# Project Summary

**Applicant Organization** University of Alaska Fairbanks

**Principal Investigator** Michael Litzow, Adjunct Research Professor, Fisheries Department, College of Fisheries and Ocean Sciences, University of Alaska Fairbanks, 118 Trident Way, Kodiak, AK 99615; mlitzow@alaska.edu;

**Co-Principal Investigator** Franz Mueter, Associate Professor, Fisheries Department, College of Fisheries and Ocean Sciences, University of Alaska Fairbanks, 17101 Point Lena Loop Road, Juneau, AK 99801; fmueter@alaska.edu;

**Title** Ecological controls of Alaskan pollock size at age under rapid environmental change

**Location** Gulf of Alaska and Bering Sea

**Requested project start period** 1 September 2018

**Federal funding requested** $199,082

**Priority** Priority #2 - Adapting to Environmental Changes and Other Long Term Impacts in Marine Ecosystems

**Summary** The fishery for walleye pollock in the Gulf of Alaska (GOA) and eastern Bering Sea (EBS) is critical to the coastal economies of Alaska, Washington, and Oregon. During 2014-2017, both the GOA and EBS ecosystems experienced an unprecedented marine heatwave. An important consequence of this climate disturbance appears to be highly unusual patterns of size (weight) at age in the GOA pollock stock. Average weights across the age classes that support the fishery have declined sharply since 2014. Extremely low average weights have resulted in economic losses to processors and harvesters. In addition to this direct economic impact, rapid change in weight at age introduces considerable levels of uncertainty into pollock management. Stock assessment models estimate population size in numbers of individuals, but important management benchmarks, including quotas, reference points for maximum sustained yield and overfishing levels, and long-term projections of stock status for use in management evaluation, all depend on converting population size to biomass using estimates of mean weight that are made outside of the assessment model. Average weight in the fishery must be predicted ahead of time for setting these management benchmarks. The sharp drop in mean weight in the GOA stock has coincided with a rapid increase in interannual variability in weight, which indicates that weights are becoming less predictable, and uncertainty in management reference points is increasing. The climate anomaly has seen a number of disruptions to GOA fisheries, including widespread failure of the 2016 pink salmon run and collapse of the Pacific cod stock. Although the GOA pollock stock remains viable, it is showing unusual characteristics under the climate

anomaly (skewed sex ratios, unusual and divergent abundance patterns in different surveys) that suggest that the fishery has entered a period of heightened uncertainty. Improved statistical approaches for estimating weight at age to reduce uncertainty in quota setting are needed for managing this fishery under a rapidly changing GOA environment. In the EBS, similar rapid change in weight at age has not been observed. However, estimating weight at age is one of the main sources of uncertainty for setting management goals for that fishery. Accordingly, improved estimates of weight at age have been identified as a leading management goal for both the GOA and EBS stocks. Current approaches do not account for either density-independent (environmental, competition) or density-dependent effects when generating weight at age estimates. Including external covariates may allow substantial increases in the accuracy and precision of these estimates, especially during the current period of rapid ecological change.

In this project, two experienced fisheries oceanographers with strong quantitative backgrounds propose to develop improved estimates of weight at age for GOA and EBS pollock, using statistical modeling approaches that account for density-independent and density-dependent effects. Our specific objectives are to: 1) generate improved year-ahead and two-year-ahead predictions of weight at age for converting abundance estimates to biomass for setting quotas and management reference points; 2) produce longer-term predictive models to support management evaluation under longer-term scenarios of climate change; and 3) produce stable R scripts to allow weight at age estimates to be updated for future management cycles.

Pollock in Alaska are extremely well studied, and a large number of data sets for weight at age or weight at length are available for different age classes, areas, and time periods. Our approach is to use a comprehensive analysis of as many of these different data sources as possible to provide a global understanding of the factors regulating growth across the EBS and GOA. Covariates for these models will include measures of environmental conditions, density dependence, and estimates of competitor biomass. A number of different statistical approaches will be used to develop improved weight at age estimates, and we will evaluate and compare these approaches in their ability to make out of sample predictions of weight at age. This is exactly the characteristic of model predictive skill that is required for reducing uncertainty when setting quotas and other management reference points.

In addition to the two PIs, our group includes the lead authors of the assessment models for the GOA and EBS stocks, who will provide input on the modeling approaches and outputs that will be most useful in the quota-setting process. Additionally, co-PI Mueter sits on the North Pacific Fisheries Management Council Scientific and Statistical Committee, which will allow our approaches and outputs to be directly integrated into the management process. Our research group also includes collaborators from NMFS and ADF&G with extensive expertise in pollock ecology and relevant modeling approaches.

*The primary benefit of the proposed project for coastal communities is reduced management uncertainty for economically critical fisheries during a period of very rapid climate change.* In addition to the creation of improved tools for the management process, we will conduct outreach activities in Kodiak, aimed at explaining the challenges facing pollock management during a period of accelerating climate change, and the ways that this project helps to address outstanding scientific questions for reducing that management uncertainty. Finally, our modeling results are expected to be relevant to fisheries managers and ecologists, and will be published in the peer-reviewed literature for dissemination to those communities.

# PROJECT SUMMARY

## Applicant Information

a. Applicant organization: University of Alaska Fairbanks
b. Principal Investigator: Anne Beaudreau, Associate Professor, University of Alaska Fairbanks, College of Fisheries and Ocean Sciences, 17101 Point Lena Loop Road, Juneau, AK 99801
c. Association, Alaska Marine Conservation Council, Alaska Charter Association, and the Alas. Email: abeaudreau@alaska.edu

## Project Information

a. Project title: Integrating local ecological knowledge and survey data to improve assessment and management of rockfishes in Alaska
b. Location: Fishing communities along the Gulf of Alaska (Kodiak and Sitka, Alaska)
c. Requested project period: July 1, 2019
d. Federal funding requested: $114,492
e. S-K research priority: #2 (Adapting to environmental changes and long term impacts in marine ecosystems)

## Partners

The research is highly collaborative and involves diverse stakeholders in design and implementation, including fishermen, state agency staff, and university faculty and students. The core research team consists of Dr. Beaudreau, co-Principal Investigators Scott Meyer and Ben Williams, and UAF students. Mr. Meyer is the Statewide Bottomfish Coordinator for the Alaska Department of Fish and Game (ADF&G) Sport Fish Division in Homer and Mr. Williams is the Statewide Groundfish Fisheries Scientist for the ADF&G Division of Commercial Fisheries in Juneau. The research team will also collaborate with fishing industry groups and community organizations, including Alaska Longline Fishermen's ka Sea Grant Marine Advisory Program.

## Summary

*Proposed activities, including species to be addressed.* Despite the wealth of data collected by state and federal agencies, there are still significant gaps in information for many harvested species in Alaska. This is particularly true for more than 30 species of rockfish (*Sebastes* spp.) that support commercial, sport, and subsistence fisheries. While rockfish populations in the Gulf of Alaska are assumed to be healthy, there have been growing concerns about the ability to sustainably manage them, given limited biological information and dramatically increasing harvest in recent years. Our project seeks to advance the use of local ecological knowledge (LEK), in combination with scientific data, to address information needs for management and conservation of rockfishes in Alaska. Fishermen's knowledge is a valuable source of place-based information about long-term changes in coastal marine ecosystems. To address information needs for management and conservation of rockfishes, we will document LEK of commercial, sport, and subsistence fishers in Southeast and Southcentral Alaska. This study will provide estimates of relative abundance from LEK of fishers that, combined with fishery monitoring data, will enable estimation of stock status and development of harvest objectives. Our analyses will evaluate ways in which scientific and local knowledge complement each other and assess sources of variation in fishers' perceptions of ecological change. The specific objectives of this project are to: (1) Synthesize local ecological knowledge of Alaskan fishers to characterize long-term trends in size, distribution, and relative abundance of rockfishes; (2) Assess variation in

fishers' perceptions of ecological change, related to age and attributes of their fishing experience; and (3) Integrate LEK and scientific data to develop distribution maps and time series of relative abundance for rockfishes that can be used in assessment and management.

Our primary research activity will be conducting interviews with fishers in two communities along the Gulf of Alaska where rockfish are an important resource—Kodiak and Sitka. To document LEK, we will conduct in-person interviews with individuals who have long-term knowledge (≥10 years) of rockfishes acquired through commercial, recreational, and subsistence fishing activities. We will use a chain referral approach, in which each interviewee is asked to refer other potential respondents, to reach a minimum of 30-50 respondents from each community. At the start of each interview, respondents will complete a picture sorting task, which will be used to understand how individuals identify and name rockfish; this is important for interpreting LEK about fish abundance changes. The interviews will be designed to document long-term patterns of relative abundance, distribution, and body size for the most commonly harvested rockfish species and associated bottomfishes in each region, including but not limited to yelloweye rockfish (*Sebastes ruberrimus*), black rockfish (*S. melanops*), dusky rockfish (*S. ciliatus*), lingcod (*Ophiodon elongatus*), Pacific cod (*Gadus macrocephalus*), Pacific halibut (*Hippoglossus stenolepis*), and sablefish (*Anoplopoma fimbria*). Respondents will be asked to classify the relative abundance and body size of each focal species on a Likert scale for each 5 to 10-year period in which they had fished. Regression models will be fit to abundance and size indices for each species and we will evaluate the degree of agreement between LEK and scientific surveys. We will quantify variation in individual fishers' perceptions of ecological change related to age or years of experience in the fishery, location or extent of fishing, or other attributes of their fishing experience. Gridded fishing distribution maps will be generated for each time period with sufficient data. Lastly, we will develop a fuzzy expert system to combine quantitative and qualitative data in a common framework. This will provide a means for including LEK as an index in statistical age-structured stock assessments.

*Anticipated benefits and outcomes.* Our project directly responds to S-K goals by engaging stakeholders in the development of shared knowledge about marine fish populations to directly address fishery management needs in Alaska. Through in-person interviews, we will keep in regular contact with many sport and commercial fishery stakeholders. The involvement of co-PIs from ADF&G will ensure that our results are immediately available to biologists and managers working on rockfish fishery issues. Furthermore, as the co-PIs are affiliated with the two major Divisions of ADF&G, the project provides a unique opportunity to improve coordination between the Commercial and Sport Divisions for rockfish research and management. The work will benefit stakeholders by generating results that directly address rockfish management needs, and highlighting the importance of local knowledge in Alaska's fishing communities and its contribution to fisheries assessment and management. We expect the following deliverables: (1) Indices of abundance and body size for rockfishes in two areas of the Gulf of Alaska from the 1970s to present. (2) Maps showing distribution of fishing activity and survey observations for rockfishes. (3) Results that will be integrated into an age-structured assessment of black rockfish in the Kodiak area. (4) Direct engagement with fishers who will be integral to the success of the research. (5) Graduate student training and completion of a Master's thesis and at least 1 peer-reviewed scientific publication. (6) Report that provides guidance to agencies on the use of LEK in fisheries. (7) Research experience for undergraduates. (8) Newsletter summarizing results for non-technical audiences. (9) Outreach presentations to share results and solicit feedback from project participants. (10) Educational materials to help anglers identify rockfish.

## A. PROJECT SUMMARY

**Applicant Information:** Marta Gomez-Chiarri, Professor and Chair
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University of Rhode Island.
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**Project Title:** Probiotics for bivalve aquaculture: Commercial production and hatchery implementation.

**Location:** University of Rhode Island (central location), Envera Inc. (PA, probiotic production); and hatcheries at the Aquaculture Breeding Center Virginia Institute of Marine Sciences (VA) and Mook Sea Farm (Maine)

**Project start period:** 9/1/2018

**Federal Funding Request:** $300,000

**S-K Priority:** Priority #1 – Marine Aquaculture - *Develop, refine and apply aquaculture technologies that improve economic performance of aquaculture, while simultaneously improving regulatory, social or environmental performance. Projects that demonstrate aquaculture technologies in operational settings, such as through a pilot or commercial-scale project, are strongly encouraged.* It will do so by implementing the use of probiotics to improve productivity in bivalve shellfish hatcheries at a pilot commercial scale.

**Collaborating Partners**

**Co-Principal Investigators:** David Rowley, Department of Biomedical and Pharmaceutical Sciences, University of Rhode Island
David Nelson, Department of Cell and Molecular Biology, University of Rhode Island

**Project Summary**

**Rationale.** Disease caused by bacterial pathogens, in particular several *Vibrio* species, has been a major cause of production losses in bivalve shellfish (oysters, clams, scallops, mussels) hatcheries worldwide. In recent years, these larval losses have led to shortages in seed supply for restoration projects and a rapidly expanding oyster aquaculture industry, significantly constraining production. Current approaches to manage disease in finfish and shellfish hatcheries include the use of expensive

water treatment systems (a combination of filtration and treatment of filtered water with ultraviolet light and/or water pasteurization) and other labor-intensive biosecurity measures (cleaning of equipment) designed to avoid the introduction of pathogens in hatcheries. However, despite these biosecurity measures, outbreaks of disease still occur There is a critical, unmet need for novel tools to prevent and treat disease outbreaks at hatchery facilities.

Probiotics (live organisms that provide a beneficial effect to the host) are a relatively inexpensive and environmentally friendly tool for managing disease in aquaculture hatcheries through prevention of disease outbreaks. The proposed project builds upon more than five years of research in probiotics by an interdisciplinary team of researchers with expertise in natural products chemistry, microbial genetics and physiology, microbial ecology, and aquatic pathology at the University of Rhode Island. This previous research demonstrates that probiotic strains *Bacillus pumilus* RI06-95 (695) and *Phaeobacter inhibens* S4 (S4) are safe to bivalve shellfish larvae, reduce the numbers of *Vibrio* spp. in treated hatchery tanks, and promote larval survival when eastern oyster and bay scallop larvae are challenged with bacterial pathogens. These probiotics also diminish the relative proportion of potential pathogens in water. We have also developed stable and effective formulations of these probiotics for commercial use in bivalve hatcheries.

**The goal** of this proposed research project to is to implement the use of probiotics to improve productivity in bivalve shellfish hatcheries at the commercial scale. The research will be focused on two probiotic strains: 695 and S4. **The objectives and approach** of this research are to**:** 1) Develop methods for commercial production of these probiotic strains; 2) Test efficacy of the formulated probiotics in a commercial setting; 3) Use data from hatchery trials and ongoing research in our laboratories funded by USDA on mechanisms of action to develop a standard protocol for the effective use of probiotics in bivalve shellfish hatcheries; and 4) Make this protocol widely accessible to the industry.

**Anticipated benefits and outcomes:** The research proposed here will result in commercial probiotics with proven ability to improve hatchery production of oyster seed. Widespread use of these probiotics in oyster hatcheries will lead to an increase in the reliability of larval production runs, and, therefore, more reliable, efficient, and cost-effective production of oyster seed for restoration projects and the aquaculture industry.

**Dissemination** of the results from the project to stakeholders, which include scientists, industry (hatchery managers and farmers), and regulators, will be performed through presentations at scientific conferences and industry meetings (including one workshop delivered with the participation of our partner hatchery managers), outreach publications through the Rhode Island Sea Grant program (e.g. websites, magazines, podcasts), scientific publications, and incorporation of materials from the research into education materials and class activities at the middle and high school and college level. We will emphasize in these dissemination venues the safety, efficacy, and cost-effectiveness of probiotics as a disease management tool.

## Project Summary

**Project Title**: Superior Eastern Oyster Stocks for Enhancing Coastal Aquaculture

**Applicant:** Rutgers, The State University of New Jersey
33 Knightsbridge Road
Piscataway, NJ 08854-3925
Phone: (848) 932-0150; Fax: (732) 932-01622

Start: 12/01/2018

**Funding Requested:** $281,080

**Principal Investigator:**

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**Co-investigators:**

Ms. Lisa Calvo, Aquaculture Program Coordinator and Sea Grant Extension
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**Priority:** Priority #1 – Marine Aquaculture: develop, refine or apply technologies that improve economic performance of aquaculture to create jobs and produce healthful local seafood.

**Summary:**

Oyster aquaculture is one of the most important aquaculture industries in the US and around the world. Oyster aquaculture is environmental friendly, family or community-based, and important to the socioeconomic well-being of coastal areas that are depressed by the decline of

wild fisheries. Oyster aquaculture has been growing steadily and has the potential for significant growth; however, further growth of this industry is hindered by a lack of suitable stocks.

With vast areas of ideal habitat, coastal bays of New Jersey have great potential for oyster culture. Recently, the State of New Jersey has opened new leases in coastal bays for aquaculture. Aquaculture in coastal bays of NJ has so far focused on hard clams, although coastal bays are also well suited for oyster farming. Hard clam culture has not seen much growth, while interests in oyster culture have been growing due to strong market demand. A diversification of crops may bring additional income to farmers and contribute to the resilience of the aquaculture industry.

Clam farmers in Barnegat Bay have been experimenting with oyster farming using disease-resistant oysters developed at Rutgers and VIMS. However, oyster breeding at Rutgers and VIMS has focused on disease resistance and fast growth in low-salinity (10-20) environments. Stocks developed at Rutgers and VIMS may not be the best stock for high-salinity (26-32) waters of coastal bays. Triploid oysters have also been developed at Rutgers and demonstrated superior growth in Delaware Bay, but their performance in coastal bays have not been fully evaluated. Delaware Bay and coastal bays differ greatly in environmental conditions. Oyster farming in coastal bays calls for the development of stocks that are well-adapted to high-salinity environments.

The overall objective of this project is to test and identify the best-performing oyster stock for aquaculture in high-salinity waters of NJ and the Northeast (NE). Previous studies have shown that diploid and triploid Rutgers NEH oysters are the best-performing stocks in Delaware Bay and some high-salinity environments. We plan to test if NEH diploids and triploids can out-perform local stocks from coastal bays, and whether hybrids between NEH and local stocks provide the best performance. Specifically, we propose to: 1) produce different stocks that may perform well in coastal bays; 2) evaluate the stocks at four sites in coastal bays in NJ; and 3) transfer project results to New Jersey and regional shellfish farmers.

We will produce and evaluate the following 5 stocks at 4 sites in coastal bays of NJ: local stock from coastal bays, diploid and triploid Rutgers disease-resistant NEH, and diploid and triploid hybrids between local stocks and NEH. Our hypothesis is that triploid hybrids or diploid hybrids may provide the best performance or highest yield, by combining benefits from the two stocks and hybrid vigor. These five crosses will be produced in Spring 2018 and deployed in triplicate bags at four participating farms in coastal bays of NJ. They will be monitored and evaluated to 20 months of age in collaboration with four industry partners. At the end of the project, the best-performing stock (with the highest yield) will be identified and provided to hatcheries for commercial production. Results of this project and resulting stock will be widely disseminated through our aquaculture extension program jointly conducted by Rutgers University and New Jersey Sea Grant.

We expect that this project will identify the best-performing oyster stock for high-salinity coastal bays. The identification of a superior high-salinity stock will not only immediately enhance oyster production in coastal waters, but also provide a foundation for long-term breeding of high-salinity varieties. This project will extend Rutgers' long history of oyster breeding, which through the development of disease-resistant and triploid oysters has contributed significantly to oyster farming in the US and around the world. Although this project does not involve other states at this stage for cost considerations, results of this project should have wide impact on oyster aquaculture in high-salinity waters of the NE. This project is highly relevant to the S-K program in contributing to sustainability of marine aquaculture in the US.

**Project Title: Do small female lobsters produce lower quality eggs?**

**2018 Saltonstall-Kennedy Competitive Research Program NOAA-NMFS-FHQ-2018-2005332. Priority #2 –** "*Adapting to Environmental Changes and Other Long Term Impacts in Marine Ecosystems.*

**Project Location**: Bigelow Laboratory for Ocean Sciences; Univ. Maine Darling Marine Center.
**Start Date:** Sept 1 2018

**Dr David M Fields** (Principle Investigator)
Bigelow Laboratory for Ocean Sciences
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**Dr Richard Wahle** (Co-Investigator)
Univ. of Maine - School of Marine Sciences
*Darling Marine Center-193 Clarks Cove Road*
*Walpole, ME 04573*
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Partners: 1) Maine Department of Marine Resources (ME-DMR); 2) Rhode Island Department of Environmental Management; (RI-DEM). Letter of endorsement - Atlantic Offshore Lobsterman Association (AOLA)

**Funds requested:** Year 1-$145K / Year 2-$140K: **Total $285K**
**Species/Resource:** American lobster (*Homarus americanus*)

**The problem:** Rising temperatures have caused the American lobster, *Homarus americanus*, to mature at a smaller size and produce fewer eggs per female. However, it is unknown if smaller maternal size also affects egg quality and/or the performance of their offspring.

The population center of the American lobster, the nation's most valuable fishery, has shifted northward by $2^{o}$ latitude over the last three decades, a process projected to continue. Southern New England lobster production is at historic lows, just as northern populations have rapidly increased. Lobsters found in the warmer, southern limits of their distribution grow more rapidly and reach sexual maturity at a smaller size and younger age than those to the north. Despite the faster initial growth in warmer water, earlier onset of maturity taxes somatic growth resulting in smaller adult size. While this north-south difference in lobster maturation and adult size is well known, recent surveys have revealed that sustained warming over the species' range has induced a downward trend in female size at maturity in all locations (Le Bris et al. 2016). For example, Long Island Sound (Landers et al. 2001), the Gulf of Maine (ASMFC 2015, Pugh et al. 2013), and the Bay of Fundy (Gaudette et al. 2014) have all reported steady declines in size at maturity since the 1990s. Along the Maine coast, the mean size of reproductive females has decreased by nearly 20% over the past two decades. With smaller body size comes exponentially lower individual fecundity. Therefore, in a warming climate, lobsters in New England are becoming progressively smaller and less fecund. Compounding decreased fecundity, recent evidence suggests smaller females also invest less energetic resources per egg than large females. In addition, eggs from smaller females appear to contain lower total omega-3 fatty acid. The consequences of these changes in egg quality and quantity for larval performance are unknown, to say nothing of the impact on future recruitment. It is reasonable to hypothesize that lower quality eggs lead to lower performance and survival during early larval development, particularly

when challenged with the increased energetic demands of higher temperature (Waller et al. 2016). This proposal is a revision of a previously well reviewed submission. In this study we ask: How does maternal size impact the reproductive performance of the American lobster, and what are the implications for the productivity of US lobster populations?

**Proposed Activity:** The goal of this work is to evaluate egg quality across thermally contrasting regions, and to compare small and large reproductive female lobsters with respect to egg quality and the performance of their larval stages. The proposed project has two objectives. ***Objective 1*** evaluates how female size impacts fecundity and egg quality at 3 study areas spanning New England's steep thermal gradient: NOAA Statistical Areas 539 (off Rhode Island), 513 (midcoast Maine), and 511 (eastern Maine). These study areas offer access to a wide range in size of mature females across the thermal gradient. We use a non-invasive image analysis method to estimate clutch sizes of egg-bearing females in our field samples. A small sample of eggs will also be collected from each female to determine total lipid content and fatty acid profiles. ***Objective 2*** evaluates larval performance as a function of maternal size. Egg-bearing females spanning a range of sizes will be collected from a single region (NOAA 513) and maintained at UMaine's Darling Marine Center until they hatch. Larval rearing experiments will be conducted at Bigelow Laboratory to assess growth, morphology and physiology of larvae originating from females of a range of sizes.

**Benefits and outcomes:** US lobster production has increased by more than three-fold since 1980 (ASMFC 2015). Topping $533 million in 2016, it is now the most valuable single-species fishery in the United States. Maine harvests about 80% of the US lobster landings, but with 75% of the state's fishery value coming from lobster, its coastal economy is perilously dependent on this single species (ME DMR 2017, Steneck et al. 2011). Although brood-stock abundance is at historic highs in the Gulf of Maine, larval settlement has been declining in many areas (Wahle et al. 2016). It is unclear whether declines in settlement may relate to reduced *per capita* reproductive output either before or after larvae hatch. This study will provide much needed data on the role of maternal body size and maternal investment in egg production that may contribute to widespread declines in larval settlement. This work aligns with S-K's overarching mission to maintain coastal ecosystems, support coastal communities and promote sustainable fisheries. This work specifically targets **SK Priority #2 –** "*Adapting to Environmental Changes and Other Long Term Impacts in Marine Ecosystems; Assess short- and long-term biological and socio-economic impacts of ecosystem changes such as long-term fluctuations in water temperature and other stressors on living marine resources and the communities sustained by these resources*". The proposed project represents a multi-institutional collaboration of investigators with complementary skills in crustacean ecology and physiology and reinforces an already strong working partnership with state marine resource agencies and the lobster industry. Data from this study are critical for life history model development, and particularly size-based stock assessment models that currently assume no difference in the per-capita success of eggs produced by females of all sizes and thermal regimes (ASMFC 2015). Insights gained from this study may motivate managers to re-evaluate minimum and maximum size limits, a key mechanism to manage fishing mortality in this fishery. The project also complements current NOAA and NSF sponsored research to evaluate the impacts of elevated temperature and $pCO_2$ on lobster larval development, and to develop forecasting tools for trends in the fishery. Stock assessment scientists, fishery managers and the industry endorse this project (see letters of support).

## A. Project summary

**Project Title**: Development Of Offshore Shellfish Aquaculture In Federal Waters Along The Atlantic Coast

**Applicant Organization:** Salem State University

**Project Location:** 1.44 million square foot area (33 Acres), around center point 42°41.000' N -70°27.000' W (42.683333 N -70.45 W) 8.5 mi from Rockport Harbor, Massachusetts

**Requested Start Date:** September 1, 2018

**Funding Requested:** $295,408

**Name and Title of Principal Investigators:** Mark Fregeau Ph.D., Professor and Edward Maney Jr. M.S., Instructor

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**Species to be addressed:** Blue mussel (*Mytilus edulis*)

**Activities/Outcomes/Connection to S-K Priorities:**
Priority 1 – Marine Aquaculture- Technology development and transfer

As the demand for seafood continues to increase nationally as well as globally, aquaculture is predicted to play an increasingly greater role in commercial fisheries. The future of commercial marine aquaculture in the US is the development of offshore farm sites. While inshore aquaculture initiatives, especially for shellfish, have grown over time; limited space in coastal waters and the competing demands from other activities such as wild fisheries, shipping, recreational activities and protected areas impede opportunities for increased operations. Moving into federal offshore waters would significantly expand the opportunities for shellfish aquaculture. Aquaculture operations must move offshore to compete with foreign aquaculture-based fisheries in Canada, New Zealand and Norway to provide American markets with quality, sustainable and abundant supply of seafood, especially shellfish. Mussels are a prime example of an underutilized aquaculture-based fishery which is currently dominated by foreign imports, such as the massive influx of product from Canada.

To date only three USACE permits have been issued for shellfish aquaculture in

federal waters, one off California and two off Massachusetts. In 2016, two farm sites were established, one off the California coast (Catalina Sea Ranch) and the other off Cape Ann, Massachusetts (NEMAC mussel farm). Catalina Sea Ranch was allowed to fully build out to commercial scale. On the Atlantic coast, the only two permitted sites are restricted to three longlines as a preliminary condition until they can demonstrate that this activity will not adversely affect migrating protected species. Permitting conditions from the USACE and NOAA involves a phased-in approach, in which gear designed to prevent and minimize possible entanglement will be initially deployed as a pilot study coupled with extensive monitoring for interactions with species that are protected under the Marine Mammal Protection Act and Endangered Species Act, and their habitats. The NEMAC site or any other proposed aquaculture project on the Atlantic coast will not be developed to full commercial scale until preliminary studies are completed.

Expansion of the NEMAC mussel farm site will provide vital data on the environmental and commercial viability of offshore aquaculture. Without two additional lines, the potential of a mussel farm cannot be accurately tested; since NOAA initially funded the work to develop a permitting protocol and implement a farm setup, it would be appropriate to the support the next step – build-out to 3 lines and eventually allow a full commercial site build out. The major deliverable is the collection of field data to support a USACE permit modification allowing full build out of a commercial scale farm. This project will serve as a template for building an offshore aquaculture-base shellfish farm and provide a protocol for establishing other aquaculture projects in offshore federal waters along the Atlantic coast.

## A.) Project Summary for the Funding Opportunity: FY2018 Saltonstall-Kennedy Competition (NOAA-NMFS-FHQ-2018-2005332)

Applicant & Principal Investigator:
Cape Cod Commercial Fishermen's Alliance
John Pappalardo, CEO
1566 Main Street, Chatham MA 02633
E-Mail: john@capecodfishermen.org

Specific S-K priority area: #3, Promotion, Development, and Marketing
Project location: Cape Cod, Massachusetts
Project period: 24 months, September 1, 2018 – August 31, 2020
Species/resources to be addressed: spiny dogfish, *Squalus acanthias*
Project title: Overcoming the Last Hurdle of Dogfish: Changing the Name
Funding requested: $37,047

Proposed activities and anticipated benefits/outcomes:
The proposed project addresses the SK priority of "Promotion, Development, and Marketing." Changing the allowable name of spiny dogfish is necessary to leverage the many efforts that have already been made to create marketing opportunities for dogfish. Creating an increase in American consumer demand for U.S.-harvested dogfish would allow fishermen to land more of these abundant low-value fish and better their bottom lines, and NOAA Fisheries would realize the full potential of these U.S. fishery resources.

The Fishermen's Alliance has conducted three years of sales and marketing efforts for spiny dogfish, *Squalus acanthias,* which have yielded promising leads from large-scale domestic buyers, such as universities, and addressed restaurants' hesitation to work with an unfamiliar fish. Spiny dogfish is delicious and relatively cheap. However, almost everyone that we talk to about dogfish suggests that spiny dogfish needs a new name to become a household staple. Americans are just too connected to their pet dogs to overcome the idea of eating a dogfish. The Food & Drug Administration (FDA) currently only allows for it to be called spiny dogfish, dogfish shark, or cape shark. Cape shark has its own host of issues, bringing up health and sustainability concerns over eating larger sharks, creating new marketing challenges.

There is precedent for name changes improving the domestic sales of seafood. These changes were easily done before rampant seafood labeling fraud required the FDA to create an onerous process to officially change the name of a fish. While we applaud rigorous labeling standards, to protect consumers and fishermen, in the case of dogfish, there is a compelling argument for a name change. The project will have the following benefits and impacts:

- Provide an alternative naming option for seafood processors and distributors to use, providing them with expanded opportunities for marketing.

- Support the building of U.S. consumer demand for dogfish, resulting in:
    - fishermen more fully utilizing the sustainable annual catch limit and increasing their annual revenues
    - a more stable market
    - potential increase in ex-vessel prices as compared with exporting, which is subject to volatile foreign markets and exchange rates
- Decrease exports and increase U.S. utilization of domestically caught fish.
- Documented process for changing the name of a fish, to serve as a resource for similar future projects.

The objective of this project is to obtain FDA approval of an alternate name for spiny dogfish, to ultimately assist with domestic dogfish marketing efforts. To achieve this, our team will undertake the following scope of work:

I. Research and preparation:
    a. Identify how other products have successfully changed names with the FDA.
    b. Document the process and requirements, to support the dogfish application and to serve as a resource for future similar projects. Contract with necessary experts as needed.
    c. Foster necessary contacts and relationships to ensure success.

II. Brainstorm potential new names:
    a. Assemble working group of industry partners, including chefs, wholesalers, distributors, processors, dealers, and fishermen, to brainstorm potential new names.
    b. Host a consumer survey via social media to further brainstorm potential new names, solicit feedback on name options, and create awareness of potential name change.
    c. Utilize working group and consumer feedback to narrow list of potential names to 2 -4 options.

III. Market testing of potential new names:
    a. Release RFP to solicit bids for market testing potential new names for dogfish.
    b. Contract with firm/consultant.
    c. Firm/consultant to complete market testing of the final 2-4 name options
    d. Finalize proposed new name.

IV. Apply to the FDA for the name change:
    a. Utilize findings from "research and preparation" to navigate the complicated FDA process for obtaining a name change.
    b. Contract with legal support as needed to complete the application.
    c. Solicit political support of application as appropriate.
    d. Submit application to FDA.

V. Evaluation, outreach, and next steps:
    a. Track and monitor application.
    b. Develop outreach plan for communicating name change across the country.
    c. Update research and formally document entire process for future projects.
    d. Assess likelihood of success if FDA decision has not been finalized by the end of the grant period.
    e. If approved, implement outreach plan to share new name throughout seafood industry to ensure widespread adaptation of new name.

**PROJECT SUMMARY**

**2018 Saltonstall-Kennedy Competitive Research Program**

Applicant Organization: Commercial Fisheries Research Foundation (CFRF); P.O. Box 278, Saunderstown, RI, 02874; amalek@cfrfoundation.org;

Project Title: Development of a Marketable Seafood Product from Scup (*Stenotomus chrysops*), an Abundant, Low Value Species in the Northeast and Mid-Atlantic USA

S-K Priority: Priority # 3 "Promotion, Development and Marketing"

Project Location: Rhode Island and Massachusetts

Requested Project Start Date: October 1, 2018

Funding Requested: $281,394

Principal Investigators: Anna Malek Mercer, PhD, Executive Director, CFRF; Fred Mattera, CFRF President and previous owner of F/V Travis & Natalie; Scott Bode, Chief Operating Officer, Pier Fish, Inc. and previous owner F/V Bulldog

Species/Resources to be Addressed: Scup (*Stenotomus chrysops*)

Description of Proposed Activities:

Due to the depletion of groundfish and other traditionally targeted commercial species, many fishermen are seeking to diversify their fishing effort with underutilized species, such as scup (*Stenotomus chrysops*). Fishermen report that scup are readily available year round, but narrow market demand for whole scup results in an extremely low and unpredictable ex-vessel price (2017 minimum scup price = $0.01 per pound). Over the past three years, the Commercial Fisheries Research Foundation (CFRF) has been working with the fishing industry to develop the processing methods to produce a more marketable product from scup that fulfills consumer and institutional demand for affordable, local, white-flesh fish fillets. The CFRF has been successful at developing machinery to fillet scup and growing local demand for scup fillets, but in order to bring this new seafood product to market additional research is needed to develop the freezing and packaging techniques to produce a stable supply of refreshed scup fillets. The high volume and variability of scup landings, in combination with the needs of large-scale seafood buyers, such as supermarkets and universities, requires that the product be frozen and refreshed. Thus, the proposed project seeks to: 1) Determine the at-sea handling, shore-side processing, and storage techniques that produce a high quality, fully traceable refreshed scup fillet product, 2) Determine the economic viability of producing refreshed scup fillets, including production costs, byproduct utilization, and retail price, 3) Certify the sustainability, organoleptic quality, and nutritional value of refreshed scup fillets to ensure suitability for retail markets, and 4) Introduce and market refreshed scup fillets to food businesses and consumers, highlighting the traceability

from fisherman to consumer, the sustainability of the scup resource, and the health benefits and culinary versatility of the product. If successful, the proposed project will enhance fishing community resiliency by enabling diversification, securing stable and profitable ex-vessel prices for a highly abundant species, and promoting the full utilization of the scup Annual Catch Limit.

The project will be approached collaboratively by a team of fishermen, fish processing companies, scientists, and culinary professionals, with the ultimate goal of developing a novel refreshed (previously frozen) scup fillet product that meets consumer demand, results in higher ex-vessel prices, and justifies expanded harvest of this underutilized species. To achieve this goal, proposed project activities include: 1) Develop the harvesting methods that produce the best scup for filleting, freezing, and refreshing, 2) Test the "freeze and fillet" and "fillet and freeze" methods to determine which produces the highest quality refreshed scup fillets, 3) Test three freezing techniques (batch freezer, plate freezer, Individual Quick Frozen) to determine which is the most effective for producing refreshed scup fillets, 4) Track the costs associated with processing, storing, and distributing refreshed scup fillets to estimate the final market price, 5) Monitor the efficiency of refreshed scup fillet production and estimate the total quantity of scup fillets available to the market, 6) Research uses and markets for scup processing byproducts, 7) Assess the shelf life and nutritional profile of refreshed scup fillets, 8) Conduct culinary evaluations of the organoleptic qualities of refreshed scup fillets in collaboration with Johnson and Wales University, 9) Work with Sustainability Incubator to complete a Fishery Improvement Project for scup to meet the criteria of large-scale retailers, such as Whole Foods, 10) Implement a marketing and traceability campaign in collaboration with Dodge Associates to promote refreshed scup fillets to seafood buyers and consumers, 11) Conduct public tasting events of refreshed scup fillets to gather consumer feedback and increase awareness of locally harvested seafood, and 12) Introduce refreshed scup fillets as a new product to the market.

The proposed project is relevant to the S-K Program as it seeks to optimize the economic benefit of a highly abundant, yet low value species in the Northeast and Mid-Atlantic regions. The results of the proposed project will create new marketing opportunities that increase revenue to fishermen and facilitate a greater diversity of species throughout the seafood supply chain. This work will ultimately serve to inform the individual business plans, investment strategies, and fishing practices of the fishing industry, with hundreds of fishing vessels and processing companies benefitting from an expanded market and fishery for scup. Finally, culinary and public tasting events conducted as part of the proposed project will educate chefs and consumers about locally landed and processed seafood products versus imported seafood products.

Anticipated Outcomes and Benefits:

The major anticipated outcomes of the proposed project are: 1) Identification of harvesting and processing techniques to produce high quality refreshed, boneless, skinless scup fillets, and 2) Certification of the scup fishery's sustainability to meet the needs of large-scale seafood retailers. If the project is successful, the fishing industry will benefit from higher ex-vessel prices, additional processing jobs, reduced dependency on depleted groundfish species, and increased support business activity. In general, opening up economic opportunities in connection with scup could be a much needed boost to a struggling fishing industry in the Northeast. Ultimately, the general public will benefit from this work as a new healthful, affordable, and sustainable seafood product that is harvested and processed domestically is made available nationwide.

PROJECT SUMMARY

**Applicant Organization:** Manomet
**Project Title:** Investigating the viability of a soft-shell green crab industry in New England
**SK Priority:** Priority # 3: Promotion, development and marketing
**Project Location:** Maine, New Hampshire and Massachusetts
**Requested Start Date:** September 1, 2018
**Funding Requested:** $267,440.00
**Name/Title Principal Investigator:** Marissa D. McMahan, Ph.D, Senior Fisheries Scientist, Manomet; mmcmahan@manomet.org
Gabriela Bradt, Ph.D., Commercial Fisheries Specialist, New Hampshire Sea Grant; gabriela.brady@unh.edu

**Species/resources to be addressed:** European green crab (*Carcinus maenas*)

The European green crab (*Carcinus maenas*) is an invasive species that was first detected in New England in the early 1800s. Green crabs have a wide range of negative impacts on local ecosystems, including reducing native bivalve populations through predation, competing with native crustaceans for food and shelter, and destruction of eel grass habitat and subsequent changes to fish community structure. Increases in green crab abundance and predation have also been linked to the recent decline of the soft-shell clam industry in New England. Compounding these issues is the link between increasing green crab abundance and increasing ocean temperature, which has had severe ecological and socio-economic consequences in areas such as the Gulf of Maine, where warming is occurring faster than 99% of the world's other oceans.

In Massachusetts, townships have attempted to reduce local green crab abundance through a bounty program that pays harvesters a fixed price per pound. In Maine, techniques have been developed to mitigate the effects of green crab predation on wild and hatchery reared juvenile soft-shell clams. It is unlikely that green crab populations could be eradicated completely; however, recent research by the Department of Fisheries and Oceans, Canada suggests that developing a green crab fishery may be a viable way to control population abundance and derive value from this invasive species. Existing fisheries in the U.S. and Canada target green crabs for lobster and whelk bait, but a higher retail price would need to be established to encourage expanded effort and new participation.

In Italy, a soft-shell green crab product exists that retails for approximately $55USD/kg. The traditional fishery, based in Venice, targets the native Mediterranean green crab (*Carcinus aestuarii*), which bears close similarity to the invasive European green crab. Harvesting occurs seasonally during peak molting and relies on the harvester's ability to detect external pre-molt indicators. Crabs exhibiting pre-molt signs are stored in floating cages and harvested as they molt. This fishery is lucrative enough to employ full-time green crab fishers. Researchers at The University of Prince Edward Island (PEI) have been investigating the implementation of a

similar soft-shell green crab fishery in Canada that would target the invasive European green crab.

In 2016, a team of researchers, fishers and local residents began investigating the viability of a soft-shell green crab fishery in midcoast Maine (although similar research began in New Hampshire in 2015). The studies in Maine and New Hampshire were funded by each state's respective Sea Grant program, and were aided and advised by researchers from the University of Prince Edward Island, as well as Venetian crab fishers. The objectives of this research were to observe distribution, abundance and molt patterns of local green crab populations and determine if external pre-molt indicators could be identified. Results were positive. With training from a visiting Venetian fisher, we successfully identified pre-molt green crabs at our research sites both in Maine and New Hampshire, using subtle but distinct color changes on the ventral margins of the abdomen and episternites. These efforts were expanded in 2017 to include the first production of soft-shell green crabs in New England. Production was small in scale and conducted by volunteers (ME) and interns (NH); however, soft-shell product was hugely successful in multiple restaurant trials, indicating market demand for this product.

The goal of this proposal is to build upon our previous research to determine the viability of a soft-shell green crab industry in New England. We specifically propose to:

1. Observe seasonal distribution, abundance and molt patterns of green crabs in New England.
2. Test methods of producing soft-shell green crabs.
3. Enhance marketing, education and outreach surrounding green crab fisheries and products.

As invasive species continue to disrupt natural ecosystems, new strategies will need to be developed to mitigate the resulting ecological and socioeconomic impacts. The creation of a wild-harvest soft-shell green crab industry would provide an economic opportunity for a region with low fisheries diversity and high dependence on a lobster monoculture that is showing signs of climate-driven decline in southern New England. A soft-shell fishery may also provide a mechanism for controlling green crab populations and reducing negative impacts on local ecosystems. Ultimately, this would enable coastal communities to benefit from a species invasion that has had significant harmful impacts in many areas. Finally, this project will involve participation from many commercial fishers in Maine, New Hampshire and Massachusetts. We believe this will spark interest in a soft-shell industry, and that the fishers involved will be able to take what they have learned from this project and directly apply it to harvesting soft-shell green crabs.

**Title:** Improving oceanographic models of bottom temperature within the Mid-Atlantic Bight through novel data assimilation and stakeholder input

**Primary Investigators:** Samir Patel and Jason Clermont

**Affiliation:** Coonamessett Farm Foundation, Inc.

**Collaborators:** Ronald Smolowitz- Coonamessett Farm, Inc.
Peter Moore, Fisheries Development International LLC
Wendell Brown, UMass Dartmouth/SMAST & MARACOOS
Bill Bright, F/V Retriever, Loper-Bright Enterprises LLC
Leah Crowe, Integrated Statistics
James Manning, Heather Haas, Northeast Fisheries Science Center

**Contact Information:** Samir Patel
spatel@cfarm.org
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jclermont@cfarm.org

**Address:** 277 Hatchville Rd
East Falmouth, Massachusetts, USA

**Funding Requested:** Federal - $257,534

**Dates:** September 2018

**S-K Priority:** #2 - adapting to environmental changes and other long-term impacts in marine ecosystems.

## A. Project Summary

**Title:** Improving oceanographic models of bottom temperature within the Mid-Atlantic Bight through novel data assimilation and stakeholder input
Start **Date:** September 2018
**Funding Requested:** Federal - $257,534.
**Personnel:** *PIs* – Samir Patel, Jason Clermont, Coonamessett Farm Foundation, Inc. (CFF *Collaborators* – Ronald Smolowitz, Coonamessett Farm, Inc., Wendell Brown, University of Massachusetts, Peter Moore, Fisheries Development International LLC, Captain Bill Bright, F/V Retriever and Loper-Bright Industries LLC, Leah Crowe, Integrated Statistics. *Partners* – James Manning, Heather Haas, Northeast Fisheries Science Center.
**S-K Priority:** #2 - Adapting to Environmental Changes and Other Long-Term Impacts in Marine Ecosystems
**Summary:** The proposed project will improve oceanographic models used to forecast temperature within Mid-Atlantic waters and produce continuously updated temperature products for fishermen and managers. We will utilize a collaborative industry-science-management Working Group approach previously developed for the US Atlantic mackerel stock assessment. Specifically, we will incorporate several years of temperature data accrued from animal-borne sensors, autonomous ocean gliders, commercial fishing gear, and trawl surveys to improve numerical modeling of the Cold Pool, Then, we will assimilate the calibrated data into existing Mid-Atlantic Bight (MAB coastal ocean models used in the historic hindcast, contemporary nowcast and future forecast modes. In each case, the spatial extent of the model 10ºC Cold Pool will be defined. The Working Group will be convened periodically to ground truth the model and products.

The MAB, shelf waters located between Long Island, NY and Cape Hatteras, NC, has a unique ecosystem that is a particularly valuable region for fisheries. Each year a seasonal Cold Pool is defined in May by surface water warming and trapping winter water below about 30 meters. During the summer months, the Cold Pool water (CPW mass warms and evolves, despite being fed by cold flows from the Georges Bank region, before dissipating in October during the fall turnover (Lentz et al. 2017. The Cold Pool is typically found between bottom depths of 40 to 70 meters and starts at 6°C, warming up to 9°C by the end of August (Lentz et al. 2017. This unique oceanographic feature of the region has been shown to be critical to the life-history of commercially-important species (Sullivan et al. 2005.

Since 2009, CFF and the Northeast Fisheries Science Center have been collaborating on sea turtle research, specifically on the deployment of satellite transmitters on loggerhead turtles within the MAB. This work has continued through 2017, with more than 150 tags deployed. Loggerheads forage within this region from late May to early October, and typically feed on slow-moving benthic species. As a result, this tagging study has accrued over 10,000 temperature-depth profiles of the entire water column and an additional 4,000 more profiles passing through the thermocline within the MAB between June 1 and Oct 5 for all years combined.

Over the past decade, repeated high-resolution Slocum glider measurements of ocean water properties along a New Jersey cross-shelf transect have helped to define the variability of the CPW structure off New Jersey. More recently the Mid-Atlantic Regional Association Coastal Ocean Observing System (MARACOOS-supported ocean gliders have occupied a series of

along-shelf zigzag trajectories from Massachusetts to Maryland. These measurements provide the ability to map the Cold Pool characteristics and extent on an MAB scale. More importantly, these measurements constrain the Rutgers real-time MAB forecast data-assimilation (DA) model system, Experimental System for Predicting Shelf and Slope Optics (ESPreSSO), with its bottom temperature product.

In the last few years, the Northeast Fisheries Science Center (NEFSC) has collaborated with local fishermen to obtain real-time bottom temperature observations from trawl gear. Since more than a dozen commercial vessels participating in the Study Fleet Program have been fitted with wireless temperature-depth probes, wheel-house computers, and satellite transmitters, a few thousand trawl-averaged temperatures have been telemetered in real-time since 2015. This data is now supplementing the long-term data collection on the NEFSC near-seasonal trawl survey.

The turtle-provided temperature profiles and the fishermen-collected bottom temperature data augment the infrequent glider flights and NEFSC bottom trawl surveys in timely and spatially relevant ways. We propose to reconcile any potential biases among all of these different data sets and use them collectively with the goal of improving the quality and frequency of the DA-model bottom temperature product.

**Rationale:** This project will yield higher quality tools to better project the overall sustainability of the MAB for the many valuable regional fisheries affected by the annual Cold Pool formation and evolution. By updating the ocean models for this region with over 10,000 temperature-depth profiles, we can establish higher quality DA-model hindcasts and forecasts to fishermen and resource managers to improve operational and management decisions.

**Project Objectives:** 1) Compare data acquired through animal-borne sensors, fishing gear, bottom trawls, and oceanographic gliders with data currently being used to inform oceanographic models for the Mid-Atlantic Bight region. 2) Improve real-time model MAB temperature forecasts for fishermen and resource managers by providing the more frequent, high-resolution turtle derived and fishermen-collected data to be assimilated by the model. 3) Develop a collaborative Working Group between industry, managers and scientists to establish practical application of improved forecast model and tools.

**Methodology:** First, full water column temperature profile data derived from the animal-borne sensors, glider deployments, research trawl surveys, and commercial trawlers in the northeast shelf region will be compared to ensure minimum bias among them. Next, the observed temperatures will be compared to those from three oceanographic models for the region, the Regional Ocean Modelling System Experimental System for Predicting Shelf and Slope Optics (ROMS ESPreSSO) model, the Finite Volume Community Ocean Model (FVCOM) and the global Hybrid Coordinate Ocean Model (HYCOM). Once all of the observed data have been calibrated, they will be assimilated into the ROMS ESPreSSO model in the hindcast, nowcast and forecast modes. We propose a 25-day MAB glider survey to verify that the proposed assimilation has improved the ESPreSSO nowcast and forecast accuracy. Finally, we will deliver an education and outreach strategy through an industry-science-management collaborative Working Group. This Working Group will include experienced fishermen, managers and scientists drawn from the stakeholder community. Outreach will be conducted through two Working Group meetings (Dec 2018 and Dec 2019) and additional ad hoc industry meetings at key commercial ports. In addition, we will provide updates and results on the websites of the project participants: CFF: SMAST; and NEFSC.

## A. Project Summary:

**Applicant Information:**

Organization: Coonamessett Farm Foundation
Principal Investigator: Samir Patel
Address: 277 Hatchville Road East Falmouth MA, 02356
Email Address: spatel@cfarm.org

**Project Information:**

Title: Using climate change scenarios to project loggerhead turtle distributions in the U.S. Mid-Atlantic
Location: Mid-Atlantic Bight
Requested start date: September 2018
Federal funding requested: $35,770
S-K research priority: **#2 -** Adapting to Environmental Changes and Other Long Term Impacts in Marine Ecosystems

**Partners:**

| | |
|---|---|
| Megan Winton | School for Marine Science and Technology, University of Massachusetts Dartmouth |
| Ronald Smolowitz | Coonamessett Farm, Inc. |
| Vincent Saba & Heather Haas | Northeast Fisheries Science Center |

**Project Summary:**

Attempts to mitigate bycatch of highly migratory protected species such as sea turtles are often based on an understanding of when and where a species occurs over time. As reptiles, the distribution of loggerhead sea turtles (*Caretta caretta*) is constrained, at least in part, by water temperatures (Hawkes et al. 2007). The temperate waters of the Mid-Atlantic Bight (MAB) provide critical summer foraging habitat for a large cohort of juvenile and adult loggerhead turtles, which migrate into the MAB in the late spring and return to overwintering grounds south of Cape Hatteras, North Carolina, in the fall (Ceriani et al. 2012; Griffin et al. 2013; Winton et al. *in press*). Currently, their summer distribution in the MAB is concentrated in the shelf waters from Maryland to New Jersey. However, sea surface temperatures on the northeast United States (US) continental shelf are warming faster than in other regions (Wu et al. 2012, Hobday and Pecl, 2014), with the largest anomalies (exceeding 2°C) occurring in the MAB (Fratantoni et al. 2017). Warming temperatures along the northeast US continental shelf will likely result in a northward distributional shift (Witt et al. 2010), as well as changes in the timing of migration into and out of the MAB.

Due to their protected status, federal regulations limit the number of interactions (often referred to as "takes") that can occur annually between loggerheads and fishing vessels; the

seasonal presence of loggerheads can restrict commercial fishing operations through the imposition of gear modifications (e.g., the Turtle Deflector Scallop Dredge, Smolowitz et al. 2012) or closures if the number of allowable interactions is exceeded (Swimmer et al. 2017). Northward shifts or the prolonged seasonal presence of loggerheads may result in increased bycatch of loggerheads in the MAB, which may substantially impact commercial fishing in the region, both economically and ecologically.

The proposed project directly addresses research needs outlined under **S-K Priority #2: adapting to environmental changes and other long term impacts in marine ecosystems.** Specifically, this project will characterize sea surface temperature (SST) conditions favored by loggerheads in the MAB using a large, long-term satellite tagging dataset. Geostatistical mixed effects models (Thorson et al. 2016) will be applied to identify sea surface temperatures associated with loggerhead habitat usage using temperature data obtained from turtle-borne data loggers and satellite SST composites (Hazen et al. 2012). These models are rooted in generalized linear mixed modeling techniques, but explicitly account for spatial and/or temporal autocorrelation using Gaussian random fields (Lindgren et al. 2011). Models will be based upon existing code developed to estimate spatial variation in monthly loggerhead densities in the MAB for each year with data available (Winton et al. *in press*). The thermal habitat model developed will be used to project how loggerhead distributions in the MAB may shift in response to climate change over long-term (i.e., 80-100 year) time scales to show impacts over the lifetime of an individual turtle **(**Crouse et al. 1987). Projections will be based on a Representative Concentration Pathway (RCP) 8.5 climate model from the fifth assessment of the Intergovernmental Panel on Climate Change (IPCC), which is consistent with current recommendations for treatment of climate change in the National Marine Fisheries Service's (NMFS's) Endangered Species Act (ESA) decisions (Sobeck 2016). We will also investigate distribution shifts under an alternative climate change scenario based on NOAA's high-resolution global climate model (CM2.6) as described by Saba et al. (2016).

The results will improve understanding of both the current and future distribution of loggerheads in the region and can be used to inform fisheries management practices in areas where overlap with fisheries is high. Information on the range of SSTs associated with a high probability of loggerhead presence will be disseminated to both the commercial and recreational fleets via online sources, meeting presentations and reports. This will provide a general, easy-to-understand guideline that will allow fishermen to identify, and hopefully avoid, areas where interactions with loggerheads are likely to occur. TurtleWatch, a similar product developed for loggerheads in the Pacific, successfully predicted areas where the majority of fisheries interactions occurred during testing (Howell et al. 2008). On a longer-term scale, the models developed will provide dynamic, quantitatively-rigorous projections of the species' distribution, which are currently lacking. Although longer-term effects of climate change on ESA-listed species will be characterized by a degree of uncertainty, an examination of a range of projected ocean temperatures can provide information about likely future scenarios and allow managers to begin to evaluate mitigation strategies and plan proactively.

## Project Summary

### Applicant Information:

*Applicant Organization:* Northeastern University

*Principal Investigator:* Dr. Jonathan Grabowski, Associate Professor, Northeastern University
Northeastern University Marine Science Center, 430 Nahant Road, Nahant, MA 01908

email; j.grabowski@northeastern.edu

Dr. Katie Lotterhos (Co-PI), Assistant Professor, Northeastern University
Dr. Steven Scyphers (Co-PI), Assistant Professor, Northeastern University
Dr. Marissa McMahan (Co-PI), Senior Fisheries Scientist, Manomet

### Project Information:

*Project Title:* The northern range expansion of Black Sea Bass: Understanding population dynamics and socioeconomic impacts of a rapid distribution shift

*Project Location***:** Northeastern University

*Requested Award Dates:* Start Date: September 1, 2018

*Funds Requested:* $270,581

*SK Priority:* This project addresses research Priority #2 *Adapting to environmental changes and other longterm impacts in marine ecosystems."* We will specifically address the focal point *"Assess short- and long-term biological and socio-economic impacts of ecosystem changes."*

### Summary:

*Species/Resource to be addressed:* Population structure and socioeconomic impacts associated with Black Sea Bass, *Centropristis striata*, range expansion into the Gulf of Maine

*Brief Description of Proposed Activities and Anticipated Benefits/Outcomes:* Climate driven distribution shifts can have wide ranging socioeconomic impacts on coastal communities. When stocks expand their range and inhabit new areas, fishers are potentially presented with a new opportunity, but only if they are able to harvest that biomass. Quantifying and allocating these newly available resources sustainably and fairly among different user groups is exceptionally challenging. Thus, resource managers have struggled to keep pace with rapidly shifting species distributions in New England and other regions globally where coastal seawater temperatures are rising rapidly. One such species that is shifting rapidly is the northern stock of black sea bass, which historically ranged from Cape Hatteras to Cape Cod, but is now common in the Gulf of Maine (GOM). While this range expansion presents a new opportunity, it has also been a source of contention for commercial and recreational fishers in areas of the western GOM where black sea bass abundances have rapidly increased. This has given rise to debate at both state and federal levels, with some federal officials demanding greater responsiveness to quota allocations. Here we aim to quantify recreational and commercial fisher perceptions of black sea bass

population increases, potential impacts that black sea bass may have on other economically important species, and ongoing efforts to manage black sea bass at the northern edge of their range. **An impediment to adaptively managing species' range shifts is that there is often little information about them in their newly expanded range.** Black sea bass are currently being fished in the GOM, even though little is known about where they are coming from or how quickly the population is growing in this region. Thus, a better understanding of their population structure and biology would benefit efforts to assess and manage black sea bass stocks at the northern edge of their range

**Our proposed study will address the following two goals:**

**(1) Evaluate current gaps in the Black Sea Bass stock assessment by determining life history characteristic and genomic population structure of Black Sea Bass in its newly expanded range.**

**(2) Identify the potential socioeconomic impacts of the rapid distribution shift on recreational and commercial fishers.**

First, we will quantify BSB growth rates and their diet throughout New England to examine potential impacts on other fisheries such as the lobsters or crabs by investigating. Second, we will fill quantify the population structure of Black Sea Bass using genomics. Third, we will measure recreational BSB angler and commercial groundfish, lobster and BSB fisher observations of and knowledge about BSB, potential impacts that BSB may have on other fisheries, adaptive capacity across fishing stakeholder groups, and their attitudes and perceptions toward current and potential BSB management scenarios. It is currently unclear whether BSB in the GOM are perceived by coastal fishing communities as an opportunity or threat, which limits efforts to integrate stakeholder knowledge into Black Sea Bass management efforts.

**Rationale**: As the distribution of sea bass and other temperate species continues to shift poleward, stock assessment and management will need to keep pace by redefining stock boundaries, incorporating stock metrics of range edge populations, and accounting for the response of recreational and commercial fishers. The recent shift in sea bass distribution, combined with evidence that life history traits and migration patterns vary with latitude, emphasizes the need to assess how the northern range expansion is changing population dynamics. The proposed project builds upon research that Grabowski and McMahan have been conducting in the GOM since 2013. This research aims to enhance understanding of life history traits and genetic population structure of sea bass in the Gulf of Maine and southern New England. Furthermore, this study will provide metrics for stock assessment of sea bass at the northern extent of its range. Greater understanding of sea bass population dynamics will ultimately lead to more informed management of the species.

We also aim to explore commercial and recreational fisher perceptions of the northern range expansion, including whether they view it as an opportunity or threat to other fisheries resources as well as how they perceive efforts to manage this range expansion. This research effort is aimed at identifying potential societal impacts and economic opportunities presented by this range expansion. Our social science research efforts will also reveal areas where potential misperceptions of ongoing black sea bass management efforts can be addressed. Our multi-faceted approach to studying the northern range expansion of black sea bass will provide data that can be used in future black sea bass stock assessments and management efforts, as well as aid in understanding ecological and socioeconomic implications of the seabass range expansion into the GOM.

## A. Project Summary

Applicant Organization: The University of Maine

Project Title: The consequences of a changing environment to the health of American lobsters

Project Location: University of Maine campus, Orono, Maine, USA

Requested Start Date: 10/1/2018

Funding Requested: $192,774

Principal Investigator and Collaborators:

- PI: Heather Hamlin, Associate Professor, School of Marine Sciences, University of Maine, Orono, Maine
- Co-PI: Deborah Bouchard, Research Coordinator and Director of the Aquaculture Research Institute, University of Maine, Orono, Maine
- Co-PI: Cathy Billings, Associate Director for Communications and Development, Lobster Institute, University of Maine, Orono, Maine
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Species Addressed: American lobster (*Homarus americanus*)

SK Priority Addressed: Priority #2 – Adapting to Environmental Changes and Other Long-Term Impacts in Marine Ecosystems

Proposed Activities: The Gulf of Maine is experiencing changes in temperature and acidification at rates greater than nearly anywhere else in the world, underscoring an urgent need to understand possible outcomes and identify threats to population resilience. For more than a decade, lobsters have been experiencing a dramatic population decline in Southern New England, and should this decline spread into the Gulf of Maine, it would threaten the livelihood and culture of fishing communities, and the multi-billion dollar industry they support. The proposed project would examine the putative role of elevated ocean temperatures combined with ocean acidification as causative agents of lobster population declines. This project will use an integrated approach to examine the significance of these two factors on lobster health, disease susceptibility and their physiological capacity to combat additional stressors.

We will address what effects temperature and acidification have on lobster health and resilience by:

1) Analyzing whether elevated ocean temperature and ocean acidification (OA) contributes to disease emergence by:

    a. Exposing sub-adult lobsters to elevated temperature and acidification, both singly and in combination, followed by a disease challenge on exposed lobsters
        i. We hypothesize that both elevated temperature and acidification will increase disease susceptibility.
2) Examining the lobsters' ability to handle a subsequent stress event following OA and elevated temperature exposures by:
    a. Examining Arrhenius Break Temperature (ABT), hemocyte abundance, and hemolymph ecdysteroid concentrations of exposed lobsters
        i. We hypothesize that higher temperatures combined with OA will weaken the lobster's natural mechanisms to combat thermal stress
3) Training citizen scientists in the lobstering community to detect early signs of disease and collect samples for analysis
    a. We hypothesize that this training will rapidly alert scientists and regulatory personnel in the event of disease emergence
4) Informing regulatory personnel and stakeholders of outcomes determined in this project through a variety of outreach efforts
    a. We hypothesize this information will:
        i. be used to create more effective management strategies by regulatory personnel
        ii. be a useful tool to predict temperatures likely to cause lobster population declines, allowing stakeholders to make informed decisions to mitigate economic losses
        iii. provide critical data that can be used to accurately inform and verify models to predict future outcomes

Proposed Benefits:

- Our predictive understanding of population stability is often determined through a modeling approach. While important, models must be "fed" biological and environmental data to formulate meaningful predictions. Expectedly, these data are likely to change in parallel with environmental perturbation. Information gained in this proposal can be used to update models, and provide a more accurate picture of future scenarios.
- We hypothesize that elevated temperature and acidification will contribute to disease susceptibility and negatively influence other metrics of health. Training citizen scientists in the lobstering community on disease detection and sampling will ensure we are at the leading edge of discovery, enabling rapidly responsive management.
- Targeted analysis of temperature and acidification effects from this study will increase information from which to base management decisions. Fisheries management draws on both catch data as well as fisheries science to protect fishery resources and support sustainable practices. Understanding environmental conditions that could threaten the health of lobster populations could allow for the proactive regulation of fishery stocks, and ensure more resilient fishing communities.
- The American lobster is an iconic species whose fishery is steeped in tradition in New England. This natural resource is critical to both the livelihood and identity of New England's coastal communities. Preserving the lobster resource and a vital fishery starts with ensuring lobster health – a focal point of this research.

**Proposal**

Submitted to NOAA's Saltonstall-Kennedy Competitive Research Program
January 8th, 2018

# Optimizing production and products for scallop aquaculture


PI: Dr. Damian C. Brady
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Co-PI Dana Morse
Marine Extension Associate
Maine Sea Grant


**Project Location**: Maine
**Requested project start date**: September 1, 2018
**Federal funding requested:** $295,380
**S-K research priority**:

**Priority #1**: Marine Aquaculture
**Topic Addressed**: Technology Development and Transfer
**Overarching Solicitation Evaluation Criteria:** Fishing Community Resiliency:

Through the *Aquaculture in Shared Waters* training program for fishermen and our partnership with fishermen diversifying their marine resource portfolio with scallop aquaculture, this proposal endeavors to increase fishing community resiliency.


**Summary**: The giant sea scallop, *Placopecten magellanicus*, supports one of the most valuable and important wild fisheries in the United States, valued at over $430 million dollars ex-vessel

value in 2015. Additionally, the U.S. imports 40 million pounds of scallops, mostly from Asia, totalling another $350 million and contributes to the US's significant seafood trade imbalance. Clearly, even with significant domestic landings, the demand for scallops and scallop products in the United States is significant. The state of Maine has the only large inshore scallop fishery in the US, and while some successes have been observed, consistent stock recovery throughout the state remains a goal. Work by several seafood companies has gained significant traction in educating buyers, chefs, and consumers of the value of a fresh, unprocessed scallops. **The market is thus primed for a cultured product, landed daily and with the additional advantage of year-round availability**. **Moreover, the northeast region of the US constitutes an appropriate growing area for sea scallops, per temperature and salinity regimes and natural distribution of scallops.** We propose to define best practices as it relates to production techniques (nursery optimization, grow out practices) and site selection (synoptic environmental monitoring) and to disseminate this information throughout the Northeast U.S. and more broadly.

In close collaboration with partnering aquaculture companies in Maine, we have identified the following bottlenecks to industry expansion and designed a plan of work to address them: (1) It is critical to optimize nursery culture, so that seed can be grown to the size for ear-hanging (50-70 mm) as efficiently as possible. (2) The development of other products beyond simply adductor muscles (scallop meats) is important; it allows farmers to get more value per individual produced, and promotes resilience in the marketplace. Toward that end, more information on toxin loads at given sites, such that regulators, producers and consumers can be ensured of product safety is needed. (3) Trials on optimizing ear-hanging are still very much needed with *Placopecten* in U.S. coastal waters, and providing data to producers about the benefits and drawbacks of each method is key to making decisions about investments and expansion. Additionally, better coupling of environmental data with observed growth rates is vital to understanding future site selection as the industry transitions from early adopters to early majority and beyond. (4) Fouling is a challenge for every marine farming operation, and no different for scallops. Machinery exists to clean grow-out equipment, such as ear-hung scallops and lantern nets. However, a central piece of understanding is the timing and degree of settlement and growth, so that producers can be efficient and cost-effective when implementing their cleaning activities. (5) A central question is the financial feasibility of growings scallops as a culture crop: can a business be profitable? We propose to answer this question using the labor, biotoxin screening, and equipment costs determined from this project and partner interviews. (6) Outreach and extension makes all the outcomes and discoveries of this proposal accessible by those who might use it. We propose a robust outreach plan to make sure that information gets to any interested party in an organized, timely and engaging way. Importantly, the best practices developed in this proposal will be communicated beyond Maine by concentrating on extendible products: identification of optimal nursery/grow-out techniques and site selection characteristics as well as using the *Aquaculture in Shared Waters* training program co-developed by co-PI Morse. We propose to provide data on nursery production, biotoxin monitoring and sales of live product, timing of fouling organism settlement, and suspension growout technology - data that will help producers become more efficient and profitable, and which will help new producers sustainably site farms. We will add to our pool of well-trained and qualified scientists in this field, and we will take robust measures to ensure that project data are available in a timely, organized and accessible fashion.

**PROJECT SUMMARY**

**Applicant Organization:** Virginia Institute of Marine Science, College of William & Mary

**Project Title: Understanding Disease Progression in Polyploid Eastern Oysters**

**Research Priority:** Priority #1–Marine Aquaculture

**Project Location:** Gloucester Point, Virginia

**Requested Start Date:** September 1, 2018

**Funding Requested for Year 1:** $119,713
**Funding Requested for Year 2:** $127,239

**Principal Investigator:** Dr. Ryan Carnegie—Research Professor

**Contact Information:** Virginia Institute of Marine Science, P.O. Box 1346, Gloucester Point, Virginia 23062; email Carnegie@vims.edu;

**Summary:**
***Species/Resources to be addressed:*** Eastern oyster, *Crassostrea virginica*

***Proposed Activities:*** Aquaculture of oysters is expanding in the eastern and southern USA, yet diseases caused by protozoan parasites such as *Perkinsus marinus* (dermo) and *Haplosporidium nelsoni* (MSX) continue to limit fishery and aquaculture production through the mortality and sub-lethal reductions in growth they impose. This project will provide critical contemporary perspective on levels of infection *P. marinus* and *H. nelsoni* in populations of eastern oysters on aquaculture farms in the Chesapeake Bay region (Virginia and Maryland), with an emphasis on comparing these observations against the backdrop of disease levels in wild oyster populations. In managing regional commerce in shellfish seed products, the East Coast regulatory community has assumed that aquacultured oyster seed, particularly of larger size cultured at high density for

several months in disease-endemic natural waters, may have potentially hazardous dermo and MSX infection levels. They have had little published data to address the question of the biosecurity of this larger seed, particularly with regard to the polyploid animals that are in wide use on farms today. This has led to policies requiring *ad hoc* disease analysis of all groups proposed for transfer. Preliminary data from such analyses, however, suggests that infection levels in cultured populations may be well below those of wild populations, which makes sense based on the relatively short periods of exposure of cultured animals and their distance from foci of infection in wild oyster populations. Using an array of conventional disease analyses, this study will evaluate multiple cohorts of cultured triploid oysters from aquaculture farms as well as tetraploid oysters from VIMS ABC holdings, at peak disease season in the spring and fall of each of two years, to provide a broad examination of the hypothesis that, contrary to the common wisdom concerning aquaculture stocks, limited pathogen exposure of these disease-resistant animals results in generally lower infection levels, and thus higher biosecurity, of the cultured polyploid product relative to wild oysters. If the project proceeds as expected based on preliminary observations, it would argue that surveillance data from monitoring of wild oyster populations could serve as a conservative proxy for disease in cultured populations, reducing the necessity that expensive and time-consuming *ad hoc* disease analyses be performed for all aquacultured animals proposed for transfer unless such analyses were specifically desired by industry. Results of this work will have value to regulators and shellfish producers coast-wide, and will be disseminated broadly through regional and national conferences as well as commercial listserves and other forums.

***Anticipated Benefits/Outcomes:*** This project will address expressed Priority #1, Marine Aquaculture, in producing tools for shellfish health management. More specifically, it will address the biosecurity of aquacultured oysters and provide basic information for regulators that will enhance the biosecurity of regional shellfish transfers. It has great promise to streamline regulation of transfers, to the significant economic benefit of the shellfish aquaculture industry, especially in areas such as the Mid-Atlantic where a wealth of basic surveillance data for shellfish diseases exists.

## Project Summary

**Applicant Organization:** Kampachi Farms, LLC

**Project Title:** Developing cost-effective fishmeal-free and fish oil minimized diets for high market value U.S. marine fish aquaculture

**Research Priority:** Marine Aquaculture - Technology Development and Transfer

**Project Location:** Kailua-Kona, Hawai'i

**Award Start Date:** 9/1/2018

**Funding Requested:** $289,480

**Principal Investigator:** Neil Anthony Sims
CEO, Kampachi Farms LLC
neil@kampachiworld.com

**Co-Principal Investigator:** Dr. Frederic T. Barrows, Aquatic Feed Technologies LLC

**Collaborating Partners:** Anthropocene Institute, and Ka'upulehu fishponds

**Species/Resources to be addressed:** *Seriola rivoliana* (amberjack; kampachi) and *Kyphosus vaigiensis* (herbivorous marine finfish)

**Summary:**

The scalability of marine finfish culture has been limited by several factors, including a lack of reliable sources for obtaining native fish fingerlings and the high cost of feed (on average at least half the cost of total farm operations). A reliance on wild fish resources for fishmeal and fish oil used in feeds is also a primary sustainability concern, which constrains the expansion of responsible mariculture.

Emerging technologies for the cost-effective production of alternative proteins and oils offer an opportunity to develop highly competitive feed formulations that are not reliant on forage fishery-sourced ingredients. The team assembled for this project has already undertaken some preliminary feeds research using such alternative ingredients, however, many of these products have not been economical due to the human-grade quality of the alternatives tested. Two such examples are whole Spirulina (which is sold at a premium for the nutraceutical market), and high-quality poultry meal, which has similarly only been tested at a human-grade standard. New alternatives, from feed-grade or by-product sources are emerging at prices that are increasingly competitive with wild fishery derived proteins. This offers a tremendous opportunity, but these products must first be tested to determine if they perform similarly to the human-grade products.

This work proposes to formulate and test fishmeal-free and fish oil minimized feeds for two high market value fish through the use of low-cost alternative ingredients: by-product from the natural Spirulina pigment market; low cost poultry meal; and saltwater-grown macroalgae.

Diets based upon low-cost poultry-meal and phycocyanin-extracted Spirulina biomass will be formulated for the carnivorous marine finfish, kampachi (*Seriola rivoliana*) to be tested in a land-based research facility. Diets based on saltwater-grown macroalgae will be formulated for the herbivorous rudderfish (*Kyphosus vaigiensis*), and tested in partnership with a local fishpond.

The anticipated outcomes from this research will be to advance environmentally responsible mariculture of both species, and support our traditional fisheries communities through partnerships with local fishpond stewards for local community-scale production of healthy marine proteins. The long-term goal is to establish the feasibility for commercial production of both of these species on fishmeal-free feeds for offshore mariculture. Rudderfish also have the potential to be raised in Hawai'i in fishpond environments, and to be sold and consumed locally.

Fishmeal-free aquaculture feeds have implications for improved economic performance (lower cost of feeds = improved bottom line for farmers); social acceptance (highly sustainable feeds would be lauded by seafood certification agencies that influence consumer choice); and for the environment (increasing the availability of marine proteins without applying more pressure to our wild fishery resources). This research, therefore, has potential benefits for food security, environmental sustainability, and commercial aquaculture in the Pacific Islands and elsewhere.

**January 4, 2018**

**PROJECT SUMMARY (2 page limit)**

**Project Title: Exploratory research and data collection to determine viability of developing a squid fishery in Guam and the Commonwealths of the Northern Mariana Islands (CNMI)**

**Sonication: S-K NOAA-NMFS-FHQ-2018-2005332**

**Name:** Kendall Wong, Applicant
**Affiliation:** Pacific Islands Fisheries Group, Federal 501C3, Non-Profit Organization
**Address:** 150 Hamakua Drive, PBN#430
**Email:** kendall.wong@gmail.com

**Investigators:**
Clayward Tam, Principal Investigator, Pacific Islands Fisheries Group, 150 Hamakua Dr. PBN#430 Kailua, HI 96732, hifish06@yahoo.com,
Kendall Wong, Pacific Islands Fisheries Group, 150 Hamakua Dr. PBN#430 Kailua, HI 96732, kendall.wong@gmail.com
Project Assistant, Position to be solicited and filled in the first quarter of the project.

**Total Estimated Budget Request: $216,260**

**Project Start Date:**1 September 2018

**Project Location:** Commonwealth of the Northern Mariana Islands, US

**S-K Funding Priority:** Territorial Science

**Project Summary Description:** Exploring the potential for a squid fishery in the Mariana Islands is timely as the cost for squid in the US Pacific Island market has increased due to reduced availability and increasing transportation costs. In addition, the Guam and Commonwealth of the Northern Mariana Islands (CNMI) economies have experienced a growth in the visitor industry from the Asian region (China, Japan, South Korea, Philippines). For example, to support a transitioning market that is primarily influenced by Asian cuisine, hundreds of thousands of pounds of squid are imported to CNMI annually at a cost of over one million dollars. By determining the viability of developing a local squid fishery in CNMI, the fishery may be able to facilitate economic growth and resilience of local fisheries.

This project aims to determine the viability of establishing a squid fishery in CNMI by collecting data through various research efforts. To accomplish this, PIFG will conduct a comprehensive literature search for information related to historical squid fisheries in the western Pacific region. In addition, local fishermen and markets will be engaged to help determine the availability and importance of squid in Guam and CNMI over the years.

This project will also support a fishery independent squid survey using charter professional fishermen to conduct standardized squid fishing in the waters around Guam and southern islands of CNMI throughout the year. To develop the fishery independent sampling design, PIFG will work with the local fishery agency and National Marine Fisheries Service staff and local fishermen. Local fishermen will be identified for potential charter vessels and captains for hire as contractors to carry out standardized at-sea sampling throughout the year. Fishermen will also be engaged and trained for use as observers and data collectors aboard chartered fishing trips.

Finally, this project will support community workshops to share information with small boat fishermen and the seafood community on squid fishing and the potential for developing a viable market for squid seafood products.

| | |
|---|---|
| Principal Investigator: | Maria Haws, PhD |
| PI Title: | Associate Professor of Aquaculture, Director, Pacific Aquaculture & Coastal Resources Center (PACRC) |
| Contact Information: | University of Hawaii |
| | Office of Research Services, 2440 Campus Road, Box 368 Honolulu, HI 96822-2234 |
| Project Title: | Developing Culture Methods for Native Fish Species in Support of New Business Models for Increased Participation in Mariculture |
| Project Location: | University of Hawaii at Hilo, PACRC, Hilo, HI 96720 |
| Start and End Dates: | 09/01/2018 |
| Federal Funding Requested: | $272,622.00 |
| S-K Research Priority: | #1 - Marine Aquaculture |
| Project Partners | Hilo Fish Company<br>Hawaii Cooperative Fishery Research Unit |

Summary

We propose to develop the aquaculture techniques for commercial production of two new species of fish native to Hawai`i within the context of two business models that make participation in and positive perception of aquaculture more likely for ordinary citizens, fishers and existing small businesses.

Hawai`i has a well-known history of mariculture. The ancient Hawaiians are believed to have been the first civilization to develop mariculture through building and utilizing traditional Hawaiian fishponds, many of which still exist. Additionally, Hawai`i has been responsible for new and innovative forms of mariculture, including the first off-shore cage farm in the U.S. Despite these accomplishments, development of mariculture in Hawai`i has been stymied for decades due to social, economic and political barriers. In short, unless one can find a form of aquaculture that is socially and culturally acceptable, has high returns, and can be sited in a location where a commercial lease and other permits can be obtained without lengthy delays and high costs, there is very little chance of being able to enter into aquaculture farming in Hawai`i.

Finding the correct "recipe" for socially acceptable aquaculture has become something of a "wicked social problem". A wicked social problem is loosely defined as a problem that is long-standing and appears intractable. The Pacific Aquaculture and Coastal Resources Center (PACRC) of the University of Hawai`i Hilo (UHH) along with a wide range of public and private partners is currently testing several initiatives designed to begin resolving the wicked problems that prevent forward progress in mariculture development. The basic working premise is that if ordinary citizens and small businesses can find ways to participate in forms of aquaculture that the public finds acceptable and beneficial, that public opposition will slowly

diminish. It is important that concrete and observable evidence of the direct and tangible benefits of aquaculture will be seen by the local community. This approach is also based on the premise that standard traditional outreach practices may not be effective. Despite clear evidence and data that aquaculture is necessary to make Hawai`i more independent of imported seafood, that it creates jobs and revenues, that environmental impacts are minimal, large segments of the population continue to ignore or refute this evidence. On the other hand, certain forms of aquaculture are readily accepted and barely scrutinized. For example, aquaculture conducted by cultural practitioners in the traditional Hawaiian fishponds has few opponents and is widely lauded as culturally appropriate, sustainable and beneficial in multiple ways despite the fact that very little fish production now occurs. Can something similarly acceptable be created outside of the ponds?

Currently two pilot initiatives are underway that will test whether forms of aquaculture that are more accessible to a larger number of stakeholders can help make headway in the effort to increase aquaculture production in Hawai`i and increase public acceptance. The first is the formation of a cooperative to develop a commercial shellfish farm in Hilo Bay. The second effort is land-based effort centered around use of small recirculation systems that can be operated by individuals or small groups. As the two business models "cooperative" and "land-based" are developed, the use of native species is desirable for several reasons. The first is that use of native species removes the difficulty of obtaining permits for the importation, propagation and use of non-native, potentially invasive species. It will also eliminate direct competition from imports.

The first candidate that emerges, primarily due to its high value is *Nabeta*, the Razor Peacock Fish (*Iniistius pavo*). It is considered a prime target species for recreational and subsistence fisheries, but sporadically appears on the market. A second species chosen for development is the *Aholehole* (*Kuhlia sandvicensis*), a well-known and highly-favored local species that tolerates a wide range of salinities (1 to 39 ppt) and temperatures (18-33 °C).

The overall approach is to develop small-scale hatchery capacity for native species which would then be raised in limited quantities (500-1000 lbs) per month for local sale by small scale farmers. If successful, these efforts could be replicated across the islands or by producing additional species. More specifically, the project objectives are

- Test spawning methods and early larvae rearing for *Nabeta* and *Aholehole*.
- Test combinations of artificial and fresh feeds on the larval and juvenile stages.
- Outreach and training for stakeholders participating in mariculture. This will include a manual and at least one peer-reviewed publication. Two graduate students and most of the PACRC undergraduate student employees (around 25 per year) will be involved.

## A. Project Summary

**Applicant organization:** Aquafeed.com, LLC.
**Project title:** Scale Up Production of a Complete Fish Feed and an Organic Fish Fertilizer from Fish Processing Waste for Sustainable Aquaculture and Agriculture in Hawaii and the Pacific Islands **Primary Research Priority:** SK Priority #3 Promotion, Development and Marketing by developing usable, value added, fishery products from underutilized, undervalued economic discards and byproducts of processing.
**Secondary Research Priority:** SK Priority #1 – Marine Aquaculture
**Project location:** Oahu, Hawai'i
**Requested project start date:** September 1, 2018
**Funding requested**: $300,000
**Principal Investigator:** Warren G. Dominy, Ph.D., aquatic nutritionist/feeds and processing specialist and Senior Technical Consultant, Aquafeed.com LLC., 1205 Aloha Oe Dr., Kailua, HI 96734. Email: consulting@aquafeed.com;

**Resources/Species to be addressed:** Utilization of fish processing waste as a complete feed for tilapia (*Oreochromis spp.*) and as an organic liquid fish fertilizer and a slow release organic solid fertilizer for field crops and aquaponics systems.

**Description of proposed activities:** Hawai'i fish processors on Oahu produce upwards of 3-5 tons of dry matter or 9-15 tons of fresh wet raw fish processing waste per day. ("*Fish Processing Waste: A valuable Co-Product of the fishing Industry" - Aquafeed.com, LLC, Dominy et al. 2014).* Much of this Fish Processing Waste (FPW) is disposed of in the landfill, creating a significant cost to the fish processors and to the environment. Furthermore, this FPW is a valuable raw material that could be turned into an income stream and become a key factor in contributing to the sustainability of Hawai'i's and Pacific Island communities' food production.

The exceptionally high cost of feed for aquaculture in Hawai'i and the Pacific Islands is one of the biggest barriers to commercially viable aquaculture in the region. High quality protein is the component of aquaculture feeds that dictates the price, and for island communities this cost is compounded by the need for shipping. This project aims to support the development of sustainable fish farming in Hawai'i and the Pacific Islands of American Samoa, Guam and the Commonwealth of the Northern Mariana Islands (CNMI) by leveraging the full potential of U.S. fishery resources in the Western Pacific Region through the full use of wet fishery processing waste to make a high protein, high quality, water stable complete fish feed. The project will also transform lower grade FPW into locally sourced, high-performing, live, organic, liquid and solid fish fertilizers that can be used for hydroponics, horticulture and agriculture.

This project will scale up and continue to refine work undertaken by Aquafeed.com under Saltonstall Kennedy award 2016/17 S-K NOAA-NMFS-FHQ-2016-2004617, CFDA #11.427, whereby we successfully developed a simple and practical method to convert fish processing waste (FPW) into an easy-to-make, high quality, high-protein, water stable supplemental fish feed and an organic liquid fish fertilizer, using technology appropriate to small scale farmers and businesses in Hawai'i and Pacific islands. To make these technologies commercially viable for larger communities and businesses, this proposed project will increase the capacity of the production methods and technologies we have developed to pilot scale, and further develop the FPW feed from being a supplemental feed to a complete diet and also make a solid FPW fertilizer. The methods and technologies will remain simple and cost effective, using easily obtainable, low cost off-the-shelf equipment, modified and scaled up to be viable for larger businesses and communities.

The project will be accomplished in two phases within 24 months: Year 1 will be a proof of concept phase. It will refine and modify the feed production methodology that was completed in the previous SK-grant 2016, and scale it up to be commercially viable for larger farmers and producers. Technology improvements and several different methodologies were developed in the earlier project to make a simple, stable, supplemental feed for tilapia and this work will be the basis for making a complete tilapia feed to totally replace an imported commercial tilapia feed. The liquid fish fertilizer developed in the earlier project will be further refined and the production methods and technology scaled up. A solid slow-release fertilizer will also be made. Testing of fertilizers will be on Piko Kea taro, one of Oahu's most culturally significant and important poi producing taro. During this scale up phase, pilot-scale feed and fertilizer production facilities will be set up and located on the east side of Oahu in Waimanalo, in cooperation with Aloha First, a Hawai'i-based Native Hawaiian non-profit (509(A)(1)) organization; and a second feed and fertilizer facility set up on the West side of the island in Waianae in cooperation with Ili' Ili Farm, a certified USDA organic aquaponic vegetable farm. Staff at each of the two facilities will be trained to conduct the feed and fertilizer production and product testing trials under the guidance of Warren Dominy, PhD. Feed made from each facility will be tested at Hawaii Fish Company, Hawai'i's longest operating commercial aquaculture farm. Each of the two pilot-scale production facilities will also provide finely ground FPW to Pacific Pure Technologies for liquid fish fertilizer experiments. In the second year, a manual and video will be produced on the manufacture and use of the feed and fertilizer, and will include the results of the feeding trials for fish. Workshops for farmers, business and extension agents will be conducted to ensure continuity of the projects improvements.

**Anticipated benefits/outcomes:** 100% utilization of FPW will help realize the full potential of U.S. fishery resources in the Western Pacific Region, and by removing it from the waste stream, will help to protect the ecosystem. Pilot-scale production will help prove the commercial viability of utilizing FPW as fish fertilizers and a complete aquatic feed to replace imported commercial tilapia feed, contributing to the sustainability and food security of Pacific Island communities. This will help support and create aquaculture, agriculture and seafood industry jobs and have the added benefit of engaging the native Hawaiian community and bringing together the marine fishing, aquaculture and agriculture industries in the Pacific.

**A. Project Summary** (2-page max)

Applicant Organization: Hawaii Seafood Council

Project Title: Fisheries 101: Capacity Building to Improve Territorial Science and Fishery Management in US Pacific Islands.

Program Priority addressed: Program Priority Theme #4. Territorial Science

Project Location: Western Pacific Region (American Samoa, Commonwealth of Northern Marianas Islands, Guam and Hawaii)

Requested Project Start Date: September 1, 2018 ,

Federal Funding Requested: $165,000

Principal Investigator: John Kaneko MS, DVM, HSC Program Manager
1130 N Nimitz Hwy, Suite A263, Honolulu, Hawaii 96817
info@hawaii-seafood.org

Collaborating Partners: American Samoa Department of Marine and Wildlife Resources
American Samoa Alia Fishing Association
Tautai O Samoa Longline and Fishing Association
American Samoa Community College
CNMI Department of Land and Natural Resources
Saipan Fishermen's Association
Northern Marianas College
Guam Division of Aquatic and Wildlife Resources
Guam Fishermen's Cooperative Association
University of Guam
Hawaii Longline Association
United Fishing Agency, Ltd.
Western Pacific Regional Fishery Management Council
NOAA Pacific Islands Regional Office (PIRO)
NOAA Pacific Islands Fisheries Science Center (PIFSC)

Species being addressed: Capacity building of human resources to enhance sustainable fishery development and management in the US Pacific Islands. Managed resources include coral reef, deep slope and pelagic fishery resources.

Brief Description of Proposed Activities:

The Project Goal is to improve fishing community resilience by enhancing the process and building capacity for local fisheries development, management and science in the US Pacific

Islands. The Project Strategy is to use the Train-the-Trainer approach to strengthen the capacity of members of the fishing community, education and fishery management sectors to participate in fisheries management, and continue effective outreach and education to expand participation in the management of local fishery resources. Project Objectives include,

Objective 1. Develop the Fisheries 101 short course: The 40-hr short course will be developed and planned to include classroom learning, site visits and meetings with the fishing and seafood industry, fishery scientists and managers.

Objective 2. Recruit and Select Island Teams from Guam, Commonwealth of the Northern Mariana Islands and American Samoa: A three (3) person team from each US Pacific Island group including a fisher, educator and fishery manager will be recruited and selected for the participation in the project.

Objective 3. Assemble Island Teams in Honolulu for the Fisheries 101 short course on fisheries and fishery management: Teams from Guam, CNMI and American Samoa will travel to Honolulu for the 40-hr short course.

Objective 4. Assist Island Teams in organizing Outreach and Education sessions in their respective communities: Upon return to their respective island groups, the teams with assistance from the Project Manager will plan and organize Outreach and Education sessions for their local communities.

Objective 5. Assist the Island Teams in delivering Outreach and Education sessions in their respective communities: The Project Manager will travel to American Samoa, and then to CNMI and Guam to assist the Island teams during the Outreach and Education sessions.

Objective 6. Provide NOAA PIRO and PIFSC with Educational Tours on Hawaii and Pacific Island fishing and seafood industries: The Project Manager will conduct four (4) educational tours for the personnel from the NOAA Pacific Islands Regional Office and Fisheries Science Center.

Anticipated Benefits/Outcomes:

US Pacific Island fishing communities will be empowered in the development and management of their fishery resources. In the short term, communities will benefit from having key individuals trained and better prepared to contribute to sustainable fishery development, management and science. Longer term benefits in support of community resilience will arise as these individuals continue to explain and promote involvement in sustainable fisheries development, management and science within their respective island fishing communities.

US Pacific Island fisheries and fishing communities (including Hawaii) will also benefit from the project outputs as NOAA fishery scientists, managers and staff new to working in Hawaii and the Pacific Islands gain understanding and appreciation for the importance of fishing, how the fishing and seafood industries operate and contribute to fishery science and management.

## A. Project Summary

A proposal submitted to NOAA-NMFS-FHQ-2018-2005332, Saltonstall-Kennedy Competitive Research Program

**Applicant organization**: Canizaro/Livingston Gulf States Center for Environmental Informatics, University of New Orleans

**Project title**: Coupling U.S. Gulf State stock assessments to shell-budget modeling to determine sustainable harvest of oysters across the Gulf of Mexico

**FFO Priorities Addressed**:
*Priority #2 –* "Adapting to Environmental Changes and Other Long Term Impacts in Marine Ecosystems" and specifically "Developing stock assessment models that consider potential changes in fishery performance and management effectiveness due to ecosystem change including ocean chemistry, changes in water temperature, and other parameters" and "Producing long-term environmental change, ocean chemistry, and other forecasting models that incorporate fishery production scenarios important to fishery managers and/or fishing operations."

**Project location**: Texas, Louisiana, Mississippi, Alabama, Florida

**Start date**: Sept 1, 2018 **Funding requested**: $299,728

**Name and title of Principal Investigators**:
Thomas M. Soniat; Professor/Research, University of New Orleans
Eric N. Powell, Professor, University of Southern Mississippi

**Species/resource to be addressed**. Eastern oyster, *Crassostrea virginica.*

**Summary of project:** The economic and ecosystem value of oyster reefs are well-documented, and threats to their existence are broadly proclaimed; however**,** solutions to the problems associated with maintaining reefs in the face of environmental impacts, climate change, and as a component of a sustainable fishery are only now emerging. Critical to the implementation of methods for the recovery of oyster reefs and the sustainable harvest of the fisheries is the understanding that oysters produce their own habitat, the reef, by adding shell carbonate through their own death. This carbonate is, however, not a temporally stable resource. Thus, maintaining carbonate balance in these systems is essential. Management must consider not only the stock (oyster abundance) but also the habitat (oyster reef) as a comprehensive whole. Today, very few reefs are in carbonate balance; that is, the loss of carbonate exceeds its natural supply through the deaths of living oysters. Cultch (e.g., oyster shell) resources must be carefully managed and gains achieved by cultch planting must be maintained through integrated stock and cultch management. A fully integrated and robust data collection and analysis program supporting sophisticated shell-budget modeling is an essential tool for restoring the oyster to its historically important position of foundational species and principal estuarine fishery in Gulf and East coast estuaries.

The contribution of the oyster as a fundamental contributor to estuarine habitat and its ability to support a flourishing estuarine fishery in the Gulf of Mexico has declined dramatically over recent decades (Kirby 2004, Beck et al. 2011). A radical change in management approach is urgently required. The fundamental innovation of our approach is the application of a Sustainable Fisheries Model (SFM) to manage the oyster resource. *Of consequence is the fact that all five Gulf States are partners on this proposal. Thus, this proposal marks the* ***first*** *Gulf-wide coordinated effort to improve oyster fisheries management and reef restoration.*

The SFM is an interface of an annual stock assessment with a constancy carbonate budget model and provides the basis for effective and long-term results from restoration programs being implemented by the Gulf States. The model, as currently implemented in Louisiana, estimates a sustainable harvest of sack (market-size) and seed oysters in which sustainability is defined as no-net-loss of the surficial cultch (carbonate) resource. By definition, this also produces a sustainable stock. Model inputs are oyster abundance and size, reef size, oyster density, and cultch density. Oyster growth and mortality rates and cultch loss rates are parameterized. Model outputs include estimates of sustainable harvest and reef mass loss or gain**.** That is, the model simultaneously balances recruitment, natural mortality (= shell addition) and shell loss, determines the population requirements to achieve this balance, and allocates the remainder of production to the fishery. Thus, the SFM provides an estimate of a sustainable harvest as one which does not decrease reef cultch mass, based on the current stock size. We propose a Gulf-wide test of this assessment approach by configuring the model for all 5 Gulf states and using it to determine for the first time the degree to which carbonate balance is maintained in Gulf coast oyster reefs as presently managed and the allowable harvest with carbonate balance as the primary reference point. This will set the stage for improved management by determining sustainability criteria and provide a basis for much wiser use of financial resources directed at carbonate addition (shell planting, limestone planting), an activity that continues to be widely employed across the Gulf with restricted long-term benefit.

**Anticipated benefits and outcomes:** Benefits and outcomes of the proposed research include (1) implementation of the SFM in all Gulf states and (2) inclusion of resource agency and industry representatives in a Stock Assessment Workshop (SAW) protocol to permit (a) development of management objectives from survey and model results, (b) development of science advice designed to improve over time state assessment procedures, and (c) provision of retrospective capability to assess the validity of model parameterization and the success of management implementation across the Gulf of Mexico. Because the SFM approach has been shown to be consistent with maximum-sustainable-yield metrics, the project will provide important support for developing an economically-important sustainable seafood designation for the Gulf oyster industry. In addition, society will benefit because the financial investment in oyster restoration will produce optimal benefits as the outcome of applying the SFM in management is the simultaneous achievement of a sustainable stock, a sustainable habitat providing a wide range of ecosystem services, and a sustainable fishery.

## PROJECT SUMMARY

**Applicant Information**
**Mote Marine Laboratory**
**Robert E. Hueter, Ph.D. – Co-Principal Investigator**
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**Project Information:**
**Project Title:** Achieving sustainability and building capacity for Puerto Rico's HMS fisheries: A fisheries-dependent and fisheries-independent research, education and outreach program [NMFS proposal tracking #18SER028]
**Project Location:** Puerto Rico
**Project Start Date:** September 1, 2018
**Federal Funding Requested**: $ 255,790
**S-K Research Priority:** Priority #4 – Territorial Science

**Partners:**

**Raimundo Espinoza – Co-Principal Investigator.** Mr. Espinoza is the founder and Managing Director of Conservación ConCiencia Inc., a not-for-profit NGO based in San Juan, Puerto Rico. He has extensive experience implementing multiple stakeholder projects, managing large grants and carrying out successful on-the-ground actions in the Caribbean region.

**Summary**:

The goal of this project is to develop and implement a collaborative research and conservation initiative in partnership with the fishing industry to improve data collection capacity and biological sampling to document, analyze and validate the true scale and scope of Puerto Rico's shark and other HMS fisheries and shark bycatch, assess critical habitat (nursery grounds, feeding areas, migratory routes) and regional connectivity for sharks and other HMS in Puerto Rico. Specifically, our objectives are to: 1. Implement a model for long-term collaborative research with commercial and recreational fishing industries in Puerto Rico and with the University of Puerto Rico-Mayagüez to enhance fisheries data-collecting capacity; 2. Improve species-specific fisheries characterization by documenting and validating HMS composition of Puerto Rico's commercial and recreational fisheries, in collaboration with MER Consultants, which has already implemented a NOAA-contracted pilot port sampling and catch verification project for non-HMS species in Puerto Rico and USVI; 3. Conduct an assessment of elasmobranch nursery grounds and other critical habitats for sharks and other HMS in Puerto Rico; 4. Expand a tagging program to study shark and other HMS movement, migration and connectivity studies using conventional and electronic tags; and 5. Conduct a training workshop and international conference to build capacity in shark research and HMS fisheries management and conservation in Puerto Rico.

**Project Summary**

**Applicant Organization:** Louisiana Department of Wildlife and Fisheries (LDWF)

**Project Title:** *Louisiana Coastal Inventory and Study*

**Project Descriptive Title:** Louisiana Estuarine, Coastal, and Offshore Marine Species Inventory: *Recreating the "1971 Cooperative Gulf of Mexico Estuarine Inventory and Study, Louisiana" a half-century later, including a compendium of historic and on-going datasets with emphasis on the characterization of inshore-to-offshore habitats, environmental parameters, and associated finfish, shellfish, cephalopod, and zooplankton biotic components*

**Research Priority:** The proposed project will address the FY18 Saltonstall-Kennedy Competition FFO Solicitation Priority #2 – *Adapting to environmental changes and other long term impacts in marine ecosystems*, by characterizing and assessing short- and long-term biological impacts of ecosystem changes in Louisiana.

**Project Location:** Inshore estuarine, coastal, and offshore waters of Louisiana

**Project Period:** The project is anticipated to begin September 1, 2018. However, preliminary work will commence in January 2018, and the total analysis will encompass a time series from 1965 to the present.

**Total Funding Requested:** $149,915; to be used in the development of the final print (100 hardbound copies) and electronic format versions of the Louisiana Coastal Inventory and Study

**Name and Title of Principal Investigator:** Andrew Fischer, Biologist Director, Fisheries Research and Assessment Section, Fisheries Research and Development Division, Office of Fisheries, LDWF, Baton Rouge, La.; afischer@wlf.la.gov;

**Species/Resources to be Addressed:** The proposed project will develop a compendium of historical-to-present-day (i.e., on-going) datasets with emphasis on the characterization of inshore-to-offshore habitats, environmental parameters, and associated finfish, shellfish, cephalopod, and zooplankton biotic components observed through the Department's routine and contractual living resource sampling and environmental monitoring activities.

**Summary Description of Proposed Activities and Anticipated Benefits/Outcomes:** We propose to recreate a modern version of the *Cooperative Gulf of Mexico Estuarine Inventory and Study, Louisiana* (GMEI-LA; Perret et al. 1971). This landmark publication was part of a effort to investigate the physical, hydrological, sedimentological, and biological characteristics of estuarine habitats bordering the northern Gulf of Mexico, with reports developed for Louisiana, Mississippi, and Alabama. Rooted in a greater focus on ecology and preservation of the

environment and its natural resources as an increasingly dominant trend during the 1960s, the GMEI was initiated by the Gulf States Marine Fisheries Commission (GSMFC) and the U.S. Department of the Interior, Bureau of Commercial Fisheries in 1966.

The overarching goal of the biology phase of the GMEI was to show the importance of the estuary in its role as a nursery and contributor to the size and success of the Gulf of Mexico fisheries. Biological sampling was conducted across six estuarine study areas of Louisiana from April 1968 through March 1969. The final results were arranged according to spatial and seasonal distribution of species observed and published in the two-volume GMEI-LA in 1971. Additionally, the correlation between hydrological characteristics and relative abundance of selected organisms, mainly with respect to salinity and water temperature, was reported based on environmental parameters collected at each sampling station.

The 1971 GMEI-LA was intended to serve as a baseline to use for evaluation of future trends; however, a study of this magnitude has not been undertaken in the years following its publication. The LDWF has continued its fisheries monitoring field work in the decades since the GMEI-LA publication, some of which is largely based upon methodology developed during the GMEI. Over the years, the LDWF fisheries monitoring program has been modified to reflect changes in aquatic habitats, management objectives, and sampling gears. The result is a tremendous amount of accumulated raw data, which has not been subjected to a holistic analysis in a manner similar to the GMEI.

The proposed creation of an updated Louisiana coastal inventory will aid in our understanding and integration of the numerous interactions that estuarine and marine species have undergone in the dynamic and continually changing coastal Louisiana waters. The results of this project will serve to establish updated baseline metrics that will be utilized by researchers in academia, fisheries managers, and others to compare data from multiple projects in the furtherance of ecosystem-level understanding of Louisiana valuable coastal resources. Monitoring metrics and data may also inform ecosystem model development, enhance understanding of large-scale ecological processes, and support decisions of where and how to implement coastal restoration projects to achieve the largest gains. Such approaches are essential for broader efforts to restore large ecosystem functions (e.g., characterize impacts to ecosystem functions provided by a variety of restoration projects including marsh creation, living shorelines, and barrier island restoration) through an adaptive management process.

The final product of the proposed project will be a hardbound publication of the updated LCIS, along with a digital version available to the public on the LDWF website (www.wlf.la.gov). All data derived from the proposed project will be communicated in a manner that maximizes the extension and outreach capabilities of LDWF. There are a sizeable number of stakeholders with diverse interests that utilize Louisiana's coastal resources, which underscores the need to disseminate all findings and results to the widest audience possible. The LDWF is heavily involved with the recreational and commercial fishing sectors, and will capitalize on these working relationships to promote the findings of the proposed research upon its completion.

**PROJECT SUMMARY**

**Project Title**: Development of Aquaculture Methods for Hogfish, a Highly Valued Sport and Food Fish of the Western Atlantic

**Species Addressed**: Hogfish, *Lachnolaimus maximus* (Walbaum, 1792)

**Resource Addressed**: Western Atlantic and Gulf of Mexico Hogfish Fishery

**Project Location**: Southern Florida

**Addressed Priority for NOAA-NMFS-FHQ-2018-2005332**: Priority #1- Marine Aquaculture

**Requested Start Date**: September 1, 2018

**Federal Funding Requested**: $288,165

**Principle Investigator**:

Dr. Cortney Ohs: Associate Professor- Aquaculture
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**Applicant Organization**: University of Florida, Gainesville, Florida

**Project Description**: The United States currently has a multi-billion dollar seafood trade deficit. Diversification of domestic seafood production with high-value species may allow the U.S. to better compete in global markets. Hogfish, *Lachnolaimus maximus*, are native to the western Atlantic Ocean and Gulf of Mexico. Highly valued as a sport and food fish, hogfish has a mild

flavor and white, flakey fillets which retail for more than $30.00 per pound in some markets. This species is often targeted by recreational anglers and commercial fishers in the southeastern U.S. and the popularity of hogfish as a sport and food fish has led to elevated fishing pressure. In 2010, hogfish were relisted as "Vulnerable" by the International Union for Conservation of Nature (IUCN), indicating a reduction of = 30% in hogfish populations over three generations. NOAA stock assessments indicate that primarily "growth" overfishing was occurring within the South Atlantic hogfish population in 2013. Overfishing is still occurring in the South Atlantic population as well as in Puerto Rico and U.S. Virgin Islands. The 2015 annual recreational catch limit for hogfish in South Atlantic federal waters was met in August, which led to a closure of the fishery until January 2016 and stricter management regulations in 2017 including reduced bag limits and quotas as well as increased minimum size limits. In addition to stricter regulations in 2017, all commercial and recreational harvest of hogfish was closed on August 24 in federal waters south of Cape Sable in the Gulf, around the tip of Florida, and up the Atlantic coast. This clearly demonstrates the popularity of the species, and that recreational and commercial fishing opportunities to supply hogfish seafood markets are becoming more limited.

Despite the high value, existing markets, and negative population trends for hogfish, information regarding aquaculture techniques does not currently exist. The research efforts of this proposal are directed towards developing spawning, egg incubation, and larval culture protocols for hogfish that will maximize juvenile production for growout. Objectives for developing spawning protocols include establishing effective broodfish quarantine, handling, husbandry, and feeding protocols that promote natural spawning of hogfish in captivity. Induced spawning protocols which employ various compounds (ie. Ovaprim® and Chorulon®) and dosages will be evaluated for successful spawning induction. Eggs obtained from spawns will be used for experiments to determine appropriate stocking densities under various incubation regimes. Larval culture objectives will elucidate effective feeding strategies which delineate appropriate live feeds, enrichment products, and feeding regimes. Established larval culture protocols will be used by local producers in Vero Beach and Dade City, Florida to conduct pilot-commercial scale larval culture and juvenile grow-out to market size. Juveniles produced during the project will be displayed at The Florida Aquarium, a highly regarded AZA institution hosting over 800,000 visitors annually, for public outreach and education about hogfish aquaculture. Results will be directly transferred to potential producers through extension literature and a hogfish aquaculture workshop hosted by a Florida Sea Grant agent.

Development of hogfish culture protocols and demonstration of culture feasibility has the potential to diversify the U.S. seafood industry while increasing employment in the aquaculture sector. Such developments would result in a reliable and more sustainable hogfish product for national markets. Furthermore, culture technologies for this species could be transferred to private, state, or federal entities for stock enhancement of wild hogfish populations, which may ultimately lead to increased fishing opportunities, and fishing related income and jobs in the U.S.

**PROJECT SUMMARY**

Title: **Novel Approaches to Age Validation in Data-Poor U.S. Caribbean Reef Fishes**

Principal Investigator(s) and Brief Statement of Qualifications: **Dr. Virginia Shervette, USC,** has 18 years of experience conducting research on fish life history (age, growth, and reproductive biology), fisheries ecology, and fish population dynamics, including several recent projects focusing on reef fishes in the U.S. Atlantic Ocean and Caribbean Sea. **Dr. Will Patterson, UF,** has 25 years of experience conducting research on age and growth, population dynamics, population structure, and habitat requirements of marine fishes, with a focus on reef fish fisheries ecology.

Project Start Date: 1 Sep 2018

Year 1 Amount = $149,088 Year 2 Amount = $150,729 Total Amount = $299,817

Reef Fishes have been utilized as food fish in U.S. Caribbean waters for centuries, with exploitation rates increasing in recent decades. As a result, many species experienced recent declines in landings, including yellowtail snapper *Ocyurus chrysurus*, queen triggerfish *Balistes capriscus*, red hind *Epinephelus guttatus*, and stoplight parrotfish *Sparisoma viride*, which are the focal species of this study Little to no current life history data exist in the peer-reviewed literature for U.S. Caribbean populations of these species, and they are all listed as priority species for basic life history research under SEDAR, the stock assessment process in the southeastern U.S. and Caribbean. Age is the fundamental biological parameter for estimating life history parameters, as well as growth and mortality rates. However, age data are lacking for our focal species, and ageing methods have not been validated for any of them. Therefore, age validation must occur prior to reliable growth and mortality estimates being computed for these species.

All four of the species listed above are also the focus of a current NOAA MARFIN-funded reproductive maturity study. However, hardparts have also been collected during sampling in that study and we aim to utilize those samples in the current study to estimate age and growth of these important fishery resources. We will also collect contemporary samples to expand sample sizes, as well as for tissue samples to conduct age validation analysis. The bomb radiocarbon ($^{14}C$) chronometer has been successfully employed to validate ageing in reef fishes from the U.S. Gulf of Mexico, and we aim to apply similar techniques to validate ageing of

Caribbean reef fishes as well. Traditionally, this approach has relied on comparing otolith core (formed in birth year) $\Delta^{14}C$ values to those sampled from regional corals. However, in the present study we will employ a recently described technique in which eye lens cores are extracted and their $\Delta^{14}C$ is analyzed as the birth year $^{14}C$ signature for a given fish. Lastly, we aim to test a novel approach to age validation based on eye lens amino acid racemization (AAR) which promises to offer a low-cost method for age validation, especially in tropical reef fishes. Details of these approaches and their rationale are provided below in the Project Description.

Project Objectives: 1) conduct contemporary sampling of each focal species in Puerto Rico and the US Virgin Islands (USVI) to enhance archived sample sizes and sample eye lenses for age validation; 2) estimate age and growth based on historical and contemporary samples, 3) employ Δ14C analysis of eye lenses to validate ageing in the 4 focal species, and 4) test the efficacy of AAR to estimate age in Caribbean reef fishes.

Specific S-K Solicitation Priorities to Which Project Responds: Priority #4 – Territorial Science: Improve the quality and quantity of fishery information from the U.S. territories covered by the Magnuson-Stevens Act, including the territory of the U.S. Virgin Islands and the Commonwealth of Puerto Rico, that can be used for establishing, enhancing and monitoring Annual Catch Limits (ACLs) and ecosystem-based information for Federal fisheries management in these territories.

Summary of Work: There are four components to this study: 1) sampling otoliths and eye lenses from yellowtail snapper, queen triggerfish, red hind, and stoplight parrotfish from the U.S. Caribbean; 2) processing ageing structures (sagittal otoliths for Yellowtail, Red Hind, Stoplight Parrotfish; dorsal spines and sagittal otoliths for Queen Triggerfish) to estimate age and growth of contemporary and archived samples of these species; 3) analyzing the eye lens core $\Delta^{14}C$ values with accelerator mass spectrometry (AMS) for a subset (n = 30) of individuals across the age range observed for each of these species; and, 4) estimating non-essential AAR of eye lens cores as a means to validate reef fish ages. This final component will involve high performance liquid chromatography analysis of non-essential amino acids to quantify L (left-handed) and D (right-handed) enantiomers (optical isomers) of eye lens cores to estimate the conversion of L to D enantiomers, which occurs naturally over time. This conversion, known as racemization, can be quantified in tissues, such as eye lenses, that are not subjected to physiological reworking to estimate the rate of racemization in known-age samples. In turn, this rate can be applied to D:L ratios in unknown-age samples to estimate age. We will attempt this analysis for lab-reared Zebrafish *Danio rerio*, Caribbean yellowtail snapper, and Gulf of Mexico red snapper *Lutjanus campechanus* in order to assess the effect of temperature on the rate of racemization and our ability to estimate age from it (i.e., progressing from a fish reared under controlled conditions, to a tropical species that experiences little within-year temperature fluctuations, to a temperature species that may experiences temperatures that vary more than 10 °C during a given year.

Results of this work will have important implications for assessment and management of marine fishes in the U.S. and beyond. Age validation is critical for growth, longevity, and mortality estimates of data-limited Caribbean fish stocks, and performing that task during this study will provide invaluable data for conducting data-limited stock assessments. The newly-developed eye lens approach to bomb $^{14}C$ age validation promises to be quite useful to validate otolith-derived age estimates of Caribbean species. Furthermore, if the AAR age validation approach is successful, then it is likely to be applied widely given its lower expense relative to AMS analysis.

## A. Project Summary

Applicant information

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Project information

*Title*: A commercial fishery census of Puerto Rico to develop a new baseline on fishery participation, markets, and infrastructure in the small-scale fishery sector

*Location*: The Commonwealth of Puerto Rico

*Project start period*: October 1, 2018

*Federal funding requested*: Total costs: $127,149 (Direct costs: $115,590; indirect costs at 10%: $11,599)

*S-K research priority*: The **primary** priority area for the project is **Priority #4 (Territorial Science)**, and a secondary priority area is Priority #2 (adapting to environmental changes and other long-term impacts)

Partners

There are no formal collaborating partners on the project, but the project will involve considerable collaboration with fishing communities in Puerto Rico's 42 coastal municipalities.

Summary

Puerto Rico's commercial fishing industry is comprised mainly of small-scale operators who target a variety of reef fish and invertebrates, small coastal pelagics, and offshore species (Valle-Esquivel et al., 2010; Matos and Agar, 2010). Effort in the fishery has traditionally fluctuated based on a combination of opportunity costs related to employment, ex-vessel values, and species abundance (Griffith and Valdes-Pizzini, 2002), but most sectors have been heavily over-exploited and under control restrictions (Tonioli and Agar, 2009), including seasonal closures, annual catch limits (ACLs), and/or limited entry.

The main project goal is to conduct a comprehensive census of the Puerto Rico commercial fishing industry. The previous such census was conducted in 2008 (Matos and Agar, 2010), which represents the last effort in quantifying and characterizing participation and fishery demographic, economic, and socioeconomic dimensions necessary for well-informed fisheries management. Also, given the widespread and largely poorly understood effects of September 2017's Hurricane Maria on the industry, including the storm's effects on participation, characteristics, and markets, the need for a new census is both urgent and timely.

The project seeks to address the following objectives:

i. The rates of participation in the total fishery and across regions, species complexes, and gear types;
ii. Characterization of fishing communities across the island's 92 fishing centers and 42 fishing communities;
iii. Evaluation of changes in input factors (effort, participation, gear) based on shifts in species abundances, economic conditions, and environmental perturbations

Objectives i and ii, which closely match previous census efforts, will develop a new baseline for the fishery, as measured by the number of active (licensed and non-licensed) fishers and fishing centers (villa pesqueras), will assess changes from the previous baseline, and will forecast trends as Puerto Rico's infrastructure is restored and fishery-related and fishery market conditions are improved. Objective iii will be employed to evaluate how fishers across different communities may modify existing strategies to adapt to natural and socioeconomic changes, and the potential effects on target species with such modifications. Together, the objectives will develop a comprehensive census that can be used as a new baseline for Puerto Rico's reconstituted fishing industry.

Also, following the devastation resulting from Hurricane Maria's landfall in September 2017, the fishery is presently at about a third of its pre-storm capacity; however, field-based information suggests that participation may recover to a new 'normal' by the end of 2018 following the full restoration of electrification and re-emergence of demand from local and San Juan markets (Matos-Caraballo, personal communication).

All work to be conducted to complete the census will be done using an in-person approach, implementing a survey questionnaire with active fishers in coastal municipalities. The effort will also involve considerable fishing community outreach and data sharing, as a means by which both maximize data collection and cooperation and to work with fishing communities as partners in the endeavor. Participatory approaches will be prioritized over others in data collection protocols.

The species of concern include all fin fish and invertebrate species targeted by the commercial fishing industry but especially those species of high value (spiny lobster, Queen conch, mid and deep-water reef fish, offshore pelagics).

**Title:** Investigating the use of eDNA sampling to locate fish spawning aggregations

**Principal Investigator:** Chelsea A. Harms-Tuohy[1]
**Co-Principal Investigators**: Evan A. Tuohy[1,2], Richard S. Appeldoorn[2] & Nikolaos V. Schizas[2] [1]*Isla Mar Research Expeditions, LLC,*
[2]*University of Puerto Rico, Mayagüez, Department of Marine Sciences*

**Budget Total:** $296,755
**Start Date:** September 1, 2018
**Research Priority**: Priority #4: Territorial Science
**Project Location:** Puerto Rico

**Background/Rationale:** Over the past several decades, fish stocks of commercially important species have been at a steady decline throughout the Caribbean. Many of these species share a common thread: the formation of fish spawning aggregations (FSAs) for the purpose of reproduction. Given their importance for population sustenance and fisheries exploitation, these aggregations are an invaluable resource to coral reefs and humans alike, and their persistence is of utmost management concern. If effective management and conservation occur before complete collapse, FSAs have been shown to recover (Nemeth, 2005). Knowledge of their location, spatio-temporal characteristics and status are important components needed for ecosystem-based management. However, locating FSAs has proven to be difficult. As an alternative, new molecular methods of sampling DNA from the environment may provide a simple and rapid-response solution to this challenge.

Environmental DNA (eDNA) is an innovative sampling strategy to address questions about biodiversity and conservation. The eDNA technique involves collecting water samples from the environment (e.g., oceans) and amplifying and/or sequencing sampled DNA to illustrate the biodiversity of organisms in that environment. Besides looking for everything in a sample (bacteria, viruses, plants, etc.), eDNA can also be used to identify target species in a forensics-like manner. A recent project recognized the potential of eDNA in marine forensic applications (Kelly et al. 2014b), including the ability to use eDNA to quantify species densities (Thomsen et al. 2012). Building on this application, the proposed study will use eDNA to sample water at known FSAs in Puerto Rico to assess the ability to use this approach in locating new FSAs.

In the US Caribbean, FSAs have been severely overfished. Recently in Puerto Rico, the approximate areas that currently or once harbored FSAs were identified in collaboration with local fishers (Ojeda et al. 2007), however, their exact locations and timing, or whether or not they still exist, remains unanswered. This project will develop and test a method to locate present FSAs. Identifying these areas that are essential for fish reproduction is a fundamental component to properly manage and enhance population recovery of these extirpated species.

**Objectives & Methods:** This project specifically supports the SK Program objective in "establishing, enhancing and monitoring…ecosystem-based information", specifically Priority #4: Territorial Science by "expanding fishery biosampling and analysis of biosampling data," through the use of novel eDNA sampling to survey reef fish presence as FSAs in Puerto Rico. The overall goal of the project is to investigate the use of this new technique in providing a rapid, non-invasive method for locating current and new

FSAs. *Objectives*: (1) Test the effectiveness of eDNA techniques to identify target fishes at known FSA sites, (2) Test the efficiency of quantifying fish density using eDNA and qPCR and (3) To apply the technique to suspected sites of fish spawning aggregations. The study will take place in Puerto Rico, at known FSA sites at Abrir La Sierra (red hind), Mona Island (yellowfin grouper), Bajo de Sico (Nassau grouper) and La Parguera (mutton snapper). *Methods:* Water (triplicate 2L samples per location) collection will involve testing three sampling methods: (1) water collected at depth by divers at these exact sites of known high fish densities, (2) water collected from sampling bottles at the surface and lowered from the boat to depth of the aggregation and (3) sediments (triplicate $10cm^2$) collected at exact known sites of high fish density at the aggregation. To range test eDNA dispersion from the target site, triplicate 2L samples will be collected stratified downstream from the center of highest density. As a control, samples will also be taken from areas without known aggregations and in surface water. Additionally, to determine the residence time of eDNA at the aggregation site, samples will be collected before, during and after the aggregation peak at each site. Samples will be preserved on site using 0.01% benzalkonium chloride. Samples will be filtered using a glass filter with 1µm pore size to collect DNA. DNA will be extracted from the filtrate and precipitate of the samples. Real-time PCR (qPCR) amplifying the Cytochrome Oxidase subunit 1 (CO1 gene) will be conducted at the Caribbean Genome Center (CGC) at UPRM. Samples will be sequenced for confirmation of species identity at the University of Texas, Austin. In conjunction with eDNA sampling, visual census (UVC) for target fish biomass will be used to assess the relationship between fish abundance and eDNA signal. Hydrophones (DSGs) will also be placed at the aggregation site for additional confirmation of species presence. Lastly, the method will be applied to suspected aggregation sites on the west coast of Puerto Rico and Mona Island.

**Anticipated Results:** Sampling FSAs for eDNA will detect the presence of target species at known aggregation sites, as the concentration of eDNA will be increased substantially in areas of high fish density (Lacoursière-Roussel et al. 2015). Correlated with UVC, the concentration of eDNA will be used to estimate fish biomass. Suspected FSAs will be located using the one or combined sampling method(s) determined from Year 1.

**Benefits/Impacts:** Fisheries managers will benefit from this non-invasive, rapid method to detect the presence of target species, using this tool to locate previously undetected FSAs. The potential to quantify target species biomass and refine estimates of population dynamics will serve to enhance fishery-independent monitoring. This research aims to enhance the speed and efficiency that fishery-independent data on FSAs can be collected, presented and incorporated into management, an aspect that is imperative for their biological and commercial persistence. A Master's Thesis will be produced. Workshops for fishers/managers will relay importance of FSAs and compliance with closures, and provide illustrated guides to the target species. A video documentary will share the project and highlight fisher/manager experiences with target fish and changes over time.

**Collaborating Partners:** Dr. Michelle Schärer (HJR Reefscaping), Dr. Carlos Fachette (CFMC), Dr. Craig Lilyestrom (DNER)
**Endorsed by:** Dr. Bill Arnold (NOAA)

## A. Project Summary

Applicant Information:

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Project Information:

Project Title: Culture of the indigenous southern quahog, *Mercenaria campechiensis*, to diversify and expand the Florida aquaculture industry

Project Location: Gulf coast of Florida, USA

Requested Project Start Period: September 1, 2018

Federal Funding Requested: $233,713

Priority Area: Marine Aquaculture

Summary
Marine aquaculture in Florida is based predominantly on the culture of the "northern" quahog (=hard clam), *Mercenaria mercenaria,* which in 2012 had a value of $12.3 million. In recent years, however, hatchery producers and growers throughout Florida have experienced increasing mortalities of clams during the summer months. Our hypothesis is that since the northern quahog is at its southern distributional limit in Florida, it is less tolerant of high summer temperatures than the native, southern quahog, *M. campechiensis*.

This project seeks to compare growth and survival of both species of clam at all life stages and at three locations along the west coast of Florida, including Tampa Bay, Pine Island Sound, and Gullivan Bay in the Ten Thousand Islands. This will demonstrate the efficacy of culturing *M. campechiensis* in southwest Florida. The anticipated benefits include the growth and expansion of clam production throughout Florida; diversification of the industry and its markets (M. campechiensis is anticipated to be primarily a frozen product); and increased ecological resilience for the industry in the face of ongoing climate change. Overall, increased domestic production of shellfish will help grow the coastal economy, improve water quality, and reduce the federal seafood trade deficit.

**PROJECT SUMMARY**

**Applicant organization:** Virginia Institute of Marine Science

**Principal investigator:** Kevin Weng, Assistant Professor, Virginia Institute of Marine Science (kevinweng@vims.edu

**Project title:** Understanding stock boundary and seasonal migration phenology of Atlantic cobia under a changing climate to inform management

**Project location:** Virginia Institute of Marine Science, Gloucester Point, VA

**Requested project start date:** 1 July 2018 (early start discussed with Dan Namur)

**Federal funds requested:** $297,008

**SK priority:** 2 – Adapting to Environmental Change and Other Long Term Ecosystem Change

**Activities:**

We propose a vertically integrated research program that will tag Atlantic cobia to understand stock boundary and migration phenology, use these data to develop a species distribution model, and then drive the species distribution model with a regional ocean model to generate seasonal forecasts for cobia distribution and relative abundance. A related proposal was previously submitted to SK, and we have subsequently built a coast-wide team of cobia biologists from multiple institutions, and brought in a climate modeler with expertise in forecasting fish occurrence. Our project leverages acoustic tagging programs that have operated in the past few years in FL, GA and SC, where 143 cobia have so far been tagged with acoustic transmitters. Weng initiated a pilot study during summer 2017 in VA and one cobia has already been detected moving through SC to FL. We are in touch with Jeff Buckel at NCSU who will begin cobia tagging soon. Furthermore, we will contribute fin clips to Jan McDowell's genetics program and thus we may learn about the subpopulation identity of our tracked fish.

To record the movement and migration of these tagged cobia, we will rely on the network of acoustic receivers already deployed by our own team as well as many other researchers along the East Coast (www.theactnetwork.com and www.secoora.org/FACT). However, there are areas in the mixing zone between the two cobia stocks that require additional receiver coverage, and we aim to fill key gaps. The improved receiver network will allow finer discrimination of the stock boundary and the degree of mixing.

Cobia will be caught in VA waters and tagged with Vemco V16 coded tags with 5-year lifespan (n=50 tags in each year, for a total of 100 tagged cobia). Several expert cobia fishermen have expressed interest in contributing to the tagging effort.

An analysis of receiver coverage in FL, GA and SC will be undertaken by surveying East Coast researchers to determine receiver locations. Gaps in receiver coverage that overlap with the putative mixing zone between Gulf and Atlantic stocks will be targeted for new receiver arrays. Based on existing information it is likely that the new array will be installed near St. Augustine FL (n=20 receivers).

Our species distribution model will go beyond traditional approaches by including empirically-derived physiological limits for several environmental variables in addition to environmental data based on the locations for tagged animals. Our lab is uniquely positioned for the species distribution modeling work as we have spent the past two years conducting challenge experiments in the lab to determine the physiological limits of cobia with respect to temperature and oxygen, and therefore we have unprecedented physiological data to parameterize the model. Temperature data for the times and locations of fish detections will be collated from either temperature loggers co-located with receivers, or available oceanographic data for the area of each receiver. These temperature data will be used to create a species distribution model for cobia. Projected temperatures will be accessed from Atlantic/GOM Regional Ocean Model Systems (ROMS). Cobia environmental preferences will be calculated for current and projected environmental conditions extracted from the ROMS model, which will determine the location of preferred cobia habitat at a given time. The skill of these forecasts will be evaluated to determine the time period that can be realistically forecast (likely a maximum of three to four months). This information will be provided to managers at a frequency that supports dynamic ocean management for cobia. Previous delivery of such information (e.g. in Australia) has been monthly. This type of information can also be incorporated into stock assessment models to correct "availability" estimates and inform CPUE standardization.

**Benefits and outcomes:**

With the management of cobia likely transferring to the ASMFC, state-by-state management will be replaced by a comprehensive coast-wide approach. Fishery managers needs to know:

**What is the southern boundary of the Atlantic stock, and how broad is the mixing area with the GOM stock?** Given the lack of data on the stock boundary, SEDAR 28 (2013) used the FL-GA border as the stock boundary. Our project aims to deliver updated stock boundary data, via tagging and improved receiver coverage in north FL. We anticipate that some data will be available prior to the 2019 SEDAR stock assessment.

**Are there subpopulations of cobia within the Atlantic stock?** If ongoing genetic studies confirm the existence of distinct subpopulaitons in SC and VA, having of genetic profiles of tagged fish can confirm fidelity to distinct spawning areas. If such fidelity exists could we see hyperstability in CPUE? Each of our tracked fish will also be analyzed for genetic markers, allowing us to see which genetic group visits which spawning area.

**Can the phenology of migration be forecasted based on environmental factors, in a way that is useful for tactical fishery management? If so, a seasonal forecast could be developed to inform the dates for open/closed seasons in each state as well as federal waters.** Our project will gather the habitat selection data for cobia to allow species distribution models and forecasts to be developed. Such tools would allow ASMFC to anticipate the availability of cobia within the waters of each state, opening the door to dynamic management approaches. This strategy has been recently used in the Australian Southern Bluefin tuna (SBT) fishery, where seasonal predictions of tuna species distribution were provided to managers who used them for dynamic management decisions.

**How will the distribution and migration phenology of cobia respond to environmental change, altering the seasonal availability of the resource on the East Coast?** Our project will drive a species distribution model with regional ocean models, providing data on the likely redistribution of the Atlantic cobia stock. If this species range is shifting north we may begin to see the line separating the Atlantic and GOM stocks shift north, and the northern boundary of the stock shift north of VA.

**PROJECT SUMMARY**

**Organization:**
University of California Santa Cruz
1156 High Street
Santa Cruz, California 95064

**PI:** Dr. Suzanne Alonzo
Full Professor
Department of Ecology and Evolutionary Biology
shalonzo@ucsc.edu

**Graduate student:** Sabrina Beyer, M.Sc.
Graduate Student Researcher, Ph.D. program
Department of Ecology and Evolutionary Biology
sbeyer@ucsc.edu

**Title:** Assessing the effects of oceanographic variability on body condition and reproductive output in economically important rockfishes (*Sebastes* spp) in the California Current Ecosystem

**Location:** Santa Cruz, California, USA
**Project Start Date:** September 1, 2018
**Federal Funding Requested:** $182,382

**S-K Research Priority #2:**
Adapting to environmental changes and other long-term impacts in marine ecosystems

**Summary:**

*Background:* Successful reproduction is crucial for recruitment and population growth. Yet, how climate change will affect reproduction in marine fishes is largely unknown. In the California Current Ecosystem (CCE), climate models predict increasing ocean temperatures and greater frequency of climatic events, such as El Niño. These warm water events negatively impact ocean primary productivity and the availability of prey to higher trophic levels supporting fisheries, such as the economically important rockfish fishery (*Sebastes* spp). Rockfishes show declines in body condition and gonad indices during El Niño, indicating reduced energy available for reproduction. Understanding how changes in body condition affect reproductive success, including patterns of multiple brooding and skipped spawning, are essential for assessing the vulnerability of these populations to climate change and developing robust management strategies. Additionally, there is an increasing appreciation that variability in annual reproductive output is likely critical to recruitment dynamics affecting future biomass available to the fishery. ***These effects are not well understood, leading to a gap in knowledge of how rockfish populations with differing reproductive strategies will respond to long-term environmental change.***

*Proposed Activities:* The project proposes a coupled empirical and theoretical approach to better understand patterns of reproductive success of rockfishes through 1) syntheses of existing datasets, 2) targeted collection of new data, and 3) by using state-dependent modeling methods to assess the vulnerability of long-term reproductive success to environmental change in the CCE. The project will partner with the California fishing community by chartering CPFVs to collect samples and with NOAA Fisheries scientists to ensure that the products of the project are informative for improving West Coast rockfish stock assessments. The project will quantify trends in fecundity and female body condition to complete development of a time-series of annual fecundity in relation to large-scale oceanographic indices. This unique time-series spans nearly three decades, over periods of contrasting environmental conditions in the CCE, for Yellowtail, Chilipepper, and to a lesser extent, Widow, Bocaccio and Rosy Rockfish in central California.

The theoretical component includes development of a state-variable model using stochastic dynamic programming to predict plasticity in individual reproductive effort in response to environmental conditions. Model outputs will include predictions for delayed maturation, skipped spawning and the possibility of multiple broods within a reproductive season. Forward simulation will be used, along with existing demographic parameters from stock assessments, to model population response under predicted climate scenarios in the CCE, such as more frequent El Niño events. This will allow for a comparison between single- and multiple-brooding reproductive strategies to assess the vulnerability of each to long-term environmental change.

*Anticipated Benefits:* The proposed project will benefit the fishery through:

- More accurate estimates of larval production for West Coast rockfish stock assessments.
- Updated NOAA Climate Vulnerability Assessments, comparing the vulnerability of single- and multiple- brooding reproductive strategies in rockfish to climate change.
- Improved knowledge for fishery management plans through predictive models of rockfish reproductive success under future ocean conditions predicted for the California Current.

# SK Proposal 2018

## A. PROJECT SUMMARY (2 pages)

Applicant Organization: Department of Biological Sciences, University of Illinois at Chicago, Chicago, Illinois, USA.
Principal Investigator: Rachel Poretsky, Assistant Professor, microbe@uic.edu Title: Optimizing Feeding and Water Quality Methods to Improve Larval Growth and Survival Locations:
University of Illinois at Chicago, 845 W. Taylor, Chicago, IL 60607
Manchester Research Station, 7305 E. Beach Dr., Port Orchard, WA 98366

Project Period (start): September 1, 2018
Funding Requested: $299,990
SK Priority: Priority #1: Marine Aquaculture: technology development and transfer

**Summary:**

**Previous Work:** Work from our 2015 Saltonstall-Kennedy grant (Development of a Greenwater Alternative for Larval Sablefish, *Anoplopoma fimbria*) generated practical, immediately implementable improvements to sablefish larviculture methods that significantly decrease operational expenses while increasing larval growth or survival. For example, we developed methods to replace expensive algae ("greenwater") with inexpensive clay ("claywater") from the second week after stock-out to weaning (Figure 1). These results have been repeated across replicate experiments. For a single 5,000 L rearing tank, this switch to claywater results in a 98% reduction in water additive costs from $1,361 per tank to $24 per tank over the 35-day larval period. Further, compared to algae, clay has caused increases in body size at weaning (22% increase, 2017 experiment, Figure 1) or survival at weaning (115% increase, 2015 experiment, not shown), without any growth or survival penalties in either experiment.

**New Work and Anticipated Benefits/Outcomes:** While we accomplished our goal of replacing algae for the majority of the larval stage, we also uncovered other very promising leads for ways to further improve larviculture methods. This FY2018 proposal addresses Priority #1 (Marine Aquaculture: technology development and transfer) by following up on three promising leads we encountered while conducting the previous work. This new work will further reduce operational costs and improve growth and survival during the sablefish larval phase. This is important because the sablefish aquaculture industry is still new, and further improvements to culture methods are needed for sablefish aquaculture to become more economically efficient. This work will focus on sablefish (*Anoplopoma fimbria*, also known as black cod or butterfish), but because the issues that we address are ubiquitous in marine larviculture, results will also have value for non-sablefish species.

We propose to address three subjects in sablefish aquaculture that will improve larval growth and survival while decreasing operational expenses. We will conduct studies on 1) the use of *Tetraselmis* and dimethylsulfoniopropionate (DMSP) to improve early larval feeding; 2) the identification of optimal tank cleaning frequencies and interactions with microbial communities;

3) whether the addition of beneficial bacteria could be better than traditional greenwater in the first week.

**Relevance to SK Priority:** This project addresses Program Priority #1--Marine Aquaculture. The project will develop hatchery technology to increase economic performance during the most costly stage of aquaculture--the larval stage--and then transfer those methods to hatcheries. Sablefish is an emerging aquaculture species--in North America, there is one established hatchery and two to three hatcheries that have recently opened or are about to open. The future success of these hatcheries in the burgeoning sablefish aquaculture industry depends on improved economic feasibility. The issues that we study are very common in marine larviculture, so results will also be applicable to other marine species. Ultimately, this work will improve and demonstrate the feasibility of culturing a candidate species for aquaculture in a pilot-scale setting. Results can be immediately implemented and will help the sablefish industry create jobs in coastal communities and produce healthy, domestic seafood.

**Technical/Scientific Merit and Applicant Qualifications:** The applicants and collaborators have extensive experience in the fields of microbiology and (sablefish) aquaculture, and have collectively conducted >20 larval sablefish experiments and published >12 peer-reviewed publications in microbiology and sablefish larviculture over the past three years. This experience, plus the fact that we are following-up on promising results from prior experiments, mean that the proposed experiments are feasible with a high likelihood of success.

**Addresses Needs of Fishing Communities:** Product yields and operational expenses are the bottom line for aquaculture. We address both by developing methods to improve growth and survival while decreasing operational costs. This project directly addresses requests from industry to improve greenwater methods and work on alternative water additives (2012 meeting with industry, 2014 World Aquaculture Society Special Session on Sablefish Culture).

**Involvement/Collaboration with Industry:** We will directly share results with tribal and industry partners. The Jamestown S'Klallam Tribe (see letter of support) is partnering with our collaborators (NOAA Fisheries) to grow-out NOAA-supplied fingerling sablefish. In the future, NOAA Fisheries may teach Jamestown S'Klallam methods for larviculture and fingerling production, so that Jamestown S'Klallam can become vertically integrated. Results from this proposal will be shared with Jamestown S'Klallam. Our collaborators at NOAA have recently supplied fingerlings for grow-out to the Perciformes Group (see letter of support), which will be opening a new sablefish hatchery this year to practice vertically integrated aquaculture, from larviculture to grow-out. We will provide them with methods from these experiments to aid their larviculture operations. As part of a different project, collaborator Matt Cook will be traveling within the next few years to HUB City Fisheries to teach them sablefish larviculture techniques. Matt will incorporate our results into his training materials for HUB City Fisheries.

Proposal to the NOAA Saltonstall-Kennedy Research Program - 2018

# Optimization of a probiotic treatment to promote oyster larval health and prevent disease

Lead PI: Prof. Chris Langdon,
Hatfield Marine Science Center,
Oregon State University
Newport, OR 97365
Email: chris.langdon@oregonstate.edu;

Requested project start date: 9/1/18

Federal funding requested: $299,972

Research priority addressed: Marine aquaculture: technology development and transfer

Shellfish (oysters, clams, scallops, and mussels) farming represents about 70% of the economic production of US marine aquaculture, with the West coast contributing about 47% of this production valued at $125 million. This proposed project supports NOAA's 2016 strategic plan in developing and refining hatchery methods to improve commercial shellfish production as well as SK's funding priority #1: Marine Aquaculture.

Most shellfish farmers depend on seed from commercial hatcheries. The seed usually consists of batches of "eyed" larvae that are shipped from hatcheries to farmers who then "set" the larvae that become juveniles or "spat". Vibrio infections are a recurrent problem for shellfish hatcheries, resulting in severe seed losses. Increasing ocean acidification has also resulted in reduced seed production, although hatcheries have now developed methods to buffer seawater entering their facilities to improve seawater carbonate chemistry. Unfortunately, these seawater-buffering measures have not completely prevented poor seed production and die-offs. As an example, one of the biggest West coast hatcheries had major undefined problems rearing Pacific oyster larvae through most of 2017, despite implementing seawater-buffering procedures. One possible explanation for poor larval performance and reduced seed production is the occurrence of pathogenic bacteria, such as *Vibrio coralliilyticus* (Vcor) and *Vibrio tubiashii* (Vt), which have been reported to cause severe mortalities of Pacific and Eastern oyster larvae, respectively.

In this project, we propose to build on our preliminary research and develop effective protocols for the use of probiotic bacteria to control Vcor in West coast hatcheries. In addition, we will determine the effectiveness of bacterial isolates against Vt. We have

already isolated several bacterial strains that significantly reduce Pacific oyster larval mortalities due to Vcor infections, as well as enhancing larval growth. Proposed research and outreach will optimize probiotic treatments so that they are effective and practical for use in commercial hatcheries. In addition, we will work to transfer the technology to interested enterprises for the use of our probiotics in commercial hatcheries.

The objectives of the proposed research are as follows:

**Objective #1: Optimize probiotic protocols to protect Pacific oyster larvae from the adverse effects of *Vibrio coralliilyticus* (Vcor)**: a) determine the minimum probiotic concentration and exposure time for effective protection; b) compare the effectiveness of mixtures of probiotic strains with single strains; c) compare different storage methods for the probiotics. In this part of the project, we plan to screen different treatments using a three-tiered larval bioassay approach, whereby only the most promising treatments are advanced to longer-term larval assays, with the final tier involving culture of larvae to settlement.

**Objective #2: Test the effectiveness of probiotics against infection of Eastern oyster (*Crassostrea virginica*) larvae by *Vibrio tubiashii* (Vt).** Probiotic isolates found to be inhibitory against Vt on agar plates will be tested with Eastern oyster larvae (*C. virginica*) exposed to Vt, using the same three-tier screening approach described in Objective 1. Eastern oyster larvae will be obtained from a West coast oyster farm (Taylor Shellfish Co., Inc., Quilcene, WA).

**Objective #3: Test the most effective probiotic treatment for Pacific oysters (developed under laboratory conditions) at West coast and Hawaiian commercial hatcheries.** The most effective probiotic treatment against Vcor for Pacific oyster larvae, developed under laboratory conditions (Objective 1), will be tested at commercial hatcheries when larval performance is poor. We will partner with West coast and Hawaiian commercial hatcheries for this component of the project (see letters of support).

**Objective #4: Outreach.** A working collaboration with members of the shellfish industry and academic researchers will be pursued to support development and application of probiotics to protect shellfish hatcheries from outbreaks of bacterial pathogens. This will be achieved by: a) documentation of our research progress using social media and Email ; b) commercialization and distribution of our technologies and c) publications in peer-reviewed journals and presentation of results at professional conferences. In addition, we will train summer undergraduate interns in microbiology and aquaculture methodologies.

The application of effective probiotic treatments will improve the reliability of hatchery production of healthy “eyed” oyster larvae for farmers. This approach will also lead to improved sustainability of US shellfish aquaculture under threat from increased ocean acidification and other adverse environmental stressors.

**Title of project**: **Staging a market come-back for West Coast groundfish**

**Project Information:** We seek federal funding of $299,898 under the "Promotion, Development, and Marketing" funding priority for a targeted marketing campaign and a supportive market research program between 09/01/18 – 08/30/19 to increase domestic demand for West Coast groundfish.

**Applicant Information**: Oregon Trawl Commission (the applicant) is seeking funds on behalf of a new cross-sector collaboration named "*Positively Groundfish*" (previously called West Coast Groundfish Marketing Initiative), of which it is a founding member. Other executive members of Positively Groundfish are: the Marine Stewardship Council, the Environmental Defense Fund and three West Coast groundfish processors – Bornstein Seafoods, Pacific Seafood and the California Shellfish Company. It is further supported by Oregon State University, Oregon Department of Agriculture, and Washington Department of Fish and Wildlife as advisory members. *Positively Groundfish*, specifically its Director, Jana Hennig, will act as the Principal Investigator of this project (contact: jana@positivelygroundfish.org). Ms. Hennig, who has 10 years of experience in marketing and sales of big food brands and holds an MBA and MS in Natural Resource Management (Oceans and Fisheries) from Stanford, will work on this project on a full-time basis.

**Project Summary**:
**The fishery is back:** The West Coast groundfish fishery has undergone a remarkable recovery since it was declared a federal disaster in 2000. Strong collaborative fishery management plans and effective compliance have resulted in rapidly recovered fish stocks, drastically reduced bycatch levels and ultimately MSC certification and positive ratings by Seafood Watch since 2014. Rockfish catch has increased from 1.4M lbs in 2010 to 21M lbs in 2017, and could double to 40M lbs in 2018. With choke species like Canary and Widow Rockfish now rebuilt, groundfish can be targeted more effectively going forward. And thanks to the latest EFP, which removed a number of outdated gear restrictions and allows for non-whiting mid-water trawl fishing from January (previously May), rockfish can again go to market reliably year-round.

**The community is still struggling**: However, this comeback story isn't complete yet. Due to two decades of absence of from retail displays, restaurant menus, cookbooks or recipe websites and no significant communication campaigns, consumers today remain largely unaware of the groundfish species' existence, their unique benefits and their incredible sustainability story. The demand that once supported the West Coast fishing communities has shifted to cheap foreign imports such as tilapia and pangasius. Even deep price cuts to match cheap tilapia have failed to generate sales lift, and alone are not enough. Today, quota attainment hovers around a meager 25% and ex-vessel prices are low. In effect, the fishery has gone from being overfished to being underutilized.

At the same time, the West Coast fishing industry faces mounting costs from increased regulation (+72% in 5 years), increased labor costs (+69% in 5 years) and debilitating repayment costs from the 2003 buy-back program, all of which are non-negotiable. Moreover, low harvest volumes keep efficiency low and cost per pound high. The industry's profits are being squeezed from both sides.

**Marketing for economic development**: Since the cost increases are largely unavoidable, the only way to solve this economic challenge is by increasing demand through promotion. Higher demand would increase utilization, improve efficiencies and profitability, and eventually, enable more investment in the fishery and keep working waterfront viable. Moreover, greater market differentiation through marketing would help fishermen attain better prices for groundfish and make it less substitutable and less vulnerable to foreign import prices. All of this would help create a positive feedback loop that brings direct economic benefits to US fishing community and industry – a stated goal of the S-K grant. Moreover, our project seeks to increase cross-sector coordination and communication, and become a model for future collaboration.

**Marketing strategy**: To catalyze demand, we have created a marketing outreach campaign that addresses the greatest barriers to demand: *low awareness* (i.e. knowing about the species, its benefits and unique story), *low trial* (i.e. having tried it, knowing what it tastes/looks like), and *low availability* (i.e. being able to find it in restaurants or stores). These are foundational enabling conditions to creating consumer demand. We specifically focus our efforts on promoting the most underutilized species that are MSC certified - rockfish and sole - in the US-domestic market. And to maximize the impact of our budget, we will focus on targeting key decision-makers (retail/institutional buyers, chefs) and influencers (food journalists, foodies, fish counter staff), who can help promote groundfish to their diners, shoppers, readers, fans and friends and help us create a food trend.

**Project objectives**:
**1. Gain market insight and baseline market performance metrics** for West Coast groundfish from the US domestic market:
**2. Increase awareness and trial** for West Coast MSC-certified rockfish and sole among decision-makers (chefs, retail/foodservice buyers) and influencers (food journalists/bloggers, foodies).
**3. Increase availability** of West Coast MSC-certified rockfish and sole in the domestic retail, foodservice and institutional market

**Marketing Outreach**: Our proposed marketing outreach follows an events-based, experiential methodology called "storied sampling", i.e. giving out high quality eating samples along with fishermen telling the story of the product, which drives awareness, trial and "talkability". "Storied sampling" enables us to control the first eating experience and engage visitors emotionally, while the "rockfish and sole tasting bar" concept showcases the variety of groundfish and versatility of the product. We will target chefs and retail/institutional seafood buyers at a minimum of eight different trade expos, hoping to gain new listings and points of distribution. Likewise, we will reach foodies and food journalists by exhibiting at 3 major public food festivals on the West Coast. And finally, we will support important new retail listings with sampling activity in a minimum of 20 retail stores along the West Coast. Targeting these groups at existing events is a highly efficient way to find and engage with target groups.

**Market Research:** We will conduct a series of baseline market research surveys across key market participant groups – consumers, chefs and fish counter staff – to better understand and quantify their awareness, usage and attitudes toward groundfish. This work has not been done before and is vital to gain a more nuanced understanding of the market challenge and inform future marketing activity. We will also invest in market data reports detailing sales and points of distribution across retail and foodservice, both before and after our campaign, which will help us evaluate our progress.

**Permits**: There are no special permits we need to obtain to carry out the proposed program.

**Project Summary**

**Title**: Gathering essential fishery information for the brown box crab, *Lopholithodes foraminatus*, to assess the potential for a new California trap fishery

**Location**: Southern California Bight (Santa Barbara to Mexican Border)

**Project Start Date**: September 1, 2018

**Amount Requested**: $279,317

**S-K Research Priority**: Promotion, Development and Marketing (Priority #3)

**Summary**
Efforts to strengthen and sustain local seafood systems, reduce trade deficits, and (re)create viable fishing careers hinge on the exploration and responsible expansion of new domestic fisheries. The brown box crab, *Lopholithodes foraminatus*, is a little utilized species that occurs from Alaska to the Mexican border and is the focus of a potential new fishery in California. Market acceptance of the product and, therefore, interest in targeting the fishery is increasing, particularly in southern California. Although some biological information on brown box crab exists, much of it comes from a few studies conducted in Oregon and British Columbia. Little is known about this species in southern California where water temperatures are higher and other environmental conditions that influence fisheries vary. Needed are biological and ecological data for this species in order to determine the feasibility of a fishery and craft responsible management strategies.

The goal of this project is to gather essential fishery information required for evaluating the feasibility of a sustainable fishery for the brown box crab, *L*. *foraminatus*, in California. Our objectives for achieving this goal are to collaboratively: 1) generate basic life history information on population size structure and growth; 2) assess reproductive capacity; 3) explore the trophic position and role in the benthic food web; and 4) identify species interactions that influence catch and bycatch.

We will use a combination of field surveys and laboratory analyses to achieve our objectives. We will work with commercial trap fishermen (our fishing partners and other box crab experimental fishery applicants) in the Southern California Bight to collect biological (Obj. 1,2) and ecological (Obj. 3,4) data. Further, we will use video cameras mounted on traps to provide supplemental data on the size of crabs and presence of other species in the vicinity of traps, that may move in and out or don't enter traps and thus are not included with the fishery-dependent data. These trap-caught data will be supplemented with trawl-caught samples providing information on inactive crabs that are not attracted to and caught in traps. Patterns of growth (Obj. 1) will be identified through cohort (size frequency distribution) analyses, molt

staging, mark and recapture and laboratory molt increment assessments, and age evaluations from microscopic examination of growth bands. Reproductive capacity (Obj. 2) will be evaluated as size at maturity, reproductive seasonality, egg production per brood, and brood development time and mortality. The trophic position and role in the benthic food web of *L. foraminatus* (Obj. 3) will be determined through a combination of stomach content and stable isotope analyses. Isotope values of likely benthic prey items also will be measured and used as a baseline. Interactions among species that influence catch and bycatch (Obj. 4) will be identified using video footage from an underwater camera system mounted on crab traps.

The information generated by this project will provide baseline data for *L. foraminatus* needed for evaluating the potential for a new fishery in California. Basic life history information will provide insights needed for management, such as identifying the size at which box crabs mature, seasonality of egg production, and how many eggs they produce that may replenish the crab population. The project findings also will help to understand potential ecological implications of the fishery that may need to be considered. For example, understanding trophic status will provide insight into their role in the food web, and the potential ecosystem-level effects of catch numbers. Behavioral information regarding species interactions around and in traps may help identify means (e.g., trap design) for reducing catch of non-targeted species and/or improving catches of box crab. It also may provide information about the California king crab, *Paralithodes californiensis*, another species of interest to our fishing partners that overlaps in distribution with the box crab.

We will inform *L. foraminatus* fishery management and educate fishing communities and the public about it using a variety of outreach methods. Through a project-end workshop, we will engage the fishing community in reviewing the project information, discussing development of a targeted fishery for box crab and identifying further research needs. Project results will be integrated into a summary report, fact sheet and peer-reviewed manuscript on the biology and ecology of the box crab and implications for management, building on information from other regions. We also will provide presentations at fisheries meetings, and develop a press release highlighting the collaborative effort and project findings.

Many will benefit from the information and products generated from this project. Resource managers will gain information that is needed to evaluate the ecological sustainability of this emerging fishery and possible management strategies (e.g., size limits, area and season closures). Resulting management decisions in turn will help sustain the resource for fishermen and the public. Commercial fishermen will benefit from proactive management actions and, if deemed feasible, a new fishery that helps to diversify their businesses. They also may benefit from Information gathered on the California king crab, another species that may support a new fishery. Through their direct engagement, they will gain skills in and knowledge about data collection that can assist with management of their fisheries. Project findings will contribute knowledge to crustacean biology, ecology and fisheries management associated with deep water ecosystems, a system little studied. More broadly, this proactive approach will provide a model for collaboratively evaluating new and emerging fisheries that balances the need for strengthening and sustaining local seafood systems while conserving marine organisms.

**Applicant:** Hubbs-SeaWorld Research Institute (HSWRI). **Principal Investigator**: Ann E. Bowles, Ph.D., Senior Research Scientist, 2595 Ingraham Street, San Diego, CA 92109. Phone: Email: abowles@hswri.org. **Partners**: Shiley-Marcos School of Engineering, University of San Diego (Dr. James Kohl, Dr. Daniel Codd)

**Title**: Monitoring Interactions and Reducing Probability of Protected Species Entanglement in Marine Aquaculture Gear: Physical Measurements and Stakeholder Workshop

**Location**: San Diego County, USA (Mission Bay; Carlsbad, CA)
**Project start date**: 7/1/18.
**Federal Funding Requested**: $250,838
**Background and Rationale**: **Priority 1, "Marine Aquaculture"**. Marine aquaculture is poised to expand greatly in U.S. waters, an important opportunity to reduce a large import/export imbalance for U.S. seafood (NOAA Fisheries 2016). Promoting this expansion is one of the priorities of the 2018 Saltonstall-Kennedy grant program. Domestic aquaculture will be in the best possible position to prosper nationally and internationally if it can guarantee that its product is produced sustainably. Some environmental concerns are already being addressed, but the potential for interactions between marine vertebrates and aquaculture nets, cages, and lines is still poorly understood. Species of concern include marine birds; bony fishes and sharks; sea turtles; sea otters; pinnipeds (seals and sea lions); and whales and dolphins.

Current best practices reduce the potential for interaction by 1) siting mariculture operations away from concentrations of protected species, 2) physically excluding predators (e.g., predator exclusion netting, bottom mounting), and 3) eliminating problematic waste. However, these measures can be defeated by accident or poorly-understood behavior of gear or animals. Once farms become widespread, they also may become attractive habitat (e.g, Fernandez-Jover et al. 2009, Sanchez-Jerez et al. 2011).

Concerns about takes in aquaculture gear have been articulated by scientists (e.g., Würsig & Gailey 2002) and management agencies (NOAA Fisheries [NOAA], U.S. Fish and Wildlife Service [USFWS]). Currently, limited information suggests that losses due to entanglement in aquaculture gear are small (e.g., Price et al. 2016), but there is concern over gaps in available information and increasing impact as U.S. marine aquaculture expands. NOAA has identified a continuing need for measurements of the properties of lines and other gear to help reduce risk (e.g., NOAA Fisheries 2015, Price & Morris 2013). The agency has also specified a need to quantify animal behavior in the presence of lines and other gear.

The few available observations of interactions between marine mammals and gear show that a quantitative approach is valuable. For example, underwater videography and measurements conducted by Northridge et al. (2013) showed that predator netting moving in real-world flow could give pinnipeds the opportunity to grasp and damage fish. Ferrari et al. (2015) found important disparities between depredation on trawls as observed underwater and activity of marine mammals and birds visible at the surface. Physical measurements have provided insights into right whale entanglement (Knowlton et al. 2016).

Appropriate best management practices will require additional basic information about interactions between marine life and aquaculture gear. Better tools are needed to characterize interactions and measure physical properties that could be used to minimize risks. The goals of this project will be to provide an in-depth review of the available information, the effectiveness of current mitigation measures, and engineering and monitoring tools likely to help reduce risks.

**A. Project Summary:**

Applicant Information:
Cal Poly Corporation (Awardee Organization)
California Polytechnic State University, San Luis Obispo (Performing Institute)
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**Project Information:**

Understanding How Climate Change Impacts Catch Rates and Composition of Nearshore Groundfish
San Luis Obispo County, central California
September 1, 2018
$299,140

**Priority:**

Priority #2: Adapting to Environmental Changes and Other Long-term Impacts in Marine Ecosystems

**Summary:**

One of the most pressing issues facing both fishers and fisheries managers is how changing ocean conditions impact the catch rates, composition, and growth of socioeconomically and ecologically important fish species (IPCC 2014). This issue is compounded for groundfish stocks on the west coast by a severe lack of data that can be applied to accurately model fish populations. By continuing to collect long-term fisheries data and using our existing information on abundance, population size-structure, and demographics of key species we propose to assess the impact of large-scale ocean perturbations (e.g., ENSO events) on the abundance and growth of nearshore groundfish species. In addition, we will build on two datasets that will be used improve models of nearshore groundfish populations (i.e., stock assessments). Last, we will use our current relationships with the local fishing community and federal stock assessors to host a workshop describing the stock assessment and quota allocation processes to commercial and recreational

fishers. This meeting will serve the dual purpose of educating anglers about these lengthy and often confusing processes while facilitating a dialogue among fishers, scientists, and resource managers. The proposed study will not only explore approaches for improving the accuracy of nearshore groundfish stock assessments, but also continue long-term datasets critical to the stock assessment process used to advance groundfish stocks from 'data-poor' to 'data moderate' or 'data rich'. Our overall goals are to foster collaboration with local commercial and recreational fishers to improve our understanding of groundfish stocks and buy-in from these stakeholders, improve the sustainability of these key fisheries, and understand the impacts of changing ocean conditions on the fishing industry.

To better understand how ocean resources will change over time due to natural and anthropogenic causes, we need high-quality, long-term datasets that have been collected in the same geographic location. Cal Poly has led two long-term groundfish monitoring projects since 2003 (Cal Poly Observer Project, CPOP) and 2007 (California Collaborative Fisheries Research Program, CCFRP). Both datasets have been obtained in collaboration with the local commercial passenger fishing vessel (CPFV) fleet, recreational anglers, university researchers, and National Marine Fisheries Service (NMFS) stock assessment scientists. The data collected from these high-value, ongoing projects have been used to improve current stock assessments conducted by NMFS scientists by refining estimates of population dynamics and demographics for nearshore groundfish species including many in the genus *Sebastes*, as well as for Lingcod and Cabezon. However, these data have utility beyond improving stock assessments, since long-term data sets like these are critical to furthering our understanding of the impact of large-scale environmental perturbations to natural systems. In fact, datasets of this nature are some of the only tools for us to ground truth how environmental changes may impact managed stocks. We propose to extend the use of these valuable datasets by NMFS as well as its relevance to the fishing fleet by improving our understanding of the impacts of large scale environmental changes to socioeconomically and ecologically important groundfish stocks.

The eastern Pacific Ocean was exposed to two anomalous warm water events between 2013 – 2016 (the warm water 'Blob' and the strongest El Niño in nearly two decades). These warm water events have a wide variety of impacts on nearshore marine ecosystems (e.g., Jacox et al. 2016, Walsh et al. 2018), and it is likely that additional impacts are yet undocumented. The impacts of large-scale ocean perturbations on adult groundfish are largely unknown, though there is some evidence that increasing water temperatures impact juvenile and adult groundfish growth and changes in currents and productivity affects recruitment (e.g., Boelert and Yoklavich 1982, Wilson et al. 2008, Caselle et al. 2010). Given the paucity of data about the impact of these types of perturbations on groundfish life history and the predicted increase in the frequency of environmental perturbations (Timmermann et al. 1999), stock assessments will benefit from additional data addressing these issues relative to groundfish. We will explore the relationships between large-scale ocean perturbations and stock assessment relevant metrics from nearshore groundfish species by utilizing long-term data sets measuring oceanographic indices (e.g., CalCOFI) in relation to our 15 and 11 year data sets.

## A. PROJECT SUMMARY

**Applicant Organization:** Catalina Offshore Products
5202 Lovelock Street
San Diego, California 92110

**Principle Investigators:** Dave Rudie - Catalina Offshore Products; Mark Helvey – Sustainable Seafood Consultants; Oriana Poindexter – Ocean Associates, Inc.

**Project title:** A Culinary Engineering Approach to Increasing the Value of Local Fisheries: Reducing Fish Discards at Sea and Promoting Full Utilization

**Pre-proposal number:** 18WCR028

**Project location:** San Diego, California

**Project start date**: September 1, 2018 to

**Funding requested**: $139,700

**Research priority:** Priority #3 - Promotion, Development and Marketing – this project will create market value that currently doesn't exist for certain species and add value to existing products.

**Species to be addressed:** Opah (*Lampris guttatus*) is a secondary target species in local fisheries from which a considerable portion of the fish is typically discarded. Other potential species include blue shark (*Prionace glauca*), common mola (*Mola mola*), longnose lancetfish (*Alepisaurus ferox*), snake mackerel (*Gempylus serpens*), Pacific barracuda (*Sphyraena argentea*) and scombrids such as Pacific mackerel (*Scomber japonicus*) and bullet mackerel (*Auxis rochei rochei*) among others. These species are typically discarded.

**Proposed activities and anticipated benefits/outcomes:** The catch of economic discards and incomplete utilization of retained species reduces the profitability to fishermen in terms of: reduced value of landings, lost bait, wasted time in removing and discarding unwanted catch, and a reduced portfolio of marketable catch. In addition, the local community is deprived of a greater range of locally sourced seafood. With a little culinary imagination, this project intends to

undertake two approaches for providing added revenue to the local fishing community by exploring the full culinary and economic potential of their catch.

The first approach is to expand an internal project undertaken by Catalina Offshore Products (COP) designed to add economic value to opah by increasing utilization of the whole fish and reducing waste. The outcome would mean that the value of opah to the fisherman is increased as more edible body parts are utilized. Expanding this project will also build the momentum of culinary appeal for a species not well known to chefs and the seafood consuming public.

The second approach is designed to develop and promote demand for fish species currently considered economic discards in two fisheries targeting highly migratory species: the drift gillnet fishery (DGN) and/or the deep-set longline (DSLL) fishery that lands their catch in California. This proposal seeks to add value to current catch by exploring and developing culinary options for particular discard species. The project provides an alternative and innovative approach for addressing National Standard 9 (Reducing Bycatch), while also contributing to national food security and self-sufficiency.

In summary, the goal of this project is to create greater demand for undervalued and underutilized species. This approach has two immediate benefits: reducing otherwise unutilized bycatch and increasing the economic value of a commercial fishing trip. The proposed project directly supports the goal of the S-K program for addressing the needs of fishing communities, optimizing economic benefits by building and maintaining sustainable fisheries, and increasing other opportunities for keeping working waterfronts viable. Both approaches also provide fresh protein and increased seafood choices for local consumers. The project is scalable to the national level.