PROGRAM and ABSTRACTS

Northeast Aquaculture Conference & Exposition

and the

39th Milford Aquaculture Seminar

January 9-11, 2019
Park Plaza Hotel
Boston, Massachusetts

The 2019 NACE-MAS at a Glance

	NACE/MAS Aquaculture Conference General Program				
	Wednesday, January 9				
8:00 AM - 5:00 PM	Workshops				
	Field Trips leaving at various times (meet in the hotel lobby)				
	Trade show setup after 12:00 PM				
4:00 PM	Registration opens in the Hotel Mezzanine Level				
5:00 PM	NECAN Meeting				
7:00 PM	Opening Reception in the Grand Ballroom (trade show opens)				
	Thursday, January 10				
7:00 AM	Registration in Hotel Mezzanine Level				
8:30 AM	Plenary Session in the Grand Ballroom				
	Rapid fire industry updates of issues facing the northeastern states and maritime provinces				
10:00 AM	Break & Trade Show in the Grand Ballroom				
	Arlington	Berkley/Claredon	Hancock	Statler	Terrace
10:30 AM	**Legal Issues In Aquaculture Panel**	**Aquaculture GIS**	**Down on the Oyster Farm: Graders, Tumblers and Solar Power**	**Shellfish Ecosystems & Services**	**Aquaculture Genetics**
12:00 PM	Lunch in the Grand Ballroom				
	Arlington	Berkley/Claredon	Hancock	Statler	Terrace
1:30 PM	**Mussel Farming**	**Seaweed Farmers Forum I**	**Oyster Growers' Forum On Blister Worm Impacts**	**Aquaculture and Ecosystems**	**NRAC Symposium**
3:00 PM	Break & Trade Show in the Grand Ballroom				
	Arlington	Berkley/Claredon	Hancock	Statler	Terrace
3:30 PM	**Climate change – why should shellfish growers care and what is the Shellfish Growers Climate Coalition?**	**Growing Aquaculture Businesses**	**Scallop Farming**	**Site Selection**	**Emerging Species**
5:00 PM	Poster Session & Happy Hour in the Grand Ballroom				
	Dinner on your own out on the town				
	Friday, January 11				
7:00 AM	Registration in Hotel Mezzanine Level				
	Arlington	Berkley/Claredon	Hancock	Statler	Georgian
8:00 AM	**Offshore Aquaculture Permitting**	**Seaweed Farmers Forum II**	**Training & Workforce Development**	**Farm Management and Record Keeping Tools**	**Ocean Acidification I**
10:00 AM	Break & Trade Show in the Grand Ballroom				
	Arlington	Berkley/Claredon	Hancock	Statler	Georgian
10:30 AM	**Offshore Aquaculture Technology I**	**Effective Communication Strategies to Engage the Public About Seafood and Aquaculture**	**Training & Workforce Development Round Table DIscussion**	**Shellfish Hatchery & Nursery Technology**	**Ocean Acidification II**
12:00 PM	Lunch in the Grand Ballroom				
	Arlington	Berkley/Claredon	Hancock	Statler	Georgian
1:30 PM	**Offshore Aquaculture Technology II**	**Disease Threats in a Changing Environment I**	**Maine SEANET Reseach Results**	**Public Health Issues on the Farm**	**Economic and Management Implications of Nitrogen**
3:00 PM	Break in the Mezzanine				
	Arlington	Berkley/Claredon	Hancock	Statler	Georgian
3:30 PM	**Right Whale Interactions with Aquaculture Gear**	**Disease Threats in a Changing Environment II**	**From BUPSY to FLUPSY – Beyond Beatrix Potter in Shellfish Nursery Technologies**	**Public Health Issues on the Farm**	**Seafood certification programs - who is doing it and who cares?**
5:00 PM	Closing Refreshments in the Mezzanine				

Welcome

The NACE – MAS Planning Committee welcomes you to this joint meeting of our organizations. We hope that by bringing together industry producers, resource managers, researchers and students in an informal setting, all can share each other's knowledge on aquaculture in the northeast region.

This year's event promises to deliver a quality program with thirty-five sessions on finfish, sea vegetables and shellfish culture, three informative workshops, seven field trips to area aquafarms, research facilities and a tradeshow including major aquaculture vendors from across North America. We hope that you enjoy the meeting.

NACE-MAS Organizing Committee

Chris Davis – Maine Aquaculture Innovation Center
Lisa Milke - NOAA National Marine Fisheries Service Milford Laboratory
Rich Langton - NOAA National Marine Fisheries Service Milford Laboratory
Gef Flimlin – Emeritus Professor of Aquaculture, Rutgers University Cooperative Extension
Anne Langston – Sea to Hearth R&D

with special thanks to:
Pat Widman - NOAA National Marine Fisheries Service Milford Laboratory
Sylvia Feeney - NOAA National Marine Fisheries Service Milford Laboratory
Jennifer Bender– University of Massachusetts Boston

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National Oceanic and Atmospheric Administration Aquaculture Program
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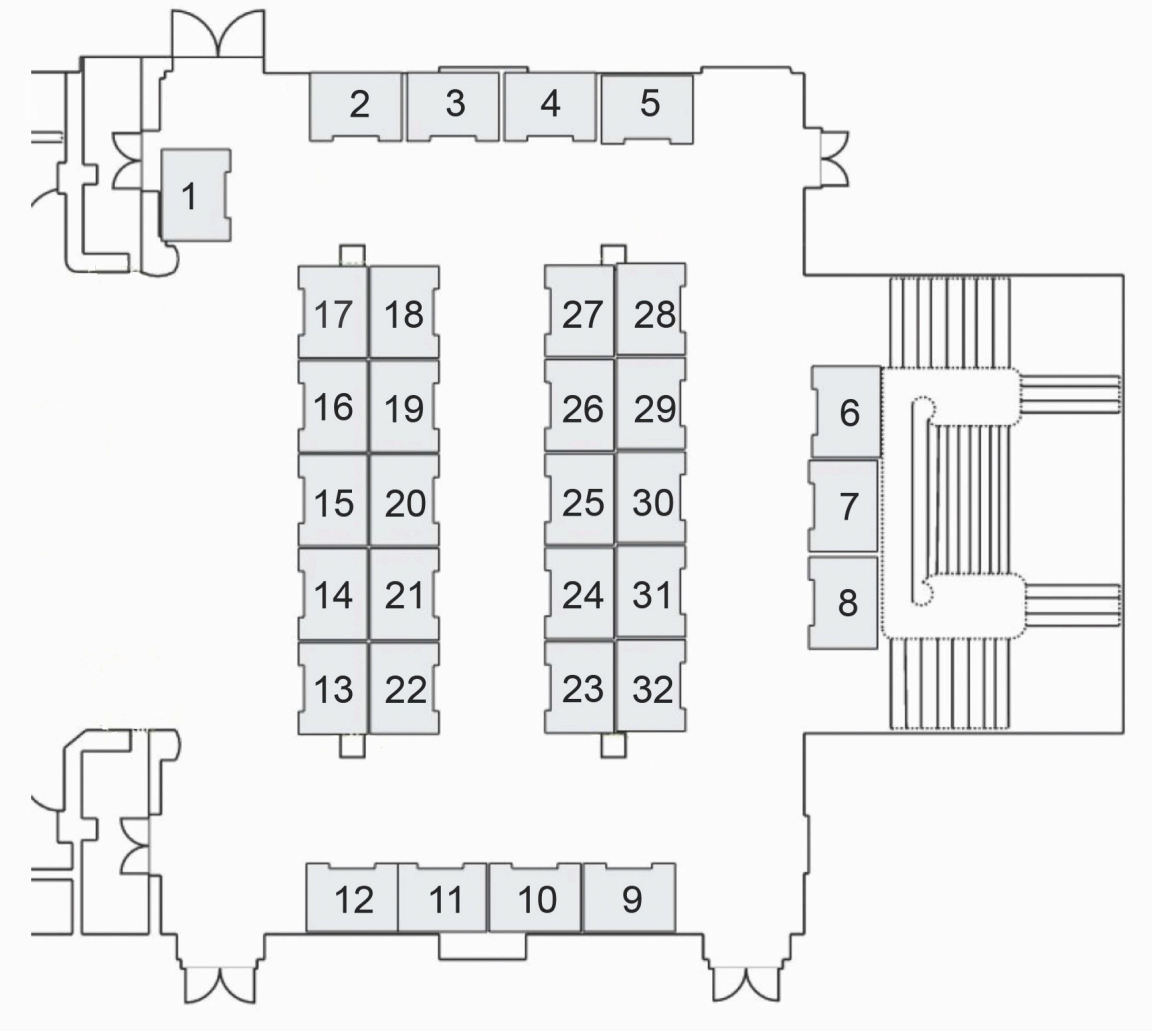
Tables are located around the Mezzanine outside the Ballroom



Program for Wednesday & Thursday Morning

	NACE/MAS Aquaculture Conference Schedule				
	Wednesday, January 9				
9:00 AM - 5:00 PM	**Workshops at various times** **Field Trips leave at vaious times (meet in the hotel lobby)** Trade show setup after 12:00 PM				
4:00 PM	**Registration opens in the Hotel Mezzanine Level**				
7:00 PM	**Opening Reception in the Grand Ballroom (trade show opens)**				
	Thursday, January 10				
7:00 AM	**Registration in the Hotel Mezzanine Level**				
8:30 AM	**Plenary Session in the Grand Ballroom**				
	Rapid fire industry updates of issues facing the northeastern states and maritime provinces				
10:00 AM	**Break & Trade Show Opens**				
	Arlington	Berkley/Claredon	Hancock	Statler	Terrace
	Legal Issues In Aquaculture Panel	**Aquaculture GIS**	**Down on the Oyster Farm: Graders, Tumblers and Solar Power**	**Shellfish Ecosystems & Services**	**Aquaculture Genetics**
	Co-Chairs: Read Porter & Lindsay Williams	*Co-Chairs: Carter Newell & Damian Brady*	*Chair: Dana Morse*	*Chair: Steve Kirk*	*Chair: Yuan Liu*
10:30 AM	This session will include a series of seven presentations on emerging legal issues affecting aquaculture in the Northeast Region. Each presentation will include a question-and-answer opportunity, and panelists will participate in a facilitated discussion to end the session. This session will not provide legal advice, but will provide information of use to growers, state regulators, researchers and others throughout the region.	Aquaculture GIS Using Shellfish Growth Models and Data From Buoys To Satellites To Improve Site Selection and Productivity of Mussels, Oysters and Sea Scallops In Maine and U.S. Waters	Oyster producers are justifiably well known for do-it-yourself equipment to do the jobs of tumbling and size sorting/grading their product. In recent years, solar power has made it on to the raft and the boat too. This 'Down on the Oyster Farm' session is a technology transfer discussion - from oyster growers to oyster growers - focused on these important pieces of production equipment. We will feature producers describing their inventions, and the pro's and con's of their use. After the presentations, all growers in the room will vote anonymously on their favorite design, and the winner will receive a copy of either The Eastern Oyster by Kennedy, Newell and Able, or Biology of Oysters, by Brian Bayne, donated by the NACE.	Science To Assess The Global Opportunity for Aquaculture To Aid Ecosystem Recovery *Seth Theuerkauf*	What We Can Learn From Environmental Dna Metabarcoding - Two Aquaculture Examples *Yuan Liu*
10:45 AM				Field Trials Using Point-Of-View Video Cameras To Quantify Fish Interactions With Oyster Aquaculture Cages and Natural Boulder Habitat *Renee Mercaldo-Allen*	Comparing Rate of Catabolic Metabolism In Diploid, Triploid, and Tetraploid Eastern Oysters *Gary H. Wikfors*
11:00 AM				Documenting Fish Behavior On Aquaculture Gear *Gillian Phillips*	Identifying Metabolite Growth Markers of Sunshine Hybrid Striped Bass (Female *Morone Chrysops* X Male *M. Saxatilis*) Through Liver Tissue Analysis *Erin Ducharme*
11:15 AM				Habitat Restoration In New Haven Harbor Utilizing Lab Cultured Oyster Sets and Reef Balls™ *Peter Solomon*	Genetics, Breeding and Genomics of Mussel Phenotypes for Aquaculture Production *Sheila Stiles*
11:30 AM				Is Oyster Aquaculture The Solution To Our Pollution Problems? *Ashley Smyth*	Progress In Genetic Improvement of Eastern Oysters *Ximing Guo*
11:45 AM				Environmental and Ecological Benefits and Impacts of Oyster Aquaculture (Chesapeake Bay, Virginia) *Andy Lacatell*	Treatment of 17beta-Estradiol and Its Metabolites To Ensure Sustainable Water Management *Jessica L. Bennett*
12:00 PM	**Lunch in the Grand Ballroom**				

Program for Thursday Afternoon

	Arlington	Berkley/Claredon	Hancock	Statler	Terrace
	Mussel Farming	**Seaweed Farmers Forum I**	**Oyster Growers' Forum On Blister Worm Impacts**	**Aquaculture and Ecosystems**	**NRAC Symposium**
	Chair: Carter Newell	*Co-Chairs: Trey Angera & Sarah Redmond*	*Chair: Paul Rawson & Dana Morse*	*Chair: Mark Dixon*	*Chair: Elizabeth Fairchild*
1:30 PM	Interannual Analysis of Reproduction and Energy Investment Within A Population of Farmed Blue Mussels (*Mytilus edulis*) *Michele Condon*	Direct Seeding of Kelp Grow Rope *David Bailey*	This forum will review the results of a recent survey of Northeastern oyster producers to determine the impacts and management options resulting from *Polydora* infestations. This will also be a venue for discussion of associated issues, including seed transfers and biosecurity, new observations on effective husbandry options, and mechanisms to aggregate observations from industry and science as tools to work toward solutions.	Ocean Food Systems: A Transdisciplinary, Ecosystems Ecology Approach To Marine Aquaculture *Barry Costa-Pierce*	What Is NRAC and How Does It Impact Me? *Reginal Harrell*
1:45 PM	Depth Suitability Assessment for Offshore Mussel Farming and *in situ* Validation *Darien Mizuta*	Epibiotic Communities On The Aquacultured Sugar Kelp *Saccharina latissima* Throughout A Growth Season *Judy Li*		Ecological Interactions of Horseshoe Crabs and Oyster Aquaculture In The Delaware Bay *Daphne Munroe*	USDA/NIFA/NRAC Aquaculture Grants Benefit The Northeast Aquaculture Industry *Elizabeth Fairchild*
2:00 PM	Serial Knots and Mesh Hemicylinders as Anti-Predator Devices On Mussel Culture Ropes *Marcel Fréchette*	Thermal Acclimation Effect On A Candidate Sea Vegetable Crop, *Alaria esculenta* *Charlotte Quigley*		Analytical Investigation of Aquaculture Farm Impacts On Estuarine Dynamics *Zhilong Liu*	Panel Conversation: How NIFA-NRAC Funding Opportunities Have and Can Continue To Address Northeast Aquaculture Needs *Elizabeth Fairchild*
2:15 PM	Analysis of an Array of Submersible Mussel Rafts In Storm Conditions *Tobias Dewhurst*	Quantifying Nitrogen Assimilation of Kelp Farms In Southern Maine *Gretchen Grebe*		Modeling Food Choice In Suspension-Feeding Bivalves *Emmanuelle Pales Espinosa*	
2:30 PM	Challenges and Solutions To Profitable Mussel Farming In Semi-Exposed Open Ocean Conditions Using Submersible Mussel Raft Technology *Carter Newell*	The Resistance of Macroalgae Including the Invasive Red Alga *Grateloupia turuturu* to Common Biosecurity Protocols *Kyle Capistrant-Fossa*		Discussion	
2:45 PM	Development of Ribbed Mussel (*Geukensia demissa*) Conditioning and Spawning Procedures *Joshua Perry*	Selectively Improving Strains of Sugar Kelp *Saccharina latissima* for Food and Fuel *Scott Lindell*			
3:00 PM	**Break in the Grand Ballroom**				
	Arlington	Berkley/Claredon	Hancock	Statler	Terrace
	Climate Change – why should shellfish growers care and what is the Shellfish Growers Climate Coalition?	**Growing Aquaculture Businesses**	**Scallop Farming**	**Site Selection**	**Emerging Species**
	Chair: Sally McGee	*Chair: Rich Langton*	*Chair: Dana Morse*	*Chair: Matthew Poach*	*Chair: Brian Beal*
3:30 PM	This session will include a presentation on the purpose and goals for the Coalition, and current and future impacts of climate change on farms and other businesses. Presenters will include Coalition members, the East Coast Shellfish Growers Association, and the Nature Conservancy. There will be ample time for questions and discussion.	Focusmaine Aquaculture Industry Growth Initiative *Chris Vonderweidt*	Bay Scallop (*Argopecten irradians*) Nursery and Growout Optimization In Diverse Environments On Cape Cod *Daniel Ward*	MA-Shellfast: A GIS-Based Tool for Shellfish Aquaculture Siting and Permitting *Read Porter*	Assessing The Potential for Aquaculture Production of Surf Clams In Southern New England *Josh Reitsma*
3:45 PM		The Massachusetts Shellfish Initiative (MSI): Developing A State-Wide Plan for Maximizing Economic, Environmental, and Social Benefits of Shellfish Resources In Massachusetts *Scott Soares*	Infection Dynamics and Mitigation Strategies of A Marine Macroparasite In Bay Scallop Aquaculture *Harrison Tobi*	Identifying Efficencies In Aquaculture Review Through The Development of A State-Wide Aquaculture Permitting Plan for Massachusetts *Chris Schillaci*	Diversifying The Northeast's Aquaculture Sector By Developing Culture Techniques for The Atlantic Surfclam (*Spisula solidissima*) *Michael Acquafredda*
4:00 PM		Maine Commercial Demonstration Oyster Farm *Chris Vonderweidt*	Advancing Purple-Hinge Rock Scallop Aquaculture In The Pacific Northwest *Joth Davis*	Optimizing Site Selection for Kelp-Oyster Cultivation Systems In Rhode Island *Lindsay Green-Gavrielidis*	Arctic Surfclams, *Mactromeris polynyma*: Growth and Survival of Cultured Juveniles Along The Maine Coast *Brian Beal*
4:15 PM		Growing Export Markets *Colleen Coyne*	Maine Scallop Aquaculture Development Initiative: Community Development Through International Tech-Transfer *Hugh Cowperthwaite*	Opportunities for Aquaculture On The Massachusetts South Coast: A Sector Analysis *Nick Branchina*	Cost Effective Production of Blue Mussel, *Mytilus edulis* , Seed for Rope Culture: A Hatchery Solution *Kyle Pepperman*
4:30 PM		Europe's Oyster Market & Trade Opportunities *Alexander Wever*	Update on Scallop Spat Collection and Biotoxin Testing in Maine *Dana Morse*	The Business of Floating Aquaculture: Reduced Mortality, Fouling Management and Floating Best Practices *Ben Lord*	Atlantic Razor Clams, *Ensis leei* , An Emerging Aquaculture Species: Field and Laboratory Trials With Cultured Juveniles In Eastern Maine *Brian Beal*
4:45 PM		DIscussion	Discussion	South Portland Pier Aquaculture and Fishing Industry Needs Assessment *Chris Vonderweidt*	Soft-Shell Clam, *Mya arenaria* , Aquaculture In Maine: Can Barriers Be Overcome To Encourage Farming Enterprises? *Brian Beal*
5:00 PM	**Poster Session & Happy Hour in the Grand Ballroom**				
6:00 PM	**Dinner on your own out on the town**				

Program for Friday Morning

	Friday, January 11				
7:00 AM	**Registration in the Hotel Lobby**				
	Arlington	Berkley/Claredon	Hancock	Statler	Georgian
	Offshore Aquaculture Permitting	**Seaweed Farmers Forum II**	**Training & Workforce Development**	**Farm Management and Record Keeping Tools**	**Ocean Acidification I**
	Co-Chairs: Dan Giza, Tim Hogan & Kevin Madley	*Co-Chairs: Trey Angera & Sarah Redmond*	*Co-Chairs: Anne Langston & Chris Vonderweidt*	*Chair: Josh Reitsma*	*Co-Chairs: Meredith M White & Carolina Bastidas*
8:00 AM	Epa's Role In Regulating Offshore Aquaculture *Eric Nelson*	Investigating The Viability of *Gracilaria tikvahiae* As A Candidate Species for Commerical Aquaculture In Connecticut *Anoushka Concepcion*	A New, International Ocean Food Systems Professional Science Masters At The University of New England *Barry Costa-Pierce*	From environmental data like temperature and salinity to husbandry practices, equipment usage and team management there is a ton of data you could collect on a farm. Likewise, there are a number of ways to collect and use that information, which will vary from operation to operation. This workshop will have several growers explain their current systems of farm management and record keeping with open discussion of merits and caveats encouraged. These will range from traditional methods to more emerging technology. Also included will be discussion on important data to collect on your farm, including input on records important for farm tools like USDA Risk Management programs.	Chemical Changes In The Environment: What Does This Mean To Shellfish? *Shannon Meseck*
8:15 AM	NOAA Fisheries Offshore Marine Aquaculture Permitting Role and Support *Kevin Madley*	Investigating Potential Supply Chains for Seaweed Production In The Northeast United States *Dawn Kotowicz*	Educating Future Seafood Producers: Seafood Science and Aquaculture Curriculum Development and Dissemination *Michael Ciaramella*		Linking Regional Ocean and Coastal Acidification Research Efforts With Community Stakeholders and Aquaculture Industry Water Monitoring *Parker Gassett*
8:30 AM	Announcing The Ocean Reporting Tool: A Web-Based Automated Spatial Analysis Tool To Inform Permitting of Offshore Aquaculture *James Morris*	Sustainable Post-Harvest Processing and Value-Addition of Aquacultured Seaweed *Balu Nayak*	Building A Skilled Seafood Workforce: Fish To Dish Education and Internship Program *Michael Ciaramella*		Effects of Repeated Exposure To Ocean Acidification On Juvenile Pacific Geoduck *Panopea generosa* *Samuel J. Gurr*
8:45 AM	The Northeast Ocean Data Portal - A Resource for Decision-Making *Nicholas Napoli*	An Ecosystem Approach to Seaweed Aquaculture, Valuing Ecosystem Services, or What's a Cow Burp Worth? *Tammy Murphy*	RI Aquaculture Training Partnership *Cameron Ennis*		Forecasting Coastal Waters In The Northeast *Parker Gassett*
9:00 AM	Aquaculture Gear and Protected Species Risk In New England *Hauke Kite-Powell*	Effects of Particle Size On The Bio-Accessibility of Bioactive Compounds of Sugar Kelp (*Saccharina latissima*) In An *in-vitro* Simulated Gastrointestinal Tract (GIT) Model *Praveen Sappati*	Maine Aquaculture Statewide Training Strategy *Chris Vonderweidt*		A Slow Growing Perspective On Multi-Generational Responses To Future Change. *Coleen Suckling*
9:15 AM	Offshore Finfish Site Selection In The Northeast United States of America - A Deep Dive Into Manna Fish Farms Site Selection Process. *Donna Lanzetta & James Morris*	Round Table Panel Discussion	Things you Should Know about Aquaponics before Investing *Joe Butner*		Effects of Ocean Acidification On The Physiology of Subadult American Lobsters *Amalia Harrington*
9:30 AM	Permitting An Offshore Mussel Farm In Federal Waters In The Gulf of Maine: A Case Study *Edward (Ted) Maney Jr.*		Aquaculture in Shared Waters Training Program *Chris Davis & Dana Morse*		Projected Impacts of Future Climate Change, Ocean Acidification, and Management On The Us Atlantic Sea Scallop (*Placopecten magellanicus*) Fishery *Jennie Rheuban*
9:45 AM	Discussion		Prototype Aquaculture Business Accelerator Program *Chris Vonderweidt*		Kelp Farming As A Potential Strategy for Remediating Ocean Acidification and Improving Shellfish Cultivation *Brittney L. Honisch*
10:00 AM	**Break in the Grand Ballroom**				
	Arlington	Berkley/Claredon	Hancock	Statler	Georgian
	Offshore Aquaculture Technology I	**Effective Communication Strategies to Engage the Public About Seafood and Aquaculture**	**Training & Workforce Development Round Table Discussion**	**Shellfish Hatchery & Nursery Technology**	**Ocean Acidification II**
	Co-Chairs: Rob Vincent & Mike Chambers	*Chair: Tessa Getchis*	*Co-Chairs: Anne Langston & Chris Vonderweidt*	*Chair: David Veilleux*	*Co-Chairs: Meredith M White & Carolina Bastidas*
10:30 AM	Design Considerations for A Kelp Longline Exposed To Waves and Currents *Tobias Dewhurst*	Communicating Aquaculture: The Role of Media & Informal Education Institutions On Public Perceptions *Kristen Jabanoski*	As the aquaculture sector has grown across the Northeast, so have training and workforce development programs been developed. We invite anyone and everyone teaching, participating in, or simply interested in aquaculture training programs to join this roundtable discussion and share details of your training and workforce development programs, tell us about your training experience, meet fellow educators , explore the use of technology to enhance training and create cross-institutional connections.	Introducing a New Disinfectant for U.S. Aquaculture - Peracetic Acid *Dave Straus*	Recirculating Aquaculture Systems and Their Use With Ocean Acidification Research *Robert Harrington*
10:45 AM	Monitoring of Macroalgae Farms With Autonomous Underwater Vehicles *Erin Fischell*	Aquaculture Tours for The Public Rhode Island: Opportunities for Cross-Learning and Conflict Resolution *Azure Cygler*		Managing Bacterial Shellfish Pathogens In Commercial Hatcheries: Advances In Probiotic Research At NOAA's Milford Laboratory Through Public and Private Partnerships. *Diane Kapareiko*	Population Differences In Response To Ocean Acidification In Blue Mussels - It Is Not All Bad News *Dianna Padilla*
11:00 AM	Development of An Integrated Multi-Trophic Aquaculture Raft for Inshore and Offshore Use. *Corey Sullivan*	Public Knowledge, Perceptions, and Preferences Towards Connecticut Wild-Caught and Farmed Seafood *Tessa Getchis*		Effects of Probiotics and Pathogen On *Crassostrea virginica* Larval Immunity. *Tejashree Modak*	Evaluating Gene Expression Responses of The Eastern Oyster, *Crassostrea virginica* , Under Ocean Acidification *Alan Downey-Wall*
11:15 AM	An Instrument for Measuring *in-situ* Tensions In Mooring System Aquaculture Gear. *David Fredriksson*	Developing Aquaculture Approaches for Communities and Stakeholders Engagement and Resiliency *Elizabeth Hayes*		Coculture of Probiotic Bacteria In Algal Feedstocks for Disease Management In Bivalve Hatcheries *Samuel Hughes*	Assessment of The Aquaculture Industry's Questions and Priorities Regarding Ocean Acidification Research Directions *Meredith M White*
11:30 AM	Design of Offshore Infrastructure for Continuous Production of Kelp *Zach Moscicki*	DIscussion		Cornell Cooperative Extension of Suffolk County Algae Expansion *Joshua Perry*	Industry discussion on concerns and priorities for OA research and management
11:45 AM	A 3D Numerical Model to Simulate the Dynamics of Longline Kelp Farms In Waves *Longhuan Zhu*			Converting Algae Hatchery Art Into Technology *William van der Reit*	
12:00 PM	**Lunch in the Grand Ballroom with guest speaker Dr. Sean Birkel, Maine State Climatologist**				

Program for Friday Afternoon

12:00 PM	**Lunch in the Grand Ballroom with guest speaker Dr. Sean Birkel, Maine State Climatologist**				
	Arlington	Berkley/Claredon	Hancock	Statler	Georgian
	Offshore Aquaculture Technology II	**Disease Threats in a Changing Environment I**	**Maine SEANET Reseach Results**	**Public Health Issues on the Farm**	**Economic and Management Implications of Nitrogen**
	Co-Chairs: Rob Vincent & Mike Chambers	*Co-Chairs: Bassam Allam & Caroline Schwaner*	*Chair: Meggan Dwyer*	*Chair: Christopher Schillaci*	*Chair: Steve Kirk*
1:30 PM	Investigating Helical Anchors for Aquaculture Anchoring Systems *Melissa Landon*	Shellfish Health In A Changing Environment *Bassem Allam*	Evaluating and Sourcing Detritus As A Supplementary Diet for Bivalve Aquaculture *Adrianus Both*	Assessment of Microbiological Pathogens On Sugar Kelp *Saccharina latissima* Farmed In Coastal Waters of Maine *Olivia Barberi*	High Density Aquaculture for Nitrogen Removal In Impaired Estuaries *Eric Karplus*
1:45 PM	Selecting The "Right" Finfish Species for Manna Fish Farms' Offshore Finfish Aquaculture Permitting In The Northeast United States of America *Donna Lanzetta*	A Histopathological Survey of Stress Conditions and Parasites in Farmed Blue Mussels (*Mytilus edulis*) in a Changing Gulf of Maine *Connor Jones*	Maine Seanet: Carrying Capacity and Food Web Interactions on Bivalve Farms *Carrie Byron*	Effect of Gear Type and Season On *Vibrio parahaemolyticus* and *V. vulnificus* In Farm-Raised Oysters (*Crassostrea virginica*), After Routine Handling *Victoria Pruente*	A Multidisciplinary Approach to Determine the Nutrient Bioextraction Value of Commercially Aquacultured Shellfish: A Pilot Study In Greenwich, CT USA *Mark S. Dixon*
2:00 PM	An Update On Results From Offshore Shellfish Aquaculture In Federal Waters of The Atlantic *Edward (Ted) Maney Jr.*	The Dynamics of The Atlantic Sea Scallop (*Placopecten magellanicus*) Infection of The Apicomplexan Parasite *Merocystis kathae* *Allex Gourlay*	Survival of Foodborne Pathogens During Production and Shelf Life of Fresh, Value-Added Seaweed Products *Jennifer Perry*	Effects of Massachusetts and Rhode Island *Vibrio* Control Plan Regulations On *Vibrio parahaemolyticus* In Post-Harvest Eastern Oysters (*Crassostrea virginica*) *Mattison Peters*	Nutrient Bioextraction Initiative: Removing Excess Nitrogen In NY and CT Waters Through Aquaculture *Nelle D'Aversa*
2:15 PM	Automated Tools for Detecting Entanglement Risks Associated with Aquaculture *Peter Vonk*	Ocean Acidification Increases Susceptibility To Infection In The Eastern Oyster (*Crassostrea virginica*) and Northern Quahog (*Mercenaria mercenaria*) *Caroline Schwaner*	Overwintering Strategies of the Salmon Louse *Lepeophtheirus salmonis* *Ian Bricknell*	A panel of diverse industry professionals, state regulatory authorities, and researchers will discuss these emerging requirements, the science behind them, and how growers are adapting to this evolving landscape. *Christopher Schillaci*	Estimation of Monetary Values Associated With Nitrogen Sequestration and Removal Functions of Clams and Oysters: An Allocated Replacement Cost Approach *Anthony Dvarskas*
2:30 PM	Minimizing Interactions With Protected Species Through Gear Design and Monitoring Efforts At An Offshore Shellfish Farm In Federal Waters In The Gulf of Maine *Edward (Ted) Maney Jr.*	Investigating The Role of Apoptosis In Disease Resistance to Dermo In the Eastern Oyster, *Crassostrea virginica* *Erin Roberts*	Examining Attitudes and Willingness To Pay for Aquacultured Seafood Attributes *Kofi Britwum*		The Role for Shellfish Aquaculture Practices In Regulatory Nitrogen Reduction On Cape Cod, MA *Sara Burns*
2:45 PM	Enabling Technologies In Open Ocean Mariculture Farming Platforms *Felipe Ramirez*	Detection of *Bonamia exitiosa* In American Oysters (*Crassostreae virginica*), a New Host Species *Cem Giray*	Impact of Product Presentation Strategy On Consumer Behavior In The Seafood Market *Olga Bredikhina*		Discussion
3:00 PM	**Break in the Mezzanine**				
	Arlington	Berkley/Claredon	Hancock	Statler	Georgian
	Right Whale Interactions with Aquaculture Gear	**Disease Threats in a Changing Environment II**	**From BUPSY to FLUPSY – Beyond Beatrix Potter in Shellfish Nursery Technologies**	**Public Health Issues on the Farm**	**Seafood certification programs - who is doing it and who cares?**
	Chair: Matthew Thompson	*Co-Chairs: Bassam Allam & Caroline Schwaner*	*Co-Chairs: Dale Leavitt & Chris Davis*	*Chair: Christopher Schillaci*	*Chair: Sebastian Belle*
3:30 PM	Panel Discussion on the Risk of Entanglement Between The North Atlantic Right Whale and Suspended Marine Aquaculture: Learning From Fixed Gear Fisheries, With A Focus On Knowledge Gaps Needed for The Aquaculture Industry.	Managing Marine Aquaculture Health in a Changing World *Ryan Carnegie*	Development of Experimental and Computational Methods for Improving Upweller Flow Characteristics *Andrew Goupee*	Continuation of Public Health Issues on the Farm Panel Discussion	This session will provide an overview of the various certification programs with respect to the technical areas they cover, and methods they use to provide assurances in a rapidly evolving and complicated production environment. A panel of buyers and growers will follow with a discussion of how markets are responding to the various programs and what challenges may occur that reduce buyer and grower engagement.
3:45 PM		East Coast Molluscan Health Initiative Part 1: The Database *David Bushek*	The floating upweller system (FLUPSY) has been in common use in the northeast for the past 20 years or more and during that time there have been numerous modifications to the technology to make it more productive. More recently, the bottle upweller system (BUPSY) has started to see more use as a nursery culture technology preceding the conventional upweller stage. This workshop will cover our current state of knowledge with these technologies and will offer strategies to make these systems work more effectively. Included will be examples of current designs and modifications to off-the-shelf systems that make them more user friendly.		
4:00 PM		East Coast Molluscan Health Initiative Part 2: Hatchery Certification *Lisa Calvo*			
4:15 PM		East Coast Molluscan Health Initiative Part 3: Interactive Database Demo *Lucas Marxen*			
4:30 PM					
4:45 PM		Discussion			
5:00 PM	**Closing Refreshments in the Mezzanine**				

Friday Luncheon Address on Climate Change with

Dr. Sean Birkel, Maine State Climatologist

Sean Birkel is a Research Assistant Professor at the University of Maine with joint appointments to the Climate Change Institute and School of Earth and Climate Sciences. Since 2014, Birkel has been the Maine State Climatologist, a position in which he collaborates with NOAA, and provides climate information and interpretation to Maine stakeholders. Birkel's research utilizes climate modeling, analysis, and data visualization to study past, present, and future climate. Although most of his work is computer-based, Birkel has also participated in field research in Antarctica, New Zealand, the Wind River Range, WY, and Sierra Nevada, CA. Birkel recently co-authored Coastal Maine Climate Futures, a report that defines plausible future climate scenarios 2020-2040 based on impacts from greenhouse-gas warming and known variability within the climate system. Since 2012, Birkel has been developing the data visualization website Climate Reanalyzer (https://Climate Reanalyzer.org), which sees ~2,000 users daily, and has garnered more than 5 million page views since its inception. Birkel advises graduate students and has taught graduate courses in climate analysis and climate modeling at the University of Maine.

ABSTRACTS OF ORAL PRESENTATIONS AND POSTERS

DIVERSIFYING THE NORTHEAST'S AQUACULTURE SECTOR BY DEVELOPING CULTURE TECHNIQUES FOR THE ATLANTIC SURFCLAM (*SPISULA SOLIDISSIMA*)

Michael P. Acquafredda[1,2], Daphne Munroe[1], Lisa Calvo[1], Michael De Luca[2]. Haskin Shellfish Research Laboratory, Rutgers, The State University of New Jersey, 6959 Miller Avenue, Port Norris, New Jersey 08349; New Jersey Aquaculture Innovation Center, Rutgers, The State University of New Jersey, 3920 Bayshore Road, Cape May, NJ 08204

Throughout much of the northeast region of the United States, shellfish aquaculture is dominated by only two species: the hard clam (*Mercenaria mercenaria*) and the Eastern oyster *(Crassostrea virginica*). Despite this, local shellfish farmers are eager to diversify and have expressed interest in culturing new species. The Atlantic surfclam (*Spisula solidissima)* represents a potentially beneficial target species for crop diversification because it is native, grows rapidly, and fits into the established farming framework. However, remaining gaps in the surfclam husbandry literature have left aquaculture practitioners without a complete understanding of how to best cultivate this species on a commercial scales. We have conducted a series of experiments related to surfclam husbandry in order to optimize the production of this species for the Northeast. Specifically, we have examined how various nursery and grow-out phase techniques and local environmental conditions impact surfclam performance (i.e. survival, growth, condition) throughout its developmental stages. We have assessed early juvenile rearing temperature, nursery phase gear types, grow-out phase locations, shelf life, and many other core components of surfclam production. We have worked closely with stakeholders, from shellfish farmers to chefs, who envision farm-raised surfclams as a possible future addition to the region's seafood marketplace. The various studies of this project will be developed into a surfclam culture handbook, which will be available to interested aquaculturists across the Northeast.

SHELLFISH HEALTH IN A CHANGING ENVIRONMENT

Bassem Allam. School of Marine and Atmospheric Sciences, Stony Brook University, Stony Brook, NY

Broad and profound ecosystem alterations have been described throughout the globe as a result of climate change. In this presentation, a few examples of the impacts of climate alterations on the health of a select number of shellfish species in the northeastern United States will be described. For example, the northern range of the most devastating microbial parasites of oysters (*Crassostrea virginica*) is expanding and this expansion was linked to the warming trends in the region (e.g. Dermo disease caused by *Perkinsus marinus*). In parallel, changes in precipitation regimes associated with projected climate alterations may cause the loss of disease refugia by lowering salinities in some estuaries below thresholds needed for oyster survival. The Atlantic surfclam (*Spisula solidissima*) is yet another species that has been suffering from increasing temperatures in the region, where significant decline in surfclam abundance was reported in near-shore waters from NY to VA. Field and laboratory studies confirmed the negative impact of ecologically-relevant high temperatures on surfclam scope for growth, reproductive effort, and immune performances. Ocean acidification represents another facet of global change and the negative effect of acidification on the physiology of calcifying organisms has been showcased in a large number of studies in the last decade. But global climate alterations may also have unexpected benefits as in the case of QPX disease in the hard clam (*Mercenaria mercenaria*) where beneficial impacts of warming trends on clam health were noticeable. Despite this willingly optimistic final note, the predicted future of shellfish resources in the Northeast is worrisome and calls for immediate mitigation actions wherever possible.

DIRECT SEEDING OF KELP GROW ROPE

David Bailey[1], Clifford A. Goudey[2], Domenic Manganelli[2], Scott Lindell[1]. [1]AOPE Department, Woods Hole Oceanographic Institution, 266 Woods Hole Rd, MS# 34, Woods Hole MA 02543; [2]C.A. Goudey & Associates, 21 Marlboro Street, Newburyport, MA 01950

The expansion of kelp farming beyond artisanal scale will require the development of methods that are less labor-intensive and amenable to mechanization. One aspect that is ripe for improvement is seeding and field planting. The traditional method involves the use of small-diameter seed-string (1 to 2 mm) wound on PVC tubes on which freshly released meiospores settle. It is an attractive method because it can be done in small, laboratory-scale aquaria and needs only modest amounts of sterilized seawater and nutrients. However, the method requires the seed-string to be applied to the grow-rope in the field once the sporophytes have reached a certain size (1-2mm), a very weather-dependent and delicate process that often results in sporadic attachment and yields.

Two different methods are being tested that eliminate the labor and risk associated with the traditional seed-string method. The first method involves the settling of meiospores and the culture of sporophytes directly on the grow-rope. Key to the method is the use of collapsible frames purposed-designed to hold lengths of grow-rope in a compact geometry that allows the efficient use of hatchery tank volume. This collapsible frame can be uncollapsed for quick rope unspooling and deployment on the farm. The second method involves attaching gametophytes or sporophytes directly to the grow-rope using a binder, then directly out-planting. Experiments are being conducted to determine the best binder, which stage of the kelp life cycle to attach, seeding densities, and binder drying times.

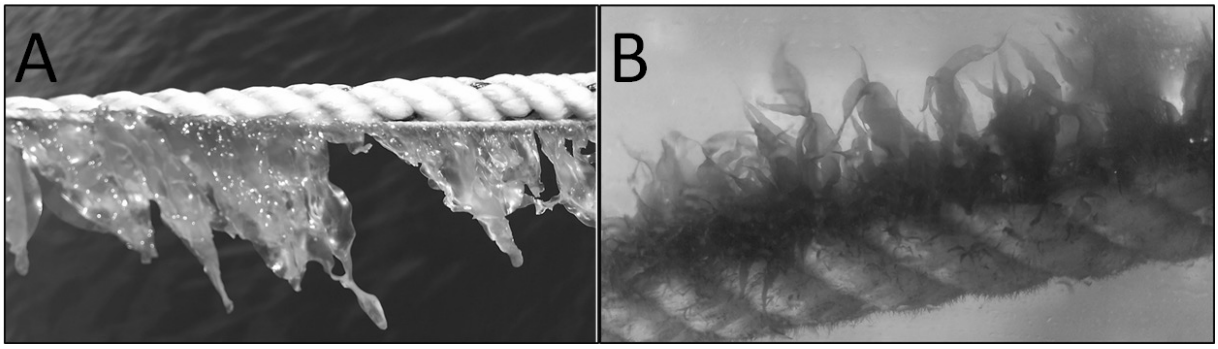


Figure 1. A. Kelp grow-rope with traditional seedstring. B. Kelp growline with sporophytes directly seeded on grow-rope

ASSESSMENT OF MICROBIOLOGICAL PATHOGENS ON SUGAR KELP *SACCHARINA LATISSIMA*FARMED IN COASTAL WATERS OF MAINE

Olivia Barberi[1], Carrie Byron[1], Kristin Burkholder[2], Adam St. Gelais[3], Alicia Williams[1].
[1]Marine Science Department, University of New England, Biddeford, ME 04005; [2]Biological Sciences, University of New England, Biddeford, ME 04005; [3]Center for Excellence in the Marine Sciences, University of New England, Biddeford, ME 04005

Kelp aquaculture is a growing industry in Maine, however there are no established methods or regulations regarding food safety of the farmed product. Bacterial pathogens may persist in waters where kelp farms are sited and could contaminate kelp grown for human consumption. The FDA prohibits bivalve aquaculture in some coastal areas due to bacterial contamination of growing waters, but kelp's winter farming season, lack of filter feeding, and suggested antibacterial properties call into question whether bivalve regulations are appropriate for kelp. This research aims to identify the relationship between water quality and kelp harvested nearshore. Sugar

kelp and water were sampled from Saco and Casco Bay kelp farms during February-May 2018.*Vibrio parahaemolyticus, V. alginolyticus* and/or *V. cholerae*, total coliforms, and *Escherichia coli* were enumerated through membrane filtration onto selective media. Minimal or no pathogens were present on kelp and were often in lower abundance on kelp than in water, suggesting that kelp should be sampled directly. Most fecal coliform counts were below the threshold set for bivalve harvest. Bacterial abundance did not vary significantly between sampling sites or dates, other than for *V. parahaemolyticus* on kelp between sites. qPCR analysis of microbiologically-enriched kelp samples improved detection of *V. parahaemolyticus* and enterohemorrhagic *Escherichia coli* (EHEC) on some dates. This work provides preliminary data needed to inform best management practices for kelp aquaculture and to help mitigate public health concerns with consumption of sea vegetables. Importantly, it also establishes methods for the detection of human pathogens on kelp tissue.

EVALUATING WATER QUALITY AT THE SITE OF A POTENTIAL OYSTER HATCHERY IN RHODE ISLAND

Joseph Barnes[1], Lindsay Green-Gavrielidis[2], Justine Sauvage[3], Perry Raso[4], Marta Gomez-Chiarri[1]. [1] Dept. of Fisheries, Animal, and Veterinary Science, University of Rhode Island, Kingston, RI; [2]Department of Natural Resources Science, University of Rhode Island, Kingston, RI; [3] Dept. of Marine Sciences, University of Gothenburg, Göteborg, Sweden; [4]Matunuck Oyster Farm, Matunuck, RI

As shellfish aquaculture demand increases, Rhode Island businesses are expanding production of the Eastern oyster, *Crassostrea virginica*. The goal of this research was to determine suitability of a target site for a shellfish hatchery by evaluating water quality. Three trials were run by placing oyster larvae in a gradient of raw water from the hatchery site, filtered through different pore sizes (0.25 μM, 5 μM, and 50 μM, and unfiltered), and water from a different site filtered to 0.25 μM (control). Larvae were counted over time and the number of alive and dead larvae was determined. We then calculated overall survival rates of each treatment per trial. Trial 1 showed a 0% survival rate by day 16, likely from starvation since the larvae were not fed in this trial. Trial 2 indicated the potential presence of pathogenic bacteria such as ciliates or *Vibrio* spp., since water filtered below 50 μM had higher survival rates. Trial 3 indicated a probiotic approach, where beneficial bacteria were filtered out below 5 μM leading to lower survival rates in these water treatments. Statistical and water analysis will show which factors are primarily responsible for larval survival. For a new oyster hatchery, the optimal filtration gradient must be cost efficient to the business, and ensure the safety of the larvae. More experiments with water filtered through pore sizes between 1 μM and 50 μM should be conducted to find a balance between leaving beneficial microbes and filtering out harmful bacteria.

ARCTIC SURFCLAMS, *MACTROMERIS POLYNYMA*: GROWTH AND SURVIVAL OF CULTURED JUVENILES ALONG THE MAINE COAST

Brian Beal[1], Cody Jourdet[2], Bennett Ellis[2], Kyle Pepperman[2], Justin Lewis[2]. [1] University of Maine at Machias, 116 O'Brien Avenue, Machais, ME 04654; [2] Downeast Institute, 39 Wildflower Lane, Beals, ME 04611

Arctic surfclams, *Mactromeris polynyma*, occur from Labrador to Rhode Island in offshore waters at depths to 65 m. A major commercial fishery exists in Canada southeast of Cape Breton Island, Nova Scotia (Banquereau Bank) and southeast of Newfoundland (Grand Bank) where reported annual landings exceed $50 million. Surfclams (9-12 cm; 20-40 yrs old) are processed at sea by blanching the whole animal, after which the feet (that turn from a deep purple to reddish/orange) are separated from other tissues, and are packaged and sold as "hokkigai." While exports of Arctic surfclams to the US from Canada represent < 2% of the commercial harvest, the goal of our work is to increase the supply, quality, and diversification of domestic seafood to help the US

seafood trade deficit, which was $21.5 billion in 2017. We have been culturing *M. polynyma* since 2010, and have discovered that they can be grown in the lower intertidal zone in eastern Maine where survival generally is size-specific and growth to 4 cm requires about 3 years. Traditional methods of seeding intertidal plots by broadcasting cultured juveniles onto the mudflat surface followed by securing protective, flexible netting (4.2 mm aperture) around the plot (as with cultured juveniles of the soft-shell clam, *Mya arenaria*) has failed repeatedly. We examined growth and survival of cultured *Mactromeris* juveniles at 15 intertidal locations from Kittery to Lubec (the entire coast of Maine) from late summer 2016 to spring 2017. We will report on which locations surfclams performed best.

ATLANTIC RAZOR CLAMS, ENSIS LEEI, AN EMERGING AQUACULTURE SPECIES: FIELD AND LABORATORY TRIALS WITH CULTURED JUVENILES IN EASTERN MAINE

Brian Beal[1], Cody Jourdet[2], Bennett Ellis[2], Bryce Kadis[2]. [1] University of Maine at Machias, 116 O'Brien Avenue, Machais, ME 04654; [2] Downeast Institute, 39 Wildflower Lane, Beals, ME 04611

The Atlantic razor clam, *Ensis leei* (= *directus*), occurs in the northwest Atlantic extending from South Carolina to Labrador. In the northeast US, razor clams live in the lower intertidal and shallow subtidal zone, and are harvested commercially, especially during winter months. In Maine, where landings are not routinely reported, the fishery has mirrored that in Massachusetts where, in 2015, $1.8 million pounds were landed. Maine's two largest bivalve fisheries, soft-shell clams and hard clams, have seen dramatic declines in landings (ca. 40%) over the past three decades that has enticed more activity in the razor clam fishery with prices nearly $5/pound in 2017-2018. We have cultured razor clam juveniles for the past two years, and have begun examining some factors affecting growth and survival in the hatchery and field. During the summer of 2018, we conducted two month-long manipulative experiments in the hatchery to examine post-settlement growth and survival. Exp. I focused on interactive effects of flow rates and density while Exp. II examined the effect of different substrates (reticulated foam vs. sand vs. no substrate). We designed two factorial field experiments. Exp. III tested interactive effects of reticulated foam (+ vs. -) and predator deterrent netting (+ vs. -), while for Exp. IV we manipulated sediment (+ vs. -) and reticulate foam (large vs. small pores) in two habitats (benthic-intertidal vs. floating-subtidal). In general, survival was best when cultured razor clam juveniles were grown in sediments vs. foam. Results of all four studies will be presented.

SOFT-SHELL CLAM, *MYA ARENARIA*, AQUACULTURE IN MAINE: CAN BARRIERS BE OVERCOME TO ENCOURAGE FARMING ENTERPRISES?

Brian Beal[1], Sara Randall[2], Chad Coffin[3]. [1] University of Maine at Machias, 116 O'Brien Avenue, Machais, ME 04654; [2] Downeast Institute, 39 Wildflower Lane, Beals, ME 04611
[3] Maine Clammers Association, 26 Litchfield Road, Freeport, ME 04032

The soft-shell clam, *Mya arenaria*, fishery is one of the most important in Maine. Record high landings occurred in 1977 with 786,000 bushels harvested. Since then, the fishery has declined by 82%, with 138,000 bushels harvested last year, the lowest landings in 88 years. Several interdependent factors have resulted in this decline: 1) ocean warming and an explosion of invasive and native predators (e.g., green crabs; milky ribbon worms); 2) limited entry and aging clammers; and, 3) lack of interest from elected officials and fisheries managers to support intertidal farming. Since 1987, hatchery-reared *Mya* has been used for fisheries stock enhancement when the Beals Island Regional Shellfish Hatchery first produced cultured juveniles for six eastern Maine coastal communities. Efforts continue today through the Downeast Institute. Over time, 75 coastal Maine towns have planted cultured seed to enhance wild stocks; however, no clam farming operations exist while farmed oysters, seaweed, and mussels are expanding rapidly. Several barriers prevent soft-shell clams from becoming an emerging aquaculture species: 1) a lack of understanding about the need to adapt the fishery to warming warmers by instituting large-scale predator protection measures to ensure that clams continue to exist as a fishery; 2)

interpretations of colonial laws that allow upland landowners to restrict shore access to the intertidal; and, 3) state aquaculture rules that give upland landowners *de facto* intervenor status in public lease hearings, and require the applicant to seek permission from landowners to farm intertidally adjacent to their upland property.

SEAFOOD CERTIFICATION PROGRAMS: WHO IS DOING IT AND WHO CARES?

Sebastian Belle. Maine Aquaculture Association, 103 Water St, Hallowell, ME 04347

In the last ten years third party seafood certification programs have rapidly emerged as an important factor in seafood markets. Why has this happened and what role do they play in establishing buyer and consumer confidence in seafood markets? Multiple certification programs have been developed with different affiliations, levels of technical detail and subject matter coverage. Different markets and customers appear to be responding to the various certification programs with different levels of interest and "buyin". This session will start with an overview of the various certification programs with respect to the technical areas they cover, and methods they use to provide assurances in a rapidly evolving and complicated production environment. After an overview of the various programs a panel, including buyers and growers will be asked to discuss how markets are responding to the various programs and what challenges may occur that reduce buyer and grower engagement in certification programs. How can programs be improved? Are they achieving what they set out to do? What role do certification programs have in increasing consumer confidence in seafood and reducing brand risk for buyers?

TREATMENT OF 17BETA-ESTRADIOL AND ITS METABOLITES TO ENSURE SUSTAINABLE WATER MANAGEMENT

Jessica L. Bennett[1], Graham A. Gagnon[1]. [1] Department of Civil and Resource Engineering, Dalhousie University, 5248 Morris Street, Halifax, NS, B3H 4R2 Canada

The American eel has recently become of great interest to the aquaculture industry. 17beta-estradiol (E2) is currently being tested as a feed additive to increase growth and feminization in American eels, however there is a need to ensure that wastewater is responsibly treated prior to disposal. Estrogenic compounds (i.e., E2, estrone, E1 and estriol, E3) can have deleterious effects on aquatic organisms in receiving water bodies if not properly managed. Our team's previous work has indicated that oxidation and advanced oxidation processes (AOPs) such as UV and UV/H_2O_2 are effective at degrading estrogenic compounds in eel aquaculture wastewater. The main goal of this study was to build on previous research by testing the effect of pH and H_2O_2 dose on the degradation of E2 and its metabolites in aquaculture wastewater. In this study we have found that removal of compounds under UV radiation increased as pH increased, with greatest removal achieved at a pH of 10. Increasing H_2O_2 dose increased analyte removal. The results of this study indicate that the pH of wastewater and addition of H_2O_2 may impact the efficacy of oxidation and advanced oxidation water treatment processes for degrading these analytes. Overall this presentation will provide impact to aquaculture producers that are targeting innovative feed additives and measures to control their impact on the environment.

CLIMATE CHANGE – WHY SHOULD SHELLFISH GROWERS CARE AND WHAT IS THE SHELLFISH GROWERS CLIMATE COALITION?

Ryan Bethea[1], Alex Hay[2], Sally McGee[3], Bob Rheault[4]. [1]Oysters Carolina, Harkers Island, NC;
[2]Mac's Seafood, Welfleet, MA; [3]Shellfish Growers Climate Coalition project manager, Nature Conservancy;
[4]East Coast Shellfish Growers Association

The Shellfish Growers Climate Coalition is a partnership, initiated by seven East and West Coast shellfish farms and The Nature Conservancy. Member businesses recognize that climate change poses a threat to businesses and food production for a rapidly growing human population. We are an "endorsement" coalition, with all members supporting the goal of reduced carbon emissions. The Coalition is open to members representing companies involved in all aspects of shellfish rearing, sales and consumption, who wish to engage with consumers and policy makers to help chart America's course towards a low carbon future. As of November 2018, the Coalition was comprised of 70 shellfish growers, hatchery operators, wholesalers, retailers, and restaurants from eighteen states.

This session will include a presentation on the purpose and goals for the Coalition, and current and future impacts of climate change on farms and other businesses. Presenters will include Coalition members, the East Coast Shellfish Growers Association, and the Nature Conservancy. There will be ample time for questions and discussion.

EVALUATING AND SOURCING DETRITUS AS A SUPPLEMENTARY DIET FOR BIVALVE AQUACULTURE

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There is a need to better define and understand how different detritus sources affect their use and importance in supporting bivalves both in the context of sustainable growth and environmental interactions of aquaculture. The goal of this study is to identify the temporal variation of detrital inputs from major primary producers (phytoplankton, macroalgae and *Spartina alterniflora*) and their contribution to the diet of *Mytilus edulis*. Supplementary diet potential was assessed based on availability and quality, estimated with C:N and lipid content. Detrital contribution to particulate organic matter (POM) and mussel diets was determined using stable isotopes $\delta^{13}C$ and $\delta^{15}N$ along with lipid and fatty acid biomarkers. Mussels were collected by hand and particulates <100 µm were sampled from the water column between May and Dec of 2016 and 2017 in Saco Bay, ME USA. Average $\delta^{13}C$ signature of POM varied throughout the study, during fall it closely resembled that of *S. alterniflora* (-13.0 ± 0.8‰) and in the summer it resembled phytoplankton and zooplankton (-22.7 ± 1.2‰) except during early July when it more closely resembled macroalgae inputs (-18.8 ± 1.4‰). Mussel $\delta^{13}C$ varied little throughout the study period (-19.8 ± 1.2‰) averaging between that of phytoplankton and macroalgae. Due a intermediate C:N (22.8 ± 8.8), the timing of occurrence and the mechanisms it enters the water column macroalgal detritus shows the most promise for further consideration to improve aquaculture site selection. Understanding macroalgal use by bivalves will better inform how to integrate bivalve aquaculture into ecosystems and food webs.

OPPORTUNITIES FOR AQUACULTURE ON THE MASSACHUSETTS SOUTH COAST: A SECTOR ANALYSIS

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Opportunities for Aquaculture on the Massachusetts south coast is described in a recently completed sector analysis study conducted by Maine based Coastal Enterprises, Inc. The report provides a regional overview of aquaculture operations in the towns of Dartmouth, Fairhaven, Marion, Mattapoisett, Wareham, Westport and the City of New Bedford. In 2016 the south coastal region produced approximately 2.2 million oysters and currently utilizes over 160 acres for farming. Over fifty regional shareholders including town harbormasters, oyster growers, municipal and state employees, non-profit entities, financiers and economic development professionals lent their expertise to the development of the study. A presentation of the findings will provide a regional

overview, discuss challenges to growth facing aquaculturists today and highlight the assets and opportunities for future economic potential. The report contains summaries of surrounding towns from Westport to Wareham, with a list of resources covering aquaculture education and training, equipment, access to capital (loans and grants), hatcheries, and municipal, regional, state and federal resources available as well as recommendations on potential aquaculture growth strategies in the region. The analysis can be downloaded online here: https://www.ceimaine.org/wp-content/uploads/2018/04/MA-South-Coast-Aquaculture-Analysis.2018.pdf

IMPACT OF PRODUCT PRESENTATION STRATEGY ON CONSUMER BEHAVIOR IN THE SEAFOOD MARKET

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During the past four decades, aquaculture has provided an increasing share of fish protein for humans – growing from 9% (1980) to over 50% (2018). Given the importance of aquaculture as a source of protein, and efforts to expand aquaculture products into new markets, there is increased interest in understanding consumer decision-making for seafood products. Discrete choice experiments (CE) offer a useful tool for exploring this behavior. Previous studies suggest that in-person CEs, which simulate real-life shopping experiences, are the "gold standard" for learning about consumer behavior. However, such experiments may be costly, especially when researchers require a larger sample. CEs conducted online provide a cheaper alternative, however, may also be more hypothetical in nature and therefore provide less quality information about consumers. As online seafood sales have risen, some of this potential hypothetical bias may be mollified. There is a gap in the literature exploring the effect of survey elicitation mode (online vs. in-person) on consumer decision-making in the market for seafood products. To this end, in July 2016 we administered identical seafood CEs to an in-person and online sample of Maine residents. We compared consumer willingness-to-pay (WTP) estimates for three product attributes – source of production (i.e., wild-capture or aquaculture), product origin, and certification – between the online and in-person samples for five seafood products: clams, mussels, oysters, scallops, and seaweed salad. Our preliminary results suggest that product presentation may affect how consumers make their choices; WTP estimates for source of production are systematically different for scallops and seaweed salad.

EXAMINING ATTITUDES AND WILLINGNESS TO PAY FOR AQUACULTURED SEAFOOD ATTRIBUTES

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As seafood demand continues to grow, so is the potential for aquaculture expansion in the United States. The case for aquaculture is given added impetus against the backdrop of continued pressure on wild-harvested marine populations. While previous studies have invariably concluded preference for wild-harvested over aquacultured seafood and price premiums for "desirable" seafood attributes, a key consideration is whether the presence of preferred attributes can confer similar notions of value to aquacultured seafood, thus presenting an adequate trade-off for wild seafood. The primary goal of this study is to examine preferences and willingness to pay for aquacultured seafood with desirable attributes, with a specific focus on aquacultured salmon. The attributes considered for the study are "local", "organic", and "produced without antibiotics."

A survey was developed that utilized contingent valuation techniques, and targeted seafood consumers in several grocery stores in Maine. Results show that about a third of participants either preferred aquacultured salmon, or were indifferent between aquacultured and wild salmon. Majority of consumers were not only indifferent between purchasing wild or aquacultured salmon with a "desired" attribute, but were willing to pay an average price

premium of 20% for aquacultured salmon with any one of the attributes. These findings would provide valuable insights to players in the aquaculture industry, and to policy makers who may have to standardize the meaning of certain seafood attributes.

ISOLATION OF PHAGES THAT TARGET VIRULENT STRAINS OF *VIBRIO PARAHAEMOLYTICUS*

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Gastrointestinal illnesses associated with the consumption of shellfish contaminated with *Vibrio parahaemolyticus* and *Vibrio vulnificus* having a negative impact on the industry due to recalls and loss of consumer confidence in the product. We aim to develop a rapid and highly sensitive bacteriophage-based diagnostic test for early detection of shellfish contamination by virulent strains of these two *Vibrio sp*. Bacteriophage test candidates infecting *V. parahaemolyticus* and *V. vulnificus* were amplified from water samples collected along the northeast Atlantic coast. Several *V. parahaemolyticus* phages were isolated via plaque assays, but none were isolated for *V. vulnificus*. This result suggests that *V. parahaemolyticus,* but not *V. vulnificus,* was present in the water at the time of collection as phages need their bacterial host to maintain their population. To assess the range of phage infectivity, plaque assays were performed on over thirty clinical and environmental *V. parahaemolyticus* isolates. Six phages with distinct infectivity patterns were selected and characterized. Electron microscopy examination of purified phages suggests they are members of the Siphoviridae family of non-enveloped, double stranded DNA viruses. Lysogens were generated by integration of phage genomes into a strain of *V. parahaemolyticus*. Sequencing of phage genomes was performed to facilitate the design of recombinant phages expressing a reporter gene for rapid detection of phage multiplication in *V. parahaemolyticus*. Our diagnostic test will have public health implications to potentially reduce the incidence of vibriosis due to consumption of industry supplied and recreationally fished *V.parahaemolyticus*-contaminated shellfish.

THE ROLE FOR SHELLFISH AQUACULTURE PRACTICES IN REGULATORY NITROGEN REDUCTION ON CAPE COD, MA.

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Shellfish aquaculture has an important role to play in regulatory nitrogen removal on Cape Cod. Nitrogen pollution is a chronic problem across Cape Cod's coastal embayments. This pollution has led to collapse of seagrass ecosystems and proliferation of macroalgae communities. The towns on Cape Cod have been tasked with managing nitrogen loads to all affected bays within their boundaries. As part of this process, the towns have been developing plans for nitrogen removal on a watershed basis. These plans consist of a range of innovative and alternative technology solutions. The third most popular solution across the Cape is shellfish aquaculture. As part of a regulatory solution, shellfish aquaculture has been assigned nitrogen removal credit rates. This presentation will review the advancements in assigning regulatory credits in Massachusetts, and update on the progress of aquaculture projects with state approval and nitrogen removal credits. Finally, this presentation will explore the potential models for private investment dollars to contribute to aquaculture in order to achieve nitrogen reduction and water quality improvement goals. This broad model for financing is called impact investing, where investments are made in order to achieve an environmental or social outcome as well as profit for investors. An

impact investment feasibility study is being undertaken by The Barnstable Clean Water Coalition, the Town of Barnstable, and The Nature Conservancy. Among other things, this study will explore the potential for using private capital in shellfish aquaculture for regulatory nitrogen removal credits.

EAST COAST MOLLUSCAN HEALTH INITIATIVE PART 1: THE DATABASE

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Following a road map laid out at the 2015 NACE in Portland, ME, we obtained funding to build the infrastructure necessary to sustain a functional, web-accessible, East Coast regional database on molluscan shellfish health that can be used to provide the best available science to regulators and industry to guide decisions on the safe and prudent inter- and intrastate movement of shellfish seed and broodstock. Back-to-back workshops were held in Cape May, NJ between October 9 and 11 to evaluate the structure and function of a web-accessible shellfish health database for the Atlantic Coast and to redevelop hatchery certification protocols including both hatchery requirements and audit procedures. Both workshops were highly productive with 20 and 25 participants representing regulatory agencies, industry, academia, and extension personnel. In this presentation, we will discuss the status of the database application, the decisions made around its development, and how we anticipate its use among all stakeholders. Database development is supported by the NOAA Saltonstall-Kennedy Program while hatchery certification protocol development is supported by the NOAA Sea Grant Aquaculture Impediments Program.

MAINE SEANET: CARRYING CAPACITY AND FOOD WEB INTERACTIONS ON BIVALVE FARMS

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To understand the ecological carrying capacity of expanded bivalve shellfish aquaculture in the coastal ecosystem, an integrated food web modeling approach was used in conjunction with laboratory and field efforts to explore fundamental drivers to the modeled production potentials. A mass-balance food web model linked with an economic model was used to calculate ecological carrying capacity for bivalves and their economic potential. The coastal bays examined had 1 - 2 orders of magnitude capacity for increase in bivalve production with little to no impact on existing food web ecology and a widespread positive economic impact. In support of these findings, a field-based examination of food webs associated with bivalve farms using stable isotope analysis confirms that they have little impact on food web structure, despite quantification of higher species biodiversity of lower trophic level organisms at bivalve farm sites compared to analogous non-farm sites (i.e. docks). These modeled high production potentials may be, in part, due to detritus - degraded particulate organic matter - subsidizing energy to these primary consumers beyond just new phytoplankton production. In particular, eroding macroalgae blades shed particulates that are the same size of those that bivalves filter. Different organic matter sources and their nutritional value to bivalves were quantified using lipid fatty acid analysis, stable isotope analysis and digestibility trials. Bivalve farms are an integrated component of the natural coastal food web allowing for a carrying capacity approach to understand sustainable production potentials.

EAST COAST MOLLUSCAN HEALTH INITIATIVE PART 2: HATCHERY CERTIFICATION

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The growth of shellfish aquaculture in the eastern United States has increased interstate commerce of hatchery seed. Receiving states typically have a review and or permit process to ensure that imported seed does not cause harm to local domestic and wild stocks. States usually require "clean bills of health" from shellfish pathologists that are costly and time consuming. Hundreds of evaluations over several decades support a widely held view that young seed cultured in filtered water are effectively free of disease and relatively safe to transfer between distinct bodies of water and states. With support from the National Sea Grant Aquaculture Impediments Program, a Hatchery Certification Working Group established at the 2015 NACE in Portland, ME has drafted an application and audit protocol to certify hatcheries that use management practices which protect against disease transfer. The objective is to provide relief from batch-by-batch seed health evaluations by describing the conditions and procedures that have consistently yielded pathogen-free seed. Through the certification process, we hope to give regulators the confidence to move to a semi-annual inspection cycle that would reduce costs while protecting local stocks and populations. The hatchery certification program is voluntary for both states and hatcheries with the alternative remaining batch-by-batch examination. It is part of a comprehensive East Coast Shellfish Health Initiative, which includes advisory and disease database components. This presentation will review progress, distribute proposed protocols, and seek comments from attendees in an effort to engage stakeholders from the entire east coast region.

CONSUMER ATTITUDES AND PREFERENCES ABOUT FARM-RAISED SHELLFISH, FINFISH, AND SEA VEGETABLES IN THE ATLANTIC COAST STATES

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Most Americans do not consume the recommended two servings of seafood per week. Opportunities exist to expand U.S. aquaculture production to improve public health, stimulate local economies, and offset foreign seafood imports. The development and implementation of data-driven marketing strategies can enhance the success of businesses providing farm-raised seafood for human consumption. While the allocation of resources to design and build sound infrastructure to support a young and growing industry is of great importance, ensuring the financial health of individual firms within the industry is reliant on operating with a business model that is to some extent market-driven. An extensive 30+ question survey was designed by the team and reviewed by three external aquaculture experts, two from the mid-Atlantic sub-region and one from the southeast sub-region for balance. The online survey was hosted and administered by Qualtrics® and resulted in 5989 completed surveys, with at least 400 from each of the 14 Atlantic states, during July and August, 2018. The Maine Statistical Analysis Center analyzed the data. Nutrition was rated the top benefit of finfish and sea vegetable aquaculture, while local economies and nutrition were considered benefits of shellfish farming. Wild-caught finfish and shellfish were preferred, but the majority of respondents had no preference for sea vegetable production method. These and other findings can help businesses engaged in farm-raised seafood for human consumption develop sales and marketing plans based on market demand. This research was supported by the National Oceanic and Atmospheric Administration, U.S. Department of Commerce.

THE RESISTANCE OF MACROALGAE INCLUDING THE INVASIVE RED ALGA *GRATELOUPIA TURUTURU* TO COMMON BIOSECURITY PROTOCOLS

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Grateloupia turuturu (Halymeniales, Rhodophyta), an invasive red alga, was discovered in the Damariscotta Estuary (ME, USA) in 2017, over 200 km of shoreline north of its last reported location. All life history stages were found, including highly reproductive individuals with a mean of 82.0 ± 17.5 (SD) cystocarps/ 0.25 cm^2. The Damariscotta holds three marine labs, shellfish aquaculture, recreational sailing, and commercial shipping. Because of multiple potential biosecurity risks, we tested a commonly used biosecurity protocol (seawater brought to 50 ppm free chlorine for ≥ 2 h) against the native *Mastocarpus stellatus* (Gigartinales, Rhodophyta) and *G. turuturu* and found unexpected resilience to bleach treatment. Holdfasts of freshly collected *G. turuturu* and *M. stellatus* survived 50 and 1000 ppm free chlorine, respectively. Cystocarps of cultured *G. turuturu* survived 100 ppm free chlorine for 4 h and produced terete outgrowths that became new plants, suggesting reproductive adaptations of cystocarps to stressful conditions that may have broader evolutionary significance. Commercially available free chlorine tests strips are inaccurate in seawater; their use could increase the risk of failed biosecurity as a vector for invasion. Because chlorination at economic and environmentally safe levels is insufficient, we recommend a combination of chlorination and heat treatment, including of solids and tank walls, for comprehensive biosecurity.

MANAGING MARINE AQUACULTURE HEALTH IN A CHANGING WORLD

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As aquaculture production expands, managing the health of cultured populations, including preventing undesired disease interactions with wild animal populations, will increasingly be a challenge. Despite best efforts to maintain biosecurity, widening commerce alters distributions of pathogens and hosts, producing outbreaks of established diseases and the emergence of new ones. Anthropogenic impacts on the marine environment including ocean warming contribute to shifting host and pathogen distributions and introduce other possible influences on disease processes, from harmful algal blooms and ocean acidification to organic pollutants and microplastic contamination. In this evolving environmental landscape, the path to more effective management of animal health in marine aquaculture is not fully clear. More widespread application of contemporary genetic methods for pathogen detection and discovery, including on-site molecular diagnostics and next-generation sequencing, has garnered recent attention as a solution. Regardless of available diagnostics, however, disease occurrence remains a product of host and environmental factors in addition to those associated with the pathogen. Thus meeting the challenges of protecting aquaculture systems in a changing world will require incorporation of broader expertise into aquatic animal health, including chemistry and toxicology, physiology, genetics, oceanography, and ecology in addition to traditional areas of parasitology, microbiology and virology to better understand more complex and multi-factorial etiologies. Capacity to explore disease-associated factors in controlled experiments will remain essential. Fundamental to maintaining capacity for understanding disease in aquatic ecosystems will be societal commitment to broad-based science programs in support of the goal of aquaculture to benefit coastal communities and support growing human populations.

EDUCATING FUTURE SEAFOOD PRODUCERS: SEAFOOD SCIENCE AND AQUACULTURE CURRICULUM DEVELOPMENT AND DISSEMINATION

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Seafood represents a highly nutritious protein source and one of the most promising sectors of the food industry with regard to increasing the nation's protein supply to feed a growing population. Farm raised seafood is the fastest growing food sector worldwide. However, American consumers are still unfamiliar and often foster negative views of aquaculture practices and its safety. It is important to provide the public with factual information to enlighten and inform present and future seafood consumers and producers. Two curriculums with lesson plans were developed by NY Sea Grant to facilitate the incorporation of seafood science and aquaculture into classrooms. The curriculums provide background information complemented with engaging lessons. In a seafood science curriculum the 4 P's of seafood science are introduced to educate teachers on what a seafood scientist must do to Produce, Preserve, Protect and Perfect seafood products. A second aquaculture curriculum provides a general overview of aquaculture, elaborating on seafood security; the stages of aquaculture; key considerations for a fish farmer; and the various types of aquaculture operations that exist. This is coupled with the "Becoming an Aquaculturist" activity, which encourages students to build their own fish farm using salvaged items.

These resources are geared towards educating middle and high school students and teachers to promote a future of better informed seafood consumers. These resources will create more informed consumers and introduce youth to new career opportunities with exceptional growth potential. These resources and best practices for use and implementation will be explored.

BUILDING A SKILLED SEAFOOD WORKFORCE: FISH TO DISH EDUCATION AND INTERNSHIP PROGRAM

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Seafood is a delicious and nutritious protein source with numerous health benefits. Growing populations and increased awareness of the nutritional benefits of consuming seafood has resulted in a growing demand globally. However, The Food and Agriculture Organization have reported that more than 90% of wild fish stocks are categorized as either overfished or fished at or close to sustainable limits, thus emphasis on alternative species, enhanced management programs, and aquaculture is integral to meet the growing demand. In order to continue advancing the industry, and increase production of domestic seafood, it is important to build an educated and skilled workforce who can facilitate advancements in sustainable harvest, farming, and processing technology/practices. The industries growth potential is limited by a lack of formal trainings on fisheries, aquaculture, and seafood. Without a steady influx of skilled professionals the industry will struggle to advance and increase production, which will result in heavy reliance on foreign imports. ThFish to Dish internship program introduces students to an industry with exceptional growth potential, with the hope of empowering them to pursue careers in seafood science, fisheries, and aquaculture. The program provides direct industry support, with interns housed at industry partners during busy summer months. The project aims to aid in the development of a skilled workforce capable of advancing and working in seafood production in the future, while meeting a serious need for seafood and aquaculture specific education programs. This presentation will review the program model, explore best practices, and share insights into the development of similar collaborative industry internship programs.

INVESTIGATING THE VIABILITY OF *GRACILARIA TIKVAHIAE* AS A CANDIDATE SPECIES FOR COMMERICAL AQUACULTURE IN CONNECTICUT

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Interest in seaweed aquaculture in Southern New England continues to expand rapidly; however, lack of federal guidelines regulating food safety of domestically cultivated sea vegetables is one barrier to the expansion of this new industry. Although state guidelines for the production and processing of sugar kelp in Connecticut have been established, this is not yet the case for *Gracilaria tikvahiae*, an edible summer species native to Connecticut waters. *G. tikvahiae* was deployed on commercial farm sites that grow kelp and shellfish in Long Island Sound, every two weeks for a total of eight weeks. Freshwater dips were conducted to mitigate biofouling. Upon harvest, tissue samples were analyzed for various pathogens and chemicals which may pose a risk to human health. In addition, an analysis of dried *G. tikvahiae* was conducted to establish guidelines for commercial dehydration processing as well as a preliminary market analysis for the species.

INTERANNUAL ANALYSIS OF REPRODUCTION AND ENERGY INVESTMENT WITHIN A POPULATION OF FARMED BLUE MUSSELS (*MYTILUS EDULIS*)

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This research analyzed trends in the reproductive cycle and energy investment within a population of farmed blue mussels. Starting in February 2017, mussels were collected biweekly from a farm site in Casco Bay, Maine and histological slides produced from these mussels were analyzed for both gonad development and energy investment. The first analysis classified gonads into different stages based upon the reproductive cycle. Based upon the loss of developed gonads, possible spawning events were determined in June 2017, October 2017, and July 2018. Through the use of image analysis, an inverse relationship was observed between energy invested in reproduction and storage, based upon a linear regression ($r^2 = 0.814$) between reproductive and adipogranular tissue (lipid and protein storage). In April 2017 and May 2018, energy investment in reproduction peaked while storage tissue availability was low. This resulted in a period of time when the mussels could have been less resilient to environmental stress. During the primary reproductive season (April-June) of 2018, mussels were observed to have a significantly higher energy investment in reproduction than mussels in the primary reproductive season in 2017. Information on the reproductive cycle, spawning time, and energy investment is critical for farmers to understand in order to improve their farming methods. With changes already being observed between 2017 and 2018, it is even more crucial to continue to monitor the reproductive cycle and energy investment within this population of mussels in the rapidly changing Gulf of Maine.

MICROBIAL SOURCE TRACKING (MST)- AN ANALYSES OF THREE CT WATERSHEDS OF LONG ISLAND SOUND

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Current US EPA protocols for water testing as a means for determining whether bathing areas and/or shellfishing areas should be open or closed utilize a process that involves a 24-hour delay between collecting water samples, obtaining the results and making decisions. Furthermore, those decisions are being made based on the presence or absence of indicator organisms, as actual pathogens are not being tested for and sources of bacteria are unknown. The purpose of this study was to examine bacterial DNA to identify the actual sources of bacteria in order to scientifically evaluate the true risk to public health.

Learning Objectives:

- Understand the current State and EPA water sampling protocols.
- Learn the importance of local health department interventions of improving water quality within our communities.
- Recognize the importance of DNA sampling as a public health water quality tool.

A NEW, INTERNATIONAL OCEAN FOOD SYSTEMS PROFESSIONAL SCIENCE MASTERS AT THE UNIVERSITY OF NEW ENGLAND

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We have developed a new Masters Degree program with Nordic partners that does not separate but combines capture fisheries and aquaculture production systems, and conservation/restoration of marine habitats and fisheries ecosystems. The program develops fully the "aquaculture toolbox" in cooperative research and uses team science to support the restoration of capture fisheries and marine ecosystems plus help redevelop working waterfronts as premier examples of a 21st century "blue-green economy". In aquaculture, we use "ecological aquaculture" and the "ecosystems approach to aquaculture" as principles to steward ocean ecosystems while also feeding a future world with nutrient-dense foods essential for human health and wellness. Ecological aquaculture is a transdisciplinary area of scholarship and practice – a "pracademic" – that combines the social-ecological wisdom of aquafarming and fishing peoples with their applied knowledge; as well as being a "team science" that develops social-ecological partnerships of scientists working with fishermen, farmers, and civil society who are central to the success of ecological aquaculture. Ecological aquaculture incorporates ecological design, ecological engineering, and ecological approaches to governance to implement and then evolve more sustainable aquaculture businesses and family farms at local to global scales. This "alternative path" of aquaculture is being used to evolve a whole new generation of aquaculture ecosystems that produce not only higher economic benefits, but also increased social contract for aquaculture due to the multiple benefits they provide not only to the economy, but also to ecosystems, and societies.

OCEAN FOOD SYSTEMS: A TRANSDISCIPLINARY, ECOSYSTEMS ECOLOGY APPROACH TO MARINE AQUACULTURE

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In 1793 the French chemist Antoine Lavoisier wrote that science and the useful arts needed to develop a team approach to meld diverse contributions from different disciplines. Over 200 years later, Illman (2007) stated that, "History may look back on these last couple of decades as a time when science grew up and took on real-world problems instead of sticking to the safe and tidy world of the tractable, in which studies are undertaken because they are doable, even if not directly useful." Global organizations such as FAO and The World Bank agree that population growth to 2050+ will increase demand for aquatic foods some 40-60 MMT. However, global analyses of the status and needs for the expansion of ocean food production systems are inadequate to inform regional policy-makers who too often use aggregated global data to validate their perceptions that fisheries are an ancient profession of a dying generation destroying aquatic ecosystems everywhere, or that aquaculture is either the savior of seafood or the next tragedy of the commons. We introduce an ecosystems ecology approach to identify collaborative research priorities between applied academic and industries. A "Taxonomy of Seafood Systems"

(TSS) is used to identify the full diversity of modern fisheries and aquaculture production systems and their local to global value chains. The TSS is then used to structure data acquisition and establish functional connections between systems. The TSS offers insights into the need for more comprehensive social-ecological approaches to identify top priorities in ocean food systems and marine conservation research. We present examples of our work being conducted in Maine, USA, and the west coast of Sweden. We are using these processes to structure partnership developments and local/regional to global training of graduate students in a new, international twinned Master's Program in Ocean Food Systems at the University of New England, and in the Sustainable Production and Utilization of Marine Bioresources at the University of Gothenburg, Sweden who coordinate 3 other Nordic universities in this consortium in Iceland and Norway. Our goal is to train the next generation of ocean food systems leaders in the ecosystems approach to aquaculture and the use of ecosystems ecology design thinking to deliver working models of more sustainable aquaculture developments that are connected closely to fisheries systems and communities.

MAINE SCALLOP AQUACULTURE DEVELOPMENT INITIATIVE: COMMUNITY DEVELOPMENT THROUGH INTERNATIONAL TECH-TRANSFER

Hugh Cowperthwaite, Coastal Enterprises, Inc., 2 Portland Fish Pier, Portland, ME 04101

Maine based Coastal Enterprises, Inc. (CEI) a private, nonprofit Community Development Corporation (CDC) and Community Development Financial Institution (CDFI) has been fostering relationships between Maine commercial fishermen and Japanese scallop farmers for the past 8 years. Several exchanges have occurred between Aomori, Japan and Maine to learn, adopt and develop a scallop aquaculture industry in Maine.

Japan produces ~500,000 metric tons of scallops per year with Aomori ranking 2nd (to Hokkaido) in scallop production for all of Japan producing ~90,000 metric tons of scallops annually. This presentation will include photos and videos illustrating the adaption of Japanese scallop culture methods applied to Atlantic sea scallop (*Placopectenmagellanicus*) in the Gulf of Maine. Scallop aquaculture production cycle and various grow out techniques including spat collection, pearl nets, lantern nets and ear-hanging will be presented. Long line system setup, equipment adaption and the use of a typical lobster fishing vessel will also be covered.

Commercial production trails are currently underway using specialized Japanese scallop farm equipment in Maine to test the feasibility of the ear-hanging technique for growing Atlantic sea scallop. Participants will gain a better understanding of progress made regarding wild spat collection and various grow out techniques. Emphasis will be placed on current efforts that are underway in Maine to develop a robust scallop aquaculture industry for growers including techniques recently learned from Aomori, Japan.

EUROPE'S OYSTER MARKET & TRADE OPPORTUNITIES

Colleen Coyne, Alexander Wever. Food Export USA-Northeast, 1617 JFK Boulevard, Suite 420, Philadelphia, PA 19103 USA

The trade embargo between the USA and the European Union (EU) for molluscan shellfish will soon be one step closer to ending. The first phase of market reopening will begin with two states, Massachusetts and Washington, and with two EU-member states, Spain and The Netherlands. Food Export-Northeast's European In-Market Representative, Alexander Wever,will detail his study of the European oyster market and the opportunities that may exist for U.S. oysters. Dutch companies are the primary importers and distributors of oysters throughout the EU. The Netherlands is also already importing, by air, significant amounts of chilled seafood from northern America via Boston's Logan airport. Those shipments are primarily live lobster, which may offer shellfish growers collaborative opportunities for product introduction, sales, and shipping. Ninety percent of the lobster, mussel, and oyster distribution is conducted by a handful of companies concentrated in the same area of The

Netherlands. Dutch importers are the primary outside suppliers of oysters, including Irish oysters, to the French market. France is the dominant oyster producing member state and oyster consumer in Europe representing at least 80% of the total market. Half of the country's annual consumption takes place around the Christmas holidays, which also coincides with the greatest demand, and import, of American lobster. French market production and consumption demographics will be discussed and opportunities for USA oysters will be detailed.

GROWING EXPORT MARKETS

Colleen Coyne. Food Export USA-Northeast, 1617 JFK Boulevard, Suite 420, Philadelphia, PA 19103

Food Export-Northeast proposes to conduct a workshop detailing the marketing tools and federal funding available from the organization to aquaculture operations that may be interested in establishing foreign market sales. Strong domestic consumer demand has helped spur a significant increase in shellfish production in the northeastern USA over the last decade. As regional production steadily increases, shellfish growers have the opportunity to strengthen their business operations through market diversification and expanded sales outlets. Food Export-Northeast, a non-profit organization of the ten northeast states, which is chaired by state commissioners of agriculture, administers USDA/Foreign Agricultural Service (FAS) Market Access Program (MAP) funds to help the region's businesses to develop sales of agricultural and fishery products in foreign markets. Cost-share funding is available to individual businesses to conduct foreign market promotions of their product(s). One-on-one export marketing business development guidance is available from the organization's Food Export Helpline™ and from a network of 20 in-market representatives worldwide who conduct customized market research, product promotions, trade missions, and trade show assistance. In 2017, Food Export-Northeast invested more than $897,000 into its seafood export promotion program. That funding enabled seafood companies to meet with 695 buyers and to generate foreign market sales in excess of $314 million. Food Export-Northeast also conducts market research and product promotions on behalf of the industry to introduce new products or to expand demand for U.S.-origin fishery products in foreign markets.

AQUACULTURE TOURS FOR THE PUBLIC IN RHODE ISLAND: OPPORTUNTIES FORCROSS-LEARNING AND CONFLICT RESOLUTION

Azure Cygler[1], Dave Beutel[2], Jennifer McCann[1]. [1]Coastal Resources Center and Rhode Island Sea Grant at URI, 220 South Ferry Rd., Narragansett, RI 02882 USA; [2]Rhode Island Coastal Resources Management Council, 4808 Tower Hill Rd. Wakefield, RI 02879;

As aquaculture grows in Rhode Island – up to 76 farms in 2017, spread over nearly 300 acres of coastal salt ponds and Narragansett Bay – there is increasing need to share this industry with the general public in meaningful, interactive ways. While overall this growth has been met with positive reviews, some coastal residents have concerns about the industry and how it intersects with the larger community and resident's way of life. The Coastal Resources Center and Rhode Island Sea Grant at URI have been offering public education opportunities for the public through winter webinar series and summer farm tours (info online at: www.ShellfishRI.com). These offerings are part of the Rhode Island Shellfish Initiative, a larger state-wide partnership supporting shellfish for their value and service to Rhode Island. The tours have been very popular, filling up quickly, and have served to connect interested citizens directly with growers to experience a farm up close and engage with seasoned aquaculture experts from industry and government. Striking results, beyond a good day on the water, include: 1) Addressing job needs of industry, 2) Working through tough use conflicts, and 3) Enhancing the RI brand and marketing for aquaculture products. These programs are worthwhile for these and other reasons, do not require large resources to orchestrate, and present opportunities for states to build partnerships and resolve community and industry concerns.

NUTRIENT BIOEXTRACTION INITIATIVE: REMOVING EXCESS NITROGEN IN NY AND CT WATERS THROUGH AQUACULTURE

Nelle D'Aversa[1], David Berg[2]. [1] New England Interstate Water Pollution Control Commission c/o NYS Dept. of Environmental Conservation, SUNY at Stony Brook, 50 Circle Road, Stony Brook, NY 11790; [2] Long Island Regional Planning Council, 1864 Muttontown Road, Syosset, NY 11791 USA

The water quality of the coastal waters of Long Island, New York and the Long Island Sound is impacted by nitrogen loading from point and nonpoint sources including wastewater treatment facilities, stormwater, and legacy nitrogen entering from groundwater and released from sediments. Excess nutrients, such as a nitrogen and phosphorus, lead to harmful algal blooms, eutrophication, and hypoxia in many coastal estuaries. This project assesses the efficacy of and potential challenges involved in advancing nutrient bioextraction using seaweed, shellfish, and integrated multi-trophic aquaculture to remove excess nitrogen loads from NY and CT marine waters. ArcGIS raster modeling is used to identify the most suitable locations for bioextraction operations by incorporating potential user conflicts; navigation data; natural resource data; water quality and sediment data; and aquaculture information including active shellfish harvesting and cultivation areas. An investigation of the markets available for bioextracted products, including animal feed, fertilizer, and extracts, will provide potential farmers with information needed to develop sustainable bioextraction operations. Seaweed (sugar kelp) is actively cultivated in other northeast states, such as CT, RI, MA, and ME. There is interest in NY, particularly by shellfish growers, but a number of barriers remain including an uncertain regulatory process. This project will provide aquaculturists and decision makers with the guidelines needed to facilitate seaweed and shellfish farming and harvest operations in NY and CT coastal waters to help remove nitrogen and improve water quality.

ADVANCING PURPLE-HINGE ROCK SCALLOP AQUACULTURE IN THE PACIFIC NORTHWEST

Joth Davis. Pacific Hybreed, Inc., 10610 NE Manitou Park Blvd., Bainbridge Island, WA, USA

Aquaculture development for rock scallops (*Crassadoma gigantea*) has progressed over the last decade and adoption of hatchery and grow-out techniques developed from recent research on this native species is expected, based mainly on recent results on grow out performance. Seed from hatchery production in Washington State was placed into grow out in seven sub-tidal Puget Sound locations and monitored for growth (size at age) and survivorship at approximate 3-5 month intervals over a 36-month period (July 2015 - July 2018). Survivorship was high across most sites at greater than 75% and size at age to a readily marketable size (90-100mm shell length) occurred in about three years at most sites as well. Early concerns over rock scallops cementing to growout gear over the growout period were unfounded as there appears to be a developmental window when cementation occurs (25-55mm), after which cementation is less obligatory. Gear type and handling schedules also appear associated with reduced cementation as well. Constraints to rock scallop aquaculture are mainly associated with providing an emerging industry sector with a reliable source of rock scallop seed. Urgently needed are better protocols for inducing sexual maturation reliably in adult scallops and increasing survivorship in seed following metamorphosis of pediveliger larvae to the juvenile stage. The development of an all triploid seed supply may also be necessary in this native species as regulatory concerns over the potential for hatchery seed to interact genetically with wild conspecifics in the aquaculture of rock scallops have been expressed.

ANALYSIS OF AN ARRAY OF SUBMERSIBLE MUSSEL RAFTS IN STORM CONDITIONS

Tobias Dewhurst [1,*], Spencer Hallowell[1], Carter Newell[2]. [1] Maine Marine Composites, Portland, Maine, Two Portland Fish Pier, Portland, ME 04101 USA; [2] Pemaquid Mussel Farm, 7 Creek Lane, Damariscotta, ME 04543 USA

A three-by-three grid of submersible mussel rafts was analyzed using an experimentally validated dynamic numerical modeling approach. When submerged, the rafts' pontoons are flooded, and they are held vertically by lines attached to surface floats and horizontally by a mooring grid. The rafts' decreased waterplane area and increased inertia reduce the heave and pitch natural frequencies so that they are below the frequencies associated with the greatest wave energy. This has been found to significantly reduce the motion of the rafts compared to the surfaced configuration. The nine submersible rafts were anchored with 16 anchors and mooring lines. These mooring lines were connected to a grid of adjacent rectangular bays, with each corner (node) supported by a grid float. Each bay contains a raft connected to the submerged nodes of the grid by four bridle lines. The dynamics of the full system were modeled using a combined multibody and Finite Element Analysis (FEA) approach with dynamic loads computed using a modified Morison formulation. This model was implemented in the commercial code Orcaflex. A similar model for a single submersible raft was previously validated with full-scale field experiments. The full dynamic system was simulated in the maximum expected waves and currents. Mean and maximum tensions in each grid line were quantified. Accelerations and velocities at the mussel rope attachment points were also examined, since these relate to mussel drop-off.

DESIGN CONSIDERATIONS FOR A KELP LONGLINE EXPOSED TO WAVES AND CURRENTS

Tobias Dewhurst [1*], David W. Fredriksson[2], Andrew Drach [3], Adam St. Gelais [4], Liz Johndrow[4], Barry Costa-Pierce[4], Neola Dewhurst[1], Spencer Hallowell[1]. [1] Maine Marine Composites. Portland, Maine. Two Portland Fish Pier, Portland, ME 04101 USA; [2] Department of Naval Architecture and Ocean Engineering, United States Naval Academy, 590 Holloway Road, 11D Annapolis, MD 21108 USA; [3] Callentis Consulting Group, LLC. Austin, Texas USA; [4] University of New England-North, 1075 Forest Avenue Portland, Maine 04103 USA

A single kelp longline was designed for an exposed site in the Gulf of Maine. The structural properties of the kelp were taken from prior measurements of fresh samples of *Saccharina latissima.* Hydrodynamic properties were derived from prior tank tests of a physical model of a 1-m section of a kelp longline with 3-m long kelp fronds. Normal and axial drag coefficients, as well as added mass coefficients, were derived from tow tank and forced oscillation testing of the physical model. These physical and hydrodynamic properties were incorporated in a dynamic Finite Element Analysis (FEA) model of the longline prototype. Wave and current forces were applied to the system using a modified Morison formulation.

The FEA model was used to quantify mooring tensions in the system under extreme current and wave loading. It was also used to evaluate design alternatives for the system configuration. A multi-variate sensitivity study was applied to understand the effects of design parameters including mooring line scope, mooring pretension, mooring line stiffness (e.g. nylon versus high modulus rope), and the inclusion of clump weights on the anchor chain. The system response was also quantified for variations in environmental forcing factors including relative current and wave direction and tidal elevation. The highest tensions were found to occur when the waves and current headings were about 75 degrees from the longline axis.

IMPACT OF OCEAN ACIDIFICATION ON BYSSAL THREAD STRENGTH IN THE BLUE MUSSEL (*MYSTILUS EDULIS*)

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Blue mussels (*Mytilus edulis*) produce byssal threads to anchor themselves to the substrate. These threads are always exposed to the surrounding environmental conditions. Understanding how environmental pH affects these threads is crucial in understanding how climate change can affect mussels. This work examines three factors (load at failure, thread extensibility, and total thread counts) that indicate the performance of byssal threads as well as condition index to assess impacts on the physiological condition of mussels held in artificial seawater acidified by

the addition of CO_2. There was no significant variation between the control (~786 µatm CO_2 / ~7.98 pH/ ~2805 µmol kg^{-1} total alkalinity) and acidified (~2555 µatm CO_2 / ~7.47 pH/ ~2650 µmol kg^{-1} total alkalinity) treatment groups in any of these factors. The results of this study suggest that ocean acidification by CO_2 addition has no significant effect on the quality and performance of threads produced by *M. edulis.*

A MULTIDISCIPLINARY APPROACH TO DETERMINE THE NUTRIENT BIOEXTRACTION VALUE OF COMMERCIALLY AQUACULTURED SHELLFISH: A PILOT STUDY IN GREENWICH, CT USA

Mark S. Dixon[1], Julie M. Rose[1], John Bohorquez[2], Suzanne Bricker[3], Roger Bowgen[4], Gary H. Wikfors[1], Anthony Dvarskas[2]. [1]NOAA Fisheries NEFSC Milford Laboratory, Milford CT 06460; [2]School of Marine and Atmospheric Sciences, Stony Brook University, Stony Brook, NY 11794; [3]NOAA National Centers for Coastal Ocean Science, Silver Spring, MD 20910; [4] Greenwich Shellfish Commission, Greenwich CT 06830

Knowing the current market price and number of individuals available to harvest provides sufficient information to determine the commodity value of a community's shellfish resources. There are, however, other important attributes of a shellfish resource to consider when defining overall value. Including ecosystem services, specifically nitrogen sequestration services, will provide a more comprehensive estimate. Until recently it has been difficult to monetize ecosystem services since such values require a combination of ecological and economic methodologies. New methods and a novel approach can help bridge the divide. The coastal community of Greenwich, Connecticut is presented as a model for this integrated approach. The northern quahog, *Mercenaria mercenaria*, and the eastern oyster, *Crassostrea virginica*, were evaluated in this study. Both species are commercially harvested and cultured in the coastal waters of Greenwich. Total particulate and nitrogen removal by clams was quantified in the field using the biodeposition method, and by application of the FARM model for oysters. There was site-dependent variability and variability associated with different cultivation practices. Ecological data was then combined with economic data to estimate the value of shellfish ecosystem services to the town of Greenwich. This study represents an innovative collaboration between municipal officials, industry partners, academic colleagues, and NOAA scientists.

EVALUATING GENE EXPRESSION RESPONSES OF THE EASTERN OYSTER, *CRASSOSTREA VIRGINICA*, UNDER OCEAN ACIDIFICATION

Alan Downey-Wall, Brett Ford, Katie Lotterhos. Marine Science Center, Department of Marine and Environmental Sciences, Northeastern University, Nahant, MA, USA

Examination of the molecular mechanisms which regulate trait plasticity under environmental stress is fundamental for understanding how species respond to dynamic environments and for improving our ability to predict how species will respond to future global change. In bivalves, the negative effects of ocean acidification (OA) are well documented, often leading to reduced calcification and growth rate, as well as malformation of their shell at early life history. Gene expression studies can offer additional insight into the underlying molecular mechanisms which may drive these responses by identifying associations between patterns of gene expression and environmental stress, and between stress induced differential gene expression and trait responses. Here, we examine the effect of OA on gene expression in adult eastern oysters over a 3 month experimental exposure. Oysters were divided into two treatment levels (ambient – 550 uatm; OA – 2800 uatm) and were sampled at two time points, once shortly after the start of the exposure and again the end of the exposure (9 days and 82 days after exposure). Tissue was harvested for RNAseq at each time point and several OA-associated traits were measured, including calcification rate and extra-pallial fluid pH. The results from this study will further our understanding of

the molecular changes associated with OA, their potential correlation with trait plasticity, and also offer insight into the stability of OA-induced differential gene expression over variable exposure lengths.

IDENTIFYING METABOLITE GROWTH MARKERS OF SUNSHINE HYBRID STRIPED BASS (FEMALE MORONE CHRYSOPS x MALE *M. SAXATILIS*) THROUGH LIVER TISSUE ANALYSIS

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Striped bass are crossed with white bass to produce a hybrid fish with superior growth, which is the fourth largest aquaculture industry in the United States. Fish growth rates may vary among hybrids, resulting in some fish failing to reach market size (runts) within the growout time period. The aim of this study is to identify physiological patterns related to growth through the analysis of hybrid striped bass liver tissue utilizing small molecule (metabolite) profiling, known as Metabolomics. Half-sibling hybrid striped bass progeny were produced by crossing multiple same aged striped bass males, of varying size, with the same white bass females. Fingerlings were sorted into top grade and runt groups based on projected growth to market size and raised common garden in earthen ponds until harvest at 14 months of age. A subset of the groups (N=20 fish each) significantly differed based on size: top grade (total length: 347 $\pm$ 19 mm; weight: 656 $\pm$ 121 g) and runts (total length: 293 $\pm$ 19 mm; weight: 391 $\pm$ 83 g) ($P < 0.0001$, Student's t). Liver samples from these subsets were analyzed through a global metabolomics panel which identified and quantified 653 metabolites. Statistical analyses revealed a prevalence of bile acids and biliary derivatives in the runts group liver samples. These results suggest poor growing aquacultured hybrid striped bass display some form of liver dysfunction. The causes of this dysfunction, whether it be genetic, dietary, or husbandry factors, remain unclear, but are the topic of current research.

ESTIMATION OF MONETARY VALUES ASSOCIATED WITH NITROGEN SEQUESTRATION AND REMOVAL FUNCTIONS OF CLAMS AND OYSTERS: AN ALLOCATED REPLACEMENT COST APPROACH

Anthony Dvarskas[1], John Bohorquez[1], Julie Rose[2], Mark Dixon[2], Suzanne Bricker[3], Gary Wikfors[2], Roger Bowgen[4]. [1]Stony Brook University, School of Marine and Atmospheric Sciences, Stony Brook, NY 11794; [2]NOAA Fisheries NEFSC Milford Laboratory, Milford, CT; [3]NOAA National Centers for Coastal Ocean Science, Silver Spring, MD 20910; [4]Greenwich Shellfish Commission, Greenwich, CT 06830

The Millennium Ecosystem Assessment spurred significant interest in tracking ecosystem services, broadly defined as the benefits that people receive from ecosystems, provided by various habitat types. Alongside the measurement of service flows have been efforts to monetize the contributions of habitats to human well-being for incorporation into benefit-cost analyses. Long Island Sound has a long history of eutrophication and hypoxia associated with the input of nitrogen from sewage, septic, and fertilizer sources, among others. The current study estimates the economic value of removal of nitrogen by farmed oysters and clams within the jurisdiction of the Town of Greenwich, CT. Unique from previous approaches, the study uses data on the allocation of nutrient inputs (i.e., from septic versus sewer versus fertilizer) to allocate the economic costs of replacing farmed clam and oyster populations with equivalent methods for removing nitrogen from the system. We also compare these allocated replacement costs to the value of credits according to the Connecticut Nutrient Credit Trading Program. Results indicate that the value of the services varies widely based on the replacement technology, with the most

efficient technologies, as expected, leading to the lowest values for nitrogen services provided by clams and oysters. Use of the Nutrient Credit Trading Program credit value may also underestimate the value of the services since, in its current form, the Program focuses only on wastewater treatment plant upgrades. Future research directions are also discussed that will provide alternative monetary estimates of the value of these nitrogen removal and sequestration functions.

RHODE ISLAND AQUACULTURE TRAINING PARTNERSHIP

Cameron Ennis. Executive Director, The Education Exchange, RI Department of Labor, Aquaculture Training Partnership, National Registered Apprenticeship, Veteran Affairs OTJ

In 2015, The Aquaculture Training Partnership (ATP), formed through Governor Gina Raimondo's Real Jobs RI Initiative, where identified growing industry sectors were awarded Planning Grants to design a training curriculum. Under the leadership of Dr. Robert Rheault of ECSGA and The Education Exchange, five RI Oyster Farmers came together to discuss and identify the critical skill-sets needed within their industry. The finished product consisted of five training modules: Boating Safety, Boating Mechanics, Shellfish Biology, Growing Techniques, and Dealer Shipper Skills while also awarding industry recognized credentials before intensive work-based learning. Over the past four years, the ATP program has grown to include 24 RI Oyster Farms, 40 Strategic Partners and now has an 80% job-placement-rate. We expanded, creating a Shellfish Hospitality Training program with 20 Hotels & Restaurants. Last year, ATP established a one-year Nationally Certified Apprenticeship with garnered Veteran Affairs approval, enabling Veterans to use their Post 9/11 GI Bill to collect $1800 in Cash Benefits in addition to their wages (aquaculture is a known therapeutic treatment for PTSD). RI Growers are ecstatic to bring on Veteran Apprentices. The Aquaculture Training Partnership screened over 250 candidates for 54 entry-level oyster farm-training which 49 completed the training and 40 are still employment. Last year, ATP consulted with Maryland to replicating this training in their successful Work-to-Live program. The Aquaculture Training Partnership and Coastal Institute seek to promote best practices by providing a platform of curriculum for other states to use at no cost while continuously gathering employer feedback for modifications.

USDA/NIFA/NRAC AQUACULTURE GRANTS BENEFIT THE NORTHEAST AQUACULTURE INDUSTRY

Elizabeth A. Fairchild[1], Kelly Cullen[2], Curt Grimm[3], Tracy Keirns[4], Andrew Smith[4]. [1]Department of Biological Sciences, 46 College Road, University of New Hampshire, Durham, NH 03824 USA; [2] Department of Natural Resources and the Environment, 56 College Road, University of New Hampshire, Durham, NH 03824 USA; [3] Carsey School for Public Policy, 73 Main Street, University of New Hampshire, Durham, NH 03824 USA; [4] Survey Center, 9 Madbury Road, Suite 401, University of New Hampshire, Durham, NH 03824 USA

Thirty-two aquaculture projects, funded during 2005-2014 by USDA NIFA via the Northeast Regional Aquaculture Center (NRAC), were evaluated. The assessment included the projects' economic impact on the aquaculture industry and overall economies in the Northeast, effectiveness in solving problems confronting the aquaculture industry, and effectiveness in securing other research grants.

The evaluation involved three surveys: one with NRAC project leaders; a second with the research, extension, and industry collaborators who were part of the design and implementation of NRAC projects; and the third with representatives from the aquaculture industry throughout the Northeast region. Data from these surveys were used in an estimation of the economic impact of the NRAC-funded projects in the region and in individual states.

Money invested in the 32 NRAC-funded projects benefitted regional Gross Domestic Product (GDP), job growth, and state and local tax revenues. A modest investment of $4.1 million resulted in an increase of almost $79 million in GDP of NRAC states; 777 new jobs; over $4 million in state and local tax revenues; over $9.5 million in federal tax revenues; and nearly $33 million in additional external grant funding secured, not including matched funds. People engaged in the aquaculture industry rated these projects as having been very important to critically important to the future of the industry. At a minimum, the overall economic impact of NRAC funding from 2005-2016 is estimated at 5.3 times the initial investment, however, depending on the assumptions of the model, the impact could be as high as 31.8.

PANEL CONVERSATION: HOW NIFA-NRAC FUNDING OPPORTUNITIES HAVE AND CAN CONTINUE TO ADDRESS NORTHEAST AQUACULTURE NEEDS

Organizers: Elizabeth A. Fairchild[1], Reginal Harrell[2], Marta Gomez-Chiarri[3], Dan Ward[4]. [1]Department of Biological Sciences, 46 College Road, University of New Hampshire, Durham, NH 03824 USA; [2]Northeastern Regional Aquaculture Center, 2113 Animal Sciences Building 142, College Park, MD 20742-2317 USA; [3] Department of Fisheries, Animal and Veterinary Science, University of Rhode Island, 169 CMBS, 120 Flagg Road, Kingston, RI 02881 USA; [4] Ward Aquafarms, 51 Falmouth Highway, North Falmouth, MA 02556 USA

Panel members, representing a variety of sectors of the aquaculture industry throughout the NRAC region plus extension, will share their knowledge of the state of aquaculture in their areas of expertise which include marine and freshwater finfish, shellfish, kelp, IMTA, marketing and sales, recirculating systems, and aquaponics. Panelists will highlight specific NRAC-funded projects that have benefited the aquaculture industry and discuss non-regulatory issues and immediate industry needs that could be addressed through additional funding and research. The audience is encouraged to participate and bring forth useful topics as well.
Panel composed of:

- Sebastian Belle – Executive Director, Maine Aquaculture Association (Hallowell, ME)
- Steve Malinowski – Owner, Fishers Island Oyster Farm (Fishers Island, NY)
- George Nardi – EON Aqua, LLC (Lee, NH)
- Greg Casten – President, OceanPro Industries (Washington, DC)
- Tessa Getchis – Aquaculture Extension Specialist, CT Sea Grant (Avery Pt, CT)
- Mike Nardella – Owner, Rainbowhead Farms (Wallace, WV)

MONITORING OF MACROALGAE FARMS WITH AUTONOMOUS UNDERWATER VEHICLES

Erin M. Fischell, Andone Lavery, Amy Kukulya, Timothy Stanton, Matthew Grund, Daniel Gomez-Ibanez. Woods Hole Oceanographic Institution, 266 Woods Hole Rd., Woods Hole, MA 02543

The long-term goal of ARPA-E's MARINER (Macroalgae Research Inspiring Novel Energy Resources) program is to increase the scale of offshore kelp aquaculture so that biofuel may be derived from macroalgae. An autonomous underwater vehicle (AUV) system including acoustic, optic, and environmental sensors has been developed to monitor these large-scale kelp farms. The primary sensor for observing farm infrastructure and kelp growth is a split-beam sonar system. Structural information such as longline droop, breakage, or entanglement is available from time-of-flight in acoustic echoes. Growth of kelp can be estimated from time-of-flight and volume backscattering echo data. Optic sensors include the KelpCam, a multiple camera system that captures images around and in front of the vehicle, and a PAR sensor. Environmental sensors for understanding farm conditions include a nitrate, turbidity, chlorophyll, salinity and temperature sensors. A vehicle carrying an initial set of sensors was used in spring of 2018 to look at a longline growing sugar kelp in Saco Bay, Maine, and additional experiments looking at farms off of Massachusetts and Maine with MARINER partners are planned for winter

and spring of 2019. The final data streams will be integrated with a web-based system for viewing farm-wide conditions and state [work supported by ARPA-E].

SERIAL KNOTS AND MESH HEMICYLINDERS AS ANTI-PREDATOR DEVICES ON MUSSEL CULTURE ROPES

Marcel Fréchette[1], Éric Bujold[2]. [1]1200 du Sanatorium, Mont-Joli, QC, G5H 3V9, Canada;[2] Ferme Maricole du Grand Large, 583 boul. Perron, Carleton-sur-mer, QC, G0C 1G0, Canada

Predation by sea ducks is a threat to mussel culture in many sites. In natural settings mussel survivorship is usually enhanced in crevices and similar roughness elements of the shore, as they provide shelter against predators. We mimicked the effect of crevices by using loosely knotted spat collector ropes. The knots used were the chain sinnet and variants thereof. The knots were tested in Cascapédia Bay, Quebec, in two similar experiments. Knotted ropes collected more spat than controls, up to 5100 and 5900 individuals per 30.5 cm collector, as compared to 2700 and 1300 individuals per 30.5 cm on controls in 2015 and 2016, respectively. In the 2015 experiment, there were barely any mussels left on the controls after the second winter of the trial. On the variants, few mussels could be ascribed to the initial cohort, although undersized mussels were abundant (roughly 750 individuals per 30.5 cm). This suggests that individual mussels had grown too large to benefit fully from the shelter provided by the knots used in 2015. Therefore in October 2017 we initiated a trial where shelter size was expanded by adding plastic mesh hemicylinders ("duckshields") to the ropes. In May 2018 the abundance of mussels (shell length 0.5 cm and more) on hemicylinder-protected ropes was roughly 1500 individuals/30.5 cm rope, as opposed to nearly none on unprotected parts of the same ropes and on separate control ropes. The experiment is presently being repeated using an improved duckshield design.

AN INSTRUMENT FOR MEASURING *IN-SITU* TENSIONS IN MOORING SYSTEM AQUACULTURE GEAR.

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Specifying mooring system aquaculture gear requires an understanding of component loads in response to forces due to winds, waves and currents. The objective of this presentation is to describe the design and utility of a self-contained, submersible, load-cell instrumentation package that can be deployed on a mooring of an aquaculture system. The instrumentation components mount to a stainless steel strongback engineered for a specific mooring line tension. A load-cell is bolted to a flange welded on one side of the strongback. The load-cell and strongback shackle inline to the mooring through heavy eyes and bushings. Separate data acquisition and battery power housings are mounted on either side of the strongback. To be stable when fully submerged, the battery pack was placed below the data acquisition housing. Submerged stability was increased with the addition of two lobster floats mounted to each side of the data acquisition housing. The addition of the floats also created an assembly with near neutral buoyancy. The instrument was tested in May 2018 on a kelp longline system deployed in Saco Bay, Maine. The sensor was tested for two, 24-hour deployments sampling at 2-Hz. An acoustic wave and current (AWAC) instrument was deployed at the same time to measure tidal elevation and velocities every 5-mintues. Resulting datasets show the correlation of the mooring line tensions to tidal elevation and velocities. The correlated data sets can be used to validate numerical modeling approaches needed to simulate system dynamics for design purposes.

LINKING REGIONAL OCEAN AND COASTAL ACIDIFICATION RESEARCH EFFORTS WITH COMMUNITY STAKEHOLDERS AND AQUACULTURE INDUSTRY WATER MONITORING

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Northeast shellfish growers have not yet experienced the devastating shellfish die offs seen by West Coast growers in response to ocean and coastal acidification. Nevertheless, they have concerns about OCA and understand that protecting Northeast marine habitats and industry is especially important at this time. Municipal management of coastal nutrients and stormwater and habitat restoration efforts can improve the resilience of coastal ecosystems to acidification. However, we lack comprehensive monitoring at spatial and temporal scales required to provide actionable information for such management. While there are a small number of existing long-term, decadal and climate-scale coastal acidification monitoring sites, the time and space scales are inadequate to understand coastal trends. Crowd sourcing monitoring and integrating disparate data streams through coordination of community science programs and aquaculture industry water monitoring offers an opportunity to expand observations of near shore conditions of acidification that would be necessary for management.

This presentation discusses work over the past year to support such collaboration; including webinars and workshops, GIS tools mapping monitoring stations, and an effort to crowd source monitoring and outreach by hosting a *Shell Day* event in 2019. Partners include NECAN (the Northeast Coastal Acidification Network), Environmental Protection Agency, Maine and MIT Sea Grant, the Connecticut Department of Energy and Environmental Protection, the Connecticut Department of Agriculture, and the Maine Ocean and Coastal Acidification Partnership (MOCA). Interested parties who are unable to attend the conference session are encouraged to reach out to parker.gassett@maine.edu and Esperanza Stancioff at esp@maine.edu.

PUBLIC KNOWLEDGE, PERCEPTIONS, AND PREFERENCES TOWARDS CONNECTICUT WILD-CAUGHT AND FARMED SEAFOOD

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An internet survey of Connecticut residents was conducted to determine consumption patterns, preferences, perceptions and interests about seafood. There was participation from all 169 towns and a total of 1,756 respondents. A non-probability quota sampling approach allowed the sample to closely mirror the distribution of Connecticut residents based on age, gender, and income.

While the United States Department of Agriculture recommends two servings of seafood a week, 50% eat seafood at least once a week, and only 15% of Connecticut residents meet that target. The top factors reported as moderately to extremely important when purchasing seafood were flavor, freshness, safety, and price. Other important considerations included knowing how to prepare/cook seafood, the water quality where the seafood was harvested, previous consumption/familiarity with the seafood product and seafood country of origin. Of lesser importance, but still relevant to a majority of consumers is knowing if the product was wild caught or farm-raised, and if it is sustainably produced. Four percent of respondents preferred farm-raised seafood, while 37% prefer wild-caught seafood and the remaining do not have a preference, don't know or claim that it depends on the type of seafood. The majority of consumers expressed slightly higher confidence in seafood harvested locally in Connecticut and in the New England region, as compared with elsewhere in the United States, and lower confidence in product harvested in foreign countries. When asked why they prefer seafood from Connecticut, the top three reasons were: it's fresher, it's easily available, and to support local fishermen and the economy. Safety, quality, and sustainability – the focus of many seafood certification programs – were the lowest ranked reasons for preferring local seafood. The answers to preference-related questions varied widely among demographic groups, and respondents sought a variety of experts for seafood-related questions.

These results suggest that having a better understanding of residents' concerns and choices can be useful in driving messages to specific demographic groups, and that it is important to ensure these messages are delivered by trusted sources.

DETECTION OF BONAMIA EXITIOSA IN AMERICAN OYSTERS (*CRASSOSTREA VIRGINICA*), A NEW HOST SPECIES

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In June 2013, during routine regulatory pathogen screening of 2-month-old American oyster (*Crassostrea virginica*) seed from an open-water nursery site in Chatham, Massachusetts, *Bonamia exitiosa* was detected by agent-specific PCR and histology. Prevalence was estimated at 23% by histology, with the parasite located in gill tissues. Elevated mortalities were not noted and infections regressed to non-detectable levels within several weeks of initial detection. This was one of the first recorded cases in this species and from the eastern United States coastline. In late spring to early summer 2018, during routine regulatory pathogen screening of *C. virginica* seed from Chatham, MA and two additional nursery sites located in Harwich and Dennis MA, *B. exitiosa* was again detected by PCR and histology. As before, infections were sub-clinical, confined to gill tissues, and elevated mortalities were not observed. Results obtained in all cases were confirmed by the USDA APHIS NVSL and reported to the OIE. In multiple cases, *Mercenaria mercenaria* (hard-shell clam) seed of similar size located adjacent to infected *C. virginica* seed did not show positive results for *B. exitiosa* in screening via agent-specific PCR. The clear observations of the parasite present in oyster tissues, combined with the absence of detection in nearby clams, indicates a clear association of *B. exitiosa* with oysters, and not simply detection of environmental parasite cells. While *B. exitiosa* infections are inconsequential with regard to oyster growth and mortality, the parasite does complicate interstate and international commerce in oysters, mitigation strategies for which will be discussed.

THE DYNAMICS OF THE ATLANTIC SEA SCALLOP (*PLACOPECTEN MAGELLANICUS*) INFECTION OF THE APICOMPLEXAN PARASITE *MEROCYSTIS KATHAE*

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Atlantic sea scallops (*Placopecten magellanicus*) first displayed a grey meat disease in 2004 that has previously been seen in the Icelandic scallop (*Chlamys islandica*). Infected animals have variations of brown or grey adductor muscle meat, rather than their traditional white color. As a result of the less appetizing color of the meat, commercial potential and profit have declined. Previous work has determined that this disease is in part due to an infection of an apicomplexan parasite named *Merocystis kathae* whose final host is the common whelk *Buccinum undatum*. To understand the infection dynamics of this disease in local populations, *P. magellanicus* adductor muscles were collected from areas south of George's Bank (2015-2018) and samples were analyzed for the presence of this specific apicomplexan parasite. Preliminary PCR results from extracted DNA of individuals with various colored meat have shown that the meat color does not necessarily indicate presence of the parasite. Individuals that were grossly observed with white meat were positive for the parasite. Histology of white meat tissue corroborates the PCR findings: individuals can be infected but not display the 'typical' meat color symptom. Based on these results, the dynamics of this disease is perhaps more complex and further hypotheses for the degenerated tissue quality/color need to be further evaluated. Further work will be essential to understand this disease including a greater sample size, the inclusion of other tissues and or parasites, and a quantitative measure of infection.

ARBACIA PUNCTULATA AQUACULTURE, A POSSIBLE CONTROL FOR THE RISE OF TURF MACROALGAE

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Changes in near shore subtidal communities from kelp forests to turf-like macroalgal systems have been documented in many areas of the world. Multiple factors are driving these regimes shift and include both biological and physical mechanisms. To date, there are no mechanisms known that would result in a decrease of turf-like macroalgal dominance and the negative consequences these opportunistic species have on local community ecology. In southern New England available herbivores include the purple sea-urchin *Arbacia punctulata* which has been observed to create incipient barrens (areas cleared of turf-macroalgae). Our interest is to examine the possibility/feasibility of culturing *A. punctulata* at NMF, NOAA laboratory and examining the urchin's ability to clear (eat) the most common turf-like macroalgal species. If it is determined that the aquaculture of these urchins are possible and they actively consume the turf-like species, controlled transplant field experiments would be undertaken to determine the ability of *A. punctulata* to clear naturally occurring turfs in areas of shellfish interest in eastern Long Island Sound. These studies would help expand the knowledge of culturing sea-urchins and using these 'crops' to control the growing world-wide populations of turf-like macroalgae.

QUANTIFYING NITROGEN ASSIMILATION OF KELP FARMS IN SOUTHERN MAINE

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Farmed kelp uses available dissolved inorganic nitrogen (DIN) from temperate marine environments to grow. When used as a management tool, assimilation and extraction of anthropogenic DIN by strategically-sited kelp

farms is known as *bioremediation*. We sought to describe the bioremediation of farms growing *Saccharina latissima* along the southern Maine coastline; focusing on total tissue N throughout the growing season, origin of tissue N (anthropogenic or marine), and relationship between total tissue N and kelp growth characteristics. DIN in water at the farms was compared to nitrate reductase and total tissue N in the kelp tissue to determine quantity and rate of nitrogen assimilation by the kelp. Origin of the assimilated nitrogen was estimated by measuring nitrogen isotope values ($\delta^{15}N$) in the kelp tissue. Preliminary analysis of the water and tissue results suggest that kelp grown at these locations is not nutrient saturated. Alternative farming locations or methods to increase the amount of nutrients received by the kelp could improve the nitrogen assimilation capacity of these farms; ultimately improving their efficacy as a bioextraction tool for maintaining healthy waterways. In an upcoming project, data from this effort will be combined with historical nitrogen datasets to generate siting and harvesting recommendations for kelp farms seeking to increase farm productivity and net income.

OPTIMIZING SITE SELECTION FOR KELP-OYSTER CULTIVATION SYSTEMS IN RHODE ISLAND

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There is a growing interest among shellfish farmers to transition from monoculture to polyculture that incorporates kelp into their existing shellfish farms. Industry interest is driving an expansion of kelp-shellfish cultivation systems, however little information is available to help farmers determine where these systems will be successful. The primary goal of this on-going research project is to develop a spatially explicit model that combines the biological requirements for kelp and oyster growth with the hydrodynamics of Narragansett Bay (NB). In order to determine conditions for optimal kelp and oyster growth, we established six kelp-oyster cultivation systems in collaboration with industry partners across a biophysical and geochemical gradient; three sites were located in shallow coastal salt ponds and three in the deeper waters of NB. Reproductive sugar kelp (*Saccharina latissima*) was wild harvested, spawned, and cultured in a nursery. Two 60m longlines of kelp were deployed at each site:the first longline was deployed in early November 2017 and the second was deployed 3-5 weeks later to test for optimal planting time. At harvest (April 2018), kelp at the most productive deep site averaged 1.35 ±0.27m long, producing 12.22 ±2.18 kg of kelp/m of longline (first line) and 0.73 ±0.07m long, producing 4.18 ±0.29 kg of kelp/m of longline (second line). At the most productive shallow site kelp at harvest averaged 1.23 ±0.27m long, producing 6.65 ±1.65 kg of kelp/m of longline (first line) and 0.81 ±0.10m long, producing 5.61 ±0.53 kg of kelp/m of longline (second line).

PROGRESS IN GENETIC IMPROVEMENT OF EASTERN OYSTERS

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Rutgers University has been breeding the eastern oyster (*Crassostrea virginica*)for disease resistance since 1960, soon after the outbreak of MSX disease (caused by *Haplosporidium nelsoni*) in Delaware Bay. During the early years, the primary goal was to obtain MSX resistance by mass or individual selection. Beginning in 1990, Dermo disease (caused by *Perkinsus marinus*) appeared in Delaware Bay and caused significant mortality in Rutgers MSX-resistant strains. Since then, selection for Dermo resistance became a part of the breeding program. Superior growth and shell shape were added to the selection criteria in 1998. Maintaining selection pressure and managing inbreeding are major challenges for long-term selective breeding. Continued breeding and improvement in targeted traits have been made through progressive rotational crossing, a process that combines controlled outcrossing, strong individual selection and rotational crossing for sustained progress. Two strains, NEH® and

DBX were developed with genetic materials originating from the Northeast region and Delaware Bay, respectively. These strains have demonstrated strong resistance to MSX and moderate resistance to Dermo. They are widely used for aquaculture production in the Northeast. Tetraploid lines have been developed from the disease-resistant strains and selectively bred for over 12 generations. Triploid oysters produced from the improved tetraploids have demonstrated significantly faster growth than diploids. New approaches to breeding and the latest performance data of Rutgers disease-resistant strains will be reviewed and presented.

EFFECTS OF REPEATED EXPOSURE TO OCEAN ACIDIFICATION ON JUVENILE PACIFIC GEODUCK *PANOPEA GENEROSA*

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Enhancement strategies in sustainable shellfish industry are critical to satisfy growing demands for food security. The Pacific geoduck, *Panopea generosa,* is a valuable clam increasing in aquaculture productivity, however rearing poses a bottleneck. Although acute stress can be harmful, a growing body of literature supports potential for environmental conditioning to improve performance. We exposed juvenile geoduck to repeated trials of low pH in a commercial hatchery to test whether physiological status is altered by stress conditioning. Shell length and standard metabolic rate (SMR) was measured for 240 geoduck periodically throughout initial (10-days) exposure in two treatments (low pH v. ambient). Initially, low pH significantly reduced SMR by 25% in comparison to ambient. Shell length did not, however, differ. After 2-weeks in ambient conditions, reciprocal exposure (6-days) to the two treatments revealed marginally smaller shells in those initially exposed to low pH and significant reduction of shell length for both initial exposures under secondary low pH. SMR did not differ during reciprocal exposure suggesting that juvenile geoduck decrease metabolic rate when initially exposed to low pH and recover when returned to ambient conditions. Results of this study reveal negative effects of repeated exposure to acidified seawater on shell growth of juvenile geoduck, but SMR indicates physiological ability to cope with short-term exposure. A variety of life stage-specific exposures to stress of different durations and frequencies need to be assessed to determine when it may be especially detrimental, or advantageous, to apply stress conditioning for commercial production of this long-lived burrowing clam.

HATCHERY TECHNOLOGY, ENGAGING IN RESEARCH, AND INTEGRATING FARM COLLECTED DATA: STRATEGIES USED BY GREENWAVE TO MAKE SMALL-SCALE, COMMERCIAL SUGAR KELP (*SACCHARINA LATISSIMA*) HATCHERIES EFFICIENT AND COST-EFFECTIVE

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GreenWave is a nonprofit organization, dedicated to the assistance and education of ocean farmers in sugar kelp (*Saccharina latissima*) aquaculture, with the overlying goals of habitat restoration, climate change mitigation, and creation of a blue-green economy. We hope to reach these goals by growing kelp seed in our hatchery, which is provided to the participants of our Farmer-In-Training program, therefore helping facilitate the creation of new ocean farms. Our objective is to make our hatchery both cost-effective and replicable to other ocean farmers in the sugar kelp industry. With this objective in mind, the 2018 hatchery season saw many improvements in hatchery technologies, including a spool wrapping device, spool stands, and a tank balancing apparatus, all of which increase hatchery efficiency and production at a low cost. Along with technology modifications, GreenWave has engaged in a number of research objectives. Specifically, we completed a trial of induced sporing experiments, which ultimately results in an earlier hatchery season and less dependence on wild, reproductive kelp blades. Additionally, we conducted a preliminary experiment investigating the traditionally used, yet expensive and

labor-intensive seawater enrichment, Provasoli Enriched Seawater (PES) versus a commercially available and cost-effective media known as Guillard's 1975 F/2 formula. Growth measurements and water quality parameters were measured in the hatchery, but the ultimate measure of success is how this will translate to farm yields. It is hoped that our look into these hatchery improvements can benefit kelp farms throughout southeast New England and their environmental surroundings.

WHAT IS NRAC AND HOW DOES IT IMPACT ME?

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The mission of the NRAC is to fund aquaculture projects that have direct application to the advancement of the aquaculture industry in the Northeast (Washington, DC to Maine). Unique to this NIFA-funded regional center operation is that its priorities for funding are industry driven. These priorities are established by a joint Industry and Technical Advisory Council (TIAC) made up of producers, scientists, and extension personnel in the Northeast Region. The industry representatives develop the priorities and jointly with the technical representatives determine their practical and technical feasibility. Once the priorities are approved by the Board of Directors they are the basis for an annual Request for Proposals advertised throughout the region. Once submitted all proposals undergo rigorous internal and external review for funding consideration. Because we seek projects of regional industry relevance there is a requirement of multistate collaboration between investigators, which can and often does include direct industry participation. Projects submitted must have a funded extension component that will work with the team from project initiation to completion. Projects are open to multistate teams working with our annual priorities. We typically annually fund projects in the range of $150-200K from a total pool of $500-750K available. The impact of NRAC funded projects on our industry growth and economics will be covered by Dr. Elizabeth Fairchild during this symposium.

EFFECTS OF OCEAN ACIDIFICATION ON THE PHYSIOLOGY OF SUBADULT AMERICAN LOBSTERS

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Increases in anthropogenic input of carbon dioxide into the atmosphere has caused widespread patterns of ocean acidification (OA) and warming. Although it is likely that both processes will have major impacts on marine calcifying invertebrates, researchers often fail to consider their combined effects. Here, we explore the sublethal effects of OA on the hemolymph chemistry and thermal physiology of the American lobster (*Homarus americanus*). We exposed subadult lobsters to current or predicted end-century pH conditions (8.0 and 7.6, respectively) for 60 days. Following exposure, we drew hemolymph for analysis of *L*-lactate and calcium concentrations (as indicators of oxygen carrying capacity), ecdysone concentrations, total protein content, and total hemocyte counts (THCs; as an indicator of immune response). We also assessed cardiac performance in the context of thermal stress using impedance pneumography. Calcium, total protein, and ecdysone concentrations were not significantly altered by OA exposure. However, control lobsters had significantly higher levels of *L*-lactate concentrations compared to acidified lobsters, suggesting reduced oxygen carrying capacity under OA. THCs were also 61% higher in control vs. acidified lobsters, suggesting immunosuppression under chronic OA. Finally, lobsters exposed to acidified conditions exhibited reduced cardiac performance under warming as indicated by significantly lower Arrhenius Break Temperatures compared to control lobsters. Together, these results suggest that some basal metabolic components of American lobster are not impacted by OA; however, the stress of OA will likely be compounded by thermal stress, which may present additional physiological challenges for this species in the face of future change.

RECIRCULATING AQUACULTURE SYSTEMS AND THEIR USE WITH OCEAN ACIDIFICATION RESEARCH

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Increases in atmospheric carbon dioxide (CO_2) in recent decades have caused ocean waters to warm and acidify (decrease in pH). These environmental changes have spurred interest in ocean acidification (OA) research, including its effects on marine species' physiology. Previous OA research has typically utilized flow-through systems, restricting efforts to shore-based research laboratories. Here, we describe a recirculating system for OA research using artificial seawater that can be easily used at land-locked locations. We used Honeywell Durafet pH electrodes in combination with a PENTAIR Point Four™ RIU to monitor and maintain desired pH values. We removed CO_2 from all incoming air for use in this system with a Puregas™ CAS1-11 CO_2 Adsorber/Dryer and monitored pCO_2 in the head space of each tank with a LI-COR® LI-840A CO_2/H_2O gas analyzer. We developed protocols to measure water chemistry and quality using the best practices available to calculate and monitor the carbonate chemistry within each experimental tank. Our system was used to successfully complete two OA experiments focusing on very different organisms, American lobster (*Homarus americanus*) and blue mussels (*Mytilus edulis*). The use of recirculating systems with artificial seawater allows researchers superior control over and standardization of environmental variables that historically have been difficult to control in flow-through, natural seawater systems (*e.g.* temperature, salinity, alkalinity, and turbidity). For these reasons, we propose that recirculating systems are a better alternative to traditional flow-through seawater systems for use in OA research.

DEVELOPING AQUACULTURE APPROACHES FOR COMMUNITIES AND STAKEHOLDERS ENGAGEMENT AND RESILIENCY

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Aquaculture or farming of aquatic organisms is a growing area for business, economics and industry in the United States and worldwide. In addition, consumption of seafood has grown considerably, while, the capture or wild fisheries has declined or remained stagnant. Despite the growth of aquaculture and the increase in seafood consumption, there are communities that reside near the coasts that may not have availed themselves of opportunities to become engaged in aquaculture activities for employment, entrepreneurships or related ventures. Moreover, many coastal communities that have been devastated by disasters such as hurricanes or even earthquakes, some of whom might be fishers or harvesters, perhaps could be more resilient, might not be aware of aquaculture opportunities or take advantage of opportunities to become involved in aquaculture endeavors. These communities also are likely to be big consumers of seafood themselves, maybe eating fish, shellfish or other aquatic products, several times a week. A goal of this project is to increase awareness of aquaculture with outreach services through training, internships, schools, industry, agencies, workshops, partnerships, conferences, meetings or other means of communication, including new technology. Contacts have already been made from these activities. Approaches will be described and discussed.

DEVELOPMENT OF EXPERIMENTAL AND COMPUTATIONAL METHODS FOR IMPROVING UPWELLER FLOW CHARACTERISTICS

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Upwellers are needed to raise juvenile oysters until they are large enough to survive being placed in bags or planted. An Upweller is a device that passes vertical flow through a bed of oysters, and typically consists of a vertical round or rectangular duct with a screen on the bottom that holds the oyster bed. Variations of flow velocity and turbulence have been observed in current designs, which can cause slow and uneven growth. To increase efficiency and reduce labor cost associated with this nursery stage of oyster farming, an optimized upweller system is desired.

In this work, a testbed for developing and improving upweller systems is created that is capable of detailed flow measurements. The testbed consists of a large water tank with viewing windows, a variable flow speed pumping loop, and a stand to hold the upweller in place. The inlet to the pumping system is designed so it can be easily modified to fit many upweller configurations. Velocity data, including flow magnitude, direction and turbulence levels, is collected by hot film anemometry at positions of interest.

In addition to experimentation, which is time and labor intensive, numerical modelling will also be employed in the optimization process. Boundary conditions and fluid flow characteristics through the oyster layer will be validated experimentally using data acquired in the testbed. This calibrated computational model can then be used to explore a large number of upweller designs under realistic conditions, with the aim of arriving at and optimized upweller configuration that delivers uniform flow across the oyster bed while remaining simple to construct and clean.

KELP FARMING AS A POTENTIAL STRATEGY FOR REMEDIATING OCEAN ACIDIFICATION AND IMPROVING SHELLFISH CULTIVATION

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Cultivated seaweed may remove sufficient amounts of CO_2 to locally mitigate acidification during peak primary production, creating a 'halo' of improved water quality. Our study investigated the spatiotemporal patterns of this halo effect and possible enhancement of shellfish production at the Ocean Approved kelp farm in Casco Bay, Maine. Both a flow-through array of sensors deployed inside and outside the farm and sampling during underway vessel operations were used to map biogeochemical conditions. Variables measured included: salinity, temperature, dissolved oxygen, pCO_2, dissolved organic matter fluorescence, and chlorophyll fluorescence. Measurements were paired with GPS data to produce high resolution maps of biogeochemical conditions around the farm. The 'halo' effect can be detected in each of the three study years, but the strength of this effect is inconsistent over time and space and is likely impacted by a variety of biological and physical factors. To investigate whether sugar kelp (*Saccharina latissima*) creates favorable conditions for blue mussels (*Mytilus edulis*), we conducted a two-month field experiment. Year-old mussel lines were deployed inside predator exclusion cages (n=3) at increasing distances from the farm (0, 125, 180, 395m). Despite variable halo strength over time, the impact of co-cultivation was measurable and significant. Mussels cultivated within the kelp farm exhibited shells with significantly greater acute pressure resistance (75%), higher force tolerances to breakage (5%), greater shell thickness (27%) and density (88%), and larger meat masses (28%). This study provides evidence that co-cultivation provides a bio-efficient methodology for reducing marine calcifier stress and increasing mussel product quality.

COCULTURE OF PROBIOTIC BACTERIA IN ALGAL FEEDSTOCKS FOR DISEASE MANAGEMENT IN BIVALVE HATCHERIES

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Bivalve hatcheries include microalgae culture operations as a food source for stock, and these algae cultures harbor dynamic bacterial communities. Because algae from these cultures and their associated microbiota are distributed to stock tanks daily upon feeding, the presence of pathogenic *Vibrio* spp. in hatchery microalgae cultures is a threat to stock health and survival. This study investigates the algal/bacterial and bacterial/bacterial interaction between four popular species of microalgae feedstock, a *Vibrio* sp. of known pathogenicity to bivalves (*V. coralliilyticus* RE22), two strains of probiotic marine bacteria with demonstrated effectiveness in reducing larval shellfish mortality in culture operations (S4 and RI06-95), and bacterial strains isolated directly from these algal cultures. Results show that the growth/persistence of RE22 or probiotic in co-culture with each of the four microalgae species was species-specific. For example, while titers of RE22 significantly decreased more than 3-log when cocultured with *Pavlova pinguis,* S4 titers only decreased by 0.3-log. Bacterial inhibition assays suggest these effects may be due to the ability of particular bacterial strains associated with the algal cultures to inhibit the growth of RE22, but not S4. These strains are now being explored as candidate probiotics for *Vibrio* sp. management. Additionally, algal growth was unaffected by the addition of probiotic and/or *Vibrio*sp. This research enhances our understanding of algal/bacterial interaction in shellfish hatcheries.

COMMUNICATING AQUACULTURE: THE ROLE OF MEDIA & INFORMAL EDUCATION INSTITUTIONS ON PUBLIC PERCEPTIONS

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As the human population and seafood consumption are on the rise, aquaculture can help make up the difference between the growing demand for seafood and the sustainable harvest that wild fisheries can support. However, media coverage and public perceptions of aquaculture's benefits and risks have been mixed, with nearly half of Americans having a negative perception of aquaculture. By reviewing data on media coverage of aquaculture, the connection between media coverage and public perceptions will be elucidated. The role of informal education institutions, particularly zoos and aquaria, in communicating the benefits and risks associated with aquaculture will also be highlighted. Examples of effective, science-based messaging about aquaculture will be shared.

FEDERAL PERMITTING OF OFFSHORE AQUACULTURE FACILITIES

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Over the past two years the Corps of Engineers – Massachusetts Permitting Branch has seen an increased interest in offshore aquaculture within Massachusetts. To date the Corps has permitted nine offshore facilities within the state of Massachusetts. Four facilities have been for shellfish aquaculture, five have been for kelp aquaculture. Permitting paths are highly dependent on the proposed size of the project. Presentation will include a review of the permitting paths utilized by the Corps, give permitting timelines and expectations to prospective applicants, and provide insight on permitting review factors that are important the regulators reviewing project proposals. Review of factors considered that result in permitting success will include endangered species review, the appropriate use of weak links, competing use factors, and project location selection recommendations.

A HISTOPATHOLOGICAL SURVEY OF STRESS CONDITIONS AND PARASITES IN FARMED BLUE MUSSELS (*MYTILUS EDULIS*) IN A CHANGING GULF OF MAINE

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Aquaculture of blue mussels, *Mytilus edulis,* is increasing in the Gulf of Maine at a time when naturally occurring mussels are disappearing and environmental conditions are rapidly changing. Through the use of histopathological techniques, a multi-year health and condition survey was created for a population of farmed blue mussels. Mussels were collected twice a month in Casco Bay, Maine to determine the intensity of pathological agents and environmental stress responses using light microscopy. Although parasite levels were low throughout this time period, there was a high prevalence of stress-induced conditions. Common stress indicators included digestive gland atrophy, hemocyte filled mantle follicles, and oocyte atresia. Oocyte atresia was the most prevalent, present in over 90% of female mussels. This suggests that there is some type of environmental stressor present. Unknown trematode species were observed in various life stages in small numbers. They may be the sub-tropical *Proctoeces maculatus*. This, if true, is troubling as it indicates possible climate-driven northward range expansion. PCR is currently being used to identify the trematode at the species level. This health assessment is designed to monitor the effect changing local environmental conditions are having on a species that is important to Maine's coastal ecology and economy.

DIFFERENCES IN ABUNDANCE AND DIVERSITY OF PLANKTON COASTALLY VS. OFFSHORE

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The Northeastern Massachusetts Aquaculture Center (NEMAC) at Salem State University has established a pilot mussel farm 7.5 nautical miles off the coast of Massachusetts. Biweekly monitoring efforts have sampled local plankton populations, which are the nutrient source of mussels. Phytoplankton and zooplankton samples have been collected from the offshore mussel farm site and compared with samples from a site near shore. The goal of the study is to observe the differences in abundance and diversity of plankton coastally versus offshore. Additionally, the presence of harmful phytoplankton has been sampled using the standardized HAB monitoring protocols. As shellfish aquaculture moves into the offshore environment it is important that the abundance of plankton is enough to support the farm year-round. This presentation will report the findings to date.

MANAGING BACTERIAL SHELLFISH PATHOGENS IN COMMERCIAL HATCHERIES: ADVANCES IN PROBIOTIC RESEARCH AT NOAA'S MILFORD LABORATORY THROUGH PUBLIC AND PRIVATE PARTNERSHIPS

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Hatchery production of shellfish seed is necessary to supplement natural recruitment, constrained by various stresses including habitat loss, pollutant contamination, overfishing, and climate change. The livelihood of the U.S. seafood aquaculture industry, valued at $1.4 billion in 2015 (FAO), depends on healthy larvae to sustain increasing needs for seafood production and provide sustainable economic benefits to the U.S. oyster aquaculture industry. However, bacterial diseases are considered to be a major cause of mortality in commercial shellfish larviculture. In an effort to improve hatchery production of Eastern oyster (*Crassostrea virginica*) seed for aquaculture and restoration, NOAA's Milford Laboratory has isolated and evaluated a naturally occurring beneficial bacterial isolate, probiotic strain OY15 (*Vibrio alginolyticus*) from the digestive glands of adult Eastern

oysters. This probiotic strain has demonstrated significant protective effects against a shellfish larval pathogen B183 (*Vibrio corallyliticus*) in experimental larval trials and can improve survival by 20-35%. Advancing efforts to develop natural methods to prevent disease in commercial aquaculture facilities has led to Milford Laboratory's partnership with public and private companies to commercialize probiotic bacterial strain OY15. NOAA's Milford Laboratory has entered into a formal cooperative agreement (CRADA) with Prospective Research, Inc., who will produce a stable, freeze-dried formulation of probiotic strain OY15 and apply it in hatchery-scale trials to Eastern oyster larvae, as well as the White Shrimp (*Litopenaeus vannamei*). The Milford Laboratory will develop flow-cytometric methods to investigate effects of probiotic bacterial strains from Prospective Research's catalog of isolates on hemocyte immune functions in White Shrimp.

HIGH DENSITY AQUACULTURE FOR NITROGEN REMOVAL IN IMPAIRED ESTUARIES

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There is increasing interest in quantifying the nitrogen uptake capabilities of oysters grown in impaired estuaries on Cape Cod for the purpose of achieving Total Maximum Daily Load (TMDL) compliance in accordance with the Clean Water Act Section 303(d). Oysters feed on phytoplankton and incorporate the nitrogen in this phytoplankton into their tissue and shell. They also repackage some of the materials that are in the water they filter into feces and pseudofeces that accumulate on the bottom around the oysters. When oysters are harvested, the nitrogen that has been incorporated in their shell and tissue is permanently removed from the estuary where they grew. Eastern oysters (*Crassostrea virginica*) that are commonly raised for harvest on Cape Cod typically require two seasons of growth before they can be legally harvested. The nitrogen uptake of populations of eastern oysters in their first (Y1) and second (Y2) season of growth was studied for three years in a row in Lonnie's Pond in Orleans. Specific gear was developed to support a high density deployment that was acceptable to abutters in a shared use area. The strategy, techniques, and findings of the study will be presented.

AQUACULTURE GEAR AND PROTECTED SPECIES RISK IN NEW ENGLAND

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Concerns over harm to protected species from entanglement in ropes and other gear interactions are a major obstacle to the expansion of marine aquaculture off the coast of New England. Interest in novel types of aquaculture, such as kelp farming and open water shellfish culture, is growing in northeast coastal and ocean waters. At the same time, the status of protected species, most prominently the North Atlantic Right Whale, is growing more tenuous, highlighting the importance of ensuring that aquaculture operations must be designed and located so as to minimize risk from gear interactions. Advances in "ropeless gear" technologies and capacity to monitor aquaculture sites continuously and in real time provide potentially important tools to reduce risk. We propose an approach to modeling the risk posed by different aquaculture gear types as a function of location in the waters off New England, identify key data gaps for risk modeling, and suggest how risk modeling can be used to proactively facilitate growth of New England marine aquaculture without harm to protected species.

INVESTIGATING POTENTIAL SUPPLY CHAINS FOR SEAWEED PRODUCTION IN THE NORTHEAST UNITED STATES

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Farmed seaweed is worth over $5 billion annually, with the primary use of this product for human consumption. Seaweed aquaculture, primarily sugar kelp *Saccharina latissima* has been increasing in recent years in the northeast, mostly from Maine to Connecticut. There is interest in seaweed from both established shellfish growers, especially as a form of diversification with its primary growing season in the winter, and dedicated seaweed growers. There is also a high level of interest in consumption of seaweed as a food product with its high nutritional content. As this nascent industry expands, information about potential supply chains and consumer demand is needed to assist new and potential growers as they consider their business plans. Focus groups and interviews with seaweed growers, regulators, potential buyers, and consumers were conducted to understand their perspectives on market potential for this product. Results identify various options for growers to sell their fresh and processed seaweed, however, although there is interest, many of the supply chains have yet to be established. Challenges to expanding the market were also identified, including the need for processing facilities and regulatory clarity especially regarding post-harvest marketing. This paper describes opportunities and challenges facing this budding industry, and further areas of research for additional potential supply chains for this sustainable and healthy product.

ENVIRONMENTAL AND ECOLOGICAL BENEFITS AND IMPACTS OF OYSTER AQUACULTURE

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To quantify the ecological benefits and impacts of oyster aquaculture, we sampled water quality, sediment quality, benthic macrofaunal communities and oysters at four oyster aquaculture sites at the Chesapeake Bay in Virginia, USA. Samples were collected from within the footprint of the aquaculture cages and from control sites in nearby areas with similar physical and environmental condition. Data collected from the water column included chlorophyll concentrations, turbidity, pH, dissolved oxygen concentrations, light attenuation, particle concentration, median particle size, total suspended solids and dissolved nutrient concentrations. Sediment and macrofaunal community data collected included sediment grain size and organic content and macrofaunal identity, abundance, biomass and species richness. We also assessed differences in the dimensions dry mass and nitrogen (N) and phosphorus (P) content of the oysters harvested at each site. Differences in water quality, sediment quality, and macrofaunal community structure between areas within and outside the farm footprint at each site were rare. Where differences existed, they were of small magnitude and varying direction (i.e. negative versus positive impact). Aquaculture sites varied by an order of magnitude in size, annual harvest and harvest per unit area and similarly by an order of magnitude in the total N and P harvested per unit. In contrast to the negative environmental impacts associated with other forms of animal protein production for human consumption, oyster harvest from the sites in the present study results in the removal of 21-372 lbs. of N and 3-49lbs of P per farm per year. Additional findings will be presented.

INVESTIGATING HELICAL ANCHORS FOR AQUACULTURE ANCHORING SYSTEMS

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To ensure the continued growth of the New England offshore aquaculture industry, engineered infrastructure must address two major needs: 1) reducing anchoring costs, and 2) increasing anchor capacity. As the industry grows, its underlying infrastructure must be scaled to support larger stocks of finfish, shellfish, and sea vegetables, and made more robust to support deeper or more energetic waters subject to tidal, wave, or storm loading. Demands on individual components are increasing, and novel anchor systems that are reliable, cost effective, and low impact are required. Helical (or screw) anchors are lightweight, highly-efficient alternatives to more traditional gravity dead weight and drag embedment anchors. Consisting of a steel shaft and one or more helical plates screwed into the soil, these anchors provide appreciable uplift resistance, and their geometry can be altered to increase in-place capacity (e.g., increase installation depth or number of helical plates). While helical anchors have been in used in land-based applications and as boat moorings for decades, design and selection is ad hoc, based on estimated soil properties, field trials and torque measurements. Only recently has their performance for offshore applications such as aquaculture become the subject of investigation. This presentation will discuss the viability of helical anchors for aquaculture, emphasizing their greater efficiency (i.e., ratio of holding capacity to anchor weight), range of viable holding capacities, ability to withstand multi-directional loading, and cost. It will also highlight recent developments related to numerical simulations of performance and provide comparisons with traditional anchor solutions for similar loading.

AQUACULTURE TRAINING AND WORKFORCE DEVELOPMENT ROUNDTABLE

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As the aquaculture sector has grown across the northeast, so have training and workforce development programs been developed.

We invite anyone and everyone teaching, participating in, or simply interested in aquaculture training and workforce development programs to join this roundtable discussion. This will be an opportunity to:

- Share details of your training and workforce development programs
- Share details of workforce training needs assessments or strategic planning efforts
- Provide industry feedback about workforce needs/challenges and workforce development programs.
- Tell us about your training experience
- Meet fellow educators
- Explore the use of technology to enhance training
- Create cross-institutional connections

OFFSHORE FINFISH SITE SELECTION IN THE NORTHEAST UNITED STATES OF AMERICA- A DEEP DIVE INTO MANNA FISH FARMS SITE SELECTION PROCESS

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Interest in offshore mariculture has grown substantially in the United States of America (USA), but has been limited by lack of a nationally recognized permitting process. Here, the site selection analyses for Manna Fish Farms will be examined. Manna Fish Farms is working with Federal (e.g. NOAA), State, and local groups to successfully permit a finfish farm 8 nm off of Suffolk County, New York, USA. Offshore mariculture site selection requires careful consideration of ocean stakeholders, marine resource distributions, and infrastructure as early in the site selection process as possible. Initially a qualitative site selection was performed using spatial datasets and local expert knowledge. Manna Fish Farms in collaboration with NOAA partners also developed a

quantitative alternative site selection analysis as requested by the lead permitting agency, the United States Army Corps of Engineers. This objective proportionally weighted site suitability analysis revealed several suitable sites for an offshore finfish farm. In addition to the site selection analysis farmers are also encouraged to perform a techno-economic analysis to ensure long term economic feasibility of the farm operation.

SELECTING THE "RIGHT" FINFISH SPECIES FOR MANNA FISH FARMS' OFFSHORE FINFISH AQUACULTURE PERMITTING IN THE NORTHEAST UNITED STATES OF AMERICA

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The development of an offshore mariculture industry has been of great interest in the United States of America for decades. However, no offshore finfish farms are currently operating in Federal waters. Manna Fish Farms (MANNA), Inc. is working with Federal (e.g. NOAA), State, and local groups to successfully permit a finfish farm 8 nm off of Suffolk County, New York, USA. Successful siting requires careful consideration of a variety of abiotic and biotic factors, as well as committed engagement with other ocean stakeholders. Aside from this, the site also needs to be able to successfully foster the growth and healthy development of the desired cultivated fish species. We present a tool developed and used by MFF to review the inventory of native finfish species found to the US East Coast and select the final preferred candidate finfish species to be used at our NY offshore farm. The species analysis decision-making tool incorporates information on the proposed site as well as publicly available biological and economic information on the potential native finfish species. We show that by using the site's environmental variables coupled with biological and economic criteria of the finfish species, an informed and objective species selection can be made. Ultimately, the creation of a finfish species selection tool will likely be a useful asset to help drive the sustainable growth of the US offshore aquaculture industry.

FROM BUPSY to FLUPSY – BEYOND BEATRIX POTTER IN SHELLFISH NURSERY TECHNOLOGIES

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The floating upweller system (FLUPSY) has been in common use in the northeast for the past 20 years or more and during that time there have been numerous modifications to the technology to make it more productive. More recently, the bottle upweller system (BUPSY) has started to see more use as a nursery culture technology preceding the conventional upweller stage. This workshop will cover our current state of knowledge with these technologies and will offer strategies to make these systems work more effectively. Included will be examples of current designs and modifications to off-the-shelf systems that make them more user friendly.

EFFECTS OF THE LIGHT SOURCES ON GROWTH AND PHOTOSYNTHESIS IN A GREEN SEAWEED *ULVA*

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To determine the effect of light sources on photosynthetic efficiency and growth, *Ulva* was cultivated under LED, T-5 and T-8 fluorescent lighting at three photosynthetically activate radiation (PAR) conditions (80, 150 and 300 $\mu mol \cdot m^{-2} \cdot s^{-1}$) for 21 days. This alga was cultured in von Stosch Enriched (VSE) medium at 25°C and 12:12 L:D photoperiod. Walts' Junior Pulse Amplitude Modulation (PAM) was used to measure photosynthetic efficiency. Results showed that quantum yield was the highest at LED, and there was no differences between T-5 and T-8. Specific growth rate was higher at LED than T-5 or T-8 under all PAR conditions, with the highest at 300 $\mu mol \cdot m^{-2} \cdot s^{-1}$ of LED (41.22 $g \cdot d^{-1}$). For all sources of light, the specific growth rate increased as PAR increased. This study suggests that LED lighting is more advantageous in photosynthetic efficiency and growth of *Ulva* sp. than fluorescent lamps.

MUSSEL RECRUITMENT NEAR SHORE VS. OFFSHORE

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Seed stock for mussel aquaculture can be obtained through wild settlement or hatchery reareing. For hatchery rearing, adult mussels are taken from lines and brought back to a hatchery to spawn. For wild settlement, clean lines are used as substrate to induce wild settlement. For an offshore site, it is not certain if wild settlement is efficient enough to supply an ample amount of seed stock needed for commercial scale production. To test if wild mussel recruitment is viable offshore, settlement substrate was deployed offshore and near shore for comparison of settlement.

Ten 0.25m x 0.25m squares were made using PVC with 12m of coconut husk rope wrapped around each square. Five squares were submerged at the NEMAC offshore mussel farm located 7.5 nautical miles off the coast of Rockport Massachusetts. The other five were cast off in Smith Pool located at the Salem State University, Cat Cove Marine Lab which was used as the near shore site. The squares were periodically inspected for recruitment.

Initial results are presented and further study is warranted. The goal is to find out if wild recruitment offshore is sufficient to supply a commercial scale farm or needs to be supplemented with hatchery seed stock.

EPIBIOTIC COMMUNITIES ON THE AQUACULTURED SUGAR KELP *SACCHARINA LATISSIMA* THROUGHOUT A GROWTH SEASON

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Surveillance of epibiota, including epiphytes and epifauna, was conducted on cultured sugar kelp collected from March to May of 2018, aiming at providing the information to farmers for maximizing production without compromising the quality, with regard to fouling. Epibiontas that are large enough to be detected by visual inspection were all present on the top one third of the blades. On average, less than 1% of blade surface was covered by epibionts. Colonial hydroids were the dominant species in this group. Brown and red algae also were observed. Up to hundreds of individual, small hydroids were present on each blade toward the end of the season. TCBS (Thiosulfate-Citrate-Bile-Sucrose Agar) culture revealed *Vibrio* spp.bacteria on the surface of one third of blades (not in the middle or stipe) in the May sample. *Vibrio* spp.bacteria were not detected in March or April. Additional information on the microbial species, including those of human health concern, will be obtained from the sixteen strains of *Vibrio* spp recovered from TCBS culture. Among the microscopic epibiota, pennate diatoms

made up more than 80% of total abundance throughout the growth season. The most abundant species were in the genera*Nitzschia, Navicula*, and *Thalassionema*. Centric diatoms, dinoflagellates, and other benthic algae were present in small abundance. Up to 1,021 cells cm^2 of microscopic organisms were present in late May. Toxic algal species that sometimes occur in the region were not present on kelp blades examined.

NEW TOOLS FOR SELECTIVELY IMPROVING STRAINS OF SUGAR KELP *SACCHARINA LATISSIMA* FOR FOOD AND FUEL

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As a part of ARPA-E's (DOE) MARINER program, we are pursuing a selective breeding project to improve the productivity and composition of sugar kelp that could serve as feedstock for biofuels. While current markets for kelp are human food, animal feed and phycocolloids, MARINER's goals are to develop a scalable pathway toward low-cost bio-energy feedstock. To facilitate swift cloning of gametophytes, the NOAA Milford Lab and UCONN developed efficient isolation by cell-sorting methods. USDA/Cornell and HudsonAlpha are employing PacBio and Illumina sequencing to create a deep-sequenced reference genome and establish a variant catalog for our founding populations and families. WHOI and GreenWave oversee field trials of thousands of unique sporophytes created from crosses at UCONN generated from hundreds of gametophytes isolated from sporophytes collected from more than a dozen locations in New England. These were outplanted in late 2018 on farm sites in Southern New England and in the Gulf of Maine. We will report on managing multiple crosses in the hatchery, field-planting, and early family phenotypic data. One of our goals is to develop methods to predict offspring (sporophytes) performance based upon genotype and breeding values of parents (gametophytes) as a short cut around extensive and expensive field-testing. Ultimately, our project goal is to select sugar kelp genetically suited to offshore farm environments and possessing qualities of increased dry matter yield per unit area (up to 10% per generation) and improved composition for use as food and eventually as a bioenergy feedstock.

WHAT WE CAN LEARN FROM ENVIRONMENTAL DNA METABARCODING - TWO AQUACULTURE EXAMPLES

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We used metabarcoding of environmental DNA (eDNA), DNA extracted from environmental samples, to obtain more comprehensive taxonomic information from two aquaculture operations than would be possible using traditional sampling methods. In one study, seawater samples were collected from two adjacent field sites in Long

Island Sound, CT, an oyster farm with 40+ cages and a natural rock reef, as part of a broader study using GoPro camera video to document fish interactions with cages and reef habitat. Through mitochondrial 12S rDNA amplicon-based next generation sequencing (NGS), finfish communities at each site were characterized. All fish observed in video were detected by eDNA metabarcoding. Additionally, eDNA metabarcoding captured species that are pelagic and/or nocturnal, associated with oyster cages or rock reef habitat, but were not detected in video. In the second project, sugar kelp (*Laminaria saccharina*) epiphytic communities were studied using samples taken from a commercial seaweed operation.We examined phytoplankton and bacterial communities using 18S rDNA and 16S rDNA amplicon-based NGS. Also, the phylum Cyanobacteria and the genus *Vibrio*were characterized using taxa-specific primers, as these taxa contain many toxic species, and we currently know little about their association with sugar kelp. Concurrent with epiphyte eDNA, microbial communities in surrounding seawater were characterized to help elucidate the relationship between epiphytic microbial communities and their local environment. The use of eDNA metabarcoding promises a more complete accounting of community structure in environments where traditional surveying methods are insufficient to address ecological questions of interest and/or needs of the resource management community.

ANALYTICAL INVESTIGATION OF AQUACLUTRE FARM IMPACTS ON ESTUARINE DYNYMACS

Zhilong Liu, Kimberly Huguenard, Lauren Ross. Department of Civil and Environmental Engineering, University of Maine, Orono, ME, 04469

Recent field observations in the Damariscotta River have suggested that floating oyster farms impose surface friction that results in elevated surface mixing and altered tidal flow. The resulting hydrodynamic impact, including its influence on long-term material transport is important to understand. A three-dimensional analytical model is proposed to understand the general impact of a floating oyster farm on tidal and subtidal flow in an idealized basin of similar size to the Damariscotta River. The model considers a semidiurnal tide, cross-sectional bathymetry with both depth and width decay, as well as surface friction induced by an oyster farm. Both tidal and subtidal flow patterns obtained from this analytical model compare favorably with the field observations. Results indicate that a floating aquaculture farms can reduce the surface current amplitude by about 50% near the farm. While the surface floating farm decelerates velocity near the surface, it accelerates velocity subsurface. Enhanced local advection imposed by the farm actually reverses the subtidal flow structure compared to the case with no farm. The extent to which the subtidal flow reversal influences residence times will be explored in the future. Results from this work imply that farm friction should be implemented in hydrodynamic and biogeochemical models in order to accurately determine the carrying capacity of a system.

THE BUSINESS OF FLOATING AQUACULTURE: REDUCED MORTALITY, FOULING MANAGEMENT AND FLOATING BEST PRACTICES.

Ben Lord. OysterGro, Bouctouche Bay Industries, New Brunswick, Canada

Floating gear for aquaculture is a relatively new idea within the last 15 years. We as a company are interested in working with farms that are looking to grow and looking to increase their yield while reducing overhead. We think that it is important to inform farmers of best practices for regional fouling control, cage and gear operation, as well as different main line and anchor configurations for their sites. During this talk I'm interested in conveying that we have a system, that if used properly within a degree of regional adjustment will help them better market their oysters, control their inventory and reduce labor. We will provide examples of site set-up and operation from oyster farmers from the cold waters of Newfoundland and Labrador to the Chesapeake and beyond. Review findings of best stocking densities and gear choice as well as talk about how they can use floating gear as a marketing tool to bring awareness to their business. While we are an equipment manufacturer we pride ourselves as being a teammate and member with the farms as they grow their business and expand their sites.

NOAA FISHERIES OFFSHORE MARINE AQUACULTURE PERMITTING ROLES AND SUPPORT

Kevin Madley. Greater Atlantic Region Fisheries Office, National Marine Fisheries Service, 55 Great Republic Drive, Gloucester, MA 01930, USA

Aquaculture is a priority for this administration via the Department of Commerce (DOC). Promoting development of a robust marine aquaculture industry, the DOC is working to facilitate permitting and siting of aquaculture facilities, assist with business development, and advance research and development. Current and proposed permitting pathways for aquaculture in federal waters of the USA will be presented. An overview of aquaculture projects in federal waters of the mid-Atlantic and northeast will be discussed. Lastly, we will review current projects to fill information gaps and develop tools related to entanglement risk of protected resources in aquaculture gear since this has been a concern in permitting along the Atlantic coast.

PERMITTING AN OFFSHORE MUSSEL FARM IN FEDERAL WATERS IN THE GULF OF MAINE: A CASE STUDY

Edward (Ted) Maney Jr., Mark Fregeau. Northeastern Massachusetts Aquaculture Center (NEMAC), Cat Cove Marine Laboratory, Department of Biology, Salem State University Salem, MA 01970 USA

In 2012, we applied for an U.S. Army Corps of Engineers (USACE) permit pursuant to Section 10 of the Rivers and Harbors Act of 1899 to establish a commercial scale (33 acre) offshore mussel farm off the coast of Cape Ann Massachusetts (NAE-2012-1598 NEMAC Aquaculture). In 2015 we were issued a permit with conditions from the USACE and NOAA that involved a phased-in approach, in which three longlines could be deployed with gear designed to prevent and minimize possible entanglement 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. Additional conditions from the USCG required our longline headers to be submerged to a depth of 50 ft to account for possible deep draft vessels transiting through the area.

This report will focus on the process of securing an USACE permit to establish this farm and disseminate what was learned about this process to others wishing to pursue offshore shellfish aquaculture.

AN UPDATE ON RESULTS FROM OFFSHORE SHELLFISH AQUACULTURE IN FEDERAL WATERS OF THE ATLANTIC

Edward (Ted) Maney Jr.[1], Mark Fregeau[1], Bill Lee[2]. [1]Northeastern Massachusetts Aquaculture Center (NEMAC), Cat Cove Marine Laboratory, Department of Biology, Salem State University Salem, MA 01970 USA; [2]F/V Ocean Reporter, Rockport, MA 01966 USA

In the summer of 2016, we deployed the first longline as a pilot study to establish a commercial scale (33 acre) offshore mussel farm7.5 nautical miles off the coast of Cape Ann Massachusetts (NAE-2012-1598 NEMAC Aquaculture).Current results indicate that mussels grow better offshore than coastally with little fouling. We monitor for harmful alga using the sampling protocol established by the Massachusetts Division of Marne Fisheries (MA DMF) who also periodically test mussels from our site for biotoxins.

We have conducted limited harvests that after clearing biotoxin testing were released for non-commercial consumption, feedback on meat quality and taste has been excellent. To supplement wild spat settlement on site, we are also spawning mussels at the Cat Cove Marine Lab shellfish hatchery to supply seed stock for the offshore farm.

We received NOAA S-K funding and will deploy two more long lines this year to complete our pilot study allowing us to file a permit modification to expand the number of longlines to a commercial scale farm with 32 – 400 ft longlines. Our ultimate objective is to refine and enhance offshore shellfish aquaculture as an alternative fishing option for fishermen and lobstermen currently displaced or negatively impacted by current fishery restrictions and provide an incubator farm site for interested parties to try offshore aquaculture.

MINIMIZING INTERACTIONS WITH PROTECTED SPECIES THROUGH GEAR DESIGN AND MONITORING EFFORTS AT AN OFFSHORE SHELLFISH FARM IN FEDERAL WATERS IN THE GULF OF MAINE

Edward (Ted) Maney Jr[1].Mark Fregeau[1], Bill Lee[2]. [1]Northeastern Massachusetts Aquaculture Center (NEMAC), Cat Cove Marine Laboratory, Department of Biology, Salem State University Salem, MA 01970 USA; [2]F/V Ocean Reporter, Rockport, MA 01966 USA

In 2015 we were issued a USACE permit (NAE-2012-1598 NEMAC Aquaculture)with conditions that involved a phased-in approach, in which three longlines could be deployed with gear designed to prevent and minimize possible entanglement with protected species. This pilot study included an extensive monitoring program to investigate the potential interactions between aquaculture gear and species protected under the Marine Mammal Protection Act and Endangered Species Act, and their habitats.

In the summer of 2016, we deployed the first longline as a pilot study to establish a commercial scale (33 acre) offshore mussel farm7 nautical miles off the coast of Cape Ann Massachusetts(NAE-2012-1598 NEMAC Aquaculture). Our longline design is required to comply with all fishing gear regulations to minimize any potential entanglement by protected species. The site is visited every 2 weeks to evaluate longline integrity and monitor for presence or evidence of negative interactions of any protected species in the area.

In the Fall of 2018, we deployed a hydrophone system to listen for marine mammals. Additionally, we deployed a surface time-lapse video surveillance system to monitor the area around the farm site 24/7. This presentation will report on the preliminary results of these monitoring activities and the effectiveness of the gear design to ensure offshore shellfish aquaculture activities are not likely to adversely affect and protected or endangered marine species.

EAST COAST MOLLUSCAN HEALTH INITIATIVE PART 3: INTERACTIVE DATABASE DEMO

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An interactive database is under construction and is being populated with data from across the Atlantic coast. Representatives of regulatory agencies, industry, research and extension met with database programmers to evaluate the structure and performance of the initial prototype during a workshop in Cape May, NJ, October 9-11, 2018. This presentation will provide a demonstration of the database in its current state to showcase some of the features and functionality that have been developed to meet the needs of the industry, regulators, academics and extension personnel in making informed decisions regarding shellfish health and intra- or interstate seed transport. Attendees will be given the opportunity to provide feedback and ask questions of the project and development team. This work is supported by the NOAA Saltonstall-Kennedy Program.

ENVIRONMENTAL IMPACTS OF CURRENT AQUAULCUTRE METHODS IN MASSACHUSETTS

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Shellfish aquaculture in Massachusetts occurs in some of the most environmentally sensitive, and economically, socially, and culturally valuable shared spaces in the Commonwealth. These areas are often modified for cultivation through the addition of gear such as nets, cages, trays, buoy markers, and other equipment. These modifications, and associated culture and harvest activities, can have negative impacts on water clarity and other water quality parameters such as dissolved oxygen, nutrients and particulate organic matter. However, with proper siting and management, impacts from aquaculture activities can be minimized, and in some cases shellfish aquaculture can provide positive value to the surrounding ecosystem. Shellfish growers in Massachusetts use a variety of on-bottom and off-bottom culture methods for oyster, clam, scallop, mussel, and kelp culture. These methods can result in varying levels of environmental impacts. As the majority of intertidal and subtidal zones along the Massachusetts coastline where aquaculture activities occur are highly vulnerable to human activities, there is keen interest from both regulators and industry in understanding and minimizing the impacts to the environment from aquaculture activities. Herein, we offer a detailed description and assessment of the potential for positive and negative environmental impacts associated with common shellfish aquaculture activities, and a ranking of different gear types based on level of disturbance as it relates to scientific literature. In addition, we offer an analysis and a description of alternatives to various shellfish grow out techniques and the feasibility of reasonable alternatives and methods that growers can follow to mitigate impacts.

AN EXAMINATION OF THE TISSUES OF AMERICAN OYSTERS FOR THE PRESENCE OF MICROPLASTICS IN THE HOUSATONIC RIVER ESTUARY

Qiana Mendez, Vincent Breslin. Werth Center for Coastal and Marine Studies, Southern Connecticut State University, New Haven, CT 06410 USA

Microplastics, plastics <5 mm diameter, represent a growing threat to coastal ecosystems due to their ability to accumulate hydrophobic contaminants and their ingestion by pelagic and benthic marine organisms. In this study, oyster (*Crassostrea virginica*) tissues were examined for the presence of microplastics to determine the types and quantities of microplastics ingested. Thirty oysters were sampled from each of two locations (Stratford and Beaverbrook) in the Housatonic river estuary in the fall 2017. Using nitric acid, the oyster tissues were digested and the digest filters analyzed for the presence of microplastics including fibers, beads, fragments and film. The predominant form of microplastic found in oyster tissues was microfibers. Beaverbrook oysters contained a total of 44 fibers (1.47 fibers per oyster) and the Stratford oysters contained a total of 41 fibers (1.30 fibers per oyster). The majority (52%) of fibers in Beaverbrook oysters were less than 1000 microns while the majority (66%) of the fibers in Stratford oysters ranged in size from 501-1500 microns. Dark blue and clear fibers were the most common colors identified with 29% of the total fibers being dark blue and 25% of the total fibers being clear. IR-ATR analysis of fibers isolated in oyster tissues showed the fibers possess similar functional groups common to polyester. The presence of microfibers in oyster tissues provides a direct source of microplastics to humans who consume seafood.

FIELD TRIALS USING POINT-OF-VIEW VIDEO CAMERASTO QUANTIFY FISH INTERACTIONS WITH OYSTER AQUACULTURE CAGES AND NATURAL BOULDER HABITAT

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Sciences & Mystic Aquarium, 1080 Shennecossett Road, Groton, CT 06340 USA; [3]Integrated Statistics, 16 Sumner Street, Woods Hole, Massachusetts 02543 USA

Studies to evaluate ecosystem services provided to fish by aquaculture gear are underway in Long Island Sound. Weekly field trials were conducted during summer 2018 to quantify fish interactions with three-dimensional oyster aquaculture bottom cages using point-of-view video cameras. Our objective was to: 1) compare fish interactions with oyster bottom cages to fish activity at a rock reef reference site, and 2) compare fish activity around cages deployed within an oyster farm to single cages deployed 70 yards apart on low-relief sand, shell seafloor. Cameras were mounted to each cage to capture top horizontal and vertical side views. Video was also collected adjacent to boulders on a rock reef using diver-deployed cameras mounted to a T-platform frame system that provided comparable horizontal and vertical views of each boulder while adding minimal structure. Cameras were deployed 24-hours prior to onset of video recording to minimize disturbance effects, and video was collected at intervals over 12 hours to cover a full tidal cycle and most daylight hours. Temperature, light level, current speed, and current direction were also measured during deployments. Noldus Observer XT software was used to aid in quantifying video. Fish abundance was determined as MaxN, the maximum number of each species observed in one video frame within each 1 minute video segment. Our ultimate goal is to use results from this and related studies to inform regulators and policymakers who make decisions about siting aquaculture gear.

CHEMICAL CHANGES INTHE ENVIRONMENT: WHAT DOES THIS MEAN TO SHELLFISH?

Shannon Meseck[1], Mark Dixon[1], Yaqin Li[1], George Sennefelder[1], Dylan Redman[1],Renee Mercaldo-Allen[1], Paul Clark[1], Lisa Milke[1], Gary H. Wikfors[1]. [1]USDOC/NOAA/NMFS, 212 Rogers Ave. Milford, CT 06460 USA

Coastal areas are experiencing an increase in carbon dioxide from human activities, resulting in ocean acidification. Increased CO_2 in the water may affect shellfish in multiple ways including: (1) food availability; (2) physiological responses, and (3) sediment acidification.

Changes in phytoplankton community structure and nutritional value may affect food availability. For example, increased carbon dioxide may cause a shift in phytoplankton biomass and community composition depending upon species' efficiency of inorganic carbon acquisition. Shifts in phytoplankton communities, may favor less – or more -- nutritional phytoplankton that support production of human food.

In addition to potential changes in food supply, ocean acidification may cause physiological changes in marine bivalves that affect how they feed. Bivalve gills are constantly exposed to ambient water, with the gill cilia moving water through the shell for respiration and feeding. Physiological changes could result in slower growth, higher mortality, or inability to maintain shell production, or the opposite responses in some cases.

Finally, the same reaction that occurs in water during ocean acidification occurs at the sediment-water interface, where bivalves settle. As particles settle, aerobic and anaerobic reactions, combined with redox processes, result in the production of CO_2in sediment porewater. Corrosive and hypoxic sediment can impede successful settlement, recruitment, and abundance in bivalve pollutions. Nutrient-enriched, coastal areas in the United States are already experiencing sediment acidification, and this might be affecting bivalve recruitment at the sediment-water interface. The research presented here will focus on how these multiple ways of ocean acidification may affect marine bivalves.

DEPTH SUITABILITY ASSESSMENT FOR OFFSHORE MUSSEL FARMING AND *IN SITU* VALIDATION

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Success of a shellfish farm is ultimately determined by the consistency of productive yields of high quality bivalves. Accordingly, when expanding aquaculture offshore, the suitability of the environment should be taken into account. As offshore culture of our target species, the blue mussel, employs submerged longlines, depth suitability is paramount for successful farm production. To define suitable depth thresholds, open-source databases were used to gather historical data of two main environmental variables: temperature and food availability, expressed as chlorophyll *a*. These environmental variables were used in conjunction with species ecological knowledge to assess habitat suitability for blue mussel aquaculture in three dimensions. To validate the analysis, in addition to the determination of depth thresholds for northern and southern areas of New England, we performed *in situ* measurements of mussel feeding performance at the experimental offshore farm of NEMAC (Salem State University) in Massachusetts. In two sampling seasons, May and August, mussel feeding performance was assessed using a biodeposition method, and environmental data were collected at the time of the experiment. Measurements showed that the local seston was of high quality, and environmental characteristics were ecologically suitable at predicted depths. Mussel performance was satisfactory, even though feeding rates were lower than in coastal areas, confirming the experimental farm as a good candidate site for offshore mussel farming. Although the *in situ* results are local, this study contributes to farm siting management decisions and further asserts that the offshore environment in New England is suitable habitat for blue mussel farming.

EFFECTS OF PROBIOTICS AND PATHOGEN ON *CRASSOSTREA VIRGINICA* LARVAL IMMUNITY

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The eastern oyster *Crassostrea virginica* is an ecologically and economically important species on the east coast of the United States and the Gulf of Mexico. Rearing of oyster larvae is a critical step in hatcheries to ensure a healthy and sufficient supply of seed to the aquaculture industry. Massive mortalities caused by vibriosis, however, prove economically detrimental to hatcheries. Probiotics are an inexpensive, practical and natural method of disease control. Two probiotics, *Bacillus pumilus* RI06-95and *Phaeobacter inhibens* S4, were previously shown to protect oyster larvae from infection of *Vibrio coralliilyticus* RE22. Understanding the mechanism of action of probiotics to provide protection from RE22 and the effect of RE22 on the larval immunity to cause disease are both important in efforts to control the disease. Evaluation of the response of *C. virginica* larvae to probiotics through transcriptomics showed immuno-stimulation in larvae exposed to probiotics in both laboratory and hatchery experiments, as evidenced by high levels of expression of the genes involved in pathogen recognition, immune signaling pathways, apoptosis and effectors such as protease inhibitors, mucins and perforin-2. In contrast, larvae exposed to the bacterial pathogen *Vibrio coralliilyticus* RE22 showed evidence of immuno-suppression. This study not only shows how probiotics modulate the larval immune system to protect the larvae from *V. coralliilyticus* RE22 infection but also demonstrates that they are safe for use in bivalve shellfish hatcheries.

PROTOCOL DEVELOPMENT FOR INVESTIGATING DETERRENTS OF PARASITIC SALMON LICE (*LEPEOPTHERIUS SALMONIS*)

Robert Morefield. University of Maine, Orono, ME 04469

The greatest barrier to growth in the salmon aquaculture industry is infestation by the parasitic copepod

Lepeophtheirus salmonis, also known as salmon lice. Through feeding on the blood, skin, and muscle tissue of their host, salmon lice can render fish unmarketable or vulnerable to secondary infections. Overuse of pesticides has resulted in drug-resistant strains, creating a need for new and effective treatments. This project aims to identify environmentally sustainable compounds for the abatement of these pests in salmon aquaculture. Protocols were developed concerning a means to measure the efficacy of anti-parasitic compounds suitable for use in aquaculture systems. Developed protocols will be used to identify compounds that deter parasitic salmon lice from their host. This study requires a viable behavioral bioassay, in-vitro rearing of salmon lice, and the initiation of bioassay trials. An aquatic Y-tube olfactometor behavioral bioassay was designed and validated to meet the requirements necessary for viable investigative trials. Specifically, the bioassay was developed to show minimal olfactory cue mixing. Sea lice were successfully reared to the infective copepodid stage after initial failure through a complete redesign of the established hatchery. Comparisons of both systems show a significant difference in lice survival as well as copepodid viability. Protocols for the creation of the olfactory cues to be used as attractants for the study were developed. Preliminary behavioral choice trials were conducted for validation of the positive control. Identifying natural compounds that deter and reduce sea lice infestations will dramatically increase salmon aquaculture profitability and environmental sustainability.

ANNOUNCING THE OCEAN REPORTING TOOL: A WEB-BASED AUTOMATED SPATIAL ANALYSIS TOOL TO INFORM PERMITTING OF OFFSHORE AQUACULTURE

James A. Morris, Jr., Christine Taylor, David Stein, Lisa Wickliffe, Seth Theuerkauf, Anna Verrill, Ken Riley, and Mark Finkbeiner. NCCOS Center for Coastal Fisheries and Habitat, Beaufort, NC

Planning for ocean-based industries such as energy production, shipping and transportation, aquaculture, fisheries, and seabed mining demands spatial science to navigate conflicting uses, environmental considerations, and assess economic opportunity. To assist with ocean commerce planning, BOEM and NOAA recently released the Ocean Reporting Tool (ORT), a web-based, automated geospatial tool for analyzing and visualizing U.S. ocean space. The ORT allows users to select an ocean space and instantaneously obtain over 80 unique infographics containing analyses of the location, its energy and minerals, natural resources, transportation and infrastructure, the oceanographic and biophysical conditions, and the local ocean economy. Users can select infographics of interest, explore pertinent ocean data through interactive popups and visualizations, toggle each layer related to infographic content, share results, and print reports to inform various permitting processes. The Ocean Reporting Tool was developed from the largest known compilation of U.S. ocean data to-date, encompassing over 100 essential data layers, which have been processed for optimal spatial and temporal resolution within an interactive tool. To explore U.S. ocean space and the Ocean Reporting Tool, visit https://marinecadastre.gov/ort/.

DOWN ON THE OYSTER FARM: GRADERS, TUMBLERS AND SOLAR POWER

Dana L. Morse. Maine Sea Grant College Program, Darling Marine Center/University of Maine, 193 Clarks Cove Road, Walpole, ME 04573 USA

Oyster producers are justifiably well known for do-it-yourself equipment to do the jobs of tumbling and size sorting/grading their product. In recent years, solar power has made it on to the raft and the boat too. This 'Down on the Oyster Farm' session is a technology transfer discussion - from oyster growers to oyster growers - focused on these important pieces of production equipment. We will feature producers describing their inventions, and the pro's and con's of their use. After the presentations, all growers in the room will vote anonymously on their favorite design, and the winner will receive a copy of either *The Eastern Oyster* by Kennedy, Newell and Able, or *Biology of Oysters*, by Brian Bayne, donated by the NACE Conference organizers and the Maine Aquaculture Innovation Center.

UPDATE ON SCALLOP SPAT COLLECTION AND BIOTOXIN TESTING IN MAINE

Dana L. Morse. University of Maine Sea Grant and Cooperative Extension, Darling Marine Center, 193 Clarks Cove Road, Walpole, ME 04573 USA

Scallop farming in Maine has occurred sporadically over that last 40 years, but since 2012 there has been a sustained and growing effort, by an increasingly broad group of fishermen and shellfish farmers. This presentation reviews two collaborative projects principally, addressing the effectiveness of spat collection materials, and testing of scallop tissues for biotoxins as a prerequisite for entry into the market for whole, live scallops.

Spat collection: Two seasons of scallop spat collection were undertaken, between 2016 and 2018. Over two seasons, five types of collection substrate - Industrial Nettings OV-7100 (4.2mm square), OV-7822 (6.4mm square) and OV-1581 (12.5mm square), Tenax R9 (7.0mm x 9.0mm), and Tenax Plurima (5.0mm x 6.0mm) - were tested against the industry standard, Netron. In both cases, the OV-7822 performed at least as well as Netron, at approximately 1/3 the cost of materials.

Monitoring for levels of saxitoxin and domoic acid in scallop tissues on two sites has been ongoing biweekly since May/June of 2017, with an additional site added in 2018. Data indicate that tissues (roe, and viscera) fluctuate around the regulatory limits for these toxins (80 µg /100g for saxitoxin and 20 µg/g for domoic acid), varying by site and over time. In instances where product has been released to the market, reception from buyers has generally been positive, though short shelf life of the product can complicate logistics. The high degree of risk with respect to phycotoxins underscores the absolute need for strict testing procedures, and close communication between producers, regulators and analytical service providers.

SCALLOP PRODUCTION

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Whether for stock enhancement or for food production, scallop farming carries distinct challenges. Long larval periods, low stocking density requirements, valves that close incompletely, and sensitivity to handling or changes in temperature and salinity, are some of the problems that scallop farmers have to cope with. The market potential is a significant draw however, with a domestic market that exceeds will over a USD$500M. Moreover, the current market value is based nearly entirely on adductor muscles alone, although evidence exists for additional markets for such products as roe-on meats, or whole, live scallops. Here, we will review projects and programs that address the opportunities and challenges of scallop culture, from wild spat collection and hatcheries, through nursery and growout equipment, siting and husbandry.

DESIGN OF OFFSHORE INFRASTRUCTURE FOR CONTINUOUS PRODUCTION OF KELP

Zach Moscicki[1], Beth Zotter[2], Pete Lynn[3], Corey Sullivan[1], Rob Swift[1], Michael Chambers[1], Igor Tsukrov[4], Tobias Dewhurst[5], Michael MacNicoll[5]. [1] School of Marine Science and Ocean Engineering, The University of New Hampshire, Durham, NH 03824 USA; [2]Trophic LLC, 1065 Stannage Ave., Albany, CA 94706 USA; [3]Otherlab, 3101 20th St, San Francisco, CA 94110 94110 USA; [4]College of Engineering and Physical Sciences, The University of New Hampshire, Durham, NH 03824 USA; [5]Maine Marine Composites, Portland, ME, 01401 USA

Trophic LLC in collaboration with University of New Hampshire and Otherlab is actively developing a conceptual macroalgae cultivation system for northern US waters, particularly the Gulf of Maine. The project is part of a larger national effort funded by the US Department of Energy's ARPA-E program to develop technologies that could enable a significant macroalgae based energy supply. At its current stage the project seeks to evaluate the cultivation structure's component technologies to better inform the concept's economic feasibility. The desired scales of production, harsh offshore environment, and low-cost requirements for commodity fuels present a challenging engineering design problem. As the design effort has unfolded, we have identified routes towards an economically feasible system by integrating: synergies between infrastructural components, scaling efficiencies, structural resilience in overlapping modularity, and strategic agronomic processes. Although conventional in choice of growth substrate, our system sets the typical hectare scale longline farm within the context of massive (square kilometers scale) arrays of semi-independent farm "modules" supported by a lattice of shared moorings capable of increasing structural efficiency and resilience through distributed accommodation of hydrodynamic loads. Wave actuated tethered hydrofoil upwellers integrated into the mooring system harness ambient renewable wave energy to elevate deep cold nutrient rich seawater enabling conditions capable of supporting algae growth year-round. Frequent mow harvests will maintain optimal biomass spatial densities allowing for elevated yields. Through ongoing validation efforts: modelling, component testing, and a pilot scale deployment, we plan to prove that our design can support a macroalgae biofuel industry.

ECOLOGICAL INTERACTIONS OF HORSESHOE CRABS AND OYSTER AQUACULTURE IN THE DELAWARE BAY

Daphne Munroe, David Bushek, Lisa Calvo. Haskin Shellfish Research Laboratory, Rutgers University, 6959 Miller Ave., Port Norris, NJ 08349

Globally, shellfish aquaculture is growing. For the first time in history, global seafood supply from aquaculture exceeded that of wild fisheries. As shellfish farm production in the U.S. expands it will face key challenges assuring ecological and social sustainability. Understanding the ways shellfish farms interact with coastal wildlife is among those challenges.

Primarily two shellfish species are farmed in the northeast: eastern oyster *(Crassostrea virginica)* and hard clam (*Mercenaria mercenaria*). Farms for both are commonly located in shallow coastal areas, use a range of equipment, and involve regular access to care for and harvest livestock. In some cases, these farms are in areas used by horseshoe crabs (*Limulus polyphemus*) as they come ashore during spring to spawn along sandy Atlantic Coast beaches. Horseshoe crabs are economically and ecologically important; their blood is highly valuable in the medical industry and migratory shorebirds including the red knot (*Calidris canutus rufa)*, a threatened migratory shorebird, feed on crab eggs when stopping in Delaware Bay. During the 2018 crab spawning season, potential farm interactions with Horseshoe Crabs were examined. Experiments included a range of controlled experiments and surveys during high and low tide using sonar and walking respectively, to observe crab behavior at farm and non-farm sites. In all cases, results indicate that crabs can successfully traverse farms and reach spawning beaches, and crabs do not differentially use farm versus non-farm areas of the Delaware Bay flats. These results provide important context for developing frameworks for ecological interactions among farms and species of concern.

VALUING ECOSYSTEM SERVICES FROM SEAWEED AQUACULTURE: WHAT IS REDUCING COW BURPS WORTH?

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Seaweeds constitute the largest single contributor to the current production of aquaculture products, in terms of wet weight. Aquaculture products will play an increasingly important role in meeting the world's food requirements, with a growing human population and corresponding demand for food security. Seaweeds also supply a suite of ecosystem services that contribute to the overall value of marine plant aquaculture. In addition to food *per se*, seaweeds are a source of biomass for fuel production, specialty biochemicals, fertilizers and animal feeds. They can also serve as nutrient scavengers, contribute to pH regulation and carbon sequestration. Seaweeds also provide habitat for marine animals. Consequently seaweeds are one of the most diverse marine aquaculture crops in terms of the ecosystem goods and services they provide. The fundamental challenge of determining the total economic value of seaweeds produced by aquaculture is applying a common measure of value or common currency (i.e., the dollar) to the various ecosystem goods and services provided by seaweed, therefore allowing for those values to be considered as part of the total economic value of seaweed. Valuation in a common currency also permits an explicit assessment of trade-offs among the various potential uses for seaweed products. The dollar value for direct use of seaweed products (e.g., as food for human consumption, a component of animal feed, fertilizer) is usually taken to be the market price of the seaweed-related product. Ecosystem services associated with seaweed production (e.g., nutrient regulation, habitat provision) are more difficult because these services are not typically bought and sold in a traditional market. Nonetheless, these services are interlinked with human well-being and therefore have economic value. This presentation will explore approaches for ecosystem valuation by considering the trade-offs and social actions that impact the ecosystem services provided by seaweeds, using the suppression of methane production by cattle whose diets are supplemented with seaweed as an example.

THE NORTHEAST OCEAN DATA PORTAL - A RESOURCE FOR DECISION-MAKING

Nicholas Napoli. Northeast Regional Ocean Council

The Northeast Regional Ocean Council (NROC) and many partner organizations maintain the Northeast Ocean Data Portal (Portal) as a centralized, peer-reviewed source of data and maps to inform decision-making in the region. The Portal contains over 4000 datasets illustrating the richness and diversity of the ecosystem and the extent and footprint of the various human activities occurring on the ocean. This presentation will include a description of the data and tools available through the Portal, examples of how the Portal has been used to inform a range of regulatory and management processes, and opportunities to provide input on regional data priorities and potential uses of the Portal in the regulatory process. There will also be an overview of how the Portal fits within the broader regional ocean planning activities that are being advanced by NROC.

SUSTAINABLE POST-HARVEST PROCESSING AND VALUE-ADDITION OF AQUACULTURED SEAWEED

Balu Nayak[1], Beth Bisson[2], Peter vanWalsum[3], Denise Skonberg[1], Jennifer Perry[1], Mary Ellen Camire[1], Jaclyn Robidoux[2], Andrew Crawley[4], John Belding[5], Seth Barker[6], Shep Erhart[7], Sarah Redmond[8], Mitchell Lench[9], Rory Dysart[10] and Rod Hathaway[11]. [1]Food Science and Human Nutrition, School of Food and Agriculture, University of Maine, Orono, ME 04469; [2]Maine Sea Grant, Orono, ME 04469; [3]Chemical and Biomedical Engineering, University of Maine, Orono, ME 04469; [4]School of Economics, University of Maine, Orono, ME 04469; [5]Advanced Manufacturing Center, University of Maine, Orono, ME 04469; [6]Maine Sea Farms, Walpole, ME 04573; [7]Maine Coast Sea Vegetables, 430 Washington Junction Rd, Hancock, ME 04640; [8]Springtide Seaweed, LLC, Sullivan ME 04664; [9]Ocean's Balance Inc., Cape Elizabeth, ME 04107; [10]Dysarts Service, Bangor, ME 04401; [11] Maine Trailer Inc., 101 Coldbrook Rd, Hampden, ME 04444

Maine provides an excellent foundation for the development of the seaweed aquaculture industry, with its cold, clean waters, long coastline, coastal infrastructure, and scientific and technical institutions. SWOT analysis of the

Maine seaweed industry by the Maine Algal Cluster Market Research Report 2015 strongly supports investment for the better processing, preservation, and value addition of seaweeds. The potential of seaweeds as sources of natural and healthful food is widely recognized. In comparison with land vegetables, seaweeds are rich sources of polysaccharides, minerals, and certain vitamins. Maine's seaweed industry sells processed or fresh wild-harvested or farmed local sea vegetables through retail and direct sales. However, the lack of infrastructure for harvesting, processing, storage, and marketing available to new seaweed farmers represents a significant barrier to the growth of the new industry. Through a NOAA Aquaculture integrated award, we are developing methods for post-harvest seaweed processing and preservation, and studying the quality, safety and consumer acceptability of the developed products. Dehydration, new freezing approaches, fermenting, and salting of Maine-grown seaweeds will be assessed. An economic evaluation of a mobile drying unit for farms is also under investigation. A unique aspect of this project is the involvement of farmers, processors, Extension faculty, and research faculty who will identify and resolve processing issues facing the nascent seaweed aquaculture industry in the United States. This presentation will provide an update on the status of kelp processing research within this project.

EPA'S ROLE IN REGULATING OFFSHORE AQUACULTURE IN NEW ENGLAND

Eric Nelson. US EPA - Region 1 - Ocean and Coastal Protection Unit, Boston, MA

This talk is intended to describe EPA's involvement in regulating offshore aquaculture. As the lead federal agency for regulating the point-source discharge of pollutants into the waters of the United States, the U.S. Environmental Protection Agency would play a role, under the Clean Water Act (CWA), in regulating offshore aquaculture facilities in the federal waters of New England. These pollutants, including unconsumed feed, metabolic waste, and medications, are typically associated with rearing finfish. EPA's permitting of aquaculture facilities located in offshore waters would also trigger a review under Section 403 of the CWA to ensure that such a discharge would not cause unreasonable degradation of the marine environment.

Under the Wildlife Coordination Act, EPA would review and comment on permits developed by other federal agencies (e.g., U.S. Army Corps of Engineers) with regulatory authority over other aspects of offshore aquaculture operations.

CHALLENGES AND SOLUTIONS TO PROFITABLE MUSSEL FARMING IN SEMI-EXPOSED OPEN OCEAN CONDITIONS USING SUBMERSIBLE MUSSEL RAFT TECHNOLOGY

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Deep open ocean bays with fetches over 10 miles but protected from long period waves provide opportunities for mussel farming due to high water quality, no conflicts with landowners and existing fisheries, and room for expansion. While mussel raft technology is required to eliminate eider duck predation through the use of predator nets, patented innovations in a submersible mussel raft design have resulted in a method which eliminates mussel drop-off and raft damage from storm waves and drift ice. After 5 years of research and testing, the challenge was to commercialize the technology using a profitable business plans, including:

- Modifications to the raft design to *reduce raft production costs* and increase *yields per raft* to 60 tons per raft
- Design, testing and utilization of a 3x3 mooring grid to *improve space efficiency* on the farm.
- Utilize the new technology to increase *yields per rope* by 200-300%
- Through technology transfer, obtain processing equipment from Europe to *increase harvesting and processing volume per day* by 400%

- Build a bagging and distribution center utilizing European technology and automation to *increase bagging and tagging rates* by 400%.

The development phase of any new technology is the most challenging aspect, since there is still risk in proving a profitable business plan and fewer opportunities for funding besides loans and private equity, but understanding the major factors which control profit and loss are a key to success.

AQUACULTURE GIS USING SHELLFISH GROWTH MODELS AND DATA FROM BUOYS TO SATELLITES TO IMPROVE SITE SELECTION AND PRODUCTIVITY OF MUSSELS, OYSTERS AND SEA SCALLOPS IN MAINE AND U.S. WATERS.

Carter Newell[1], Damian Brady[2,3], Andrew Thomas[3], Emmauel Boss[2], Nicholas Keeney[3], Dana Morse[3], Kevin Morris[4], A.J.S. Hawkins[5]. [1]Maine Shellfish R+D, 117 Sandy Point Road, Stockton Springs, Maine 04981 USA; [2]Darling Marine Center, 193 Clark's Cove Road, Walpole, Maine 04573 USA; [3]School of Marine Sciences, 5706 Aubert Hall, University of Maine, Orono, Maine 04469 USA; [4]Discovery Software Ltd.,11 St. Mary's Park, Paignton, Devon, TQ4 7DA, UK; [5]Plymouth Marine Laboratory, Prospect Place, Plymouth, PL1 3DH, UK

This session is a series of presentations and a panel discussion involving NSF EPSCoR (SEANET), and National Sea Grant funded projects in Maine with the goal of producing an aquaculture GIS system useful to growers of shellfish and sea vegetables. Simulation of shellfish growth using SHELLSIM software requires knowledge of the spatial and temporal variation of shellfish growth drivers of temperature, salinity, phytoplankton and detritus, as well as water velocity, stocking densities and grow-out technology. Using LOBO buoys and water sampling transects, we could understand factors contributing to primary production and temporal variation in growth drivers, and using Landsat and Sentinel satellites we could understand how these drivers vary with snapshots of conditions over vast geographical regions during the growing season. Putting the growth drivers in a GIS system (SHELLGIS), and applying shellfish growth model results for different bivalve species allowed for coast-wide comparisons of mussel and oyster (previous work) and scallop (new initiative) growing conditions in web-based images. In one estuary, additional data on temporal variations in the growth drivers, as well as results from a georeferenced flow model and user defined husbandry practices and allow for modeling the effects of different scenarios on oyster farm productivity.

A NOVEL SUBMERSIBLE MUSSEL RAFT FOR USE IN SEMI-EXPOSED OCEAN WATERS AND AREAS EXPOSED TO DRIFT ICE

Carter R. Newell, Victoria C. Shadis. Undine Marine, LLC, 117 Sandy Point Road, Stockton Springs, Maine 04981 USA

A patented novel submersible mussel raft was developed for use in semi-exposed ocean waters exposed to drift ice in Maine, USA in cooperation with Pemaquid Mussel Farms. The larger "Mark II" design was developed in 2017 and is currently being evaluated under commercial conditions in a 9 raft system in eastern Maine, expected to produce 1 million pounds a year. Raft performance and yield is superior to floating designs, eliminating the risk of storm damage and mussel drop-off, while protecting from sea duck predation. Commercial production of the raft for sales in the U.S. and export world-wide is planned for 2019.

FURTHER INVESTIGATIONS INTO GROWING SUGAR KELP (*SACCAHARINA LATISSIMA*) ON THE ISLAND OF MARTHA'S VINEYARD, MA

Otto Osmers[1], Shelley Edmundson[1], Amandine Surier Hall[2], Christopher Edwards[2], Dave Bailey[3]. [1]The Martha's Vineyard Fishermen's Preservation Trust, P.O. Box 96 Menemsha, MA 02552 USA;[2]The Martha's Vineyard Shellfish Group, Inc., P.O. Box 1552, Oak Bluffs, MA 02557 USA; [3]Woods Hole Oceanographic Institution, 86 Water Street, Woods Hole, MA 02543 USA

Kelp culture has the potential to improve Martha's Vineyard, MA waters while producing anew, locally grown product that could benefit the island's economy. Previous studies deployed kelp lines in sheltered harbors and ponds on Martha's Vineyard with variable growing results. This project aimed to test a new kelp grow-out location subject to higher currents and deeper waters. In November 2017, one 18m seeded kelp line was deployed off of Menemsha, MA within the Town of Chilmark's outer mooring field. Water temperature and light intensity was monitored over the 5-month project. In February 2018, high winter storm action destroyed half of the kelp line. In May 2018, kelp blades were harvested from the remaining line. Approximately 514g/m (wet-weight) of kelp blades with mean blade lengths of 36.1 ± 27.4 (SE) cm were harvested. While kelp growth was observed to be faster and blade color appeared darker brown than previously tested Martha's Vineyard locations, a more secure growing design is needed to prevent loss from winter storms and expand harvest capabilities.

POPULATION DIFFERENCES IN RESPONSE TO OCEAN ACIDIFICATION IN BLUE MUSSELS - IT IS NOT ALL BAD NEWS

Dianna K Padilla[1], Lisa Milke[2], Shannon Meseck[2], Allison Rugila[1], Dylan Redman[2], Mark Dixon[2], David Veilleux[2], Alyssa Liguori[1], Maria Rosa[1] Nils Volkenborn[3], Samuel Gurr[3]. [1]Department of Ecology and Evolution, Stony Brook University, Stony Brook, NY 11794;[2]NOAA Fisheries, Northeast Fisheries Science Center, Milford Laboratory, 212 Rogers Avenue, Milford, CT 06460 USA; [3]School of Marine and Atmospheric Sciences, Stony Brook University, Stony Brook, NY 11794

Most research to date suggests that bivalve molluscs are particularly sensitive to the impacts of ocean acidification (OA). But, at present we do not know whether differences among local environmental conditions has selected for animals with different sensitivities to stressors. Similarly we do not know whether responses to environmental stressors are phenotypically plastic, allowing animals with broad physiological tolerances to be robust to environmental stress. Therefore, blue mussels, *Mytilus edulis*, were collected from sites around Long Island Sound (LIS) with different water quality conditions to test whether mussels from more stressful environments are more resilient to the impacts of OA. We found that mussels from different populations show different responses to OA (manipulating aragonite saturation) in terms of larval survivorship and growth, juvenile growth and shell structure, thickness and breaking strength. We also found differences in heart rates among individuals from different populations in response to OA stress. In addition, these different response metrics were not always concordant for animals exposed for different levels of OA stress. Preliminary results from mussels reared for a second generation under OA stress indicates that in some cases robustness to OA stress was masked in the first generation but was revealed in the second generation. As a whole, these results suggest that there is variation in both genetic and phenotypically plastic robustness to OA stress in blue mussels. Experiments to test whether such variation is found in other species of bivalves, especially commercially important species, are needed.

MODELING FOOD CHOICE IN SUSPENSION-FEEDING BIVALVES

Emmanuelle Pales Espinosa, J. Jones, Robert M. Cerrato, Bassem Allam. School of Marine and Atmospheric Sciences, Stony Brook University, Stony Brook, NY

Suspension-feeding bivalves are able to sort and select food particles from a complex mixture. Recent reports have indicated that this selection is mediated by interactions between lectins present in mucus covering the feeding organs and carbohydrates associated with the surface of microalgae. In this study, several statistical methods were evaluated to predict the likelihood for a microalga to be ingested or rejected based upon its cell-surface carbohydrate signature. First, the carbohydrate signatures of 16 microalgae were characterized using 10 different lectins. A subset of microalgae (12 species) was then used in feeding experiments where different pairs of microalgae were presented to scallops (*Argopecten irradians*), oysters (*Crassostrea virginica*), clams (*Mercenaria mercenaria*) and mussels (*Mytilus edulis*) to evaluate selection. Results show that cell-surface carbohydrates are good predictors for particle fate. Specifically, microalgae rich in glucose/mannose residues were preferentially selected by each bivalve. Statistical methods for predicting the likelihood of an alga being ingested or rejected were evaluated, and decision trees that model selection in the four bivalves is proposed even though the stability of the model should be tested under different environmental conditions. Overall, these findings provide a promising predictive tool that could be used to assess bivalve performance and benthic-pelagic coupling under ecological or aquaculture contexts.

CLIMATE CHANGE, ENVIRONMENTAL, AND PUBLIC HEALTH IMPACTS OF SOLAR-ELECTRIC PUMP-OUT BOATS

Michael A. Pascucilla. East Shore District Health Department, 688 East Main St. Branford, CT 06405

The East Shore District Health Department (ESDHD) of Branford, Connecticut is pioneering the implementation of the nation's largest solar-electric pump-out boat to replace an older gasoline- powered model. The purpose of a Pump-out Boat is to collect and prevent the sewage holding tank waste from recreational boats from being discharged into marine waters, thus protecting the Long Island Sound Estuary. This free service is essential in protecting our local coastal shoreline beaches, commercial/recreational shellfish beds and our newly established kelp farms. This study, conducted in collaboration with ESDHD and Yale University, sought to assess the environmental and health effects of solar-electric pump-out boat technology. We conducted national surveys of pump out program managers and boat operators to gauge pump-out boating costs, cultures, and best practices. We also conducted life-cycle analyses of gasoline-powered and solar-electric pump-out boats to compare their production of environmental pollutants. Our work constitutes the most comprehensive study into pump-out boating in the United States to date, and identifies challenges and opportunities that remain for the widespread adoption of solar-electric pump-out boat technology.

Learning Objectives

- Learn the importance of a Pump-out Boat service on improving water quality.
- Understand the environmental impacts & obstacles of traditional and solar-electric vessel technology.
- Recognize the Climate Change impacts and life-cycle analyses

COST EFFECTIVE PRODUCTION OF BLUE MUSSEL, *MYTILUS EDULIS*, SEED FOR ROPE CULTURE: A HATCHERY SOLUTION

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Blue mussel, *Mytilus edulis*, aquaculture in Maine is based solely on wild seed settling and recruiting onto ropes within commercial leases. The vagaries associated with dependence of wild seed production (both spatially and temporally) is real, and may leave farmers with fewer seed than they need to sustain their businesses or expand

production. Hatchery production of mussel seed may add reliability to business models for new and existing mussel farmers. In addition to reliable seed production, hatchery-reared mussels can be bred selectively to enhance genetic characteristics (e.g., phenotype, faster growth, higher meat yield, and increased byssal strength). Cultured juveniles can be seeded onto ropes and deployed any month of the year that could help create new markets for sustainably sourced mussels. In 2018, we examined the economic viability and commercial scale production of hatchery-reared blue mussels by seeding multiple sets of ropes in the hatchery and transferring the ropes onto three existing mussel farms in Maine (Portland, Blue Hill, and Lamoine). Growth and field retention were examined by rope substrate, deployment time of year, and farm site. Also, we are experimenting with cryopreservation of gametes, embryos and larvae to make seed production more cost effective by limiting the need for broodstock conditioning and spawning to a once a year event and having seed available year round. We will present a cost assessment that examined costs to produce hatchery seed and ways to lower production costs to make hatchery-reared mussel seed an economically viable option for farmers.

SURVIVAL OF FOODBORNE PATHOGENS DURING PRODUCTION AND SHELF LIFE OF FRESH, VALUE-ADDED SEAWEED PRODUCTS

Jennifer Perry, Kilee Nile, Denise Skonberg. Food Science and Human Nutrition, School of Food and Agriculture, University of Maine, Orono, ME 04469

While the popularity of seaweed consumption is growing both in Maine and the United States, infrastructure and markets to efficiently support its production are lagging. Low-input processes to increase the shelf life of fresh seaweed may improve the efficiency of seaweed distribution and sale, boosting the profitability of Maine's agricultural sector. Fermentation and dry salting processes were assessed for this purpose. Fermented products consisted of 25%, 50%, and 75% kelp (*S. latissima* or *A. esculenta*) in a salted, shredded cabbage matrix. Salted products consisted of alaria combined with 3-20% salt (wt/wt). Two strain cocktails of bacterial pathogens (*L. monocytogenes, Salmonella, S. aureus,* and *Vibrio* spp.) were added to the seaweed during initial processing and populations were monitored throughout expected shelf life. Pathogens demonstrated superior survival in salted, as opposed to fermented, product, with pathogens (other than *Vibrio* spp.) commonly remaining detectable for greater than thirty days. The use of higher salt concentrations did not decrease pathogen survival. In fermented product, neither the ratio of seaweed to cabbage nor the species of seaweed utilized exerted a significant differential effect on pathogen survival. Regardless of treatment, duration of viability was shortest for *Vibrio* spp. Pathogenic microorganisms in fermented and salted seaweed products were undetectable after 15 and 46 days following inoculation, respectively. Further study is warranted to explore the effects of bactericidal processing steps that may enhance safety of these products.

CORNELL COOPERATIVE EXTENSION OF SUFFOLK COUNTY ALGAE EXPANSION

Joshua Perry. Cornell Cooperative Extension of Suffolk County Marine Program, Suffolk County Marine Environmental Learning Center, 3690 Cedar Beach Road, Southold, NY 11971

Algae culture is an essential component for shellfish aquaculture. For over 20 years Cornell Cooperative Extension of Suffolk County (CCE) has cultured various algae species for shellfish cultivation. Recently Cornell Cooperative Extension has expanded their existing hatchery with the development of a second hatchery in order to increase shellfish production numbers. With this expansion, algae production needed to increase as well. To meet this demand CCE purchased a 40 bag SEA CAP algae system as well as two 1250L bioreactors made by Industrial Plankton. The SEA CAPS algae system is a continuous bag system that is used by many hatcheries around the world. Water, nutrient, and algae inflow and outflow is all contained in a system of glass tubes. Water flowing into the system passes through a pasteurizer ensuring a constant source of clean water, nutrients are directly injected into the system via a peristaltic pump. The bioreactors however are new technology that has the

capability to grow high density algal cultures in a hyper-controlled environment. The machine, as advertised once inoculated automatically adjusts light, PH, temperature and nutrient amounts based on the density of the culture. CCE is beyond ecstatic to have the ability to expand their algae production capacity using both the SEA CAPS system and bioreactors. I will be discussing the differences in algal output, cost, benefits and drawbacks of each system. This comparison will give other people who are considering these systems insight into choosing which system would work best for them.

DEVELOPMENT OF RIBBED MUSSEL (*GEUKENSIA DEMISSA)* CONDITIONING AND SPAWNING PROCEDURES

Joshua Perry. Cornell Cooperative Extension of Suffolk County Marine Program, Suffolk County Marine Environmental Learning Center, 3690 Cedar Beach Road, Southold , NY 11971 USA

Ribbed mussels (*Geukensia demissa)* are a species of mussel found on the banks of salt marshes along the east coast of the United States. These mussels, although edible are not sought after by humans for consumption. This in turn makes them a perfect candidate for restoration projects. Mass cultivation practices have not yet been observed for this species, as most hatcheries have no need to cultivate ribbed mussels. However, as the need for shoreline restoration and nutrient extraction projects increase the benefits of cultivating the ribbed mussel would be a major milestone to aid in these projects. Cornell Cooperative Extension saw some success cultivating ribbed mussels last growing season in 2017 but methodology to develop a standard operating procedure is ongoing. During the 2018 season we saw some success conditioning and spawning ribbed mussels. Conditioning was achieved by feeding the mussels a mixture of commonly grown algae species used in shellfish aquaculture. Spawning was induced via temperature shock. Larval husbandry techniques varied upon the two spawns. However again, developing a standard operating procedure for conditioning, spawning and larval rearing is ongoing. This talk will focus primarily on the 2018 spawning period. I will discuss the methodology we used to condition, spawn and rear ribbed mussels, as well as the success and failures throughout the process.

EFFECTS OF MASSACHUSETTS AND RHODE ISLAND *VIBRIO* CONTROL PLAN REGULATIONS ON *VIBRIO PARAHAEMOLYTICUS* IN POST-HARVEST EASTERN OYSTERS (*CRASSOSTREA VIRGINICA*)

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Vibrio parahaemolyticus is a chitinolytic, gram-negative bacterium that is found in seawater. It commonly colonizes shellfish and seafood, causing gastroenteritis and septicemia in humans. Because humans often eat oysters raw, *V. parahaemolyticus* poses a significant health risk. Within New England, Massachusetts and Rhode Island are two of the largest producers of eastern oysters (*Crassostrea virginica)*. Both states have *Vibrio* Control Plans that specify regulations geared towards minimizing *V. parahaemolyticus*growth within shellfish. These regulations vary, and data is lacking on the correlation between the efficacies of regulatory guidelines and effects on *V.parahaemolyticus* growth and virulence. In this study, *C. virginica* were harvested and treated according to each state's *Vibrio* Control Plans for two weeks. Samples were taken at specific intervals throughout, and bacteria were quantified using the Most Probable Numbers (MPN) method outlined by the FDA Bacteriological Analytical Manual. Preliminary MPN results suggest a net reduction in *V. parahaemolyticus* under MA regulations and a net increase in *V. parahaemolyticus* under RI regulations. Because of the variation inherent within the MPN method and the role of virulence factors in determining risk to human health, pending qPCR analysis to identify and quantify virulent *V. parahaemolyticus* will further evaluate the efficacy of the MA and RI regulatory guidelines.

DOCUMENTING FISH BEHAVIOR ON AQUACULTURE GEAR

Gillian Phillips[1, 2],Renee Mercaldo-Allen[1], Peter Auster[3], Paul Clark[1], Erick Estela[1], Yuan Liu[1, 2], Lisa Milke[1], Dylan Redman[1], Julie M. Rose[1].[1]NOAA Fisheries, Northeast Fisheries Science Center, Milford Laboratory,212 Rogers Avenue, Milford, CT 06460; [2]Integrated Statistics, 16 Sumner Street, Woods Hole, Massachusetts 02543; [3]University of Connecticut, Department of Marine Sciences & Mystic Aquarium, 1080 Shennecossett Road, Groton, CT 06340

One approach for understanding the role that aquaculture gear may play as fish habitat is quantifying fish species diversity, patterns of relative abundance, and variation in behavioral activities using point-of-view (GoPro) video cameras. Analysis of video from oyster cages is underway using Noldus Observer XT (version 14.0) software to observe, categorize and quantify fish and associated activities. Video observations are being used to compile a matrix of fish behaviors associated with cages along with detailed, mutually-exclusive descriptions of each behavior and the location relative to the cage where it occurs. Examples of observed fish behaviors include: station keeping (small fin movements to maintain position adjacent to the cage), scan and pick (based on bites or browsing in water column in non-linear movements and on cage surfaces), territoriality (defense of space resources with fin flaring or face to face defense), and flight response to cage (rapid retreat into cage). An open access web-based video repository is under development containing video clips of fish behavior with corresponding functional descriptions to promote common classification of behaviors and collaboration amongst scientists and managers. By performing robust data collection and developing publicly-accessible outreach materials we intend to both provide information useful to the regulatory community and also contribute to increased public awareness of ecosystem services provided to fish by aquaculture gear.

*The Federal Government does not endorse GoPro™ cameras or Noldus Observer XT software.

A COMPARISON OF TISSUE AND SHELL NUTRIENT CONTENT BETWEEN DIPLOID AND TRIPLOID *CRASSOSTREA VIRGINICA* FROM TWO FARM SITES.

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One of the ways oysters remove nitrogen and phosphorus from the local environment is by assimilating nutrients into their tissues and shells through consumption of organic matter (e.g., algae) from the water column. This nutrient reduction service is of interest to coastal states that have sought to reduce the symptoms of eutrophication through nutrient management. In 2016, the Chesapeake Bay Program approved the use of private oyster aquaculture as a best management practice for nutrient reduction, with an option of using a reduction effectiveness applied across all seasons and assuming the same nitrogen content per gram dry weight for diploids and triploids. The goals of this research were to assess whether diploid and triploid oysters differ in tissue and shell nutrient content and whether nutrient content of tissue varies seasonally in diploids due to gametogenesis. One to two year old oysters were collected in 2017 from two industry partners in Virginia and Maryland who grew both diploid and triploid oysters at the same farm site with the same gear. Oysters were collected five times throughout the year; February, May, June, August, and October. Oysters were shucked to separate the tissue and shell. Tissue and shell were then oven dried, weighed for dry weight determination, and ground for elemental analysis. Carbon and nitrogen content of tissue and shell subsamples were determined by a CNS elemental analyzer. The phosphorus content was determined by spectrophotometry after acid digestion of subsamples. Results of this study can be used for adaptive management of the oyster best management practice by the Bay Program.

MA-ShellfAST: A GIS-BASED TOOL FOR SHELLFISH AQUACULTURE SITING AND PERMITTING

Read Porter[1], Rebecca Kihslinger[2], Brooke Hodge[3], Michael Tlusty[4], Diane Murphy[5]. [1]Marine Affairs Institute & Rhode Island Sea Grant Legal Program, Roger Williams University School of Law, 10 Metacom Ave., Bristol, RI 02809; [2]Environmental Law Institute, 1730 M Street, NW, Suite 700, Washington, DC 20036; [3]Anderson Cabot Center for Ocean Life, New England Aquarium, Central Wharf, Boston, MA 02110; [4]School for the Environment, University of Massachusetts at Boston, Boston, MA 02125; [5]Cape Cod Cooperative Extension & Woods Hole Sea Grant, Box 367, Barnstable, MA 02630

Massachusetts shellfish growers face a complex array of permitting requirements when selecting new sites or expanding existing operations, including municipal, state, and sometimes federal approvals. All too often, growers may overlook requirements or may not select sites with lesser permitting burdens. The Massachusetts Shellfish Aquaculture Siting Tool (MA-ShellfAST) was developed to assist prospective growers with the siting and permitting process, with a focus on legal compliance and ease of use. This GIS-based, online tool, now available to the public along with extensive documentation, provides key environmental and legal data for consideration by prospective growers, local officials, and state regulators. By using MA-ShellfAST, growers can identify legal and permitting issues at the outset, easily identify site boundaries, and work seamlessly with regulators during site selection and permitting. This presentation will discuss how the tool was developed, demonstrate how it is used in practice, and identify lessons learned during the tool development process.

2019 NACE LEGAL ISSUES IN AQUACULTURE PANEL SESSION

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As aquaculture continues to grow in the northeast, questions about the intersection of law and policy on aquaculture operations grow. Ranging from the Jones Act to litigation under the Magnuson-Stevens Act to "right-to-farm" laws that protect aquaculture from nuisance lawsuits in 27 states, there are a wide range of legal issues with bearing on where aquaculture goes in the future. This session will include a series of six presentations on emerging legal issues affecting aquaculture in the northeast region (see list below). Each presentation will include a question-and-answer opportunity, and panelists will participate in a facilitated discussion to end the session. This session will not provide legal advice, but will provide information of use to growers, state regulators, researchers and others throughout the region.

1. Legislative Efforts to Exempt Aquaculture Workers from the Jones Act – Robert Rheault, ECSGA
2. State Policy Change through Aquaculture Initiatives – Dr. Amanda Wenczel, NJ Dep't of Agriculture (invited)
3. Right-to-Farm Laws and Aquaculture: A New England Perspective – Amanda Nichols, National Sea Grant Law Center
4. Siting of Nursery Upweller Systems – Jordan Viana, Roger Williams University School of Law
5. Industry Perspectives on Legal and Regulatory Challenges in Shellfish Aquaculture: A New Hampshire Case Study – Lindsey Williams, MIT Sea Grant
6. Developments in Offshore Aquaculture Litigation under the Magnuson-Stevens Act – Read Porter, Marine Affairs Institute / RI Sea Grant Legal Program

THE EFFECTS OF SEDIMENT ACIDIFICATION ON THE IMMUNE CAPACITY OF THE ATLANTIC JACKKNIFE CLAM (*ENSIS DIRECTUS*)

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Ensis directus has been identified as a species with potential for use in aquaculture operations. The grow-out phase for *E. directus* requires that the animals be planted outside the hatchery in their natural environment to keep algae-growing costs for the operation down. During this phase the clams are constrained to their holding containers and must cope with a variety of environmental factors, such as sediment acidification. The surface sediment pH can vary greatly from site to site, making it crucial for growers to understand the sensitivity of their species to pH before selecting a location. To this end we tested the impact of acidified surface sediment (~0.8 pH unit lower than control) on the internal immune capacity of adult *E. directus* at 10.2°C and 20.1°C. Hemocytes (circulating blood cells) are responsible for carrying out immune functions in bivalves and were thus the target for our immune capacity assays. Hemocyte parameters measured included cell viability, total cell counts, differential cell counts, and phagocytic capacity. A condition index was also calculated using the wet flesh weight and dry shell weight to assess the physiological condition of the animals. A 30-day exposure period to the acidified sediment had no significant impact on any of these parameters at the 0.05 significance level. In addition, all the clams buried into the sediments of their respective treatments within an hour of being placed there. These results indicate that *E. directus* adults have the capacity to cope with low pH surface sediments for at least 30 days.

EFFECT OF GEAR TYPE AND SEASON ON *VIBRIO PARAHAEMOLYTICUS* AND *V. VULNIFICUS* IN FARM-RAISED OYSTERS, *CRASSOSTREA VIRGINICA*, AFTER ROUTINE HANDLING

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Oyster aquaculture involves routine handling that exposes oysters to elevated temperatures, causing growth of *Vibrio parahaemolyticus* (*Vp*)and *V. vulnificus* (*Vv*). Farmers can re-submerse oysters in the water, allowing elevated levels of *Vibrio* to return to ambient levels before harvesting. Re-submersion studies have been performed in Alabama during the summer, when risk is assumed to be the highest. However, these studies did not cover all periods when a risk may be likely, or examine other factors that could influence recovery times. In this study, gear type and season were tested to examine their effects on re-submersion periods. The two common gear types used for off-bottom aquaculture, floating cages and suspended gear, were compared during a spring and summer trial. Three treatments were tested for each gear type: 1) tumbled and refrigerated, 2) desiccated, 3) submersed control. The oysters were removed from the water, treatments were applied, and then re-submersed at the farm. The recovery of total *Vv* and *Vp,* and pathogenic *Vp* (*tdh+/trh+*),over a 14-day re-submersion period was examined. Preliminary data show that all *Vibrio* recovered to ambient levels after 7 days of re-submersion, regardless of gear type. Although the 7-day re-submersion period was sufficient, the levels of pathogenic *Vp* were higher during the spring trial, suggesting that the summer months may not have the highest risk of *Vibrio* illness. These data indicate that the spring shoulder season hold the potential for increased risks from *Vibrio*, and future re-submersion studies should consider the shoulder seasons and the summer season.

THERMAL ACCLIMATION EFFECT ON A CANDIDATE SEA VEGETABLE CROP, *ALARIA ESCULENTA*

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Sea vegetable aquaculture will require a greater diversity of strains that are tolerant to coastal warming as the industry expands. Market demand offers increased opportunities for development of sea vegetable crops in Maine. This project aims to determine temperature tolerance of *Alaria esculenta* (L.) Greville and to understand its potential as an aquaculture crop in Maine's warming waters. We previously cultured gametophyte seedstocks from two source locations that span the Maine shore. Cultures were gradually acclimated to 22 °C or maintained at 12 °C (controls). The health of thermally acclimated strains was significantly affected compared to controls, but source location had no effect on gametophyte health. Control and heated strains from each source location were crossed (within treatment) to produce sporophyte blades. Juvenile blades were grown in a common garden study in tanks at our aquaculture center, and then were transferred to a sea farm for grow-out. Blade surface area was measured at three points throughout the growing season. The largest blades produced were from northern strains that were previously acclimated to 22 °C. Both previous acclimation and source location of gametophytes affected the surface area of sporophyte blades at every collection point (PERMANOVA; Treatment: $p \leq 0.003$, Location: $p \leq 0.010$). This research demonstrates that thermal tolerance of seedstock may vary by source location, but thermal acclimation protocols in seedstock nurseries may help boost crop yields universally, further supporting the sea vegetable aquaculture industry.

ENABLING TECHNOLOGIES IN OPEN OCEAN MARICULTURE FARMING PLATFORMS

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Since 1994, the FAO has published "The State of World Fisheries and Aquaculture" report and this has shown the growing gap in the wild fish landings and aquaculture production. What is clear from this annual analysis is that the gap in protein production will not be sufficient to provide enough protein to feed the estimated 9 billion people by 2050. It is also clear that marine protein is one of the most viable solutions to address this growing gap, but only if done responsibly and with sustainable methods.

InnovaSea Systems, Inc believes that the solution lies in being able to farm fish in the open ocean and by using parts of the ocean that today are considered unsuitable forraising fish. In order to do this, we rely on technology to face the challenges that current and future open ocean fish farmers will experience; most of which are magnified when moving from sheltered to more exposed sites; potential for damage to the pen and grid systems in high energy environments, how to determine fish satiation during feeding, and how to incorporate environmental and biological real-time data for day-to-day and strategic decisions to name a few.

InnovaSea has completed and proven its fish farming platform. By addressing all required operations, fish farmers will be able to feed their fish submerged, harvest in the open ocean, and monitor fish and water conditions in real-time without installing cables/wires. To put it simply, imagine being able to monitor in real-time dissolved oxygen within and without the pen, currents, water temperature, tension on the grid lines, or biomass estimates on your smart-phone from the other side of the world.

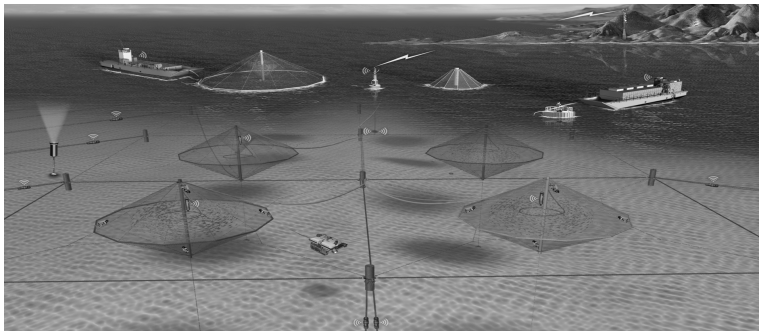

Figure 1: Complete fish farming platform

A phased-approach business model allows farmers to scale their operation and reach profitability efficiently. Based on the shared experiences of InnovaSea's many customers over the years, we have identified the most important success factors any entrant into this market must consider. After all, what the industry needs now, more than ever, are success stories to bolster confidence in what the industry is doing.

OYSTER GROWERS' FORUM ON BLISTER WORM IMPACTS

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Polychaete worms in the genus *Polydora* continue to be of concern to oyster producers in the northeastern US; heavy infestations can cause reduced growth and condition, while producers are concerned about marketability of infested oysters and incur costs in managing the problem. While some management measures have shown promise in reducing the frequency or degree of blister worm infestation on individual farms, growers still have many basic questions relating to *Polydora* biology and ecology and the implications for husbandry measures. A producers' survey, sponsored by the USDA Northeast Sustainable Agriculture Research and Education Program and designed by Dr. Paul Rawson (University of Maine) and Dana Morse (Maine Sea Grant), was distributed to growers between Maine and Virginia. The survey investigated several aspects of the issue: influences of the physical environment on infestation rates and severity; influences of gear type and production system; the level of industry concern with respect to potential or realized impacts to the crop or in the market; feedback from producers are effectiveness of various remedies; and suggestions for additional work that would lead to more workable solutions. This forum will review the results of the survey, and will be a venue for discussion of associated issues, including seed transfers and biosecurity, new observations on effective husbandry options, and mechanisms to aggregate observations from industry and science as tools to work toward solutions.

DEVELOPMENT OF FIELD MATERIALS FOR VISUALIZING AND COLLECTING FISH UTILIZING AQUACULTURE GEAR AND A NATURAL REEF

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Preliminary trials conducted during summer 2017 near Milford, CT developed methods for using GoPro camera video to document fish interactions with aquaculture gear and boulder habitat. Cameras mounted to the side and top of oyster cages provided vertical and horizontal fields of view. To collect video adjacent to boulders, T-stand platforms were constructed for mounting cameras to provide a field-of-view similar to cage-mounted cameras while adding minimal structure. Three T-stands were lowered from the boat and positioned by SCUBA divers near different boulders for every deployment.

In 2018, divers selected specific boulders to return during bi-monthly deployments. Four T-stands were situated near each boulder at the desired distance and orientation. A central hub and ground lines were used to orient divers to the T-stand and boulder pairs. One day after diver-deployment, timer-activated cameras recorded at 8 minute intervals every hour over a 12-hour tidal cycle. Once video collection was complete, divers retrieved cameras while T-stands remained in place.

To study food habits of fish associated with oyster cages, a prototype deep holding box net (3m X 3m X 1.5m with 3.2mm mesh) was tested to collect live fish. A cage was placed inside the net, and lowered to the seafloor. Divers were deployed to confirm proper net configuration. To keep the net from billowing in currents, the opening was trimmed with lead core line. When retrieved, the net enveloped the oyster cage and cinched closed. This allowed collection of live fish associated with oyster cages for stomach content analysis.

TOOLS FOR FARM MANAGEMENT AND RECORD KEEPING

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From environmental data like temperature and salinity to husbandry practices, equipment usage and team management there is a ton of data you could collect on a farm. Likewise, there are a number of ways to collect and use that information, which will vary from operation to operation. This workshop will have several growers explain their current systems of farm management and record keeping with open discussion of merits and caveats encouraged. These will range from traditional methods to more emerging technology. Also included will be discussion on important data to collect on your farm, including input on records important for farm tools like USDA Risk Management programs.

ASSESSING THE POTENTIAL FOR AQUACULTURE PRODUCTION OF SURF CLAMS IN SOUTHERN NEW ENGLAND

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Atlantic surf clams, *Spisula solidissima*, have shown potential in aquaculture conditions with preliminary studies in the 1980's and 90's. These early studies indicated relatively fast growth and market potential for sublegal clams. Production methods were never fully explored, but interest has grown and Massachusetts now allows the sale of 1.5" aquaculturally-grown surf clams. Surf clam seed was hatchery-produced in 2017, held in nursery conditions, and then deployed at four grow-out locations during the summer of 2017 and monitored for 18 months. At each site seed was deployed in 3 treatments; 1) planting in the sediment under protective netting, 2) in soft nylon mesh bags, and 3) in rigid plastic mesh oyster bags in cages off-bottom or attached to lines along the bottom. Survival and growth varied by site and grow-out methodology. Prolonged exposure during extreme hot or cold weather events caused significant mortality at higher intertidal site locations. Mortality at subtidal sites was more general and likely related to either predation or smothering by mounding sand. Seed grew in all treatments, though at different rates, until 18mm in length. After 18mm, growth was improved if the clams could dig into the sediment. The surf clams did show remarkable growth when conditions were right; 18mm seed planted under nets in July 2017 reached a marketable average length of 39mm (>1.5") by the end of 2017 (6 month grow-out) at one site.

EAST COAST MOLLUSCAN HEALTH INITIATIVE PART 2: HATCHERY CERTIFICATION

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The growth of shellfish aquaculture in the eastern United States has increased interstate commerce of hatchery seed. Receiving states typically have a review and or permit process to ensure that imported seed does not cause harm to local domestic and wild stocks. States usually require "clean bills of health" from shellfish pathologists that are costly and time consuming. Hundreds of evaluations over several decades support a widely held view that young seed cultured in filtered water are effectively free of disease and relatively safe to transfer between distinct bodies of water and states. With support from the National Sea Grant Aquaculture Impediments Program, a Hatchery Certification Working Group established at the 2015 NACE in Portland, ME has drafted an application and audit protocol to certify hatcheries that use management practices which protect against disease transfer. The objective is to provide relief from batch-by-batch seed health evaluations by describing the conditions and procedures that have consistently yielded pathogen-free seed. Through the certification process, we hope to give regulators the confidence to move to a semi-annual inspection cycle that would reduce costs while protecting local stocks and populations. The hatchery certification program is voluntary for both states and hatcheries with the alternative remaining batch-by-batch examination. It is part of a comprehensive East Coast Shellfish Health Initiative, which includes advisory and disease database components. This presentation will review progress, distribute proposed protocols, and seek comments from attendees in an effort to engage stakeholders from the entire east coast region.

PROJECTED IMPACTS OF FUTURE CLIMATE CHANGE, OCEAN ACIDIFICATION, AND MANAGEMENT ON THE US ATLANTIC SEA SCALLOP (*PLACOPECTEN MAGELLANICUS*) FISHERY

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Ocean acidification has the potential to significantly impact both aquaculture and wild-caught mollusk fisheries around the world. Here, we present the results of an integrated assessment model of the US Atlantic Sea Scallop (*Placopecten magellanicus*) fishery to determine the possible future of the fishery under a suite of plausible climate, economic, biological, and management scenarios. We developed a 4x4x4x4 hypercube scenario framework that resulted in 256 possible combinations of future scenarios. Under a climate mitigation scenario and the highest acidification impact and management catch limits, sea scallop biomass declines by approximately 13% by the end of century; however, the lesser biological effects cause very little change. Under a business-as-usual climate scenario, sea scallop biomass may decline by more than 50% by the end of century, leading to subsequent declines in industry landings and revenue. Management-set catch limits improve the outcomes of the fishery under both climate scenarios, and the addition of a 10% area closure increases future biomass by more than 25% under the highest ocean acidification effects. However, increased management still does not stop the projected long-term decline of the fishery under ocean acidification scenarios. Given our incomplete understanding of acidification impacts on *P. magellanicus*, these declines, along with the high value of the industry, suggest population-level effects of acidification should be a clear research priority.

INVESTIGATING THE ROLE OF APOPTOSIS IN DISEASE RESISTANCE TO DERMO IN THE EASTERN OYSTER, *CRASSOSTREA VIRGINICA*

Erin M. Roberts[1], Dina Proestou[2], Gary Wikfors[3], Tal Ben Horin[1, 2], Kate Markey-Lundgren[2], Marta Gomez-Chiarri[1]. [1]Fisheries, Animal and Veterinary Science Dept., University of Rhode Island, Center for Biotechnology and Life Sciences, 120 Flagg Rd., Kingston, RI, 02881; [2]USDA ARS, National Cold Water Marine Aquaculture Center, 120 Flagg Rd., Kingston, RI, 02881; [3]USDOC, NOAA, National Marine Fisheries Service, Milford Laboratory, 212 Rogers Avenue, Milford, CT 06460

Apoptosis regulation is critical to oyster immune defense and plays a key role in Dermo disease pathogenesis. The causative agent of Dermo, *Perkinsus marinus*, invades hemocytes and increases hemocyte apoptosis following challenge *in vivo*. Hemocyteapoptotic death may limit pathogen spread inside tissues and promote survival, though survival varies naturally in the wild. This project investigated 1) whether apoptosis phenotypes in genetically distinct oysters vary and 2) whether they correspond with measured levels of Dermo resistance. Juvenile oysters from six selectively-bred families were injected with a weight-standardized dose of *P. marinus* and monitored for 64 days. At days 7 and 50-post exposure, the following apoptosis phenotypes were measured in hemocytes: cell viability, execution of apoptosis, and activation of the caspase-dependent pathway of apoptosis. In addition, Dermo resistance phenotypes were defined as survival and change in parasite load over time. At days 7 and 50, agranular hemocytes were more frequent than granular hemocytes and had a higher percentages of live and dead apoptotic hemocytes, though live and dead apoptotic hemocyte percentages were significantly different between families of both cells. A significantly higher percentage of caspase-dependent apoptotic hemocytes was found for only agranular hemocytes at day 7 and 50. These results demonstrate variance in apoptosis phenotype across oyster families and suggest a caspase-dependent pathway of apoptosis may be triggered in agranular cells in response to *P. marinus* infection. Correlations between apoptosis and dermo resistance phenotypes will highlight the potential for apoptosis phenotypes to predict levels of resistance among selected families.

THE USE OF IN SITU HYBRIDIZATION AND QPCR TO DETERMINE THE LOCATION AND QUANTITY OF *VIBRIO PARAHAEMOLYTICUS* IN *CRASSOSTREA VIRGINICA*

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Vibrio parahaemolyticus (Vp) is a pathogenic bacterium that can be filtered out of the water by eastern oysters (*Crassostrea virginica)* during feeding. Unfortunately oysters with high levels of Vp may cause human gastrointestinal illness when consumed raw. Vp populations in estuaries increase during the summer months, sometimes causing aquaculturists to shut down their harvest during an economically important part of the year. Research has shown that depuration of oysters can rid them quickly of Vp. This work attempts to identify the location(s) of Vp in oyster bodies by utilizing two methods: quantitative PCR (qPCR) and In situ hybridization (ISH). Eastern oysters were inoculated with various concentrations of Vp and organ systems were sampled for quantification of Vp through qPCR. ISH methods were used to locate Vpusing digoxigenin-labeled oligonucleotide probes, which are complementary to the DNA of various Vp specific genes. ISH was performed on histological sections of fixed oysters to identify the occurrence and location of Vp. This work attempts to better understand the possible implications of depuration, and ultimately the infection mechanisms for future management methods.

CREATING FLOW REFUGIA TO AUGMENT AND RESTORE FRESHWATER MUSSEL POPULATIONS IN THE TIDAL FRESHWATER DELAWARE RIVER

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Freshwater mussels (Order Unionoida) remain one of the most imperiled taxonomic groups in North America. Recent attention on population restoration and augmentation in tidal areas of the Delaware Estuary with historic populations has proven challenging as benthic conditions in urbanized areas may not provide readily suitable habitat. Lower benthic shear stress and increased sediment stability may promote mussel retention and recruitment; however, few studies have examined how such physical factors govern habitat suitability in tidal freshwater systems.

In fall 2017, experimental structures comprised of salvaged logs and cobble were constructed along a shallow subtidal shoreline of the Delaware River where the preexisting mussel abundance was greatly reduced compared to a nearby reference site. The structures were oriented to stabilize sediments and reduce benthic shear stress while not interfering with seston delivery. Passive Integrated Transponder (PIT) tagged mussels were subsequently deployed into each structure and untreated controls. Changes in Plaster-of-Paris "Clod" sphere dissolution rates, sediment grain size, and organic content were monitored for a full year starting in Fall 2017. Dissolution rates of clods were significantly lower in experimental structures and mussel retention averaged 71.6% in structures compared to 67.4% in control plots after 1 year. This suggests that the structures may serve as refugia from high flow that typically mobilizes the substrate. If confirmed with extended monitoring, these results should support design of living shoreline projects aimed at boosting populations of native unionids.

A REGIONAL OVERVIEW OF SHELLFISH AQUACULTURE USE IN SUPPORTING COASTAL NUTRIENT MANAGEMENT PROGRAMS - IMPLICATIONS FOR GROWERS AND RESOURCE MANAGERS

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A variety of policy initiatives in the Northeast have led to the formal recognition of the nutrient reduction services that shellfish aquaculture can provide, allowing for its use in nutrient management programs. These initiatives provide an exciting opportunity for coastal communities to both support the production of local sustainable seafood and help achieve water quality objectives. The end goal for the nutrient management programs that support these initiatives is to provide additional tools to resource managers who seek to improve water quality. But policy decisions made during program design and implementation can yield very different results for the local shellfish aquaculture industry.

This talk will compare several programs in various stages of development and implementation, from an aquaculture perspective. Approved oyster best management practices in Chesapeake Bay have yielded various implementation possibilities. One possibility with direct benefits to growers is the inclusion of oyster aquaculture in Virginia's nutrient trading program. Shellfish aquaculture contributions to nitrogen management planning are being explored at the municipal level on Cape Cod, MA. Large structural differences exist between the programs underway within the Towns of Mashpee and Falmouth, with implications for the local shellfish aquaculture industry. These programs range in scale from the municipal, to single state, to the multistate, whole-estuary. They also differ in the benefits and opportunities offered to shellfish aquaculture: from marketing opportunities that may result from the recognition that shellfish aquaculture can provide environmental benefits, to streamlining of the permitting process for new or expanding operations, to payments for the nutrients removed through shellfish harvest.

NAVIGATING THE LEGAL REQUIREMENTS OF AQUACULTURE WORKER CITIZENSHIP

Andrew I. Rubin. Rubin, Winston, Diercks, Harris & Cooke, L.L.P., 1201 Connecticut Avenue, N.W. Suite 200, Washington D.C. 20036

Determining legal obligations to foreign employees and the significance of citizenship requirements for coastal aquaculture workers are both complex issues confronting many shellfish farms. Successful compliance with applicable labor laws requires careful planning, analysis, and operational awareness. In this session, attorney Andrew Rubin will guide shellfish aquaculture stakeholders in understanding and applying these labor laws.

Stakeholders attending the session will gain valuable general legal knowledge related to the employment of foreign individuals.

EFFECTS OF PARTICLE SIZE ON THE BIO-ACCESSIBILITY OF BIOACTIVE COMPOUNDS OF SUGAR KELP (*SACCHARINA LATISSIMA*) IN AN IN-VITRO SIMULATED GASTROINTESTINAL TRACT (GIT) MODEL

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Seaweeds, such as sugar kelp, are rich source of vitamins, minerals, antioxidants, omega-3 fatty acids and especially the medicinal bioactive active compounds in the form of dietary fibers (alginates, carrageenan, fucoidan, laminarin) and secondary polyphenolic metabolites (fucoxanthin, phlorotannins). The chemical composition and nutritional content of seaweeds depends mostly on species, geography, location, season, water temperature, salinity and light intensity. The active metabolites found in seaweed have been documented for exhibiting the various biological activities such as anticancer, antitumor, antiviral, anti-inflammatory and anti-angiogenic effects. Obesity is increasing worldwide at an alarming rate and it is estimated that by 2030 with 58% of global population will become obese. Many studies have found that the consumption of high dietary fibers of seaweed could also help in prevention of obesity related disorders and metabolic syndrome. The objective of this research is to study the effect of different particle size on the bioaccessibility of bioactive phytochemicals tested under gastrointestinal tract (GIT) condition. Fresh sugar kelp was procured from the local Maine seaweed farmer and is freeze dried. Dried sample were sifted at different particle size level range from >250 µm, 250-500 µm, 0.5-1 mm and >1 mm, respectively. After passing the dried samples through the different GIT (saliva and gastric) phase, the samples were centrifuged. The collected supernatant and pellet were tested for proximate content, antioxidant and phenolic activity. These studies will help in understanding the digestion of sugar kelp and the absorption of bioactive compounds in human digestive system.

IDENTIFYING EFFICENCIES IN AQUACULTURE REVIEW THROUGH THE DEVELOPMENT OF A STATE-WIDE AQUACULTURE PERMITTING PLAN FOR MASSACHUSETTS

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The Massachusetts Division of Marine Fisheries, in coordination with partner agencies, industry representatives, and other marine related user groups, are in the process of developing the Massachusetts Aquaculture Permitting Plan (MAPP). The MAPP is primarily intended to encourage sustainable growth in the Commonwealth's marine aquaculture industry and the responsible implementation of municipal shellfish propagation and restoration activities. The marine aquaculture industry in Massachusetts has experienced remarkable growth in the past decade. In 2006, shellfish aquaculture landings were valued at $6.2M. In 2017, shellfish aquaculture production exceeded $28M and supports over 375 local businesses. This growth has led to the need for the Commonwealth to review its aquaculture management framework with the goal of expanding and modernizing its scope while addressing stakeholder concerns regarding potential user group conflicts and the cumulative environmental impacts associated with some aquaculture activities. In order to continue sustainable growth in the sector, better information is needed. Growers need to know what to expect from permitting agencies in order to make salient investments, and permitting agencies need to know alternatives designed to avoid and minimize impacts to the environment and other user groups. The MAPP will lead to the creation of practical standards under which most aquaculture projects can be evaluated and outline an inter-agency approach to aquaculture review and permitting in the Commonwealth. Herein, we discuss how development of MAPP will create environmental and public use

standards for aquaculture projects, and expand opportunities for agency, industry and public input on future aquaculture development in the Commonwealth.

PUBLIC HEALTH ISSUES ON THE FARM PANEL DISCUSSION

Christopher A. Schillaci[1], Chris Sherman[2], Miranda Ries[3], Robert Rheault[4], Meredith White[5],Kristin Derosia-Banick[6], Wade Cardin[7], Stephen H. Jones[8],Victoria L. Purente[9]. [1]Massachusetts Department of Fish and Game, Division of Marine Fisheries, 251 Causeway St Suite 400, Boston, MA; [2]Island Creek Oysters,401 Washington Street Duxbury, MA;[3]Pacific Seafood, 16797 SE 130th Avenue, Clackamas, OR; [4]East Coast Shellfish Growers Association, 1623 Whitesville Road. Toms River, NJ; [5]Mook Sea Farm, 321 ME-129, South Bristol, ME; [6]State of Connecticut, Department of Agriculture, Bureau of Aquaculture, 190 Rogers Avenue, Milford, CT; [7]NYS Dept. of Environmental Conservation, Division of Marine Resources, 205 N. Belle Mead Rd. Ste. 1, East Setauket, NY; [8]Department of Natural Resources and the Environment, University of New Hampshire, Durham, NH; [9]Auburn University Shellfish Lab, 150 Agassiz St., Dauphin Island, Alabama 36528

Shellfish aquaculture production in the U.S. has more than doubled in the past two decades and is expected to continue to increase as the U.S. works to bolster domestic production and exports of seafood through the promotion of aquaculture in state and federal waters.

The majority of this recent growth has been in single oyster production. Single oyster production allows growers to maximize production per acre by utilizing the entire water column; however, it often requires extensive pre-harvest handing and other practices that have the potential to create pathogen exposure pathways not commonly attributed to traditional culture methods such as bottom planting. In addition, surface gear has been associated with waterfowl and mammal congregations that can have negative impacts on water quality.

In recent years, the NSSP has adopted requirements for State control authorities to evaluate how these emerging gear types and culture activities may impact the levels of pathogens in shellfish at harvest; and if needed, to develop protocols to mitigate such hazards. A number of states have also put in place requirements regarding the extended handling of oysters, growout of seed in closed areas, land based overwintering, and record keeping. Additionally, a number of countries and shellfish buyers have put in place product testing requirements beyond those required under the NSSP that may limit emerging trade opportunities.

Herein, a group of diverse industry professionals, state regulatory authorities, and researchers will discuss these emerging requirements, the science behind them, and how growers are adapting to this evolving landscape.

AN ASSESSMENT INTO VEGETATION FARMS AS A SOLUTION TO COASTAL EROSION IN SOUTHERN MAINE

Dylan Schlichting, Brandon Lieberthal, Kimberly Huguenard. Department of Civil and Environmental Engineering, University of Maine, Orono, 04469

Rising sea levels and increased storm intensity highlight the need for shoreline protection strategies that attenuate incoming wave action but do not negatively alter littoral sediment transport. Nearshore vegetation farms have been shown to attenuate incoming wave energy; however their viability from an engineering perspective has never been conducted in the southern Maine. To assess reduction in beach volume loss, exploratory analytical modeling of the local wave climate and analysis of near shore morpho-dynamics is used to identify seasonal variability among beach profiles. Camp Ellis of Saco Bay, Maine, which suffers the highest erosion in the State, is used as a case study because alongshore sediment transport was halted by the construction of a jetty in the 1800s. Beach profile changes are analyzed through Empirical Orthogonal Functions (EOFs) on two beaches in Saco Bay and compared with an undeveloped beach. The EOFs suggest that long term erosion processes linked to the jetty

result in the greatest beach volume losses despite short term volume loss induced by coastal storms. Analytical model results indicate that vegetation farms attenuate incoming wave action, however seagrass is more effective at attenuating wave heights in shallow water than kelp. The suspension of kelp from long lines offers a practical advantage over seagrass farms because their capability to attenuate waves is independent of sea level rise and storm surge. A vegetation farm will reduce beach volume loss caused by wave action and coastal storms but will not protect against volume loss induced by the presence of the jetty.

OCEAN ACIDIFICATION INCREASES SUSCEPTIBILITY TO INFECTION IN THE EASTERN OYSTER (*CRASSOSTREA VIRGINICA*) AND NORTHERN QUAHOG (*MERCENARIA MERCENARIA*)

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The eastern oyster (*Crassostrea virginica*) and northern quahog (*Mercenaria mercenaria*) are sensitive to coastal ocean acidification. Exposure to elevated pCO_2makes it more difficult to form biogenic $CaCO_3$, and increasing pCO_2 in seawater can affect survival, growth, development, physiology, and alter energetic demands. Even if they survive early development, there still might be a cost to maintaining basal metabolic functions under stressful conditions, such as immune functioning. We assessed the impacts of elevated pCO_2 on the susceptibility to bacterial pathogens of the eastern oyster and northern quahog, through several laboratory experiments throughout various life stages, and evaluated the growth and persistence of *Vibrio* spp. under acidified and control conditions. When exposed to bacterial pathogens, clams and oysters in acidified seawater had significantly higher mortality as compared to controls. Counts of *Vibrio* spp. and other marine bacteria were significantly higher in seawater samples and bivalve tissues collected from the acidified treatments as compared to controls. We further tested the survivorship and growth of bacterial pathogens (*V. coralliilyticus, V. splendidus, and Listonella anguillarum*) and found significantly higher growth in acidified seawater. Clams raised in acidified seawater were transferred to ambient seawater and clams from ambient seawater were transferred to acidified seawater and then exposed to bacteria. Here, results showed that acute exposure to acidified seawater impairs immune functioning, and that a period of relief from acidified seawater can improve immune functioning. Our preliminary analyses demonstrate that future acidification could increase susceptibility to infection by bacterial pathogens in clams and oysters.

IS OYSTER AQUACULTURE THE SOLUTION TO OUR POLLUTION PROBLEMS?

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Increased nutrient loading along with a sharp decline in bivalve abundance have negatively impacted estuarine ecosystem function. Restoration aims to recover lost ecosystem services and optimize fisheries yield. However, shellfish aquaculture can be an alternative to restoration, providing similar ecosystem services with additional economic benefits. Few studies have examined the effect of aquaculture on sediment microbial community structure and function. We conducted sediment samplings at three commercial scale oyster *(Crassostrea virginica)* aquaculture farms a long a salinity gradient in Chesapeake Bay. Nutrient fluxes, denitrification rates, sediment organic matter and microbial community composition (16S rRNA gene) were measured from sediments underlying oyster aquaculture cages and compared to control sediments without aquaculture influence. Oyster aquaculture enhanced nitrogen removal via denitrification by 125% to 450% over the controls, likely due to an increase in organic carbon load to the sediments from oyster biodeposition. Denitrification rates measured in aquaculture sediments were similar across sites, suggesting oysters had a stronger influence on sediment denitrification than salinity or other site-specific environmental conditions. Within a site, microbial community

structure was different between control and aquaculture sediment. The microbial community varied by site (salinity). Within a site, microbial communities differed between control and aquaculture sediments, with higher microbial diversity associated with aquaculture. This suggests that, despite differences in community structure between sites, aquaculture had a similar effect on biogeochemical function. Understanding the interactions between aquaculture and the environment will help preserve ecosystem services of coastal ecosystems.

THE MASSACHUSETTS SHELLFISH INITIATIVE (MSI): DEVLOPING A STATE-WIDE PLAN FOR MAXIMIZING ECONOMIC, ENVIRONMENTAL, AND SOCIAL BENEFITS OF SHELLFISH RESOURCES IN MASSACHUSETTS

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The MSI is an iterative and collaborative process that has been facilitated by the Cape Cod Commercial Fishermen's Alliance, Massachusetts Aquaculture Association, and The Nature Conservancy, with early support from UMass- Boston and the Massachusetts Division of Marine Fisheries. In 2017 the initial project partners sought public input on the interests, concerns, and commonalities across various shellfish resource stakeholders, to establish broad support for the development of an MSI taskforce. Those efforts led to the recruitment of 18 shellfish community leaders and managers who represent the Massachusetts Environmental Secretariat, state agencies, municipal representatives, fisheries and aquaculture trade associations, and members of the Massachusetts Legislature to serve as the initiative's taskforce. The project has also identified a number of other shellfish stakeholders to serve on three sub-committees whose work will inform the taskforce's formulation of a strategic plan for the future of Commonwealth's shellfish resources. The initiative's primary goal is to balance growing and competing demands for shellfish and coastal resources, including the development of policy, regulatory, and legislative recommendations and strategies and tactics (built from the stakeholders up) that can be implemented to make progress towards maximizing the economic, environmental, and cultural value of the state's shellfish resources. The partners have sought to implement the most effective pieces of other established shellfish initiatives, while adapting the concept to fit the unique Massachusetts landscape. Herein we discuss the efforts of the MSI team to provide ground up guidance for balancing the growing and often competing demands on the State's shellfish resources.

HABITAT RESTORATION IN NEW HAVEN HARBOR UTILIZING LAB CULTURED OYSTER SETS AND REEF BALLS™

Peter Solomon, Samuel Greenvall, Louis Laudano, Kelly Roper, Stuart Mattison, John Roy.
The Sound School, 60 S. Water St. New Haven, CT 06519 USA

Oyster reefs have been documented to provide valuable habitat structure and ecosystem services as well as socioeconomic benefits. Native reefs once dominated many estuaries ecologically and economically. Studies have shown depletion and degradation of oyster reefs worldwide. Successful restoration efforts have further demonstrated the value of oyster reefs to coastal ecosystems and communities.

Reef Ball™ Modules (RBM's) are designed to mimic natural bottom structure and are being used to address a variety of environmental concerns. Initial investigations suggest that these artificial forms may have far reaching effects in habitat and species restoration efforts including; designing and growing artificial reefs, coral

propagation and planting systems, estuary restoration, mangrove plantings, erosion control, and oyster reef restoration.

Students and faculty at the Sound School built five Mini-Bay RBM's (width: 0.76m, height: 0.53m, weight: 91kg) using oyster shell as a cement additive. In May of 2018 the aquaculture laboratory at the school successfully spawned oysters. After the spawn three RBM's were placed in a set-tank with 200 micron spat. The RBM's soaked for ten days. In June 2018 the RBM's, three with set and two unseeded, were deployed in near shore waters by the school campus. To date the three modules with oyster set have demonstrated successful oyster growth and survival over their entire surface while the unseeded modules have no oyster growth. A variety of crab and fish species were observed using the seeded RBM's. Oyster growth and species interactions continue to be monitored.

GENETICS, BREEDING AND GENOMICS OF MUSSEL PHENOTYPES FOR AQUACULTURE PRODUCTION

Sheila Stiles[1], Elizabeth Hayes[1,2], Melanie Dore[1,2], Steven Pitchford[1], Joseph Choromanski[1], Helen Poynton[3], William Robinson[3], Jared Goldstone[4], Bren Smith[5], Jill Pegnataro[5]. [1]USDOC, NOAA Fisheries, NEFSC, Milford Laboratory, Milford, CT 06460;[2]Integrated Statistics, 16 Sumner Street, Woods Hole, MA 02543[3]University of Massachusetts, Boston, MA 02125; [4]Woods Hole Oceanographic Institution, Woods Hole, MA 02543; [5]GreenWave, 43 E Pearl Street, New Haven, CT 06513

Shellfish genetics, breeding, and genomics can contribute to increasing production, sustainability and profitability for aquaculture. As in applied agriculture, aquaculture genetics technology could advance such efforts through marker-assisted selective breeding (MAS) by improving desirable traits such as fast growth, better survival, disease resistance and greater tolerance and adaptation to changing environmental conditions. For example, it is generally acknowledged that the mussel, *Mytilus edulis*, is an ecologically and economically valuable bivalve that is harvested globally. Despite numerous studies, however, there still are gaps and limitations in information and understanding with respect to some life history and recruitment characteristics, reflected in periods of low abundance. To aid in assessing populations, including comparing cultured vs. wild populations and to determine overall genetic diversity or signs of inbreeding, investigations were initiated to develop and evaluate genetic approaches for mussel aquaculture in Long Island Sound. Major components of this initiative in progress encompass breeding, molecular genetics, and performance and site evaluations. Selective breeding for brown vs. black shell phenotypes has been initiated. Additionally, DNA has been extracted from tissues and shells. Mussels also have been provided to an industry partner to evaluate an ocean farm site for growth and survival. Preliminary challenges include gender bias of some mostly all female lines known as doubly uniparental mtDNA inheritance, which could have implications for production. Additional studies should elucidate the consistency of mussel seed supply for aquaculture.

INTRODUCING A NEW DISINFECTANT FOR U.S. AQUACULTURE - PERACETIC ACID

David L. Straus. USDA - Agricultural Research Service, Harry K. Dupree - Stuttgart National Aquaculture Research Center, Stuttgart, AR 72160

Peracetic acid (PAA) is a promising disinfectant for biosecurity in the US aquaculture industry to prevent disease outbreaks from fish pathogens. PAA is a stabilized mixture of acetic acid, hydrogen peroxide and water that breaks down quickly to water and vinegar. It is being increasingly used to replace chlorine in many industries. The U.S. Environmental Protection Agency (EPA) first registered PAA as an antimicrobial in 1985 for indoor use on hard surfaces (e.g., hospitals). Registrations have been expanded to include: sanitation in food/beverage plants, agricultural premises, wineries/breweries, greenhouse equipment, animal housing, as well as commercial laundries, prevention of bio-film formation in pulp/paper industries, and as a disinfectant for wastewater

treatment. PAA is approved for use in Denmark, Germany and Norway as a water disinfectant, and our labs international collaborations have studied its effectiveness to many pathogens including *Ichthyophthirius multifiliis*, *Saprolegnia* spp., and various bacteria.

PAA is approved as a disinfectant for the US aquaculture industry for two products:
PeroxyChem's VigorOx® SP-15 Antimicrobial Agent (EPA registration June 26, 2017) is for: 1) Sanitizing surfaces of harvesting equipment used in the aquaculture industry, and 2) Cleaning and disinfecting fish culture tanks and raceways when water is drained and fish are not present.

AquaTactics' Aqua Des™ (approved November 3, 2017) is for: 1) In-water use in fish ponds/raceways (remove fish from pond prior to use and test for residual PAA levels prior to restocking), 2) Use on aquaculture equipment (pumps, boots, foot bath mats, net dips, waders, dive equipment, etc.), and 3) Use on fish pond equipment (water free raceways, gratings, pipes, etc).

FORECASTING COASTAL WATERS IN THE NORTHEAST

Aaron Strong[1], Jackie Motyka[2], Parker Gassett[3], Meredith White[4], Jennifer Brewer[5]. [1]Hamilton College, 198 College Hill Rd, Clinton, NH 13323; [2]NERACOOS, 195 New Hampshire Avenue, Portsmouth, NH 03801; [3]Universityof Maine, 360 Aubert Hall, Orono, ME 04469; [4]Mook Sea Farm, 321 ME-129, Walpole, ME 04573; [5]University of New Hampshire, 105 Main St., Durham, NH 03824

We want to hear from you! A newly funded research project will be working with NECAN, the Northeast Coastal Acidification Network, to work toward creating forecasts for ocean and coastal acidification conditions in near shore and coastal waters in the northeast. To ensure that the forecasts from our models are as useful to the shellfish industry as possible, we want to hear from you. Specifically, we want to know what you would like to see in terms of forecasts from our models and what types of forecasts might be useful to your business. Are you concerned about certain conditions, such as freshwater input, temperature or pH; would you like to receive alerts? Attend this session to learn more about this project and to let us know what matters most to you.

In recent years, a changing ocean environment has become of particular interest and concern to the coastal industry, resource managers and policy makers. However, we have limited understanding of how near shore and coastal ecosystems will respond to ocean and coastal acidification and how these impacts will affect coastal communities. An absence of actionable information and the dynamic nature of coastal carbonate systems pose major challenges to industry, resource managers, and coastal policy makers. To better understand these changes and to ensure that the model provides information needed by potential users the project team will be reaching out to and garnering feedback from the community; we hope you'll attend this session to help steer the outcomes of this project.

A SLOW GROWING PERSPECTIVE ON MULTI-GENERATIONAL RESPONSES TO FUTURE CHANGE

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Our oceans are changing, lowering in pH as atmospheric CO_2 concentrations increase. Predicting how ecologically and economically important organisms will respond to these changes has become a major area of

research, particularly for those species needing to maintain biomineralizing processes. In recent years there has been a shift in focus from shorter (hours-weeks) towards assessing responses over longer term exposure periods (months-years) advancing our understanding in this field. Given that predicted changes span across years and decades, and that organisms will be producing offspring, a greater consideration of multi-generational response is needed to better understand how organisms will respond under future climates. For many species, this is still in its infancy with the majority of focus on organisms with rapid life cycles. In an experimental context this is convenient as numerous generations can be achieved within weeks/months. However, they cannot be a substitute for higher trophic level organisms that have much more complex life cycle processes. High trophic levels typically comprise of slower growing organisms with longer life cycles and deferred maturity (i.e. years). With these, rearing multiple generations becomes time-consuming, difficult and almost unfundable within normal grant time-scales (i.e. 2-3 years). This presentation will address this knowledge gap by discussing the physiological, somatic, reproductive and commercially relevant responses of a slow growing benthic invertebrate, the sea urchin, bred across several generations under IPCC predicted CO_2 conditions. Although we present the findings on a European species (*Psammechinus miliaris*) this information brings important considerations for other commercially relevant organisms.

DEVELOPMENT OF AN INTGREATED MULTI-TROPHIC AQUACULTRE RAFT FOR INSHORE AND OFFSHORE USE

Corey Sullivan, Rob Swift, Michael Chambers, Barbaros Celikkol. School of Marine Science and Ocean Engineering, University of New Hampshire, Durham, NH 03824

An aquaculture floating platform to support the growth of steelhead trout (*Oncorhynchus mykiss*), blue mussels (*Mytilus edulis*) and sugar kelp (*Laminaria saccharina*) was developed for small operator use in near shore waters. The raft was designed to grow-out a maximum of two tons of finfish between two net-pens as well as the necessary mussel (6 ton) and kelp (1 ton) mass needed to offset nitrogen output of the finfish. The raft was designed to maintain sufficient buoyancy throughout the growing season and to operate in a variety of sea states. Once designed, fabricated and deployed, an on-site observational experiment to monitor waves, currents, raft motion and mooring line tension was completed in January 2016. The finite element analysis program Aqua-FE was applied and evaluated using data from the observational experiment. The raft has been deployed since 2015 and has performed well throughout a variety of sea conditions. Success on the water as a working platform and multiple successful harvests has led to the development of a larger scale raft. Final design and construction planning are underway for a deployment at the University of New Hampshire Open Ocean Aquaculture site, 13 km offshore New Hampshire and 2 km south of the Isle of Shoals. The second iteration, designed to produce 20 tons of seafood annually, is a step forward in surface cage design, building on aspects of the pilot system. This cage will serve as a learning platform, training location and commercial farm that will be studied to investigate future commercial operations.

OVERWINTERING STRATEGIES OF THE SALMON LOUSE *LEPEOPHTHEIRUS SALMONIS*

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The salmon louse *Lepeophtheirus salmonis* is the primary parasitic disease of salmon aquaculture and affects populations of wild and farmed fish. Despite the current understanding of its detrimental effects on host salmonids, its complete life history strategy remains uncertain – particularly regarding overwintering prior to infection blooms in the spring. Baseline ecology and physiology of overwintering sea lice in Maine were investigated via host choice comparisons of adults and lipid analysis throughout larval development. Stable isotope analysis was assessed as a quantitative tool to distinguish where sea lice originate from, in terms of host population and geographical region. $\delta^{13}C$ and $\delta^{15}N$ isotopic values of parasites were compared across host cohorts (salmon tissue

type, and farmed versus wild salmon), geographical region (Maine, Washington, and Canada), and years (2015-18). Results suggest clear separation in isotope signatures across months, and between farmed and wild hosts. Survival at each larval stage through the infectious copepodid stage was tracked in two 12°C incubators; each egg string was monitored for: (1) total number of individuals, (2) days to hatched nauplii, (3) survival at nauplius stages, (4) days to copepodid molt, and (5) survival at copepodid stage. Subsamples of developing egg strings, nauplii, and copepodids from the incubators were histologically processed and stained for quantification of lipids. Whole mounts of egg strings, larvae, and maternal lice were also stained with Oil Red O for semi-quantification of lipids. More effective pest management on salmon farms may only be achieved with an improved understanding of the parasite itself.

SCIENCE TO ASSESS THE GLOBAL OPPORTUNITY FOR AQUACULTURE TO AID ECOSYSTEM RECOVERY

Seth Theuerkauf[1, 2], Tiffany Waters[1], Robert Jones[1]. [1]The Nature Conservancy Global Oceans Team, 4245 North Fairfax Drive, Arlington, VA 22201; [2]CSS, Inc. under contract to National Oceanic and Atmospheric Administration, 101 Pivers Island Road, Beaufort, NC 28516

The Nature Conservancy has launched an ambitious new program to understand the potential of commercial aquaculture to restore coastal ecosystems globally. Shellfish and seaweed play an essential biophysical role in coastal ecosystems; they filter estuaries, provide vital fish habitat and can help mitigate climate change. Yet, these species and the services they provide are fast disappearing from the wild; 85% lost in the case of shellfish reefs. The Conservancy and its partners have invested over $200m over the last 20 years in coastal restoration and despite tremendous progress, the impact has been insufficient to address the overall challenge.
We hypothesize that commercial aquaculture has significant potential as a market-based solution to accelerate global restoration efforts by providing some of the same function as traditional restoration efforts and natural systems. These benefits include pollution mitigation, habitat provision, fish production and climate mitigation. Aquaculture presents a unique opportunity to unleash the power of the market to help address major conservation challenges while providing sustainable seafood and jobs in coastal communities. The Conservancy's restorative aquaculture strategy pairs global analyses with on-the-ground projects to fill data gaps, test and apply concepts in real-world settings. In our presentation, we highlight the components of our scientific research portfolio that address the following key questions: (1) What are the ecosystem services of aquaculture? (2) Where does aquaculture have the most potential to restore coastal ecosystems? (3) How much aquaculture does it take to make a significant difference? and (4) Which gear types and growing practices maximize benefits?

THE RISK OF ENTANGLEMENT BETWEEN THE NORTH ATLANTIC RIGHT WHALE AND SUSPENDED MARINE AQUACULTURE: LEARNING FROM FIXED GEAR FISHERIES, WITH A FOCUS ON KNOWLEDGE GAPS NEEDED FOR THE AQUACULTURE INDUSTRY.

Matthew Thompson, New England Aquarium, 1 Central Wharf, Boston, MA 02110

The growth of marine aquaculture in New England requires successful permitting of new sites. An obstacle to permitting, particularly offshore, is the potential risk of interactions between protected species, especially the north Atlantic right whale (NARW), and marine aquaculture production systems that use vertical mooring lines and horizontal longlines suspended in the water column. Similar lines used in fishing gear have been involved in at least three NARW deaths in 2017, with the total population currently estimated at only 442 individuals. A NOAA report identified that baleen whales have the highest risk of entanglement in offshore longline mussel aquaculture gear. While historical interactions with right whales are few (including an entanglement with aquaculture gear off the North American east coast and a north Pacific right whale in mussel farm gear off South Korea), there are only a few offshore aquaculture operations currently operating, thus, increasing the number of farms may increase this risk. An entanglement of a single NARW could have severe economic impact on the

farmer, negative implications for the NARW population, and further impede the ability to obtain future permits. To further complicate matters, since 2010, NARW migration behavior has become less predictable and gear modification may be the only realistic way to reduce the potential risk. A panel of experts will share the current state of knowledge on these risks, as well as prospective gear modifications. This will be followed by a discussion with the audience on potential further research needs to resolve this issue.

INFECTION DYNAMICS AND MITIGATION STRATEGIES OF A MARINE MACROPARASITE IN BAY SCALLOP AQUACULTURE ON CAPE COD, MA

Harrison Tobi. Ward Aquafarms, LLC, 51 North Falmouth Highway, North Falmouth, MA 02556

Bay scallops *Argopecten irradians* once supported a successful wild fishery that collapsed in the 1980's due to habitat loss and overfishing. In order to replace lost economic value and ecological benefits in coastal areas along the northeastern United States, bay scallop restoration and aquaculture efforts have been ongoing for many decades. However, these efforts can be complicated by parasites known to reduce growth and reproductive success of bay scallops. Pea crabs *Pinnotheres maculatus* and mud blister worms *Polydora spp.* are two parasites that infect wild and captive bay scallop populations, both of which are known to cause reductions in fitness and reproductive potential of their host. The goals of this study were to 1) Describe the natural infection dynamics of mud blister worms and pea crabs in host bay scallops; 2) Determine effective mitigation strategies to avoid macroparasites; 3) Determine susceptibility of bay scallops to infection by adult male and female pea crabs. Results from this study will help illustrate when pea crabs and mud blister worms naturally infect their host bay scallops, how to avoid pea crab and mud blister worm infections in bay scallop aquaculture, and what life stages of pea crabs may be able to infect bay scallops.

EFFECTS OF BROWN ALGAL EXTRACTS (AMPEP, KELPAK®) ON THE GROWTH AND THERMAL RESISTANCE IN *SACCHARINA LATISSIMA* AND *S. ANGUSTISSIMA* AT DIFFERENT TEMPERATURES

Schery Umanzor[1], Sookkyung Shin[2], Michael Marty[1], Augyte Simona[1], Charles Yarish[1], Jang K. Kim[1, 2].
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Acadian marine plant extract powder (AMPEP) and Kelpak® are commercial extracts made from brown seaweeds. These commercial extracts are mainly used in agriculture to increase crop yields. According to recent research, these commercial extracts can enhance the temperature tolerance of algae. To determine the effect of AMPEP and Kelpak® under thermal stress conditions, juvenile sporophytes of *Saccharina angustissima* and *S. latissima* were dipped in the extract solutions with different concentrations (0.001, 0.005, 0.05, 1 and 5 mg·L^{-1}) for 30 and 60 min intervals at the beginning of the experiment. Sporophytes were cultivated in half strength Provasoli´s Enriched Seawater (PES) medium at different temperatures (12, 16, 19, 23 and 26°℃) using a temperature gradient table for 15 days. Photoperiod was maintained at 12:12 L:D and the photosynthetically active radiation (PAR) was 100 µmol m^{-2} s^{-1}. The sporophytes cultured 23 and 26°℃ died during the experiment in both extracts. The sporophytes exposed to higher concentration (1 and 5 mg·L^{-1}) of AMPEP were able to survive at 19 °℃ or lower temperatures. These results indicate that the commercial extracts from the brown seaweeds may enhance the growth capacity of *Saccharina* at high temperatures (e.g. 19°℃). Growth rates of *Saccharina* at different extract concentrations are currently estimated and will be presented.

CONVERTING ALGAE HATCHERY ART INTO TECHNOLOGY

William van der Riet. Tomalgae C.V.B.A, Graaf van Hoornestraat 1, 9850 Nevele, Belgium

Belgium based Tomalgae is a young company which has developed its own microalgal 'cultivar' and manufactures' a freeze dried product exceptionally rich in Omega 3 fatty acids (EPA and DHA), proteins and vitamins for feed in hatcheries for shrimps, mollusks and as an enrichment source for rotifers and *Artemia*.

Traditionally, algae are grown on-site, where live feed is often unstable, producing unpredictable yields and using a large amount of space that could otherwise be utilized to grow commercial species. Tomalage offers products that can be stored on farm and readily prepared into a suspension on site whilst maintaining cell integrity and biochemical value, thereby mitigating the risk of seasonal fluctuations in quality and volume. The product is rich in Omega-3 fatty acids and is pathogen free, are readily digestible and of suitable cell size; live algae are the principle vector for vibrio and protozoal infections in shrimp production, converting to Tomalgae's offered solution eliminates this risk. Tomalgae's production takes place in open raceway ponds inside greenhouses – a proven and scalable controlled environment technology that enables year-round production.

Tomalgae is part of the Benchmark Holdings Group. Benchmark is a pioneering innovation company operating in the aquaculture, agriculture and animal health sectors. The company brings together knowledge of breeding and genetics, vaccines, health products, veterinary science, farming and husbandry to set a new benchmark for sustainable living – starting with food production.

This talk will describe the impact this approach will have on the hatchery operation, its performance and the additional qualitative benefits. Additionally, a glance of the setup and will give the audience a good impression of the activities of Tomalgae.

INFECTION DYNAMICS OF AN ACANTHOCEPHALAN PARASITE *PROFILICOLLIS BOTULUS* IN THE GREEN CRAB *CARCINUS MAENAS* (L.) ON THE COAST OF MAINE

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The European green crab *Carcinus maenas* is an invasive species to the coast of Maine that shows demonstrable negative impacts to local ecosystems and economies. *C. maenas* is also the intermediate host of the Acanthocephalan parasite *Profilicollis botulus*. Little is known about the temporal and spatial infection dynamics of this parasite, and more information will allow ecologists to understand the parasite's role on the coastal ecology of Maine.

Crabs were collected from May to August of the summers of 2017 and 2018. Crabs were sampled from three alternating locations on the Maine coast. Data collected were put through preliminary analysis to test the impact of a variety of factors on parasite prevalence and intensity at each location. Seven pieces of data were collected: sex, color phase, carapace width, claw width, testes weight, parasite presence, and number of parasites. Fisher's Exact Tests and Kruskal-Wallis Tests were used to compare prevalence among different sub-samples.

Overall prevalence was 17.8% in 2017 and 12.9% in 2018. For the entire coast, an insignificant increase from 14% in the summer of 2016. Prevalence was significantly higher in the southernmost bioregion of Maine compared to the other two sites. Significant relationships between subpopulations and infection risk were determined for year-to-year, color phase, carapace width, and sex of the crab. These data support the hypothesis that a changing environment could significantly impact host-parasite dynamics of green crabs on the Maine coast.

ADDRESSING SHELL MORPHOMETICS IN LARVAL BIVALVE CULTURES USING DYNAMIC IMAGING PARTICLE ANALYSIS

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Using the automated flow cytometry instrument, FlowCam™, it is possible to view and classify abnormalities in larval shellfish. This technique provides additional measurements not commonly seen in traditional slide microscopy at a higher rate of speed. By applying a suit of over 40 analytical measurements, such as length, height, depth, opaqueness, etc., using this software to 2D images taken from multiple views of eggs and larvae, it can begin to classify shell metrics and abnormalities. The ability to view eggs and shells in multiple orientations can add further detail to the assessment of larval health in experimental and commercial applications. The goal is an automated analysis of the percentage of abnormalities in a sample, as well as introducing a new "depth" measurement to our data for bivalve larvae. The database produced by these methods can then be directly applied to a variety of situations to help quantify animal health by measuring the amount of deformations in left or right valves.

FOCUSMAINE AQUACULTURE INDUSTRY GROWTH INITIATIVE

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The Gulf of Maine Research Institute (GMRI) and Maine Aquaculture Association (MAA) have partnered with FocusMaine - a group of proven, private-sector Maine business leaders – to accelerate development of Maine's aquaculture industry for its economic prosperity to the state.

Between January and October 2016, MAA and GMRI led an intensive strategic planning process to identify effective methods and key actions necessary to significantly expand Maine's aquaculture sector. Step one was formation of the Aquaculture Implementation Team (AIT) – a distinguished group with expertise in business, aquaculture, and finance. Guided by the MAA report, *Directing the Future of Maine's Aquaculture Industry: An Economic Development Plan*, the AIT spent the next 9 months identifying areas of opportunity and need and developing actionable implementation measures to bring lacking resources to bear and remove roadblocks. Strategy-specific workgroups were used to inform the strategies along the way. The process resulted in creation of three highly-interrelated strategies and actionable strategy-specific implementation measures.

1. Accelerate Growth of Small Aquaculture Businesses: Develop foundational support resources to assist and support start-ups during their formative years and established companies during scaleup; and address business inhibitors.
2. Facilitate Access to Capital and Risk Management Solutions: Develop effective methods of financing and controlling financial risks associated with aquaculture financing and investment.
3. Recruit Large Aquaculture Firm Investment: Attract large firm investment by out of state aquaculture firms and/or investors.

MAINE AQUACULTURE STATEWIDE TRAINING STRATEGY

Chris Vonderweidt, Sebastian Belle, Julia Maine. Gulf of Maine Research Institute, 350 Commercial Street, Portland, ME 04101

The Gulf of Maine Research Institute (GMRI) and Maine Aquaculture Association (MAA), through the FocusMaine partnership, are developing a strategy to provide a comprehensive training pipeline to meet the labor

needs of Maine's growing and developing aquaculture industry. The work, anticipated to begin in fall 2018, will involve administering an in-person industry survey to understand current workforce needs, challenges, and hiring experiences; mapping current workforce skills and positional needs; forecasting the future workforce needs of Maine's growing and evolving industry; a gap analysis of existing training programs (e.g., academic, vocational) for meeting skills needs of the industry; and providing short-term and long-term recommendations for developing a robust and cohesive aquaculture training pipeline.

Our approach is to rely heavily on a foreign consulting team from a developed aquaculture country (e.g., Norway, Scotland) to understand aquaculture industry development, the workforce needs of developing and mature aquaculture sectors, and education systems that produce business ready graduates. Further, the consultant, having no ties to Maine, will bring objectivity to the process.

Our presentation will give an overview of the approach, high-level findings of the research, and recommendations to provide a comprehensive training pipeline for Maine aquaculture businesses.

PROTOTYPE AQUACULTURE BUSINESS ACCELERATOR PROGRAM

Chris Vonderweidt[1], Sebastian Belle, Chris Davis, Laurie Johnson, Julia Maine, John Pavan, and Tom Rainey. [1]Gulf of Maine Research Institute, 350 Commercial Street, Portland, ME 04101

Through the FocusMaine partnership, the Maine Center for Entrepreneurs (MCE), Gulf of Maine Research Institute (GMRI), and Maine Aquaculture Association (MAA) developed and administered an intensive 15-week aquaculture-themed entrepreneur development program to further their shared goal of creating aquaculture jobs in Maine. The class was coordinated by investor and entrepreneur John Pavan of Pavan Enterprises.

The prototype program – titled Aquaculture Top Gun 2018 – was modeled after MCE's established Top Gun entrepreneur development program that teaches business fundamentals and provides one-on-one mentoring to early-phase businesses. The focus on early-phase and startup businesses – who represent 40 – 50% of Maine's sector by number – offered the highest potential for job creation (and preventing business failure). Utilizing the core curriculum and framework of an established and well-regarded accelerator program was an efficient and effective implementation approach. While confident that helping early-phase aquaculture companies navigate their business challenges would yield new jobs, the formula of an aquaculture-only class challenged conventional thinking about accelerator class makeup. Would a homogeneous class of aquaculture companies (primarily producers) share ideas or be guarded; and would cross-sector idea sharing suffer?

In fall 2017, the development team met regularly to tailor the Top Gun core curriculum to the unique challenges faced by aquaculture businesses and leverage networks to recruit aquaculture business experts as presenters and mentors. Twelve businesses were selected through a competitive application process and the program ran from February – May 2018. The program culminated with a Shark Tank style "pitch-off" with the two most outstanding presenters each receiving a $5,000 cash prize to invest in business growth.

This presentation will provide a high-level overview of the development process, program implementation, lessons learned, and next steps.

MAINE COMMERCIAL DEMONSTRATION OYSTER FARM

Chris Vonderweidt, David Hunter, Jeff Auger, Nicole Twohig, Julia Maine. Gulf of Maine Research Institute, 350 Commercial Street, Portland ME 04101

Though an abundance of oyster farming support resources exists in Maine and the Gulf of Maine, detailed financial information about the real-world costs, revenues, profits, and losses of a commercial-scale oyster farm are unavailable. Without this critical business planning information, new farms must learn as they grow, repeating the mistakes of established farms.

Over the last 5 years, Maine has seen a precipitous increase in startup oyster farms and it has been estimated that 40% or more of the industry is pre-revenue. The majority of these new businesses have small 400 square foot aquaculture permits and will need to transition to a commercial lease to be viable at a commercial scale. Scaling up and increasing production from tens-of-thousands to hundreds-of-thousands brings with it significant challenges. Accordingly, these farms are vulnerable to business failure in the coming years.

The Gulf of Maine Research Institute and Quahog Bay Conservancy (QBC) have partnered on an oyster farm demonstration project to generate real-world financial data and equip Maine's pre-revenue oyster farms with information they need to successfully scale. Currently, QBC operates a small farm where Snow Island Oysters are grown. The goal of this project is to facilitate scale-up of Snow Island Oysters to a commercial scale, document the process, and open the books to industry. The team also includes Jeff Auger of Mook Sea Farms and a professional aquaculture accountant. The outputs of this project will be a case study documenting our experience scaling the farm and open source financial records.

SOUTH PORTLAND PIER AQUACULTURE AND FISHING INDUSTRY NEEDS ASSESSMENT

Chris Vonderweidt, Julia Maine. Gulf of Maine Research Institute, 350 Commercial Street, Portland, ME 04101

Portland Harbor, at the western end of Maine's Casco Bay, is a historic commercial hub for shipping, fishing, commerce, and travel; and most recently aquaculture. The Portland Street Pier (Pier), owned and operated by the city of South Portland (City) has played a vital, but perhaps underutilized role in Portland Harbor's working waterfront.

In recent years, City leadership have recognized the potential for the Pier as a commercial fishing and aquaculture hub; and set out to develop a long-term vision, or Master Plan, for the Pier as fishing and aquaculture support infrastructure, rather than simply repairing the existing structure as it stands. Their goal is to understand how the Pier can be most effectively utilized to cover costs, while providing critical support infrastructure to Portland Harbor's working waterfront.

In 2017, the Gulf of Maine Research Institute officially partnered with the City and GEI Consultants to develop the Pier Master Plan. Our role was to conduct a needs assessment of Portland Harbor's aquaculture and commercial fishing industries to understand who the most likely users are and how they might use the Pier. Data sources included: publicly available permit and landings data sets; structured interviews with aquaculturists and commercial fishermen; unstructured conversations with aquaculturists and commercial fishermen (typically as follow-up conversations); a Casco Bay aquaculture needs assessment survey; an aquaculture industry listening meeting, and a commercial fishing industry listening meeting.

AUTOMATED TOOLS FOR DETECTING ENTANGLEMENT RISKS ASSOCIATED WITH AQUACULTURE

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Risk of entanglements inherent in aquaculture installations creates a critical roadblock for many interested parties seeking to obtain aquaculture permits in the U.S., particularly as we push further off-shore in to Federal waters. Currently, the only monitoring tools available are basic sensors and cameras, but monitoring these data streams 24/7 is not feasible as the cost of 24-hour staffing to monitor a farm site is prohibitively expensive and, in many cases, practically infeasible. And while passive sensing may be capable of alerting farm managers to an active crisis, there is nothing that could help them prevent a crisis before it occurred. For unmanned farm sites located miles offshore, early detection and mitigation of entanglement risk could provide deeply valuable protection. Most of the entanglement events that could occur at aquaculture installations remain unknown to the operators absent a human site visit; and animals that become entangled stand very little chance of surviving or escaping and may cause considerable damage to equipment.

Working with the National Oceanic and Atmospheric Administration (NOAA), we are developing and deploying technology that can sense animals likely to become entangled and deter them, and immediately alert farmers. If an entanglement has occurred, the farmers can take a very rapid, specific action in response (as opposed to physically visiting the site, discovering a problem and having to make a return trip to the site to resolve it). In addition to protecting marine mammals and other species of concern, this system can potentially prevent damage to equipment, escape events, and the tremendous time and expense to operators incurred while resolving entanglements. Providing farmers with a tool to reliably and affordably avoid and cope with animal entanglements will significantly improve success rates of permit applications and allow for increased growth of U.S. aquaculture. Potential users of this technology will be aquaculture producers who have a need for farm-side monitoring that can alert them to events that threaten their crops and/or equipment. Research institutions may also require such equipment to protect experimental farms and research installations.

We introduce a Computer Vision and Machine Learning (CV/ML) methodology to detect and respond to entanglement risks specifically associated with aquaculture operations in coastal or offshore environments (e.g. entanglements of offshore marine aquaculture systems and gear with marine mammals and turtles, or other species of concern). The system will use a suite of modern sensors to observe areas in and around a marine aquaculture facility. This sensor data is processed using advanced computer vision and machine learning-based methods, and when an endangered marine animal is detected, a warning system is triggered to help guide the animal away from the area and prevent a potentially deadly entanglement event.

NON-TOXIC PHOTOACTIVE RELEASE COATINGS FOR BIOFOULING CONTROL

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Novel non-toxic coating technology for biofouling control developed for the aquaculture industry is presented that relies on the photoactive generation of hydrogen peroxide to reduce the settlement of biofouling organisms rather than the leaching of pesticides. Biofouling, the unwanted growth of biological organisms on underwater surfaces, has long been recognized as a major problem for commercial aquaculture. Biofouling dramatically increases labor costs, reduces the value of product, and can harm cultured species. Fouling clogs gear, stops water flow and food delivery, can compete with culture organisms for food or space, and can directly affect the growth and survival of cultured organisms. As a result, considerable physical and economic effort is directed toward the prevention and control of biofouling at culture facilities. Cleaning of gear and use of toxic coatings are the primary methods employed by the industry to maintain biofouling-free surfaces. Time and energy expended to keep gear clean taxes aquaculturalists consuming as much as 30% of labor costs and contributing 15% to operational costs. A novel bio-based release coating was developed that, when immersed in water, controls the settlement of biofouling organisms. This release coating is based on a hyper-branched polymer derived from natural product chemistries. Biofouling control is accomplished by the release properties of the polymer that degrades and dissolves when exposed to sunlight. Catalysts in the formula generate low levels of hydrogen peroxide when exposed to sunlight. Peroxides are oxidizing agents known to thwart the settlement of biofouling organisms.

Peroxides also facilitate the gradual breakdown of the bio-based coating resulting in a release of the surface layer, and along with it any biofouling that may have attached. This solution to the biofouling problem is sustainable because peroxides quickly dissociate back to oxygen and water after leaving the coating surface, and all ingredients in the bio-based coating are generally regarded as safe (GRAS).
Results from biofouling resistance testing on PVC test panels and aquaculture gear (bags, trays and cages) performed from 2015 to 2018 are presented. Oysters and scallops grew significantly larger in treated bags and trays over a three month grow-out period. Treated gear requires less maintenance and can be reused without cleaning. Results from field testing demonstrate that photoactive release coating technology is a viable solution to the biofouling problem experienced by shellfish farmers, who rely on gear changes and cleaning to control biofouling.

BAY SCALLOP (*ARGOPECTEN IRRADIANS)* NURSERY AND GROWOUT OPTIMIZATION IN DIVERSE ENVIRONMENTS ON CAPE COD

Daniel Ward and Harrison Tobi, Ward Aquafarms, LLC, 51 North Falmouth Highway, North Falmouth, MA 02556

Since the 1980's, wild bay scallop (*Argopecten irradians*) landings have been declining due to overfishing, habitat loss, and coastal water quality degradation. There is potential for bay scallop aquaculture to fill the void left by the decline of the wild fishery, though further investigation into optimizing growth and survival in the nursery, grow-out, and overwintering phases are needed. Growth and survival as it relates to stocking density was investigated during the nursery phase using a floating downweller system, a land-based upweller system, rack-and-bag bottom cages and floating lantern nets. Growth and survival were tracked over a six week nursery period in each method, for each of two years, and were then evaluated in relation to flow rates and initial stocking densities. At the end of the six week nursery period, bay scallops were moved out of the nursery system to four different commercial farms for grow-out on Cape Cod; Wellfleet, North Truro, Woods Hole and North Falmouth. At each location, bay scallops were stocked into six different gear types; floating bags of two different mesh sizes, lantern nets, bottom cages, rack-and-bag cages, and in the intertidal site, bags-on-racks, and circular vinyl-coated mesh growout enclosures. Growth, survival, condition index, and meat weight was documented for each treatment and was evaluated in reference to labor, cost and overall product yield.

ASSESSMENT OF THE AQUACULTURE INDUSTRY'S QUESTIONS AND PRIORITIES REGARDING OCEAN ACIDIFICATION RESEARCH DIRECTIONS

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Changes in water chemistry due to ocean and coastal acidification (OCA) have been clearly demonstrated to negatively impact bivalve larvae in laboratory and industrial settings, causing several shellfish hatcheries around the United States and Canada to take corrective action by buffering the water the larvae are reared in. However, engagement of industry members outside of hatchery operators remains a challenge as few, if any, aquaculturists

have experienced production issues definitively related to OCA. The Northeast Coastal Acidification Network Industry Working Group has distributed a survey to wild harvest and aquaculture industry members in the Northeast United States and Canadian Maritimes to assess what questions industry has regarding how OCA will impact their livelihood and what they consider to be OCA research priorities. Anonymous survey results will be shared with federal funding agencies and scientists to help them develop new research funding opportunities that best meet the needs of industry members. We present survey results today in an effort to create dialog among attendees of NACE to further add to the list of questions and research priorities.

METABOLIC RESPONSES OF TWO SPECIES OF CRABS TO MULTIPLE-STRESSORS

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Few simulated climate change studies focus on decapod crustaceans (crabs) because they are largely thought to be tolerant to a future ocean. Most existing studies are relatively short-term and utilize IPCC forecasted pCO_2 and temperature conditions. More studies are needed to consider other forecasted fluctuations, such as salinity. Here we present the first study to assess the longer-term (up to 1 year) responses of temperate crab species to multiple-parameters (elevated pCO_2 and reduced salinity) under year 2100 IPCC forecasts. Two species of crabs with contrasting abilities to compensate for environmental change were used in our study: the highly tolerant and invasive European shore crab, *Carcinus maenas*, inhabiting the intertidal; and the less tolerant edible crab, *Cancer pagurus* a commercially important European species inhabiting sub-littoral areas. Crabs were exposed to elevated pCO_2 and reduced salinity to assess the physiological response to change. Here we report some of the key mechanistic responses (e.g. body fluid pH regulation) determining their abilities to survive under future forecasted conditions. Our results indicate that we cannot generalize responses across taxa, as vulnerabilities vary among species with differencing experiences of environmental change, as explained by differences in physiological capacities to respond to change.

COMPARING RATE OF CATABOLIC METABOLISM IN DIPLOID, TRIPLOID, AND TETRAPLOID EASTERN OYSTERS

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Triploid eastern oysters produced by breeding tetraploid males and diploid females are increasingly being cultured, especially in the Chesapeake Bay. Advantages to growers of triploid oysters, i.e., rapid growth and marketability during the summer spawning season, are thought to arise largely from a re-direction of energy from gametogenesis to growth in triploids. Possible differences in feeding or metabolic rates of oysters with different ploidy, however, have not been explored thoroughly. Previously, we found no statistically-significant differences in filtration and feeding between diploid, triploid, and tetraploid oysters held and tested under the same conditions. More recently, we conducted an exploratory study of possible differences in catabolic metabolism, therefore energy requirement, in oysters of different ploidy. Again using different ploidies held under the same experimental conditions, we measured oxidation rate of the non-fluorescent substrate DCFH-DA to a fluorescent product, DCFH, by oyster hemocytes *in vitro*, using flow-cytometry. Catabolic rates of agranular hemocytes were the same for all ploidy groups and lower than those of granular hemocytes, as granular oxidation rates include oxidative burst during immune function. Mean granular hemocyte oxidation rate of diploid oysters was

statistically higher than means for triploid and tetraploid oysters, which were statistically indistinguishable. These results indicate that either granular hemocytes from diploid oysters have higher basal metabolic rates than those of triploids or tetraploids, or more likely that the diploid granular hemocytes were more active in immune response to endemic bacteria. Physiological consequences of polyploidy in oysters remain a research topic of both scientific and practical importance.

HORSESHOE CRABS ON BEACHES NEAR ACTIVE OYSTER AQUACULTURE FARMS ON THE NEW JERSEY DELAWARE BAYSHORE

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Delaware Bayshore beaches provide important spawning habitat to Atlantic horseshoe crabs (*Limulus polyphemus*) from late April to mid-June with peak activity around new and full moons. Crabs can strand as the tide recedes, a portion of which may be flipped upside down or impinged. The Wetlands Institute runs ReTurn the Favor to right flipped crabs and free impinged crabs as a public awareness effort that may help increase crab survival while identifying impingement areas that with management actions could reduce rates of impingement. Some of these beaches are home to several New Jersey oyster farms and some conservation groups have expressed concern that farms may negatively impact spawning by impeding access to or increasing stranding on spawning beaches. This study compared abundances of stranded horseshoe crabs along a stretch of beach with and without farms. During nesting seasons from 2016 to 2018 we counted all stranded crabs along five adjacent beach segments three hours after high tide – two segments had active farms, three did not. Crab abundance was not associated with presence or absence of oyster farms regardless of density. Horseshoe crab abundance appeared more strongly associated with beach nesting quality, i.e., beaches with more sand and a gentler slope contained more crabs. We suggest that changes in beach morphology from the late 1970's to the present have had a dramatic impact on horseshoe crab activity in this region of Delaware Bay, but by comparison, the effects of the oyster farming on adult horseshoe crabs are inconsequential.

A 3D NUMERICAL MODEL TO SIMULATE THE DYNAMICS OF LONGLINE KELP FARMS IN WAVES

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Understanding the dynamics of a longline kelp farm under wave action can provide insight for optimized farm layout and mooring system design. In this study, a 3D numerical model was developed to analyze the dynamics of these ocean deployed structures. In the model, kelp blades suspended from a near surface longline were represented as a series of compliant, cylindrical elements. The computational model is formulated by coupling the dynamics of the longline, the kelp blades, buoys, and mooring lines into a system of partial differential equations based on cable model theory. Hydrodynamic loads are calculated using a form of Morison equation with environmental condition and hydrodynamic coefficient input. The governing equations are solved using a Newton-Raphson iteration approach with Keller Box finite difference scheme. The model will be compared with the physical model tests in a wave tank for the kelp blade swaying motion and the field measurements for the hydrodynamic load on a kelp longline. Then the model will be applied to the longline kelp farm at Saco Bay, Maine for scenario studies to investigate the impacts of the position, configuration, and orientation of the longline kelp farm. For the next step, this dynamic model will be implemented into an OpenFOAM-based wave solver to study the value of kelp farms on wave attenuation.

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