# <u>List of NOAA Sea Grant/Ocean Acidification Program Funded Projects</u>

**Increasing hatchery production of larval eastern oysters, *Crassostrea virginica*, in the northern Gulf of Mexico through optimization of carbonate chemistry and salinity in source water**

Region: Gulf of Mexico; Federal Funding: $895,884 (35% allocated for shellfish growers)

Co-Principal Investigators:

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The Gulf of Mexico (GOM) contains the largest remaining natural oyster *(Crassostrea virginica*) reefs in the world and off-bottom oyster aquaculture is expanding in Alabama, Louisiana, Florida, Texas, and Mississippi. However, natural and anthropogenic events have converged to threaten the GOM oyster industry. In the northern Gulf of Mexico, acidification accompanied by summertime bottom water hypoxia is projected to worsen due to climate change. Freshwater discharges and unpredictable fluctuations in salinity also threaten oyster growing habitats in the Mississippi Sound and other areas in northern Gulf of Mexico. The temporal and geographic trends in salinity, carbonate chemistry, and other water quality parameters in northern GOM coastal areas from which oyster hatcheries would draw water are currently unknown. Likewise, the manner in which these multiple stressors interact and correlate with hatchery production in the northern GOM is also unknown. Therefore, **this project will investigate the effects of brackish water under different alkalinity regimes, acidification conditions, and salinities on the survival and development of larval eastern oysters**. To achieve this work, researchers from the University of Southern Mississippi, Auburn University, and Texas A&M University are partnering with shellfish growers from across the region. Water quality parameters such as temperature, salinity, pH, and dissolved oxygen will be monitored at select sites near existing and/or proposed hatcheries in the northern GOM, and the data collected will be correlated with oyster production. Laboratory experiments will also be conducted to examine the individual and combined effects of salinity and aragonite saturation levels on larval oyster survival and growth. The environmental and experimental data will be analyzed and synthesized to identify optimum conditions for oyster larval survival, and this information will then serve as the foundation for improved management strategies and specific guidelines for GOM shellfish hatcheries.

**Improving resilience of hatchery-reared blue mussels (*Mytilus edulis*) to interactive effects of ocean acidification and warming with diet and seawater buffering**

Region: New England; Federal Funding: $413,240 (17% allocated for shellfish growers)

Co-Principal Investigators:

Dr. Robert Holmberg, Research Scientist, Downeast Institute, Beals, ME

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Matt Moretti, Owner, Bangs Island Mussels, Portland, ME

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Marine ecosystems are under pressure from anthropogenic CO2 emissions, which contribute to ocean warming and, upon dissolution in seawater, acidification. The Gulf of Maine warmed faster than 99% of the global ocean between 2004-2013, and has experienced marine heatwaves during and after that period. Concomitantly, coastal seawater around Maine is expected to acidify faster than most other regions in the United States, with aragonite saturation state decreasing to 1.5 (a threshold of disruption to calcification and development in shelled mollusc larvae) by 2050. Marine bivalve aquaculture is a growing industry in Maine, yet early life stage bivalves are believed to be most vulnerable to ocean and coastal acidification (OCA) and other environmental stressors. Despite evidence that diet *restriction* will interact with OCA/warming to diminish bivalve condition in the wild, to date, no studies have inverted that premise to test whether diet *enhancement* can improve bivalve resilience to OCA/warming in the hatchery. To address this knowledge gap, **this project will test the efficacy of various alternative diet regimes to bolster *M. edulis* resilience to experimental OCA and warming, as well as test for an interaction between diet enhancement and seawater buffering on both laboratory and commercial scales.** If successful, this mitigation strategy could easily be implemented by hatcheries. The strategy could complement existing protocols for seawater buffering, or even replace buffering where equipment for monitoring and controlling seawater carbonate chemistry is prohibitively expensive. This project also seeks to strengthen an existing community of practice composed of mussel growers and researchers at the Downeast Institute and the University of Maine. By co-producing a technology transfer and outreach plan, this team will help ensure the information generated by this project reaches the shellfish aquaculture community in Maine and beyond.

**Susceptibility of Atlantic surfclams (*Spisula solidissima*) grown in the coastal ocean to multiple environmental stressors**

Region: Mid-Atlantic; Federal Funding: $518,693 (19% allocated for shellfish growers)

Co-Principal Investigators:

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Sam Martin, Chief Operating Officer, Atlantic Capes Fisheries Inc., Cape May, NJ

Tom Dameron, Government Relations & Fisheries Science Liaison, Surfside Seafood Products, Port Norris, NJ

Dr. Shannon L. Meseck, Research Chemist, NOAA Northeast Fishery Science Center, Milford, CT

In the Northeast, the Atlantic surfclam (*Spisula solidissima*) is a species that is beginning to be cultured, yet it remains underdeveloped. Advancing surfclam farming requires addressing the challenges presented by the Northeast's unique and changing coastal environment. A key unknown that this proposal aims to address is how farming this crop could be enhanced by growing it in the habitat it naturally occupies – the coastal ocean – rather than coastal backbays. Farming surfclams in the coastal ocean would make use of clean, nutrient-rich ocean habitat that is currently underutilized. However, this habitat is challenging to work in, requiring heavy vessel and coastal infrastructure. Moreover, this habitat is subject to ocean acidification and warming water conditions. Surfclams are susceptible to both of these environmental stressors independently (Narváez et al., 2015; Pousse et al., 2020), but the interactive influence of these stressors is unknown. **This project will expand our understanding of multistressors on surfclams and will provide both existing farmers and the surfclam fishing sector with commercially relevant data for use in farm-scale business planning.** The growth and survival of surfclam seed under various combinations of carbonate chemistry and temperature will be assess under controlled, laboratory conditions. The growth and survival of surfclam seed will also be assessed under commercial farm-scale conditions in the coastal ocean, where environmental parameters including $pCO_2$, pH, temperature, dissolved oxygen, chlorophyll, and salinity will be continuously recorded. Finally, this project will support an existing community of practice (composed of Rutgers University, the Northeast Fisheries Science Centers, and the surfclam fishing industry). The experimental data will identify environmental thresholds and be used in a SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis, which will help the industry refine business practices, improve culturing protocols, and inform planning, siting and development of surfclam aquaculture efforts.

**Mitigating the effects of multiple stressors in oysters: comparison of diploid and triploid *Crassostrea gigas***

Region: West Coast; Federal Funding: $672,026 (14% allocated for shellfish growers)

Co-Principal Investigators:

Dr. Jacqueline L. Padilla-Gamiño, School of Aquatic and Fishery Sciences, University of Washington, Seattle, WA

Dr. Jonathan P. Davis, Baywater Shellfish Farms, Bainbridge Island, WA

Dr. Paul McElhany, Northwest Fisheries Science Center, National Oceanic and Atmospheric Administration, Manchester, WA

Dr. Shallin Busch, Northwest Fisheries Science Center, National Oceanic and Atmospheric Administration, Manchester, WA

Ocean warming, acidification, and hypoxia are increasing threats in the world's coastal waters, with potentially severe consequences for marine organisms and ocean economies. Waters in the Northeast Pacific have naturally low pH values, making this region particularly vulnerable to the effects of acidification. While the Pacific Northwest region is a leading producer of farmed shellfish in the US, summer mortalities of Pacific oysters *Crassostrea gigas* are a growing concern for the shellfish industry. There is also an increasing concern that triploid (i.e., seedless) oysters are more sensitive to summer mortality events; this is problematic because in this region, triploids are preferred over diploids since triploids grow faster and diploids are less marketable during their summer spawning season. Previous work suggests that oyster mortalities are the result of stress associated with multiple stressors. However, not much is known about the mechanisms related to this mortality and the extent to which ploidy (number of chromosome copies) influences physiological tolerance. **Researchers at the University of Washington and the Northwest Fisheries Science Center, and shellfish growers from Baywater Shellfish will collaborate to integrate oceanographic measurements, field work, and laboratory experiments to examine the physiological tolerance and survival of diploid and triploid oysters under multiple stressors.** The natural variability of pH, temperature, and dissolved oxygen will be monitored on commercial farms and the influences of these conditions on the survival, gametogenesis and physiology of the farms' diploid and triploid oysters will be examined. The effects of pH, temperature, and dissolved oxygen on oyster performance will also be assessed in a controlled, laboratory setting. Finally, a decision tool for growers will be developed by combining economic information with the data collected from the farm and laboratory experiments. This simple-to-use planning tool will help Puget Sound shellfish growers balance the risks and benefits of planting triploid oysters (that are marketable in summer) against the potentially higher mortality of triploids compared to diploids as a function of the multi-stressor environment.