Sea Grant 2019 National Aquaculture Initiative Funded Projects and Programs

Projects were submitted to one of three opportunities identified by Sea Grant as specific needs in U.S. aquaculture.

Advanced Aquaculture Collaborative Programs

Ten projects will develop integrated teams of professionals focused on accelerating the development of specific aquaculture topics. These teams will establish a collaborative program to plan for and appropriately focus the next generation of aquaculture investments while enhancing the synthesis and transfer of past research advances to the industry.

East Coast Hard Clam Selective Breeding Collaborative

Applicant: New York Sea Grant
Lead PI: Bassem Allam, New York Sea Grant
Co-PI(s): Emmanuelle Pales Espinosa, Stony Brook University; Ximing Guo, Rutgers University Kimberly Reece, Virginia Institute of Marine Science; Antoinette Clemetson, New York Sea Grant (subawardee), Huiping Yang (University of Florida)
Partner(s): Stony Brook University; Rutgers University; Virginia Institute of Marine Science; Cornell University
Federal Funding: $1,200,000

The hard clam, *Mercenaria mercenaria*, is among the most economically valuable bivalve species in the United States, representing the most important marine resource in several Atlantic states (e.g. NY, VA, FL). The species is extensively aquacultured from Massachusetts to Florida. Maintenance and growth of this aquaculture industry relies on hatchery production of seed, and billions of seed clams are produced annually to fulfill aquaculture and restoration needs. In this context, the production of quality seed able to survive under harsh biological and environmental conditions represents a major priority for the aquaculture community. Development of genetically improved strains of clams will allow the sustainability and the continued growth of clam aquaculture along the Atlantic coast. This collaborative proposal builds on ongoing cooperation and new partnerships among Sea Grant programs, scientists and extension teams in 5 Atlantic states to develop a hard clam selective breeding program for the benefit of clam farmers throughout the region. In this proposal, we describe our plan to build on this major progress by completing the sequencing of the clam genome and using this resource to build a single nucleotide polymorphism (SNP) array as an effective genotyping platform for the identification of clam stocks that are resistant to biological and environmental stressors hampering the growth of hard clam aquaculture in the region. The overarching aim of this proposal is to accelerate and enhance the selective breeding of the hard clam and develop superior clam stocks for aquaculture operations for all growing regions along the Atlantic seaboard.

Catalyzing a Cross-Pacific Regional Collaborative Hub to Advance Indigenous Aquaculture Practices and Enhance Marine Food Production for Cultural-Ecological Benefits

Applicant: Washington Sea Grant
Lead PI: Russell Callender, Washington Sea Grant
Co-PI(s): Melissa Poe, Washington Sea Grant; Rosanna (Rosie) Alegado, Hawaii Sea Grant, Julie Barber, Swinomish Indian Tribal Community , Ginny L. Eckert, Alaska Sea Grant, Courtney Greiner, Swinomish Indian Tribal Community, Katy Hintzen, Hawaii Sea Grant, Darren T. Lerner, Hawaii Sea Grant
Partner(s): Skye Augustine, Parks Canada Gulf Islands National Park Reserve and Simon Fraser University; Central Council of the Tlingit and Haida Indian Tribes of Alaska; Marco Hatch, Western Washington University; Kua'āina Ulu 'Auamo; Northwest Indian College; Puget Sound Restoration Fund; Anne Salomon, Simon Fraser University; Sitka Tribe of Alaska
Federal Funding: $587,127
Washington Sea Grant, Hawaii Sea Grant and Alaska Sea Grant propose to catalyze a cross-Pacific regional collaborative hub integrating research, outreach and education to advance sustainable Indigenous Aquaculture practices and enhance seafood production in the broader Pacific region. Indigenous Aquaculture management practices have the potential to strengthen community access to traditional and customary foods, increase local seafood production, and deepen collaborative engagement between Sea Grant and local tribal communities for aquaculture advancement, climate adaptation, and coastal restoration. Integral to the success of the project is developing a community of practice that involves diverse partnerships and stakeholders, comprised of Sea Grant staff, Northwest tribes, Native Hawaiian communities, universities, minority-serving colleges, and local non-profit organizations. Activities include conducting a comprehensive assessment of cross-Pacific Indigenous Aquaculture to improve local and regional learning about existing and emerging projects on Indigenous Aquaculture initiatives. Additionally, the collaborative will support inclusive workforce and leadership development through fellowships for students from historically underrepresented or underserved colleges.

Nurturing the Successful Growth and Maturation of a Domestic Seaweed Aquaculture Industry: Identifying and Removing Barriers and Promoting Opportunities

Applicant: Connecticut Sea Grant
Lead PI: Anoushka Concepcion, Connecticut Sea Grant
Co-PI(s): Jaclyn Robidoux, Maine Sea Grant; Melissa Good, Alaska Sea Grant; Stephanie Showalter Otts, National Sea Grant Law Center
Partner(s): Connecticut Department of Agriculture, Bureau of Aquaculture; Cape Cod Cooperative Extension; Washington Department of Agriculture; Washington Department of Fish and Wildlife; Washington Department of Natural Resources; Hood Canal Mariculture, Inc.; Puget Sound Restoration Fund; The Suquamish Tribe; The Sustainable Collective; Alaska Sea Grant; Maine Sea Grant; New Hampshire Sea Grant; National Sea Grant Law Center; New York Sea Grant; Oregon Sea Grant; ; Rhode Island Sea Grant; Washington Sea Grant; WHOI Sea Grant; Rhode Island Sea Grant Legal Program
Federal Funding: $1,085,131
Connecticut Sea Grant, in partnership with the above state programs, is proposing to establish a National Sea Grant Seaweed Hub. The topic-based Hub would serve as a central clearinghouse for available science-based, non-proprietary, practical resources related to previous and current seaweed aquaculture research and extension efforts. The Seaweed Hub would enable Sea Grant

programs as well as federal and state agencies to access current information to guide their own planning and outreach efforts. The establishment of the Seaweed Hub will also provide seaweed aquaculture stakeholders with the information they need to make better informed decisions.

Maine Aquaculture Hub: Building capacity for industry-driven innovation, diversification, and workforce development

Applicant: Maine Sea Grant
Lead PI: Gayle Zydlewski, Maine Sea Grant
Co-PI(s): Deborah Bouchard, University of Maine; Sebastian Belle, Maine Aquaculture Association; Hugh Cowperthwait, Coastal Enterprises, Inc./Maine Aquaculture Innovation Center; Chris Davis, Coastal Enterprises, Inc./Maine Aquaculture Innovation Center
Partner(s): Maine Aquaculture Association; Maine Aquaculture Innovation Center; Coastal Enterprises, Inc.
Federal Funding: $1,199,996

Increased demand for domestic, locally-sourced and sustainably produced protein, a strong need for working-waterfront diversification, and a national effort to reduce the seafood trade deficit are all driving an increase in diverse entrants to the aquaculture industry. Sea Grant's 10-year Aquaculture Vision outlines barriers and mechanisms for Sea Grant to aid the industry to overcome barriers associated with commerce, permitting and policies, new species, production systems, and seafood safety and quality (SGA 2016). More recently, laws and regulations have been identified as perceived impediments to shellfish aquaculture industry growth and research and outreach efforts have been identified as possible mechanisms to a better understanding and identification of policy alternatives that could benefit the industry (National Sea Grant Law Center 2019). Common themes across the nation include complex permitting requirements that vary among states and regions and the need to partner early with permitting agencies and stakeholders to overcome regulatory barriers. Issues among the commerce, production systems and seafood quality issues can be addressed through research, outreach, and partnerships. Sea Grant is committed to investing in priorities identified nationally while enabling flexibility to address relevant state and local issues (SGA 2016). This proposal focuses these efforts through a transdisciplinary hub that is responsive to local and state-level needs in Maine.

Atlantic and Gulf Shellfish Seed Biosecurity Collaborative

Applicant: New Jersey Sea Grant
Lead PI: Peter M. Rowe, New Jersey Sea Grant Consortium
Co-PI(s): Ryan Carnegie, VIMS; William Walton, Auburn University; David Bushek, Rutgers
Partner(s): USDA APHIS Veterinary Services; Florida Sea Grant/UF; Gulf Shellfish Institute; New Jersey Aquaculture Association; Delaware Department of Natural Resources and Environmental Control; Delaware Sea Grant; Massachusetts Division of Marine Fisheries; New Jersey Bureau of Shellfisheries; Oyster South; Rhode Island Coastal Resources Management Council; South Carolina Department of Natural Resources; North Carolina State University; Georgia Sea Grant; Texas Sea Grant College Program
Federal Funding: $1,172,732

Aquaculture continues to expand rapidly along the East Coast and is beginning to grow along the Gulf Coast with increasing requests for transfers of shellfish that can potentially spread disease harming the industry and natural resources. Regulators to have access to an understanding of disease dynamics and distributions in order to appropriately evaluate risk and gain confidence in justifying transfer decisions one way or the other. Similarly, industry members, including

hatcheries, nurseries and farms, must understand the basics of disease risks to protect themselves, neighboring farms, and wild stocks as they seek to source seed for their needs. Developing this understanding and transferring the knowledge to employ these tools is a primary role of extension and represents an important element of this project. The authors aim to (1) Collaboratively assess the previously piloted shellfish health initiatives (hatchery certification, decision process, and database functionality) to enhance program efficacy and expand extension opportunities to broaden industry participation with new Gulf partners as the authors prepare to expand the initiative into the Gulf. (2) Expand the database and hatchery certifications to the Gulf States. (3) Establish a surveillance program structure that supports the database with the minimum information necessary and identifies the optimal level of information as a target to maximize its value. (4) Develop a management and funding structure to sustain the database and hatchery certification programs, in particular, beyond this or other funding cycles.

Advancing Southern New England Shellfish Aquaculture Through an Engaged Public and Next Generation Decision Support Tools

Applicant: Connecticut Sea Grant
Lead PI: Tessa Getchis, Connecticut Sea Grant
Co-PI(s): Azure Cygler, University of Rhode Island; Abigail Franklin Archer, WHOI Sea Grant; Read Porter, Roger Williams School of Law
Partner(s): New England Aquarium; UConn Center for Land Use Education and Research; University of Rhode Island Environmental Data Center; National Marine Fisheries Service, Milford; George Perkins Marsh Institute
Federal Funding: $1,173,284
Through this project, the Connecticut, Rhode Island and Woods Hole Sea Grant Programs (herein called the “Sea Grant Programs”) and partners, will expand available science-based tools and information to proactively and effectively engage the public, press and decision-makers about the social, economic and environmental effects of shellfish aquaculture, to expand entry level training opportunities and to improve decision-making for permitting. Finally, the use of social science will ensure that we develop and provide information that is supported by science and that addresses public concerns and interests. The overall goal is an effective strategy to identify and promote beneficial bivalve aquaculture development in New England.

West Coast Aquaculture Collaborative

Applicant: Washington Sea Grant
Lead PI: Russell Callender, Washington Sea Grant
Co-PI(s): Paul Dye, Washington Sea Grant; David Hansen, Oregon Sea Grant; Theresa Talley, California Sea Grant Extension Program
Partner(s): Pacific Coast Shellfish Growers Association; Western Regional Aquaculture Center; Willapa Bay Oyster Growers Association; Agricultural Research Service; Pacific Shellfish Institute
Federal Funding: $1,193,009
Washington Sea Grant, Oregon Sea Grant, and California Sea Grant propose to form a collaborative unit to engage science and education partners, industry and resource management agencies in tackling complex, region-scale barriers to sustainable aquaculture on the West Coast. The operational approach is to launch the collaborative by participating in a pilot project that addresses an urgent need in shellfish aquaculture and builds on the collective

strengths of the programs and partners. Outcomes of the three-year effort will include an effective collaborative structure, enhanced program capacity in two states, the completed pilot project, and scoping information and lessons learned to apply to future projects, as well as advanced oyster and clam aquaculture practices developed to address interactions specifically around eelgrass and burrowing shrimp challenges. If the pilot project is successful, it will represent progress toward a novel, replicable approach to other complex issues.

Great Lakes Sea Grant Aquaculture Collaborative

Applicant: Minnesota Sea Grant
Lead PI: John A. Downing, Minnesota Sea Grant
Co-PI(s): Trey Malone, Michigan State University; Richard "Max" Melstrom, Loyola University Chicago; Stuart Carlton, Illinois-Indiana Sea Grant
Partner(s): Minnesota Aquaculture Association; Michigan Aquaculture Association; Wisconsin Aquaculture Association; Ohio Aquaculture Association; Indiana Aquaculture Association, Inc.; North Central Regional Aquaculture Center (USDA); Aquaculture Demonstration Facility; UW-Stevens Point, UW-Extension, Sea Grant, Eat Wisconsin Fish, WI Aquaculture Association
Federal Funding: $1,026,820
Several significant barriers have been identified within the Great Lakes region that prevent growth of existing aquaculture businesses and startup of new ones, though research targeted toward identifying these barriers has been limited in scope to specific states. Aquaculture industries in each state are unique, yet share challenges that could be efficiently resolved by a collaborative multi-disciplinary team. As such, the authors propose an interdisciplinary Great Lakes Sea Grant Aquaculture Collaborative (AC) to address these barriers and develop opportunities for aquaculture in the region. This proposal creates a new region-wide collaboration and enhances existing collaborations across multiple Sea Grant jurisdictions. The primary goal is to support an environmentally responsible, competitive, and sustainable aquaculture industry in the Great Lakes region through relevant, science-based initiatives.

Establishing a Hawai'i-Pacific Aquaculture Consortium: A Revitalization and Expansion of the Aquaculture Development Program

Applicant: Hawai'i Sea Grant
Lead PI: Darren Lerner, Hawaii Sea Grant
Co-PI(s): Maria Haws, University of Hawaii at Hilo; Darren K. Okimoto, Hawaii Sea Grant; Andre Seale, University of Hawaii at Manoa; Simon Ellis, The Marine and Environmental Research Institute of Pohnpei; Kelley Anderson Tagarino, Hawaii Sea Grant; Max Sudnovsky, Hawaii Sea Grant
Partner(s): American Samoa Community College; Hawaii Department of Agriculture Aquaculture and Livestock Support Services; College of the Marshall Islands; University of Hawaii at Manoa College of Tropical Agriculture and Human Resources; Guam Sea Grant; HATCH Accelerator; Hawaii Aquaculture and Aquaponics Association; Hawaii Strategic Development Corporation; Kuaaina Ulu Auamo; Natural Energy Laboratory of Hawaii Authority; Oceanic Scientific; University of Hawaii at Hilo Pacific Aquaculture and Coastal Resources Center; National Oceanic and Atmospheric Administration Pacific Islands Regional Office; The Marine and Environmental Research Institute of Pohnpei; University of Hawaii System; Waiwai Ola Waterkeepers Hawaiian Islands; Washington Sea Grant; University of Hawaii Windward Community College
Federal Funding: $1,196,344

The aim of this project is to revitalize, solidify, and expand an aquaculture development program through the establishment of an aquaculture-focused, collaborative program that engages in robust and diverse geographic and sectoral inclusivity across Hawai‘i and the Pacific region. In 2015, the University of Hawai‘i Sea Grant College Program (Hawai‘i Sea Grant) initiated a memorandum of agreement with the Pacific Aquaculture and Coastal Resources Center at the University of Hawai‘i at Hilo to create a Hawai‘i Sea Grant Center in Sustainable Aquaculture and Coastal Resources (CSACR). CSACR will serve as a hub which fully integrates research, extension, and education services directed towards supporting the continued development and enhancement of indigenous practices and the aquaculture industry in Hawai‘i and the Pacific region. The CSACR collaborative efforts will include researchers, extension faculty, state and local government representatives, industry, and community members. It will serve as a vehicle for building connections university-wide and community-wide to engage the best and brightest minds available to address the pressing needs and issues facing the aquaculture industry across the state of Hawai‘i and Pacific region.

Building capacity of land-based Atlantic salmon aquaculture in the US.

Applicant: Maryland Sea Grant
Lead PI: Yonathan Zohar, University of Maryland
Co-PI(s): Allen Place, University of Maryland; Allen Place, University of Maryland Center for Environmental Science (UMCES); Kevin Sowers, UMBC; Keiko Saito, UMBC; Ten-Tsao Wong, UMBC; John Stubblefield, UMBC; Brian Vinci, The Conservation Fund Freshwater Institute; Christopher Good, The Conservation Fund Freshwater Institute; William Hubbard, University of Maryland College Park, Sea Grant Extension; J. Adam Frederick, Maryland Sea Grant; Rose Jagus, UMCES; Scott Knoche, Morgan State University PEARL; Greg Fischer, University of Wisconsin-Stevens Point (UWSP); Chris Hartleb, UWSP; Emma Wiermaa, UWSP and Wisconsin Sea Grant; Deboarh Bouchard, University of Maine; Brian Peterson, USDA National Cold Water Marine Aquaculture Center; Chris Bartlett, Maine Sea Grant Extension; Steven Summerfelt, Superior Fresh LLC; Brandon Gottsacker, Superior Fresh LLC; Jason Mitchell, Whole Oceans LCC; Jennifer Fortier, Whole Oceans LLC; Christopher Hlubb, American Salmon; Bill Keleher, Kennebec River Biosciences; Jesse Trushenski, Riverence
Partner(s): Maryland Sea Grant; Maine Sea Grant; University of Maine; Wisconsin Sea Grant; University of Wisconsin Stevens Point; University of Maryland; Morgan State University; The Conservation Fund; American Salmon; Kennebec River Biosciences; Agricultural Research Service (ARS), Whole Oceans Maine Sustainable Salmon; Riverence; Superior Fresh
Federal Funding: $1,198,466

The recent exponential growth in established or planned US closed-containment Atlantic salmon production has been associated with over $1B investment into this aquaculture sector. The success of this dramatic expansion/investment in land-based, RAS salmon production requires a national, coordinated and interdisciplinary effort to ensure that current barriers are eliminated and efficiency and cost-effectiveness are attained. While major progress has been achieved in recent years in RAS technology, its scaling up may face biological, engineering, technological, economical and societal constraints that should be addressed via a fully integrated research, extension, outreach, education and workforce development network. This network will provide broad support, as well as guide future federal investment toward responsibly building the Atlantic salmon aquaculture industry in the US. This proposal recognizes that we are at an important juncture requiring a solid and effective support base for the development of sustainable land-based RAS salmon producers. To provide this support base, the authors

propose to establish a National Coordinated RAS Network (NCRN) focused on Atlantic salmon RAS aquaculture that will provide crucial support and a capacity-building framework to address current issues/pitfalls and promote success in US salmon RAS production. To ensure the success of the recent dramatic expansion/investment in land-based salmon production, the authors propose to establish a coordinated national effort that will review and identify challenges and bottlenecks, and develop a road map and comprehensive strategic plan to address and overcome them. The Maryland, Wisconsin and Maine Sea Grant programs will spearhead the integration of the academic and industrial collaborators into a National Coordinated RAS Network (NCRN) that will support US salmon Recirculating Aquaculture Systems (RAS).

Exploring New Aquaculture Opportunities

Sixteen projects will focus on the development of new, and at times higher-risk, topics for which minimal foundation currently exists to inform and focus potential future investments.

The Perfect Storm: Establishing a Pilot Seaweed Farm in the Alaska Peninsula

Applicant: Alaska Sea Grant
Lead PI: Melissa Good, Alaska Sea Grant Marine Advisory Program
Co-PI(s): Charlotte Levy, Aleutians East Borough
Partner(s): Aleutians East Borough
Federal Funding: $99,751

The Alaska Peninsula and Aleutian Islands are made up of thousands of miles of pristine coastline that have a high-biodiversity of naturally occurring seaweed populations. Although the indigenous peoples have been harvesting seaweed for thousands of years, the subsistence-use is minimal and have resulted in very healthy natural seaweed populations. Although wild kelp is healthy in the Alaska's coastal region, harvest on an commercial-scale will be restricted to Aquaculture farmed kelp to protect wild kelps from over-harvest and to maintain this essential ecosystem for the rich marine environment of the area. Interest and initiatives to develop a seaweed or kelp industry for Alaska is now a priority for the region. This interest leads to Alaska's Governor Walker creating an 11 member Alaska Mariculture Task Force (AMTF) by Administrative Order in 2016. The AMTF has since developed a comprehensive Alaska Mariculture Development Plan that outlines priorities to move this industry forward. Alaska's potential for cultivation of kelp and other seaweeds in the vast natural marine habitat can be a significant economic and employment engine for the several struggling coastal communities of the state.

Modeling to inform seaweed farm design for optimizing growth, production, and advancement of the U.S. marine aquaculture industry

Applicant: MIT Sea Grant
Lead PI:Michael Triantafyllao, MIT
Co-PI(s): Andrea Angera, Springtide Seaweed and Maine Seaweed Exchange; Sarah Redmond, Springtide Seaweed
Juliet Simpson, MIT Sea Grant
Federal Funding: $94,689

Seaweeds represent an ecologically and economically significant marine resource with great potential for growth. Seaweeds are diverse species of marine macroalgae with a wide range of applications in human food, animal feed, fertilizers, cosmetics, medical, pharmaceutical, fuel, and manufacturing industries, as well as provide ecosystem services in the form of nutrient bioextraction (Rose et al, 2015), wastewater management, integrated aquaculture (Chopin et al, 2001), and ecosystem restoration. The global commercial seaweed market was valued at $10.31 billion in 2015, and is expected to grow to $22.13 billion by 2024 with increased demand in food, pharmaceutical, and agricultural markets, with human consumption emerging as the leading application segment (Grand View Research, 2016). A growing recognition of seaweeds as healthy "superfoods" (Holdt and Kraan, 2011) is driving increased consumption in Western countries, with US sales of seaweed snacks alone valued at $240 million in 2014 (Mellentin, 2015). Unprecedented growth in organic and sustainable seafood (estimated 2015 global value of sustainably certified seafood $11.5 billion (Potts et al, 2016)) creates a market opportunity for

new sustainably farmed organic seaweed products.

The potential for sea vegetable aquaculture in New England is immense. Therefore, this project aims to better understand the flow of nutrients and light so that larger and more densely configured farms can be developed. Essential to this increase in density, and thus biomass, is understanding of the loads that these new configurations will place on the farm running gear. We will test multiple farm layouts, including both parallel and "X" arrays, and develop configurations that will reduce entanglements while increasing biomass yield and quality. This work is especially important if we are to develop open water and offshore aquaculture farms that will be subject to wave, wind and tide action not experienced before in seaweed aquaculture.

Seaweed lines of change: Laying the groundwork to advance the practice of sustainable seaweed farming in the Pacific Northwest

Applicant: Washington Sea Grant
Lead PI: Russell Callender, Washington Sea Grant
Co-PI(s): Meg Chadsey, Washington Sea Grant; Teri King, Washington Sea Grant; Betsy Peabody, Puget Sound Restoration Fund; Joth Davis, Hood Canal Mariculture; Jodie Toft, Puget Sound Restoration Fund
Partner(s): Puget Sound Restoration Fund; Hood Canal Mariculture
Federal Funding: $99,997
Washington Sea Grant, working with Hood Canal Mariculture and Puget Sound Restoration Fund, is proposing to develop and deliver a tiered training program for potential seaweed farmers in Washington State. This program consolidates the team's practical seaweed farming knowledge gained through a collaboration with NOAA and the University of Washington, to assess the ability of cultivated sugar kelp to mitigate local ocean acidification. The program includes an online introductory half-day workshop and a multi-day intensive training; guidance documents and recorded instruction to be archived on a free online resource library. Research and stakeholder information needs identified during trainings and follow-on technical assistance are to be shared with Sea Grant programs to help inform the development of seaweed aquaculture program priorities in Washington and beyond.

Developing new oyster sterilization technology to avoid triploid summer mortality

Applicant: Maryland Sea Grant
Lead PI:Ten-Tsao Wong, University of Maryland
Co-PI(s): Yonathan Zohar, University of Maryland; Louis Plough, University of Maryland Center for Environmental Science; Donald Webster, Wye Research & Education Center, Maryland Sea Grant
Partner(s): True Chesapeake Oyster Company; Madhouse Oyster Company
Federal Funding: $98,789
The eastern oyster (*Crassostrea virginica*) is a key aquaculture species on the East and Gulf coasts of North America, comprising almost 20% of all shellfish aquaculture production in the United States, with a total value of $68 million (USDA 2014). During spawning season, oysters undergo sexual maturation using their glycogen for gametogenesis and the preparation for spawning events, which causes loss of texture and flavor. As a result, sale and profits of oysters decline drastically during summer months. In addition, there is also a correlation between summer mortality syndrome with sexual maturity. The collective evidence suggests that

summer mortality involves a collection of intrinsic and extrinsic factors, in which the most important intrinsic factor is gametogenesis and spawning, placing the animal in a relatively unstable physiological condition to face elevated temperature, physical stressors and pathogens. It is recorded that summer mortality can kill up to 90% of affected eastern oysters within a few weeks. In this proposed research, the authors aim to extend and optimize bath-immersion sterilization technology to produce sterile eastern oysters. Since in vitro fertilization has been well established in oysters, the bath-immersion approach can be easily incorporated into the oyster via an in vitro fertilization procedure. By extending this fish sterilization technology to eastern oyster, the main hypotheses to be tested in this research is that the transient silencing of the genes responsible for the early establishment of gonads in oysters will lead to reproductively sterile animals.

An innovative bottom-culture cage to improve yield, manage biofouling, diversify crops and minimize social conflict as shellfish aquaculture expands

Applicant: Maine Sea Grant
Lead PI:Jeff Auger, Mook Sea Farm
Co-PI(s): William Mook, Mook Sea Farm; Meredith White, Mook Sea Farm
Partner(s): Maine Sea Grant
Federal Funding: $76,868
The authors propose to develop an innovative bottom-culture cage suitable for multiple shellfish species, which will address multiple challenges facing expansion of shellfish aquaculture on the East Coast and around the country. The project will develop the cage, explore adaptations to make it suitable for a variety of shellfish species and bottom types, and will develop the hauling technology to effectively manage this new culturing method on a commercial scale. End users will be commercial shellfish growers. As one of the largest oyster farms in Maine, with a history of innovation in regard to both hatchery and grow-out production, those at Mook Sea Farm are well suited to carry out this project and communicate the results to our fellow shellfish growers.

Investigating the viability of quahog and oyster polyculture in Maine

Applicant: Maine Sea Grant
Lead PI:Marissa McMahan, Manomet, Inc.
Co-PI(s): Ethel Wilkerson, Manomet, Inc.; Caitlin Cleaver, FB Environmental; Jordan Kramer, Winnegance Oyster
Partner(s): Maine Sea Grant
Federal Funding: $65,172
Quahog (*Mercenaria mercenaria*) aquaculture is a potential diversification strategy for shellfish harvesters hit hard by historically low soft-shell clam landings and for oyster farmers looking to hedge against a rapidly increasing supply of oysters in Maine and across the Northeast. Quahog aquaculture is not commonly practiced in Maine, but it is a lucrative and growing industry in nearby Massachusetts with a value estimated at $1.36 million in 2016 (MDMF 2016). Manomet and our partners believe that quahog aquaculture could provide a strategy to diversify resources and expand and strengthen fishing opportunities in Maine.

Culture of Native Bivalve Species to Expand Mariculture Opportunities and Improve Coastal Environments

Applicant: Hawai'i Sea Grant
Lead PI:Darren Lerner, Hawaii Sea Grant

Co-PI(s): Maria Haws, University of Hawaii at Hilo; Rhiannon Chander-`Iao, Waiwai Ola Waterkeepers; Keahi Warfield, One Youth Development Keaukaha; Timothy Grabowski, U.S. Geological Survey; Darren Okimoto, Hawaii Sea Grant
Partner(s): University of Hawaii at Hilo, Pacific Aquaculture and Coastal Resources Center (UHH); One Youth Keaukaha/RISE; Waiwai Ola Waterkeepers Hawaiian Islands; Hawaii Sea Grant
Federal Funding: $100,000
This work proposes to develop hatchery and nursery methods for selected bivalve species from the Pinnidae family for aquaculture and environmental purposes in Hawai`i and the U.S. Affiliated Pacific Islands (USAPI). The Black-lip Pearl Oyster (*Pinctada margaritifera*) and the several species of Pen Shells (Pinna spp., Atrina spp., Streptopinna spp.) are known to offer economic potential, and can provide ecosystems services to improve water quality and aquatic habitats. The challenge lies in developing and refining hatchery and nursery methods to allow for reliable and scalable production. This is particularly important for Hawai`i and the USAPI which have few native bivalves species fully developed for aquaculture. The authors also intend to utilize the highly attractive topics of pearl farming and the large, but widely unknown pen shells (Figure 1), to encourage the public to engage in outreach efforts to promote sustainable forms of aquaculture and raise awareness about the status and impacts of water pollution in Hawai`i.

Enabling terrestrial omega-3 production for aquaculture from local natural resources

Applicant: South Carolina Sea Grant
Lead PI:Mark Blenner, Clemson University
Partner(s): Animal Coproducts Research and Education Center at Clemson University, with funding from the Fats and Proteins Research Foundation.
Federal Funding: $100,000
The long-term goal of the group's research is to utilize renewable agricultural products and wastes, such as rendered animal fats and plant oils as sustainable feedstocks for the production of food, chemicals, and materials. The overall objective of this project is to engineer a biocatalyst that is able to efficiently utilize liquid and solid fats and convert them into higher value omega-3 fats, at high yield, productivity, and titer. Microbial systems make excellent biocatalysts due to their inherent flexibility in feedstock use, highly specific enzymes, and scalability through industrial fermentation processes. Our central hypothesis is that an oleaginous yeast (one that can naturally accumulate a significant amount of neutral lipids), such as *Yarrowia lipolytica*, is well positioned to efficiently utilize liquid and solid fats to produce fatty acid-derived chemicals. This hypothesis was formulated based on prior work to engineer industrial scale production of single-cell protein and citric acid using Y. lipolytica, and our previous work growing Y. lipolytica on animal fats. We further hypothesize that metabolic engineering can effectively alter the cellular reaction network for the production of omega-3 fatty acids from shorter and more saturated fats and oils. This hypothesis was formulated based on prior work to engineer Y. lipolytica to produce lipids at greater than 90% w/w, and our work in metabolic engineering and enzyme localization. The rationale behind this project is that the abundance of waste animal fats or commodity plant oils are a more logical and economic feedstock for oleochemical production, and that metabolic engineering of oleaginous yeast enables it to be a platform organism for the production of other oleochemicals beyond the scope of this work.

Developing a Framework to Expand Comprehensive Training Opportunities for Prospective Shellfish Growers in North Carolina, South Carolina, and Georgia

Applicant: North Carolina Sea Grant
Lead PI: Frank Lopez, NC State University
Co-PI(s): David Cerino, Carteret Community College; Thomas Bliss, University of Georgia (UGA); Susan Lovelace, South Carolina Sea Grant Consortium
Partner(s): Carteret Community College; South Carolina Sea Grant Consortium; Georgia Sea Grant
Federal Funding: $95,538
Due to industry development and expansion, North Carolina, South Carolina, and Georgia each have a definitive need for the establishment of a comprehensive shellfish aquaculture training program combining classroom studies with hands-on field training to support the needs of prospective growers. It is important to note that shellfish aquaculture training programs have been established in recent years in the states of Rhode Island, Maryland, Virginia, Florida, and Alabama, and the need for a training program in NC is endorsed by the NC Shellfish Growers Association as well as the NC Division of Marine Fisheries, the latter of which has recently developed a revised lease application that demands applicants have a good understanding of the physical, biological, and financial requirements of a successful shellfish aquaculture operation, including a detailed farm management plan. The need for training is also extremely important in South Carolina and Georgia and, as in North Carolina, is supported by both industry and coastal regulatory agencies. The overall goal of this project is to expand comprehensive shellfish aquaculture training opportunities in North Carolina, South Carolina, and Georgia to support beginning and prospective growers towards development and expansion of the industry in each state.

Innovative restoration aquaculture of freshwater mussels in the tidal freshwater zone of the Delaware Estuary Watershed for water quality improvement

Applicant: New Jersey Sea Grant
Lead PI:Peter Rowe, New Jersey Sea Grant Consortium
Co-PI(s): Danielle Kreeger, Partnership for the Delaware Estuary; Roger Thomas, Academy of Natural Sciences of Drexel University
Partner(s): US Fish and Wildlife Service; Beni Hanna Aquaponics; Upper Montgomery Joint Authority; Montgomery County Division of Parks, Trails, and Historic Sites; Winterthur Museum, Garden and Library
Federal Funding: $100,000
New Jersey Sea Grant, in conjunction with CO-PI's, seek to advance scientific research of aquaculture techniques needed to rear juvenile freshwater mussels for water quality improvements in the Delaware Estuary watershed, particularly the tidal freshwater zone between Trenton, New Jersey, and Wilmington, Delaware. With each mussel filtering up to 10 gallons of water every day, the large mussel beds which once existed throughout coastal streams and rivers of the mid-Atlantic region, helped sustain water quality by filtering vast quantities of suspended pollutants. The goal of this study will be to develop and test new aquaculture methods that overcome the mortality bottleneck between hatchery propagation and mussel bed restoration. Once produced in a hatchery, very young mussels should be cultured for a year in ponds to achieve rapid growth prior to being transferred to targeted restoration streams. It is this rearing step of the mussel reseeding process that requires local research and testing, such as by screening ponds and culture systems to determine which ones

can support the best mussel growth and survival. This research will result in new discoveries regarding optimal rearing processes that will enhance the success of future seeding projects that lead to functionally robust mussel beds that provide diverse benefits such as water quality enhancement.

Walleye Aquaculture Working Group: developing walleye aquaculture in Illinois and Indiana

Applicant: Illinois-Indiana Sea Grant
Lead PI: Stuart Carlton, Illinois-Indiana Sea Grant
Co-PI(s): Kwamena Quagrainie, Illinois-Indiana Sea Grant; Robert Rode, Purdue University Department of Forestry and Natural Resources; Joseph Balagtas, Purdue University Department of Agricultural Economics
Federal Funding: $96,278

U.S. aquaculture is a growing industry with the potential to ease demand on overexploited capture fisheries and reduce the significant edible-seafood trade deficit by providing consumers with a source of healthy locally grown protein. However, the growth in aquaculture in the US, generally, and the Midwest, specifically, has lagged expectations (NCRAC 2017). Indeed, the seafood trade deficit remains considerable in both weight and dollar value despite increased focus on aquaculture. Research and anecdotal evidence suggest that farmed fish with a stronger local identity may be more successful in the marketplace because it is more familiar to Midwesterners as a local, native fish as opposed to the exotic species that are currently the focus of regional aquaculture (Quagrainie et al., 2008). Walleye is one such fish: it has a strong association with the Midwest, is available in restaurants as a commercially caught species, and may be suitable for aquaculture. However, there is currently minimal walleye aquaculture in Illinois or Indiana. This proposal will assemble a transdisciplinary Walleye Aquaculture Working Group (WAWG) to explore the potential walleye aquaculture in Illinois and Indiana. The WAWG will consist of IISG aquaculture staff, aquaculture production professionals, and policy and market researchers who can bring expertise to bear on developing walleye aquaculture in the bi-state area. At the end of the project, the WAWG will have identified barriers to walleye aquaculture, begun initial work on methods to address those barriers, synthesized the findings and remaining issues, and have developed a plan of action for how to fund and perform future work to continue to develop walleye aquaculture in Illinois and Indiana.

Lease or Permit?: Security of Tenure Workshop to Advance Offshore Aquaculture in the U.S. EEZ

Applicant: National Sea Grant Law Center
Lead PI:Stephanie Otts, National Sea Grant Law Center
Co-PI(s): Catharine Janasie, University of MS School of Law
Partner(s): National Aquaculture Association; Fearless Fund
Federal Funding: $97,129

A lack of a comprehensive federal framework for the long-term authorization of offshore aquaculture operations, including the right to physically occupy space, is a significant barrier to the expansion of aquaculture offshore into federal waters of the U.S. Exclusive Economic Zone (EEZ). Regardless of the type of aquaculture practiced, from using fixed cages to raise finfish to culturing algae suspended from ropes or floating racks, aquaculturists need a legal right to occupy a given area of the ocean. The permits currently issued by the federal agencies state that they do not provide a property interest for the project location. Therefore, one of the most crucial unaddressed aspects of any legal framework affecting marine aquaculture is security of tenure; i.e., whether the legal rights to farm in a specified area that an aquaculturist receives

from the government provides sufficient property interest to support development of a viable business model, including the ability to secure insurance and adequate financing. The NSGLC will begin this project by undertaking research to assess the current state of the debate regarding security of tenure for offshore aquaculture operations in the U.S. EEZ.

Novel Mariculture of the Caribbean King Crab for Market and Coral Reef Restoration

Applicant: Virginia Sea Grant
Lead PI: Mark Butler, Old Dominion University
Co-PI(s): Abigail Clark, Mote Marine Laboratory; Angelo Spadaro, Old Dominion University
Partner(s): Florida Sea Grant; Florida Keys Commercial Fisherman's Association; Mote Marine Laboratory
Federal Funding: $100,000

The authors propose the development of a new, potentially high-value seafood commodity based on the low-overhead, semi-wild mariculture of the herbivorous Caribbean King Crab (*Maguimithrax spinosissimus*); the largest crab in the Caribbean. The project capitalizes on the use of existing, but underutilized, land-locked saltwater quarries in south Florida where Maguimithrax already occurs or can be introduced. This is a novel opportunity to foster the emergence of a nascent seafood product whose biological attributes are ideal for mariculture but whose commercial production in laboratories proved too costly under those labor-intensive conditions. The approach is unique in its application of land-locked saltwater quarries for Maguimithrax production but whose foundation is based on first investigating the optimal conditions for semi-wild crab production, determining the genetic structure of crab populations in the wild and in land-locked quarries, and assessing the marketability and economics of this species.

Developing eDNA tool for early detection of two main fouling organisms of oyster aquaculture farms

Applicant: Virginia Sea Grant
Lead PI: Karen Hudson, Virginia Sea Grant Marine Extension Program
Co-PI(s): Bob Fisher, Virginia Sea Grant Marine Extension Program; Jan McDowell, VIMS Fisheries Science
Partner(s): Virginia Institute of Marine Science (VIMS); Bay Oyster Company
Federal Funding: $92,829

Virginia's shellfish aquaculture industry, consisting of hard clams and oysters, is currently valued at over $53 M in annual farm gate value (Hudson, 2018). The oyster component continues to expand in Virginia as well as nationally, and with that expansion comes a more competitive market where shell quality is of the utmost importance. It is widely known that cultured oysters can be negatively impacted by fouling organisms, which differ by species and community composition from region to region (Watson et al., 2009). These fouling communities impact farm management by increasing labor costs for removal, and negatively impact shell integrity, costing valuable market share (Adams et al., 2011). Two of the most common fouling organisms in Virginia, and arguably on the east coast, are the boring sponge, Cliona spp. and the mud blister worm, *Polydora websteri*. Growers on farms heavily impacted by Cliona and Polydora report shells that crumble and break when shucked due to the shell boring from these organisms (Watson et al., 2009). Neither is a new pest; however oyster farmers in Virginia have reported a range expansion of the boring sponge in recent years which is becoming a more widespread problem for expanding oyster aquaculture farms. In response to the identified need of industry, the authors propose to investigate the development of a new tool, species-specific

environmental DNA (eDNA) assays, for early detection of the boring sponge, Cliona spp. and the mud blister worm, P. websteri. If this proof-of-concept project is successful, they envision this technology would be further tested and developed into a rapid field detection method used by industry as an early warning to initiate mitigation.

Nanobubble oxygenation of recirculating aquaculture systems to increase fish production

Applicant: Wisconsin Sea Grant
Lead PI:Christopher Hartleb, University of Wisconsin
Co-PI(s): Sameer Israni, Praxair, Inc.; Gregory Fischer and Emma Wiermaa, UW-Stevens Point, UW-Extension, Sea Grant, Eat Wisconsin Fish, WI Aquaculture Association
Partner(s): Praxair, Inc.
Federal Funding: $83,619
The presence of stable nanobubbles in water has been experimentally confirmed, yet little applied research on the mechanisms of physical and biological effects of nanobubbles has been completed. Additionally, even with a limited amount of work that has focused on the effect of nanobubbles on fish growth rate and health, the role of increased dissolved oxygen (DO) has not been separated from the effect of the nanobubbles itself. The authors seek to study the revolutionary potential of nanobubbles in recirculating aquaculture systems (RAS) by: (i) Comparing traditional pure oxygen delivery using diffusers and speece cones compared to nanobubble delivery of pure oxygen in RAS, (ii) Documenting the differences in amounts of oxygen required and the overall power required for maintaining the same DO levels in the tanks using the identified delivery systems, (iii) Documenting and characterizing nanobubbles to better understand their chemistry in an RAS and their effects on the growth of fish, fish health, and water quality in cool and cold-water RAS, (iv) Determining a cost-benefit analysis model for the use of nanobubbles in RAS, and (v) Through a well-established aquaculture outreach (extension and communication) and education program share results with stakeholders interested in applying this innovative technology.

Exploring the Potential for Sustainable Capture-Based Aquaculture of Spiny Lobster (Panulirus spp.) in Pohnpei, Federated States of Micronesia

Applicant: Hawai'i Sea Grant
Lead PI:Simon Ellis, Marine and Environmental Research Institute of Pohnpei
Co-PI(s): Darren Lerner, Hawaii Sea Grant; Darren Okimoto, Hawaii Sea Grant
Partner(s): Marine and Environmental Research Institute of Pohnpei
Federal Funding: $100,000
There is a clear need to develop economic alternatives for fishing communities in Pohnpei, the Federated States of Micronesia, and elsewhere in the Pacific where over-fishing and climate change are putting stress on natural resources. Pohnpei, the proposed study site, has three native species of spiny lobster with commercial value: *Panulirus penicillatus*, P. versicolor, and P. ornatus (Smith 1992). There is a limited fishery for these species mainly because they are not widely eaten on the island, where mangrove crab (Scylla serrata) is the preferred eating crustacean. Commercial export of wild captured spiny lobsters is also banned; because of this it is presumed that local populations are not over exploited, providing a solid base for larval production and subsequent recruitment. The single goal of this project is to test the efficacy of sustainable wild capture of spiny lobster peuruli and juveniles as a basis for forming an aquaculture industry in the western Pacific.

Social, Behavioral and Economic Research Needs

Sixteen projects will address critical gaps in social, behavioral, and economic knowledge as it relates to U.S. aquaculture and the communities impacted and served by it.

Fish, farms, and shared futures: Defining public perceptions of land-based aquaculture to support sustainable decision-making

Applicant: University of Maine System acting through the Univ. of Maine
Lead PI: Laura Rickard, University of Maine
Co-PI(s): Bridie McGreavy, University of Maine; Branden Johnson, Decision Research
Partner(s): Maine Sea Grant and California Sea Grant
Federal Funding: $249,424

Along with identifying a viable market for products, development of a thriving aquaculture business rests on the ability to site and operate the facilities where aquaculture will occur, whether for hatcheries, grow-out, or gathering (e.g., coastal shellfish). Thus, siting aquaculture entails engaging with local communities, where such facilities may be greeted with delight (e.g., more jobs, tax revenues, enhancement of local food markets), despair (e.g., competition with wild harvesters, environmental impact, incompatibility with tourist and/or local amenities), or some combination of both (D'Anna & Murray, 2015; Hanes, 2018). Greater understanding of these local responses, and the dynamics between aquaculture entrepreneurs and local residents and officials, can enhance Sea Grant's ability to promote a strong U.S. aquaculture sector. In particular, as land-based recirculating aquaculture systems (RASs) are increasingly proposed and installed to raise a variety of finfish species across the U.S., research is needed not just to inform technical and biological decision-making, but also to guide best practices for understanding, documenting, and responding to community concerns about proposed sites, practices, and facilities. The proposed research takes a two-pronged approach to exploring local RAS siting dynamics, entailing 1) perceptions and 2) communication. On the perception side, in addition to trust, the authors propose to explore several complementary social psychological constructs that may assist entrepreneurs and regulators, as well as local communities, in identifying and addressing potential barriers to siting aquaculture facilities, including sense of place and perceived naturalness.

Assessing public perceptions of aquaculture and the broader impacts of K-12 aquaculture education

Applicant: University of Hawaii
Lead PI: Cheng Sheng Lee, University of Hawaii
Co-PI(s): Catherine Chan, University of Hawaii
Partner(s): Waianae High School; University of Hawaii in Manoa
Federal Funding: $165,582

The U.S. is the second largest importer of seafood products -- including those from aquaculture -- in the world, yet our country only grows 5% of the seafood we consume. It is safe to say that aquaculture is not well understood by the general public, and as a result we are missing out on opportunities to improve our food security, economy, and even environment. It is important to overcome the communication obstacles and, as FAO recommends in its report, actively shape the debate on aquaculture because "a lack of information leaves room for speculation." This is especially true if we are going to meet the growing national and global demands for seafood. Furthermore, the FAO recommends investing in education to provide more fact-based information to consumers to address the various perceptions that impact the growth of the

aquaculture industry.

A primary goal of this grant opportunity is to increase seafood consumption via education. One key assumption for this approach is that students can influence the perception of the whole family. The authors will assess public (including students and students' family) perceptions of aquaculture and aquaculture products before and after implementing an aquaculture education program. If the United States is to advance promotion of seafood and in particular aquaculture products, it is important to understand what information students are currently using to convey consumption preferences to their parents with regards to 'origin' of fish. In addition, consumers are becoming more health and safety conscious on how their food is grown and where it comes from. Any assessment is likely to assert that education and outreach are important to consumer acceptance of aquaculture.

Developing Policy Consensus to Facilitate State Regulation of Seaweed as Food Product

Applicant: The University of Mississippi
Lead PI: Stephanie Otts, National Sea Grant Law Center
Co-PI(s): Catherine Janasie, University of Mississippi School of Law; Anoushka Concepcion, Connecticut Sea Grant
Partner(s): Connecticut Sea Grant
Federal Funding: $212,977

Sea Grant programs throughout the nation are currently helping growers in their states enter the U.S. seaweed aquaculture industry. In addition, the National Sea Grant Law Center (NSGLC) has been working for the last year on identifying regulatory hurdles impeding the expansion of the seaweed industry in the United States. Through this initial research, the NSGLC and Sea Grant partners have identified an important regulatory issue: the lack of a federal framework for the regulation of seaweed as a food source in its whole form. Without a federal framework, states are unsure of how to structure their regulatory approaches to the emerging seaweed industries in their states, impeding the growth of this important future food source.

The NSGLC proposes to enhance coordination and cooperation among states to build policy consensus as to the preferred approaches for regulating the sale of seaweed in its whole form for food. The primary goals of this project are: (1) facilitate communication and collaboration among states; (2) improve stakeholder understanding of the regulatory options; and (3) develop guidance to assist with state implementation of preferred policy options. The NSGLC plans to achieve these goals by carrying out the following objectives: (1) Conduct legal research to identify and assess potential regulatory models for the sale of seaweed in its whole form as food; (2) Convene a collaborative learning workshop to engage stakeholders in discussions regarding preferred policy options; and (3) Develop a model law, regulation, or guidance document for the sale of seaweed in its whole form as food.

An Assessment of Mariculture Feasibility in American Samoa

Applicant: Lynker Technologies, LLC
Lead PI: Elizabeth Tarquin, Lynker
Co-PI(s): Sarah Pautzke, Lynker; Kate Taylor, NOAA NMFS Pacific Islands Regional Office
Partner(s): American Samoa Government Department of Marine and Wildlife Resources; American Samoa Department of Commerce; NOAA-NMFS; NOAA-OCM
Federal Funding: $180,906

American Samoa is a small isolated US territory in the South Pacific with a fairly narrow economic base. Mariculture has been identified by local planners in both the American Samoa Comprehensive Economic Strategy (ASCES) and the American Samoa Ocean Plan as one prong of economic development and as a way to increase resilience and food security of the Territory. Implemented on a broader scale, mariculture could contribute significantly to job creation, the production of healthy food for residents of American Samoa. This project will inform myriad social, economic, and geographical questions that surround the development of mariculture in American Samoa - fully in line with the Sea Grant Aquaculture mission to assess potential for aquaculture development, including identifying barriers to entry, identifying social and cultural perceptions of commercial aquaculture, and economic analyses to evaluate the relative cost and value of various aquaculture ventures.

Strategies to increase consumer perceptions and attitudes towards integrated multi-trophic aquaponics

Applicant: Bowling Green State University
Lead PI: Jonathan Kershaw, Bowling Green State University
Co-PI(s): Kevin Neves, Bowling Green State University; Fei Lee Weisstein, Bowling Green State University
Federal Funding: $213,704
The widespread acceptance of aquaculture will be limited until consumers and producers are reassured that health, taste, safety, and marketability will not be compromised. Despite progress to understand consumer acceptance of “green” products, knowledge of consumer attitudes/market acceptability toward aquaponics is largely unknown. Because of the significant environmental benefits of aquaponics compared with conventional fisheries (e.g., reduced land conversion, water usage, energy usage, and waste; and increased food production in regions with minimal water supply, cold climates, and urban areas), a greater understanding of consumer acceptance of products from these systems is critical to increasing the practical use and conservation of natural resources. To address critical perception gaps, the authors propose to (1) perform sensory (e.g., taste, texture, appearance) and physicochemical analyses to quantify consumer acceptance and nutritional qualities of products from an aquaponic system, (2) identify effective communication strategies (e.g., text vs video, emphasizing environmental vs taste/health benefit) to improve consumers’ perceptions, attitudes, and willingness to pay for aquaponic produce, (3) conduct a field experiment selling aquaponic produce at a local farmer’s market to evaluate the feasibility of aquaponic commercialization, and (4) disseminate the findings through a social media campaign featuring a professionally-made promotional video, and an educational workshop for prospective producers.

Economic and environmental sustainability decision-support tool for fish-free aquafeed

Applicant: The Regents of the University of California, Santa Cruz
Lead PI: Anne Kapuscinski, University of California Santa Cruz (UCSC)
Co-PI(s): Elliott Campbell, University of California Santa Cruz (UCSC); Pallab Sarker, University of California, Santa Cruz (UCSC)
Partner(s): California Sea Grant Extension Program; Anthropocene Institute F3 Team; Calysta, Inc.; Cellana, LLC; Corbion Biotech, Inc.; Ziegler Bros., Inc.
Federal Funding: $244,416
The U.S. aquaculture value chain—from companies developing alternative ingredients to aquafeed manufacturers and aquaculture farms—lack a scientifically verified and common

platform for comparing economic and environmental performance of alternative ingredients (e.g., yeast, bacterial biomass, insect meal, microalgae) versus conventional ingredients (e.g., fish meal, fish oil corn meal, soybean meal, canola oil) for aquaculture feeds. Available tools for evaluating economic costs of conventional aquafeed ingredients lack robust methods for evaluating alternative ingredients. Existing tools also do not consider critical aquaculture performance parameters (e.g., digestibility of ingredients or growth metrics of fish fed the feed) nor do they consider environmental impacts. To address these critical knowledge gaps, we will provide an open-access decision-support tool that allows users to assess if alternative aquafeed ingredients meet nutritional requirements and promote growth of the farmed organisms, ensure high quality of the final edible product, have low environmental impact, and compete with costs of conventional aquafeed ingredients. To enable comparisons between alternative and conventional ingredients across studies we will develop: (1) a meta-model database of life-cycle assessments (LCA) of environmental effects (e.g., marine eutrophication, global warming potential (GWP), freshwater consumption, land use change); (2) a meta-model database of techno-economic analysis (TEA) of economic performance (e.g., least cost formulations, economics of scale); (3) a meta-model database of digestibility and nutritional feeding studies; and (4) a decision-support tool, with open-source software, that integrates the three meta-model databases and ingredient-specific process models. Results of our project will produce the first decision-support tool that is a common platform for comparing economic and environmental performance of alternative ingredients. This open-source software, informed by a community of aquaculture stakeholders across the supply chain (e.g. aquafeed companies, fish farmers, consultants, investors, nonprofits, researchers and government leaders), will help drive innovation, commercialization, adoption and acceptance of more sustainable aquafeeds.

Mariculture Tourism: Cultivating Consumer Demand & Coastal Community Supply

Applicant: North Carolina State University
Lead PI: Whitney Knollenberg, North Carolina State University
Co-PI(s): Carla Barbieri, North Carolina State University; Emily Yeager, East Carolina University
Jane Harrison, North Carolina State University; Julie Leibach, North Carolina Sea Grant
Partner(s): North Carolina Sea Grant; North Carolina Coastal Federation; North Carolina Department of Agriculture and Consumer Services; North Carolina Economic Development Partnership; East Carolina University
Federal Funding: $119,784

Interest in food tourism has grown considerably among tourists in the United States (Stone, Migacz, & Wolf, 2018). Mandala (2013) reported that 77% of U.S. travelers recently participated in food tourism activities such as experiences at breweries, wineries, cooking schools, culinary events, or operations where food is produced and harvested, such as farms (Phillip, Hunter, & Blackstock, 2010; Stone et al., 2018). Tourists build meaningful connections to the food they eat through these experiences, and the majority of them indicate that they seek out the food they enjoyed while traveling when they return home (Stone et al., 2018). The authors propose to develop a profile of potential shellfish mariculture tourists so coastal communities can capitalize on the growing interest in food tourism and agritourism. Through a survey of visitors to the Mid-Atlantic and Southeast coastal regions, the researchers will identify potential shellfish mariculture tourists' experience preferences and the barriers to their participation, in addition to other demand indicators (e.g., demographics). Using North Carolina as a case study, the researchers also propose to compare coastal communities' current shellfish mariculture tourism product supply (identified through community-based asset mapping) with potential shellfish

mariculture tourists' demand. This comparison will allow them to identify where demand for shellfish mariculture tourism can be met and opportunities for business and resource development related to mariculture tourism.

Growing Oyster Aquaculture in Georgia: Assessing the Legal and Public Perception Landscape to Address Barriers and Promote Success

Applicant: University of Georgia Research Foundation, Inc.
Lead PI: Shana Jones, University of Georgia
Co-PI(s): Theresa Wright, University of Georgia; Scott Pippin, University of Georgia; Thomas Bliss, University of Georgia
Partner(s): Georgia Sea Grant Marine Extension
Federal Funding: $250,000
This project will equip state and local decision-makers as well as current and future oyster growers with the tools necessary to navigate the legal obstacles, avoid common pitfalls, and mitigate future conflicts as they work together to develop a successful oyster aquaculture industry in Georgia. To that end, the authors will research the legal, regulatory, and policy framework governing oyster aquaculture in Georgia and analogous states, and investigate public perceptions affecting the oyster industry and how those perceptions are likely to change as the industry changes. The deliverables and other information developed in this project will be communicated through a robust outreach and engagement plan that builds upon the project team's existing and long-standing outreach and training relationships designed to engage state and local decision-makers, oyster growers and other stakeholders.

Fisheries Interactions & Carbon Offsets: Assessing Existing and Potential Seaweed Aquaculture

Applicant: The Regents of the University of California, Santa Barbara
Lead PI: Steve Gaines, Marine Science Institute, University of California, Santa Barbara (UCSB)
Co-PI(s): Charles Lester, Marine Science Institute(UCSB); Roland Geyer, Bren School (UCSB); Simona Augyte, University of Connecticut (UCONN)
Partner(s): University of Connecticut (UCONN);
Federal Funding: $220,255
As demand grows and land resources become more scarce, society is increasingly looking to the sea to meet the needs of our growing populations. Culture of seaweeds is particularly appealing for a variety of markets, since they require few inputs to grow, including no fresh water, and in many settings can derive all of their nutrients from the surrounding environment. Despite these benefits, growth for seaweed farming in the U.S. has been slow due in large part to regulatory bottlenecks and the generally poor public perception of aquaculture driven by uncertainty about various conflicts, specifically with existing industries. As a result, managers and academia have focused on developing effective tools to minimize conflicts more than investigating the broader potential for synergies and benefits when grown with best practices. This work, housed within a cross-disciplinary seaweed mariculture working group, will explore an array of impacts, both positive and negative, that may arise from expansion of seaweed aquaculture. As the US examines the potential for large-scale seaweed production, the authors aim to develop frameworks for two complementary environmental issues. First, how will seaweed farms interact with wild fisheries in a region, both positively and negatively? Second, what roles can seaweed cultivation play in driving environmental benefits through carbon sequestration?

Addressing constraints to shellfish aquaculture through quantifying public perceptions and attitudes along the Atlantic coast of the U.S.

Applicant: Northeastern University
Lead PI: Jonathan Grabowski, Northeastern University
Co-PI(s): Randall Hughes, Northeastern University; David Kimbro, Northeastern University; Steven Scyphers, Northeastern University
Partner(s): The Nature Conservancy; MIT Sea Grant
Federal Funding: $248,526

Shellfish aquaculture is currently conducted almost completely in state waters. With over a dozen coastal states, the Eastern U.S. offers an excellent opportunity to explore how perceptions and potential barriers to oyster aquaculture vary regionally. For example, is NIMBYism consistently a problem for aquaculture throughout the Eastern U.S.? Have states created local policies that have created barriers to expanding aquaculture? The authors propose to use multiple regions throughout the Eastern U.S. to explore how coastal resident perceptions of aquaculture vary, and which drivers correspond with support for versus opposition to oyster aquaculture. This regional approach will build towards a more holistic understanding of oyster aquaculture perceptions and barriers. In addition to regional variation in perceptions and attitudes, aquaculture growers use a wide variety of different gear types. For instance, aquaculture methods can include placing oysters directly on bottom, growing them in floating bags, or using cages on bottom. Yet, it is
unclear whether certain types of aquaculture gear are perceived more favorably than others, making it challenging for growers to anticipate and avoid conflicts with other stakeholder groups. Therefore, the authors also propose to survey coastal residents and members of each shellfish sector to better understand their beliefs and attitudes about different types of shellfish aquaculture.

Assessment of perceptions of marine aquaculture by the US food service industry: Finding challenges and opportunities for expanding the US aquaculture industry

Applicant: University of Southern Mississippi
Lead PI: William Walton, Auburn University
Co-PI(s): Adriane Michaelis, University of Maryland
Federal Funding: $165,698

In an effort to help marine aquaculture producers better understand existing and potential markets, the authors will investigate the factors that shape purchase-related decision-making within the seafood service sector as well as how seafood service sector members use their placement to influence subsequent seafood choice. In other words, they aim to answer two broad questions: 1) What perceptions guide seafood purchasing by wholesalers/distributors and chefs?; 2) At each level of the food service sector (distributor, chef, and restaurant staff), how are consumers influenced, guided, or advised by these food service professionals with regard to seafood choice? The authors will employ a mixed-methods approach that involves three phases. During Phase 1 they will conduct semi-structured interviews and participant observation in 12 cities across the United States. They will interview various members of the seafood service sector (distributors, chefs, and servers) to answer the questions outlined in the objectives. Finally they will use data from Phase 1 to generate a survey to be administered to a much larger

sample size of seafood service sector members in 48 cities nationwide. Survey data will be analyzed to identify patterns and drivers in US seafood purchasing within the food service sector as well as how knowledge transfer affects seafood sales. Results will be shared with end-user groups and made publicly available in Phase 3.

A Mixed-Methods and Comparative Approach to Understanding the Social Dimensions of Aquaculture Production, Consumption, and Siting

Applicant: Duke University
Lead PI: Luke Fairbanks, Duke University
Co-PI(s): Grant Murray, Duke University; Lisa Campbell, Duke University; Joshua Stoll, University of Maine; Linda D'Anna, Coastal Studies Institute; Noëlle Boucquey, Eckerd College
Partner(s): North Carolina Sea Grant; Florida Sea Grant; Maine Sea Grant
Federal Funding: $249,564

As aquaculture is poised to grow across the United States, it is important to develop effective and efficient tools to assess the social dimensions of the activity. State and federal managers are required to consider the impacts of alternative management measures on coastal communities, and to consider those impacts in both economic and social terms. Yet finding methods for doing so presents challenges in the context of rapid and ongoing changes in the ways that seafood is produced—particularly regarding the desired and actual expansion of aquaculture across coastal states and communities. Social values and conflicts often lie at the heart of aquaculture siting and expansion issues. However, few empirical studies exist about the different perceptions, values, and attitudes that underlie these conflicts, how they overlap across the production and consumption sides of the sector, how they vary (or not) across contexts, and how they are changing in response to shifts in seafood production—and with what implications for community wellbeing. Further, few methodological tools exist to assess these social dimensions in an efficient way that can be integrated in planning activities. The overarching goal of this project is to use the concept of wellbeing as a holistic lens to consider these values, preferences, and their implications for aquaculture production, seafood consumption, and the stakeholders and coastal communities affected by changes in the sector. The project has three objectives: 1. Identify the range and structure of social values and perceptions associated with aquaculture in three regions (ME, NC, and FL) that can be used to inform aquaculture planning and siting. 2. Provide generalized information about the social dimensions of aquaculture through a comparative analysis of the three regions. 3. Develop and refine a pair of tools (survey and Q methodology) that can be used in the future to assess the social dimensions of aquaculture across locations and contexts in a standardized way.

The GIS Based Tool for Spatial Planning and Management of Shellfish Aquaculture in New Jersey

Applicant: Rutgers, The State University of New Jersey
Lead PI: Michael DeLuca, Rutgers University
Co-PI(s): Lisa Calvo, Rutgers University; Jeanne Herb, Rutgers University;
Lucas Marxen, Rutgers University
Partner(s): New Jersey Department of Land Use and Regulation; New Jersey Division of Shellfisheries; New Jersey Coastal Management Program
Federal Funding: $249,989

Shellfish aquaculture continues to increase in importance in the U.S. providing a steady supply of sustainable domestic seafood, uplifting coastal economies, and enhancing the ecological health of our estuaries. National aquaculture strategies acknowledge the value of shellfish

aquaculture and call for increased production. With its 117 miles of shoreline, New Jersey has extensive coastal bays that have supported bountiful natural resources, wildlife, recreational and commercial fisheries, tourism, culture, recreation, and aquaculture. The State's shellfish aquaculture industry is poised to grow; however, competing demands for suitable space with other coastal uses present challenges to expansion. A lack of understanding of industry practices, scale, scope, and potential growth underlie regulatory and social concerns that have hindered the vitality and expansion of the shellfish farming in the State. Further, the lack of a comprehensive spatial plan for shellfish aquaculture in New Jersey has promoted fear of uncontrolled industry growth. Several neighboring States have demonstrated the successful application of tools and spatial planning programs to successfully foster sustainable growth of shellfish aquaculture while balancing competing uses of coastal waters. GIS has proven to be an effective tool for integrating complex spatial layers in planning efforts (Longdill et. al. 2008, Hawkins et. al. 2013, Hawkins et. al 2012,). The authors propose to (1) develop an interactive shellfish aquaculture siting tool for New Jersey; (2) utilize this tool to model different scenarios for the expansion of aquaculture in the state; and (3) gather stakeholder input for valuation of critical areas. The continued vitality and potential for growth of shellfish aquaculture in New Jersey will be dependent on a comprehensive spatial planning effort that examines the existing footprint and seeks smart growth that is compatible with other valued uses of state coastal waters.

Oyster Crop Insurance Basic Research

Applicant: Crop Insurance Systems, Inc.
Lead PI: Robert Cerda, Crop Insurance Systems, Inc.
Co-PI(s): Clifton Ray Parker, Crop Insurance Systems, Inc.; David Clauser, Crop Insurance Systems, Inc.; LeWayne Jansonius, Crop Insurance Systems, Inc.
Partner(s): North Carolina Shellfish Growers Association; East Coast Shellfish Growers Association
Federal Funding: $30,000

The proposal focuses on the socio-behavioral and economic sciences. The proposal seeks to gather, study and evaluate information needed to develop an insurance product for oysters produced via off bottom aquaculture in Georgia, South Carolina, North Carolina and northward to Maine. The Information gathered will inform the crop insurance industry and the aquaculture community about the cost of pure risk arising from all-natural causes to the oyster aquaculture community. The information gathered in this basic research will be used to propose development of an insurance product covering off bottom oyster aquaculture to the USDA' s Federal Crop Insurance Corporation according to the rules and regulations at 7CFR part 400. This proposal will assist Sea Grant institutions to enhance the practical use and conservation of coastal, marine and Great Lakes resources to create a sustainable economy and environment by: (1) Identifying sources of production risk to the oyster aquaculture community. (2) Modeling the cost of production losses attributable to weather related conditions as well as predation and disease (i.e. naturally occurring events beyond the control of the grower) using historical data supplied by publicly available data sets and individual data sets. 2a. The data sets will be used to predict both the frequency of loss beyond a selected trigger level and the severity of those losses; and 2b. An analysis of the data will yield an estimated cost of crop loss to the oyster producer and how that risk may vary geographically. (3) Estimating the cost of a Federal Crop Insurance product in various growing areas from Georgia to Maine; and (4) Estimate the willingness of the oyster aquaculture community to participate in a risk

management product using a fully funded and federally subsidized risk transfer instrument (insurance).

Enhancing community resilience and seafood sustainability through a diverse seafood processing workforce

Applicant: Oregon State University
Lead PI: Lori Cramer, Oregon State University
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Federal Funding: $249,992

"Marine aquaculture enhances coastal resiliency" states the Preface of the NOAA Fisheries Services "Marine Aquaculture Strategic Plan FY 2016-2020" (NOAA, 2015). The Strategic plan elaborates on how marine aquaculture represents an increasingly important economic sector to communities around the world. Nearly everything in the human-natural seafood system is changing – climate, markets, resources, and the sociocultural characteristics of coastal communities themselves. Change in all these realms poses both risks and opportunities that need to be ascertained and managed. The best coping and adaptation strategies come with planning, and the best planning incorporates transdisciplinary, collaborative, applied science, outreach, and engagement. This project utilizes a mixed-methods social science approach to investigate the current and future workforce needs emanating from increased cultured and captured seafood processing. A stable and reliable workforce enhances community stability and resilience. Resilience of human systems is the ability of communities to cope and recover, in order to maintain essential system functions (Folke 2006). The overall purpose of this study is to understand and enhance human capacity building for adaptation, innovation, and resiliency in seafood systems. The authors will do this by examining coastal communities, the seafood-processing workforce, and identifying potential barriers and opportunities for a transition to sustainable aquaculture.

Assessing Policy Barriers for Mariculture in the United States while Accounting for Fisheries Context

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Federal Funding: $199,272

There is substantial potential for sustainable marine aquaculture in U.S. waters (Gentry et al., 2017; Lester et al., 2018a), yet non-standardized, sometimes opaque, and often cumbersome policies and regulations have long been suggested as major barriers to domestic aquaculture growth in state and federal marine waters (Davies et al., 2019; DeVoe, 1999; Lester, et al., 2018b; Sea Grant, 2019). However, there has not been a large-scale, multi-state analysis of how different aquaculture- and fisheries-specific policies have supported or hindered aquaculture development in U.S. state and federal waters. There is increasing interest in the potential for marine aquaculture to expand to complement fishing, and the proposed project will strengthen our understanding of what policies might best support such expansion and how to cater such

policies to different aquaculture and fisheries contexts. Accounting for the state of fisheries alongside aquaculture policies and regulations could be critical for understanding barriers to aquaculture growth. One way to uncover policy barriers is through case studies, such as research conducted by the Sea Grant Law Center (e.g., Sea Grant, 2019), providing important local insights and detailed information for action within a county or state. However, applying only case study approaches may miss broader-scale and/or longer-term trends and important linkages potentially supporting or excluding the growth of aquaculture. Ther authors propose a large-scale data synthesis and time-series analysis of all 24 coastal marine states on the adoption of marine aquaculture under changing policy and fisheries' conditions. This approach will allow the researchers to move beyond anecdotal evidence of the policy and regulatory barriers to aquaculture development to better understand the efficacy of species policies and regulations (including under different fisheries contexts) that can enable sustainable aquaculture development. The multi-state analysis will be complemented by detailed case studies for California and Florida -- two states with the largest coastlines in the nation, diverse fisheries portfolios, and active policy development around aquaculture -- as well as a workshop with state and federal stakeholders. This research will provide a new, more holistic view of the possible patterns of marine aquaculture production in the U.S. to inform its growth into the future, including identifying states with less friction and/or greater need for aquaculture (e.g., more fisheries collapses, low diversity of fisheries) and determining the efficacy of current aquaculture policies given the state of aquaculture-fisheries linkages.