAS site selection criteria (e.g., water supply, power supply, market access, etc.) but also on a) restorative opportunity based on adaptive re-use of existing infrastructure, b) spatial explicit survey results from empirical research relating to risk/benefit perceptions and SLO, and c) ecological components such as proximity to protected areas and habitats. The first iteration of this spatial model is complete, with future iterations planned in the near future.

EMBRYO INCUBATION, HATCHING, AND LARVAL REARING STRATEGIES FOR PRODUCTION OF YELLOW PERCH (*Perca flavescens*) FEED TRAINED FINGERLINGS FOR STOCKING IN RECIRCULATING AQUACULTURE SYSTEMS (RAS)

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Food insecurity is a major problem for many local communities in the Twin Cities metro area and beyond. Increased local food production via aquaculture is one way to reduce food insecurity, increase availability of healthy and high nutrient foods, and provide employment opportunities. The highly desirable and native food fish Yellow Perch (*Perca flavescens*) has historically supported a large commercial and recreational fishery within the Midwest United States. Over the last 30-40 years, low recruitment and over harvest of Yellow Perch have reduced abundance and made aquaculture an alternative approach to fill the demand for fresh, locally produced fish. However, limited access to biosecure feed trained fingerlings currently hinders the ability of small to medium scale aquaculture producers to reliably grow, harvest, and distribute locally grown fish.

Previous research has explored embryo incubation, hatching, and larval rearing of Yellow Perch, but no clear standardized protocol exists, and most farmers report low larval survival and unreliable growout to harvest. In the wild, recently hatched Yellow Perch larvae feed on zooplankton from relatively small taxa such as rotifers and copepods (size = 80-235μm) due to the small gape size of their mouth. However, most producers rely on much larger (size = 300μm) Brine Shrimp as the only live, early-stage larval feed, which may partially reduce larval survival. We have now successfully incubated, hatched, and feed trained three separate batches and two distinct geographical strains (i.e., Green Bay, WI & Northeast River, DE) of Yellow Perch from embryos to fingerling stage. We have also developed a protocol using several live feeds (i.e., S & L strain rotifers and Brine Shrimp) to rear larvae to fingerling size for stocking and growout in RAS.

Herein, we will discuss the many challenges associated with incubation, hatching, and feed training Yellow Perch fingerlings, and outline our current procedures for successful live feed culture, first feeding, and transfer from live feeds to formulated diets.

EXAMINATION OF GREENHOUSE WATER EFFCIENCY USING SMART-WATER TECHNOLOGY AT SANTA FE COMMUNITY COLLEGE

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The Santa Fe Community College's Controlled Environment Agriculture (CEA) greenhouse is one of the leading commercial aquaponics education programs in the United States. The 12,000 square foot commercial greenhouse facility houses 5 commercial aquaculture species paired with commercial crop varieties in both turnkey and DIY aquaponic and algal production systems. The school's location in the high desert of northern New Mexico has brought attention to the water use efficiency potential of CEA crop production. A widely cited claim of 90% water efficiency in crop production when compared with field production lacks a solid body of research and often discounts volumes of water spent on cooling, cleaning, and loss. This lack of research and a need to understand the implications to water supply led to a partnership between SFCC and the City of Santa Fe Water Conservation Office. The Partnership seeks to answer three main questions, how efficient is recirculating greenhouse crop production, how much of total water use does evaporative cooling consume, and what volume of water goes down the drain.

Three Phyn smart-water meters were deployed to monitor water use at three strategic locations in the greenhouse water system, 2" main, rainwater harvesting system, and evaporative cooling reservoir. During the first year of the audit the water use totaled 918,492.3L, which is less than 1,233.5, one acre foot, of water. 843,7664.84L(92.3%) of the water used was supplied by the utility. Cooling consumed 672,371L(73.2%), while only 74,046.4L(8.06%) was supplied by rainwater collection. Student collected data indicates that the UVI style deep water culture systems are 99.5% recirculating. These results have led to the expansion of the project to correlate water use and total yields.

EVALUATING THE EFFECTS OF SKIN INTEGRITY AND DIETARY STATUS ON MOTILE *Aeromonas* SEPTICEMIA INFECTIONS IN CHANNEL CATFISH *Ictalurus punctatus*

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Virulent *Aeromonas hydrophila* (vAh) has been identified as the main pathogen in recent occurrences of motile *Aeromonas* septicemia (MAS) in commercial-sized channel catfish (*Ictalurus punctatus)* and hybrid catfish (*Ictalurus punctatus X I. furcatus).* In 2021, 2.05 million pounds of catfish were lost to vAh in West Alabama alone and at current live fish prices the estimated monetary loss is roughly US $2.6 million annually. Field reports suggest that mortality is often observed after feeding or seining catfish. Therefore, using an existing bath immersion infection challenge model with fin clipping, we investigated the effects of skin integrity (fin-clipping) and dietary status (feeding) on channel catfish infected with vAh.

A total of 425 channel catfish (mean weight = 30g) were challenged with vAh strain, ALG-15-097, at a concentration of 1.5×10^7 CFU/mL in 4 treatment groups. Group 1 was fin clipped and fed (FCF, n=100), group 2 was not fin clipped but fed (NCF, n=100), group 3 was fin clipped but not fed (FCN, n=100), and group 4 was not fin clipped and not fed (NCN, n=100). The fed groups that were fed 2 h prior to the challenge on commercial diet at 3% of their average body weight. All fish were anesthetized (MS-222 at 150mg/L), fin clipped treatments had their adipose fin cut off with scissors before being placed in flow-through tanks. No fin clipped fish were placed in the tanks after anesthesia. The mortalities were recorded at 0, 1, 2, 4, 6, 8, 12, 20, 24, 36, 48 and 72 hours. The control group (n=25) were manipulated like groups 1 (FCF) and 2 (NCF) but were mock challenged with sterile tryptic soy broth.

After 72 h post challenge, we observed 30%, 38%, 23% and 55% survival rate in groups 1 (FCF), 2 (NCF), 3 (FCN) and 4 (NCN) respectively. Overall, statistically significant differences were observed between treatments, except between groups 2 (NCF) and 4 (NCN) (Fig. 1). Results suggest skin integrity and dietary status are important factors in MAS pathogenesis.

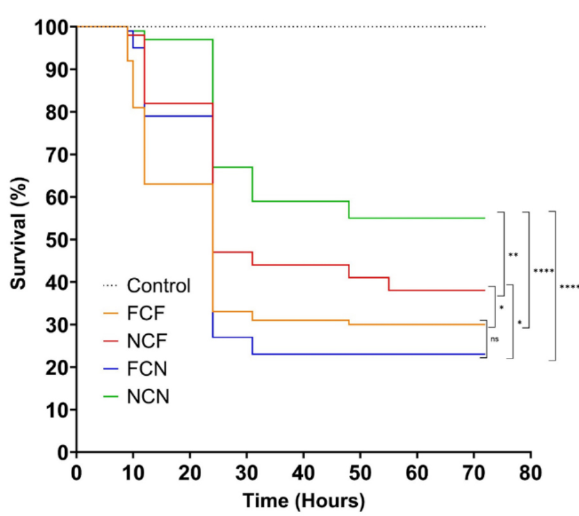

Figure 1: Kaplan-Meier survival curve of the various treatment groups. FCF = Fin clip fed, NCF = No fin clip fed, FCN = Fin clip not fed, NCN = No fin clip not fed

COMMERCIAL FISHERIES AND ENDANGERED SPECIES: A TOOL FOR AQUACULTURE PLANNING TO MINIMIZE TWO UNWANTED INTERACTIONS

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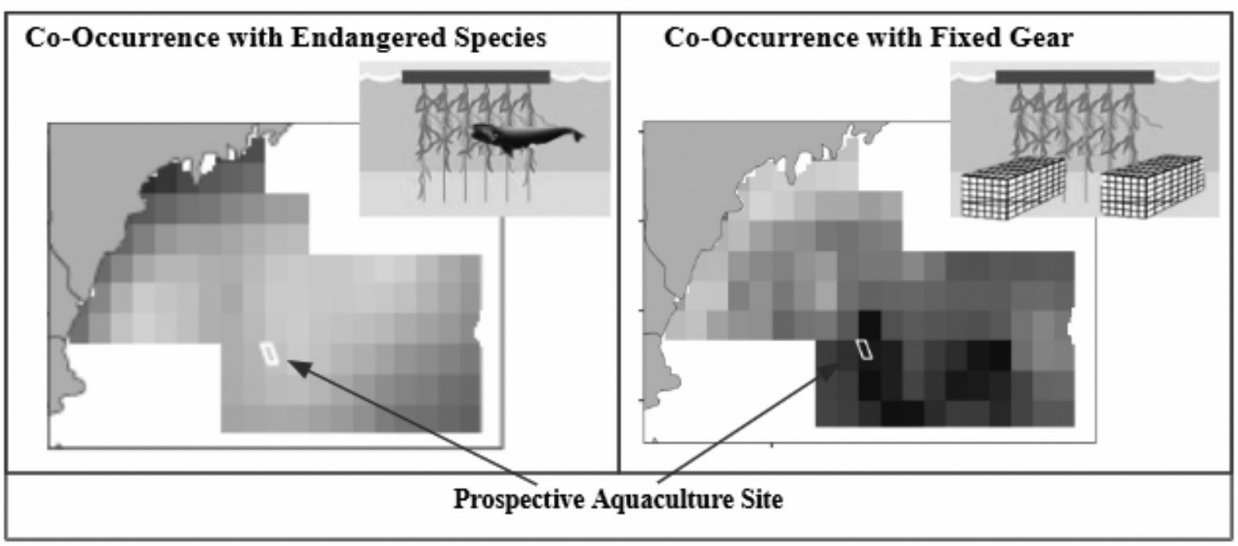
American lobster (*Homarus americanus*), Jonah crab (*Cancer borealis*), and other fixed-gear fisheries operating in the Northwest Atlantic Ocean from the Gulf of Maine through Southern New England have been subject to new regulations to reduce entanglement risk of the endangered North Atlantic right whale (*Eubalaena glacialis*). A Fixed-Gear Fishery Layer (FGFL) was constructed alongside a Decision Support Tool (DST) to help stakeholders and managers weigh alternative management options and to achieve risk reduction thresholds. Risk of the FGFL was based largely on the overlap of commercial fisheries with a North Atlantic right whale habitat density model. As offshore aquaculture develops in U.S. waters, the DST and FGFL present an opportunity to model both the design and placement of aquaculture facilities in a manner that reduces (1) entanglement risk for protected species and (2) conflict with fixed-gear fisheries. To demonstrate this, we used the dimensions and gear configurations for a proposed kelp farm to develop a baseline Kelp Aquaculture Layer (KAL), mirroring the FGFL structure. Co-occurrence with both the FGFL and North Atlantic right whale habitat density model were then estimated. This work demonstrates a functional method for aquaculture project proposals to plan and mitigate conflicts with current ocean use industries as well as to reduce the potential for additional entanglement risk of protected and endangered species.



SOCIAL LICENSING – BUILDING COMMUNITY TRUST FOR LAND BASED RAS

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Kingfish Maine is fully permitted to construct a land-based recirculating aquaculture system (RAS) facility growing yellowtail kingfish, Seriola lalandi, on an approximately 94-acre parcel of land in Jonesport, Maine.

Kingfish Maine is part of the Kingfish Company [Euronext: KING] and is currently operating at the University of Maine's Center for Cooperative Aquaculture Research (CCAR), where it is building its Yellowtail broodstock for production at the proposed Jonesport facility. Earlier this year, a limited release of Dutch Yellowtail from Maine (8000 lbs.) was distributed to and served at restaurants in Maine, Boston, DC and California. Another harvest is scheduled for late this year.

From its introduction in 2019, the Kingfish team launched an extensive community engagement campaign to educate and inform the community of Jonesport on the economic benefits of the project as well as RAS technology. Kingfish's community outreach is grass-roots and focused on in-person meetings. Over four years, the team held more than 30 community gatherings including library information sessions, "Coffee with Kingfish" informal meetings and "Talk and Taste" sessions featuring a chef preparing Kingfish Yellowtail.

Also, Kingfish Maine began building its future work force. The team donated a small recirculating aquaculture system (RAS) to Jonesport Beals High School. Now in its fourth year, the Kingfish is helping students stock the system and learn the process of growing and harvesting fish. Statewide apprenticeship programs and new college-level aquaculture courses are in development with the help of Kingfish.

There is an anti-aquaculture group in Maine, backed by wealthy landowners and well-funded consultants, which is taking aim at large aquaculture projects in the state. And Kingfish has been targeted as well. After Kingfish received all its federal and state permits, this group began a misinformation campaign against the project.

Also, a six-month moratorium on all large scale aquaculture projects in Jonesport was introduced in 2022, backed by the anti-aquaculture forces. This Kingfish team and its supporters banded together to "get out the vote" and, in the end, the moratorium was defeated by a record 2 to 1 margin.

Over four years, the Kingfish Maine team has built understanding and trust for a project to bring jobs and economic development to the Downeast region of Maine. Early community engagement and a continued commitment to honest and open dialogue has paved the way for development of this successful RAS project.

THE MODULAR LARVAL REARING SYSTEM (MoLaRS): A VERSATILE PLATFORM FOR ADVANCING DEVELOPMENTAL EVOLUTION STUDIES IN NON-MODEL AQUATIC ORGANISMS

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To advance the development of a sustainable aquarium aquaculture program, a small scale, fully adjustable system that can easily meet the needs of most aquarium fishes was fabricated. This resulted in Roger Williams University creating the Modular Larval Rearing System (MoLaRS), which has since been dispersed to numerous aquarium institutions globally. Within the MoLaRS, specific needs of the species being reared (water flow, light levels, live feed retention, aeration, etc.) can be tailored throughout the larval duration and even into juvenile growout. This allowed aquariums to have a multifaceted system that could work within their spaces and facilitate the production of their spawning species on exhibit. The success of this larval rearing platform has allowed it to be fully transferable.

Applying the MoLaRS technique for rearing non-model species is an area where aquaculture is currently underutilized. RWU's MoLaRS was successful in producing searobins (*Prionotus carolinus* and *P. evolans*). Searobins are an interesting non-model species allowing for the study of limb development and evolution. These fish have well developed fin rays that are modified for walking, digging, and sensing prey connected to specialized spinal lobes, hereafter referred to as legs.

Genetically edited Striped and Northern searobins (*Prionotus spp*.) were cultured to pinpoint essential transcription factors that are differentially expressed in leg development. These transcription factors play a vital role in ensuring accurate leg and neurological development in sea robins.

These species are a promising model for exploring the regulation of leg development genes in humans and other vertebrates' traits. This work also opened the ability to answer additional questions, including developmental attributes, such as the genes responsible for their characteristic armor, and electrical signal transduction. Traditionally, marine aquaculture has focused on food production and recreation. Marine aquaculture of non-model species can expand biological research traditionally reserved for zebrafish and other model freshwater species.

UNDERSTANDING INTERACTIONS WITH ENDANGERED MARINE MAMMALS AND TROPICAL AQUACULTURE

Tori Spence McConnell, Dr. Stacie Robinson, Lesley Hawn, Angela Amlin, Haley Durbin, Kristina Dauterman

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In the Pacific Islands Region, the Hawaiian monk seal (*Neomonachus schauinslandi*) is an endangered and endemic species whose range overlaps with an aquaculture facility which uses open-water finfish net pens. Such net pens are a novel approach to aquaculture in the Hawaiian Islands, and there is high interest in replicating this model to expand the local aquaculture industry. Thus there is an imperative to ensure that open-water aquaculture operations can coexist safely with native protected species. Aquaculture facilities can attract wildlife, including protected species. NOAA Fisheries has been working with an aquaculture facility to understand interactions with monk seals, following a mortality event and subsequent reinitiation of Endangered Species Act Section 7 consultation. This work is a coordinated effort between the regulatory branch at the Pacific Islands Regional Office, scientists at the Pacific Islands Fishery Science Center, and the farm. This work aims to identify monk seal behaviors associated with the farm and implement protocols and mitigation measures to reduce the risk of monk seal injury or death. Outcomes from this work will provide a more detailed understanding of protected species behaviors around the pens and supports the industry by providing regulatory processes to reduce these risks.

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DEVELOPMENT OF SUSTAINABLE PRODUCTION, PROCESSING, AND VALUE-ADD STRATEGIES FOR TROPICAL SEAWEED SPECIES TO BUILD IMTA CAPACITY IN THE SOUTHEAST U.S. AND CARIBBEAN

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There is a growing interest within the U.S. and globally in aquaculture of macroalgae ("seaweeds") for use in a variety of food, bioremediation, and industrial use sectors. Currently macroalgae comprises over 50% of global mariculture production, though the vast majority of culture operations are concentrated in Asia. Within the U.S. there is an increasing interest in the expansion of seaweed aquaculture, particularly within coastal fishing communities, yet the main focus for such expansion has been in northern climates with temperate macroalgae species. There is incredible untapped potential for tropical seaweed species native to the southeast U.S. and Caribbean regions to gain a stronger foothold in the marketplace, particularly markets for direct human consumption and value-added products. However, some of the most common impediments to such growth in the southeast U.S. and Caribbean regions come from a lack of tropical U.S. fishing community exposure to sustainable production, processing, and value-added strategies for tropical seaweed species in the region, particularly in terms of how tropical seaweed species can be readily incorporated into existing finfish culture operations through utilization of integrated multi-trophic aquaculture (IMTA) techniques and systems design. Aspects of ongoing research and development activities aimed at resolving these issues will be presented, and opportunities for working waterfront communities to implement IMTA culture operations will be discussed. This work has been supported by the Gulf States Marine Fisheries Commission (GSMFC) and the National Oceanic and Atmospheric Administration (NOAA).

APPLICATIONS AND INSIGHTS OF BIOENERGETICS RESEARCH FOR IMPROVING AQUACULTURE PRODUCTION OF *Seriola spp.*

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Marine finfish aquaculture production continues to expand around the world, with new species, sites, and production processes continuing to develop in this growing industry. The yellowtail jacks (*Seriola spp*.) are increasingly viewed as some of the most promising marine finfish species for both ocean-based and land-based culture operations due to a number of favorable aquaculture production characteristics. However, there are notable differences between individual *Seriola* species, not only from biological and physiological standpoints, but also when it comes to production strategies and market considerations. Such differences have made it difficult for both prospective and existing producers to implement production strategies that maximize the profit potential associated with the various *Seriola* species being cultured throughout the world. Advancements in fish bioenergetics research have allowed for important insights to be gained which can be directly applied to help develop effective strategies for maximizing the production potential and growth efficiencies of *Seriola* in the aquaculture industry. Bioenergetics applications and findings will be presented, including aspects of comparative physiology between *Seriola spp*. and other high-value marine fish species. Specific case examples related to various commercially-relevant *Seriola* species and the regions and systems utilized for culture of these high-value marine fish will be discussed. Improved understanding of bioenergetics in *Seriola* aquaculture can aid in improving the economic viability and ecological sustainability of culture operations.

KEEPING YOUR POOP IN A GROUP: IMPROVING FISH HATCHERY EFFLUENT

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The Michigan Department of Natural Resources' (MDNR) Platte River State Fish Hatchery is considered the birthplace of the upper Great Lakes salmon program, where successful pacific salmon stocking began in 1966. Returning mature Coho Salmon the following years prompted construction of a large scale coldwater fish production facility on the Upper Platte River, where only a satellite trout rearing facility previously existed. Construction of this facility was completed by 1973, and salmon production in the form of both Coho and Chinook Salmon ramped up to meet the demands of anglers and fisheries managers alike. However, with the increased feeding and production, came increased effluent waste loading to the watershed and by the mid 1970's peak effluent loading reached 4,321 pounds of phosphorus annually. This phosphorus was carried downstream to Big Platte Lake, where algal blooms began to negatively impact water quality.

After lengthy court battles between the Platte Lake Improvement Association (PLIA) and the MDNR, in 2000, both parties agreed to a Consent Judgement that outlined changes required by law to limit hatchery effluent to only 175 pounds of phosphorus annually among other operational restrictions. To meet this new stringent and protective effluent waste level, the MDNR had two options; 1.) reduce production to pre-salmon levels at the relatively newly constructed facility, or 2.) invest in engineering and technology, and renovate the facility so it could meet these limits without reducing production levels. The MDNR chose the former option and by 2012 had renovated the Platte River State Fish Hatchery to be one of the most state-of-the-art flow-through coldwater production facilities in the world with respect to effluent management. This focus on effluent management and an eventual partnership between the MDNR and PLIA truly make this a success story you will not want to miss.

INTERMEDIARIES IN NORWEGIAN SALMON EXPORTS

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Globally, salmon is now the aquaculture species with the second-highest export value after shrimp, and Norway is the largest producer. Salmon is also among the most traded fish species globally with the most advanced logistics. During the last two decades, the size of the largest firms has increased significantly, and a number of companies are also integrating vertically towards the market. Many of these producers, though not all, operate their own harvesting plants and manage their own exports, and some even operate secondary processing facilities downstream in the supply chain.

A substantial and increasing share of international exports is facilitated by intermediaries, such as trading companies, merchant wholesalers and custom brokers. This is also true for trade in salmon products. The role of intermediaries has so far received limited attention in the literature on seafood markets and trade.

We examine the role of intermediaries (e.g. trading companies) in Norwegian salmon exports. Using customs data for the period 2016-2019, we identify two groups of firms in Norwegian salmon exports according to their main economic activity: producers that also export their salmon and traders (independent intermediaries). We show that although both groups of firms have established a global trade network, several interesting differences exists between the two groups. A relatively small number of producers take a significant higher share of overall exports than a large number of traders, as there is a large number of smaller companies in the trader group. On average, producers supply more distant markets with larger volumes than traders. Market concentration measures indicate that a very large share of exports is concentrated among the top three exporters in both groups of firms. Interestingly, traders are in many markets able to charge a price premium for several salmon products relatively to the producers.

FIRST CONTROLLED SPAWNING FOR CALIFORNIA YELLOWTAIL (*Seriola dorsalis*)

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Here we describe the first documented photothermal spawning control of California yellowtail (CYT; *Seriola dorsalis*) broodstock. Over one spawning season we tracked two groups of F1 generation broodstock and recorded metrics for spawns (egg production, viability), eggs (egg diameter, oil diameter, percent oil volume, hatch rates), and larvae (notochord length at hatch, survival to first feeding). Spawning Group 1 was comprised of two females (16.0 ± 0.1 kg) and five males (15.4 ± 2.4) that were held under ambient light and temperature and produced eggs from March through October. Spawning Group 2 was also comprised of two females (12.8 ± 3.1 kg) and five males (12.7 ± 2.2 kg) that were photothermally shifted to spawn from October through April.

The majority of spawning occurred between 13-14 hr of daylight and water temperatures between 15 – 21° C. Group 1 spawned 47 times, producing 22 million eggs and 486,873 eggs per spawn (Table 1). Group 2 spawned less (n=34) and had lower egg production (20 million eggs), but the eggs per spawn was higher at 604,825 (Table 1). Egg quality was similar between both groups. We showed that spawning of CYT can be photothermally controlled with no impacts on egg production or egg quality.

Table 1. Egg production and quality for California yellowtail (*Seriola dorsalis*) broodstock held under ambient and controlled photothermal conditions. Averages shown with ± STDev, where appropriate.

2022-2023	Spawning Group 1 (Ambient)	Spawning Group 2 (Controlled)
Number of Spawns (#)	47	34
Egg Production (total #)	22,883,054	20,564,037
Egg per spawn (#)	486,873 ± 229,149	604,825 ± 315,412
Viability (%)	75.7 ± 14.4	80.1 ± 14.2
Egg Diameter (mm)	1.32 ± 0.04	1.38 ± 0.02
Oil Diameter (mm)	0.29 ± 0.01	0.32 ± 0.02
Oil:Egg Volume (%)	1.03 ± 0.11	1.22 ± 0.20
Notochord Length at Hatch (mm)	4.01 ± 0.24	4.02 ± 0.20
Hatch Rate (%)	70.4 ± 13.1	75.1 ± 15.5
Survival to First Feeding (%)	75.5 ± 20.5	61.8 ± 25.8

EVALUATION OF THE ANTIMICROBIAL ACTIVITY OF CARVACROL, THYMOL, AND CITRAL AGAINST CATFISH BACTERIAL PATHOGENS

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One of the main challenges that has arisen due to the accelerated development of the aquaculture industry is the emergence of antibiotic-resistant pathogens. And this issue is aggravated by the limited FDA approved chemotherapeutics available for aquaculture. A primary approach to address this challenge and mitigate infectious diseases is the use of functional feeds that has bactericidal/bacteriostatic properties and/or immunostimulate the host. In this context, numerous investigations have been carried out testing phytocompounds supplemented to the feed. Their antimicrobial, immunostimulant, and anti-stress antioxidant features can interact with the host, and ultimately act as growth promoters. Nevertheless, the use of these class of compounds is challenging when the phytocompounds can widely vary depending on the extraction method, climate conditions when growing the plants, soil composition, or phenotypic differences in the intrinsic variation between the variety of plants.

The present study focused on analyzing the inhibitory activity of main active compounds (carvacrol, thymol, and citral) and the guava extract against pathogenic fish bacteria such as *Aeromonas hydrophila, Edwarsiella ictaluri*, and *E. piscicida*. This evaluation was carried out using the test sensitivity by diffusion disc, the microdilution method in culture broth for antimicrobial activity, and the evaluation of bacterial biofilm formation and inhibition through the gentian violet assay. In the diffusion disc test, the carvacrol and thymol extracts had significant differences compared to a control (without exposure to the extracts) in all strains evaluated. Additionally, *E. piscicida* had higher diameters of zones of inhibition (ZOI) being significantly different with the pure guava extract.

In the pilot tests of bacterial growth against serial dilutions of the extract, significant reductions in the growth curve have been observed. The minimum inhibitory concentrations (MIC), and minimum bactericidal concentrations (MBC) will be determined, and these concentrations will be further evaluated during the bacterial biofilm formation. In conclusion, the phytocompounds tested presented promising inhibitory activity against common pathogenic bacteria for catfish, and future studies evaluating these compounds as feed additives for channel and hybrid catfish in feeding trials are encouraged.

EXPANDING NORTHEASTERN US GREEN SEA URCHIN AQUACULTURE PRODUCTION AND THEIR POTENTIAL TO REDUCE BIOFOULING OF SHELLFISH

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The green sea urchin (GSU), *Strongylocentrotus droebachiensis*, is an economically important species in the Northeastern US, with production primarily based in Maine. The fishery has dramatically declined since the 1990s, but the demand for GSUs has increased. GSUs can be grown in open water in a wide range of gear types either alone, in polyculture with shellfish or algae or as part of integrated multi trophic aquaculture systems. They are a high value luxury seafood product and global and national demand is unmet creating an opportunity for aquaculture. This talk will overview project efforts working towards expanding the emerging aquaculture industry. These include optimizing hatchery production methods, outreach to increase the awareness of seed availability, and facilitating uptake by providing new growers with seed and technical support for experimental growth to market. Sea urchins also offer a low trophic solution towards reducing nuisance shellfish biofouling species through polyculture. Biofouling can prevent shellfish from reaching their full growth potential by >30% and sea urchins can reduce this fouling through grazing. This talk will overview projects partnering shellfish growers, hatchery producers and researchers on the use of GSUs for reducing biofouling on various shellfish species. This work is funded by the US Department of Agriculture's Northeast Sustainable Agriculture Research and Education, National Institute of Food Agriculture, and the Northeastern Regional Aquaculture Center.

THE EFFECTS OF GLYCINE SUPPLEMENTATION IN SOYBEAN MEAL-BASED DIETS AS A FUNCTIONAL AMINO ACID FOR JUVINILE HYBRID STRIPED BASS (*Morone chrysops x M. saxatilis*)

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As global fishmeal demand outpaces capture fisheries supply, the aquaculture industry has made alternative protein feedstuffs, especially from plant sources, a focus to support the continued expansion of world aquaculture. However, extensive replacement of fishmeal in aquatic diets may lead to a limiting availability of some amino acids (AAs), especially in high- protein diets for carnivorous fish. As industry standard inclusion levels of fishmeal decrease, traditionally classified dispensable AAs could become limiting, leading to both decreased growth and metabolic disorders. Therefore, an 8-week comparative feeding trial followed by an immune challenge was conducted to assess the effects of glycine supplementation as a functional AA in soybean-meal (SBM)-based diets fed to hybrid striped bass with a mean initial body weight of 1.6 g/fish. The basal diet (38% crude protein (CP), 2.23% glycine, and 10% crude lipid) was composed of practical ingredients with SBM contributing 75% of total CP. Along with the basal diet, experimental diets were supplemented with either 2% glycine, 0.2% glutathione, 0.1% buthionine sulphoximine (GSH inhibitor), and combinations thereof. At the conclusion of the comparative feeding trial, 100 μg of 2,4,6-trinitrophenyl lipopolysaccharide (TNP-LPS) or phosphate buffered saline were injected intraperitoneally into fish fed the basal and 2% glycine diets, which were then sampled for superoxide anion and hydrogen peroxide production 7 days post injection to assess innate immune responses.

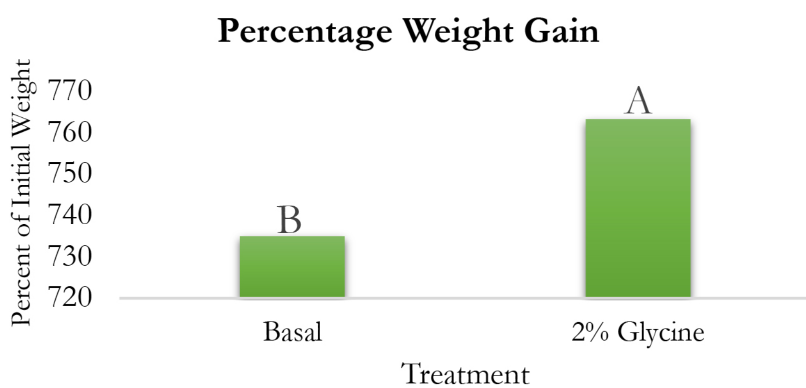

Figure 1. Percentage weight gain of main effects of HSB supplemented with 2% of dietary glycine.

HEMATOLOGICAL EVALUATION OF *Labeo rohita* INHABITING DIFFERENT ENVIRONMENTS

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The present study was designed to evaluate certain hematological parameters of fresh water fish *Labeo rohita* in relation to the physiochemical properties of river and farm waters. For this purpose, the control group fish *Labeo rohita* collected from Fish Seed Hatchery Satiana Road Faisalabad, Pakistan. The experimental group fish was sampled from River Chenab, Chiniot, Pakistan. The physicochemical parameters like temperature, pH, dissolved oxygen, hardness and total dissolved solids were measured for both experimental and control groups. For hematological study the blood collected in Eppendorf tube with EDTA. Blood was drawn from the posterior caudal vein. Hematological analyses include RBC, WBC, PLT, HGB, HCT, MCV, MCH, MCHC, LYM, PW and PCT. The data was analyzed for significant results.

In case of morphometric parameters, weight of control fish was found higher 983.3±60.09 g than the weight of experimental fish 866.6±44.09 g. Length of control fish was found greater 7.1±0.33 inch than that of experimental fish 5.8±0.17 inch. Width of control was larger 3.1±0.05 than that of experimental was 3.06±0.08 inch. In case of physicochemical parameters of water like temperature of control fish water was higher 19.23±0.57 °C than that of experimental fish water 18.20±0.20 °C. pH of control fish water was lesser 7.54±0.27 than that of experimental fish water 8.64±0.29. DO of control fish water was higher 5.99±0.07 mg/L than that of experimental fish water 2.74±0.23 mg/L. Hardness of control fish water was less 74.70±3.30 mg/L than that of experimental fish water 143.8±4.41 mg/L. TDS of control fish water was lesser 979.3±27.45 mg/L than that of experimental fish water 1813.7±34.22 mg/L.

Table Comparison of hematological parameters between experimental and control groups.

Parameters	Treatment	Mean	SE	P-value
WBC ($\times10^{12}$/L)	Experiment	3.00	.577	0.000**
	Control	16.7	.622	
RBC ($\times10^{12}$/L)	Experiment	.52	.067	0.013**
	Control	.9	.057	
HGB (g/dL)	Experiment	3.2	.611	0.009**
	Control	6.9	.493	
PLT ($\times10^{9}$/L)	Experiment	23.3	.881	0.007**
	Control	16	1.154	

INDUSTRIAL EFFLUENTS INDUCED HISTOPATHOLOGICAL ALTERATIONS IN VARIOUS ORGANS OF MAJOR CARPS

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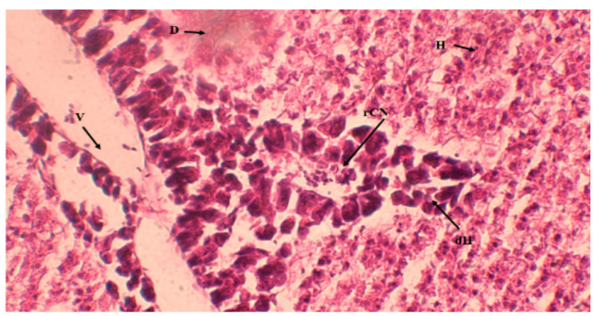
The objective of present study was to determine the effect of different concentrations of industrial effluents on water quality, growth performance and histology of major carps. LC_{50} for each species *Catla catla*, *Labeo rohita* and *Cirrhinus mrigala* were determined separately as 275.42 ml/L, 245.47 ml/L and 186.21 ml/L, respectively. Three sub-lethal concentrations of textile industries effluents were made as E-1 (1.5 %), E-2 (3 %) and E-3 (4.5 %) given to polyculture experimental groups in triplicates for three months.

Histopathological changes in the gill, kidney and liver of three species were observed. Histopathology of various organs showed maximum damage in the fishes of E-3 containing aquariums while E-1 and E-2 showed mild changes in the histology of organs. Gills were found to more damaged among all organs and muscles were least.



c. *Cirrhinus mrigala*

Figure. E-3 treated fish liver tissue showing vacuolization (V), damaged hepatocytes (dH) and ruptured central nucleus (rCN), hyperplasia (H), dysplasia(D). (Hematoxylin & Eosin stain, 40X.)

FACTORS INFLUENCING US CATFISH SUPPLIES

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As one of the most successful and established U.S. aquaculture sectors, the catfish industry has experienced notable fluctuations over the years. While there has been an overall upward trend in the farmer's price and production efficiency due to technological advancements and effective production strategies, the farming area has witnessed a noticeable decline over the last two decades. Yet the production volumes have stabilized over the last decade. This study investigated the factors influencing domestic catfish supply from farms. Using 25 years of supply data (Figure 1), this study focused on establishing a relationship between the round weight processed and various factors including feed prices, the area under farming, and macroeconomic indicators like soybean and corn mill prices, imports, population, inflation, and unemployment rates. This paradoxical situation called for a detailed study. A Trans-log generalized regression model indicated an inverse relationship between feed prices and the quantity of catfish supplied. Conversely, a positive relationship existed between the area under production and the quantity of catfish supplied, suggesting that increased production area boosted catfish production. Macroeconomic factors played a significant role as well; with population growth and inflation positively influencing the quantity supplied, as producers increase output to meet rising demand and counter inflationary pressures. The findings highlighted the influence of various micro and macroeconomic factors that shaped this vital US aquaculture sector.

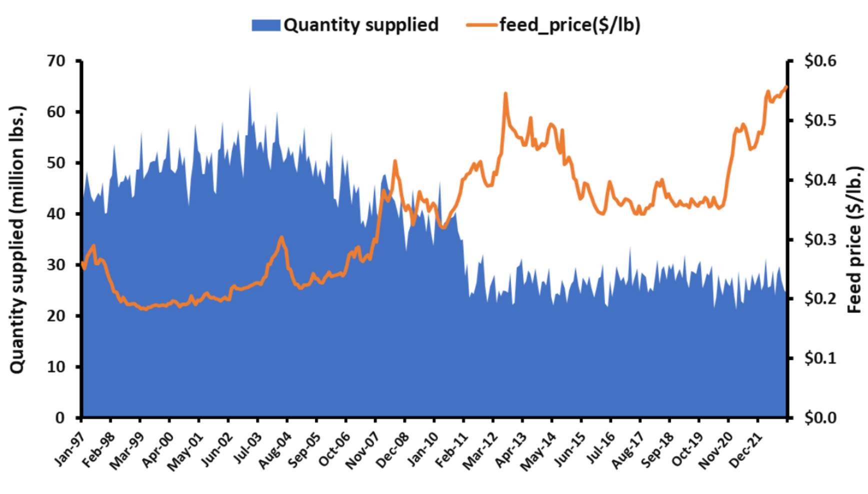

Figure 1: The trends for quantity supplied from catfish production and feed prices.

EXPLORING ELASTICITY PATTERNS AMONG MAJOR FINFISH PRODUCTS IN THE U.S. RETAIL MARKET

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This study utilized the AC Nielsen retail scanner data to present a comprehensive analysis of substitution patterns among various finfish products in the U.S. retail market. A weekly scanner data spanning 260 weeks from September 2016 to August 2021 was employed for this work. Previous studies have identified frozen and refrigerated fillets as the most common seafood products for major species such as salmon, tilapia, catfish, swai, and trout. We employed a non-linear Almost Ideal Demand System (AIDS) model for assessing the elasticity of demand and identifying substitution and complementarity relationships between these five major seafood categories. The detailed implications of these trends, revealing both complementarity and substitutability among the finfish categories, will be further explored in our presentation. The findings are critical for domestic aquaculture stakeholders as they help them position their products relative to other similar finfish products

CHARACTERISTICS OF U.S SEAFOOD CONSUMERS: PERSPECTIVES BASED ON HOME SCANNER DATA

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This study utilized AC Nielsen Home Scanner data to analyze consumer characteristics and their impact on seafood consumption in the United States. Weekly data spanning from January 2019 to June 2021 (130 weeks), encompasses purchasing information from 1,635 retail outlets, detailing over 7,500 UPC codes and 8000 different brands of seafood products. The demographic analysis of the data reveals insightful trends and patterns in seafood consumption across various household types. Sixty-six percent of the household consumers identified themselves as Caucasians, 19% as African American, 9% as Asian, and 6% represented other races. The majority (63%) of seafood-consuming households were married couples, while single female consumers account for 16%, and single male consumers for 6% (see Figure 1). Income distribution shows a concentration in the middle-income quintile, with more than half of the households earning around $81,800 in 2019. Within this group, 31% have incomes of $100,000 and above, while 23% earn between $70,000 and $99,999. Household size also plays a significant role, with 45% of households comprising two members and 22% with single individuals. Only 7% of households have children aged 13 to 17 years. Additionally, the educational background of the male household head is predominantly at least some college degree, with 26% having attended grade school and 24% holding post-graduate degrees. Interestingly, the female head age distribution showed an equal percentage of individuals aged 55-64 and those under 25. The data also suggested that high-income neighborhoods with predominantly Caucasians, married households with fewer children are prime targets for seafood consumption. This information is vital for targeted marketing strategies, potentially enhancing seafood sales in various cities. Further analysis using mixed logit models is proposed to estimate the impacts of consumer characteristics on seafood consumption more accurately. Such models will enable a deeper understanding of the factors driving seafood purchase decisions, providing a strategic edge to seafood marketers and industry stakeholders. This comprehensive approach to consumer analysis offers a path to optimizing marketing efforts and expanding seafood consumption across diverse demographic groups.

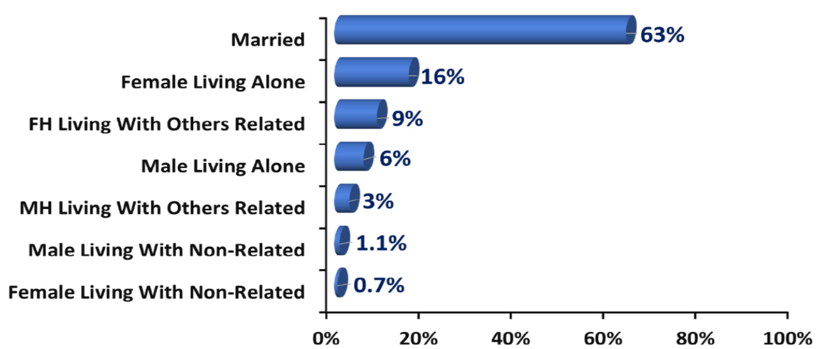

Figure 1: Frequency distribution of household composition.

RETAIL PRICE INDICES FOR MAJOR SEAFOOD SPECIES IN THE U.S. RETAIL MARKET

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Using AC Nielsen retail scanner data, this study provides an in-depth analysis of the price index for eight major seafood species in the U.S. retail market, encompassing both farm-raised (catfish, trout, and crawfish) and major imported species (salmon, tilapia, shrimp, oyster, and swai). By setting September 2016 as the base period, monthly price indices were calculated as a ratio of the current price to the base price, enabling an accurate reflection of market trends and price fluctuations over the past five years (Figure 1). Our findings reveal distinct trends across different species. Catfish experienced a significant upward price shift, primarily attributed to increased production costs and potential supply shortages. Trout demonstrated a steady yet gradual price increase, maintaining relative market stability. Among imported species, shrimp, salmon, and tilapia have shown relatively higher price stability, underscoring their increased supply. However, swai presented an unusual price trajectory with alternating increases and decreases, highlighting its unique market position. The study also uncovers distinct seasonal patterns in the pricing of oysters and crawfish, linked to their high natural seasonal aspects of production, growth, and harvest cycles. These patterns underscore the influence of supply and reliance on environmental factors on market prices. Farm-raised products such as salmon, tilapia, and shrimp - dominant global products with steady and continual supply, avoided high fluctuations in prices. However, the sectors that relied on forage (crawfish) and open coastal waters (mollusks) showed high fluctuations and seasonality of prices. This shows the importance of control over production processes. Major domestic aquaculture products such as catfish and trout reflected more dynamic market responses, sensitive to supply chain variations and complex market structures. Insights on retail price trends facilitate a nuanced understanding of market dynamics, vital for aquaculture farmers, processors, and other supply-chain members while providing clues for strategic market expansion.

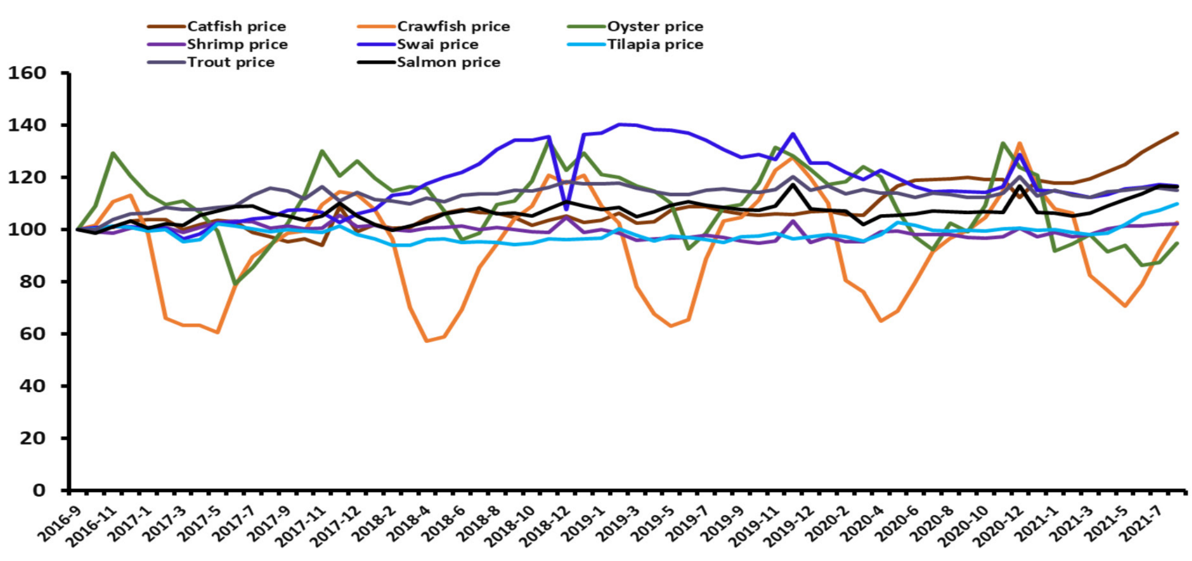

Figure 1: Price index for major seafood species over the past five years.

CREATIVE SOLUTIONS TO RISING ENERGY COSTS WHILE DRIVING FACILITIES TOWARDS ENERGY EFFICIENCY

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What began as an exercise in attempting to produce savings with rising energy costs in 2015, has turned into the Michigan Department of Natural Resources (DNR) - Fisheries Division - Fish Production Section being leaders in energy efficiency projects in Michigan's DNR and likely beyond. The intent of this presentation is to explore how we got here, what we have accomplished and where we are going with energy efficiency to mitigate global climate change.

EFFICACY OF A BACTERIAL BIOMASS AS A BIOACIVE COMPONENT OF PACIFIC WHITE SHRIMP *Litopenaeus vannamei* FEEDS

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Shrimp growth is a primary production consideration for good economic returns. Hence, there is considerable interest in developing diets that promote growth and survival. A number of bioactive feed components are supplemented in shrimp feed to improve feed intake and growth. NovaqPro® is a high ash low protein marine microbial biomass proven to improve *Litopenaeus vannamei* growth. The present study evaluated the effects of supplementing the bacterial biomass on feeding behavior, growth, and feed intake of juvenile *L. vannamei*. Six isonitrogenous (36% crude protein) and isolipidic (6% crude lipid) diets were prepared to include graded levels (0-20% of the diet) of the bacterial biomass. Diets were used in two growth trials, where 15 juvenile *L. vannamei* (0.27±0.01g and 0.58±0.02g, respectively) were size sorted and stocked in an indoors recirculating aquaculture system. Each diet was randomly assigned to five replicate tanks. In the second trial, two additional treatments consisting of providing the basal and the 10% bacterial biomass diets in excess (+15% of the standard ration), were added. Additionally, feed intake was assessed by offering shrimp one gram of "as is" feed, then siphoning leftovers after 30 minutes to calculate feed consumption. Feed intake was also assessed via passive acoustic monitoring of shrimp feeding behavior. Results of the present study suggest that the bacterial biomass can be supplemented at up to 20% of shrimp diets without significant effects on growth, survival, and FCR ($p>0.05$) (Table 1). However, when offered in excess, diets containing 10% bacterial biomass resulted in better growth, and FCR. Acoustics data support the growth results. Bacterial biomass as bioactive feed component promotes shrimp growth, and helps improve production and increase profit.

Table 1. Growth performance of *L. vannamei* (average initial individual weight 0.58 ± 0.02g) offered diets containing increasing levels of the bacterial biomass for 42 days (n=5).

Diet	Final biomass (g)	Final average individual weight (g)	Weight gain (%)	FCR	Survival (%)
Basal	86.03[b]	7.26	1206.20	1.63	80.00
2.5% bacterial biomass	100.80[ab]	8.03	1290.14	1.45	84.00
5% bacterial biomass	111.59[a]	8.21	1292.55	1.42	90.67
7.5% bacterial biomass	109.60[a]	7.88	1286.67	1.49	93.33
10% bacterial biomass	107.45[a]	8.57	1362.37	1.34	84.00
20% bacterial biomass	86.64[b]	7.75	1235.98	1.54	76.00
PSE*	5.21	0.34	60.66	0.07	5.47
p value	0.003	0.1742	0.5696	0.0990	0.2613

*Pooled standard error.

USE OF PASSIVE ACOUSTIC MONITORING TO EVALUATE THE EFFECTS OF A FEED EFFECTOR ON FEEDING BEHAVIOR, GROWTH PERFORMANCE, AND SALINITY STRESS TOLERANCE OF *Litopenaeus vannamei*

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Feed effectors can improve palatability of shrimp feed formulated with byproducts or high levels of plant proteins. Additionally, recent data suggests that feed effectors can positively influence shrimp survival, especially under stressful conditions. The present work evaluates the use of a chemosensory feed effector on the feeding behavior, growth performance, and salinity stress tolerance of juvenile *Litopenaeus vannamei*. Nine diets were formulated to contain either poultry meal (6%), or fishmeal (6% or 12%) as animal protein source, with feed effector supplemented at 0, 0.1, and 0.2%. The various diets were offered to naïve and non-naïve shrimp to evaluate feed consumption. Concurrently, shrimp feeding behavior was monitored using passive acoustic monitoring, a non-invasive technique that allows to study shrimp behavior without stressing the animals. Afterwards, a 42-days growth trial followed by a salinity stress test were performed to assess animal growth, survival, and stress tolerance as a response to the experimental diets. Results of the present study indicate significant positive relationships between the number of clicks and feed consumed after 30 minutes ($p < 0.001$, r=0.46 to 0.69). Additionally, the shrimp consumed poultry meal-based diets similarly to the fishmeal-based diets, only when supplemented with the feed effector. Interestingly, no significant differences were observed in terms of final biomass, final average individual weight, weight gain, FCR, or survival of shrimp offered the various test diet ($p > 0.05$). The salinity stress test indicated significantly better survival when offered diets supplemented with the feed effector, regardless of the level of inclusion. Results of the present work suggest that supplementing the feed effector to shrimp diets improves palatability and shrimp acceptance of diets formulated with poultry meal as sole animal protein source, as well as improves shrimp tolerance to salinity stress.

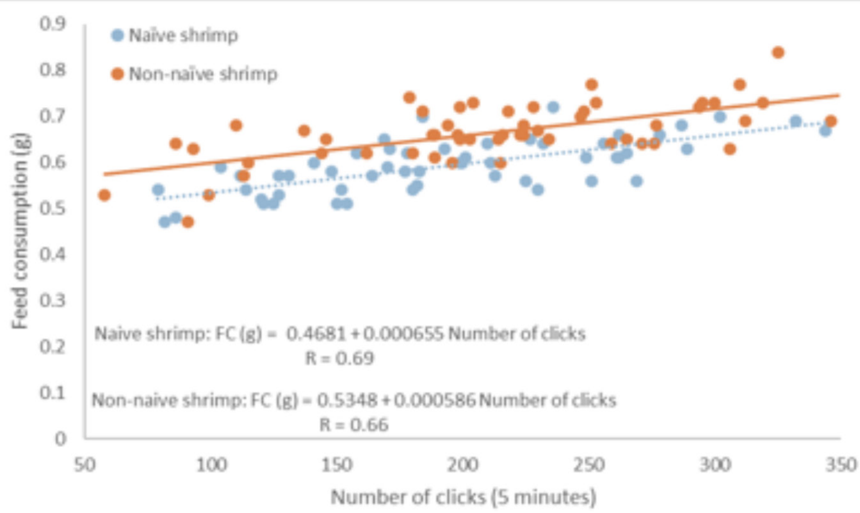

Figure 1: Linear regression between feed consumption (g) after 30 minutes and the number of clicks during the first 5 minutes for naïve and non-naïve shrimp. Data from all diets were pooled.

USE OF HYDROLYZED FEATHER MEAL AS PARTIAL REPLACEMENT OF SOYBEAN MEAL IN *Litopenaeus vannamei* DIETS

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In an era of limited resources, there is a need to use as many byproducts as possible to not only reduce cost but assist in balancing the nutritional profile of the feed. Hydrolyzed feather meal is a high-protein by-product, rich in sulfur-containing amino acids. If used in low animal meal diets, it can serve as an inexpensive source of amino acids, which contributes to decreasing the cost of production. The present study evaluates the use of various hydrolyzed feather meals as partial substitute to soybean meal in *Litopenaeus vannamei* diets. Eight isonitrogenous (35% protein) and isolipidic (5% lipid) diets were formulated. The basal diet includes 6% fishmeal and 49% soybean meal as proteins sources. The remaining seven diets were modifications of the basal diet, with hydrolyzed feathermeal with coagulated chicken blood (HFM-CCB; River Valley Ingredients, Tyson Food Inc.) or without blood (HFM-A; River Valley Ingredients, Tyson Food Inc) partially replacing soybean meal at 3, 6, and 9%, and another hydrolyzed feathermeal without coagulated chicken blood (HFM-B; River Valley Ingredients, Tyson Foods Inc.) replacing soybean meal at 6%. Fifteen juvenile *L. vannamei* were stocked in each of the 32 tanks of an indoors recirculating aquaculture system. Diets were randomly assigned to four replicate tanks. The experiment was performed for 42 days, during which the shrimp were offered feed manually four times throughout the day, and the feed ration adjusted on a weekly basis after shrimp count and survival assessment. The feed ration was based on a standard feeding protocol of the laboratory that assumes the shrimp will double in weight until 0.8g is reached, then will grow by 0.8g per week for the rest of the experiment. The expected FCR used in the present experiment was 1.8. At termination, shrimp were counted and group weighed to assess survival, growth, and FCR. Subsequently, four shrimp from each tank were preserved and later analyzed for whole body proximate composition. Results of the present study suggest that up to 9% of soybean meal can be replaced with hydrolyzed feathermeal (with or without coagulated blood) without significant effects on shrimp growth or survival. Shrimp offered the various diets had an average final individual weight of 5.60g, and the overall survival among treatments was around 81%. However, significant yet limited differences were observed in terms of FCR and apparent net protein retention among treatments ($p<0.05$). Shrimp offered the 9% HFM-CCB diet had a significantly bigger FCR (1.47) than other shrimp offered the remaining diets. Shrimp offered 3% HFM-A diet had the smallest FCR among treatments (1.30). Similarly, shrimp offered the 9% HFM-CCB diet retained significantly less protein than the remaining shrimp (ANPR = 31.01%). Hydrolyzed feathermeal can serve as an inexpensive nutritious ingredient for shrimp diets. Low animal protein shrimp diets formulated with hydrolyzed feathermeal ensure good shrimp growth by providing essential amino acids without the need for supplementation.

EVALUATION OF THE USE OF PHYTOSTEROLS AS A PARTIAL SUBSTITUTE FOR CHOLESTEROL IN PACIFIC WHITELEG SHRIMP *Litopenaeus vannamei* DIETS

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Cholesterol is a critical nutrient in shrimp as they cannot synthesize it and it is found in limited levels in animal-based ingredients. Hence it is an important yet extremely expensive supplement in shrimp diets. Alternatively, phytosterols are sterols of similar chemical structure to cholesterol but less expensive as they can be isolated from plants. Use of phytosterols in low-animal protein shrimp feeds could help decrease the cost of feed production and expand our use of alternative ingredients. Therefore, the aim of the present work was to evaluate the use of a phytosterol (CardioAid®, ADM, Chicago, IL) as partial replacement of cholesterol in juvenile *Litopenaeus vannamei* diets. The basal diet was formulated to be deficient in cholesterol, but otherwise designed to meet the nutritional requirements of *L. vannamei*. The basal diet was systematically supplemented with increasing levels of cholesterol (0.04, 0.08, 0.10, 0.12, and 0.16%) or phytosterols (0.04, 0.08, 0.10, 0.12, 0.16, and 0.20%), resulting in a total of 12 diets. Afterwards, 15 juvenile *L. vannamei* (average individual weight 0.51 ± 0.012 g) were stocked into each tank of an indoors recirculating aquaculture system. Diets were randomly assigned to five replicate tanks for the duration of the trial (6 weeks), during which shrimp were offered feed manually four times a day. Feed ration was determined using a standardized feeding table that assumes weekly shrimp growth with an assumed feed conversion ratio (FCR) of 1.8. At termination, shrimp in each tank were counted and group weighed to determine survival, weight gain, and FCR. Hemolymph was collected from four shrimp per tank, and the remaining shrimp frozen for subsequent analysis. Results of the present experiment indicated significant differences in terms of growth, survival, and FCR among treatments. Shrimp offered feed containing 0.16% cholesterol and 0.20% phytosterols exhibited the biggest average individual weights (7.13and 6.62g, respectively). Additionally, shrimp offered the basal diet and 0.04% phytosterol diet exhibited significantly lower survival than remaining shrimp (68 and 74.67% survival, respectively). Moreover, FCR was significantly influenced by dietary treatments, as shrimp offered the basal diet and 0.04% cholesterol had a significantly higher FCR than shrimp offered the rest of the diets. Shrimp offered the 0.16% cholesterol diet had the lowest FCR among treatments (1.30). Furthermore, serum cholesterol analysis demonstrated significant differences among treatments in a dose response fashion. Shrimp offered the basal diet had significantly lower levels of cholesterol than those offered 0.04% or higher. However, shrimp offered phytosterol diets exhibited a larger variation in serum cholesterol. In conclusion, phytosterol can be a viable cost-effective alternative to cholesterol in practical shrimp feed, despite having a slightly lower bioavailability than cholesterol.

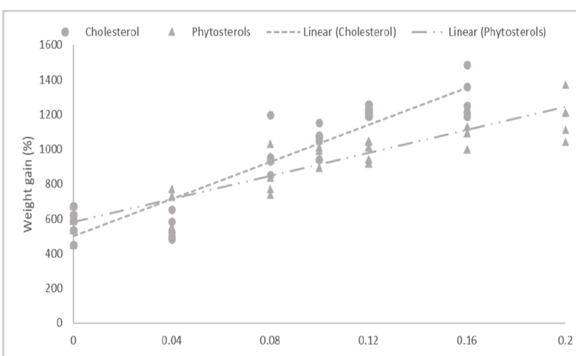

Figure 1: Growth response of juvenile *L.vannamei* offered diets containing increasing levels of cholesterol or phytosterols for 42 days (n=5).

BLACK SOLDIER FLY FRASS AS PARTIAL SUBSTITUTE FOR SOYBEAN MEAL IN CHANNEL CATFISH *Ictalurus punctatus* DIETS

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The need for alternative, sustainably produced feed ingredients encourages the incorporation of insect meals and by-products in fish feed. Black soldier fly by-products are excellent fish feed ingredient candidates as they contain adequate proteins and lipids and are sustainably produced. The present study evaluated the growth performance of black soldier fly frass as a partial substitute for soybean meal in channel catfish diets. Three experimental diets were formulated to include a commercial black soldier fly frass at 0, 7.5, and 15%. Afterward, 50 *Ictalurus punctatus* fingerlings (average initial individual weight = 3.04 ± 0.07 g) were stocked into 15 glass aquaria within an indoor recirculating aquaculture system. Diets were randomly assigned to five replicate tanks, and the catfish were fed to apparent satiation on a dry weight feed basis by feeding at a set percentage of biomass. The fish were weighed biweekly, and the feed ration was adjusted accordingly. The feed ration was increased by 1-2% of the biomass on weeks when the fish were not weighed. At termination, fish were group-weighed and counted to evaluate growth and survival. No significant differences were observed among treatments in terms of final biomass, final average individual weight, weight gain (%), and survival (P>0.05) (Table 1). However, fish offered 7.5 and 15% black soldier fly frass in their diets had significantly smaller FCR than fish offered the basal diet (1.40 and 1.46 for 7.5 and 15% black soldier fly frass respectively, compared to 1.58 for the basal diet). Results of the present study suggest that black soldier fly frass can be effectively used as a partial substitute for soybean meal in channel catfish diets without adverse effects on growth or survival. Black soldier fly frass can be used as a sustainably produced, nutritious, and environmentally friendly feed ingredient for channel catfish feed.

Table 1. Growth performance of *I. punctatus* fingerlings (average initial individual weight = 3.04 ± 0.07 g) offered diets containing increasing levels of black soldier fly frass for 84 days.

Diet	Final biomass (g)	Final average individual weight (g)	Weight gain (%)	FCR	Survival (%)
Basal	2166.6	43.50	1312.26	1.58[a]	99.60
7.5% Black soldier fly frass	2152.9	43.97	1384.92	1.40[b]	98.00
15% Black soldier fly frass	2195.2	44.07	1330.53	1.46[b]	99.60
PSE[*]	66.3973	1.3656	43.3564	0.0297	0.6110
P value	0.9006	0.9527	0.4889	0.0033	0.1442

[*]Pooled standard error.

EXPANDING AQUACULTURE AND HEALTHY FOOD CHOICES TO REDUCE ECONOMIC AND HEALTH DISPARITIES AFFECTING MINORITY AND LIMITED-RESOURCE STAKEHOLDERS

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The advent of the COVID-19 pandemic has brought about a surge in global economic, health, and food insecurity, thereby aggravating the health and economic welfare of minority and limited resource communities. This intensified the urgency for local access to food for socially disadvantaged communities, and it highlighted the need for self-sufficiency in local food production. In a bid to stimulate local food production and to increase economic opportunities for rural and small businesses, a Tilapia Capacity Building Project (2021-2024) was developed at Kentucky State University (KSU) to methodically diversify Kentucky food products and to provide economic opportunities for small-scale farms to integrate Nile Tilapia fish with superior growth performance into production. The project is comprised of four main areas: (i) genetic improvement of Nile Tilapia, (ii) demonstration of on-farm growth, (iii) development of resources for marketing and sales of locally produced Nile Tilapia, and (iv) production of resources for human nutrition and healthier living for training and education of field Extension agents and seafood consumers. The project is in its third year of implementation, and the four major objectives have had varying degrees of progress and challenges. The Genetically Improved Farmed Tilapia has been maintained and propagated at KSU, but there is still a need to work on the import of YY males to produce fish for on-farm demonstrations, and marketing and sales work. However, major progress has been achieved in human nutrition. This has included training and education of students (high school, undergraduate, graduate) and Extension personnel on Genetics, Reproduction, and Aquaculture of Nile Tilapia, including methods of preparation for cooking and eating in a healthy manner (Figure 1).

Figure 1. Farm to Table Chef demonstrates healthy cooking of Nile Tilapia in Fayette County, KY.

SENTIMENT ANALYSIS OF SHRIMP AND SALMON USING ONLINE CHATTER

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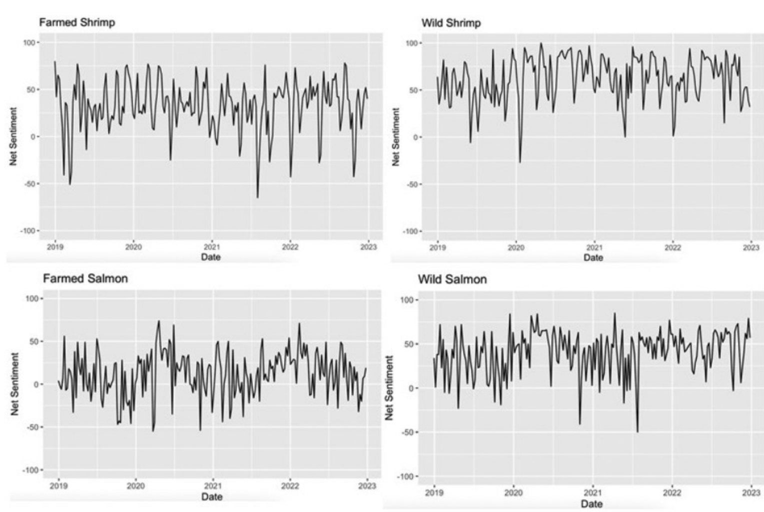
Seafood, especially farmed seafood is getting more attention to meet the increasing seafood demand. Meanwhile, online chatter about seafood and aquaculture shows an array of opinions, positive and negative, suggesting growing interest in where people's seafood comes from. This study analyzes online media opinions to assess consumer seafood sentiments and perceptions relating to salmon and shrimp. This study focuses on shrimp and salmon because they are two top-selling species and the most consumed seafood that also garner considerable attention online. Such analysis could give insights into potential demand signals for the species.

NetBase®, an online media listening platform, was utilized to quantify online and social media chatter regarding U.S. seafood during a 48-month period, January 2019 through December 2022. We utilized the Internet of Things (IoT) and data analytics approaches to examine national online information about shrimp and salmon and compare farm-raised and wild-caught separately. Search hits and mentions were quantified for top sources, domains, and prevalent terms. In addition, sentiment drivers and sentiment values were identified using natural language processing tools. Our findings revealed a consistent tendency for farmed shrimp and salmon to exhibit lower net sentiments compared to their wild counterparts during the study period (Figure 1). The exception, when the net sentiment of wild seafood was below that of farmed seafood, was usually linked with the topic of climate change.

When data are disaggregated into census regions, public attitudes toward both farmed shrimp and salmon in the East North Central have a greater net sentiment on average. Whereas the New England and Middle Atlantic have a lower net sentiment for farmed shrimp and salmon respectively. Public sentiments in East South Central and Middle Atlantic are characterized by higher variability for farmed shrimp and the East North Central and New England regions exhibit greater sentiment variability for farmed salmon.

Figure 1: Weekly Net Sentiment Trends for Shrimp and Salmon



THE COMMERCIAL OYSTER AQUACULTURE SECTOR TRAINING (COAST) PROGRAM

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One of the hurdles for a sustainable off-bottom oyster aquaculture industry, not only in the northern Gulf of Mexico but across the United States, is limited availability of skilled employees. As such, workforce development has become a primary initiative throughout the industry.

In 2023, the Commercial Oyster Aquaculture Sector Training (COAST) program for the northern Gulf of Mexico was launched. This program is a workforce development initiative aimed to recruit workers to the oyster aquaculture industry and provide them with training to meet industry demand. Current funding allows for the teaching of 10 apprentices over the course of two years in various aspects of oyster farming, including production and rearing, business management, food safety, and serving. Participating businesses from Alabama and Mississippi receive a portion of the apprentice's wages to support training efforts.

This presentation will provide a one-year update on the COAST program, including plans for program development and enhancement (Fig. 1), general logistics, business and apprentice recruitment, an update on participants, and challenges encountered.

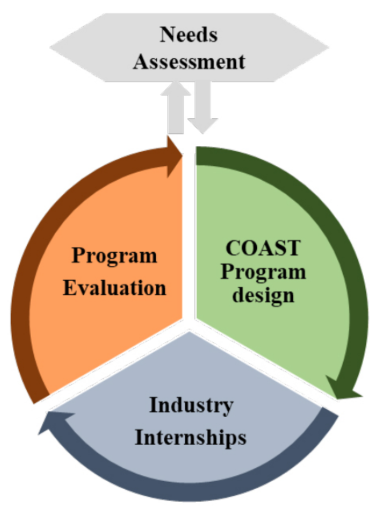

Figure 1. Outline for COAST Program development and enhancement.

2023 TALE OF THE KENTUCKY STATE UNIVERSITY UNITED STATES AQUACULTURE SOCIETY STUDENT SUBUNIT

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The KSU USAS Student Subunit embarked on a number of activities. This included invitation of guest speakers to address members of the subunit on new technologies in aquaculture production, and how these technologies could be used for effective output maximization in the aquaculture industry. The members of the subunit were educated on the use of drone technology, and its application in aquaculture. There was barbecue during the seminars, and high members and guest speaker interaction. The subunit conducted elections for new executive leaders (Figure 1A). We had a field trip to the water quality department of the Louisville Zoo to learn about their operations (Figure 1B). A seminar on oyster production by a notable oyster producer from New York (The East Hampton Town Shellfish Hatchery) was special because members had little or no experience in this area (Figure 1C). We participated in fish processing and short video production activities to encourage healthy cooking for healthy living especially for socially disadvantaged Kentuckians as part of a Tilapia Extension Capacity Building Project. This activity was presented in the poster session of Aquaculture America 2023 in New Orleans with the topic ‘Encouraging Healthy Lean Protein Choices from Local Farmed Based Tilapia Through the Development of Educational Videos for Virtual Platforms,’ and the presenter, Mr. Oluwafemi Adebayo, received the

Figure 1. Images in order from top to bottom: (A) New Executive officers, (B) Louisville Zoo Visit, and (C) members at the first 2023 presentation on Oysters organized by Vice-President, Ashton Schardt.

INTEGRATING AQUACULTURE IN AND OUTSIDE THE CLASSROOM THAT SUPPORTS STEM EDUCATION

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This study explored the impact of an active aquaculture project-based learning program, as perceived by high school students. The purpose of this case study was to discover if participation in the program influenced students' interest, engagement, and future educational and career aspirations in science, technology, engineering, and mathematics (STEM) when integrating aquaculture in, and outside, the classroom. Likewise, the study also wanted to explore students' knowledge about aquaculture and skill development after their participation in the program.

The study employed a qualitative methods approach to explore students' attitudes and experiences. Qualitative data were collected from post student focus groups at three different public high schools in Kentucky. Other qualitative data included teacher journal reflections and public newspaper article. Four emergent themes were found: 1) students show excitement and enthusiasm in the hands-on, aquaculture program; 2) students show attention to detail in the hands-on, aquaculture tasks, it sticks, and are more responsible; 3) students are collaboratively engaged with their peers; and 4) Greater interest and confidence in STEM through practical application.

Results demonstrated that the program engaged learners in real-world problem solving and decision-making situations while working collaboratively in small works. Students also gained an important life skill - responsibility - as well as self-confidence in STEM, after participating in the program.

NUTRITIONAL VALUE OF AN AQUEOUS-PROCESSED CANOLA PROTEIN CONCENTRATE FOR ATLANTIC SALMON: DIGESTIBILITY AND GROWTH PERFORMANCE

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Canola, the world's second most produced oilseed crop, has a great potential to be a major protein ingredient in aquafeeds due to its high nutritional values and good amino acid profile. Recent advances in aqueous processing have enabled the scalable production of environmentally friendly and nutrient-rich canola protein concentrate (CPC: 75.8% crude protein, 4.4% crude lipid). The objectives of this study were to 1) determine the nutrient digestibility of CPC; and 2) evaluate the effects dietary inclusion levels of CPC on Atlantic salmon growth performance, feed efficiency, nutrient utilization, gut histology and fillet color.

Two digestibility trials using settling column and stripping method were conducted for juvenile (57.3 ± 6.7 g) and post-smolt (227.7 ± 4.1 g) Atlantic salmon, respectively. The results demonstrated that the nutrients in CPC were well digested by Atlantic salmon, with mean apparent digestibility coefficients for crude protein, crude lipid and essential amino acids of 87.1, 93.3 and 81.5-97.0% for juvenile fish and 95.7, 90.9 and 93.9-98.0% for post-smolt fish, respectively. In a long-term growth study, eight experimental diets containing 0% (Diets A, E), 10% (Diets B, F), 15% (Diets C, G), and 20% (Diets D, H) CPC were formulated to mimic commercial salmon feeds in different geographies: Americas-style diets (A through D) contained processed animal protein (PAP), whereas Europe-style diets (E through H) did not include PAP. Each diet was randomly allocated to triplicate groups of 33 fish (228.0 ± 4.9 g) per 750-L tank. Fish were hand-fed to apparent satiation for 168 days. The result showed that thermal-unit growth coefficient and feed intake were comparable between treatments (Table 1). 10% CPC inclusion was optimal for feed conversion ratio. There was no significant difference in final whole-body composition or nutrient retention among treatments. Increased dietary CPC inclusion from 0-20% resulted in positive associations with intestinal villi length and fillet redness value. In conclusion, CPC is a highly digestible nutrient-dense ingredient that can be safely included in Atlantic salmon diets up to at least 20%.

Table 1. Initial body weight (IBW), final body weight (FBW), weight gain (WG), feed intake (FI), feed conversion (FCR), thermal-unit growth coefficient (TGC) and survival of Atlantic salmon fed experimental diets containing graded levels of canola protein concentrate (CPC) using either American or European formula for 168 days. Data are means ± SEM. Means within a column with no superscript in common differ significantly ($P<0.05$) based on two-way ANOVA followed by Tukey test.

Treatment		IBW	FBW	WG	FI	FCR	TGC	Survival
Formula	CPC	(g fish^{-1})	(g fish^{-1})	(g fish^{-1})	(g fish^{-1})		[g$^{1/3}$ (ºC d^{-1})]	(%)
Americas	0	228.2 (3.2)	972.4 (29.6)	744.2 (26.5)	779.8 (26.0)	1.05 (0.00)^{ab}	0.160 (0.004)	93.9 (0.0)
Americas	10	223.6 (2.0)	961.8 (48.5)	738.1 (46.6)	757.2 (42.3)	1.03 (0.01)^{b}	0.160 (0.006)	100.0 (0.0)
Americas	15	228.3 (1.6)	916.7 (44.6)	688.4 (43.0)	744.0 (46.0)	1.08 (0.01)^{a}	0.152 (0.006)	100.0 (0.0)
Americas	20	228.5 (0.9)	920.7 (30.2)	692.2 (31.1)	744.6 (24.6)	1.08 (0.02)^{a}	0.152 (0.004)	100.0 (0.0)
Europe	0	230.1 (6.6)	863.8 (44.9)	633.7 (38.5)	668.1 (46.5)	1.05 (0.00)^{ab}	0.143 (0.005)	89.9 (6.1)
Europe	10	227.5 (2.7)	946.5 (16.0)	718.9 (13.9)	753.1 (15.5)	1.05 (0.01)^{ab}	0.156 (0.002)	99.0 (1.0)
Europe	15	230.3 (2.0)	913.6 (19.0)	683.3 (17.6)	734.4 (14.4)	1.08 (0.01)^{a}	0.151 (0.002)	100.0 (0.0)
Europe	20	227.7 (1.6)	908.6 (16.8)	680.9 (16.3)	728.6 (12.2)	1.07 (0.01)^{ab}	0.151 (0.002)	100.0 (0.0)
Two-way ANOVA (P-value)								
Formula		0.4357	0.1630	0.1205	0.1321	0.7335	0.0604	0.6577
CPC		0.6104	0.5950	0.4777	0.8028	0.0033	0.1769	0.0004
Formula x CPC		0.8912	0.3839	0.3260	0.3035	0.4297	0.0769	0.9356

FACILITY SHOWCASE: THE RIVERENCE GROUP

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Riverence is a group of privately-owned aquaculture companies based in Washington and Idaho. Great seafood means wholesome fish, raised sustainably and ethically, that's within everyone's reach. But fish is more than food. It's well-being, resilience, identity—for people and the planet. Riverence is here to conserve wild fish while satisfying demand for delicious seafood. How do we do it? Through mindful breeding, sustainable land-based production, efficient distribution, and the development of industry-leading technologies.

- Our farms are located in the Magic Valley, named for its water resources and the transformative effect they've had on life in Southern Idaho. Water is the reason we're in Idaho and the reason for our success.
- By maintaining our own genetics, we protect our seedstock supplies now and into the future. Riverence fish are robust, resilient, and bred for success—and shaped by our own hands.
- Our production farms, located along the Snake River, have the capacity to produce 35 MM pounds fish every year. Our centrally located processing facilities produce a range of cuts to satisfy the needs of a diverse market. Together with several value recovery operations, we ensure nothing our farms produce goes to waste.
- Seafood is one of the most perishable products, and carefully controlled cold chain and distribution is key to ensuring our products meet customers and their expectations. By managing our own fleet of refrigerated trucks and driver teams, Riverence can consistently deliver quality, nationwide from egg to plate.
- When you know better, you do better, and Riverence recognizes the power of rigorous scientific inquiry and the importance of evidence-based decision-making. Our scientific portfolio emphasizes applied science and is solutions-oriented, but it is more than a response to current pressures—the initiatives addressed by our Lab Services and R&D team are forward-looking and intended to help us shape the future of aquaculture in the USA and beyond.

Water resources, genetics and breeding, farming and processing, distribution, science and innovation—Riverence is all of this, but more than the sum of these parts. This presentation will provide an overview of the Riverence group, its facilities and operations, and current professional development and career opportunities.

CREATION OF A COMPREHENSIVE OPEN-SOURCE MANUAL FOR THE RESTORATIVE AQUACULTURE OF THE PURPLE URCHIN *Strongylocentrotus purpuratus*

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Purple sea urchin *Strongylocentrotus purpuratus* populations have increased dramatically along the west coast of the United States, resulting in areas known as "urchin barrens" with little to no kelp due to grazing pressure. Concurrently, ocean warming and marine heat waves have further stressed kelp populations. These factors have contributed to a >95% decline in bull kelp *Nereocystis luetkeana* forests off the Northern California coastline since 2014. These habitats are critical to supporting California's coastal ecosystem and fisheries.

Urchin roe, or uni, is a high-value food item for which there is a global shortage and high demand. Urchins in barrens can persist for decades without food and are left with inedible gonads. Establishing an aquaculture industry to remove adult urchins from the wild to enhance and sell their roe incentivizes the restoration of both the kelp forests and local urchin fishing communities which have been in decline since the contraction of the red urchin *Mesocentrotus franciscanus* fishery in the 1990s.

Over the past 5 years, we conducted a series of experimental ranching trials to test the feasibility of and develop techniques for roe enhancement, also known as urchin ranching. Based on this experience, we created a manual intended to jump-start the ranching industry and help future urchin ranchers quickly develop and scale their businesses. It is focused on practical applications of the existing literature and recommendations for aquaculture system design, collection, transportation, maintenance, feeding, and managing urchin health, growth, and mortality. Additionally, it details the design of a low-cost urchin ranching bin system using readily available materials which we developed to further facilitate the adoption of urchin ranching. Rather than a definitive rulebook, this manual serves as a best practices guide that mitigates the risk shouldered by ranchers developing a novel restorative aquaculture industry by identifying key points of failure in the ranching process. It will also be available online as a living document that is continually updated as insights from future research trials and commercial-scale operations are gathered and tested. Given that urchin barrens can occur in many areas globally, this manual may also serve as a useful reference for urchin ranchers working to solve the urchin barren problem with other species around the world.

INCREASING ACCESSIBILITY TO INNOVATIONS IN AQUACULTURE TECHNILOGY AND EDUCATION THROUGH VIRTUAL TOURS

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To meet the demands of the aquaculture industry's workforce development and consumer education, we are leveraging virtual technology through UMaine's Cooperative Extension 4-H, Center for Cooperative Aquaculture Research, the Aquaculture Research Institute, and Maine Sea Grant. Through virtual tours, we aim to enhance educational accessibility, diversify learning experiences, and broaden career opportunities in the seafood sector. For instance, communities in rural Maine lack coastal access, hindering exposure to the seafood industry even though Maine's seafood industries are growing expoentially. Our virtual tours, encompassing various seafood organizations and emerging technologies, bridge this gap not only for local communities but on a national and potentially a global scale. These tours, covering land-based RAS, net pen, shellfish, and seaweed culture, provide insights into career paths and combat misinformation by educating consumers. The ultimate goal is to break down entry barriers into the aquaculture industry and facilitate widespread access to quality education for learners and educators alike. Additionally, these virtual technologies will revolutionize knowledge/skill acquisition and assessment methods for learners of all ages with realtime response to industry needs.

CELLULOSE NANOMATERIALS: A NOVEL ADJUVANT AND DELIVERY SYSTEM FOR AQUACULTURE VACCINE APPLICATIONS

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Disease outbreaks are a major impediment to aquaculture production and are forecasted to continue as the industry grows and the climate warms. Vaccines are integral for disease management in aquaculture but they can be expensive, vary in effectiveness, and come with adjuvant-induced adverse effects causing fish welfare issues and negative economic impacts. The goal of this interdisciplinary project is to develop a new generation of vaccines for sustainable aquaculture. Our project uses novel nanomaterials produced from renewable wood fiber as depots/adjuvants in vaccine formulations to modulate the immune response of Atlantic salmon in a biocompatible, environmentally friendly, and cost-effective manner.

Our interdisciplinary research team is elucidating the role of cellulose nanomaterials (CNM) as a vaccine depot and mobile immunostimulant, the extent of CNM migration *in vivo*, and the efficacy of CNM bound antigen as an immunostimulant for protection against two Atlantic salmon pathogens. To accomplish this, we have prepared and conducted *in vitro* characterizations of CNM shear-thinning hydrogels and CNM/antigen (vaccine) formulations by scanning electron microscopy and rheology of CNM variants (CNM) and *in vivo* migration using histopathology. Additionally, we assessed safety/toxicity and immunogenicity of CNM shear-thinning hydrogel formulations *in vivo* as a vaccine depot in Atlantic salmon by quantifying the antibody kinetics in vaccinated fish serum using enzyme-linked immunosorbent assays and gene expression. The next phase of our work will involve conducting *in vivo* studies to evaluate the efficacy of the CNM vaccine(s) in protecting against *Vibrio anguillarum* in Atlantic salmon by performing a pathogen challenge study.

Our results to date will be reported and discussed.

EVALUATION OF VARIOUS CONCENTRATIONS OF A PROTEASE COMPLEX FEED ADDITIVE IN LOW-SALINITY CULTURE OF *Litopenaeus vannamei*

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Protease feed additives have been proven to improve digestibility and obtain improved growth while using less protein in aquatic feeds. Some of these protease complexes have been shown to have immunostimulant effects that significantly improve growth performance, survivability, and disease resistance in many commercially important aquaculture species. However, with the variety of available immunostimulants, differing feed preparation methods, and diversity of finfish and invertebrate species grown commercially, there is still the potential to optimize which concentrations of proteases would yield the most efficient, biologically beneficial, and cost-effective growth. One of the most economically important and versatile aquaculture species is the Whiteleg shrimp *Litopenaeus vannamei*, known to tolerate salinities between 0.5 and 40 ‰.

To evaluate growth, physiological, and immunological parameters of *L. vannamei* fed a diet containing differing amounts of a protease complex under low-salinity culture conditions, 360 shrimp (mean ± SD = 0.35 ± 0.03 g) were stocked equally into a low-salinity recirculating system consisting of 24, 67-L tanks. Four treatment diets were formulated, each containing 35% protein, 8% lipid, and 27% carbohydrates. Three of the four treatment diets contained 131, 175, and 208 mg/kg of Jefo's AG-175 protease complex. Each treatment diet was fed to shrimp in six replicate tanks, four times daily, for six weeks. Final biomass, final individual weights, feed conversion ratios (FCR), and weight gains were compared. Physiological parameters including hemolymph osmolality, hemolymph ion concentrations, whole body proximate analysis, and intestinal histology were evaluated. Immunological parameters such as hepatopancreas gene expression and intestinal microbiota were analyzed. There were no differences in final individual weight (P = 0.0975) or weight gain (P = 0.2849) between treatments. There were differences in FCR (figure 1) between treatments. Physiological and immunological results will be presented. The findings of this comprehensive study will determine which concentration of the AG-175 protease will yield the most effective growth in low-salinity *L. vannamei* culture.

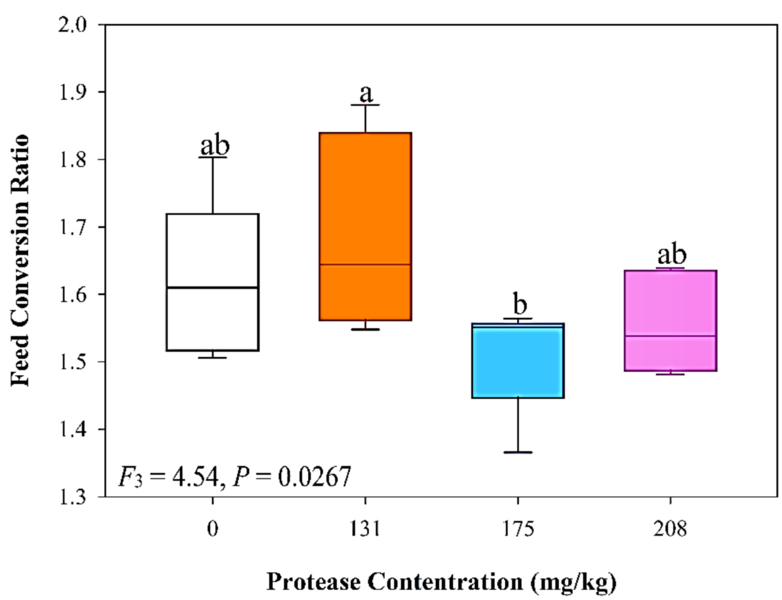

Figure 1: Feed conversion ratio (FCR) comparisons between treatment groups containing different protease AG-175 concentrations, using one-way analysis of variance test. Solid boxplot lines designate mean. Different letters indicate significant differences at $p < 0.05$.

IMPACT OF VARIED DROUGH PERIODS ON CAPSAICIN CONCENTRATION IN EARLY JALAPEÑO, *Capsicum annuum,* cv. EARLY JALAPEÑO GROWN IN AQUAPONIC SYSTEMS

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Consumption of spicy peppers in the U.S. has increased 133% over the past 40 years, with domestic production declining by 50% over the same period; being the principal causes: trade agreements, labor availability, new crop introduction and significant water issues in the main chili producer states like New Mexico and California. This leads to the necessity to improve the water usage and enhance pepper quality regarding capsaicin concentration, the main alkaloid responsible for the spicy sensation in hot peppers. This compound can represent up to 1% of dry weight is more concentrated during periods of drought stress. As in most aquaponics systems there is a constant water supply, it is hypothesized that this can lead to poor concentration of this compound. The aim of this study was to determine whether the concentration of capsaicin varies within fruits of Early jalapeño peppers subjected to different irrigation periods in a media-based aquaponic system. The study took place between the months of September and December in the Kentucky State University aquaculture facility greenhouse. The system was composed of 250-gal fish tank, a 60-gal sump, two 30-gal biofilters and 9 media-based troughs. Additionally, four complementary LED lights (Neosol DS) were placed at an average PAR of 300 PPFD for a period of twelve hours every day. Nutrients were provided by Koi fish, daily fed 190g of 36% protein Rangen feed. Initial individual average weight was 250g with a total stock density of 12.35 kg/m^3. This study evaluated three different drought periods 2h, 4h and 6h, each with three replicates and three early jalapeño plants per replicate. Fruits were harvested at botanical maturity and classified into nine combined samples (one per replicate). Treatments were compared based on total plant biomass (g), quantity and weight of peppers (g), and concentration of capsaicin. The 2-hour treatment showed significant differences in height and number of fruits compared to all other treatments, and only in number of flowers between 6-hour treatment. All parameters didn't show statistics differences between 4-hour and 6-hour treatment. Results regarding nutritional analysis and root to shoot ratio will be shown at the presentation.

TABLE 1. *LSD All-Pairwise Comparisons Test of height, flowers and peppers by Trt.*

Variables	2-hr	4-hr	6-hr
Plant height (cm)	$74.75 \pm 5.96_{a}$	$60.82 \pm 3.71_{b}$	$49.30 \pm 5.91_{b}$
# flowers	$10.44 \pm 7.52_{a}$	$6.78 \pm 3.23_{ab}$	$2.22 \pm 4.02_{b}$
# fruit	$2.00 \pm 2.12_{a}$	$0.11 \pm 0.33_{b}$	$0.11 \pm 0.33_{b}$

SETBACKS AND PROGRESS IN CULTIVATING RIBBED MUSSEL (*Geukensia demissa*)

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Ribbed mussel, (*Geukensia demissa*), can be found, usually in dense clumps, along the coastlines where salt marsh habitat exists. They are an important species for this habitat and have a mutualistic relationship with the marsh cord grass (*Spartina alterniflora*). The value and importance of salt marsh habitat is becoming even more prevalent due to rising sea levels and coastal erosion due to the magnitude and frequency of storms. Marsh restoration is fairly common, but it lacks the ability to incorporate the ribbed mussel into the restoration projects.

Shellfish aquaculture typically focused on species that were consumed and since ribbed mussel are generally considered inedible, they were not a species that were of interest in being cultivated. For that reason, the consistent and reliable methods for culture have not been thoroughly developed. Pilot level cultivation efforts were explored at the Aquaculture Innovation Center for Rutgers University. These efforts had some success in providing ribbed mussel seed for shoreline restoration projects that were being conducted by the Partnership for the Delaware Estuary. It was during this work that the "Bin-Silo Method" was developed as a spawning technique by Landau (2014) to overcome various issues for spawning shellfish species, including ribbed mussel.

The traditional method of thermal cycling to induce spawning of the ribbed mussel was found to have minimal success. Numerous attempts using the "Bin-Silo Method" and allowing the broodstock to be thermally shocked and then slowly cooling down overnight, has yielded relatively consistent spawning opportunities. The successful cultivation practices for the ribbed mussel follow a similar process to other shellfish culture but there are adjustments that must be made due to the presence of the byssal threads and the mobile behavior of the juvenile seed. The larval stage is similar to oyster where eyespots are developed prior to metamorphosis into the pediveliger stage. The downwelling stage is consistent with oyster and clam, however, at a size of approximately 300-400μm, the juveniles become highly mobile and migrate up to the waterline. This behavior makes the remaining grow-out stages different from that of oyster and hard clam.

While working to refine the methodology for consistently producing ribbed mussel, several hatchery staff members from different organizations began discussing their findings and decided to work together. The Ribbed Mussel Aquaculture Collaborative (RMAC) is a partnership that was developed to share methodology and for collaboration to pursue the ongoing desire to reliably produce ribbed mussel for various projects in different regions. RMAC includes staff from New York Sea Grant, Cornell Cooperative Extension of Suffolk County, CUNY Baruch, Martha's Vineyard Shellfish Group, and the Aquaculture Innovation Center for Rutgers University.

GREAT LAKES AQUACULTURE DECISION MAKER'S DAY: AN EVENT BRINGING STATE LEGISLATORS TO MEET WITH AQUACULTURE FARMERS & TOUR A FARM

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The aquaculture industry in New York encompasses a wide array of operations that stretch from the Great Lakes watershed to the surrounding marine waterbodies of Long Island. Current operations are producing freshwater finfish, shellfish, macroalgae as well as a few aquaponic farms. Despite having the third longest coastline and fifth largest land area among the Great Lakes and Northeast States, according to the USDA's 2018 Aquaculture Census, New York ranked 19th in the country for aquaculture production, behind several smaller states. There is significant room for the aquaculture industry to grow and expand in New York, but the industry has been facing challenges and limitations that have restricted its growth. Many of these challenges are not unique to New York and have impacted the aquaculture industry across the nation. Some of these issues are very complex and cannot be resolved with a simple change but rather require small steps to be taken over time. Other issues can only be addressed by having changes made on a state legislative level but often, the aquaculture industry problems are not at the forefront for local politicians.

To highlight some of the aquaculture industry issues for local state legislators, the Great Lakes Aquaculture Collaborative (GLAC), which is a Sea Grant Network for the Great Lakes States, has created an opportunity to bring legislators to aquaculture farms. The event(s), known as the Great Lakes Decision Maker's Day, is being organized by the Sea Grant programs in most of the region's states. The objective is to invite legislators from districts with aquaculture farms or that are on relevant legislative committees (*e.g.,* agriculture, commerce, small business, etc.) to the event which will be held at an aquaculture farm. At the event, numerous farmers were invited to meet with the legislators and tell them about their operations, in particular, the economic value their businesses have to the state as well as the challenges that they are facing, specifically those that can be alleviated with better state support.

In New York, the event was held at Local Coho, located in Auburn which is in the Finger Lakes region. This farm uses a recirculating aquaculture system (RAS) to raise coho salmon (*Oncorhynchus kisutch*) that are sold for consumption purposes only. A total of 12 legislators and 10 farmers from other operations were invited to the event. The legislators were provided with a packet of information summarizing the industry, its ongoing needs they could assist with, and information from each farm highlighting the economic impacts and the challenges they face. Following the discussion with the farmers, legislators were given a tour of the farm, and then during an open networking session, refreshments were shared that contained fish raised at the farm where the tour was held.

ATTRIBUTES AND ADVERTISING PREFERENCES AFFECTING AT-HOME SEAFOOD CONSUMPTION DURING THE PANDEMIC AND THROUGHOUT THE RECOVERY

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The unprecedented COVID-19 health crisis and subsequent shocks to the economy raise questions about how the attributes that affect at-home seafood consumption changed during the pandemic, but perhaps more importantly throughout the recovery. This study aimed to identify the factors influencing seafood consumption at home during these two periods and to discern changes in information and advertising preferences related to at-home seafood consumption. Five consumer surveys were conducted throughout the pandemic and the recovery phase and compared seafood consumption before and after the onset of the pandemic. Surveys were administered at three-month intervals beginning in Quarter 1, 2021, with the last two surveys conducted at six-month intervals. Participants were asked to assess 15 attributes that influenced their at-home consumption of seafood and assess 18 preferences for receiving information and advertising for at-home seafood consumption. The six attributes that influenced respondents' at-home consumption of seafood were, in order of importance (those with a mean score of 4 or greater on a scale of 1 to 5 with 5 being most important): taste/flavor, expiration date on the package, appearance of the fish/shellfish, texture, price and easy availability in stores. The six most preferred methods for receiving information or advertising for at-home seafood consumption, with a mean of 2.5 or greater (on a scale of 1 to 5, with 5 most important) were, in order of importance: recommendation from seafood counter clerk (supermarket) or restaurant waitstaff, recommendations of family or friend, in-store cards, table tops, discount coupons, rewards, and online reviews (Table 1). No trends were identified for preferences amongst respondents for receiving information or advertising about seafood or for the most important attributes affecting seafood purchase decisions for at-home consumption during the pandemic or throughout the recovery period. The one exception in the data was the importance of price; which exhibited an apparent trend of increasing importance from Q1 to Q4, perhaps in response to changes in incomes and inflation. Findings from this study may inform future strategies for seafood suppliers, retailers, and government agencies to continue to promote seafood consumption at home.

Table 1. Preferred sources of information or advertising for at-home seafood consumption throughout the pandemic and the recovery.

Mean Score (on a scale of 1 to 5, with 5 being most important)			
3+	2.5 to 3	2 to 2.5	<2
Recommended by seafood counter clerk & waitstaff	In-store card, table top	In-store text, notification	Website pop-up ads
Recommended by family/friend	Discount coupon	Mailed flyer	Web banner
	Reward	Email	Twitter message
	Online review		Reddit posting

DEVELOPMENT OF A USER-FRIENDLY TOOL TO MEASURE THE ENVIRONMENTAL IMPACT OF KELP AQUACULTURE THROUGH THE LIFE CYCLE ASSESSMENT (LCA) METHODOLOGY

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The U.S. kelp aquaculture industry has experienced significant growth over the last 15 years. Given the potential for market saturation of edible seaweed, further growth of the industry might depend on finding additional revenue sources such as Payment for Ecosystem Services schemes and blue carbon markets. In order to receive proper compensation for the flows of ecosystem services from kelp farms (e.g., removal of nutrients and atmospheric CO_2), it is imperative to develop methodologies and tools to assist farmers with the measurement of these flows.

As a major component of the Sea Grant project "Business and Economic Planning for Seaweed Aquaculture Systems in the U.S.", a fully-interactive, user-friendly tool was designed which allows stakeholders (farmers, extension agents, etc.) to develop their own Life Cycle Assessments (LCAs) for integrated kelp nursery-growout operations. The tool has two major components: 1) an Excel spreadsheet aimed at collecting basic production parameters and material input requirements for the model farm; and 2) a customized LCA model built within the open-source platform openLCA, which accesses data from the Excel spreadsheet to generate a comprehensive assessment of the environmental impact associated with the aquaculture operation, including the potential for bioremediation (i.e., N and P removal) and negative CO_2 emissions. The LCA model relies on open-source process databases (USLCI and US Environmental Protection Agency/USEEIO) compiled by the U.S. government and made accessible through the Federal LCA Commons website. A major feature of the tool vis-à-vis commercial alternatives is its reliance on open-source platforms and databases as it allows users to develop state-of-the-art LCAs while avoiding interaction with expensive proprietary software.

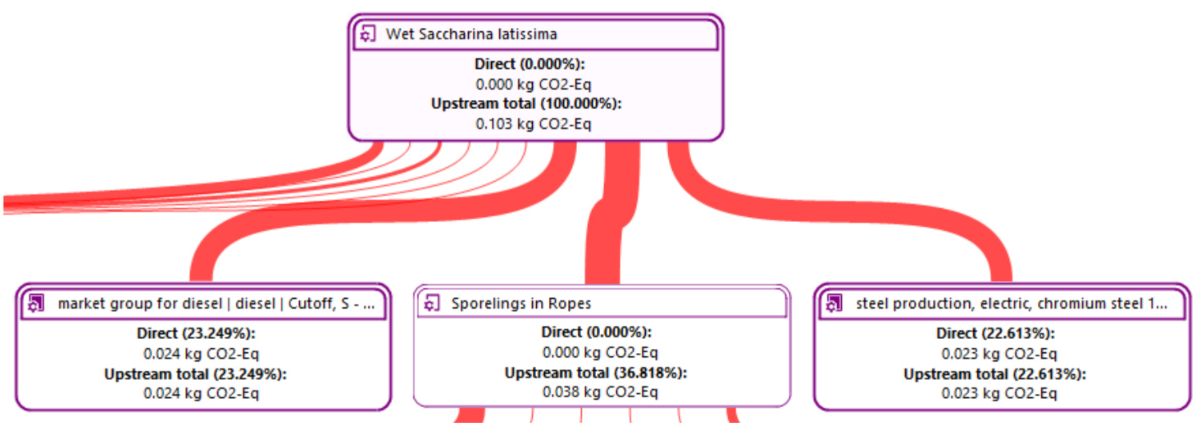

Figure 1. Partial Sankey diagram displaying the positive emissions (kg CO_2-Eq) associated with the production of one kg of fresh kelp (based on model assumption).

ARE HIGH-QUALITY FEEDS STILL A GOOD VALUE IN AN ERA OF HISTORICALLY LOW SHRIMP PRICES?

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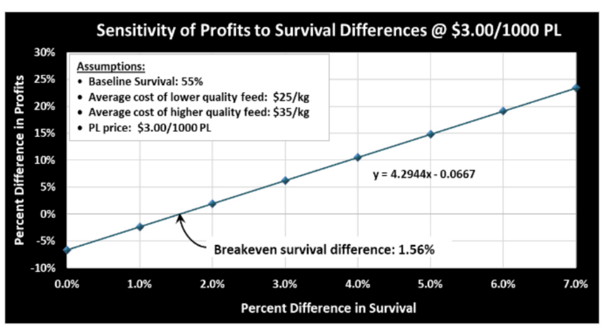
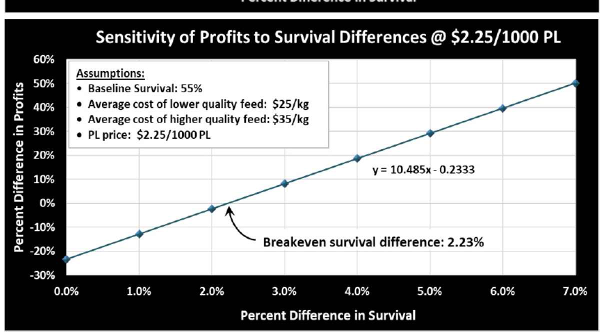
In 2022 and 2023, global farmed shrimp prices dropped to near historic lows due to high inventories of frozen shrimp, overproduction, and weak demand in key markets. Shrinking margins forced shrimp hatchery managers to cut costs in an effort to remain profitable. With feed costs representing a significant portion of overall production expenses, many producers switched from high-quality, expensive feeds to cheaper, lower-quality alternatives. However, this raises the question: Is substituting cheap, low-quality feeds for expensive, high-quality feeds a wise strategy for maximizing profits during price slumps? To answer this, an economic model was used to evaluate the sensitivity of hatchery profits to feed price and survival.

Shrimp postlarvae prices ($/1000 PL) are based on numbers rather than weight. In the short term, PL producers are not penalized for selling undersized PLs. This tempts hatchery managers to replace higher-cost feeds that support higher growth rates and improved PL vigor with lower-cost feeds. However, in the long term, undersized PLs perform poorly on the farms and are less tolerant of environmental and disease challenges, reflecting upon the hatchery. Lower-quality feeds also impact shrimp survival in the hatcheries. An economic model was used to study the impact of feed price and survival on shrimp hatchery profitability under two PL price scenarios ($3.00/1000 PL and $2.25/1000 PL). The model compared the profitability of a hatchery using lower-cost feeds ($25/kg) to that of a hatchery using higher-cost feeds ($35/kg), with improvements in survival associated with the use of the more expensive high-quality feed ranging from 0% to 10%. When PL prices were $3.00/1000 PL, only a 1.56% improvement in survival was needed to cover the difference in feed price, and profits increased by 4.3% for each 1% improvement in survival. When the price received for PLs was reduced to $2.25/1000, a 2.23% improvement in survival was required to break even, while profits increased by 10.5% for each 1% improvement in survival. When margins are low, investing in quality feeds to improve survival is more important than ever for hatchery profitability.





A PRELIMINARY ASSESSMENT OF THE POTENTIAL OF RED EARTHWORM, *Perionyx excavates,* MEAL AS AN ALTERNATIVE PROTEIN SOURCE FOR NILE TILAPIA

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Red Earthworm (EW), *Perionyx excavates*, could be an excellent source of aquafeed as it contains a high amount of nutrients and has the potential to be an alternative protein source for fishmeal (FM). The purpose of this study was to examine the impact of substituting FM protein with EW meal on the growth, haemato-biochemical response, intestinal histomorphology, and lipid droplets assessment in the liver and muscle tissue of Nile tilapia, *Oreochromis niloticus*.

For the study, four different diets were tested, including an FM-based reference diet (control) and three test diets with the EW meal replacing FM in proportions of 10% (D1), 20% (D2), and 40% (D3). Nile tilapia, with an initial weight of 3.47±0.02g, were fed the experimental diets for 56 days.

The results indicated that replacing up to 20% of fishmeal with EW meal (D1 and D2) did not have any adverse effects on weight gain and the specific growth rate of fish. Quadratic analysis between FBW and EW meal showed the best growth performance when replacing 17.5% FM with EW in the diet. However, adverse effects were observed at the 40% replacement level (D3) compared to the control. The feed conversion ratio and survival rate appeared to be similar in all dietary groups. Condition factor was significantly reduced ($p<0.05$) compared to the control diet when replacing the highest (40%) FM by EW meal in the diet.

Fish fed the D3 diet had a significantly decreased height and width of intestinal mucosal folds and the number of mucosal goblet cells compared to the control ($p<0.05$). Although red and white blood cell counts (RBC and WBC, respectively) were found unchanged between the control, the D1 and the D2 dietary groups, a significantly higher number of WBC and a lower number of RBC were found in the D3 group when compared to the control. Blood glucose level was higher in the D3 group, while the haemoglobin level was the lowest in the same group. A significantly ($p<0.05$) higher frequency of erythrocyte cellular and nuclear abnormalities were noted in fish fed the D3 diet.

Furthermore, lipid droplet accumulation in the liver and muscle was significantly higher in D3, whereas diet D1 and D2 showed no significant difference compared to the control. Overall, the study indicates that up to 20% EW could replace fishmeal in the diet of Nile tilapia without compromising growth and the examined key physiological parameters.

EXPLORATION OF *Cetobacterium* sp. AS A POTENTIAL PROBIOTIC FOR NILE TILAPIA (*Oreochromis niloticus*) CULTURE

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Recent research has unveiled the pivotal role of anaerobic bacteria in maintaining fish health and homeostasis of the intestinal microbiome. Most previous studies have identified Fusobacteria and *Cetobacterium* as prominent inhabitants of the gut microbiota in freshwater fish. Nevertheless, it is only in recent years that *Cetobacterium* species have been isolated and characterized.

In this study, we report the isolation of *Cetobacterium* sp. from the intestines of juvenile Nile tilapia (*O. niloticus*). This bacterium was successfully cultured, and *in vitro* characterized, based on whole genome sequencing, evaluation of bacterial survival on bile salts (0,3%) and low pH, extracellular enzyme production, antibacterial activity, intestinal adhesion potential, and safety aspects, including toxin production and antibiotic resistance.

Our findings reveal the potential of *Cetobacterium* as a probiotic candidate for Nile tilapia culture. The *in vitro* assessment demonstrated the probiotic potential of *Cetobacterium*, suggesting its ability to survive and colonize in the intestines.

To further explore its practical application, *in vivo* experiments were carried out by administrating *Cetobacterium* sp. 1x10^6 CFU/g to tilapia fingerlings for 5 days. The results of these experiments provide valuable insights into the potential benefits of using *Cetobacterium* sp. as a probiotic in fish culture due to the bacterial colonization and regulation of intestine microbiota and modulation of the immune system as seen by transcriptomic analysis of head kidney in treated fish vs control group.

This study underscores the importance of understanding and harnessing the role of anaerobic bacteria, such as *Cetobacterium* in promoting fish health and enhancing the sustainability of aquaculture practices. The findings presented here contribute to the growing body of knowledge on probiotics in aquaculture and open new avenues for improving fish gut microbiome homeostasis and overall fish health.

OPTIMIZING SUPER-INTENSIVE SHRIMP TANKS

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Bacterial, viral, and parasitic disease outbreaks have severely impacted shrimp production over the last thirty years, leading to ongoing modifications to farming practices. While most shrimp are still produced in extensive or semi-intensive (high volume, low density) ponds, there is recognition of and movement toward intensive (low volume, high density) techniques to achieve production goals (Villarreal & Juarez, 2022) and reduce per unit carbon emissions. However, with intensification comes increased waste production, which, if not appropriately managed, can contribute to significant problems in the production system and the surrounding environment, ultimately leading to a recurring disease cycle. Control and management of waste solids in ponds and tanks are essential for improving production outcomes and reducing the environmental impact of this farming practice. Engineered solutions to control waste solids, like self-cleaning tanks, are used in intensive land-based finfish aquaculture operations to enhance rearing conditions. Applying this technology to intensive shrimp production is promising; however, there is a need to establish and understand key technical and biological parameters that impact the feasibility, operation, and, ultimately, the performance of self-cleaning tanks and small-scale ponds for shrimp.

The impact of key design parameters on intensive shrimp tank self-cleaning and mixing was evaluated using computational fluid dynamic modeling (CFD). Model results for water velocity magnitude and direction were the major factors evaluated for performance. Water velocity magnitude data was assessed relative to literature values for shrimp swimming capacity. Velocities greater than 25–30 cm/s were considered excessive for shrimp; velocities less than 10–15 cm/s were considered too low to move waste solids toward a central drain adequately.

Major findings point to the potential of using an independent method to create the radial current that carries waste solids to the center drain, separate from the primary rotating flow. In finfish aquaculture applications, a tank's primary rotating flow creates the secondary radial current for self-cleaning with an appropriate center drain hydraulic loading rate. However, tanks used in shrimp aquaculture have significant differences in design and operation. Major differences include lower tank diameter-to-depth ratios, longer hydraulic retention times, and processes for aeration and oxygenation. These design and operational differences increase the difficulty of relying on the primary rotating flow to create self-cleaning conditions. The results of this study highlight this difficulty and propose a potential solution by utilizing a separate method that creates and/or enhances the radial current needed. The proposed solution of a pipe around the tank perimeter with water jets flowing towards the tank center drain combined with a method that creates a primary rotating flow resulted in the highest proportion of the tank bottom velocities in the ideal range of 15–25 cm/sec for self-cleaning.

COLLABORATIVE DESIGN AND OPERATION OF FISH FARMS, MARINE VEHICLES AND WIND-SOLAR HYBRID POWER SUPLY SYSTEMS

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The synergy between renewable energy, mariculture and shipping emerges as a promising direction to reduce environmental concerns and optimize resource utilization. This work discusses such opportunities for combining fish farms, electrified ships, floating photovoltaic (FPV) systems, and offshore wind farms. The integration of fish farms with marine vehicles FPV and offshore wind farms represents a triple-win scenario. Firstly, the floating photovoltaic panels provide a dual-purpose function: harnessing solar energy for power generation while concurrently protecting fish farms. Such an arrangement optimizes the use of water surfaces, reducing land footprint and fostering a mutually beneficial relationship between renewable energy infrastructure and aquaculture operations. Secondly, offshore wind farms complement this integration by providing an additional renewable energy source. The open sea locations of wind farms can be strategically chosen to minimize interference with fish farming activities, ensuring sustainable coexistence. The economic viability of such a cooperative model is underscored by the potential for shared infrastructure and reduced operational costs, while co-located facilities can benefit from streamlined logistics, shared maintenance resources, and land and sea use, fostering a more sustainable and cost-effective approach to both energy production and aquaculture. Moreover, the energy excess could be used to charge electric marine vehicles leading to substantial environmental implications. The energy planning of this collaborative system is simulated by means of EnergyPLAN software developed and maintained by the Sustainable Energy Planning Research Group at Aalborg University, Denmark. Although, developed for land-based systems, the tool can be successfully used for number of marine applications, as indicated in some similar application cases [1,2].

[1] [Lovro Frković, Boris Ćosić, Tomislav Pukšec, Nikola Vladimir: Offshore Floating Charging Platform for All-Electric Vessels Powered with Renewable Energy Sources: Techno-Economic Feasibility and Emission Reduction Potential. The 25th Conference on Process Integration, Modelling and Optimisation for Energy Saving and Pollution Reduction, J.J. Klemeš, S. Nižetić, P.S. Varbanov (eds.), Split/Bol, Croatia, September 2022. Paper No. PRES22.0467. 16 pages.

[2] Marija Koričan, Lovro Frković, Nikola Vladimir: Electrification of Fishing Vessels and their Integration into Isolated Energy Systems with a High Share of Renewables. Journal of Cleaner Production (ISSN: 0959-6526, eISSN: 1879-1786), Vol. 425, 2023. Paper No. 138997. 14 p.

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VIRULENCE OF NOVEL FLAVOBACTERIACEAE ISOLATES FROM THE WESTERN UNITED STATES AND ASSESSMENT OF POTENTIAL CROSS-PROTECTION OF AN ATTENUATED BCWD VACCINE

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In salmonid production, the most common pathogenic threats to fish stocks arise from members of the family *Flavobacteriaceae*, most notably: *Flavobacterium psychrophilum, F. branchiophilum,* and *F. columnare*. Clinical cases of disease caused by new and emerging bacterial strains in this family (*Flavobacteriaceae*) have been increasing. In this study, an assessment of virulence was conducted on four novel *Flavobacterium* spp. isolated from clinical disease cases from hatcheries in the Western region of the United States: 11299 (WA), 3gHT (UT), CA143 (CA), and CO45A (CO). Juvenile rainbow trout, *O. mykiss*, were challenged with the isolates mentioned above. Each isolate was administered via intramuscular injection at a dose of 10^7 CFU·fish^{-1}. Results showed that these four Flavobacteriaceae isolates were highly virulent and caused acute clinical disease. Cumulative percent mortality (CPM) for isolates 11299, 3gHT, CA143, and CO45A was 46.7%, 93.3%, 96.7%, and 96.7%, respectively. Following virulence analysis, an investigation of cross-protection against these four isolates was initiated. A live-attenuated *F. psychrophilum* vaccine, previously developed and demonstrated to provide protection against an array of *F. psychrophilum* strains as well as mixed groups of *Chryseobacterium* spp. and *Flavobacterium* spp., was utilized. Juvenile rainbow trout (*Oncorhynchus mykiss*) were vaccinated by immersion and high serum anti-*F. psychrophilum* antibody titers developed. Fish were then challenged with isolates 11299, 3gHT, CA143, CO45A, and a mixed combination. Cross-protection to isolate 11299 was demonstrated with a relative percent survival (RPS) of 36.21% compared to the unvaccinated 11299 control group ($p < 0.05$). Cross-protection was also observed in groups challenged with the mixture of the four isolates with an RPS of 41.46% ($p<0.05$). However, no protection was observed in groups challenged with the 3gHT, CA143, and CO45A isolates alone. Results from this study confirm that these emerging flavobacterial strains cause clinical disease and suggest that an attenuated *F. psychrophilum* vaccine may provide some benefit through cross-protective immunity.

PRODUCTION OF LARGEMOUTH BASS *Micropterus salmoides* STOCKERS FOR FOOD FISH PRODUCTION USING COMMERCIAL SPLIT-POND SYSTEMS

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Largemouth bass (LMB; *Micropterus salmoides*) production for the food fish market is growing in the US. Traditionally, LMB producers in the US have relied on traditional earthen ponds as their primary production system for culturing this species. Largemouth bass producers using traditional earthen ponds are plagued by low survival, slow growth, poor food conversion ratio (FCR), losses to bird depredation, water quality problems, and disease issues. Largemouth bass producers believe these production-related obstacles, inherent to culture in traditional earthen ponds, have translated to reduced efficiency and profitability of farming operations and are inhibiting the growth of this aquaculture sector. The culture of LMB in a split-pond system (SPS) can ameliorate many of the inefficiencies documented by commercial LMB producers using traditional earthen pond systems. A SPS for LMB has the potential to solve the inherent limitations of low oxygen and waste treatment of traditional earthen ponds, as it confines LMB to a smaller area (fish basin, 15–20% of total pond area) in a pond. As a result, energy-efficient aeration and water circulation are improved over the entire culture area. The advantages of the SPS for LMB production can revolutionize the production of this expanding food fish species in the US. The objectives of this project were to evaluate the production performance, water quality, fish health metrics, and economic feasibility of raising stocker LMB (15–25 cm fingerlings) in SPS compared to traditional earthen ponds. The experiment was conducted at American Sport Fish in Montgomery, Alabama. A total of 8 ponds were used, including four traditional earthen ponds (0.4 ± 0.0 ha) and four SPS (0.24 ±0.11 ha). Fish weights and lengths were obtained at stocking and thereafter monthly until harvest. Commercial ponds were stocked with feed-trained LMB fingerlings (5–7 cm total length) sourced from American Sport Fish. Pond water samples were collected weekly from study ponds and transported to the E.W. Shell Fisheries Research Center, Auburn University, on ice for water quality analysis. Weekly water quality tests were conducted using a photometer (YSI 9300 Photometer) and included ammonia and nitrite testing, while monthly water quality tests included total alkalinity, total hardness, chloride, and nitrate. Weekly water parameters measured on-site at the farm included dissolved oxygen, temperature, salinity, pH, and Secchi disk depth. Ponds were sampled monthly throughout the 4-month trial to track the growth of LMB fingerlings. Approximately 30–50 fish were sampled from each pond to determine length and weight. During monthly sampling, a subset of fish was transported on ice to the diagnostic laboratory at the Alabama Fish Farming Center in Greensboro, Alabama for a fish health assessment. Commercial ponds were harvested in October 2023 when LMB reached stocker size (15–25 cm total length), and analysis of production parameters is underway. An enterprise budget will be developed from fixed and variable costs associated with this project to compare the cost of production of raising LMB fingerlings to stocker sizes using SPS and traditional earthen ponds.

USAS STUDENT SUBUNITS: WHO, WHAT, WHEN, WHERE, WHY, AND HOW?

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Student Subunits advance the objectives of the United States Aquaculture Society (USAS) through the involvement of its student members. Students are significant constituents of the USAS membership, and student excellence is an essential component of the USAS strategic role in assuring the progressive development of aquaculture in the United States. Student Subunits are vital to the organization. They further USAS outreach, bringing the benefits, activities, and news of USAS to students at their institutions. Student Subunits also provide increased opportunities for student involvement in USAS and World Aquaculture Society activities and help students to organize and participate in aquaculture-related activities on a local scale.

Student Subunits are defined by academic institutions, must comply with the rules and regulations set forth by the educational institution of affiliation, and are maintained under the auspices of the USAS Board of Directors. A petition to create a Student Subunit must be signed by at least six (6) USAS members in good standing at the educational institution. Each Student Subunit is responsible for the adoption and amendment of its own bylaws, the election of its own officers and directors, and the conduct of its own affairs.

USAS may provide up to $500 in start-up funds if requested when a potential subunit submits its formation package. In addition, each active subunit is eligible for a student travel award covering the cost of one early bird student registration to the annual Aquaculture America or Triennial AQUACULTURE conference each year.

Currently, there are nine (9) USAS Student Subunits: Auburn High School, Auburn University, The College of the Florida Keys, Kentucky State University, Lake Superior State University, The Ohio State University, University of Arkansas at Pine Bluff, University of Florida, and Virginia Institute of Marine Science.

An annual report of activities and events (including, but not limited to, trips, conference participation, awards received or given, fundraisers, workshops, collaborative efforts, guest speakers, meetings, socials, etc.) conducted by each USAS Student Subunit must be submitted to the Student Subunit Committee by January of each year. This USAS Student Subunit Showcase session highlights the accomplishments outlined in those reports.

Figure 1: Representatives of four (4) USAS Student Subunits attend the "Women of the Water" Conference in Sarasota, FL in September 2023.

EFFECTS OF REPLACING SOYBEAN MEAL WITH CORN FERMENTED PROTEIN ON GROWTH PERFORMANCE, FEED UTILIZATION AND BODY CONDITION INDICES OF JUVENILE TILAPIA *Oreochromis niloticus*

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Fish farming is growing faster than other animal protein producing sectors and will play a significant role in global food security. Therefore, it is utmost important to increase both fish production sustainability and economic viability. The use of renewable alternative ingredients, such as plant-based feedstuffs, can improve fish farming sustainability and potentially reduce production costs. Corn fermented protein (CFP) is a co-product of the ethanol industry and is considered a promising feedstuff to partially replace soybean meal (SBM) and other protein feedstuffs in aquafeeds. In the present study, a feeding trial was conducted to evaluate the growth performance of juvenile tilapia *Oreochromis niloticus* fed diets in which CFP was substituted primarily for SBM. A reference diet was formulated to contain ~45% crude protein contributed by dehulled, solvent-extracted SBM (25% by weight), poultry byproduct meal (14% by weight), hydrolyzed feather meal (6% by weight), and menhaden fishmeal (5% by weight). Five isonitrogenous experimental diets were prepared by primarily replacing SBM in the Reference diet with CFP at 10, 15, 20, 25, and 30%, respectively. Lysine (Lys) was supplemented in all diets to the established requirement level. Diets were fed to quadruplicate groups of juvenile fish with average initial weight (±SEM) of 2.32±0.01 g/fish for 8 weeks. All dietary groups had 100% survival. No significant effects due to the different diets were observed in fish responses including percent weight gain (WG), feed efficiency (FE), feed intake (FI), protein efficiency ratio (PER), condition factor (CF), and hepatosomatic index (HSI) (Table 1). In fact, WG of fish fed the CFP30% diet was 15% higher than that of fish fed the Reference diet, suggesting that CFP improved juvenile tilapia growth performance and could completely replace SBM in the Reference diet.

Table. 1 Effects of replacing SBM with CFP on growth performance of juvenile tilapia *Oreochromis niloticus* for 8 weeks. Each column represents the mean ± S.E.M.

Diet designation	FW (g)	WG (%)	FE	FI (g/fish/d)	PER	CF	HSI	Survival (%)
Reference	33.3±2.1	1321.3±75.3	0.77±0.03	0.83±0.06	1.67±0.05	1.94±0.04	3.53±0.20	100
CFP10%	31.6±1.8	1261.3±69.0	0.77±0.03	0.75±0.02	1.62±0.08	1.89±0.03	3.63±0.14	100
CFP15%	35.6±3.6	1439.1±159.4	0.81±0.04	0.81±0.03	1.74±0.10	1.96±0.02	3.62±0.21	100
CFP20%	31.5±1.8	1268.7±104.0	0.77±0.02	0.72±0.02	1.66±0.04	1.89±0.03	3.59±0.16	100
CFP25%	36.0±2.8	1449.7±93.2	0.80±0.01	0.81±0.06	1.71±0.03	1.93±0.03	3.67±0.20	100
CFP30%	38.3±1.3	1551.7±74.2	0.82±0.01	0.83±0.02	1.76±0.04	1.90±0.03	3.17±0.16	100
ANOVA (Pr > F[b])	0.091	0.095	0.376	0.253	0.601	0.14	0.091	-

THE SMART, SUSTAINABLE SHELLFISH AQUACULTURE MANAGEMENT (S^{3}AM) – SMART PRECISION HARVESTING: SIMULATION MODEL AND FIELD TEST

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Shellfish aquaculture plays an important role in the coastal economy. The United States is the world's second largest seafood consumer and ranks 17th in total aquaculture production. Among the marine aquaculture species, oysters are one of the top U.S. species, which produced more than $200 million worth of oysters in 2018. The Smart, Sustainable Shellfish Aquaculture Management (S3AM) program integrates the fields of Engineering, Computer Science, Biology, Environmental Science and Aquaculture to address the identified industry needs and tackle the challenge of establishing sustainable shellfish farming with significantly enhanced productivity and profitability. This presentation will focus on the smart precision harvesting in this program.

A towed dredge is the primary tool for harvesting oysters, which has changed little in the past 200 years. However, this traditional method is inefficient, since the oyster distribution is unknown and the farmers can only blindly and randomly tow the dredge in a certain area. To improve efficiency, we proposed a precision harvesting system. In the precision harvesting system, we considered the oyster distribution maps and dredge localization, and applied path planning techniques to obtain an optimal harvesting path for boats. Besides, we also collected real harvesting paths through field experiments and developed a simulator for comparing the traditional random path with our optimized path.

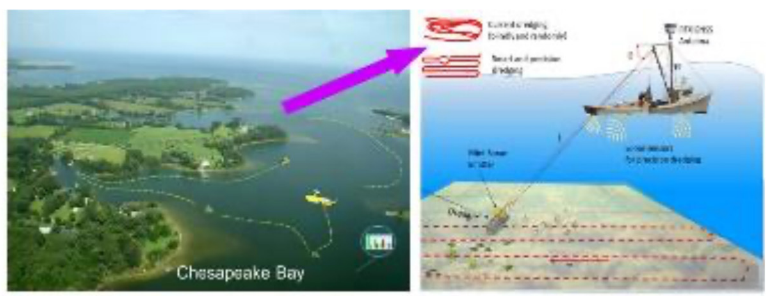

Figure 1. General idea of smart and precision harvesting.

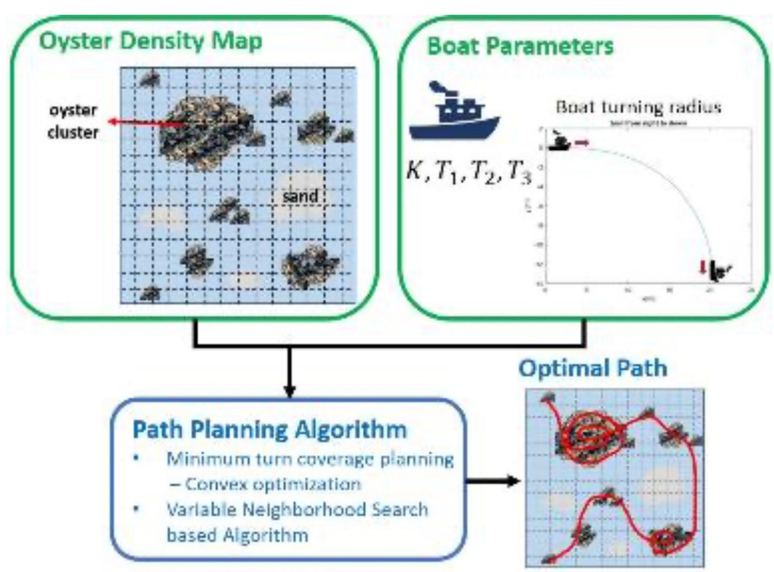

Figure 2. Framework of our proposed precision harvesting system.

A DECADE OF THE SCDNR SPOTTED SEATROUT STOCK ENHANCEMENT PROGRAM

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Following back-to-back winters (2009/2010 and 2010/2011, Figure 1) with periods of sustained cold temperatures, significant effects on the wild spotted seatrout, *Cynoscion nebulosus*, populations in South Carolina estuaries were observed. Reduced CPUE (Figure 1) and noticeable die-offs, especially of larger individuals were observed throughout the state's estuaries, prompting the exploration and development of a stock enhancement program as an additional management tool for this species.

Over the course of a decade, SCDNR biologists developed hatchery production techniques, established a microsatellite-based parentage tool, and released approximately 3 million juvenile seatrout (Table 1) into the Charleston Harbor estuary system in order to answer questions about seatrout life history and develop protocols to optimize stock enhancement contribution to wild populations. Utilizing unique genetic families as experimental treatments allowed for the exploration of optimal size at release, season to release, and release methods.

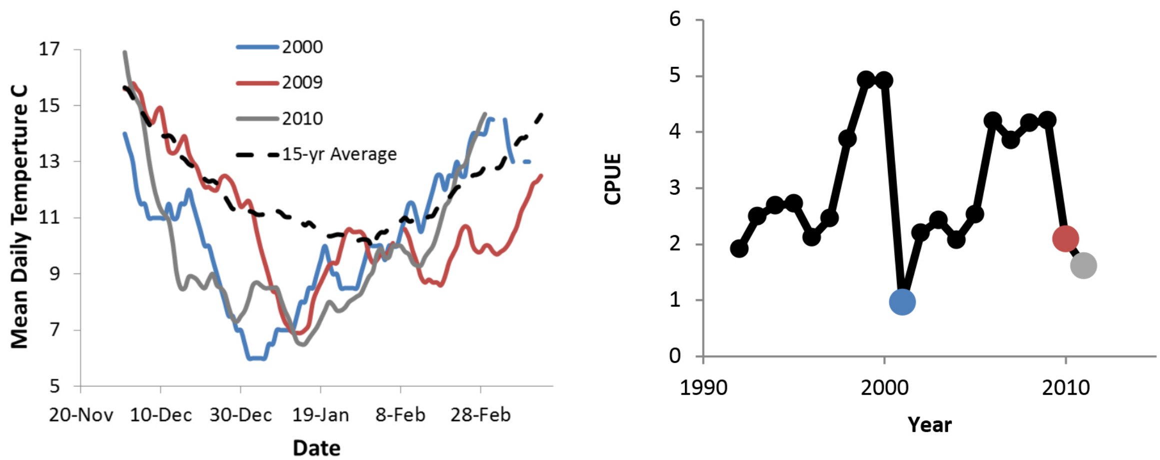

Figure 1. Mean daily winter temperatures (left) and SCDNR Inshore Fisheries trammel net survey catch per unit effort (CPUE) for spotted seatrout (right). Three individual cold years highlighted with subsequent CPUE indicating immediate and significant effects observed on seatrout populations.

Table 1. Annual release numbers for Spotted Seatrout from the SCDNR Stock Enhancement Program.

Year	Total Released
2012	520,291
2013	236,072
2014	299,035
2015	315,206
2016	106,071
2017	782,562
2018	309,301
2019	448,876

A GUIDE FOR SHELLFISH & SEAWEED FARMERS IN MAINE: WORKING TOWARDS SOCIAL LICENSE TO OPERATE

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In an effort to increase integration and understanding of aquaculture in Maine's coastal communities, Goal 2 of the Maine Aquaculture Roadmap 2022-2032 highlights the need for farmer resources that outline community engagement strategies. Through 30 semi-structured interviews with Maine shellfish and seaweed farmers, we have created an in-depth guide to gaining community support using a social license to operate lens. Rooted in the social license literature—but told through real life stories of farmers who are experiencing social license challenges and successes—this guide is a co-created document. In addition to participating through interviews, farmers also reviewed and edited the final draft of this manuscript so that it is in its most useful form for both beginning and veteran farmers looking for guidance on practical and meaningful ways to engender community support. Results from this project highlight the importance of proactive, ongoing outreach and communication, responsible, aquaculture-specific operating practices, and meaningful community benefits in earning social license from their communities.

Table 1. Farmer Identified Trust Generating Action

Trust Generating Action
Communication
Voluntary communication (not legally mandated)
Consulting & making accommodations
Honesty & transparency
Operational Practices
Keeping a tidy farm
Reducing impacts
Being visible
Abiding by regulations
Community Benefits
Providing product
Filling community needs
Helping others
Being a good employer

PROTEOMIC PROFILING OF BCWD RESISTANT AND SUSCEPTIBLE RAINBOW TROUT LINES AND IDENTIFICATION OF NOVEL BIOMARKERS

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At the U.S. National Center for Cool and Cold Water Aquaculture, we have selected a line of rainbow trout with increased innate resistance against bacterial cold water disease (BCWD) caused by *Flavobacterium psychrophilum* (*Fp*). After five generations of selection, the resistant line (ARS-Fp-R) exhibits over 60 percentage points higher survival compared to a reference susceptible line (ARS-Fp-S). To gain insight into the differential host response between genetic lines, we compared the plasma proteomes on day 6 following injection challenge. Pooled plasma from unhandled, PBS-injected, and *Fp*-injected groups were simultaneously analyzed using a TMT 6-plex label and 513 proteins were identified and compared. Differentially abundant proteins included tissue-damage proteins, acute phase proteins, protease inhibitors and chemotactic factors. Novel ELISA and Spatial Proximity Analyte Reagent Capture Luminescence (SPARCL™) assays were developed to confirm differential abundance. In the susceptible line, a secreted C1q family member (designated complement C1q-like protein 3; C1q-LP3) was upregulated over 20-fold while only modestly upregulated, 1.8-fold, in the resistant line. Skeletal muscle troponin C (STNC), cathelcidin 2 (CATH2), haptoglobin, leptin, and growth and differentiation factor 15 (GDF-15) exhibited elevated concentration in susceptible-line plasma. Complement factor h like-1 (CFHL-1) exhibited higher abundance in the resistant-line compared to the susceptible-line in both control and challenged fish and thus was a baseline differentiator between lines. C1q-LP3 and STNC were elevated in Atlantic salmon plasma following experimental challenge with *Fp*. In summary, this study furthers the understanding of the differential host response to *Fp* and identifies salmonid biomarkers that may have use for genetic line evaluation and on-farm health monitoring.

Acknowledgements: This work was supported by the US Department of Agriculture, Agricultural Research Service [Project number 8082-32000-007]. Mention of trade names or commercial products is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U.S Department of Agriculture

EVALUATION OF ORAL ADJUVANTED KILLED *Aeromonas hydrophila* VACCINES IN CHANNEL CATFISH *Ictalurus punctatus*

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Virulent *Aeromonas hydrophila* (vAh) attributes nearly \$35 million dollars in economic losses within the southeastern catfish aquaculture industry. This bacterial pathogen infects channel and hybrid catfish inducing skin necrosis, internal and external hemorrhaging, and exophthalmia. Farmers can lose over 50% of a harvest yield in less than a week when infected, increasing the urgency for more effective preventative measures. Oral bacterin vaccination with the inclusion of an adjuvant is a promising solution providing ease of administration for farmers, while decreasing stress put onto the catfish. Bacterin vaccines typically mediate a high antibody response and even more so when boosted. Research has been conducted demonstrating adjuvant's ability to also increase protection and duration of protection, thus this study's first objective is to determine whether the addition of an adjuvant increases vaccine efficacy. Over the years, multiple strains of vAh have caused catastrophic mortalities in both Mississippi (S14-452) and Alabama (ALG-15-097). Due to the variation within vAh strains, objective two is to determine whether bacterin vaccines with adjuvants demonstrate cross-protection amongst S14-452 and ALG-15-097. Bacterin vaccines were made for S14-452 (1.10 x10^7) and ALG-15-097 (1.0 x10^7). To test objectives one and two, channel catfish (13 g) were separated into treatments (ALG-15-097, ALG-15-097 + adjuvant, S14-452, S14-452 + adjuvant, adjuvant only, sterile TSB). Feed was top-coated with each treatment and fed for 7 days at 2% body weight and boosted at 9 weeks. Fish were challenged at 3 and 12 weeks post-vaccination and boost. At 3 weeks, treatment groups were challenged with ALG-15-097 (3.4×10^7 CFU mL^{-1}), and cumulative percent mortality was evaluated to determine efficacy and cross-protection. ALG-15-097 (49.3% ± 9.23) experienced significantly less mortality ($P < 0.05$) compared to adjuvant only (92% ± 6.93) and placebo groups (97.3% ± 2.31). At 12 weeks, treatment groups were challenged with ALG-15-097 and S14-457. Post ALG-15-097 exposure, all vaccinated groups experienced significantly less mortality than adjuvanted groups ($P < 0.05$). No significant differences between vaccinated strains or adjuvanted vaccines were documented. Post S14-457 exposure, ALG-15-097 (10.0% ± 10.0) experienced significantly less mortality ($P < 0.05$) compared to adjuvant only (56.6% ± 6.93) and placebo groups (73.3% ± 11.5). S14-457 vaccinated groups demonstrated protection ($P < 0.05$) as well compared to placebo groups. Oral feed vaccines developed in this study demonstrated protection against vAh strains, while adjuvanted vaccines did not increase efficacy. Results from this study allows for the development of more efficacious vaccine components and delivery on catfish farms, ultimately, preventing mass mortality due to vAh.

ON THE MAP: LEARNING THE IMPACT OF THE GREAT LAKES FRESH FISH FINDER ON FISH PRODUCING BUSINESSES

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The Great Lakes Fresh Fish Finder is a website developed by Great Lakes Sea Grant programs to directly connect consumers with fish farmers and commercial fishers. Originally a response to the COVID-19 pandemic in 2020, the site had 127 businesses listed across 9 states by the end of 2022. A survey evaluation was launched in January 2023 to understand what the real and perceived benefits or concerns were for businesses as a result of being listed on the website along with assessing whether businesses were still in business, wanted to remain on the site, and had any updates to their information. Analysis of survey results will be discussed along with the websites role as an educational tool and the challenges of keeping such a website current and responsive to the needs of those it's meant to serve. Ideas will be shared for potential next steps to better understand the direct impact the Great Lakes Fresh Fish Finder may have in helping consumers connect with commercial fishing and the aquaculture industry in the region.

WILLINGNESS TO PAY FOR RAS ATLANTIC SALMON BY THE U.S. CONSUMER

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Over the last decade, per-capita consumption of farmed Atlantic salmon (Salmo salar) in the U.S. increased by 75% while that of all seafood increased by just 1.27% (NOAA, 2019; Shahbandeh, 2021). As demand for farmed salmon grows, it becomes increasingly important to address the challenges of production. Farmed salmon is produced with open net pen (ONP) aquaculture, which presents challenges such as byproduct release and the spread of pathogens. An emerging alternative to ONP is the recirculating aquaculture system (RAS). RAS involves rearing salmon in tanks where water is constantly recirculated and byproducts are captured, addressing the main environmental challenges caused by ONP farming. However, because of high operating costs, broad adoption of RAS salmon in the U.S. depends heavily on sufficient consumer demand, the data on which is limited.

To fill this gap, we conduct a discrete choice experiment, distributed to 2400 U.S. consumers, to elicit willingness-to-pay (WTP) for RAS-farmed Atlantic salmon. Besides production method, we estimate WTP for 5 other attributes that are crucial to understanding consumer preferences for farmed salmon: *Byproduct Management, Stocking Density, Omega-3 Content, Days Since Harvest,* and *U.S. Production*. A sample choice set presented to respondents is pictured.

Our research seeks to inform policymakers and producers about the potential of RAS Atlantic salmon in the U.S. Results will guide future policies and production roadmaps pertaining to this growing commodity that is crucial to the health of both the environment and population of the U.S.

	A	B	Neither
Production Method	ONP	RAS	
Byproduct Management	Not captured	Captured & repurposed	
Stocking Density	25 kg/m³	85 kg/m³	
Omega-3s per serving	2400 mg	1800 mg	
Time from Harvest to Store	1 day	5 days	
US Production	Farmed abroad	Farmed in the USA	
Price / lb.	**$12.99**	**$18.99**	**$0**

Which option would you choose?

- I would purchase A
- I would purchase B
- I would not purchase either product

2022 NATIONAL AQUACULTURE EXTENSION CONFERENCE PARTICIPANT EVALUATION RESULTS

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National Aquaculture Extension Conferences (NAECs) are interregional projects funded by the USDA-supported Regional Aquaculture Centers (USDA RACs). NAECs provide the only dedicated national aquaculture Extension event that allows participants to present programs and trainings, tour aquaculture operations and exchange information and network. Conferences have been held in Little Rock, AR (1992), Annapolis, MD (1997), Tucson AZ (2003), Cincinnati OH (2007), Memphis, TN (2011), Boise, ID (2017) and Portland, ME (2022). Both NOAA Sea Grant and the USDA RACs provided funding for the 2017 and 2022 NAECs. During the COVID-19 pandemic, the first virtual NAvEC was hosted by the University of Maine Sea Grant Program in June 2021, when an in-person meeting had originally been scheduled. Approximately 160 aquaculture professionals participated virtually over three days. An Agriculture and Food Research Initiative grant was secured by Dr. Reggie Harrell, Northern Regional Aquaculture Center Director to fund speakers travel for the 2022 NAEC Mentoring and Diversity training session.

2022 NAEC survey evaluation comments were largely favorable. Of the 77 attendees, 32 surveys were collected (42%). Day one sessions rated in percentage of most interest included: Aquaculture Literacy (74%, 27 respondents), Aquaculture Marketing (86%, 28 respondents), and Aquaculture and the Environment (93%, 28 respondents). The day one poster session reviews were more mixed with 52% more favorable and 48% neutral to less favorable from 27 respondents. Damariscotta River and Portland waterfront and Casco Bay field trips on day two received 100% positive reviews, however only 14 and 11 attendees responded, respectively. Day three sessions including Shellfish and Finfish Production was rated positively with 94%, from 30 respondents, and Youth, Education and Skills from 93% and 29 respondents. The Professional Development session received more mixed reviews with 60% positive and 50% neutral to less positive from 30 respondents. The fourth half day session on Mentoring and Diversity received 83% positive reviews with 17% neutral and less positive scores from 23 respondents.

Hotel accommodations, receptions and meals were generally reviewed favorably. All 26 respondents were in favor of a proposed 2027 NAEC to be held in Duluth, MN.

EXPLORING THE NUTRITIONAL VALUE OF FERMENTED CORN PROTEIN AS A REPLACEMENT FOR SOYBEAN MEAL IN CHANNEL CATFISH *Ictalurus punctatus* JUVENILE FEEDS: IMPACTS ON PRODUCTION PERFORMANCE, INTESTINAL HEALTH, AND DISEASE RESISTANCE

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The price and availability of several feed commodities were heavily affected by recent global events, such as supply chain issues caused by the pandemic and the conflicts in Europe. With that in mind, the use of fermented corn protein (FCP) can be a promising alternative ingredient to replace soybean meal (SBM) in aquafeeds, because of its attractive price and constant supply. FCP is a by-product from the ethanol industry, and depending on the fermentation process, it can generate a high protein (>50 %) ingredient, with a relatively well-balanced amino acid profile, and low fiber content (~7.3%). The present study evaluated the nutrient and energy digestibility of FCP by channel catfish, followed by a comparative feeding trial with juvenile channel catfish evaluating graded levels of replacement of dehulled solvent extracted SBM replacement with FCP in experimental feeds. The digestibility study was performed using the indirect method, with experimental feeds supplemented with 0.1% of yttrium oxide (inert marker), and fecal samples were collected with the modified Guelph method. A significant, but minute apparent protein digestibility coefficient was observed for SBM (91%), when compared to FCP (89%). However, phosphorus was twice as available for FCP (85%) than SBM (42%). For the comparative feeding trial, 900 channel catfish juveniles (~11.6 g initial weight) were equally distributed in 30 aquaria (110-L) working as a recirculating system and offered the experimental diets twice a day to apparent satiation for 60 days. The dietary treatments consisted of gradual replacement of SBM by FCP on an equal-nitrogen basis (0, 25, 50, 75, and 100%). At the end of the study, production performance parameters, viscerosomatic indices, blood, and whole-body proximate composition samples were collected. Fish were fed their assigned experimental diets for an additional three days and digesta samples were collected from the posterior segment of the intestine. Digesta samples were subjected to DNA extraction, and the 16S rRNA gene will be sequenced using an Illumina MiSeq to profile the intestinal microbiota. No differences were observed for hepatosomatic index, and survival, nor for whole-body protein, ash, and protein conversion efficiency. However, weight gain, feed efficiency, intraperitoneal fat, and whole-body lipid were significantly affected by the dietary treatments. The obtained results indicate that up to 50% of SBM can be replaced by FCP without causing any detrimental effects to juvenile catfish. After the feeding trial, the remaining fish were moved to a flow-through system and exposed to *Edwardsiella ictaluri* through immersion and mortality was monitored daily for 21 days. Interestingly, survival after the bacterial challenge gradually increased as the inclusion levels of FCP increased in the diets, with the 100% replacement treatment being significantly different than the basal diet (control). In conclusion, FCP is a promising alternative protein ingredient with high protein digestibility, and it can replace half of the soybean meal in feed formulations for juvenile channel catfish, while enhancing disease resistance against *E. ictaluri*.

ACUTE HYPOXIA PROMOTES THE LIVER ANGIOGENESIS OF LARGEMOUTH BASS (*Micropterus salmoides*) BY HIF - DEPENDENT PATHWAY

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Dissolved oxygen is an important abiotic factor in aquatic ecosystems. To investigate the effects of acute hypoxic exposure on liver angiogenesis in largemouth bass, acute hypoxic exposure for 24 h was performed in this study. The results showed that the immunohistochemical analysis showed that hypoxia exposure promoted angiogenesis in the liver of largemouth bass. During 8h hypoxic exposure, the concentration and activity of vasodilator factors were significantly increased ($P < 0.05$). Hypoxia exposure promoted angiogenesis by upregulating the expression of MMP-2, jagged, AKT, PI3K and MAPK genes. On the contrary, the expression of anti-angiogenic genes was up-regulated at 8h ($P < 0.05$). Finally, genes and proteins that regulate angiogenesis show a clear temporal order. The expression of genes that promoted vascular sprouting and elongation was up-regulated within 4h to 8h of hypoxia exposure ($P < 0.05$). Genes that promote vascular maturation were highly expressed within 12-24 hours ($P < 0.05$). In conclusion, acute hypoxia promotes hepatic angiogenesis in largemouth bass via HIF-dependent pathways.

OBSERVATION OF GROWTH, MORPHOLOGICAL AND GENETICAL CHANGES OF ZEBRAFISH *Danio rerio* AFTER TREATMENT WITH THREE CHEMICALS (N-ETHYL-N-NITROSOUREA, COLCHICINE AND HYDROXYLAMINE)

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Representative methods for inducing mutations include chemical treatment, radiation treatment, and genetic modification, and recent research on mutation has focused on genetic techniques. Among them, chemical mutagenesis substances have been studied in various ways, such as body color change by inducing mutations for the purpose of developing application technologies for the aquarium fish industry. In this study, three chemical mutagens were analyzed at a concentration of 2 mM. The zebrafish breeding water was immersed for 1 hour 3 times for 6 days at a concentration of 2 mM of each chemical mutagenic substance. And then after7 days, quantitative PCR were analyzed using the brain, liver and kidney. To obtain F1, after immersion, zebrafish were housed in a cage at a male/female ratio of 2:1, and F1 fertilized eggs were obtained 5 days later.

Internal bleeding and fin damage were observed in colchicine and hydroxylamine, and severe organ damage was observed in colchicine. In gonad, a dead egg were observed in colchicine. As a result of comparative analysis after production of F1 individuals, there was no difference from the control group.

In the growth results from crosses between normal and mutant individuals, the best growth was observed in the cross between normal individuals, which was the control group. In hydroxylamine, the best growth was achieved in crosses between hydroxylamine male individuals and normal individuals, and it was confirmed that growth was fastest in that order: ENU and then colchicine.

As a result of observing changes in growth related genes in individuals immersed at a concentration of 2mM by qPCR, growth hormone receptor A (ghra) gene, a growth-related gene, was significantly different from the colchicine-treated experimental group in males, the control group, and the other chemical treatment group. On the other hand, females showed higher levels of hydroxylamine than females. The lysozyme gene, an immune-related gene, was highly expressed in colchicine in males, while the level in females was the same as in all chemical treatment groups. The nestin gene, a nerve-related gene, showed higher expression in all experimental groups compared to the control group in males, with the highest level in colchicine, and in females, it also showed the highest level in colchicine.

This Results related to immunity, neurons, and growth related to mutant substances have not been reported in many existing studies, and it is believed that the results of this study can be used as basic data. In addition, the results of this study were conducted on zebrafish that had previously been treated with mutagenic chemicals, and the mutational changes in F1 and F2 will later be compared and analyzed.

NOVEL SOYHULL FEED BINDER -EFFECTS ON WATER STABILITY, NUTRIENT LEACHING AND POTENTIAL HEALTH BENEFITS ON PACIFIC WHITE SHRIMP, *Litopenaeus vannamei*

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Binders are used in aquafeed with the purpose of maintaining pellet integrity, increasing water stability, and decreasing nutrient loss. Novel feed binders from soybean hulls (SBH) were developed to further improve water stability of the compound feed. Three (SBH) -based binders were evaluated as binding agent (2%) against three natural control binders (carboxymethyl cellulose (CMC), corn starch (CS) and wheat gluten (WG)) with respect to water stability and nutrient leaching after being immersed in water up to 48 h at two water temperatures (22 ◦C and 28 ◦C). A 10-week feeding study was also conducted to evaluate the effect on physiological and immunological status of novel SBH feed binders on juvenile Pacific white shrimp, *Litopenaeus vannamei* (4.35 ± 0.10 g) were fed in triplicate aquaria at a rate of 4% of body weight per day, four times daily in a recirculating water system.

Diets with SHB had significantly improved pellet water stability compared to the diets with control binders (CS and WG) after being immersed in water for longer than 12 h. CMC had the poorest water stability at 3 h and longer water immersion. Recovery of pellets with soybean hull binders was significantly higher than the pellets with control binders at 24 h of water immersion. After 48 h of water immersion, only diets with SHB were recovered ranging from 30% to 40%. Increasing water temperature resulted in a corresponding decrease in water stability of all pellets. At higher water temperature, however, water stability of pellets with control binders were significantly lower compared to pellets with SHB. The binder that best retained crude protein in all time periods was SHB-3. However, it was not significantly different from other soybean hull binders. Percent lipid remained unchanged in all leached pellets up to 12 h of water immersion and increased afterward. Percent ash of the leached pellets increased at 3 h of immersion and continued to increase with the increasing period of water immersion. Diets with SHB retained higher nutrients than the diets containing control binders after being immersed in water 3 h or longer. Weight gain, feed efficiency, and survival of shrimp fed diets with control or SHB were not significantly influenced by binder type. Total hemocyte count (THC) and hemocyte lysate phenoloxidase activity was significantly higher in shrimp fed diet incorporated with SBH-2 binders than those of shrimp fed diet with CS. No significant differences in immune statues were observed among shrimp fed other diets. In summary, the SBH-bound pellets were more water stable than the control binders and produced better performing and less expensive natural alternatives to conventional binders. Additionally, the SBH binder may prove beneficial by improving the health status of shrimp.

SUSTAINABILITY ASSESSMENT OF COASTAL FISH HATCHERIES IN SAUDI ARABIA

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This study evaluated the Red Sea and Arabian Gulf coastal fish hatcheries of leading aquaculture companies in Saudi Arabia for future sustainability strategies. Seven marine fish hatcheries were assessed for the year 2021. Factors assessed included production capacity, existing infrastructure, main species farmed, source of broodstock and seedstock, and range of water temperature and salinity. Six of the seven coastal marine fish hatcheries lacked broodstock capacity. All hatcheries have adequate water supply from the Red Sea and Arabian Gulf coastline; two of the seven hatcheries are constrained by discharge restrictions. The live feed production section was absent in 5 out of 7 hatcheries. Most of the cultured species in the hatcheries were Asian sea bass Lates calcarifer, gilt-head seabream *Sparus aurata*, Sabaki tilapia *Oreochromis spilurus*, and sobaity seabream *Sparidentex hasta*. Only two hatcheries produced fry, with an average monthly fry production of 500,000-1,000,000 individuals. The source of broodstock for 5 out of 7 hatcheries depended on imports or other hatcheries. Sustainability strategies may focus on increasing broodstock capacity, live food production, and new culture species.

SOBAITY SEABREAM *Sparidentex hasta* FARMING IN HIGH-TEMPERATURE CONDITIONS

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The survival, growth performance, feed intake and feed conversion ratio of the culture of Sobaity seabream *Sparidentex hasta* in local high temperatures of 24°C, 28°C, and 32°C were estimated in this study. Experiments were conducted in triplicates with 40 fish (99 g average body weight; 17 cm average total length) in each indoor 1-metric ton fiber-reinforced plastic tank. For 96 days, fish were fed a commercial diet (6 mm, 46.36% crude protein, and 12.54% crude lipid). The results showed that survival and growth performance of juvenile Sobaity seabream were affected by temperature. Total weight gain was significantly higher in the 32°C group (158.57 g) followed by the 28°C group (138.25 g), and the lowest weight gain was observed in the 24°C group (116.98 g). The feed conversion ratio (1.62) was significantly lower in the 32°C group than in the 28°C (1.8) and 24°C (1.85) groups. Feed intake was significantly higher in the 32°C and 28°C groups (6.20–6.43 g) than in the 24°C group (5.41 g). In the 32°C group, the survival rate was significantly lower. The condition factor showed no significant difference among the three temperatures. Overall, Sobaity seabream farming is feasible at temperatures ranging from 24–32°C.

STATUS AND OUTLOOK OF AQUACULTURE CAREERS IN SAUDI ARABIA: HOW WE WORK IN THE MIDDLE EAST

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Due to sustainable economic development and food security for Saudi Arabia, aquaculture is essential for the national development sectors. To support the national GDP (gross domestic product) by creating job opportunities for aquaculture and Food security, the National Fisheries Development Program has been promoting to advocate for sustainable development and food security of national policies. However, the Saudi Arabian aquaculture industry has faced many problems related to the need for a broader range of aquaculture species, the absence of local hatchery facilities or inadequate production, diseases, and the lack of well-trained personnel. The National Fisheries Development Program have been designing programs for developing aquaculture. We are joining all major programs, such as policymaker assistance, aquaculture promotion, evaluation, farm management, applied research, farmer training, etc. We try to combine the resources of the private and public sectors to create job opportunities for all Saudi nationals and expatriates.

RECENT ADAPTATIONS OF THE KOOTENAI RIVER NATIVE FISH CONSERVATION AQUACULTURE PROGRAM TO RESTORE WHITE STURGEON AND BURBOT

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The Kootenai River White Sturgeon *Acipenser transmontanus* and Burbot *Lota lota maculosa* were once abundant in the Kootenai/ay River Basin in Idaho and Montana, USA, and British Columbia, Canada. Kootenai White Sturgeon remain listed as endangered in both countries, and Burbot natural recruitment remains very low despite recent successes meeting interim goals of warding of extinction / extirpation by filling recruitment gaps and re-building population structures via conservation aquaculture, and ecological restoration actions. The Kootenai Tribe of Idaho's (KTOI) Kootenai River Native Fish Conservation Aquaculture Program (KRNFCAP) goals are, avoid extirpation and rebuild abundance to jump-start natural recruitment, and support cultural and recreational harvest. Beyond rebuilding abundance, the conservation hatcheries also 1) spawn, rear, and release fish in a manner that supports monitoring, research, and evaluations of post-release performance of hatchery White Sturgeon and Burbot; and 2) release early life stages across habitat types/conditions in a manner that allows long-term evaluation of recruitment failure, and habitat restoration outcomes. By doing so, conservation aquaculture is an integral part of a large multi-strategy ecosystem restoration RM&E effort. The presentation will provide a summary of recent program adaptations implemented in response to recent RM&E results concerning the current status of the focal species and to the current ecological state of the Kootenai Basin.

INTRODUCING OR PROMOTING FEED CROPS FOR AQUACULTURE CAN LEAD TO CHANGES IN CROP ACREAGE PORTFOLIO: A CASE STUDY OF HEMP AND CROP MIX CHANGES IN KENTUCKY

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The best seafood sources of omega-3 PUFA (larger, carnivorous fish) tend to contain the highest levels of methylmercury and polychlorinated biphenyls (PCBs), have the most significant environmental impact, and are the most expensive at market. Rainbow trout is a predatory freshwater fish with high levels of omega-3 PUFA, which can be produced across the US in sustainable aquaculture systems devoid of methylmercury or PCBs. For predatory fish such as trout, fish meal and fish oil – usually obtained from wild-caught sources – must be included in feeds to maintain healthy fish development. Inclusion of fish meal and oil in feeds creates an expensive and environmentally unsustainable system. Hemp is a renewable resource with great potential for use in agricultural products. However, hemp producers are currently hindered by limited market opportunities, and hemp is not approved as an animal feed ingredient. Labeling hemp grain for use in feeds would expand economic opportunities for producers. This study tries to answer the question of how this alternative fish feed crop impacts crop production using a case study in Kentucky.

Introducing new crops or promoting environmentally beneficial crop incorporation into working agricultural fields can change crop acreage, crop mix, and on-farm revenue portfolios. When hemp is more grown, it will change the crop portfolio in accordance with the producers' desire to maximize their profitability. Despite the perceived benefits of crop portfolio changes with new or promoted crops, less attention has been paid to analyzing and modeling crop portfolios because the multiple output model, i.e., modeling multiple dependent variables, can be technically challenging. This study utilizes a Dirichlet regression model with fixed effects to fill this gap in the literature. As a case study, we collect county-level hemp production data for 2017 – 2022 from the USDA Farm Service Agency and include weather, geographical characteristics, and production-related variables. This study first estimates the response parameters to describe changes in crop ratios in Kentucky counties in the midterm, assuming no innovative changes in production technology and an extensive margin of agricultural expansion. Then, we project potential changes following representative scenarios, discuss the effects in harvested acres, and review by crop.

UNLOCKING THE POTENTIAL OF SORGHUM PROTEINS: EXTRACTION APPROACHES, AMINO ACID PROFILES, AND FUNCTIONAL CHARACTERIZATION

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Addressing the growing global demand for food production, especially in the context of a 70% increase by 2050, necessitates innovative approaches to sustainable protein sources. This study focuses on harnessing the potential of sorghum proteins through a comparative analysis of two extraction methods—alkaline (NaOH) and NaOH-Ethanol-Reducing Agent (NER). The aim is to identify the technique with a higher extraction yield and subsequently characterize the extracted proteins. The NaOH method exhibited an extraction yield of 1%, equivalent to 7.2% of the total protein content, with a protein isolate content of 56.11%. In contrast, the NER method demonstrated a significantly higher extraction yield of 7.55%, constituting 58.1% of the total protein. The resulting sorghum protein isolate from the NER method displayed a remarkable protein content of 88.83%, differing significantly from the NaOH method. Amino acid composition analyses unveiled distinctive profiles. Glutamic acid, leucine, and alanine emerged as predominant amino acids in sorghum protein, while the NaOH-extracted proteins showcased elevated levels of glutamic acid, arginine, and leucine. Notably, the NER method did not exhibit amino acids Taurine and Hydroxyproline. Glutamic acid, leucine, and alanine remained prominent, accounting for 22.42%, 14.65%, and 9.43%, respectively. Selected for its higher extraction yield and protein purity, the NER method was further scrutinized for functional properties. Solubility analysis across pH levels revealed optimal solubility at pH 8 to 11, emphasizing potential applications in various pH-dependent formulations. Water Holding Capacity (WHC) was 178%, and Oil Holding Capacity (OHC) reached 424%, positioning sorghum proteins favorably compared to soybean and mung beans. This holistic exploration not only unveils the extraction nuances and amino acid intricacies of sorghum proteins but also sheds light on their functional prowess. The findings underscore sorghum's viability as a protein source with diverse applications in the rapidly evolving landscape of sustainable food technology.

Table 1. The extract yield and protein content of sorghum in NaOH and NER and Sequential Dual-Stage Methods

Method	Raw Ground Sorghum	Extraction Yield (%)	% of Total Protein	Protein content of Extracted Isolate (%)
Single-Stage- NaOH	13.85	1.00	7.22	56.11
Sequential Dual-Stage	13.85	4.39	31.69	Step 1: 40.15
				Step 2: 78.90
Single-Stage (NER)	13.85	7.55	54.51	88.83

BIOPHYSICAL FACTORS, ENVIRONMENTAL REGULATIONS, AND SUSTAINABLE EARNINGS: THE CASE OF SALMON FARMING COMPANIES

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The biological production process of farmed salmon is highly vulnerable due to biophysical shocks, including sea temperature changes, fish diseases (especially sea lice infection), and toxic algae. Meanwhile, environmental externalities of salmon farming trigger stringent regulations, influencing production costs and profitability. This study first reviews studies on the impact of biophysical factors on the profitability of salmon farming companies. Then we evaluate the impact of biophysical factors and environmental regulations on sustainable earnings using the industry benchmark. In particular, we explore the differences in sustainable earnings for small and large firms.

We estimate the deviation from sustainable earnings (DSE) against biophysical factors and firm size (Model 1 in Table 1) and interaction terms between them (Model A2-A5 in Table 1). Our empirical results indicate that diseases and capacity utilization under output restrictions-based regulations influence sustainable earnings but with differing impacts on small and large firms. While capacity utilization causes a positive deviation of large firms' gross profit from the industry norm, its impact is ignorable for small firms.

From the empirical results, we formulate managerial and policy-relevant recommendations for the salmon farming industry to improve profitability and, meanwhile, pursue sustainable development.

Table 1. Estimation results for Deviation from Sustainable-Earnings (DSE)

Variable	Model A1	Model A2	Model A3	Model A4	Model A5
Intercept	0.8447 *	1.1188 **	0.9199 *	0.8723 *	0.6254
	[0.5179]	[0.5548]	[0.5156]	[0.525]	[0.542]
Temperature	-0.015	-0.0391 **	-0.0124	-0.0141	-0.0154
	[0.0102]	[0.0194]	[0.0103]	[0.0103]	[0.0101]
Diseases	-0.0023 **	-0.0021 **	-0.0067 ***	-0.0023 **	-0.0023 **
	[0.0011]	[0.0011]	[0.0024]	[0.0011]	[0.0011]
Sea-Lice	0.1015	0.1107	0.1031	-0.0726	0.0943
	[0.1278]	[0.1291]	[0.1288]	[0.323]	[0.1278]
Capacity-Utilization	-0.0163	-0.0171	-0.0159	-0.0162	0.0931 **
	[0.013]	[0.0129]	[0.0129]	[0.013]	[0.0463]
Small-Firm	0.0633	-0.2195	0.0197	0.035	0.2368 **
	[0.0428]	[0.2083]	[0.047]	[0.0718]	[0.0943]
Small-Firm*Temperature		0.0313			
		[0.0215]			
Small-Firm*Diseases			0.0052 **		
			[0.0025]		
Small-Firm*Sea-Lice				0.1832	
				[0.3406]	
Small-Firm*Capacity-Utilization					-0.1142 **
					[0.0483]
Control variables	Yes	Yes	Yes	Yes	Yes
Adj. R^2	0.0811	0.0873	0.0887	0.0804	0.0873
Observations	720	720	720	720	720

Note: *, **, and *** stand for the significance level of 10%, 5%, and 1%, respectively.

INVESTIGATING WHALE SAFE CONCEPTS FOR KELP AQUACULTURE SYSTEM DESIGNS

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The development of open ocean aquaculture in the United States has been difficult due to, in part, compliance with the Marine Mammal Protection and Endangered Species Acts. In the northeast, the intent of these efforts is often to protect the North Atlantic right whale (NARW), since entanglement in rope can be deadly, especially for this species. Opportunity exists, however, to develop kelp aquaculture in many exposed sites in New England providing both economic and ecosystem benefits. Kelp farming, however, typically uses rope components and therefore an entanglement risk exists. The objective of this presentation is to build upon simple design concepts described in [1] to replace rope with components that could reduce the chances of entangling the NARW. A system design will be presented that incorporates the strategic positioning of weak links and shortened lengths of rope, strategies described in *Atlantic large whale take reduction plan regulations* for fixed gear [2]. The design will also include sections of fiberglass rebar introduced for kelp farming in [3] and high density polyethylene pipe (HDPE) as the cultivation structure. The hypothesis is that HDPE will not wrap tightly around whale parts. Even if the HDPE becomes 'kinked' in failure [4], it will shed off the whale easier than rope. This presentation will show system design details with construction, deployment and seeding at an Isles of Shoals site operated by the University of New Hampshire.

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PRE-METHYLATION OF FOREIGN DNA OVERCOMES THE RESTRICTION-MODIFICATION BARRIER OF *Flavobacterium psychrophilum* AND ALLOWS EFFICIENT SPECIES-WIDE GENETIC MANIPULATION

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Flavobacterium psychrophilum is the causative agent of bacterial cold-water disease (BCWD) in salmonids and other fish, resulting in substantial economic losses in aquaculture worldwide. The mechanisms of *F. psychrophilum* in causing the disease are poorly understood. Currently the control of BCWD mainly relies on the use of antibiotics. Efficient and universal vaccines against this disease are not commercially available. One of the major obstacles for the identification of virulence factors and development of live attenuated vaccines in *F. psychrophilum* is the difficulties in genetic manipulation. Most strains of this fish pathogen are resistant to foreign DNA transfer, due to the presence of the protective restriction-modification (RM) "immune" systems. In this study, we identified two critical methyltransferases, HpaIIM and ScrFIM, belonging to the type II RM systems, in *F. psychrophilum* CSF259-93. A helper plasmid pSS05 carrying both HpaIIM and ScrFIM encoding genes was constructed, and was shown to protect the target DNA from restriction digestion and ensure successful conjugative DNA transfer from *Escherichia coli* to *F. psychrophilum* CSF259-93. By using pSS05 and a previously developed *sacB*-mediated deletion system, we constructed the first gene deletion mutant in *F. psychrophilum* CSF259-93. The mutant lacking *gldN*, a core component of the T9SS, is deficient in secreted proteolytic activity, colony spreading, single cell motility, and virulence on rainbow trout. Genomic analysis of 16 *F. psychrophilum* strains, isolated in Chile, China, Denmark, Finland, France, and the United States, revealed the strains that are phylogenetically close tend to carry the same RM systems, and the HpaII and ScrFI RM systems are present in 13 of the 16 analyzed genomes. We further found the pre-methylation system developed in this study functions in most of the 16 strains. These newly developed genetic tools may allow the identification of key virulence factors and facilitate the development of live attenuated vaccines in multiple *F. psychrophilum* strains to prevent BCWD.

ADDENDUM

IMMUNOGENICITY AND GROWTH RESPONSE OF ATLANTIC SALMON TO THE ADDITION OF MARINE DIATOM, *Skeletonema marinoi* AS A FUNCTIONAL FEED INGREDIENT

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Atlantic salmon (*Salmo salar*) is one of the most commercially farmed aquaculture species in the world. As with all cultured species, disease can be a major impediment to production activities. Functional feed ingredients with antimicrobial activities are being explored as a tool to mitigate disease and the marine diatom, *Skeletonema marinoi* is known to have antimicrobial activity. Here we study the effects of dietary *Skeletonema marinoi* on the growth, health, and immunogenicity of Atlantic salmon. Two separate experiments were conducted: a bacterial challenge (Exp.1) and a growth study (Exp.2).

In Exp.1, a 28-day bacterial challenge using *Vibrio anguillarum* S03*,* the causative agent of Vibriosis, was conducted at the University of Maine, Aquaculture Research Institute. Thirty-six fish (100-150g/fish) were stocked into each tank (150 liters), brackish water (18 ppt) at 14°C in recirculatory aquaculture systems (RAS). Fish were acclimatized to the RAS system for 14 days by feeding twice a day, one group was fed with 0.5% diatom, *Skeletonema marinoi* top-coated on a reference diet, and the other group was fed with a reference diet in triplicate. The liver, blood plasma, and intestine samplings were collected before (initial 0 days) and post-challenge (5, 10, 28 days) to assess the effect of the addition of the diatom in feed on the immune response in Atlantic salmon exposed to a bacterial challenge. In Exp 2. a 16-week growth trial was conducted at the USDA-ARS National Cold Water Marine Aquaculture Center, Franklin, Maine. Ten fish were stocked into each tank with replicates of five tanks per treatment and fed twice a day. The growth trial involved two treatments: a reference diet and the reference diet supplemented with 0.5% *Skeletonema marinoi* diet.

According to the bacterial challenge results, salmon fed the antimicrobial algal diet showed significantly higher liver oxidation levels on day 5 post-bacterial challenge but not at 10- and 28-days post-challenge compared to salmon fed a reference diet. By 28 days post challenge, intestinal immunoglobulin (IgM) gene expression was significantly higher in fish fed *skeletonema marinoi* diets ($P< 0.05$). These data suggest that the addition of the diatom, *Skeletonema marinoi* in feed may enhance the salmon immune response. In Exp 2., there was no significance difference in survival, weight gain, feed conversion ratio, hepatosomatic index, and condition factor between fish fed with the 0.5% *Skeletonema marinoi* diet and the reference diet, suggesting general growth performance of cultured salmon was uncompromised by the addition of algae to the feed. Results of additional measured parameters from these experiments will be discussed.

INDUSTRY SOLUTIONS TO WATER QUALITY CHALLENGES AND OFF-FLAVOUR/ GEOSMINE BUILD-UP IN RAS

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Some of the main challenges in RAS feasibility are related to water quality. When the water is repeatedly recirculated, water quality becomes increasingly deteriorated mainly due to organic matter accumulation. High concentrations of organic matter lead to pathogens blooming since it is utilized as substrate, which might affect adversely the cultivated species. Several costly technological solutions have been implemented to solve water quality issues, including mechanical and biological filtration systems, degassing units, skimmers, and UV systems. Even then, a significant build-up of undesirable by-products from the bacterial communities, such as 2-methylisoborneol (MIB) and geosmin, is still detected. These substances accumulate in the fish flesh leaving a muddy/musty flavor and taste, thus making it unsuitable for human consumption. As there are no technological solutions to this problem today; the primary producers purge all fish before they are slaughtered. This is both costly and time-consuming and significantly increases the environmental footprint of the product.

To avoid costly purging, ozone, which is a strong oxidizing agent with disinfection properties, has been introduced as an alternative in RAS. Ozone is a strong oxidizing agent (removing non-biodegradable DOM and proteins), a good disinfectant (killing bacteria, parasites, and viruses) and it can improve the taste (removing geosmin and MIB). Implementing ozone in freshwater RAS is less complicated than treating seawater RAS. In the presence of ozone, bromide is initially converted to hypobromite, which can then either be reduced back to bromide or oxidized further to the carcinogenic bromate which is also known to be toxic (acutely toxic at 0.05 mg/L). This is a major issue that needs to be addressed since the risk of killing the fish is high and it comes with enormous costs for the fish farmers. Therefore, it is important to know how much ozone each system requires to improve the water quality without forming the brominated by-products. OxyGuard Group has developed a reliable, easy-to-work-with, and safe ozone generator, with stable output. OxyGuard Group has also developed a very sensitive and fast-in-response ozone sensor and a control unit to continued monitoring and control the ozone process. In combination with other water treatment technologies, we are close to solving the Geosmin challenge.

In this presentation we will present the solution we have worked on for the past 4 years and the results from our field studies.

DESIGNING AND CONSTRUCTING OF DNA VACCINE-VECTOR SYSTEM TO PROTECT FISH AGAINST MULTIPLE INFECTIOUS DISEASES

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We have newly developed an innovative mucosally delivered DNA vaccine vector system that should prevent important infectious diseases in the aquaculture industry. Starting with the invasive fish pathogen *Edwardsiella piscicida*, we have successfully designed a recombinant attenuated *Edwardsiella* vaccine (RAEV) vector system that is sensitive to all antibiotics and exhibits complete biological containment with no persistence in vivo or ability to survive in the environment. The RAEV vaccine vector strains have the features of (i) regulated delayed attenuation, (ii) regulated delayed lysis in vivo, (iii) increased plasmid survival/stability and (iv) reduced pyroptosis/apoptosis attributes. The regulated delayed attenuation attributes were designed to enhance induction of immunity to *Edwardsiella* species. The timing of events has been programmed to maximize the ability of vaccines to colonize internal lymphoid tissues in fish to produce and deliver DNA vaccine by lysis, which precludes persistence in vivo and viability in the environment. The decreased *Edwardsiella*-induced pyroptosis/apoptosis feature allows the DNA vaccine time to traffic to the nucleus for efficient synthesis of encoded protective antigens. For this study we have used our improved DNA vaccine vector pYA4545 which encodes a domain that contributes to the arabinose-regulated lysis phenotype but has a eukaryotic promoter. The vector was improved by insertion of multiple DNA nuclear-targeting sequences for efficient nuclear trafficking and gene expression, and by increasing nuclease resistance to protect the plasmid from host degradation. DNA vaccines encoding *Ichthyophthirius multifiliis* (Ich) antigens to be delivered by RAEV and synthesized in fish host cells are enabled to perform post-translational modification. Synthesis of Ich antigens were confirmed in vitro by transfecting into a fish cell line. We will validate the RAEV vectored DNA vaccine encoding Ich antigen(s) by bath immersion to induce protective immunity to white spot disease in catfish. We will also validate this vectored vaccine to induce protective immunity against *E. piscicida* infection thus contributing a second benefit to enhance productivity in aquaculture.