



Aquaculture Research, Education and Engagement Plan



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Introduction

This Sea Grant Research, Education and Engagement plan provides the results of a Sea Grant supported Great Lakes and marine aquaculture research, education, and engagement needs assessment. The needs assessment is a synthesis of input from Sea Grant professionals and a synthesis of input from 19 state, regional and national plans developed by gathering input from 1000s of people contributing 1000s of hours to produce the plans analyzed during the development of this plan. Needs identified in those plans and used in this plan had to be actionable items that could be addressed by Sea Grant’s functional areas of research, education and engagement (communications, extension and legal).

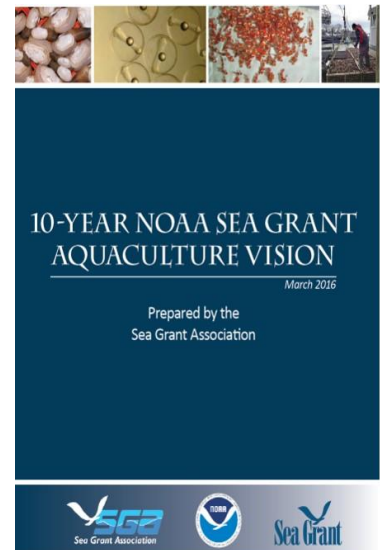
Background

Sea Grant invests approximately \$20 million in federal funds annually to support aquaculture, research, education and engagement. Sea Grant should continuously engage with farmers and other stakeholder to understand the short- and long-term needs of the aquaculture industry to effectively and efficiently expend the funds Congress appropriates each year.

Sea Grant has produced planning documents on a variety of topics including aquaculture dating back to the 1990s through topical area “theme teams”. The theme team approach was beneficial to Sea Grant in developing programs to respond to stakeholder needs. In 2016 the Sea Grant Association’s released a [10-year Aquaculture Vision](#) to serve as a framework for Sea Grant’s role in development of sustainable U.S. aquaculture industry. Input for the Vision was provided by the Sea Grant Network and the stakeholders who they serve. The Vision includes research and extension strategies for the following 5 focus areas:

1. Commerce
2. Permitting and Policies
3. Current and Emerging Species
4. Production Systems
5. Seafood Safety and Quality

The vision document had been helpful in establishing an operational framework for Sea Grant programming and has been referenced in Sea Grant funding requests. The vision, however, did not attempt to gather nationwide industry needs to guide Sea Grant funding investments. This Sea Grant Research, Education and Engagement Plan identifies stakeholder needs which are appropriate for Sea Grant investments.



Planning Process

The planning process consisted of two phases. The first phase involved an internal and external Sea Grant online needs assessment survey. The Sea Grant survey gathered 110 responses from stakeholders on research, communication, education, extension and legal needs using open-ended questions based on the 5 focus areas in the Sea Grant 10-Year Aquaculture Vision. The second phase involved analyzing 19 industry, state, regional and national aquaculture research, extension and education needs assessments. Below is a list of the data sources used to develop this document.

Sea Grant

1. 2020 Internal Sea Grant Needs Assessment
2. 2021 External Sea Grant Needs Assessment

State, Regional and National Plans Analyzed

1. DRAFT National Strategic Plan for Aquaculture Research 2021-2025 Joint Subcommittee on Aquaculture
2. 2021 National Aquaculture Association US Aquaculture Research and Extension Priorities
3. 2021 East Coast Shellfish Growers Association Research Priorities
4. 2021 Pacific Coast Shellfish Growers Association Research Priorities
5. 2021 Alaskan Shellfish Growers Association Research Priorities
6. RAS-N land-based salmon stakeholder priorities (no date)
7. 2019 Maine Aquaculture Report
8. 2020 ERG Workforce Development in Aquaculture & Fisheries
9. New York Aquaculture Needs Assessment Report 2021
10. 2021 NOAA Office of Education Aquaculture Literacy Stakeholder Input
11. 2021 Willapa-Grays Harbor Oyster Growers Association Research Priorities Guidance Document
12. 2020 Florida Aquaculture Plan
13. 2018 Alaskan Mariculture Development Plan
14. 2018 Gulf of Mexico Shellfish Initiative
15. 2018 Sea Grant Aquaculture Communications Vision
16. 2016 Sea Grant Aquaculture Vision
17. West Coast Shellfish Research Goals -- 2015 Priorities
18. Strategic Plan for Federal Aquaculture Research (2014-2019)
19. 2000 Sea Grant Aquaculture Theme Team

The remainder of this plan presents industry needs for research, education and engagement for the five focus areas identified in the Sea Grant 10-Year Aquaculture Vision. In addition, a sixth focus area for Aquaculture Literacy and Workforce Development was added to address needs which did not align well with the five focus areas in the 10-Year Aquaculture Vision. The needs

identified in the plan were prioritized and some of the needs within a focus area are cross-cutting and could also fit in other focus areas.

Commerce

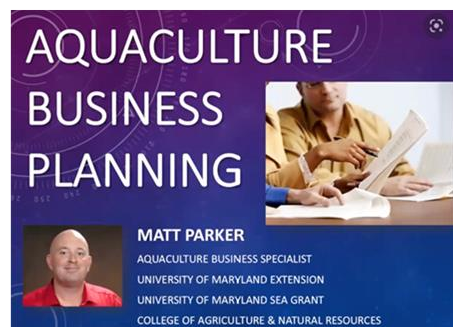
Research

1. Identify ways to develop new or expand existing market channels for aquaculture products.
2. Develop risk management tools to integrate production and financial risk.
3. Determine operational costs of production and marketing for use in enterprise budgets with sensitivity analysis for current and emerging species.
4. Identify effective production and marketing strategies for various scales of production, recognizing that profitable strategies will differ for smaller-scale as compared to larger-scale farms.
5. Develop web-based break-even analysis planning tools that can be used to explore the effects of farm scale, production intensity, scope, and location on financial viability of aquaculture businesses.
6. Establish yield verification trials for multiple emerging species and production systems.



Engagement and Education

1. Provide training to farmers for:
 - a. Business planning
 - b. Market analyses
 - c. Aquaculture business assessments related to capital investments
 - d. Financing
 - e. Insurance
 - f. Financial risk management
2. In partnership with farmers establish demonstration sites as teaching tools for new and existing farmers.
3. Establish training programs address inequity among seafood consumers.
4. Develop streamlined data analysis and workflow systems to support stakeholder business operations.

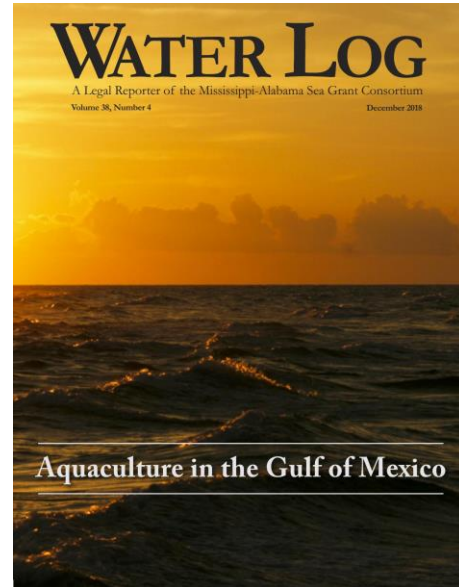


Maryland Sea Grant

Permitting and Policy

Research

1. Identify the effects of existing and proposed policy options on farmers.
2. Identify ways to reduce redundancy in permitting, data reporting, testing requirements.
3. Identify common policies that will ensure uniform regional governance.
4. Develop tools for state and federal regulators and producers to assess potential production sites.
5. Develop models that account for the potential effects from environmental change on aquaculture production.
6. Develop nutrient credit policies and guidelines for shellfish and algae aquaculture industry as a general template for individual states.



Engagement and Education

1. Assist farmers in navigating the permitting and regulatory processes.
2. Increase understanding of current laws and policies, the needs of the aquaculture industry, and options for legal and regulatory reform to reduce the cost of regulatory compliance.
3. Facilitate the development of model state laws and guidance to address typical legal and regulatory barriers to the aquaculture industry.
4. Implement programs for aquaculture stakeholders to increase awareness of the legal responsibilities of state agencies, the challenges of balancing multiple uses of coastal lands and waters, and the legal authority of local governments to regulate land uses in certain zones.
5. Develop streamlined data analysis and workflow systems to support regulatory and policy processes and stakeholder planning efforts.
6. Use best available science to assist regulatory agencies in modifying rules and regulations as conditions change (e.g. improvements in water quality due to adopting a new technology).
7. Provide training on NEPA requirements and submissions.

Current and Emerging Species

Research

1. Develop cost-effective ways to improve sustainable production efficiencies of commonly cultured species.
2. Create emerging species hubs to focus on understanding the hatchery and production requirements to maintain broodstock, spawning requirements, and nursery and production requirements for emerging species.
3. Identify species that are best suited for multi-trophic aquaculture (e.g. seaweeds, sea cucumbers, shellfish, finfish) and are profitable.
4. Hatcheries
 - a. Develop long-term selective breeding programs, hybridization, sterility and genetic modification.
 - b. Improve hatchery production to produce reliable shellfish seed, macroalgae seedlings and finfish juveniles.
 - c. Develop out of season spawning protocols (i.e. bivalves and finfish).
 - d. Determine the types of and causes of hatchery and nursery pathogens (viruses, fungi, bacteria and parasites) and develop mitigation techniques.
 - e. Improve techniques for ornamental and medical-use fish and invertebrate species reproduction and grow-out.
5. Feeds and Feeding
 - a. Develop new cost-effective feed ingredients, and improve feed production technologies.
 - b. Determine nutritional requirements of early life stages of emerging species.
 - c. Support the development of palatable, nutritionally complete finfish diets that minimize or eliminate the use of fish oil and fish meal.
 - d. Provide feed manufacturers with cost-effective choices in feed ingredients.
 - e. Develop production system and broodstock specific feeds (e.g. recirculating aquaculture systems).



6. Aquatic Animal Health
 - a. Develop strategies to protect the health and well-being of aquaculture species (predators, pests, pathogens, and a changing climate).
 - b. Develop economical and practical means to diagnose and mitigate pathogens in grow-out systems.
 - c. Improve farm-level biosecurity and management practices to maintain adequate water quality, minimize animal stress, and prevent diseases.
 - d. Understand and characterize the aquaculture microbiome and create technologies or techniques to improve favorable microbiome conditions.
7. Environmental Impacts
 - a. Fully understand the suite of ecosystem services provided by cultured species (i.e. bivalves) and using different production methods (floating vs. bottom culture).
 - b. Determine current and future impacts of a changing climate change on aquaculture.
 - c. Identify new pollution mitigation technologies and the impacts of these technologies on farms and the environment.
 - d. Determine the role of aquaculture in transmission of pathogenic or parasitic species into wild populations.
 - e. Develop data visualization, analysis, and management tools and technology to improve monitoring and assessment of environmental conditions and impacts.

Engagement and Education

1. Support collaborative, multidisciplinary research partnerships involving academia, private industry and federal partners to bring promising new species into commercial production.
2. Use best available science to inform the production of sustainable alternative, emerging, and native species.

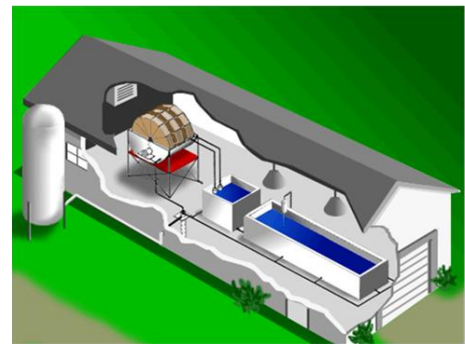


Production Systems

Research

1. Improve the cost effectiveness of production systems, product quality, and species well-being and health.

2. Implement production yield verification studies in partnership with farmers to better inform business planning.
3. Develop technologies and practices to prevent or reduce interactions and competition with native wild populations.
4. Develop cost-saving technologies for production, harvest and processing.
5. Create low-cost technological solutions for labor-intensive tasks.
6. Determine the impact fish farm effluent has on the environment.
7. Develop better modeling tools for farm water quality and carrying capacity in estuaries.
8. Implement controlled comparison studies at various production densities on the water quality inside and outside net pens to inform stakeholders.
9. Develop multi-trophic systems for raising food and bait species.
10. Identify the most cost-effective production system designs, and management and maintenance strategies to:
 - a. Decrease effluent and improve its treatment
 - b. Improve water quality
 - c. Improve water conservation
 - d. Reduce off-flavor
 - e. Decrease biofouling
 - f. Improve hazard mitigation
 - g. Mitigate for pathogens
11. Develop cost-effective engineering solutions for:
 - a. Integrated use of robotics
 - b. Increasing production system yields
 - c. Instrumentation:
 - i. Environmental parameter and biomass monitoring, crop inventory
 - ii. Farm security surveillance
 - iii. Harmful algae bloom (HAB) detection and quantification
 - d. Improve oxygen technology for recirculating aquaculture systems (RASs).
 - e. Minimizing energy costs in RASs.
 - f. Develop cost-effective treatments of organic waste in RASs.
 - g. Open Ocean Aquaculture
 - i. Remote offshore communications, monitoring, and control technology.



- ii. Offshore cages and net pens.
- iii. Offshore infrastructure that can withstand extreme conditions.
- iv. Harvesting and transport engineering and technology for open ocean aquaculture.
- v. Develop technologies to minimize protected species entanglement issues with open ocean aquaculture.



- h. Develop production systems that can be co-located with, and synergistic to the operations of other offshore structures (e.g. wind farms)

Engagement and Education

1. Establish a network of regional aquaculture demonstration and yield verification sites where species, systems and culture practices can be refined, validated and demonstrated to the private sector. These centers could be:
 - a. Led by extension and in partnership with farmers, researchers, and educators.
 - b. Seafood produced should not compete in the marketplace with product produced on commercial farms.
 - c. Include field days (in-person and virtual) where perspective farmers can interact and learn from participating farmers.
2. Provide training on adapting existing oyster production methods to diploid oyster production for restoration.



Seafood Safety and Quality

Research

1. Cost-effective technologies
 - a. Develop improved processing technology, infrastructure, and value-added products.
 - b. Develop better monitoring and tracking technology for seafood safety and quality.
 - c. Rapid, affordable, and FDA-approved tests to detect human pathogens and toxins.

- d. Develop tools to improve traceability and species identification.
 - e. Develop sensitive, rapid identification tools for bacterial and viral pathogens, and HABs.
 - f. Develop cost-effective rapid shellfish tissue biotoxin assays for saxitoxin and domoic acid.
 - g. Develop post-harvest processing methods that reduces pathogenic *Vibrio* counts while maintaining flavor and texture of live shellfish.
 - h. Develop “smart packaging” to assess the quality of aquaculture products.
 - i. Identify causes and solutions for off-flavor.
2. Risk management of toxins and pathogens
 - a. Conduct pathogen horizon scanning and investigate zoonotic pathogens.
 - b. Develop predictive tools for HAB outbreaks.
 - c. Assess uptake and purge rates of pathogens at various water temperatures.
 - d. Evaluate the FDA and Canadian Norovirus risk assessment tool.
 - e. Understand the impact of microplastics and nanoplastics in seafood
 - f. Improve heavy metal, steroid hormone and pesticide detection and to develop strategies for mitigation in system water, feed and cultured products.
 3. Conduct research and outreach targeting behavioral and consumer sciences.
 4. Determine which types of value-added products are likely to be profitable for various sectors of U.S. aquaculture.
 5. Identify alternative, lower-cost testing and monitoring methods for regulatory compliance, including non-lethal tests for aquatic animal health.
 6. Increase therapeutant development and testing – vaccines, antibiotic and other medicines.
 7. Improve the understanding of aquaculture interactions with wild stocks and the natural environment relative to diseases and other factors affecting product quality and sustainability.



Connecticut Sea Grant

Engagement and Education

1. Provide formal educational opportunities and training for veterinarian and fish health professionals.
2. Education and engagement with communities to better understand safety measures to ensure safe seafood production and handling.



Photo by Karen Templeton

3. Develop web-based and smart phone apps for Hazard Analysis Critical Control Point (HACCP) and seafood safety and quality education.
4. Provide technical assistance for:
 - a. Risk management
 - b. Value-added aquaculture products.
 - c. Improve the understanding of aquaculture interactions with wild stocks and the natural environment relative to diseases and other factors affecting product quality and sustainability.
 - d. Maintaining seafood quality.

Aquaculture Literacy and Workforce Development

Aquaculture Literacy

1. Define agreed upon principles and concepts that represent the knowledge and understanding of aquaculture literacy.
2. Align literacy principles and concepts with national standards.
3. Develop an aquaculture literacy program that is NON-advocacy and science-based for educational purposes on topics such as:
 - a. Aquaculture and the environment
 - b. Seafood safety and consumer confidence
 - c. Fish feces and uneaten food entering surrounding production areas waters.
 - d. Species escapement from farms into the environment
 - e. Social acceptance of aquaculture by the public
 - f. Public and commercial use conflicts (e.g. NIMBY and potential conflicts between wild harvest and aquaculture stakeholders)
 - g. Animal welfare
 - h. Aquaculture impacts on climate
 - i. Opportunities for careers in aquaculture
 - j. Diversity, equity and inclusion in aquaculture



Workforce Development

1. Develop, implement and evaluate a needs-based national aquaculture information clearinghouse for multiple audiences including farmers, K-12 and college students, academia, and governmental and non-governmental organizations.
2. Aquaculture and seafood safety training for food processors and restaurateurs
3. Implement programs to increase the diversity and equity of the aquaculture workforce.
4. Incorporate traditional ecological knowledge principles into education and engagement programs.
5. Farmers
 - a. Increase the social, environmental and economic resilience of farms to natural, technological and economic disasters.
 - b. Implement certificate programs for farm laborers (i.e. through extension, trade schools or community colleges)
 - c. Develop a better understanding and dissemination of occupational health risks across all aquaculture sectors.
 - d. Provide farmer education about biosecurity risks.
 - e. Communicate case studies on successes and failures in the permitting process.
6. K-Graduate Education
 - a. Expand standard-based primary and secondary education.
 - b. Expand training opportunities high school, vocational schools, community colleges which includes on-farm internships, mentorships and career and technical education (CTE).
 - c. Continue to support formal and informal education for undergraduate and graduate degree granting institutions.



Concluding Comments

Historical Context of Sea Grant's Aquaculture Planning

In the 1990s and early 2000s Sea Grant had multiple theme teams including one for aquaculture. Needs Identified around more than 20 years ago are similar to the needs identified in this plan. For example, the 2000 Aquaculture Theme Team identified the following areas of investment to support the sustainable development of the Great Lakes and marine aquaculture industry:

1. Siting and permitting
2. Emerging species development
3. Marketing and consumer education
4. Feeds and feeding
5. Technology development
6. Diagnostic capabilities and new drug development

Clearly, there is has been a good understanding of the industry's top-line needs for decades. Tracking progress in addressing the needs is more problematic if industry growth is the only metric used to measure success.

Key Points for Sea Grant to Consider

1. There are many more needs than resources available for a single identity to address. It is, therefore, important to engage regularly with the aquaculture industry to reassess which needs require immediate attention and which needs can be addressed over a longer period of time.
2. Sea Grant has a robust reporting system best suited for tracking the progress of its investments over 2-3-year blocks of time. It is generally accepted that the impact of a line of research is difficult to document by the end of the funded project. Longer-term tracking of lines of research is needed to better document the positive impacts of Sea Grant investments and to identify ongoing gaps in the science.
3. Many of the problems facing the industry can only be solved through strong collaborations and partnerships. Focusing on the Sea Grant mission, will allow Sea Grant to address the needs best suited for Sea Grant.
4. An Aquaculture Literacy and Workforce Development focus area was not explicit in the 10-Year Sea Grant Aquaculture Vision. Including this cross-cutting focus area provides a way to connect the needs of citizens who are not directly involved in the industry but are affected by it as consumers, property owners, communities, and environmental organizations.
5. Sea Grant should continue to be adaptable and nimble enough in its programs to respond to emerging industry needs (e.g. COVID-19).
6. Sea Grant staff working with the aquaculture industry should participate in continuing education to maintain their technical competence.

7. Sea Grant should continue to integrate extension, education and engagement objectives into research projects.
8. Sea Grant should continue to serve at the boundary of science and policy and avoid the perception of advocating.

Acknowledgements

Many people spent countless hours producing the 19 plans analyzed for this plan. The plan builds on those efforts and hopefully shines a light on the value of state, regional and national planning efforts. I thank those groups for allowing me to draw the needs identified in those plans and include the needs suitable for investments by Sea Grant. The internal and external Sea Grant needs assessment was valuable because the results from those two surveys validated information found in other aquaculture plans and by identifying areas of investment not identified in those plans. I sincerely appreciate members of the Sea Grant Network and industry members who shared their knowledge and insights. I thank the National Sea Grant Office aquaculture staff including Kola Garber, Mark Rath and Chuck Weirich who provided valuable input during the development of this plan. Finally, I thank the National Aquaculture Association (NAA) Board of Directors and Paul Zajicek, NAA Executive Director, who spent many hours reviewing stakeholder input and collecting most of the documents reviewed for this plan

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