PROGRAM and ABSTRACTS

Northeast Aquaculture Conference & Exposition

and the

35th Milford Aquaculture Seminar

January 14-16, 2015

Holiday Inn by the Bay

Portland, Maine

The 2015 NACE-MAS at a Glance

NACE/MAS Aquaculture Conference Schedule					
Wednesday, January 14					
8:00 AM - 5:00 PM	**Recirculating Aquaculture Systems Workshop (Connecticut/Rhode Island Room)**				
	Field Trips (meet in the hotel lobby) Bigelow Laboratory, Darling Marine Center & Mook SeaFarm tour (departs at 8:30 AM) University of New England Aquaculture Facilities tour (departs at 9:00 AM) Portland Fish Exchange, Gulf of Maine Research Institute & Fish Vet Group tour (departs at 10:00 AM) Ocean Approved & Trundy Point Farm Tours (departs at 10:00 AM)				
12:00 PM - 5:30 PM	**Aquaculture Research & Development Networking Forum (New Hampshire Room)**				
4:00 PM	**Registration opens in the Hotel Lobby**				
7:00 PM	**Opening Reception in the Casco Bay Exhibit Hall (trade show opens)**				
Thursday, January 15					
7:00 AM	**Registration in Hotel Lobby**				
7:00 AM	**Breakfast in Casco Bay Exhibit Hall**				
8:00 AM	**Plenary Session in the State of Maine Ballroom (Vermont/New Hampshire)** Rapid fire industry updates of issues facing the northeastern states and maritime provinces				
9:30 AM	**Break & Trade Show Opens in the Casco Bay Exhibit Hall**				
	Vermont	**New Hampshire**	**Massachusetts**	**Rhode Island**	**Connecticut**
10:00 AM	**General Aquaculture**	**Seaweed Farming**	**Vibrios in Shellfish: Public Health Management and Research**	**Predators, Nuisance Species and Biofouling**	**General Shellfish**
12:00 PM	**Lunch in the Casco Bay Exhibit Hall** Special guest speaker John Bullard				
	Vermont	**New Hampshire**	**Massachusetts**	**Rhode Island**	**Connecticut**
1:30 PM	**Ocean Planning for Offshore Aquaculture**	**Finfish**	**Shellfish Farming 101**	**Mussel Farming**	**Sustainabilty**
3:00 PM	**Break at the Casco Bay Exhibit Hall**				
	Vermont	**New Hampshire**	**Massachusetts**	**Rhode Island**	**Connecticut**
3:30 PM	**ECSGA Annual Meeting**	**Eel Culture Symposium**	**Use of Instrumentation for Aquaculture Site Selection and Water Quality Monitoring**	**Mussel Farming**	**NE Oyster Breeding Update and Roundtable**
5:00 PM	**Poster Session & Happy Hour in the Casco Bay Exhibit Hall**				
6:00 PM	**Dinner on your own out on the town**				
Friday, January 16					
7:00AM	**Registration in the Hotel Lobby**				
7:00AM	**Breakfast in the Casco Bay Exhibit Hall**				
	Vermont	**New Hampshire**	**Massachusetts**	**Oxford/Somerset**	**Kennebec/Lincoln**
8:30 AM	**US/Canada Roundtable**	**Green Crabs I**	**General Shellfish**	**The Billion Oyster Project: Engaging Students in the Restoration of a Degraded Estuary**	**Preparation of Shellfish for Disease Diagnotics I**
10:00 AM	**Break at the Casco Bay Exhibit Hall**				
	Vermont	**New Hampshire**	**Massachusetts**	**Oxford/Somerset**	**Kennebec/Lincoln**
10:30 AM	**Scallop Culture**	**Green Crabs II**	**USDA Opportunities In Aquaculture**	**Physical Therapy for Aging Aquaculturists**	**Preparation of Shellfish for Disease Diagnotics II**
12:00 PM	**Lunch in the Casco Bay Exhibit Hall** Special Guest Speaker Barton Seaver				
	Vermont	**New Hampshire**	**Massachusetts**	**Oxford/Somerset**	**Kennebec/Lincoln**
1:30 PM	**Gear Entanglement Workshop**	**Ocean Acidification I**	**Aquaculture Farm Modeling and Site Selection**	**Making the leap: strategies, people and resources to help you go from part-time to full-time in aquaculture**	**Preparation of Finfish for Disease Diagnotics I**
3:00 PM	**Break in the Foyer**				
	Vermont	**New Hampshire**	**Massachusetts**	**Oxford/Somerset**	**Kennebec/Lincoln**
3:30 PM	**Shellfish Health**	**Ocean Acidification II**	**Farm Modeling & ShellGIS Workshop**	**Aquaculture Permiting & Management**	**Preparation of Finfish for Disease Diagnotics II**
5:00 PM	**Closing Remarks (Vermont Room)**				

Welcome

The NACE – MAS Planning Committee welcomes you to this joint meeting of our organizations. This year, we welcome the producers and suppliers from Atlantic Canada though a meeting partnership with the Aquaculture Association of Nova Scotia, the Prince Edward Island Aquaculture Alliance and the Atlantic Canada Fish Farmers Association. Working with a theme of ***Bridging the Gulf in a Changing Environment***, 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 production.

This year's event promises to deliver a quality program with twenty six special sessions on finfish, algae and shellfish culture, informative workshops, field trips to area aquafarms, research facilities and a tradeshow including major aquaculture vendors from New Brunswick to California. We hope that you enjoy the meeting.

NACE-MAS Planning Committee

Walter Blogoslawski – NOAA National Marine Fisheries Service Milford Laboratory
Chris Davis – Maine Aquaculture Innovation Center
Gef Flimlin – Rutgers University Cooperative Extension
Danielle Goodfellow – Aquaculture Association of Nova Scotia
Lisa Milke - NOAA National Marine Fisheries Service Milford Laboratory
Vicki Swan – Aquaculture Association of Nova Scotia

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National Oceanic and Atmospheric Administration Aquaculture Program
New England Sea Grant Consortium
USDA/NIFA Northeastern Regional Aquaculture Center

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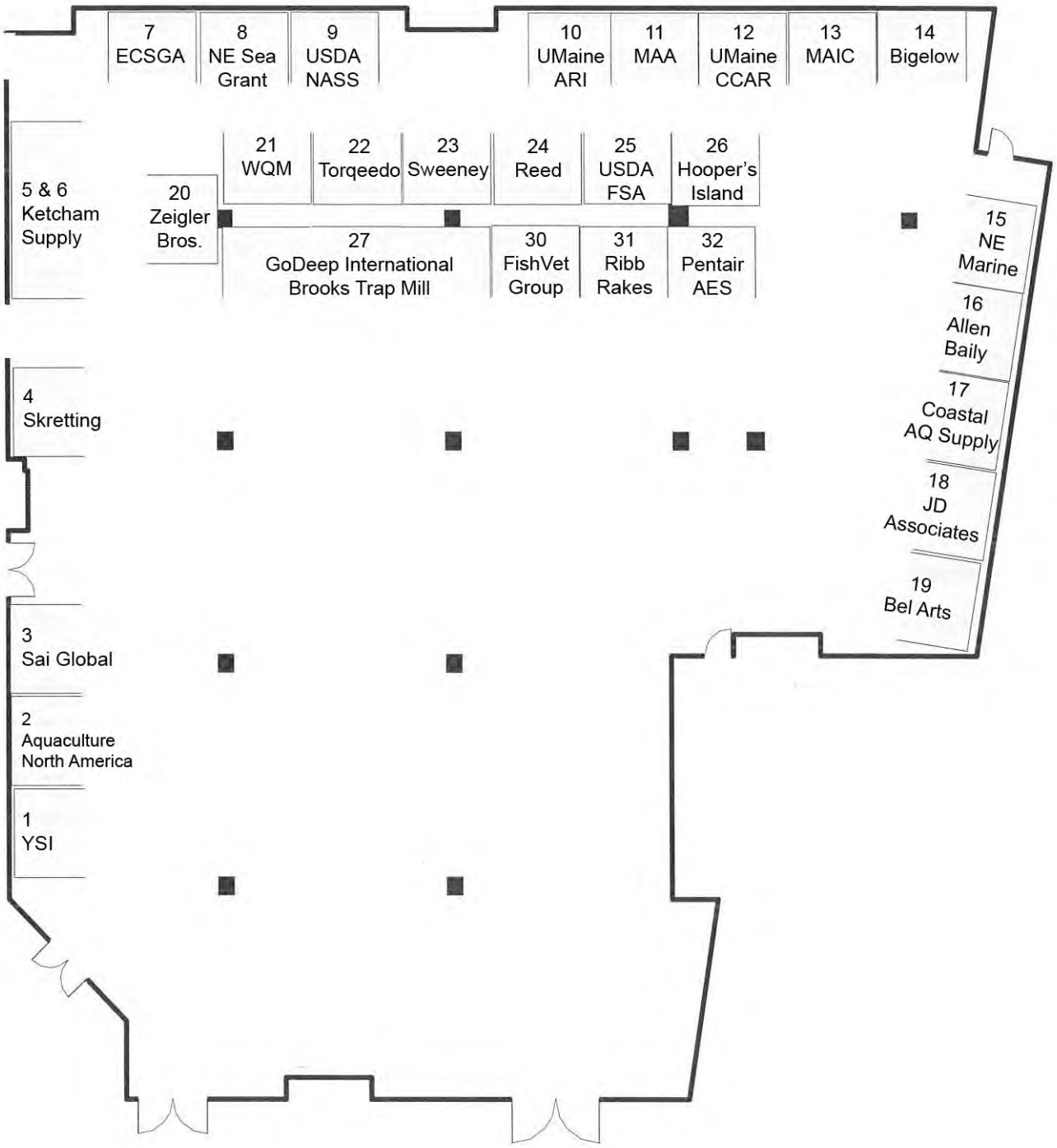

Program for Wednesday & Thursday Morning

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	General Aquaculture *Chair: Walter Blogoslawski*	**Seaweed Farming** *Co-Chairs: Jang Kim, Sarah Redmond & Charles Yarish*	**Vibrios in Shellfish: Public Health Management and Research** *Chair: Steve Jones*	**Predators, Nuisance Species and Biofouling** *Chair: Sandra Shumway*	**General Shellfish** *Chair: Lisa Milke*
10:00 AM	Aquaculture as a vital component of the new ocean clusters at the University of New England *Barry Costa-Pierce*	Introduction to the kelp nursery technologies: Wild-sourced seeding and hybridization *Jang Kim*	Genetic characterization of clinical and environmental *Vibrio parahaemolyticus* from the northeastern US reveals emerging resident and invasive pathogen lineages *Feng Xu*	Aquatic invasive species in Prince Edward Island, Canada: A look at industry innovation *Kim Gill*	The Connecticut shellfish initiative: building on the past and creating a vision for the future *Tessa Getchis*
10:15 AM	Demonstration of living shoreline technology on Martha's Vineyard, MA *Emma Green-Beach*	Introduction to the kelp farming technologies: Open water farming *Sarah Redmond*	*Vibrio parahaemolyticus* prevalence in Maine oysters *Cem Giray*	Why seaducks forage in mussel farms? Preferrences and efficiencies when foraging on cultivated or intertidal mussels *Elisabeth Varennes*	Development of Maryland shellfish aquaculture: a ten-year assessment *Don Webster*
10:30 AM	Getting the N out - a search for bioremediation alternatives to sewage treatment *Richard Karney*	Development of a cultivation program for a morphologically distinct strain of the sugar kelp, *saccharina latissima* forma *angustissima* from Southern Maine *Simona Augyte*	*Vibrio parahaemolyticus* control for oysters in Massachusetts *Christopher Schillaci*	High brightness LEDs deter eider predation at mussel rafts *Donald Ronning*	Comparison of bottom and floating gear for growing American oysters (*Crassostrea virginica*) in Southeastern Massachusetts. *Abigail Archer*
10:45 AM	Eastern Maine Skippers Program: 21st Century Pedagogy found on the water, on the shore and in eastern Maine schools *David Mckechnie*	Kelp farm design for Long Island Sound *Clifford A. Goudey*	Connecticut's *Vibrio parahaemolyticus* control plan and monitoring program *Kristin Derosia-Banick*	Sea duck predation in mussel farms: the best nets for excluding common eiders safely and efficiently *Elisabeth Varennes*	Arctic surfclam, *Mactromeris polynyma*, Culture at the Downeast Institute: exploring methods to diversify domestic seafood by creating a new, farmed-raised bivalve *Brian Beal*
11:00 AM	Maine seafood study: a look at the integration of Maine seafood into food distribution systems *Hugh Cowperthwaite*	Experience with the culinary industry-Developing new seaweed products *Paul Dobbins*	Effect of intertidal exposure on *Vibrio parahaemolyticus* levels in Delaware Bay oysters *Lisa Calvo*	Novel anti-predator coatings for shellfish aquaculture *Daniel Ward*	Fresh local shrimp in the northeast: can recirculating systems make it happen? *Josh Reitsma*
11:15 AM	Capitalizing on waste streams in aquaculture *Patrick Arnold*	Training guidance to new kelp growers *Bren Smith*	Development and application of a duplex QPCR for the detection of *Vibrio parahaemolyticus* and *Vibrio vulnificus* in enriched oyster homogenates from Rhode Island and Massachusetts *Kathryn Markey*	Development of novel antifouling coatings for the aquaculture industry *Alex Walsh*	An initial look at batch culture of juvenile American lobsters, *Homarus americanus*, at the Sound School Aquaculture Center *Sarah Vedder*
11:30 AM	*Common mistakes for new growers to avoid*	Development of laver, dulse, and alaria in the University of Maine's Sea Vegetable Nursery Facility *Susan Brawley*	Human health safety considerations for using *Vibrio* sp. Probiotic strain oy15 as a feed supplement to improve survival of larvae of the eastern oyster (*Crassostrea virginica*): genome sequencing and mammalian cytotoxicity assay *Diane Kapareiko*	Treatments to eradicate invasive tunicate fouling from blue mussel seed and aquaculture bags *Mary Carmen*	Summarizing Milford Laboratory's research on the ecological effects of hydraulic dredging, as used in clam cultivation in Long Island Sound *Ronald Goldberg*
11:45 AM	*Robert Rheault*	Seaweed farming in the Northwest Atlantic: A Roundtable Discussion *Yarish, Redmond & Kim*	Long-term trends of pathogenic *Vibrio* spp. Populations in New Hampshire oysters *Stephen H. Jones*	Two potential passive anti-predator techniques for longline mussel culture *Marcel Fréchette*	Discussion
12:00 PM	**Lunch in the Casco Bay Exhibit Hall** Special guest speaker John Bullard				

Program for Thursday Afternoon

	Vermont	New Hampshire	Massachusetts	Rhode Island	Connecticut
	Ocean Planning for Offshore Aquaculture *Chair: John Weber*	**Finfish** *Chair: William Wolters*	**Shellfish Farming 101** *Co-Chairs: Gef Flimlin, Dale Leavitt and Bob Rheault*	**Mussel Farming** *Chair:Scott Lindell*	**Sustainabilty** *Chair: Paul Anderson*
1:30 PM	This session will provide an overall update on the progress since the last discussion at the NACE meeting in Mystic in 2012, including the results of discussions with industry, government, and non-governmental organizations about ways in which regional plan data and guidance can enhance the regulatory process.	Selection responses for carcass weight in four atlantic salmon year classes *William Wolters*	Initiating a shellfish culture operation can be quite challenging. This workshop will focus on several of the basic concepts that new growers must face when starting a shellfish aquaculture business. The session will cover the basics of shellfish animal husbandry; an overview of nursery and growout techniques for clams and oysters; common mistakes for new growers to avoid; recordkeeping makes good business sense; addressing hazards in shellfish farming/biosecurity; and niche marketing for oyster growers.	Advancing blue mussel longline aquaculture techniques in Rhode Island *Mason Silkes*	Sustainable Ecological Aquaculture Network (SEANET): A Maine EPSCoR Project *Paul Anderson*
1:45 PM		Investigating factors contributing to reduced embryo survival in farm-raised Atlantic salmon, *Salmo salar* *Leeanne Thayer*		Establishing offshore mussel farms in federal waters *Edward (Ted) Maney Jr.*	
2:00 PM		A strain comparison of striped bass cultured in salt water recirculating systems *Linas Kenter*		Facts and figures for farming, business planning and marketing mussels *Scott Lindell*	An integrated ecological-economic modeling framework for the sustainable management of oyster farming *Carrie Byron*
2:15 PM		Structural and functional advantages of *Ciona intestinalis* for use as fish feed *Nathaniel Mulcahy*		Annual consistency in blue mussel, *Mytilus edulis*, seed production using hatchery methods at the Downeast Institute *Brian Beal*	Research to support aquaculture and fisheries: the sustainable ecological aquaculture and fisheries (seafish) programme at the University of New England *Adam St. Gelais*
2:30 PM		Student run recirculating aquaculture system for aquaculture of the kamloops variety of steelhead trout (*Oxyrynchus mykiss*) *Adam St. Gelais*		The effects of temperature and photoperiod on blue mussel (*Mytilus edulis*) health *Kyle Pfau*	Are the aquaculture practices sustaining our goal to restore oysters (*Crassostrea virginica*)? *Gulnihal Ozbay*
2:45 PM		Initial training of fishermen on small scale, intergrated multi-trophic aquacutlure in New Hampshire, USA. *Michael Chambers*		Hydrodynamics and mussel raft technology *Carter Newell*	Building a national financing fund for responsible fisheries and aquaculture businesses *Richard Clime*
3:00 PM	**Break at the Casco Bay Exhibit Hall**				
	Vermont	**New Hampshire**	**Massachusetts**	**Rhode Island**	**Connecticut**
	ECSGA Annual Meeting *Chair: Bob Rheault*	**Eel Culture Symposium** *Chair: Barry Costa-Pierce*	**Use of Instrumentation for Aquaculture Site Selection and Water Quality Monitoring** *Co-Chairs: Dale Leavitt & Chris Davis*	**Mussel Farming** *Chair:Scott Lindell*	**NE Oyster Breeding Update and Roundtable** *Chair: Paul Rawson*
3:30 PM	East Coast Shellfish Growers Association Annual Meeting	Eel aquaculture team: a partnership to develop eel aquaculture and enhance eel value chains *Barry Costa-Pierce*	Identification of optimal aquaculture sites and monitoring the water quality on those sites depends on a variety of physical, chemical and biological factors such as bathymetry, currents, temperature, salinity, dissolved oxygen, turbidity and phytoplankton abundance. This hands-on workshop will demonstrate a wide range of instruments available to aquaculturists and how they can be used to assist growers in site selection and monitoring water quality both shore-side and out on the farm.	Mussel farming – a vertical integration approach – it's risks and rewards *Ian Jefferds*	Disease-resistance and improved performance for genetically improved and cross-bred eastern oysters *Crassostrea virginica:* results from a decade of field trials in New England *Paul Rawson*
3:45 PM		Research and development challenges leading to viable farming of *Anguilla rostrata* in North America *Paul Smith*			Performance of selectively-bred lines of Eastern oysters, *Crassostrea virginica*, at different locations along the east coast of the United States *Marta Gomez-Chiarri*
4:00 PM		Management, regulation and stock assessment for *Anguilla rostrata* *Mitchell Feigenbaum*		Mussel farming in state and federal waters of southern New England *Scott Lindell*	Round Table Discussion of Oyster Breeding Efforts in the Northeast Region
4:15 PM		Eel diseases in aquaculture *Michael Pietrak*		An overview of the PEI cultured mussel industry: Ongoing challenges and recent developments *Peter Warris*	
4:30 PM		A handful of eels: sharing initial experiences and observations Sara Radamaker		Direct measurements of the nutrient management potential of ribbed mussels, *Geukensia demissa*, at two sites in upper Narragansett Bay, Rhode Island *Mark S. Dixon*	
4:45 PM		Discussion		Discussion	
5:00 PM	**Poster Session & Happy Hour in the Casco Bay Exhibit Hall**				
7:00 PM	**Dinner on your own out on the town**				

Program for Friday Morning

Friday, January 16					
7:00AM	**Registration in the Hotel Lobby**				
7:00AM	**Breakfast in the Casco Bay Exhibit Hall**				
	Vermont	**New Hampshire**	**Massachusetts**	**Oxford/Somerset**	**Kennebec/Lincoln**
	US/Canada Roundtable *Chair: Dana Morse*	**Green Crabs I** *Chair: Joe Buttner*	**General Shellfish** *Chair: Lisa Milke*	**The Billion Oyster Project: Engaging Students in the Restoration of a Degraded Estuary** *Chair: Peter Malanowski*	**Preparation of Shellfish for Disease Diagnotics I** *Co-Chairs: Dale Leavitt & Roxanna Smolowitz*
8:30 AM	This session will feature a panel of producers from both sides of the border, and an open discussion of issues that limit production and profitability, and how we might work together to find solutions	Green crab, *Carinus meanas*, wars in southern Maine: managing public shellfish stocks during times of exploding predator abundance *Brian Beal*	Remote setting training program: supporting seed production for Maryland oyster growers *Don Webster*	Students of the aquaculture program at the New York Harbor School will present their work on the Billion Oyster Project (BOP) including the history of oyster restoration in New York Harbor, Harbor School's work to date and the development of the BOP. The aquaculture students will discuss how they work with other career and tech ed programs at Harbor School to restore oysters to New York Harbor. A detailed overview of the oyster cultivation process and the future plans of the BOP will be discussed. Students will also present short explanations of their own research projects. These projects are designed to better understand and improve on the oyster cultivation techniques employed by the school. Finally, students will lead the audience in an oyster gardening workshop.	This hands-on laboratory will provide both practical experience and useful knowledge to culturist. In the first session, participants will examine the anatomy of 3 important bivalves, eastern oysters, surf clams (as a proxy for hard clams), and sea scallops. Participants will learn how to identify disease abnormalities and evaluate the animal's condition. The how and why of sample submission to a diagnostic lab will be discussed.
8:45 AM		European green crabs in southern Maine marshes: trends in abundance and marsh impacts *Kristin Wilson*	Derived macroalgae feed and its potential use in shellfish aquaculture *Zach Hope*		
9:00 AM		Northwest Atlantic population structure and gene flow in the green crab: an update on the crab's dynamic invasion front *April Blakeslee*	The effects of candidate probiotics on several sepecies of cultured larvae shellfish *Saebom Sohn*		
9:15 AM		Economic assessment of using a commercial fishery to control the invasive green crab in PEI *Sophie St-Hilaire*	Microalgae concentrates: a "disruptive technology" that can revolutionize bivalve hatchery operations *Eric Henry*		
9:30 AM		Comparison of proposed control methods for the invasive European green crab (*Carcinus maenas*) *James Elliott*	New insights into the development and function of hemocyte types in oysters *Gary Wikfors*		
9:45 AM		Invasive European green crabs: sudden increase in erosion potential on salt marshes in southern and central coastal Maine *Daniel Belknap*	Classification of Atlantic razor clam (*Ensis directus*) hemocytes using light and transmission electron microscopy *Brian Preziosi*		
10:00 AM	**Break at the Casco Bay Exhibit Hall**				
	Vermont	**New Hampshire**	**Massachusetts**	**Oxford/Somerset**	**Kennebec/Lincoln**
	Scallop Culture *Chair: Dana Morse*	**Green Crabs II** *Chair: Joe Buttner*	**USDA Opportunities In Aquaculture** *Chair: Ken Gustin*	**Physical Therapy for Aging Aquaculturists** *Chair: Kassia Garfield*	**Preparation of Shellfish for Disease Diagnotics II** *Co-Chairs: Dale Leavitt & Roxanna Smolowitz*
10:30 AM	Progress in aquaculture of sea scallops (*Placopecten magellanicus*) in Maine *Dana Morse*	Trapping green crabs (*Carcinus maenas*) in Salem Sound, Massachusetts *Alan M. Young*	Results of the 2013 U.S. Census of Aquaculture show industry growth *Gary Keough*	This hand's on workshop will provide information on how to make better work habits, how to maximize efficiency and save your back! Exercises will be provided with demonstrations. This fun, interactive presentation will show you how to create better work environments in the aquaculture workplace	Continuation of the previous session
10:45 AM	Shellfish sanitation management framework for aquaculture scallops *Kohl Kanwit*	Potential use of the invasive European green crab (*Carcinus maenas*) as an ingredient in Atlantic salmon (*Salmo salar*) diets; a preliminary analysis *Gary Burr*	Aquaculture in the Northeast is a major economic activity, and FSA program and loan offerings provide options to mitigate risk of loss, improve financial viability, obtain critical working capital for operating needs, make improvements or accomplish updates and refurbishments of equipment and facilities, and meet storage needs following harvest. USDA representatives from the Farm Service Agency (FSA) will present a workshop on program and loan opportunities for the aquaculture industry.		
11:00 AM	Scallops and algal toxins – same threat different day *Sandra Shumway*	The European Green crab - Finding alternative uses for an invasive predator in Prince Edward Island *Luke Poirier*			
11:15 AM	Recent developments in purple hinged rock scallop culture on the US west coast *Joth Davis*	Preliminary results generated by MTI CIP 163 "Under-Utilized Shellfish Products With Emphasis on Green Crab". *John Der Kinderen*			
11:30 AM	Magellan Aqua Farms utilizes lantern nets suspended from a buoyed long line *Steven Bachman*	Discussion			
11:45 AM	Discussion				
12:00 PM	**Lunch in the Casco Bay Exhibit Hall** Special Guest Speaker Barton Seaver				

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	Vermont	New Hampshire	Massachusetts	Oxford/Somerset	Kennebec/Lincoln
	Gear Entanglement Workshop *Chair: Scott Lindell*	**Ocean Acidification I** *Chair: Mark Green*	**Aquaculture Farm Modeling and Site Selection** *Chair: Damian Brady*	**Making the leap: strategies, people and resources to help you go from part-time to full-time in aquaculture** *Co-Chairs: Dana Morse & Don Gooding*	**Preparation of Finfish for Disease Diagnotics I** *Co-Chairs: Ian Bricknell, Debbie Bouchard & Mike Pietrak*
1:30 PM	Collaborating to develop offshore aquaculture while minimizing potential impacts to protected species *David Bean*	Ocean acidification: The current state of knowledge *Mark Green*	Merging, modeling and mapping to improve shellfish aquaculture site selection *Julie M. Rose*	Making the leap from part-time to full-time activity is often a challenging and scary time for aquaculture businesspeople. As always, good planning can really help, and knowing the right people to turn to for advice and business services can make the difference between profitability, and 'back to your old job.' This session will help you to anticipate some of the likely challenges that you'll face when making this transition, and how to prepare as fully as possible, so that the job you love to do, can actually become your daily job.	The goal of the workshop is to provide commercial aquaculturists and extension professionals with a working knowledge of what constitutes good quality fish disease diagnostic specimens, how to select those specimens, how to properly package those specimens for shipment to a fish disease diagnostic laboratory and what information should be provided with those specimens. Information will also be provided describing the various testing methods and time required to obtain test results.
1:45 PM	Entanglement risk reduction in aquaculture gear *Clifford A. Goudey*	Upwelling of acidified water: Not just an issue for shellfish hatcheries on the West Coast of the US *Daphne Munroe*	A proactive GIS assessment of suitable offshore aquaculture sites in the Gulf of Maine integrating social, biological, and economic factors *Michael Tlusty*		
2:00 PM	Entanglements of North Atlantic right whales in fishing ropes *Scott Kraus*	Emergent regional interest to combat ocean acidification *Suzanne Arnold*	Production modeling and siting for mussel and oyster farms in the Northeast *Carter Newell*		
2:15 PM	Fixed gear and protected species in Massachusetts - implications for sub-tidal aquaculture gear *Erin Burke*	Subaqueous soils and coastal acidification: A hydropedology perspective *Brett Still*	Modeling flow through aquaculture farms *John Richardson*		
2:30 PM	What we can learn from entanglement cases of whales and turtles in mussel farming gear *Scott Lindell*	Acidic mud and clam shell pitting in Casco Bay, Maine *Joe Payne*	*In vivo* fluorescence based chlorophyll *a* measurements - how close are we to the truth? *Judy Li*		
2:45 PM	Spatial-temporal management of conflicts with protected species *Hauke Kite-Powell*	Coping with copious freshwater in midcoast Maine *Bill Mook*	Sediment flux modeling of bivalve aquaculture spatial impacts on sediments (BASIS) *Damian Brady*		
3:00 PM	**Break in the Foyer**				
	Vermont	**New Hampshire**	**Massachusetts**	**Oxford/Somerset**	**Kennebec/Lincoln**
	Shellfish Health *Chair: Tim Bowden*	**Ocean Acidification II** *Chair: Mark Green*	**Farm Modeling & ShellGIS Workshop** *Chair: Carter Newell*	**Aquaculture Permiting & Management** *Chair: John Ewart*	**Preparation of Finfish for Disease Diagnotics II** *Co-Chairs: Ian Bricknell, Debbie Bouchard & Mike Pietrak*
3:30 PM	Detection of bivalve mollusc pathogens: Are we heading in the right direction? *Ryan Carnegie*	Biological responses of multiple Northeast taxa to ocean acidification *Meredith M. White*	Clearance rate regulation in mussels: adding the effect of organic seston level to a model of internal state-based regulation *Marcel Fréchette*	Seaweed production in Connecticut: An interagency effort to establish permitting guidance for seaweed intended for human consumption *Kristin Derosia-Banick*	Continuation of the previous session
3:45 PM	Skulking behind an MSX smokescreen: SSO prevalence in Maine and Massachusetts *Cem Giray*	A preliminary assessment of the effect of increased seawater acidity on juvenile bay scallops (*Argopecten irradians irradians*) from two genetic lines *Isaiah Mansour*	Ecosystem modeling has been widely used to predict the carrying capacity for bivalve culture in numerous estuaries. System scale approaches often have limited spatial resolution that adequately represent critical localized effects of current flow on the supply and use of food particles. ShellGIS was developed as a practical tool for bivalve mollusc farmers for selecting good sites and managing them for optimal growth rates and seed to harvest yields. This workshop will demonstrate the capabilites of ShellGIS in assisting shellfish farmers in identifying optimal growing sites and management conditions.	Identifying and addressing process-related challenges to the expansion of sea vegetable aquaculture in Connecticut *Anoushka Concepcion*	
4:00 PM	Screening biofouling organisms around oyster cages for potential reservoir species or intermediate hosts of the oyster parasite MSX in the Damariscotta estuary *Nicole Messerman*	Why ocean acidification may not be the end of shellfish *Robert Rheault*		Shellfish aquaculture in Delaware's coastal (inland) bays: regulatory status and outlook for 2015 *John Ewart*	
4:15 PM	The application of a quantitative PCR with a plasmid standard curve to evaluate *Perkinsus marinus* levels in the Eastern oyster, *Crassostrea virginica* *Whitney Jaillet*	Lessons learned from stakeholders at Maine's Ocean Acidification Workshop towards an implementation plan *Esperanza Stancioff*		Aquaculture and the Rhode Island Shellfish Management Plan *David Beutel*	
4:30 PM	Epizootiological analysis of QPX disease data from hard clam (aka quahog) monitoring in an enzootic estuary. *Soren Dahl*	Discussion		Aquaculture standards and certification	
4:45 PM	Prevalence of the oyster parasite MSX in the Damariscotta estuary during 2012 *Nicole Messerman*			*Cormac O'Sullivan*	
5:00 PM	**Closing Remarks (Vermont Room)**				

About our Guest Speakers

We are fortunate to have two distinguished speakers who will present their thoughts on the role aquaculture can play in meeting the growing demand for sustainably sourced seafood products.

John K. Bullard serves as the Regional Administrator for the National Oceanic and Atmospheric Administration' s (NOAA) Northeast Regional Office. He is responsible for administering NOAA programs for the management of living marine resources from Canada to Cape Hatteras. In this capacity, he directs NOAA Fisheries' programs in support of responsible international and domestic fisheries management in the Northeast Region.

A native of New Bedford, Massachusetts, with a lifelong interest in the ocean, he joined NOAA Fisheries following his retirement at the end of June as the President of the Massachusetts-based Sea Education Association, a non-profit education organization headquartered in Woods Hole that teaches college students and others about the science and culture of the sea.

From 1993 to 1998, Mr. Bullard was a member of the Clinton Administration in Washington, D.C., where he led NOAA's first federal Office of Sustainable Development and Intergovernmental Affairs. There, he created programs to assist fishing families in New England, the Gulf of Mexico, the Pacific Northwest, and Alaska, and around the nation, advised communities on sustainable development, and helped set policy for aquaculture. He also worked on the President's Council on Sustainable Development developing policies to unite the goals of economic opportunity, environmental health, and social equity. Following federal service, he completed a fellowship at Harvard's Institute of Politics. From 1986 to 1992, Mr. Bullard was Mayor of the City of New Bedford, Massachusetts. During his three terms he introduced community policing, recycling, AIDS prevention and other programs.

Mr. Bullard earned his Bachelor of Arts magna cum laude at Harvard in 1969. He received both a Master of Architecture and a Master of City Planning from MIT in 1974. He has lectured widely and received numerous awards including an Honorary Master of Public Service from University of Massachusetts Dartmouth.

Barton Seaver is on a mission to restore our relationship with the ocean, the land, and with each other—through dinner. He has translated his illustrious career as a chef into his leadership of the Sustainable Seafood and Health Initiative at the Center for Health and the Global Environment at the Harvard School of Public Health. In this role, Barton spearheads initiatives to inform consumers and institutions about how our choices for diet and menus can promote healthier people, more secure food supplies, and thriving communities.

Through his collaborative work with industry leaders, institutions, policymakers, media, and conservationists, Barton has become one of the nation's leading voices for sustainable food systems. Barton's vision for the Center's Sustainable Seafood and Health Initiative reflects his experience as a successful chef serving fish that was completely sustainable, and completely delicious—he seeks to connect environmental resiliency to human health while ensuring that local food producers can make a living. He believes that bringing people together around a shared meal may be the best way to join people together in understanding the importance of protecting access to one our most basic needs: food.

Barton contributes frequently to TV and radio programs on sustainability, and writes regularly for National Geographic and The Huffington Post. He is the author of several books, including the critically acclaimed For Cod and Country (Sterling Epicure, 2011) and Where There's Smoke (Sterling Epicure, 2013)—each serving as the benchmark volumes for making sustainable seafood accessible to the home cook.

A highly in-demand lecturer, Barton has delivered major addresses to a wide range of audiences, including the U.S. State Department, National Institutes of Health, National Academies of Science, the Smithsonian, the prestigious TED conference, and is a regular participant at the Aspen Institute. His work on sustainable seafood lead to being named Chef of the Year by Esquire magazine in 2009 and has garnered accolades from the Seafood Choices Alliance, Blue Vision, and the Blue Ocean Institute.

In addition to his role at the Center, he is an Explorer with the National Geographic Society and is the first Sustainability Fellow in Residence at the New England Aquarium, where he helps relate the Aquarium's conservation messages with the food we serve at our dinner tables. In 2012, Barton was named by Secretary of State Hillary Clinton to the United States Culinary Ambassador Corp.

Oral and Poster Presentations

The first author is the presenting author unless otherwise indicated by *

David Alves, David Bean, Ellen Keane, John Kenney, David Morin and Christine Vaccaro
COLLABORATING TO DEVELOP OFFSHORE AQUACULTURE WHILE MINIMIZING POTENTIAL IMPACTS TO PROTECTED SPECIES

Paul Anderson, Carol Kim, David Neivandt, Barry Coasta-Pierce, Laura Lindenfeld and Krish Thiagarajan
SUSTAINABLE ECOLOGICAL AQUACULTURE NETWORK (SEANET): A MAINE EPSCoR PROJECT

Abigail Archer, Josh Reitsma and Diane Murphy
COMPARISON OF BOTTOM AND FLOATING GEAR FOR GROWING AMERICAN OYSTERS (*CRASSOSTREA VIRGINICA*) IN SOUTHEASTERN MASSACHUSETTS

Patrick Arnold
CAPITALIZING ON WASTE STREAMS IN AQUACULTURE

Suzanne Arnold, Nick Battista and Heather Deese
EMERGENT REGIONAL INTEREST TO COMBAT OCEAN ACIDIFICATION

Simona Augyte, Charles Yarish and Sarah Redmond
DEVELOPMENT OF A CULTIVATION PROGRAM FOR A MORPHOLOGICALLY DISTINCT STRAIN OF THE SUGAR KELP, *SACCHARINA LATISSIMA* FORMA *ANGUSTISSIMA* FROM SOUTHERN MAINE

Steven Bachman
MAGELLAN AQUA FARMS UTILIZES LANTERN NETS SUSPENDED FROM A BUOYED LONG LINE

Brian Beal, Cody Jourdet, George Protopopescu, Kyle Pepperman, Christopher Davis, Sandra Shumway and Kevin Athearn
ARCTIC SURFCLAM, *MACTROMERIS POLYNYMA*, CULTURE AT THE DOWNEAST INSTITUTE: EXPLORING METHODS TO DIVERSIFY DOMESTIC SEAFOOD BY CREATING A NEW, FARMED-RAISED BIVALVE

Brian Beal, Chad Coffin, Clint Goodenow and Sara Randall
GREEN CRAB, *CARCINUS MAENAS*, WARS IN SOUTHERN MAINE: MANAGING PUBLIC SHELLFISH STOCKS DURING TIMES OF EXPLODING PREDATOR ABUNDANCE

Brian Beal, Kyle Pepperman, George Protopopescu, Cody Jourdet and Scott Lindell
ANNUAL CONSISTENCY IN BLUE MUSSEL, *MYTILUS EDULIS*, SEED PRODUCTION USING HATCHERY METHODS AT THE DOWNEAST INSTITUTE

Daniel Belknap and Kristin Wilson
INVASIVE EUROPEAN GREEN CRABS: SUDDEN INCREASE IN EROSION POTENTIAL ON SALT MARSHES IN SOUTHERN AND CENTRAL COASTAL MAINE

David Beutel, Azure Cygler, Monique LaFrance, Dale Leavitt, Jennifer McCann and Jeff Mercer
AQUACULTURE AND THE RHODE ISLAND SHELLFISH MANAGEMENT PLAN

April Blakeslee and Joe Roman

NORTHWEST ATLANTIC POPULATION STRUCTURE AND GENE FLOW IN THE GREEN CRAB: AN UPDATE ON THE CRAB'S DYNAMIC INVASION FRONT

Damian Brady, J.M. Testa, Larry P. Sanford, J. C. Cornwell, Roger E. I. Newell, Carter Newell and John Richardson

SEDIMENT FLUX MODELING OF BIVALVE AQUACULTURE SPATIAL IMPACTS ON SEDIMENTS (BASIS)

Ian Bricknell, Mike Pietrak and Deborah Bouchard

PREPARATION OF FINFISH FOR DISEASE DIAGNOSTICS

Erin Burke

FIXED GEAR AND PROTECTED SPECIES IN MASSACHUSETTS - IMPLICATIONS FOR SUB-TIDAL AQUACULTURE GEAR

Gary Burr and William Wolters

POTENTIAL USE OF THE INVASIVE EUROPEAN GREEN CRAB (*CARCINUS MAENAS*) AS AN INGREDIENT IN ATLANTIC SALMON (*SALMO SALAR*) DIETS; A PRELIMINARY ANALYSIS

Carrie Byron, Di Jin and Tracey M. Dalton

AN INTEGRATED ECOLOGICAL-ECONOMIC MODELING FRAMEWORK FOR THE SUSTAINABLE MANAGEMENT OF OYSTER FARMING

Lisa Calvo, Tal Ben-Horin and David Bushek

EFFECT OF INTERTIDAL EXPOSURE ON *VIBRIO PARAHAEMOLYTICUS* LEVELS IN DELAWARE BAY OYSTERS

Mary Carmen, Scott Lindell, Emma Green-Beach* and Victoria R. Starczak

TREATMENTS TO ERADICATE INVASIVE TUNICATE FOULING FROM BLUE MUSSEL SEED AND AQUACULTURE BAGS

Ryan Carnegie

DETECTION OF BIVALVE MOLLUSC PATHOGENS: ARE WE HEADING IN THE RIGHT DIRECTION?

Michael Chambers, Hunt Howell and Erik Anderson

INITIAL TRAINING OF FISHERMEN ON SMALL SCALE, INTERGRATED MULTI-TROPHIC AQUACULTURE IN NEW HAMPSHIRE, USA.

Richard Clime

BUILDING A NATIONAL FINANCING FUND FOR RESPONSIBLE FISHERIES AND AQUACULTURE BUSINESSES

Anoushka Concepcion, Kristin DeRosia-Banick, Nancy Balcom and Tessa Getchis

IDENTIFYING AND ADDRESSING PROCESS-RELATED CHALLENGES TO THE EXPANSION OF SEA VEGETABLE AQUACULTURE IN CONNECTICUT

Barry Costa-Pierce, Dana Morse, Mike Timmons and Dave MacNeill

EEL AQUACULTURE TEAM: A PARTNERSHIP TO DEVELOP EEL AQUACULTURE AND ENHANCE EEL VALUE CHAINS

Barry Costa-Pierce, Jeri Fox, Carrie Byron, Adam St. Gelais, Shaun Gill and Tim Arienti
AQUACULTURE AS A VITAL COMPONENT OF THE NEW OCEAN CLUSTERS AT THE UNIVERSITY OF NEW ENGLAND

Hugh Cowperthwaite
MAINE SEAFOOD STUDY: A LOOK AT THE INTEGRATION OF MAINE SEAFOOD INTO FOOD DISTRIBUTION SYSTEMS

April Croxton and Gary Wikfors
INTRACELLULAR PH IN BIVALVE HEMOCYTES AND RESPONSES TO *IN VITRO* ACID CHALLENGE

Soren Dahl, Debra Barnes, Wade Carden and Bassem Allam
EPIZOOTIOLOGICAL ANALYSIS OF QPX DISEASE DATA FROM HARD CLAM (AKA QUAHOG) MONITORING IN AN ENZOOTIC ESTUARY

Soren Dahl and Bassem Allam
WILL CLIMATE CHANGE HELP NEW YORK HARD CLAMS FIGHT DISEASE?

Jonathan P. Davis
RECENT DEVELOPMENTS IN PURPLE HINGED ROCK SCALLOP CULTURE ON THE US WEST COAST

John der Kinderen
PRELIMINARY RESULTS GENERATED BY MTI CIP 163 "UNDER-UTILIZED SHELLFISH PRODUCTS WITH EMPHASIS ON GREEN CRAB".

Kristin DeRosia-Banick, David Carey, Anoushka Concepcion, Nancy Balcom, Tessa Getchis, Frank Greene, Jenna Nicol, Tracey Weeks and Christine Applewhite
SEAWEED PRODUCTION IN CONNECTICUT: AN INTERAGENCY EFFORT TO ESTABLISH PERMITTING GUIDANCE FOR SEAWEED INTENDED FOR HUMAN CONSUMPTION

Kristin DeRosia-Banick, David Carey and Joseph DeCrescenzo
CONNECTICUT'S *VIBRIO PARAHAEMOLYTICUS* CONTROL PLAN AND MONITORING PROGRAM

Mark S. Dixon, Genevieve Bernatchez, Eve Galimany, Judy Yaqin Li, Shannon L. Meseck, Julie M. Rose and Gary H. Wikfors
DIRECT MEASUREMENTS OF THE NUTRIENT MANAGEMENT POTENTIAL OF RIBBED MUSSELS, *GEUKENSIA DEMISSA*, AT TWO SITES IN UPPER NARRAGANSETT BAY, RHODE ISLAND

Paul Dobbins
EXPERIENCE WITH THE CULINARY INDUSTRY- DEVELOPING NEW SEAWEED PRODUCTS

James Elliott, Alan M. Young and Mae Taylor
COMPARISON OF PROPOSED CONTROL METHODS FOR THE INVASIVE EUROPEAN GREEN CRAB (*CARCINUS MAENAS*)

John Ewart and EJ Chalabala
SHELLFISH AQUACULTURE IN DELAWARE'S COASTAL (INLAND) BAYS: REGULATORY STATUS AND OUTLOOK FOR 2015

Mitchell Feigenbaum and Doug Huntley
MANAGEMENT, REGULATION AND STOCK ASSESSMENT FOR *ANGUILLA ROSTRATA*

Marcel Fréchette and Éric Bujold
TWO POTENTIAL PASSIVE ANTI-PREDATOR TECHNIQUES FOR LONGLINE MUSSEL CULTURE

Marcel Fréchette, José M. Urquiza, Gaétan Daigle and Dominique Rioux-Gagnon
CLEARANCE RATE REGULATION IN MUSSELS: ADDING THE EFFECT OF ORGANIC SESTON LEVEL TO A MODEL OF INTERNAL STATE-BASED REGULATION

Kassia Garfield
PHYSICAL THERAPY FOR AGING AQUACULURISTS WORKSHOP

Tessa Getchis, Nancy Balcom, Anoushka Concepcion, Sylvain De Guise and Julie Rose
THE CONNECTICUT SHELLFISH INITIATIVE: BUILDING ON THE PAST AND CREATING A VISION FOR THE FUTURE

Tessa Getchis
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Kim Gill
AQUATIC INVASIVE SPECIES IN PRINCE EDWARD ISLAND, CANADA: A LOOK AT INDUSTRY INNOVATION

Cem Giray, Diane Murphy and Marcy Nelson
SKULKING BEHIND AN MSX SMOKESCREEN: SSO PREVALENCE IN MAINE AND MASSACHUSETTS

Cem Giray, Victoria Bowie, Christopher Davis and William Mook
VIBRIO PARAHAEMOLYTICUS PREVALENCE IN MAINE OYSTERS

Ronald Goldberg, Julie M. Rose, Renee Mercaldo-Allen and Shannon Meseck
SUMMARIZING MILFORD LABORATORY'S RESEARCH ON THE ECOLOGICAL EFFECTS OF HYDRAULIC DREDGING, AS USED IN CLAM CULTIVATION IN LONG ISLAND SOUND

Marta Gomez-Chiarri, Dina Proestou, Ryan Corbet, Kehan Bao, Jessica Piesz, Anu Frank-Lawale, Ximing Guo, Paul Rawson and Standish K. Allen Jr.
PERFORMANCE OF SELECTIVELY-BRED LINES OF EASTERN OYSTERS, *CRASSOSTREA VIRGINICA*, AT DIFFERENT LOCATIONS ALONG THE EAST COAST OF THE UNITED STATES

Clifford A. Goudey, Jang K. Kim and Charles Yarish
KELP FARM DESIGN FOR LONG ISLAND SOUND

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Mark Green

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Emma Green-Beach, Richard Karney, Amandine Surier and Chris Edwards

DEMONSTRATION OF LIVING SHORELINE TECHNOLOGY ON MARTHA'S VINEYARD, MA

Ken Gustin

USDA OPPORTUNITIES IN AQUACULTURE THROUGH THE FARM SERVICE AGENCY (FSA)

Eric Henry and Tim Reed

MICROALGAE CONCENTRATES: A "DISRUPTIVE TECHNOLOGY" THAT CAN REVOLUTIONIZE BIVALVE HATCHERY OPERATIONS

Katherine Hladki, Krystin Ward, Raymond Grizzle and Christopher Neefus

FARMING *GRACILARIA TIKVAHIAE* IN THE GREAT BAY ESTUARY

Zach Hope

DERIVED MACROALGAE FEED AND ITS POTENTIAL USE IN SHELLFISH AQUACULTURE

Whitney Jaillet, Kathryn Markey and Roxanna Smolowitz

THE APPLICATION OF A QUANTITATIVE PCR WITH A PLASMID STANDARD CURVE TO EVALUATE *PERKINSUS MARINUS* LEVELS IN THE EASTERN OYSTER, *CRASSOSTREA VIRGINICA*

Ian Jefferds

MUSSEL FARMING – A VERTICAL INTEGRATION APPROACH – IT'S RISKS AND REWARDS

Stephen H. Jones, Erin Urquhart, Meghan Hartwick, Michael Taylor, Vaughn S. Cooper and Cheryl A. Whistler

LONG-TERM TRENDS OF PATHOGENIC *VIBRIO* SPP. POPULATIONS IN NEW HAMPSHIRE OYSTERS

Kohl Kanwit, Alison Sirois and Meggan Dwyer

SHELLFISH SANITATION MANAGEMENT FRAMEWORK FOR AQUACULTURE SCALLOPS

Diane Kapareiko, Harold Schreier, Eric Schott, Dorothy Jeffress and Gary Wikfors

HUMAN HEALTH SAFETY CONSIDERATIONS FOR USING *VIBRIO* SP. PROBIOTIC STRAIN OY15 AS A FEED SUPPLEMENT TO IMPROVE SURVIVAL OF LARVAE OF THE EASTERN OYSTER (*CRASSOSTREA VIRGINICA*): GENOME SEQUENCING AND MAMMALIAN CYTOTOXICITY ASSAY

Richard Karney, Emma Green-Beach and Paul Carey

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Amanda Keegan and Mark Fregeau

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Jang Kim, Charles Yarish and Sarah Redmond
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ENTANGLEMENTS OF NORTH ATLANTIC RIGHT WHALES IN FISHING ROPES

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Judy Li, Mark Dixon, Shannon Meseck, Barry Smith, Julie Rose and Gary Wikfors
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Scott Lindell, David Bailey, Michael Chambers and Richard Langan
FACTS AND FIGURES FOR FARMING, BUSINESS PLANNING AND MARKETING MUSSELS

Scott Lindell, Bill Silkes, Adam Silkes, Mason Silkes and David Bailey
MUSSEL FARMING IN STATE AND FEDERAL WATERS OF SOUTHERN NEW ENGLAND

Scott Lindell and David Bailey
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Joseph Looney, Lauren Huey, William Schroer, Tal Ben-Horin, Daphne Munroe and David Bushek
VIABILITY OF *PERKINSUS MARINUS* IN SEAWATER

Peter Malinowski
THE BILLION OYSTER PROJECT: ENGAGING MIDDLE AND HIGH SCHOOL STUDENTS IN THE RESTORATION OF A DEGRADED ESTUARY

Edward (Ted) Maney Jr., Mark Fregeau and Bill Lee
ESTABLISHING OFFSHORE MUSSEL FARMS IN FEDERAL WATERS

Isaiah Mansour, Sheila Stiles and Joseph Choromanski
A PRELIMINARY ASSESSMENT OF THE EFFECT OF INCREASED SEAWATER ACIDITY ON JUVENILE BAY SCALLOPS (*ARGOPECTEN IRRADIANS IRRADIANS*) FROM TWO GENETIC LINES

Kathryn Markey and Roxanna Smolowitz
DEVELOPMENT AND APPLICATION OF A DUPLEX QPCR FOR THE DETECTION OF *VIBRIO PARAHAEMOLYTICUS* AND *VIBRIO VULNIFICUS* IN ENRICHED OYSTER HOMOGENATES FROM RHODE ISLAND AND MASSACHUSETTS

Kelly Markowitz, Maureen Krause and Jason Williams
PREVALENCE, INTENSITY AND MOLECULAR DETECTION OF THE TREMATODE *PROCTOECES MACULATUS* IN *MYTILUS EDULIS*

David McKechnie, Todd West, Carla Guenther, Val Peacock, Avery Waterman and Maddie Hallowell
EASTERN MAINE SKIPPERS PROGRAM: 21ST CENTURY PEDAGOGY FOUND ON THE WATER, ON THE SHORE AND IN EASTERN MAINE SCHOOLS

Nicole Messerman, Katherine Johndrow and Timothy Bowden
PREVALENCE OF THE OYSTER PARASITE MSX IN THE DAMARISCOTTA ESTUARY DURING 2012

Nicole Messerman
SCREENING BIOFOULING ORGANISMS AROUND OYSTER CAGES FOR POTENTIAL RESERVOIR SPECIES OR INTERMEDIATE HOSTS OF THE OYSTER PARASITE MSX IN THE DAMARISCOTTA ESTUARY

Bill Mook
COPING WITH COPIOUS FRESHWATER IN MIDCOAST MAINE

Dana Morse, Don Gooding and Dick Clime
MAKING THE LEAP: STRATEGIES, PEOPLE AND RESOURCES TO HELP YOU GO FROM PART-TIME TO FULL-TIME IN AQUACULTURE

Dana Morse, Togue Brawn, Marsden Brewer, Terry Gray, Mark Green, Kohl Kanwit, Nate Perry, Kevin Scott, Peter Stocks and Evan Young
PROGRESS IN AQUACULTURE OF SEA SCALLOPS (*PLACOPECTEN MAGELLANICUS*) IN MAINE

Dana Morse and Don Webster
US/CANADA ROUNDTABLE ON COLLABORATIONS TO SOLVE COMMON PROBLEMS

Nathaniel Mulcahy, Michael Chambers and Larry Harris
STRUCTURAL AND FUNCTIONAL ADVANTAGES OF *CIONA INTESTINALIS* FOR USE AS FISH FEED

Daphne Munroe, Matthew Poach, Ian Abrahamsen and Sarah Borsetti
UPWELLING OF ACIDIFIED WATER: NOT JUST AN ISSUE FOR SHELLFISH HATCHERIES ON THE WEST COAST OF THE US

Zachary Murphy, Jake Phillips, Timothy GersonBradford Bourque, Joseph Szczebak and Andrew Rhyne
MODULAR LARVAL REARING SYSTEM FOR INTEGRATING AQUACULTURE INTO PUBLIC AQUARIUMS

Carter Newell
PRODUCTION MODELING AND SITING FOR MUSSEL AND OYSTER FARMS IN THE NORTHEAST

Carter Newell
HYDRODYNAMICS AND MUSSEL RAFT TECHNOLOGY

Carter Newell, Kevin Morris, John Richardson, Christopher Davis and Tessa Getchis
SHELLGIS WORKSHOP

Cormac O'Sullivan
AQUACULTURE STANDARDS AND CERTIFICATION

Gulnihal Ozbay, Brian Reckenbeil, Frank Marenghi and Patrick Erbland
ARE THE AQUACULTURE PRACTICES SUSTAINING OUR GOAL TO RESTORE OYSTERS (*CRASSOSTREA VIRGINICA*)?

Alisha Patel, Melanie Fuoco, Bradford Bourque, Joseph Szczebak and Andrew Rhyne
PRODUCTION OF THE FIRE SHRIMP *LYSMATA DEBELIUS* USING A CLOSED-LOOP RECIRCULATING LARVAL REARING SYSTEM

Joe Payne
ACIDIC MUD AND CLAM SHELL PITTING IN CASCO BAY, MAINE

Dean Perry, Dylan Redman, James Widman Jr., Shannon L. Meseck, Andrew King and Jose Pereira
JUVENILE SCUP, *STENOTOMUS CHRYSOPS*, ARE RESILIENT TO INCREASING OCEAN ACIDIFICATION

Kyle Pfau, Brian Preziosi and Timothy Bowden
THE EFFECTS OF TEMPERATURE AND PHOTOPERIOD ON BLUE MUSSEL (*MYTILUS EDULIS*) HEALTH

Michael Pietrak
EEL DISEASES IN AQUACULTURE

Luke Poirier, Sophie St. Hilaire, Jeff Davidson, Jonathan Hill and Pedro Quijon
THE EUROPEAN GREEN CRAB - FINDING ALTERNATIVE USES FOR AN INVASIVE PREDATOR IN PRINCE EDWARD ISLAND

Brian Preziosi and Timothy Bowden
CLASSIFICATION OF ATLANTIC RAZOR CLAM (*ENSIS DIRECTUS*) HEMOCYTES USING LIGHT AND TRANSMISSION ELECTRON MICROSCOPY

Dina Proestou, Ryan J. Corbett, Marta Gomez-Chiarri, Jessica Moss Small and Standish K. Allen Jr.
ASSESSING THE EXTENT OF PHENOTYPIC VARIATION FOR DERMO RESISTANCE AMONG SELECTIVELY-BRED FAMILIES OF THE EASTERN OYSTER, *CRASSOSTREA VIRGINICA*

Sara Rademaker
A HANDFUL OF EELS: SHARING INITIAL EXPERIENCES AND OBSERVATIONS OF *ANGUILLA ROSTRATA*

Paul Rawson, Scott Lindell, Ximing Guo and Inke Sunila
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ABSTRACTS

COLLABORATING TO DEVELOP OFFSHORE AQUACULTURE WHILE MINIMIZING POTENTIAL IMPACTS TO PROTECTED SPECIES

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NOAA Fisheries is working with industry, the scientific community, and other stakeholder communities to better understand the potential for interactions between protected species and offshore aquaculture gear in order to support the NOAA Aquaculture program goals. Recently, there has been increased interest in developing aquaculture within the Exclusive Economic Zone and with this expansion into new territory, comes uncertainty surrounding the potential risk for interactions with protected species. By involving scientists, biologists, engineers and stakeholders in early dialogue with the applicants, we can better understand potential impacts and, as needed, work to develop ways to minimize any potential impacts. Initiating this dialogue as projects begin to expand into these new waters will also allow us to gather information during the permitting and consultation process with the Army Corps of Engineers. Our goal is to provide technical guidance and eventually develop best management practices which can help minimize impacts to protected resources, expedite the reviews of these offshore projects, as well as provide the necessary information to inform decision making and effectively streamline the required Endangered Species Act and Marine Mammal Protection Act consultations.

SUSTAINABLE ECOLOGICAL AQUACULTURE NETWORK (SEANET): A MAINE EPSCoR PROJECT

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The University of Maine and the University of New England are co-leading a five-year infrastructure improvement research program funded through the National Science Foundation's Experimental Program to Stimulate Competitive Research (EPSCoR) that supports key research and integrated workforce development activities in the area of sustainable ecological aquaculture. Of particular importance to Maine's economic future, this five-year, $20 million award, supports a newly established Sustainable Ecological Aquaculture Network (SEANET) that will help advance understanding of how we can support coastal communities and marine ecosystems through science. This multi-institutional, public-private partnership uses Maine's 3,500 miles of coast as a living laboratory to study biophysical, biogeochemical, socio-economic, and policy interactions that have local, bioregional, national, and global implications. Research elements focus on ecosystem support for marine aquaculture, effects of climate change on aquaculture, and innovations in aquaculture that can enhance economic diversity and add value to the sector. Multiple institutions with world-class expertise in the marine sciences, climate change, social sciences, marine policy, and engineering in Maine are contributing to this network, including the University of Maine, University of New England, University of Southern Maine, University of Maine Machias, Bowdoin College, Maine Maritime Academy, St. Joseph's College, Southern Maine Community College, Bigelow Laboratory for Ocean Sciences, and the Cobscook Community Learning Center. This presentation provides an overview of the project's strategic research, focus areas and plans for community and educational outreach.

COMPARISON OF BOTTOM AND FLOATING GEAR FOR GROWING AMERICAN OYSTERS (*CRASSOSTREA VIRGINICA*) IN SOUTHEASTERN MASSACHUSETTS

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During the 2011-2012 growing season the Cape Cod Cooperative Extension Marine Program conducted research in partnership with five shellfish growers from different growing areas on Cape Cod to examine differences between floating gear and bottom gear for growing oysters. The objective of the study was to compare oysters grown in each gear type in terms of average percent survival, daily growth rate, and condition index. For each gear type oysters grown in the top shelves and those grown in the bottom shelves were also examined for differences. Gear and oyster seed were deployed in June 2011 at an initial stocking density of 500 oysters per bag. In spring of 2012 the stocking density was reduced to 150-200 oysters per bag. To estimate percent survival oyster bags were subsampled in May 2012, and in November 2012 - all oysters in the bags were counted. To determine daily growth rate and condition index in November 2012 fifteen oysters from each bag were measured, and five of those were shucked and the meats dried. Pooling the data together from all five sites, mean percent survival was significantly lower in the bottom cages than in the floating cages, the mean daily growth rate of oysters in floating gear was approximately 15% higher than those grown in bottom gear, and the condition index of oysters grown in floating gear was higher than those grown in bottom gear. Differences were observed among sites illustrating that the floating gear does not perform the same in all growing areas.

CAPITALIZING ON WASTE STREAMS IN AQUACULTURE

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Maine's marine and marine-related industries are a thriving, important sector of the state's economy. In 2013, over 150,000 tons of seafood was landed. While much of that is processed for food and other industries, what remains is a sizable portion of waste. There are many efforts to utilize seafood waste, from scientific study to fertilizer additives, though the combined impact of these actions do not fully realize the potential value that remains. In Iceland, the Iceland Ocean Cluster has a goal of utilizing 100% of fish waste in the nation. In 2012, the seafood catch declined by 8%, yet the value of the catch increased by 16%. The cluster was also responsible for increasing new jobs in the sector by 1-3%, making the ocean cluster directly or indirectly responsible for employing 15% of Iceland's workforce. By focusing on streamlining and enhancing waste utilization efforts in a similar way in Maine, the newly launched New England Ocean Cluster is creating an optimal approach to engage companies doing innovative and unique work in the marine sector, with the goal of increasing the value of seafood landed in the state.

EMERGENT REGIONAL INTEREST TO COMBAT OCEAN ACIDIFICATION

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Ocean acidification is a global problem, but it will impact ecosystems and societies unevenly and under different time frames. This perceived vulnerability has largely prompted motivation for action. Washington State was the first in the country to experience major economic repercussions from ocean acidification, and thus, created a blue ribbon panel to address the issue. Maine has come out as a "vulnerability hotspot" in a recent nation-wide study, focusing specifically on mollusks only, which assessed communities' social and economic vulnerability to ocean

acidification related declines in these species. While, Maine and Maryland have not yet documented major declines in production or landings due specifically to ocean acidification, both recognize their dependence upon shell-forming species and have taken the proactive step to establish legislative study commissions. In Maine, LD 1602, introduced by Representative Mick Devin, established a commission to study the effects of coastal and ocean acidification on species that are commercially harvested and grown along the Maine coast. The commission is reviewing the state of the science on ocean acidification in Maine, identifying knowledge gaps, and making recommendations to fill these gaps and implement mitigation, remediation, and adaptation strategies and policies. The report to the Maine legislature is due on December 5th. At the conference, I will share final results from the Maine Commission's report, the process leading up to taking this action in Maine, ongoing efforts to sustain the momentum, and updates on other emergent policy actions in the region and at the federal level.

DEVELOPMENT OF A CULTIVATION PROGRAM FOR A MORPHOLOGICALLY DISTINCT STRAIN OF THE SUGAR KELP, *SACCHARINA LATISSIMA* FORMA *ANGUSTISSIMA* FROM SOUTHERN MAINE

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The sugar kelp found in the North Atlantic is typically up to 3.5m long and 20-30cm wide. A unique form of sugar kelp has been discovered that is 5-12 times narrower and is very limited in it's distribution; it is found only on the wave-exposed ledges around Harpswell, in southern Maine. Our work focuses on innovative and environmentally sustainable cultivation technology for the production this unknown narrow-bladed kelp from Bailey's Island, Harpswell. Currently we are working to determine the phenology of sorus formation that will enable us to provide a reliable source of meiospores. From meiospore collections we are now doing gradient table experiments, which will determine optimal light and temperature cultivation conditions for our seedstock nursery in order to optimize the growth of the early developmental stages. We are also collaborating with Maine seaweed aquaculture farmers to cultivate this unusual kelp at two sites; in Clarks Cove, with Damariscove Seafood, LLC / Permaquid Mussel Farms, LLC and one in Sorrento, ME. Preliminary results of our nursery and aquaculture farm operations will be discussed. We anticipate our successful implementation will enhance opportunities for a new cash crop of kelp for the Gulf of Maine farmers for culinary and other applications.

MAGELLAN AQUA FARMS UTILIZES LANTERN NETS SUSPENDED FROM A BUOYED LONG LINE

Steven Bachman
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This technology was originally developed for suspended oyster culture and has not significantly changed since its original inception. In productive environments these culture methods suffer from high operational and maintenance cost. Magellan Aqua Farms is looking for innovative ways to improve efficiencies by adapting salmon cage technology with traditional lantern methods in combination with the addition of beneficial communal species. This project utilized modified Salmon Cage bird net stands constructed from High Density Polyethylene.

ARCTIC SURFCLAM, *MACTROMERIS POLYNYMA*, CULTURE AT THE DOWNEAST INSTITUTE: EXPLORING METHODS TO DIVERSIFY DOMESTIC SEAFOOD BY CREATING A NEW, FARMED-RAISED BIVALVE

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The foot of adult Arctic surfclams, *Mactromeris polynyma*, is prized for its visual and gustatory uniqueness as a sushi and/or sashimi menu item for domestic and Asian dining experiences. In the Northwest Atlantic, this deep-water, shallow-burrowing bivalve is harvested commercially only in the Canadian Maritime Provinces and Quebec (mouth of the St. Lawrence River) by factory ships that use hydraulic dredges to capture individuals and bring them to the surface. Although *M. polynyma* occurs in the Gulf of Maine, densities are too low to support a commercial fishery. In an attempt to increase the supply, quality, and diversification of domestic seafood, we have begun a multi-year study of the hatchery, nursery, and field-growout parameters of Arctic surfclams with a goal of creating a new culture industry based on whole animals between 1 ½ - 2-inches. At the Downeast Institute, broodstock are conditioned at temperatures below 8ºC over 3-4 months, and larvae reared at 8-10ºC for 3-4 weeks. Juveniles (> 3 mm) have attained sizes of 10-12 mm SL in both surface (floating) and subsurface trays with and without sediment during summer and fall at a nearby protected cove in the town of Beals. As importantly, we have discovered that it is possible to rear post-nursery juveniles to market size in 18-24 months in the lower intertidal (Beals, Machiasport, Cutler) in a wide variety of soft-sediments (mud, muddy sand, sand). The largest single impediment to commercial production to date has been predation by crustaceans, even when deterrent netting is used.

GREEN CRAB, *CARINUS MAENAS*, WARS IN SOUTHERN MAINE: MANAGING PUBLIC SHELLFISH STOCKS DURING TIMES OF EXPLODING PREDATOR ABUNDANCE

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Although green crabs, *Carcinus maenas*, have existed in Maine since 1905, their populations have exploded along the Maine coast at least twice since the early 1950's. Both times the increases have been correlated with warming ocean temperatures (1950-1954; 2011-2013). The effect of this invasive species on wild and cultured populations of soft-shell clams, *Mya arenaria*, was examined during 2013-2014 in and around southern Maine's Harraseeket River, Freeport. A series of manipulative field experiments examined the growth and survival of cultured soft-shell clam juveniles along with numbers of wild recruits in studies designed to examine the relative efficacy of netting vs. fencing to deter green crab foraging, the combined effect of netting and green crab trapping, and the interactive effects of predator exclusion and presence of clam adults. In addition, the dynamics of green crabs populations were assessed using a series of standard, baited traps in both years in both intertidal and subtidal locations along the river. Trapping showed important differences in crab biomass and mean carapace widths between years at all locations. Results of field experiments suggest that site- and season-specific factors play an important role in survival and settling success of soft-shell clams, and that new strategies that incorporate leasing of intertidal flats and/or the implementation of modern municipal intertidal protection requirements should be

weighed seriously by coastal communities that co-manage their clam stocks and clamming habitat with Maine's Department of Marine Resources.

ANNUAL CONSISTENCY IN BLUE MUSSEL, *MYTILUS EDULIS*, SEED PRODUCTION USING HATCHERY METHODS AT THE DOWNEAST INSTITUTE

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Blue mussel, *Mytilus edulis*, was the first cultivated bivalve species in Maine, and has been farmed here since the early 1970's. Currently, sixteen sites are approved by Maine's Department of Marine Resources for suspended culture and six sites for bottom culture. Both forms of culturing mussels depend on consistent sources of wild seed that settle onto ropes, nets, or the bottom that originate from poorly understood biotic and abiotic processes affecting both the spawning stock and swimming larvae. Mussels settle onto hard surfaces at sizes of approximately 200-microns (1/5th of a millimeter, or 1/125th of an inch). Whether or not a farmer has a successful year growing mussels hinges on the many uncontrollable features affecting the early life-history of mussel larvae. Business planning depends on knowing how many animals will be grown to harvest each year; yet, no mussel aquaculturist is able to predict with any accuracy or confidence this basic statistic out beyond the current year, and that is only after the culturist sees what settles onto his/her collector surfaces in the spring/early summer. To reduce the vagaries of wild seed collection, we are beginning to examine methods of culturing blue mussels in a hatchery setting that will allow us to produce seed year-round, settle millions of juveniles (1-2 mm) onto ropes and other surfaces, and grow the animals to sizes of 12-15 mm in field- based nurseries prior to their use by farmers. We will discuss results of our work funded by the UMaine System, NSF and NOAA-SK.

INVASIVE EUROPEAN GREEN CRABS: SUDDEN INCREASE IN EROSION POTENTIAL ON SALT MARSHES IN SOUTHERN AND CENTRAL COASTAL MAINE

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The Maine coast has experienced an explosive population growth of the invasive European Green Crab (*Carcinus maenus*), which started in 2012. Green crabs are causing widespread destruction of juvenile clams, eelgrass beds, with critical consequences for ecosystems. In 2013 we noticed severe dieback of low salt marshes in the Damariscotta River Estuary, later observed in many localities along the southern Maine coast. Green crabs caused the widespread clipping of *Spartina alterniflora* low-marsh grass, denuding the surface and increasing surficial erosion. Teeming hordes of crabs were observed burrowing into peat banks, increasing calving of peat-bank flaps and increasing erosional retreat. Salt marshes are critical in the bluff erosion/stability cycle. Rapid dieback and consequent marsh erosion could lead to greater bluff erosion and land loss. After a cold winter in 2013-2014, the extent of low-marsh clipping was much reduced. Using Maine Sea Grant, Casco Bay Estuary Partnership and other funding, we have installed 8 stations in 3 estuaries in southern and central coastal Maine to monitor horizontal marsh peat-bluff retreat (stake arrays) and deposition/erosion rates on marsh surfaces (SET – surface elevation transects). Preliminary data show expected seasonal accumulation on the SET's, which we anticipate will be reduced over the winter. Peat bluff retreat rates have been inconclusive over the summer, but we anticipate increases over the winter. These stations serve as long-term monitoring baselines. This geological study is coupled with investigation of the crab population densities, through netting and trapping, and direct study of crab burrows through coring and CT scans.

AQUACULTURE AND THE RHODE ISLAND SHELLFISH MANAGEMENT PLAN

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In January 2013, Rhode Island started the process to create the state's first comprehensive shellfish management plan (SMP). With URI's Coastal Resources Center facilitating the effort, a stakeholder-driven process ensued, bringing together vested parties from the state management agencies, the wild harvest shellfish industry, the shellfish restoration community, and growing aquaculture industry, as well as recreational diggers, researchers, and concerned citizens. The crux of the process was to create a set of management recommendations for the resource and associated industries that would honor and enhance existing activities through a transparent process that builds upon and incorporates best science, through an adaptive management framework. The plan culminated in November 2014, with the following year dedicated to creating an Implementation Plan and Research Agenda for the management recommendations, as well as improved marketing of shellfish. Some early actions of the SMP focused on the aquaculture industry:1) Creating and Implementing a Vibrio Control Plan for oysters in 2014, using the industry template of proactive controls and making the state's Division of Agriculture as the lead. 2) Cross-agency participation in upweller and lease inspections. 3) Overall aquaculture regulation reform to simplify and streamline the process for industry, consisting of transfer of much authority from R.I. Department of Environmental Management (RI DEM) to Coastal Resources Management Council (CRMC). These actions were achieved through collaborative decision-making between RI DEM (charged with managing wild shellfish resources), CRMC (overseeing aquaculture leasing), and the aquaculture industry – An example of the positive change assisted by the SMP process.

NORTHWEST ATLANTIC POPULATION STRUCTURE AND GENE FLOW IN THE GREEN CRAB: AN UPDATE ON THE CRAB'S DYNAMIC INVASION FRONT

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The European green crab (*Carcinus maenas*) is one of the most notorious marine invaders globally—established on nearly every continent on Earth but native to just one. In eastern North America, *C. maenas* has had two major introduction events—the first represents a historical invasion in the 1800s that introduced western European genotypes to the US, which expanded northwards, eventually reaching Atlantic Canada about 100 years later. The second cryptic invasion likely occurred in the 1980s-1990s, introducing novel northern European genotypes to eastern Atlantic Canada, which then began to spread through the region, especially with the mean flow of currents to the southwest. Not only did this new introduction lessen the genetic bottleneck in the region, but it also lead to admixture of genotypes from the two invasions along the Scotian shelf. Several of those admixed genotypes were recently transported to Newfoundland, likely via ballast water originating in the central/western Scotian shelf. Moreover, this admixture zone has spread further southwest and northeast over time, representing a highly dynamic system. Here, we update the present understanding of this system, adding mitochondrial sequence data from 2013-2014 to the 15 year historical dataset. We find that the invasion front of admixed genotypes has continued to expand southwestwards, reaching new locations and with greater frequencies for the novel northern genotypes in regions of northeast US and western Atlantic Canada as predicted by models of its spread. Continued monitoring of this dynamic system is important for better understanding the crab's overall impact in the region.

SEDIMENT FLUX MODELING OF BIVALVE AQUACULTURE SPATIAL IMPACTS ON SEDIMENTS (BASIS)

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Bivalve aquaculture relies on naturally occurring phytoplankton and detritus as food sources, thereby avoiding external nutrient inputs associated with finfish aquaculture. However, high filtration rates and concentrated biomass of bivalves focus intense particle deposition on surrounding sediments, with potentially adverse environmental impacts. Estimating this depositional flux is notoriously difficult due to methodological constraints and dynamic processes such as resuspension and advection. This study used a pattern search algorithm and a mechanistic sediment flux model to estimate seasonal particulate organic carbon deposition in the vicinity of an eastern oyster farm in the lower Choptank River, MD, USA. The model is the standalone version of the two-layer sediment flux model (SFM) currently implemented for Chesapeake Bay TMDL management. The pattern search algorithm tunes the depositional flux to fit ammonium flux at a transect of sites from the farm to a control site in the open estuary. Subsequently, modeled sediment-water fluxes were compared to observed denitrification rates and nitrate fluxes. Thus, this method calculates the aerobic layer depth and integrated measures of nitrogen cycling as a function of seasonal farm dynamics. Model derived estimates of biodeposition were compared with sediment trap estimates as well as estimates from a particle tracking algorithm in a fine scale hydrodynamic model that accounts for tidal flows and wind-waves. Large differences between modeled and sediment trap derived estimates highlight the role of sediment erodability and episodic events in transporting biodeposits away from this particular farm, resulting in a diminished local environmental impact.

DEVELOPMENT OF LAVER, DULSE, AND ALARIA IN THE UNIVERSITY OF MAINE'S SEA VEGETABLE NURSERY FACILITY

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We are developing new crops for sea vegetable aquaculture that are suitable for current conditions and the future climate. Laver (*Porphyra umbilicalis*) seed stock on kuralon line was acclimated briefly in a raceway at the CCAR Sea Vegetable Facility with nutrients provided by land-based sea urchin aquaculture; laver lines out-planted to experimental sea farms on the Maine coast in fall 2014 then grew to maturity in two months. We are continuing this development with additional strain isolation and by developing prototype field gear for raising nets periodically. As part of identifying specific environmental cues that stimulate production and release of dulse tetraspores, we confirmed that short days are best for induction of tetrasporogenesis in vegetative Maine dulse, and are evaluating several techniques to seed spores onto lines and grow out young plants for sea farms. Alaria is an exciting potential addition to kelp crops on the Maine coast, and we are growing out test lines on experimental sea vegetable farms; however, it is a sub-Arctic kelp and temperature tolerance of candidate sea vegetables needs to be considered as appropriate strains for aquaculture are isolated due to pending climate change. Thus, we will

expose newly isolated gametophytes to a temperature selection regime to identify cultivars with tolerance to the elevated temperatures predicted for the Gulf of Maine in the future. Transcriptional studies with RNA-Seq will define temperature tolerance and reveal marker genes for additional, economical identification of temperature-tolerant strains with high growth rates.

PREPARATION OF FINFISH FOR DISEASE DIAGNOSTICS

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The goal of the workshop is to provide commercial aquaculturists and extension professionals with a working knowledge of what constitutes good quality fish disease diagnostic specimens, how to select those specimens, how to properly package those specimens for shipment to a fish disease diagnostic laboratory and what information should be provided with those specimens. Information will also be provided describing the various testing methods and time required to obtain test results.

FIXED GEAR AND PROTECTED SPECIES IN MASSACHUSETTS - IMPLICATIONS FOR SUB-TIDAL AQUACULTURE GEAR

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Massachusetts coastal waters are home to both fixed gear fisheries and protected and endangered species populations. The Division of Marine Fisheries works to mitigate the risk of entanglement by minimizing the spatial-temporal overlap between fixed gear and endangered species. The profile of aquaculture gear is similar in many ways to fixed gear, which we know is an entanglement risk. As aquaculture gear moves further into sub-tidal waters, we must to monitor the potential for entanglement interactions and develop mitigation strategies that reduce that risk. It is in the best interest of managers and the aquaculture industry to be proactive about reducing the potential for interactions with endangered species

POTENTIAL USE OF THE INVASIVE EUROPEAN GREEN CRAB (*CARCINUS MAENAS*) AS AN INGREDIENT IN ATLANTIC SALMON (*SALMO SALAR*) DIETS; A PRELIMINARY ANALYSIS

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Atlantic salmon (*Salmo salar*) is an important cultured carnivorous species with wide consumer acceptance. With the finite supply of available fishmeal and fish oil available for aquafeeds, research on and utilization of alternative protein and lipid sources is expanding. We examined the nutritional profile of deshelled green crab, both muscle tissue and gastrointestinal tract. Generally green crabs have high levels of protein (around 83% on a dry basis) and low lipid levels (1.2% on a dry basis) and high moisture levels (~80+%). The major concern is the high ash content in the gastrointestinal tract (21.3%), which could be sand that the crabs have consumed. The amino acid profile is acceptable for use in salmonid feeds and can be combined with other ingredients to provide optimal amino acid levels for growth. Green crab lipids are high in both eicosapentaenoic acid (EPA, 20:5 n-3) and docosahexaenoic acid (DHA, 22:6 n-3), but this is of limited value due to the low overall lipid content of the

crabs. Future studies will be need to optimize the extraction of shell from the soft tissue, removal of the possible sand from the GI tract material and feeding trials to determine the acceptable levels for use in aquafeeds.

AN INTEGRATED ECOLOGICAL-ECONOMIC MODELING FRAMEWORK FOR THE SUSTAINABLE MANAGEMENT OF OYSTER FARMING

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Sustainable resource management requires improved understanding of complex ecological processes and the socioeconomic drivers shaping human-environment interactions. To better understand complex interconnections among ecological and economic systems, this study integrates a coastal marine ecosystem model with a model of the associated coastal economy. Through simulations of different ecological and socioeconomic scenarios, the integrated model can be used to generate predictive ecological and economic values for policy analysis, providing an opportunity for more rational and informed debate concerning sustainable marine resource development. To demonstrate utility of this integrated model, it was applied to coastal shellfish aquaculture production in Narragansett Bay, Rhode Island, US, a coastal ecological-economic system that provides important ecosystem services and contributes to the regional economy.

EFFECT OF INTERTIDAL EXPOSURE ON *VIBRIO PARAHAEMOLYTICUS* LEVELS IN DELAWARE BAY OYSTERS

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Oyster grounds located along the extensive intertidal sand flats of the Delaware Bay Cape Shore region support an emerging and productive aquaculture industry. Here, oysters experience moderate to high salinity and are exposed twice daily during low tide. Previous studies from the Pacific Northwest indicated that intertidal exposure can accelerate the proliferation of vibrios, common estuarine bacteria responsible for sporadic cases of illness associated with the consumption of raw or undercooked shellfish. To evaluate whether this result applies to the mid-Atlantic, we conducted a preliminary study testing whether levels of total and pathogenic *Vibrio parahaemolyticus* (Vp) differ between oysters cultivated intertidally and subtidally along the Delaware Bay Cape Shore. We did not find significant differences in levels of total and pathogenic Vp between subtidal and intertidal oysters, nor did we see a significant increase in vibrio burdens over a time course of intertidal exposure. This initial result suggests that the relationship between intertidal environmental conditions and vibrio levels in harvested oysters is not as straightforward as previously thought. Locally relevant harvest and management practices are required to minimize the risk of vibrio illness.

TREATMENTS TO ERADICATE INVASIVE TUNICATE FOULING FROM BLUE MUSSEL SEED AND AQUACULTURE BAGS

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In New England and elsewhere, invasive species of colonial tunicates commonly foul wild and cultured blue mussels and aquaculture gear. Eco-friendly experimental treatments were selected for trial application with the intention of destroying tunicates without causing significant mortality to mussel seed, compared to controls. Chemical (acetic acid) and water (brine and freshwater) treatments were applied short-term and long-term to juvenile mussels with and without the presence of tunicates. Acetic acid baths were lethal to tunicates and juvenile mussels. Brine baths killed tunicates but less mussel death occurred in the short-term brine bath. Both long-term and short-term freshwater baths were effective against tunicates but less mussel death occurred in the short-term bath. Tunicates survived short-term freshwater sprays and not long-term freshwater sprays, however, long-term freshwater sprays were slightly more lethal to mussels than short-term freshwater sprays. With these results, freshwater baths are the recommended method to eradicate colonial tunicates from mussel seed and aquaculture gear.

DETECTION OF BIVALVE MOLLUSC PATHOGENS: ARE WE HEADING IN THE RIGHT DIRECTION?

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North American laboratories remain leaders in the development and application of diagnostics for shellfish pathogens. So what's the problem? The World Organisation for Animal Health (OIE) has begun to cast a critical eye over the state of diagnostics for pathogens of concern as well as the laboratories that perform them. A look at the diagnostic methods for shellfish diseases reveals a continued proliferation of molecular diagnostic tools but with infrequent attempts to perform basic assessments of the performance of these assays. Full validations are essentially non-existent. The OIE expects that laboratories themselves be accredited to the ISO 17025 or equivalent level for quality management, yet few of our laboratories can claim this level of accreditation. We should be concerned, individually and collectively, that at some point in the near future our ability to provide a trustworthy product may be questioned. The solution to this may lie in part in a more determined focus on assessment and validation of assays, in greater standardization of the tools in use, and in the regular use of proficiency tests and training to ensure laboratory competence. Accreditation of laboratories performing diagnoses in the service of national and international health management, as opposed to research, will eventually be a must. Beyond this, we should more actively engage in educating the next generation of diagnosticians and researchers in shellfish health, including in the microscopic observation of pathology and parasitology. As senior scientists in the field continue to retire this is at risk of becoming a lost art.

INITIAL TRAINING OF FISHERMEN ON SMALL SCALE, INTERGRATED MULTI-TROPHIC AQUACULTURE IN NEW HAMPSHIRE, USA

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Over the last five years, the commercial fishing fleet in New England has been subjected to increasingly restrictive management measures established to rebuild declining stocks. By design, these measures have limited fishing opportunities and significantly reduced the inshore small vessel fleet. To help support New Hampshire (NH) fishermen, an extension program was developed by the University of New Hampshire (UNH) and NH Sea Grant, to train fishers on small scale integrated multi-trophic aquaculture (IMTA) in the Piscataqua River, NH. Regulatory agencies had concern of nutrient input from fish production so a model was designed to measure

nutrient uptake from shellfish and seaweed integrated into the growout platform. The model was demonstrated while fishermen were trained "hands on" with the necessary husbandry skills for culturing the three species together. Nutrient extraction, both organic and inorganic, was greater than the input from trout production resulting in additional nitrogen being drawn from the river. The training program provided the fishermen with a new skill set that they could adopt part time or full time. In addition, the IMTA farm created extra income for the fishers as they traveled to and from their daily fishing grounds.

BUILDING A NATIONAL FINANCING FUND FOR RESPONSIBLE FISHERIES AND AQUACULTURE BUSINESSES

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If technology is the engine to drive aquaculture, then financing is the fuel to keep the engine moving. Lack of adequate financing has been a significant barrier to the development of businesses based on the adoption of innovative technologies, like kelp farming and fish cultivation in improved recirculating systems. CEI (a Maine based non-profit Community Development Finance Institution) working in partnership with the National Fish and Wildlife Foundation (a 25 year conservation grant-maker) proposes a national Fisheries [and Aquaculture] Financing Fund to provide a dependable source of capital for businesses adopting responsible fisheries and aquaculture practices. In a series of communications and surveys, twelve non-profit lenders from the Atlantic, Pacific, and Gulf Coasts have expressed considerable interest in joining an investment collaborative to increase the flow of capital into sustainable fisheries and aquaculture businesses in their regions. The fund will provide efficiently managed access to a large pool of money at relatively low interest rates, will provide for information exchange among financers, will complement investment with focused grants to build capacity, and develop uniform access to business counseling services for entrepreneurs. While clients and deals will be developed locally, capital will be sourced and coordinated nationally. A pilot demonstration in 2015 will raise and disburse $5 million over five years as a conservative test of the market, the methods, and the effectiveness of new capital to accelerate commercial activities. If successful, a second round of at least $20 million will build a self-sustaining mature fund with lasting impact.

IDENTIFYING AND ADDRESSING PROCESS-RELATED CHALLENGES TO THE EXPANSION OF SEA VEGETABLE AQUACULTURE IN CONNECTICUT

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Interest in sea vegetable aquaculture in Southern New England is increasing; however, lack of federal guidelines regulating domestically cultivated sea vegetables poses a challenge to the timely introduction and growth of this new industry. The leading aquaculture regulatory agency in CT requires guidelines be in place for any organism cultivated and processed in the state. Lack of approved processing facilities poses an additional challenge to potential sea vegetable producers. Identifying and addressing potential hazards associated with the culture and processing of sea vegetables will lead to established guidelines allowing for the sale of sea vegetables for human consumption. Upon the completion of this project, a hazards guidance document including biological, chemical, and/or physical hazards on the production and processing of sea vegetables in CT will be developed. In addition, companion GMPs, SOPs, and SSOPs will also be produced. Processing techniques will be evaluated to determine if and where hazards exist and various types of processing facilities for sea vegetables in CT will be investigated.

EEL AQUACULTURE TEAM: A PARTNERSHIP TO DEVELOP EEL AQUACULTURE AND ENHANCE EEL VALUE CHAINS

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A workshop to form a strategic partnership was held at UNE October 16-17, 2014 to review eel biology, growout technologies, fisheries and value chains, and to take the first steps to develop eel aquaculture in the Northeast. Important findings were: a successful eel fisheries management structure exists in Europe to recover eel stocks; numerous unanswered questions on sex differentiation and reproductive biology remain for the North American eel, *Anguilla rostrata*; in 2013, Haiti and the Dominican Republic increased elver harvests to 5-6 metric tons (MT), Maine's was 5.5 MT, and Canada's 7.5 MT; in Maine over 900 people catch elvers, ~100% are shipped to China/Korea for aquaculture; elver prices peaked in 2013 at $1,800-$2,000/lb. but are now $400-$650/lb; eel aquaculture in Europe is most developed in intensive systems in the Netherlands; in China eels are grown semi-intensively as "mom and pop" pond operations; eels reportedly grow better in saltwater, have better quality, and are less affected by parasites but there are no commercial seawater eel aquaculture operations; Japan eats 70% of the world's eels; ~98% is farmed in China/Korea; ~100% of eels are processed into *unagi kabayaki* (Japanese broiled eel) for sushi markets; domestic markets for eels in North America are large, in 2006 1498 MT were imported from Asia, ~90-100 containers, each ~20 MT; and numerous legal/policy, stock assessment/management questions remain. The workshop was funded by the USDA Northeast Regional Aquaculture Center and the UNE's Center of Excellence in the Marine Sciences.

AQUACULTURE AS A VITAL COMPONENT OF THE NEW OCEAN CLUSTERS AT THE UNIVERSITY OF NEW ENGLAND

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In 2013 a 5-year Strategic Plan for UNE's Marine Science Center (MSC) was issued highlighting the leadership theme of *Marine Science for a Vibrant Coastal Economy* and the MSC was designated by President Ripich as the UNE Center of Excellence in the Marine Sciences. The UNE Marine Animal Rehabilitation Center (MARC) was closed in 2014 after 13 years working on the rehabilitation of marine mammals/turtles. UNE has reopened the former MARC area into its new "Marine Learning Laboratories" which now contain 11 "Ocean Clusters" (OCs) which are student-centered, research-education marine partnerships of internal and external partners. Current OCs are: Spiny dogfish shark-exploring the use of dogfish as a potential source of innovative marine bioproducts (food, fins, fertilizers, oils, gelatins, composts, pharmaceuticals, nutraceuticals); Steelhead trout-exploring aquaculture, seafood science, animal welfare, water quality/chemistry/management, plus applied mathematics, systems engineering and regulations; Sturgeon-understanding recovery, working to domesticate and reproduce sturgeon to advance sturgeon restoration and aquaculture; Aquaponics-developing an integrated system using fish to provide nutrients to grow leafy greens or seaweeds; Microalgae/Seaweed-expanding production of marine micro- and macroalgae and developing new collaborations; Saco Bay Mesocosm-replicating a subtidal ecosystem of Saco Bay for marine science studies in all seasons; Green Crab-supporting biological research and development of commercial markets for green crabs; Pollution Effects-investigating fish populations and variations in their

behaviors caused by novel pollutants. UNE Marine Sciences now has 7 academic marine programs, ~240 students, including an interdepartmental, interdisciplinary Aquaculture and Aquarium Science major.

MAINE SEAFOOD STUDY: A LOOK AT THE INTEGRATION OF MAINE SEAFOOD INTO FOOD DISTRIBUTION SYSTEMS

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In the current movement to support locally produced foods and rebuild local and regional food systems, the emphasis to date has been on agricultural products. Seafood (including aquaculture products) has not been well-integrated into these discussions and efforts. To advance the goal of integrating seafood into a comprehensive Maine food distribution and sales network, CEI has researched and inventoried the seasonality, sources, and market utilization of locally produced seafood within the state. Only by understanding the status quo of current patterns of production, destination, and use can a viable alternative distribution plan be created in collaboration with agricultural products. In addition to the research findings, CEI has developed an online tool to help potential buyers at many different levels of geography and distribution, find the products and the companies that sell them. The different resources provided by the online tool will be reviewed including: seafood products available throughout the year in Maine waters, suppliers of value added seafood, Maine based processors and their products, distribution and transporting companies carrying Maine seafood, cold storage warehouses and facilities in Maine, buyers who operate at the Portland Fish Exchange, aquaculture lease holders and the products they offer. The presenter will offer a working demonstration of navigating the tool which is currently accessible on CEI's website.

INTRACELLULAR PH IN BIVALVE HEMOCYTES AND RESPONSES TO *IN VITRO* ACID CHALLENGE

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Lowered pH levels in oceanic and estuarine systems have caused great concern for the future adaptability of mollusk species. Vulnerability of bivalve species to decreasing pH levels will depend upon their ability to maintain homeostasis as external conditions change. The objective of this study was to measure the intracellular pH (pH_i) of hemocytes, as representative cells, of several molluscan species and to determine the rate of recovery of pH_i following *in vitro* exposure to acidified conditions. Intracellular pH of hemocytes from several estuarine bivalve species (bay scallop, blue mussel, eastern oyster, northern quahog, and soft-shell clam) and an oceanic species (surf clam) were determined using fluorescent SNARF probes and flow cytometry. Hemocyte pH_i of these species ranged from 7.0-7.5, with the oceanic surf clam well within this range. Rapid pH_i recovery rates of estuarine species indicate widespread ability to maintain homeostasis when challenged with extracellular acidification. Recovery time for hemocytes of the surf clam was longer than for estuarine species, suggesting that estuarine species may be more adaptable than oceanic bivalves. These results indicate the need for further analysis of additional marine species to be able to provide better understanding of the physiological responses of bivalves to acidifying environments.

EPIZOOTIOLOGICAL ANALYSIS OF QPX DISEASE DATA FROM HARD CLAM (AKA QUAHOG) MONITORING IN AN ENZOOTIC ESTUARY

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Since the 2002 discovery of hard clams (*Mercenaria mercenaria*) dying from QPX disease in Raritan Bay (NY), the Bureau of Marine Resources, New York State Department of Environmental Conservation (NYSDEC), has developed a partnership with Stony Brook University's Marine Animal Disease Lab (MADL), School of Marine and Atmospheric Sciences, to monitor the microbial (protist) pathogen QPX. Hard clam histological and molecular diagnostics from this program have been compiled with environmental measurements, creating a unique data set that is being analyzed for a better understanding of the basic ecology and epizootiology of this infectious disease. Infection seasonality is evident across the time series, with summer peaks that have shifted earlier in the year toward late spring. Monitoring stations across the estuary reveal that some fishery areas are virtually unaffected by QPX disease. These areas are characterized with lower salinities, which is common with other microbial infections afflicting marine bivalves, but uncommon dynamics are observed with the least infected clam areas having the highest summer temperatures. Experimental QPX studies conducted by the MADL provide supportive insight regarding environmental relationships with QPX disease dynamics. Analysis of hard clam cofactors shows no difference in infection according to gender but there is a difference in size, with infected clams being a little smaller on average, and there is a significant positive relationship of clam density with infection. Additional analyses of infection relationships that include multiple environmental parameters will be presented.

WILL CLIMATE CHANGE HELP NEW YORK HARD CLAMS FIGHT DISEASE?

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In projections of climate change for the Northeastern US, warming trends will progress along with increased precipitation, particularly during winter and spring. Hard clams suffered significantly from QPX disease under cool water (13°C) laboratory treatments compared to warm water treatments (21°C and 27°C). Coastal New York (NY) waters are expected to experience more days of temperatures above 21°C. QPX related hard clam mortalities in the lab were greater under high (30ppt) versus low (17ppt) salinity treatments and *in vitro* studies have shown QPX growth to be inhibited by low salinities. Increased precipitation to watersheds and heavier river flow will alter estuarine salinity regimes that could restrict the distribution of QPX in hard clam habitats. Analysis of field monitoring data from an enzootic NY estuary reveal areas of lower salinity and higher summer temperatures have limited QPX infections. Climate change is often considered a source of potential stressors to marine organisms that increases their susceptibility to physiological ailments and opportunistic disease. In this particular scenario of QPX disease in NY coastal waters, climate change may become more detrimental to this specific opportunistic pathogen and benefit the health of hard clam populations.

RECENT DEVELOPMENTS IN PURPLE HINGED ROCK SCALLOP CULTURE ON THE US WEST COAST

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There is a strong desire to develop native species for aquaculture development to diversify the shellfish industry, help alleviate production declines associated with oyster seed shortages, and avoid concerns often voiced today about the use of non-native species. The purple-hinged rock scallop (*Crassadoma giganteus*) is a large scallop native to the North American west coast from Alaska to Baja, California. It's large adductor muscle, rapid growth, and wide natural distribution makes it an excellent candidate for culture, especially in the southerly portion of its range. The goals of a four-year USDA funded project to help establish purple-hinged rock scallop culture on the US west coast is to expand the west coast shellfish industry through creation of triploid seed and demonstration of efficient culture methods for this native scallop. Results to date include the production of diploid and triploid seed with growth trials for both ploidies poised to start early in 2015. A viable shellfish industry in the United States is critical to maintain rural economies that are dependent on marine resource development and working waterfronts and scallop culture can contribute to the range of species presently in aquaculture production. Larval, seed and juvenile growout techniques are under development; larval scallops are amenable to standard rearing techniques so long as diatoms (*Chaetoceros* spp.) and the red algae, (*Rhodomonas salina*) are included in the diet. Juvenile growout is sensitive to density with scallops growing rapidly at 400 scallops per M^2; optimal conditions in north Puget Sound. Technologies to accommodate the cementation stage in this species will be discussed as well as prospects for developing a new aquaculture industry sector on the US west coast.

PRELIMINARY RESULTS GENERATED BY MTI CIP 163 "UNDER-UTILIZED SHELLFISH PRODUCTS WITH EMPHASIS ON GREEN CRAB".

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The ongoing feasibility study supported by a Maine Technology Institute cluster grant is beginning to yield some preliminary results. The primary focus of this grant has been to identify potential uses/markets for green crab and other underutilized shellfish and to explore how those markets might be translated into new economic activity. Emphasis has been on green crab due to the negative economic impact it has had on the bivalve industry and the pressure it has exerted on coastline ecology. The study has so far revealed various economic uses for green crab which, although encouraging, require more study. Among these uses, the most promising are 1) human consumption made possible by new processing equipment, 2) production of animal feed ingredients (fish meal and oil substitute), 3) production of chitin, chitosan, and derivative products and 4) integrated utilization where all of the above products can be generated through a single process. There is much greater consumption demand for crab (including small crabs) in Asia than there is in the U.S. There is active exploration of the economic potential of the Asian markets, not only for green crab but other species as well.

SEAWEED PRODUCTION IN CONNECTICUT: AN INTERAGENCY EFFORT TO ESTABLISH PERMITTING GUIDANCE FOR SEAWEED INTENDED FOR HUMAN CONSUMPTION

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Seaweed production is an emerging aquaculture industry in the Northeast. The Connecticut Department of Agriculture Bureau of Aquaculture (DA/BA) is the lead agency for Aquaculture permitting in Connecticut, and has issued a number of seaweed aquaculture permits since 2012. Several state agencies are involved in seaweed aquaculture permitting in terms of food processing and food protection, including the Department of Agriculture,

the Department of Consumer Protection and the Department of Public Health. Based on a review of available literature and consultation with the Food and Drug Administration's (FDA) Center for Food Safety and Applied Nutrition (CFSAN), seaweed is considered a Generally Recognized as Safe (GRAS) food when used as a spice, seasoning, or flavoring. When sold as a raw or processed sea vegetable product, the serving size would be significantly greater and it is appropriate to assess potential human health hazards that may be associated with the consumption of seaweed species cultivated in Long Island Sound. The interagency group has used data gained through research and field studies to conduct a hazard analysis of the cultivation and production processes, which have been used to guide policy and recommendations for seaweed production in Connecticut. Guidance and permitting requirements vary depending on the end use of the product, a raw agricultural commodity or processed seaweed commodity. Permitting agencies in Connecticut conduct sanitation inspections of producers and have recommended seaweed producers follow Best Management Practices (BMPs) and HACCP in order to ensure the quality and safety of seaweed produced for human consumption.

CONNECTICUT'S *VIBRIO PARAHAEMOLYTICUS* CONTROL PLAN AND MONITORING PROGRAM

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Vibrio parahaemolyticus is a naturally occurring marine bacterium in the same family as those that cause cholera and *Vibrio vulnificus i*nfection. This bacterium lives in brackish saltwater and causes gastrointestinal illness in humans. Prior to 2012, *Vibrio parahaemolyticus* typically caused sporadic food-borne illnesses related to raw molluscan shellfish consumption in the Northeast region of the US. In 2013, the state of Connecticut closed harvest areas associated with illnesses from August 2 to September 17. Illnesses were subsequently determined by serotyping of clinical isolates to be linked to a specific virulent strain of *Vibrio parahaemolyticus*. During 2014, Connecticut's *Vibrio parahaemolyticus* control program managers worked with industry to incorporate more stringent time to temperature requirements in order to minimize the proliferation of this virulent strain of bacteria, and reduce the risk of consumer illness associated with molluscan shellfish. In order to gain a better understanding of *Vibrio parahaemolyticus* levels and their relevance to implementing meaningful Vibrio controls in Connecticut growing waters, Connecticut's *Vibrio parahaemolyticus* monitoring plan includes the collection of environmental parameters such as water temperature, air temperature, salinity and depth that may correlate to levels of Vibrio bacteria in shellfish. In addition, post-harvest time and temperature controls currently in place as required by Connecticut's *Vibrio parahaemolyticus* Control Plans are evaluated by using continuous temperature data loggers to determine the effectiveness of post-harvest temperature controls and correlating these controls to quantifiable impacts on Vibrio levels in shellfish and the associated risk of consumer illness.

DIRECT MEASUREMENTS OF THE NUTRIENT MANAGEMENT POTENTIAL OF RIBBED MUSSELS, *GEUKENSIA DEMISSA*, AT TWO SITES IN UPPER NARRAGANSETT BAY, RHODE ISLAND

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There is growing interest in the ability of suspension-feeding bivalve shellfish to filter and assimilate organic matter in seston, thereby removing nutrients from eutrophic coastal waters. The term "nutrient bioextraction" has been coined to identify this ecosystem service. Accurate measurements of clearance and assimilation are needed to estimate the potential of bivalves to contribute to water quality and nutrient management. The ribbed mussel, *Geukensia demissa*, is capable of filtering a wide size-range of particles, has shown adaptability to a broad range of habitats, and has exhibited high organic-matter assimilation efficiency. Results from previous studies, however, have shown site-specific variability in the capacity of mussels to assimilate nutrients. The need for site-specific testing is evident. Two sites in Narragansett Bay, Rhode Island were selected for the current study. The biodepostion method, coupled with water quality measurements, was used to quantify filtration and assimilation of ribbed mussels at each site monthly from June through September 2014. Total particulate matter and percent organic were higher, 8.12 mg/L and 59%, respectively, at Field's Point in the Providence River than at Greenwich Bay in the upper bay, 6.80 mg/L and 48%, respectively. Mussels had a lower clearance rate at Field's Point, 0.98 L/hour but higher assimilation rate, 2.12 mg/hour, compared to Greenwich Bay, 1.76 L/hour and 0.97 mg/hour. Mussels in Field's Point had higher absorption efficiency 56% versus 38% in Greenwich Bay. Results indicate that ribbed mussel bioextraction would be more effective at the more eutrophic Field's Point site than in Greenwich Bay.

EXPERIENCE WITH THE CULINARY INDUSTRY - DEVELOPING NEW SEAWEED PRODUCTS

Paul Dobbins
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Seaweed is not trendy. It has been a staple for thousands of years and its popularity is returning to North America as modern diners look for healthier and more adventurous menu items. Today's diners are looking for sustainably harvested, healthy and sometimes adventurous alternatives when dining out. There is pressure on today's chefs to surprise and delight diners with new ideas. The versatility of seaweed brings a new texture, flavor and attitude to their kitchen's palette. As seaweed from questionable sources continue to enter the market, knowing the pedigree of ingredients is an increasing concern for chefs and their diners. Maine's cold clean water is an ideal environment to grow seaweed. However, to grow a domestic seaweed aquaculture industry that can compete with Asian imports, American producers need to develop innovative products. These products must appeal to many segments of the culinary service industry and to support our high cost structure in New England, command a premium price. Developing innovative products can be best accomplished by partnering with culinary partners in academia and industry. Ocean Approved takes a customer focused approach to developing products. Over a period of 3 years its team has spoken with over 21,000 consumers to determine the product attributes that are important to current and prospective seaweed eaters. The company incorporates this information when working with chefs, academic partners, and equipment suppliers as it develops a new product. Domestically farmed, and fresh frozen, our products provide an easy to use domestic alternative to imported seaweeds.

COMPARISON OF PROPOSED CONTROL METHODS FOR THE INVASIVE EUROPEAN GREEN CRAB (*CARCINUS MAENAS*)

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The European Green Crab is a universal problem for the New England shellfish industry. Recently, several statewide and region-wide meetings have been held to discuss methods to control this invasive and destructive species. Preliminary results of a trapping survey of green crabs in Salem Sound, Massachusetts suggest that the crab density is not as great as in some areas in New Hampshire and Maine. Nevertheless, these crabs do have a negative impact in Salem Sound. Ways to decrease the green crab population throughout New England are being

considered, including creating a soft-shell crab market for human consumption, a practice that seems to have been mastered in parts of Europe for a similar species. This presentation will compare the latest suggested control methods for the omnipresent green crab, such as using the crab for bait or fish meal, selling the meat as fertilizer, and harvesting the chitin for pharmaceuticals thus providing an optimal dress out of the product. An emphasis will be put on the importance of the exploration of endocrinology to obtain a better understanding of the molting process. Preliminary results of an ongoing study may be shared related to this topic hormones and molting.

SHELLFISH AQUACULTURE IN DELAWARE'S COASTAL (INLAND) BAYS: REGULATORY STATUS AND OUTLOOK FOR 2015

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In 1998, the Delaware Center for the Inland Bays (CIB), a National Estuary Program, and Delaware Sea Grant initiated a program of applied shellfish research, and demonstration field work culminating in 2012 that documented the value and effectiveness of aquaculture technologies as a restoration and management tool for fisheries habitat, shellfish stock enhancement and seafood production. During 2012, the CIB convened a diverse Inland Bays stakeholder work group (Tiger Team) to identify policy constraints and legislative changes needed for reinstatement of commercial shellfish aquaculture bottom leases. House Bill 160 "AN ACT TO AMEND TITLE 3 AND TITLE 7 OF THE DELAWARE CODE RELATING TO AQUACULTURE", introduced in June 2013 during the 147th session of the Delaware General Assembly, was passed unanimously by the House and Senate and was signed into law by Governor Jack Markell on August 28, 2013. The Delaware Department of Natural Resources and Environmental Control (DNREC) Division of Fish and Wildlife, charged with developing a bottom leasing program and regulatory framework, completed the drafting and public education/hearing process with release of final regulations on August 11, 2014. The present status of commercial shellfish aquaculture development is reviewed with regulatory and additional information also available at the Delaware Inland Bays Shellfish Aquaculture website <darc.cms.udel.edu/ibsa>.

MANAGEMENT, REGULATION AND STOCK ASSESSMENT FOR *ANGUILLA ROSTRATA*

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American eel (*Anguilla rostrata*) is a catadromous, panmictic species. It breeds as a single population in the Sargasso Sea, and inhabits both estuarine and freshwater habitats stretching from South America and the Caribbean to Labrador and the Great Lakes. The eel fishery is managed by multiple jurisdictions among and within the United States and Canada, as well as several Caribbean nations. Several agencies and international bodies have also been reviewing the American eel under a variety of endangered species regimes, including the Canadian Species at Risk Act (SARA), the U.S. Endangered Species Act (ESA) and the International Convention on Endangered Species (ICES). In this presentation, we will survey the regulation of American Eel, describing the basic structure and process of the Canadian and U.S. fish management agencies and highlighting the major elements of each countries' fishery management plans (FMPs) for eels. (Limited information about the Caribbean fishery will be included.) The survey will also cover the results of multiple stock assessments for American eel that have been conducted in the past decade and the status of the various, ongoing, endangered species reviews. We will discuss matters of consensus and identify differences and areas of uncertainty among the various

stakeholders interested in American eel. The presentation will conclude with recommended strategies to close knowledge gaps and enhance inter-jurisdictional cooperation in order to achieve effective management of the species.

TWO POTENTIAL PASSIVE ANTI-PREDATOR TECHNIQUES FOR LONGLINE MUSSEL CULTURE

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Near Carleton-sur-Mer, Québec, mussels are left on spat collectors and grown profitably on longlines without density adjustment. Duck predation, however, has been a growing problem in the recent years, causing up to 95% reduction of mussel spat biomass. Active anti-predator techniques appear inefficient. Therefore we focussed on developing passive duck-control methods. The first protective device reported here is made of a top steel ring and a lower steel ring connected by 3m long collector ropes. Once spat collection is complete the rings and collectors are placed within a netting bag. The resulting cylindrical cage is immersed for the rest of the culture cycle. After two migratory episodes biomass was reduced by only 20%. An improved version of these modular cages is being tested to ensure that they are totally innocuous for ducks. The second method currently being tested is based on the use of knots of the type of the chain sinnet. Knots add structural complexity to spat collectors and therefore may provide anti-predator spatial refuges to spat just as crevices in natural settings do. A critical characteristic of the different potential knots is that they be easily undone at harvesting. Early results of an ongoing experiment using the chain sinnet suggests that the presence of knots increases spat collection. So far, however, the anti-predator effect of the knot presently tested is negligible. The experiment will be pursued for two more years in order to study a complete production cycle. Other knot types will be tested in the near future.

CLEARANCE RATE REGULATION IN MUSSELS: ADDING THE EFFECT OF ORGANIC SESTON LEVEL TO A MODEL OF INTERNAL STATE-BASED REGULATION

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Dynamic energy budget simulations of mussel clearance rate based on an internal state feeding module (ISFM) provide better results than when based on an externally (e.g.: phytoplankton concentration) regulated model (Fréchette 2012 J. Mar. Sci. 73:32-40). We report an experiment designed to test ISFM. Mussels were grown along a natural seston gradient in the lab. According to ISFM, differences in energy reserves would cause differences in clearance rate along the food gradient. We found no significant effects of the food gradient on clearance rate. However, we found significant effects of time at all time scales studied – tens of minutes, hours, days. We focussed on hourly averages of clearance rate and extended the initial ISFM model to include the effect of phytoplankton level. We found an excellent fit between the model and the data. Thus, although the present experiment was inconclusive with respect to bioenergetics, the extended ISFM model provided a solid framework for modelling hourly mean clearance rates. This is strong indirect evidence in support to the extended ISFM model. This adds to the evidence found in the literature, which supports the bioenergetics part of the model. We conclude that feeding modules of simulation models should be based on ISFM.

PHYSICAL THERAPY FOR AGING AQUACULURISTS WORKSHOP

Kassia O. Garfield
Back in Motion Physical Therapy, LLC, 185 Ocean Street, South Portland, ME 04106 USA

To provide information on how to make better work habits, how to maximize efficiency and save your back! Exercises will be provided with demonstrations. Should be a fun interactive power point presentation to try and create better work environments for the hands on workers in aquaculture. Presenter is an oyster farmer by childhood and physical therapist by career path. Presentation will be looking at different work stations in the oyster farming environment. Ways of encouraging more healthy work choices and keeping staff safe will be addressed. I am always trying to incorporate wellness into everyday work places, even the water farmers.

THE CONNECTICUT SHELLFISH INITIATIVE: BUILDING ON THE PAST AND CREATING A VISION FOR THE FUTURE

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Shellfish are an important ecological, economic and recreational resource to Connecticut citizens. While there is considerable opportunity and growth in the various shellfish sectors, significant challenges exist and risk is pervasive. Lack of formal communication avenues and potential conflicts among industry, regulators, municipal officials and other shellfish stakeholder groups have limited much-needed collaboration to deal with emerging environmental and economic threats. In response to these challenges, Connecticut Sea Grant (CTSG) in collaboration with NOAA National Marine Fisheries Service Milford Laboratory convened meetings with shellfish interest groups and citizens across the State and proposed the development of a vision plan for the future of Connecticut shellfisheries and natural shellfish resources. Modeled after the NOAA National Shellfish Initiative, the Connecticut Shellfish Initiative is a stakeholder-driven effort to map out a vision for the future of Connecticut shellfish resources. The plan, now in development, will document the importance of the various shellfish sectors, identify and characterize issues of importance to Connecticut shellfish stakeholders and citizens and will establishes specific and time bound goals, objectives and actions to be taken. To learn more, visit: http://shellfish.uconn.edu.

A NEW EDUCATIONAL OFFERING FOR PRODUCERS: THE NORTHEASTERN U.S. AQUACULTURE MANAGEMENT GUIDE

Tessa Getchis
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A new 285-page illustrated manual, the Northeastern U.S. Aquaculture Management Guide, was recently published by the U.S. Department of Agriculture Northeastern Regional Aquaculture Center. The manual, targeted for prospective and new aquaculture producers, is a wealth of useful information on potential hazards for those who grow fish, shellfish, and seaweed. Every year, the aquaculture industry experiences economic losses due to diseases, pests, adverse weather, or operational mishaps. This manual identifies many specific risks to help seafood growers identify, manage and correct production-related problems. The guide also includes monitoring and record-keeping protocols, and a list of aquaculture extension professional contacts who can help when there is a problem. Twenty-five aquaculture extension professionals and many researchers, aquatic animal health professionals and farmers contributed to the information presented in this volume which is now offered in print and online, and soon to be available on an interactive website.

AQUATIC INVASIVE SPECIES IN PRINCE EDWARD ISLAND, CANADA: A LOOK AT INDUSTRY INNOVATION

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Since the arrival of the green crab and clubbed tunicate in 1997, several more aquatic invasive species (AIS) have become established in Prince Edward Island (PEI) waters. Colonial tunicates and the vase tunicate are now also prevalent in several estuaries in PEI. The arrival and subsequent spread of these AIS has greatly impacted the PEI aquaculture industry, specifically the shellfish industry. Despite this challenge, the industry continues to produce high quality product. Through innovative and adaptive processes, the mussel and oyster aquaculture industries have developed ways to mitigate the impacts of AIS. Innovative technologies have been explored and many new devices have been, and continue to be, fabricated to control AIS fouling.

SKULKING BEHIND AN MSX SMOKESCREEN: SSO PREVALENCE IN MAINE AND MASSACHUSETTS

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Haplosporidium costale (SSO) has been reported in US oysters since the 1980's from Maryland to as far north as Maine. However, in part due to the relatively low level of mortality reported in association with its detection in more recent years, this organism is often overlooked in routine testing and due to the potential for high level of associated mortality, regulatory testing has typically targeted another Haplosporidian, *H. nelsoni* (MSX). Testing conducted in Maine and Massachusetts since 2010 indicates varying prevalence of SSO in wild and farmed populations of the Eastern oyster (*Crassostrea virginica*). In rare cases SSO detection was also associated with disease and mortalities; in some cases SSO was present solo, while in others in co-occurrence with MSX and/or *Perkinsus marinus*. SSO prevalence, co-occurrence with MSX, detection via PCR versus histology, relationship with any mortalities, and shifts in presence of MSX versus SSO in farmed and wild *C. virginica* and potential relationship with the use of MSX-resistant *C. virginica* in aquaculture are investigated.

VIBRIO PARAHAEMOLYTICUS PREVALENCE IN MAINE OYSTERS

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Vibrio parahaemolyticus associated with bivalve shellfish has in recent years become a major concern in southern New England states, but limited information was available with regards to its presence in Maine. Previously, this organism had shown rare occurrence in Maine and the majority of isolates had been composed of non-pathogenic strains. Collaborative work was performed during 2014 by Kennebec River Biosciences (KRB), Mook Sea Farm (MSF) and Pemaquid Oyster Company (POC) to examine the occurrence of this organism in Damariscotta River oysters. Findings by bacterial culture and molecular testing showed intermittent *V. parahaemolyticus* presence in

grow-out oysters from several sites. Isolates were identified by biochemical and DNA sequence analyses, and evaluated for presence of genes associated with pathogenicity. Results were used by MSF and POC to conduct voluntarily established harvest, handling and monitoring practices and minimize any potential effect of this organism on their market product. Further work, funded by the Maine Aquaculture Innovation Center, is planned for 2015 to screen oysters from additional Maine river systems in order to gain a better understanding of *V. parahaemolyticus* presence in Maine, determine pathogenicity of detected strains and provide growers data on any *V. parahaemolyticus* presence in their grow-out area and help them assess the efficacy of their harvest biosecurity protocols.

SUMMARIZING MILFORD LABORATORY'S RESEARCH ON THE ECOLOGICAL EFFECTS OF HYDRAULIC DREDGING, AS USED IN CLAM CULTIVATION IN LONG ISLAND SOUND

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Aquacultural cultivation of Northern quahogs (*Mercenaria mercenaria*) in Long Island Sound (LIS) is conducted on leased beds and relies on natural recruitment. Harvest is accomplished by using hydraulic dredges that pump seawater under pressure into sediment to loosen clams, which are then retained by the dredge. The shellfish industry and managers requested an assessment of dredge harvest on marine habitat. We conducted a literature review of the ecological effects of dredging, considering physical, biological, and chemical impacts. Much of the literature was specific to either navigational dredging or to harvest fisheries, where continual dredging is conducted by many, seeking a common resource on common grounds. The review indicated that dredging impacts vary with harvest practice, sediment type, season, location, biological community, and many other factors. We then conducted several years of field experiments to address the effects of dredging on benthic habitat. In all experiments the benthic community and sediment chemistry were assessed on a weekly basis over several months. We found that seasonality and sediment grain size had greater effect on benthic communities than the impacts of dredging. Some impacts to sediment chemistry were observed post-dredging, but these disappeared within a few weeks. In one experiment we found significantly more newly-settled hard clams on plots that had been dredged, compared to non-dredged plots. Near-shore ecosystems are dynamic and are inhabited by assemblages that are resilient to natural disturbance. Farming practices typical of LIS appear to have minimal and short-lived effects on habitat, biota, and sediment chemistry.

PERFORMANCE OF SELECTIVELY-BRED LINES OF EASTERN OYSTERS, *CRASSOSTREA VIRGINICA*, AT DIFFERENT LOCATIONS ALONG THE EAST COAST OF THE UNITED STATES

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Populations of the eastern oyster, *Crassostrea virginica* have been severely affected in the last few decades by diseases such as Dermo, MSX, SSO, and ROD. In order to manage these diseases, there is a need for effective breeding programs that produce specific genetic lines that perform optimally in very diverse shellfish-growing

environments. Six selectively-bred lines of *C. virginica* were deployed in five sites along the east coast of the US, from Virginia to Maine, in August 2012. Growth and survival were measured for 16 months and samples were collected in cases of high-mortality events for disease diagnosis and future genotyping. Line performance (yield) was mainly driven by survival. Strong genotype by environment interactions were observed: three of the northern lines (UMaine, NEH-RI, and Clinton) were significantly larger and had significantly higher survival rates than the southern lines (hANA and DEBY) in the Rhode Island sites, while the southern lines had a higher yield than the northern lines in the Delaware and Chesapeake Bay sites. Dermo and MSX were the most-likely causes of high mortality among the northern lines in the Delaware and Chesapeake Bay sites, while ROD caused large mortalities in oysters deployed in Maine. More research needs to be done to identify what other diseases or environmental factors drove the site-specific performance of these lines at northern sites. These results suggest local adaptation of selectively-bred oyster lines to the site of origin and a need for the development of regional breeding programs.

KELP FARM DESIGN FOR LONG ISLAND SOUND

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The growth of marine aquaculture in the US will require an enabling regulatory framework and the development of economically viable grow out systems. Important to that viability is the system cost, the infrastructure needed to deploy and service it, and its reliability while in use and in the face of extreme weather events. The biological potential for the expansion of the macroalgae culture sector in Long Island Sound has been demonstrated and a permitting framework is in place in Connecticut due its history of shellfish aquaculture leases. An affordable and reliable approach to building and operating a farm for the sugar kelp (*Saccharina latissima*) has been developed based on conditions present at five candidate sites. Depths, currents, bottom type, and growth projections of *S. latissima* were used to design a baseline system. Guidance is provided on how to adapt that design to the specifics of the site. Various approaches to anchoring are discussed including deadweight, drag embedment, and helical technologies. Methods of anchor and array installation with limited vessel capacity are presented. The design of a kelp farm is a balance between the desire for the stable and predictable performance of the long-line array and the need to bring the kelp crop to the surface for growth monitoring and harvesting. Catenary support lines are introduced as a way to provide array stability and reduce the overall cost of the installation.

ENTANGLEMENT RISK REDUCTION IN AQUACULTURE GEAR

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The growth of marine aquaculture in the US is constrained by a regulatory review process that requires strict compliance to regulations related to marine mammals and endangered species. Real or perceived risks presented by aquaculture gear to protected species can prevent or greatly complicate the steps associated with obtaining a permit for an aquaculture site even though those activities are benign compared to others that are routinely allowed. While the entanglement events documented in commercial fishing gear present cause for concern, the types of gear used in aquaculture, its location, and its operation may reduce the actual risks presented to marine

mammals and sea turtles. In addition, because such gear can be custom designed for the particular site and is not tended in the same manner as fishing gear, innovative approaches to risk reduction offer the potential to reduce or eliminate risks. While the entanglement causes and risk factors of various aquaculture gears are poorly understood, several candidate approaches to reducing entanglement risk will be presented and the limited studies on their efficacy will be described. A goal of this presentation is to obtain feedback from the aquaculture sector on which of these innovations are most practical and likely to provide assurances to reviewing agencies that aquaculture can grow without undue risks to other species.

THE PERFORMANCE OF A SINGLE CELL PROTEIN AS A FISHMEAL REPLACEMENT USING THE COMMON CLOWNFISH *AMPHIPRION OCELLARIS*

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KnipBio created a commercially scalable single cell protein product (KBM) containing proteins, amino acids, and low-cost carotenoids. Two experiments were conducted on the common clownfish, *Amphiprion ocellaris*, to determine if KMB is a viable replacement for fishmeal in aquaculture feed. Four different diets were evaluated and the effect of each diet on fish feed efficiency, survival, growth, and coloration was examined. Both experiments were conducted in closed recirculating systems at a constant temperature (28±0.5°C) and salinity (31±1.5 ppt). Fish were fed four times daily until satiation. In the first experiment, juvenile clownfish (1.08±0.13 g) were stocked in 10-gallon tanks at 17 fish per tank with four replicates of each diet. In the second experiment, juvenile clownfish (0.60 ±0.02 g) were stocked in 6 L floating mesh baskets within 30-gallon tanks at 18 fish per basket with three replicates of each diet. After the completion of the experiment (day 100 for experiment 1; day 75 for experiment 2) the weight (g) and length (mm) of each fish was measured and each fish was placed on a high-resolution digital scanner to generate a digital image. With this data, fish growth, feed conversion ratio, and percent red color ratio was determined using Photoshop. There was no significant difference in feed conversion, growth, or survival between the diets (ANOVA test followed by post hoc analysis). The effect of diet on coloration will be explained in detail. These preliminary results suggest that KBM may serve as a partial fishmeal replacement in aquaculture feeds.

OCEAN ACIDIFICATION: THE CURRENT STATE OF KNOWLEDGE

Mark Green
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Fundamental changes are occurring to the chemistry of the world's ocean. Since the beginning of the industrial revolution, carbon dioxide (CO_2), from the combustion of fossil fuels and from deforestation of the tropics, has increased steadily in the atmosphere. The ocean absorbs roughly a quarter of this CO_2 each year, slowly lowering the pH, the carbonate ion concentration (CO_3^{2-}), and carbonate mineral saturation state. Collectively, these changes are known as 'ocean acidification'. Current CO_2 concentrations in the atmosphere are higher than at any time in the last 800,000 years. Based on current CO_2 emission scenarios, surface water pH by 2050 will be lower than anything experienced in the last 20 million years. By 2100, the current pH trajectory means that ocean pH will be lower than at any time in the last 300 million years. One of the most important factors to consider when contemplating the biological impacts of ocean acidification is not just the absolute pH of seawater, but the rate at which ocean pH is changing. *The current rate of acidification is at least 100 times faster than any time in the last several hundred thousand years and, very possibly, is unprecedented in Earth's history*. This talk will present the

current state of knowledge on the chemical changes now documented in every corner of the world ocean and will introduce some of the known biological changes which will occur as a result of ocean acidification.

DEMONSTRATION OF LIVING SHORELINE TECHNOLOGY ON MARTHA'S VINEYARD, MA

Emma Green-Beach, Richard Karney, Amandine Surier and Chris Edwards
Martha's Vineyard Shellfish Group Inc., PO Box 1552, Oak Bluffs MA 02557 USA

On Martha's Vineyard there is little salt marsh compared to more southern locations. Marshes on Martha's Vineyard are not threatened by storm erosion or boat wake to the same degree as other locales, yet there is great ecological value in the small amount that exists. Nutrient cycling and attenuation is one of the most critical services provided by marshes and nitrogen eutrophication is perhaps the greatest threat to the health of salt ponds and embayments on Martha's Vineyard. This project was designed with the goals of demonstrating "Living Shoreline" techniques in embayments on Martha's Vineyard that can be used elsewhere in our region, and also to conduct preliminary investigations into the hatchery production of the ribbed mussel *Geukensia demissa*. Four sites were selected for installation of coir logs, marsh grass, and ribbed mussels for pilot-scale marsh restoration. Two of the four sites are in Lagoon Pond and two are in Sengekontacket Pond; one site in each coastal pond experiences low wave-energy, while the other is in a more high energy location. The rational for this design is to be able to evaluate the application of the technology at different types of sites. To date, living shorelines have been installed in both low-energy sites. Progress, observations and challenges will be discussed.

USDA OPPORTUNITIES IN AQUACULTURE THROUGH THE FARM SERVICE AGENCY (FSA)

Ken Gustin
Farm Service Agency, 967 Illinois Ave, Bangor, ME 04401 USA

USDA representatives from the Farm Service Agency (FSA) will present a workshop on program and loan opportunities for the aquaculture industry. The workshop will engage audience members in discussions of current FSA program offerings in the Noninsured Crop Disaster Program (NAP), which provides financial risk management assistance when eligible losses occur, and FSA loan programs wherein producers can receive low interest loans for real estate, operating expenses and emergency purposes. Aquaculture in the Northeast is a major economic activity, and FSA program and loan offerings provide options to mitigate risk of loss, improve financial viability, obtain critical working capital for operating needs, make improvements or accomplish updates and refurbishments of equipment and facilities, and meet storage needs following harvest. Join us for an informative discussion and learn how FSA program and loan offerings can benefit your operation.

MICROALGAE CONCENTRATES: A "DISRUPTIVE TECHNOLOGY" THAT CAN REVOLUTIONIZE BIVALVE HATCHERY OPERATIONS

Eric Henry and Tim Reed
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The critical bottleneck in bivalve production is an inadequate supply of quality microalgae for every life stage—broodstock, larvae, hatchery set, remote set, and nursery. Algae concentrates are a game-changer for bivalve production, particularly for smaller facilities with limited space and labor. Now they can operate their own hatcheries without the complexity and expense of building and running algae culture systems that must reliably produce several different algae species. This innovative technology makes it possible for hatcheries to always

keep on hand a reliable supply of algae, available for use in any season and when unexpected needs arise, often at lower cost than algae produced on-site. Algae concentrates preserve the cellular integrity and nutritional value of the algae. Non-viable concentrates eliminate the risk of introducing exotic algal strains to the local environment. Concentrates produced at inland facilities free of shellfish pathogen vectors pose no danger of introducing diseases or parasites along with the feed. The best-quality refrigerated concentrates typically have a shelf-life of several months, and frozen products several years. There are critical differences in the nutritional content (Omega fatty acids, sterols, carotenoids, amino acids, etc.) and cell sizes of different algae. Even different strains of the same algae "species" can differ significantly, so the choice of which algae to feed is vitally important. Reed Mariculture's Instant Algae® concentrates are composed of algae strains that we have selected to deliver optimal nutritional value for bivalves. Reed Mariculture's Instant Algae can be your source of *Algae When You Need It!*

FARMING *GRACILARIA TIKVAHIAE* IN THE GREAT BAY ESTUARY

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The Great Bay Estuary is located in southeast New Hampshire and is the convergence of coastal waters from the Gulf of Maine and several freshwater tributary rivers. The estuary is an important economic, environmental, and cultural resource in New Hampshire. Over the last several decades The Great Bay Estuary has suffered from several environmental issues most notably eutrophication from nitrogen inputs. Currently, the waters of Great Bay are considered to have eutrhopic or hypertrophic nitrogen levels. As autotrophs, algae take up nutrients such as nitrogen for growth. Therefore, seaweed farming could be an important resource in the work to reduce the nutrient concentration in Great Bay. *Gracilaria tikvahiae* is native to the Great Bay Estuary and has economic value for the production of agar. *Gracilaria* farming in North American is a relatively new industry. In order to obtain the potential environmental and economic benefits of *Gracilaria* farming in Great Bay more research is needed. Experimental farming of *Gracilaria tikvahiae* using three different gear methods took place during the summers of 2013 and 2014. The purpose of this study was to determine if aquaculture method (gear type) had any impact on the growth, epiphyte cover, and nitrogen content of *Gracilaria tikvahiae*. Further studies will continue to look at different methods for out-planting of seaweed in Great Bay. Future research will also explore methods for epiphyte control and the impact of site location (sub-tidal vs. intertidal) on growth and nitrogen content of *Gracilaria tikvahiae*.

DERIVED MACROALGAE FEED AND ITS POTENTIAL USE IN SHELLFISH AQUACULTURE

Zach Hope
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The green macroalgae *Ulva* is a globally distributed seaweed with fast growth rates and relatively high nutritional value. In recent years, massive accumulations of "green tides" of *Ulva* have occurred with increased frequency and magnitude resulting in deleterious effects to coastal ecosystems. If left in coastal waters, decomposing biomass results in oxygen-depleted waters inhospitable to other organisms. If harvested, the biomass is often incinerated or buried due lack of commercial use and value. The present study will investigate the potential use of *Ulva* in hatchery diets for shellfish. *Ulva* will be analyzed for its chemical composition and compared to traditional feeds used in aquaculture. *Ulva* will be broken down to a size fractionation suitable for shellfish ingestion both mechanically and with bacteria. Bacterial degradation is beneficial in breaking down the seaweed as well as increasing protein content. A suitable use for *Ulva* in aquaculture would help alleviate problems caused by "green tides" as well as supply shellfish hatcheries a sustainable supplement or replacement for currently, more costly feeding regimens.

THE APPLICATION OF A QUANTITATIVE PCR WITH A PLASMID STANDARD CURVE TO EVALUATE *PERKINSUS MARINUS* LEVELS IN THE EASTERN OYSTER, *CRASSOSTREA VIRGINICA*

Whitney Jaillet, Kathryn Markey and Roxanna Smolowitz
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Dermo Disease, caused by the endoparasite *Perkinsus marinus,* is responsible for significant morbidity and mortality in populations of *Crassostrea virginica* along the Atlantic coast of the United States. Currently, the gold standard for detection of Dermo disease is the Ray's Fluid Thioglycollate Medium (RFTM) assay. The RFTM method reports animal infection intensities using the Mackin scale, where 0 indicates no infection and 5 indicates heavy infection. In order to improve upon several shortfalls of RFTM, several molecular assays have been developed to increase specificity, accuracy, and speed of results. Recently, the Aquatic Diagnostic Laboratory (ADL) at Roger Williams University has developed a quantitative PCR (qPCR) that has been adapted from previous qPCR assays to employ a plasmid standard curve in lieu of a standard curve based on dilutions of cell cultures. The use of plasmid DNA allows us to generate a consistently linear and highly reproducible standard curve for the assay without the need to culture and extract *P. marinus* cells regularly. This new assay has been equated to the traditional Mackin scale by extracting tissues of oysters (n=86) with known Mackin ratings, running them in the qPCR, and comparing the results to the original Mackin ratings. Subsequent results of our qPCR can be translated into the Mackin scale for direct comparison to historical data. This new diagnostic test is currently being used by the ADL for restoration disease surveys in Rhode Island as well as health checks for local aquaculturists.

MUSSEL FARMING – A VERTICAL INTEGRATION APPROACH – IT'S RISKS AND REWARDS

Ian Jefferds
Penn Cove Shellfish, LLC, P.O. Box 148, Coupeville, WA 98239 USA

Penn Cove Shellfish, LLC started out as a small family mussel farm in 1975 in Penn Cove on Washington's Whidbey Island. As America's oldest and largest commercial mussel farm, there was not an existing farm to learn from, a market to sell to, or an infrastructure to support development; so as a result the company needed to innovate and take care of itself at all stages of their operations. Vertical integration was important to get the company up and going and has been instrumental to the company's success. This presentation will discuss how site specific mussel culture is and how that fact may influence the product raised, the culture methods, seed supply, predation control, disease, farm and equipment design, harvest methods and schedules, and how the company became vertically integrated due to these various factors and challenges.

LONG-TERM TRENDS OF PATHOGENIC *VIBRIO SPP.* POPULATIONS IN NEW HAMPSHIRE OYSTERS

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The incidence of confirmed vibriosis in the Northeast US has increased over the past decade. Whereas these include some cases not associated with shellfish consumption, the more recent trend of increasing incidence of regional shellfish-borne *Vibrio parahaemolyticus* outbreaks has resulted in closed harvesting in some areas as well as product recalls. A long-term (2007-2014) Vibrio surveillance program in the Great Bay estuary of New Hampshire has tracked *V. parahaemolyticus, Vibrio vulnificus* and *Vibrio cholerae* in oysters, sediments, plankton and overlying water. The goals of this program include tracking the potential emergence of pathogenic sub-populations of these species, providing strains for in-depth determination of lineage and evolution, and determining environmental conditions that explain Vibrio population dynamics. Here we summarize our progress with empirical modeling of *V. parahaemolyticus* populations and with pre- and post-harvest strategies to reduce Vibrio levels to minimize public health risks. These results provide a framework for understanding the recent emergence of Vibrios as a significant issue for shellfish aquaculture in the Northeast US.

SHELLFISH SANITATION MANAGEMENT FRAMEWORK FOR AQUACULTURE SCALLOPS

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The Maine Department of Marine Resources has worked with the sea scallop (*Placopecten magellanicus*) aquaculture industry over the past few years to develop a protocol for biotoxin monitoring and testing. In 2014, the first whole scallops were harvested and sold from Maine aquaculture sites. Unlike scallop adductor muscles, whole or roe-on scallops are included in the National Shellfish Sanitation Program (NSSP) and are therefore subject to the NSSP Model Ordinance. This includes compliance with harvester and dealer tagging, harvesting from growing areas with appropriate water quality standards, and biotoxin testing. Sea scallops are known to retain naturally occurring marine biotoxins longer than some other species of shellfish (e.g. blue mussel), so testing whole or roe on scallops for Paralytic Shellfish Poisoning (PSP) is of particular concern. Establishing a regulatory framework for sea scallop aquaculture with regard to shellfish sanitation will ensure the growth, profitability and safety of an emerging product from Maine waters.

HUMAN HEALTH SAFETY CONSIDERATIONS FOR USING *VIBRIO* SP. PROBIOTIC STRAIN OY15 AS A FEED SUPPLEMENT TO IMPROVE SURVIVAL OF LARVAE OF THE EASTERN OYSTER (*CRASSOSTREA VIRGINICA*): GENOME SEQUENCING AND MAMMALIAN CYTOTOXICITY ASSAY

Diane Kapareiko[1], Harold J. Schreier[2], Eric J. Schott[3], Dorothy Jeffress[1] and Gary H. Wikfors[1]
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Use of beneficial bacterial probiotics for controlling microbial pathogens in aquaculture is an environmentally-friendly alternative management practice for disease prevention. The Milford Laboratory has isolated and evaluated a naturally-occurring *Vibrio* sp. probiotic isolate (OY15) from the digestive glands of adult Eastern oysters (*Crassostrea virginica*) that has been confirmed safe for use with oyster larvae and their microalgal feed T-ISO, and can improve survival of larvae challenged with a shellfish pathogen by 20-35%. Sequence analysis of OY15 revealed closest matches to *Vibrio* sp. EX25 and *Vibrio alginolyticus*. This study discusses a three-part human health safety assessment to determine probiotic strain OY15's safety during applications in commercial larviculture. First, antibiotic sensitivity testing against 14 antibiotics used for humans confirmed OY15's

sensitivity to 12 of these antibiotics. Next, annotation of a draft genome sequence for probiotic OY15 indicated the genetic capacity to produce a variety of potentially probiotic proteins. Several Rhs family genes were present that stimulate host immunity and may be partially responsible for OY15's probiotic effects. Genes for quorum sensing regulators and siderophores important for colonization of the digestive tract were found, as well as an accessory colonization factor (AcfA). A number of virulence-related hemolysins, regulators and secretion system components were found. However, *tdh* and *trh* genes associated with virulent *V. parahaemolyticus* were absent. Lastly, a mammalian-cell culture bioassay used to test OY15 for cytotoxicity confirmed no cytotoxic effects on the human cell line Caco-2 by OY15. Taken together, these data suggest a low human virulence risk for probiotic strain OY15.

GETTING THE N OUT - A SEARCH FOR BIOREMEDIATION ALTERNATIVES TO SEWAGE TREATMENT

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In recent years, studies by the Massachusetts Estuaries Program (MEP) have confirmed that high nitrogen loading, especially from onsite septic systems, is the primary driver of the degraded environmental quality observed in many of the state's estuaries. The MEP studies have developed target Total Maximum Daily Loads (TMDLs) for nitrogen required to reverse eutrophic conditions and restore water quality. Local municipalities have been tasked with developing plans to meet the target nitrogen reductions. Conventional tertiary sewage treatment systems are the likely means to that end. However, because of the high costs for construction and operation of these systems, municipalities are seeking more affordable alternatives. Further, because much of the problematic nitrogen enters the embayments though slow moving groundwater plumes, the damaging impacts of nitrogen will continue for years after the installation of treatment systems. The Martha's Vineyard Shellfish Group is investigating a number of potential methodologies to enhance bioremediation of nitrogen within our local estuaries. Within the environmental, social and regulatory conditions that exist at various sites, we are exploring the feasibility of using oysters, ribbed mussels *Geukensia demissa*, *Phragmites australis*, Floating Islands and living shorelines to reduce nitrogen levels in the impaired estuaries. The promises, limitations and challenges of each option will be discussed.

PREDATION ON JUVENILE SOFT SHELL CLAMS: THE SCOURGE OF THE GREEN CRABS

Amanda Keegan and Mark Fregeau
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Shellfish farmers suffer a significant loss of their crop each year due to a variety of predators, specifically green crabs (*Carcinus maenas*). Trapping studies show that green crabs can occur in high densities in clam flats, which can result in high mortalities of juvenile clams. Although baited traps provide some general information on crab population dynamics, there are few quantitative studies to examine actual crab densities in naturally occurring clam flats. This study was designed to quantitatively observe the green crab impacts on juvenile soft shell clams (*Mya arenaria*) in situ utilizing multiple mudflat plots. Experimental design included four treatments consisting: seeded covered by a net, seeded without net, no seeding with net, and no seeding without net (control). Weekly monitoring recorded clam densities and size of resident, planted, and newly recruited clams; along with the presence and size of green crabs. The data shows that small, newly recruited green crabs have minimal impact on juvenile soft shell clams. These smaller, newly settled green crabs may be too small to effectively prey on juvenile clams. While larger green crabs can consume netted clams, the use of nets to exclude these crabs in addition to regular net monitoring to remove newly settled green crabs may drastically reduce the impact of crab

predation and enhance clam survival. This study will continue through the winter to explore possible seasonal trends in clam-crab interactions.

A STRAIN COMPARISON OF STRIPED BASS CULTURED IN SALT WATER RECIRCULATING SYSTEMS

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Although striped bass and their hybrids are widely cultured in freshwater ponds, relatively few studies have compared strain differences for production characteristics in salt water systems. Striped bass juveniles originating from wild-caught broodstock from rivers in Delaware, Florida, South Carolina, Texas and Virginia were reared in triplicate salt water (30 ppt) recirculating systems for up to 18 months. At 30- day intervals, a minimum of 20% of the fish from each tank were sampled for growth parameters, and feeding rates were adjusted for tank biomass (1.25% BW). After 1 year, the growth parameters of all fish were determined and a subset were PIT tagged and grown in a larger, "common-garden" salt water recirculating system. Specific growth rates were calculated for each strain and differences among families within strains were determined using microsatellite markers. Preliminary analyses confirmed growth differences among strains of juvenile striped bass grown in salt water. This research was funded by the Northeastern Regional Aquaculture Center

RESULTS OF THE 2013 U.S. CENSUS OF AQUACULTURE SHOW INDUSTRY GROWTH

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Total sales of U.S. aquaculture products in 2013 was $1.37 billion, an increase of 26 percent from 2005. Mollusk sales led the way with an increase of 62 percent from 2005-2013. The U.S. Department of Agriculture's National Agricultural Statistics Service (NASS) released these and many more results of the 2013 Census of Aquaculture on September 29, 2014. The aquaculture census provides detailed information relating to production volume and methods, surface water acres and sources, sales, point of first sale outlets, and aquaculture distributed for restoration, conservation, enhancement, or recreational purposes. NASS conducted the third national census to measure the U.S. aquaculture industry. The last Census of Aquaculture was conducted in 2005 and provides broad, invaluable data for and about the industry. Data from the census allow government leaders to more accurately allocate national and local funds to support the future of the industry, such as extension service projects and agricultural research. Extension and university representatives in the United States rely on the data to help determine research needs and to justify funding for programs aimed to develop new and improved methods of aquaculture production and profitability.

INTRODUCTION TO THE KELP NURSERY TECHNOLOGIES: WILD-SOURCED SEEDING AND HYBRIDIZATION

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Growing kelp in the temperate climates of the northeastern U.S. has been shown to be both feasible and economically practical. For the expansion of the kelp aquaculture industry, the new growers need to obtain sustainable seedstock and introduced to proper cultivation technologies. Kelp nursery techniques have been developed at the University of Connecticut during the past several years. Mainly two nursery techniques for kelp species have been utilized, wild-sourced (sorus tissue) seeding and hybridization techniques. In the wild-sourced seeding technique, mature reproductive tissues (known as sorus tissues) need to be collected in autumn, to obtain sufficient number of spores for seeding. Four to five weeks after sporelings have attached to the seedstring (~1 mm in size), the seedstring can be transferred to the open sea. Alternatively, hybridization techniques can be used. We have isolated and established clonal cultures of male and female gametophyte of different kelp species from New England, including *Saccharina latissima, Alaria esculenta,* and *Laminaria digitata*. We have successfully grown the sugar kelp (*Saccharina latissima*), derived from gametophyte clones, in open water kelp farms in New England (Maine and CT). We have also determined genetic features of male and female gametophytes in terms of the morphology of offspring and physiological attributes. The protocols for strain isolation and maintenance and rapid sporophyte production to inoculate seed string with juvenile kelp plants will be discussed.

SPATIAL-TEMPORAL MANAGEMENT OF CONFLICTS WITH PROTECTED SPECIES

Hauke Kite-Powell
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Interactions between aquaculture gear and protected species are a significant concern in northeastern coastal waters. As with fishing gear, lines and other devices associated with aquaculture operations may pose an entanglement risk to marine mammals and turtles. This risk is best addressed in the site selection and permitting process. Risk models developed to reduce entanglement of right whales in lobster fishing gear off the coast of Maine illustrate how spatial and temporal management measures can reduce entanglement risk in that industry, and provide a useful example for managing similar conflicts in the contact of aquaculture. This approach requires understanding both the spatial and temporal distribution of encounter risk (also referred to as "co-occurrence") and the likelihood that an encounter will result in an entanglement or other injury. With guidance from such models informing the design and siting of the aquaculture installation, it is possible to achieve meaningful statistical reductions in the risk posed by aquaculture to protected species.

ENTANGLEMENTS OF NORTH ATLANTIC RIGHT WHALES IN FISHING ROPES

Scott Kraus and Timothy Werner
John H. Prescott Marine Laboratory, New England Aquarium, Central Wharf, Boston, MA 02110-3399 USA

Entanglements in fishing ropes, primarily those used in lobster trap and gillnet fisheries, are a principal threat to the endangered North Atlantic right whale off the east coast of North America. Recent reviews and analyses suggest the problem has not abated despite more than 10 years of US regulatory changes to the fishing industry. Both NOAA Fisheries and regional experts on large whales have concluded the same thing, which is that any ropes in the water column pose an entanglement risk to this species. As aquaculture operations expand into offshore waters, it will be important to consider the risk that particular gear components pose to right whales and other endangered species. To inform this process, we present an overview of the characteristics of right whale entanglements in lobster trap and gillnet gear based on more than three decades of monitoring right whales, and review various research projects undertaken to reduce their bycatch. This body of research can inform the development of potential bycatch mitigation approaches for offshore aquaculture gear, where needed, especially by considering particular gear components that are analogous in construction and deployment to those that have been involved in past entanglements.

PREPARATION OF SHELLFISH FOR DISEASE DIAGNOSTICS

Dale Leavitt and Roxanne Smolowitz
Roger Williams University, One Old Ferry Road, Bristol, RI 02809 USA

This hands-on laboratory will provide both practical experience and useful knowledge to culturist. In the first session, participants will examine the anatomy of 3 important bivalves, eastern oysters, surf clams (as a proxy for hard clams), and sea scallops. Participants will learn how to identify disease abnormalities and evaluate the animal's condition. The how and why of sample submission to a diagnostic lab will be discussed.

IN VIVO FLUORESCENCE BASED CHLOROPHYLL A MEASUREMENTS - HOW CLOSE ARE WE TO THE TRUTH?

Judy Li, Mark Dixon, Shannon Meseck, Barry Smith, Julie Rose and Gary Wikfors
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Food availability is one of the most important factors in bivalve shellfish aquaculture site selection, whether the goal is food production or ecosystem restoration purposes. Although bivalve shellfish consume bacteria, detritus, and small-sized zooplankton, phytoplankton is typically the most abundant food group available. Ways to measure the availability of food include cell abundance, chlorophyll *a* concentration and dry weight of particular organic matter in the water. These methods all involve collecting discrete water samples and processing samples in the lab. Alternatively, *in vivo* fluorescence based chlorophyll *a* estimate allows unattended continuous data collection. The high efficiency fluorescence method makes excellent temporal coverage possible, which is important given large temporal variability in phytoplankton abundance in the estuarine environment. There are, however, inherent problems associated with converting the fluorescence signal into chlorophyll *a* concentration. The taxonomical composition of phytoplankton assemblage and the physiological status of the community all affect the *in vivo* fluorescence. Moreover, the non-photochemical quenching of fluorescence at high irradiance causes the underestimation of chlorophyll a concentration during the day. Long-term time series of *in vivo* fluorescence data collected from Riverhead, Long Island, New York and Milford Harbor, Connecticut using a YSI sensor were corrected for non-photochemical quenching. Data collected from the East River tidal strait, New York did not seem to be greatly influenced by the non-photochemical quenching. The turbid condition at the East River tidal straight may be shielding phytoplankton community from high irradiance during the day.

FACTS AND FIGURES FOR FARMING, BUSINESS PLANNING AND MARKETING MUSSELS

Scott Lindell[1], David Bailey[1], Michael Chambers[2] and Richard Langan[2]
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Aquaculture production of mussels has been conducted in US nearshore protected waters for decades, however, expansion has been limited by space constraints and competing activities. Over the last 10 years there has been an accumulation of data about what it takes to farm mussels in less protected waters offshore. Here we present different scenarios and plans including start-up, scale-up and mature business models for practical guidance and expectations for operating an offshore mussel farming businesses in New England. We will also share the latest sales and marketing data available along the Eastern seaboard.

MUSSEL FARMING IN STATE AND FEDERAL WATERS OF SOUTHERN NEW ENGLAND

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[2] American Mussel Harvesters, 165 Tidal Drive, N. Kingston RI 02852 USA

There is a growing market for fresh mussels ($30 to $40 million/yr) in the United States, of which 85% is presently served by farmed imports from Canada. Domestic wild supply is limited. New England shellfish farmers could capitalize on the many advantages they have over Canadian producers including faster growth to market size, shorter distance to market, and better meat yield for prime summer markets. This presentation will address the opportunities, constraints and the progress to date for creating a vibrant mussel farming industry in Southern New England (SNE) waters, including new permits in Federal waters.

WHAT WE CAN LEARN FROM ENTANGLEMENT CASES OF WHALES AND TURTLES IN MUSSEL FARMING GEAR

Scott Lindell[1] and David Bailey[1]
[1] Scientific Aquaculture Program, Marine Biological Laboratory, 7 MBL Street, Woods Hole, MA 02543 USA

As the social and economic pressures to farm the oceans increases, there is an increasing need to understand the potential risk posed between new structures and protected species that roam those areas. A summation of the literature and informal interviews yielded a few but mostly not very well-documented cases of entanglement of whales or turtles in mussel farming gear. Either entanglements are rare or they may go unreported. Nevertheless, lessons can be drawn about the nature of the documented entanglements and the gear involved to draw some conclusions about how these interactions can be avoided.

VIABILITY OF *PERKINSUS MARINUS* IN SEAWATER

Joseph Looney[1], Lauren Huey[1], William Schroer[1,2], Tal Ben-Horin[1], Daphne Munroe[1] and David Bushek[1]
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Understanding the inactivation kinetics of pathogenic microorganisms in seawater is essential for predicting the spread of infectious diseases through populations of fish and invertebrates. The protozoan *Perkinsus marinus* causes significant mortality in its ecologically and commercially important host, the eastern oyster *Crassostrea virginica*. As part of a broader effort to develop predictive models of disease transmission and spread in marine systems, we inoculated an environmental *Perkinsus marinus* isolate (ATCC® strain 50509, "DBNJ") into sterile filtered seawater microcosms at varying salinities (15, 20 and 25 ppt), and fitted daily cell viability data to competing models of pathogen survival. We found the survival of *Perkinsus marinus* to increase with salinity, a result that echoes patterns of this pathogen's virulence across estuary salinity gradients. Our results also suggest that the rate of pathogen inactivation increases with the amount of time cells are in seawater. These results provide new insights into the transmission of *Perkinsus marinus* and will be used to improve ongoing efforts modeling the transmission and spread of marine diseases.

THE BILLION OYSTER PROJECT: ENGAGING MIDDLE AND HIGH SCHOOL STUDENTS IN THE RESTORATION OF A DEGRADED ESTUARY

Peter Malinowski
New York Harbor School Battery Maritime Building, Slip 7, 10 South Street, New York, NY 10004 USA

Students in the Aquaculture Program at the New York Harbor School will present their work on the Billion Oyster Project (BOP). The students will first present as a group, general information about the project. This will include the history of oyster restoration in New York Harbor, Harbor School's work to date and the development of the BOP. The Aquaculture students will discuss how they work with other Career and Tech Ed programs at Harbor School to restore oysters to New York Harbor. There will also be a detailed overview of the oyster cultivation process and the future plans of the BOP. Students will each present short (five minute) explanations of their own research projects. These projects are designed to better understand and improve on the oyster cultivation techniques employed by the school. Students will lead the audience in an oyster gardening workshop. This will be an abbreviated version of the training that middle school teachers receive before they can participate in the oyster gardening program. Participants will measure oysters, learn to test basic water quality parameters and dissect and eat oysters.

ESTABLISHING OFFSHORE MUSSEL FARMS IN FEDERAL WATERS

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For the past 2 years we have been working through the permitting process to obtain an Army Corps of Engineers (ACOE) permit pursuant to Section 10 of the Rivers and Harbors Act of 1899 to establish a commercial scale (33 acre) offshore mussel farm 8.5 miles off the coast of Cape Ann Massachusetts (NAE-2012-1598 NEMAC Aquaculture). We plan to begin deployment of 1 to 3 longlines this spring as a pilot research study to explore best practices for offshore shellfish aquaculture as well as monitoring potential fishery and habitat enhancement effects attributed to shellfish aquaculture in offshore waters. This site is within the Northern Temporary Paralytic Shellfish Poison Closure Area (50 CFR Part 648). We will acquire a Letter of Authorization (LOA) to conduct research on controlled experimental harvests to provide samples to indicate the PSP toxin levels are below the regulatory limit necessary to allow commercial harvests. After this initial pilot research study, we plan to expand the number of longlines to a commercial scale farm with 32 to 400 ft longlines. Our ultimate objective is to refine and enhance offshore mussel culture as an alternative fishing option for fishermen and lobstermen currently displaced or negatively impacted by current fishery restrictions by providing an incubator farm site for interested parties to try offshore aquaculture. This report will focus on the process of securing an ACOE permit to establish offshore shellfish farms in federal waters and disseminate what was learned about this process to others wishing to pursue offshore shellfish aquaculture.

A PRELIMINARY ASSESSMENT OF THE EFFECT OF INCREASED SEAWATER ACIDITY ON JUVENILE BAY SCALLOPS (*ARGOPECTEN IRRADIANS IRRADIANS*) FROM TWO GENETIC LINES

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Geographically isolated populations of the bay scallop *(Argopecten irradians irradians*), may exhibit differential resistance to developmental inhibition and mortality caused by ocean acidification. The determination of pH-resilient genetic lines for wild stock supplemental aquaculture would aid ongoing population conservation efforts. For this purpose, juvenile scallops from the F_2 generation of two genetic lines, one from Niantic, CT broodstock and the other from Nantucket, MA broodstock, were exposed to seawater of increased acidity with CO_2 in a short-term study. Three replicates each of 35 F_2 Niantic scallops and three replicates each of 35 F_2 Nantucket scallops were maintained in beakers of seawater with a pH of 7.9 as controls, for 6 days. Simultaneously, similar groups of juvenile bay scallops were maintained in seawater with a pH of 7.5, as experimental groups. *Tetraselmis* was drip fed into the system. The effect of acidified seawater on the growth of the scallops was measured by individual shell length at the beginning and end of the study. Scallops from the CT broodstock grew larger in both control and acidified seawater than the scallops from the MA broodstock. There was negligible mortality in all groups. Thus genetic background might be a relevant factor, in addition to environmental parameters, in predicting juvenile scallop growth under various conditions. Should continued investigations yield similar results, a well-adapted genetic line could be developed for aquaculture and conservation.

DEVELOPMENT AND APPLICATION OF A DUPLEX QPCR FOR THE DETECTION OF *VIBRIO PARAHAEMOLYTICUS* AND *VIBRIO VULNIFICUS* IN ENRICHED OYSTER HOMOGENATES FROM RHODE ISLAND AND MASSACHUSETTS

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Increased summer water temperatures have heightened human health concerns for the shellfish aquaculture industry. Increased temperatures potentiate a proliferation in the growth of *Vibrio parahaemolyticus* (Vp) and *Vibrio vulnificus* (Vv) in cultured oysters. The Aquatic Diagnostic Laboratory (ADL) at Roger Williams University in Bristol, RI has been monitoring Vp and Vv levels in two local oyster farms (one in RI and one in MA) during the summer of 2014. Samples from these sites were processed using traditional 3-tube MPN along with MPN-qPCR. The qPCR technique used is a duplex assay for both Vp and Vv, using the general *tlh* gene for Vp and the *toxR* gene for Vv. The assay was developed in 2013 in the ADL and continues to be an accurate and reliable method. Post-enrichment MPN samples were cultured using TCBS and Vibrio CHROM agar to verify the presence of the Vv and Vp. An efficient and reliable DNA extraction method has been determined for post-enrichment MPN samples. The method focuses on comparing qPCR data from a subsample of the 10g sample of enriched oyster homogenate with the 3-tube MPN using the duplex qPCR. Highlights of results to date will be presented.

PREVALENCE, INTENSITY AND MOLECULAR DETECTION OF THE TREMATODE *PROCTOECES MACULATUS* IN *MYTILUS EDULIS*

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The digenetic trematode *Proctoeces maculatus* (Looss 1901) is a pervasive parasite of numerous mollusc and fish species. Infections of sporocyst stage *Proctoeces maculatus* are predominately found in the mantle tissue of molluscan hosts such as *Mytilus edulis*. Although it is not well studied, it has been suggested that infection by this trematode may contribute to mussel mortality. The purpose of this study was to assess the prevalence and intensity of *P. maculatus* parasitism in mussels from several sites along coastal Long Island, NY, and from a few sites further north along the New England coast. Finally, we wanted to develop a species-specific molecular assay to detect these trematode parasites in mussel tissue. We sequenced a region of the 18S rDNA and used this to develop a molecular assay for detection of *P. maculatus*. Overall our results from microscopic and molecular

detection of the parasite suggest that trematode intensity is much greater than previously reported. Parasitization of the mantle tissue may reach 350 sporocysts/100mm^2 in some mussel populations. Even when there is no evidence of either live sporocysts or cercaria, remnant sporocysts are often found in mussels. Climate change may be contributing to a northern range expansion for this parasite, as they are found in mussel populations from New England, with potential impacts on mussel aquaculture.

EASTERN MAINE SKIPPERS PROGRAM: 21ST CENTURY PEDAGOGY FOUND ON THE WATER, ON THE SHORE AND IN EASTERN MAINE SCHOOLS

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In 2012, Deer Isle Stonington High School and Penobscot East Resource Center collaborated to create the Eastern Maine Skippers Program (EMSP). EMSP is a regional program which aims to provide aspiring commercial fishermen in schools from North Haven to Eastport the skills needed to be successful fishermen in a time of rapid environmental and regulatory change. A cohort of more than 40 students from the eastern Maine high schools of Vinalhaven, North Haven, Deer Isle-Stonington, Ellsworth, MDI, Narraguagus, and Jonesport-Beals as well as George Stevens Academy remain in their schools and collaborate in the program via technology-based "anytime, anywhere" learning. Students in the Eastern Maine Skippers Program learn as a community alongside teachers, fishermen, and other local marine professionals in school, on shore, and on the water. They develop and use the leadership skills, knowledge, and expertise to speak for themselves, their communities, and the fisheries. The program produces graduates who are flexible and adaptive fishermen and can advocate for the resource, the industry, and their communities. Focus points of the EMSP allow for the students to learn skills which can be useful and on display at industry, research, and educational meetings while advocating their position based on their fluency with EMSP collected data and data obtained from various research projects on state, national, and international levels. Short term research projects for the students, such as this year's Green Crab marketing/mitigation project, allow for local data collection and regional problem analysis.

PREVALENCE OF THE OYSTER PARASITE MSX IN THE DAMARISCOTTA ESTUARY DURING 2012

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The cultivation of oysters represents a multi-million dollar industry within the state of Maine. Parasite diseases had previously affected the oyster industries around the Chesapeake and Delaware Bays for over 40 years. It appeared that the cooler waters of the Gulf of Maine would keep these parasites at arms length. However, in 2010 the oyster parasite MSX was reported in the Damariscotta Estuary resulting in significant mortalities. One of the control measures implemented to limit the impact of the parasite was to switch the preferred oyster strain being used in the commercial operations to one that was more resistant to MSX which occurred in 2011. In 2012 we began a study on the prevalence of the parasite within commercial and natural beds in the Damariscotta Estuary. In this presentation we will show our findings and discuss the issues.

SCREENING BIOFOULING ORGANISMS AROUND OYSTER CAGES FOR POTENTIAL RESERVOIR SPECIES OR INTERMEDIATE HOSTS OF THE OYSTER PARASITE MSX IN THE DAMARISCOTTA ESTUARY

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In 2010 the oyster parasite MSX was reported in the Damariscotta Estuary resulting in significant mortalities. Whilst there are many studies on this parasite very little is known about its life cycle as it has proved impossible to transfer the infection to naive oysters. This has always indicated that an intermediate host is necessary. In an effort to identify potential reservoir species or even an intermediate host, we screened local biofouling organisms and plankton samples for the presence of the parasite. Using PCR techniques we found no obvious candidates for either reservoir species or intermediate host, although the parasite did seem to be present at low levels in some of the samples

COPING WITH COPIOUS FRESHWATER IN MIDCOAST

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While the global ocean acidification process is inexorably occurring, in nearshore coastal areas other acidifying forces can eclipse it. The most publicized example of this occurs on the West Coast, where wind driven upwelling of acidic waters caused the near collapse of the oyster industry in Washington. Another nearshore effect of increasing atmospheric greenhouse gases may account for observations of oyster larvae performance made at Mook Sea Farm (MSF), on the Damariscotta River in Midcoast Maine. Over the last 50 years the northeastern U.S. has experienced an increase in both annual precipitation and the frequency of large precipitation events. At MSF, reductions in larval feeding and growth were observed to occur in conjunction with storms resulting in large amounts of freshwater runoff. Over the course of several years a suite of changes in larval culture techniques have been tested and made part of MSF's standard protocol. All of these changes are aimed at improving carbonate chemistry parameters experienced by the larvae, and in the 2014 production season they were applied consistently to all spawns. In sharp contrast to other years, every larval cohort reached setting size in 14-16 days, and conversion rates from larvae to post-set averaged over 60%. Starting in April 2014, monitoring equipment was installed on MSF's intake line to continuously measure (and calculate) key carbonate parameters. The results suggest that natural populations are experiencing sub-optimal conditions as determined by recent studies. This raises questions about genetic adaptation and recruitment success of natural shellfish populations.

MAKING THE LEAP: STRATEGIES, PEOPLE AND RESOURCES TO HELP YOU GO FROM PART-TIME TO FULL-TIME IN AQUACULTURE

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Perhaps you have a small oyster or clam farm, or you sell a few baitfish on the side to supplement your income, and because you love working in aquaculture. What happens when you want to make this your full-time income,

or at least much more of your daily work, than it presently is? This leap into more full-time activity is often a challenging and scary time for aquaculture businesspeople, and everyone wants to find success. As always, good planning can really help, and knowing the right people to turn to for advice and business services can make the difference between profitability, and 'back to your old job.' This session will help you to anticipate some of the likely challenges that you'll face when making this transition, and how to prepare as fully as possible, so that the job you love to do, can actually become your daily job.

PROGRESS IN AQUACULTURE OF SEA SCALLOPS (*PLACOPECTEN MAGELLANICUS*) IN MAINE

Dana Morse[1], Togue Brawn[2], Marsden Brewer[3], Terry Gray[4], Mark Green[5], Kohl Kanwit[6], Nate Perry[7], Kevin Scott[8], Peter Stocks[9] and Evan Young[10]
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Progress in the production of sea scallops (*Placopecten magellanicus*) in Maine has been rapid in the years 2011-2014, spurred by a combination of changes in the regulatory environment and support at the state level, and through collaborations between shellfish growers, commercial fishermen and extension professionals. The results to date have shown that sea scallops can be sourced, grown and sold successfully and safely, and initial returns indicate that scallop production can be a profitable enterprise. Significant contributions to local knowledge have also come through conversations with scallop producers in Atlantic Canada and Japan. Presently, scallops are in production on seven Maine shellfish farms, and recent grant support will advance understanding of market conditions and preferences. Importantly, by virtue of the scallops' ability to absorb and retain high levels of biotoxins, the sale of live/whole/roe-on scallops represents a unique risk, and the importance of proper product testing and knowledgeable producers cannot be overstated. This presentation will review practices for spat collection and production technologies, biotoxin testing and regulatory requirements, public health risk, markets, and shipping.

US/CANADA ROUNDTABLE ON COLLABORATIONS TO SOLVE COMMON PROBLEMS

Dana Morse[1] and Don Webster[2]
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There's nothing like a chance for farmers to talk one to another, in identifying common issues and to discuss ways of solving problems. This session will feature a panel of producers from both sides of the border, and an open discussion of issues that limit production and profitability, and how we might work together to find solutions. Come and add your own voice to this session, meet your counterparts, and help growers take a step forward.

STRUCTURAL AND FUNCTIONAL ADVANTAGES OF *CIONA INTESTINALIS* FOR USE AS FISH FEED

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Ciona intestinalis is found on every continent but Antartica. Biological risk assessments such as those conducted by Therriault and Herborg (2008) and Madariaga et. al. (2014) indicate how *C. intestinalis'* ability to tolerate a wide variety of conditions makes it particularly suited as an invasive. Because of its rapid growth rates and capacity for fouling gear it has serious economic impacts for fishing and aquaculture industries. *C. intestinalis* management practices range from mechanical or manual removal to chemical treatment which in the case of aquaculture leads to higher product prices. One option that many have tried is using *C. intestinalis* as a source of fish feed. In some cases this polyculture approach to *C. intestinalis* can possibly lead to the reduction of management costs and has the potential of providing an additional revenue source for the aquaculture industry. This study examines the established techniques for using *C. intestinalis* as feed, and focuses on our work on the structural and functional properties of *C. intestinalis* . These unique characteristics would seem to indicate that *C. intestinalis*, as a feed source, may provide more advantages than simply the economic and nutritional properties of a low cost fish feed. Rather than a problem of biofouling for aquaculturaists C*iona intestinalis* may in fact be a useful element of polyculture systems.

UPWELLING OF ACIDIFIED WATER: NOT JUST AN ISSUE FOR SHELLFISH HATCHERIES ON THE WEST COAST OF THE US

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Periodic summer upwelling events are known to occur off the coast of New Jersey. As with upwelling off the US West Coast, these events can transport deep, acidified water to the surface and shoreward. To determine if upwelling events have the potential to impact shellfish hatcheries in New Jersey, a monitoring study was conducted at the Aquaculture Innovation Center (AIC) of Rutgers University. The AIC is an important research hatchery that currently supports the New Jersey oyster aquaculture industry through the production of disease resistant and triploid seed oysters. Starting in June of 2014, temperature, salinity, dissolved oxygen, turbidity and pH were continuously monitored at the AIC's intake pipe located in the Cape May Canal. Periodic duplicate grab samples were also collected at the intake and at locations within the facility. One of each duplicate grab samples was preserved and analyzed for pH and dissolved inorganic carbon (DIC), whilst the other was preserved for analysis of the planktonic community. DIC and pH were used to calculate the aragonite saturation state of the sampled water. During an upwelling event in early July, a decrease in pH was measured at the intake. Likewise, grab samples showed that water of low pH and aragonite saturation was entering the facility. These results show that hatcheries along the NJ coast need to be aware that upwelling may bring reduced shellfish production conditions, and highlights the need for continued monitoring.

MODULAR LARVAL REARING SYSTEM FOR INTEGRATING AQUACULTURE INTO PUBLIC AQUARIUMS

Zack Murphy[1], Jake Phillips[1], Timothy Gerson[1], Bradford Bourque[1], Joseph Szczebak[1] and Andrew Rhyne[1,2]

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Public aquariums create long-term and stable environments for fishes that spawn regularly. As such, public aquariums create unique opportunities to collect eggs and rear larvae of a variety of fishes important to public aquariums, the marine ornamental industry, and food fish aquaculture. Through collaboration between New England Aquarium (NEAq) and Roger Williams University (RWU), funded by the Institute for Museum and Library Sciences, the Modular Larval Rearing System (MoLaRS) was developed as a training tool for public aquariums and a means to raise larvae in a compact system. To date, MoLaRS has been used to raise neon gobies (*Elacatinus oceanops)*, ternate chromis (*Chromis ternatensis)*, blue damsels (*Chrysiptera cyanea)*, numerous species of clownfish (*Amphiprion* spp.), Catalina gobies (*Lythrypnus dalli)*, black sea bass (*Centropristis striata*), tautog (*Tautoga onitis*), cunner (*Tautogolabrus adspersus*), and scup (*Stenotomus chrysops*). Our ability to produce fish in large numbers has increased immensely since the introduction of this system. For example, RWU used MoLaRS to supply the NEAq with 2,000 small mouth grunts (*Haemulon chrysargyreum*) for the Giant Ocean Tank. Furthermore, RWU hosted and operated several workshops in 2013-2014 for public aquarium employees across the country that trained aquarium personnel on all facets of larval fish rearing, introduced them to MoLaRS, and provided them with their own MoLaRS for their respective institution. Presentation of this system and the success we have had will expand to our peers a compact and versatile fish rearing system to take advantage of unique fish rearing opportunities at public aquariums and similar institutions.

PRODUCTION MODELING AND SITING FOR MUSSEL AND OYSTER FARMS IN THE NORTHEAST

Carter Newell
Maine Shellfish R&D, 7 Creek Lane, Damariscotta, ME 04543 USA

The productive capacity of shellfish farms is a function of site specific biophysical factors, culture technology, and farm management. This talk will review key parameters for choosing and managing a successful suspended or bottom cultured mussel or oyster farm, and present models and GIS platforms which allow for maximum productivity and environmental sustainability.

HYDRODYNAMICS AND MUSSEL RAFT TECHNOLOGY

Carter Newell
Maine Shellfish R&D, 7 Creek Lane, Damariscotta, ME 04543 USA

Mussel rafts are the culture technique of choice for blue mussels in the northeast due to the presence of eider ducks and the ability to grow lots of mussels in a small area and protect them using predator nets. This talk will review the effects of ambient and aquaculture structure hydrodynamics on the food supply and demand of mussel rafts, the effects of predator nets on mussel raft productivity, and the development of a submersible mussel raft for use in semi-exposed waters subject to drift ice.

SHELLGIS WORKSHOP

Carter Newell[1], Kevin Morris[2], John Richardson[3], Christopher Davis[4] and Tessa Getchis[5]
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ShellGIS is a desktop-based software tool which, for choice of 14 commonly cultured shellfish species, enables dynamic predictions of shellfish production, environmental effects and profitability according to culture practice and site selection within given a detailed coastal GIS domain. This software will be presented in a workshop where the data, assumptions, background models, and calibrations will be presented, followed by a live demonstration of the software and grower's user interface using the American oyster in the Damariscotta River, as an example.

AQUACULTURE STANDARDS AND CERTIFICATION

Cormac O'Sullivan
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There has been a significant development of Aquaculture Standards in recent years, in attempts to address perceived concerns about sustainability of farmed products. Aquaculture Standards are covering everything from Environmental Responsibility, Food Safety, Traceability, Organics, Worker Welfare, Community, Social Responsibility and Fish Welfare. Some Aquaculture Industry sectors have been certified to Standards for over 10 years and these range from Second Party Private Label Standards to Third Party Accredited Standards, which commonly involves annual audits on farms and facilities to demonstrate compliance to the standards. Some Industries have used Standards as a means of gaining and securing market access, whilst others have used it to gain a price differential with their product. Standards convey different messages to retailers and consumers and there can be some confusion on what standards actually represent in Aquaculture. Some markets have very specific requirements and consequently the need for a range of standards exists. Most retailers have clearly defined Seafood Sourcing policies and very clear direction on which standards are preferred when supplying the public, to the point that some retailers have developed their own standards for aquaculture. There has also been the development of Consumer Buyers Guides which serve to assist consumers with more ethically produced seafood products. There has been a move to rationalize the range of Aquaculture and Seafood Standards and achieve some common benchmark, with a number of global initiatives currently in progress such as The Sustainability Consortium and the GSSI (Global Sustainable Seafood Initiative).

ARE THE AQUACULTURE PRACTICES SUSTAINING OUR GOAL TO RESTORE OYSTERS (*CRASSOSTREA VIRGINICA*)?

Gulnihal Ozbay, Brian Reckenbeil, Frank Marenghi, and Patrick Erbland
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Decline of eastern oyster stocks along the east coast of the United States, particularly in the Mid-Atlantic area, have prompted the implementation of many types of restoration efforts. Delaware's oyster gardening program cooperates with volunteer growers in the three coastal bays of the Delaware Inland Bays. Research efforts in the DIB have focused on monitoring oyster growth and survival, water quality conditions, species diversity and abundance in and around oyster aquaculture and riprap habitats. Riprap is designated as the final destination of oysters cultured by the volunteer oyster gardeners. Our research effort provides baseline information on the ecological value of oyster aquaculture in Delaware's Inland Bays. We found newly settled juvenile oysters for the first time within floating oyster gear in man-made, residential canal systems, and on riprap shorelines around

the DIB. Many species of economic and ecological importance are considered habitat-limited in the Inland Bays, particularly regarding juvenile refugia and forage areas. Oyster aquaculture gear can provide habitat for these native estuarine fauna at small scales, while supplementing oyster spawning stocks and enhancing natural recruitment, without difficult and costly types of habitat modifications. Although aquaculture sites or gears are clearly not structurally or functionally equivalent to natural reefs, research conducted over eight years in Delaware Inland Bays revealed the diversity of species found in and around oyster culture sites to be quite encouraging. As enhancement and restoration efforts of oysters move forward, it is important to understand the impacts of oyster aquaculture on the surrounding habitat and biological community.

PRODUCTION OF THE FIRE SHRIMP *LYSMATA DEBELIUS* USING A CLOSED-LOOP RECIRCULATING LARVAL REARING SYSTEM

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[2] John H. Prescott Marine Laboratory, The New England Aquarium, Central Wharf, Boston, MA 02110 USA

The fire shrimp, *Lysmata debelius*, is one of the top marine invertebrates sold in the aquarium trade. Wild capture of fire shrimp from Sri Lanka is the primary source to the aquarium trade and aquaculture of this species would help prevent over-exploitation of wild populations. To date, large-scale aquaculture of fire shrimp has been bottlenecked by the long planktonic larval stage in combination with strong juvenile aggression. A closed recirculating larval rearing system was developed to optimize the production of this species. The design and operation of this rearing system have increased production efficiency to a potentially commercial-scale level. Larvae are hatched directly into the larval system and are evenly distributed throughout the rearing tanks. The shape and water flow dynamics of the larval rearing tanks suspends shrimp within the water column without damaging their delicate appendages, which greatly affects survival and growth. Fire shrimp larvae are fed N1-stage *Artemia* for the duration of the larval period. The system is equipped with changeable overflow screens, which allow retention of N1 *Artemia* for feeding and removal of N2+ *Artemia* before the next feed. Post-metamorphisis shrimp are weaned onto a pellet diet. Survival rates have exceeded 75% using this system while previous production techniques averaged below 10%. The time to metamorphosis has also improved from over 160 days to less than 60 days, and over 800 of juveniles have been produced from a single hatch using these methods.

ACIDIC MUD AND CLAM SHELL PITTING IN CASCO BAY, MAINE

Joe Payne
Friends of Casco Bay/Casco Baykeeper, 43 Slocum Drive, South Portland, ME 04106 USA

Soft shell clam (*Mya arenaria*) harvesting is the third largest fishery in Maine and important to the coastal economy. Research has shown that clam spat can dissolve in low pH (acidic) mud. It is also known that clam spat can reject settling on mud if the conditions are unfavorable, including low pH. In order to determine if there were flats in Casco Bay with acidic mud, we did a survey checking pH at the tidal midpoint on 30 clam flats. Results showed that most of the flats had pH levels significantly below the ambient water pH. Some mud had pH levels at or lower than laboratory values that caused complete dissolution of clam spat. Next, we sampled one flat more intensively checking pH at five stations on a transect from high tide to low tide. We did this twice a month from June through September. The pH varied with seasonal temperatures but the relative trend was stable through all months: the pH continually decreased from the high tide zone toward the low water mark. Mud samples were also taken and the pore water analyzed for dissolved inorganic carbon and total alkalinity; then pH and $\Omega_{aragonite}$ were calculated. There was strong correlation between the field pH and the calculated pH, and between the field pH and

$\Omega_{aragonite.}$ Lastly, hatchery clam spat were set out at the same flat then recovered after one week. Heavy pitting was observed. Natural spat were collected at the same location and pitting was also observed.

JUVENILE SCUP, *STENOTOMUS CHRYSOPS*, ARE RESILIENT TO INCREASING OCEAN ACIDIFICATION

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Increasing amounts of atmospheric carbon dioxide (CO_2) from human industrial activities are causing changes in global ocean carbon chemistry resulting in a reduction in pH, a process termed ocean acidification. Studies have demonstrated adverse effects on calcifying organisms, particularly some invertebrates, such as corals, sea urchins, pteropods, and coccolithophores. It is important to determine which species are sensitive to elevated levels of CO_2 because of potential impacts to ecosystems, marine resources, biodiversity, food webs, populations, and effects on human communities and economies. This study examined the effects of elevated partial pressure CO_2 (pCO_2) on the growth, survival, otolith (ear bone) condition and skeleton of juvenile scup, *Stenotomus chrysops*, a species that supports both important commercial and recreational fisheries. Elevated levels of pCO_2 (>1,300 μatm) had no statistically significant effect on growth, survival, or otolith condition after 8 weeks of rearing. While there appears to be a trend towards a greater gain in weight in scup exposed to the mid-level (1,726 μatm) and the high level (2,614 μatm) treatments of pCO_2 when compared to the fish in the control (1,205 μatm) treatments, the differences were not statistically significant. X-ray analysis of the fish revealed a slightly higher incidence of hyper-ossification in the vertebrae of a few scup from the highest treatments compared to fish from the control treatments. Our results show that juvenile scup are tolerant to increases in seawater pCO_2, possibly due to the conditions this species encounters in their naturally variable environment.

THE EFFECTS OF TEMPERATURE AND PHOTOPERIOD ON BLUE MUSSEL (*MYTILUS EDULIS*) HEALTH

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The blue mussel, *Mytilus edulis*, is an important aquaculture species in Maine. To help growers better understand the combined effects of photoperiods and temperature on *M. edulis* we maintained this species at the University of Maine's Aquaculture Research Center in 2 different photoperiods (16 h light/ 8 h dark and 16 h dark/ 8 h dark) and temperatures (5°C and 15°C) for 3 months. A treatment group was created for each temperature and photoperiod combination, each containing 2 tanks. Mussels were sampled 3 times during the duration of the experiments (n=14 per treatment) with 6 weeks between each sample point. We measured lysozyme content in the serum, superoxide dismustase (SOD) content in the gills, flesh to shell weight ratios, and mortality. For serum lysozyme levels, no significant differences were found between any of the treatments. SOD values were immensely elevated at the second sample point for both the 15°C treatments and then, at the third sample point, we observed a decrease down to values that were still at least twice the values found at the first sample point. SOD values for 5°C treatments varied by photoperiod treatment with the 16 h light cycle showing no difference and the 8 h light cycle showing a gradual increase as the experiment progressed. Flesh to shell weight ratios

decreased as the experiment progressed much faster in 15°C groups than it in 5°C groups. Mortality was much higher in the 15°C tanks than the 5°C tanks.

EEL DISEASES IN AQUACULTURE

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Maine's long-standing glass eel fishery has received prominent attention over the past several years due to the high prices, up to $2000 a pound, seen for glass eels. This attention has brought new interest in the glass eel fishery and regulatory scrutiny. Among the many questions arising is "why should we ship all of our glass eels to Asian aquaculture farms, when Maine has a strong aquaculture industry?" Recently, a team of eel fishermen, eel buyers, researchers, aquaculture specialists, regulators and entrepreneurs formed the Eel Aquaculture Team (EAT). This group held a workshop to explore the growing questions about the sustainability, marketing and aquaculture of native eels, *Anguilla rostrata*, in the Northeast. One issue that was clearly important was diseases and their role in aquaculture production; however the potential impacts of specific diseases on a new culture industry in the Northeast was not clear. Some diseases were clearly potential issues for wild fisheries such as the nematode *Anguillicoloides crassus*, while others such as gill parasites or *Vibrio anguillarum* might be an issue depending on the salinity of the water. As the culture of native eels is started in the region a better understanding of the potential diseases that may impact us here is important. This presentation will evaluate those diseases known to cause issues in both wild and cultured eels and present some risk assessment for future culture efforts in the region.

THE EUROPEAN GREEN CRAB – FINDING ALTERNATIVE USES FOR AN INVASIVE PREDATOR IN PRINCE EDWARD ISLAND

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Over the past decade and a half, the growth of green crab (*Carcinus maenas*) populations has become a concern to the sustainability of shellfish resources and healthy aquatic systems in Atlantic Canada. With most attempts at eradication in this and other regions proving unsuccessful, there is a distinct need for novel mitigation measures. Recently, the Department of Fisheries and Oceans (DFO) Canada established a fishery for green crab in Atlantic Canada, but the long-term viability of this fledgling fishery is questionable without the identification of suitable marketable products. The development of a "soft-shell" product is an attractive option that could mimic the successful soft-shell Blue crab industry in the USA and the soft-shell Mediterranean crab (*moleche*) industry in Venice, Italy. In order to assess its feasibility, a pilot project was initiated in PEI in spring 2014. Crabs were collected using both passive and active trapping methods and external physical characteristics were carefully identified and recorded based on traditional knowledge acquired from Venetian *moleche* fishers. Crabs were then held in individual compartments for 2 to 3 weeks and molting occurrence was observed. Initial results suggest synchronized "molting windows" during the spring (males) and autumn (females). Based on preliminary molting rates, a second phase of this study intends to work in co-operation with local shellfish processors to assess the feasibility of an economically viable and ecologically sustainable strategy based on molting recognition or induction in Green crabs.

CLASSIFICATION OF ATLANTIC RAZOR CLAM (*ENSIS DIRECTUS*) HEMOCYTES USING LIGHT AND TRANSMISSION ELECTRON MICROSCOPY

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The Atlantic razor clam *Ensis directus*, is currently being researched as a potential species for aquaculture operations in Maine. To help lay the foundation needed for future health studies in this species, we looked at the morphology of their circulating hemocytes using light and transmission electron microscopy (TEM). The 2 main types of hemocytes found were granulocytes (granulated cells) and hyalinocytes (agranular cells). The granulocytes were subdivided into eosinophils and basophils due to the respective pink and purple shades their cytoplasm turned when stained with Hemacolor. Hyalinocytes were subdivided into large hyalinocytes and small hyalinocytes (blast-like cells) based on their nucleus to cytoplasm ratios. The large hyalinocytes had a small nucleus to cytoplasm ratio while the small hyalinocytes had a very large nucleus to cytoplasm ratio. In TEM micrographs, granulocytes observed were filled with many small granules and vacuoles while large hyalinocytes had cytoplasm comprised of mostly empty space. Small hyalinocytes had very little cytoplasm and contained only a few mitochondria. Differential hemocyte counts showed that granulocytes are present in much greater numbers than hyalinocytes in this species. We found that *E. directus* contains all cell types previously described in the literature for the related razor clam species *Ensis siliqua* with the addition of the large hyalinocyte cell type.

ASSESSING THE EXTENT OF PHENOTYPIC VARIATION FOR DERMO RESISTANCE AMONG SELECTIVELY-BRED FAMILIES OF THE EASTERN OYSTER, *CRASSOSTREA VIRGINICA*

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Dermo disease impacts nearly every region where oysters are cultured in the Eastern U.S. and is a significant concern to industry stakeholders. Efforts to breed for Dermo resistance in the Eastern Oyster have had modest success, yet the range of existing phenotypic variation with respect to Dermo resistance among selectively bred families is not well characterized. The purpose of this study was to quantify the extent of phenotypic variation in the performance of *C. virginica* families upon exposure to the Dermo-causing parasite *Perkinsus marinus* under controlled conditions. Oysters (N = 48) from each of 23 families were subdivided into challenged (N = 24) and control (N = 24) groups. Challenged oysters were notched and injected with 5×10^6 cultured *Perkinsus* cells per gram wet tissue weight while control oysters were injected with sterile salt solution. The two groups were maintained in separate flowing static systems at 25°C and 25 ppt and mortalities were monitored each day for 42 days. Mantle, gill and digestive tissues were sampled from moribund oysters during the experiment as well as survivors at the end of the experiment to assess *Perkinsus* load. Mortality among challenged oysters varied by family and ranged from 42 to 100%. The difference in mortality between challenged and control groups also spanned a wide range across families (4 – 54%). These results suggest there is ample phenotypic variation in how oyster families respond to Dermo and will be coupled with parasite load data to identify which families best represent Dermo resistant oysters.

A HANDFUL OF EELS: SHARING INITIAL EXPERIENCES AND OBSERVATIONS OF *ANGUILLA ROSTRATA*

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Transitioning from wild to aquaculture conditions is an important step in raising eels. A small trial was started last spring with the 2014 eel season to transition *Anguilla rostrata* glass eels onto commercial feeds. Information from this trial on handling, survival, feed, grading, and growth will be shared.

DISEASE-RESISTANCE AND IMPROVED PERFORMANCE FOR GENETICALLY IMPROVED AND CROSS-BRED EASTERN OYSTERS *CRASSOSTREA VIRGINICA*: RESULTS FROM A DECADE OF FIELD TRIALS IN NEW ENGLAND

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Substantial effort has been expended over the past five decades to develop genetically improved lines of eastern oysters (*Crassostrea virginica*) and has resulted in the production of several lines that demonstrate enhanced survival under specific disease pressures. In two field trials, we investigated the relative performance of the Rutgers University NEH, University of Maine UMFS, and Clinton lines, and interline hybrids when grown at sites across New England. Line performance in both trials was highly site-specific; while there were significant differences in growth between sites, there was only subtle growth variation among lines. In contrast, line performance was heavily dependent on survival which was, in turn, dependent on disease pressure and line-specific disease resistance at each of our grow-out sites. Hybrid lines displayed very little, if any, improvement in growth relative to parental lines, and inherited varying degrees of disease resistance depending on the particular disease pressure experienced at a site. The differences in line performance are indicative of a high degree of genotype by environment interaction for survival and yield among the parental and hybrid lines. The prevalence of such interactions suggest that regional breeding programs should take advantage of the superior characteristics of the extant lines, but will need to consider alternatives to mass selection in order to build a breeding program that benefits growers and hatcheries throughout the region.

EXPERIMENTAL SYSTEM DESIGN FOR STUDYING THE EFFECTS OF ELEVATED LEVELS OF CO_2 ON VARIOUS MARINE SPECIES

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At the NOAA laboratory in Milford, CT we have constructed a replicated flow-through seawater system capable of exposing an array of marine organisms to various levels of pCO_2. The system uses water pumped into the lab from the Wepawaug River which is then sand-filtered and mixed with either heated or chilled seawater to achieve the desired water temperature. The system allows users to choose two treatment levels and a control which each feed three replicate 76 liter aquariums. Two 7' (2.1 m) sections of 4" (10.16 cm) PVC pipe mounted vertically side by side make up the saturation chamber for each treatment. The level of pCO_2 is achieved for each treatment

by mixing the correct ratio of compressed air with research grade CO_2 using mass flow controllers. The system can be setup to run in a flow-through mode which provides 1 liter per minute of seawater to each aquarium, or can be run statically. To date we have exposed blue crabs, *Callinectes sapidus,* black sea bass, *Centropristis striata,* scup, *Stenotomus chrysops,* and larval bay scallops, *Argopecten irradians,* to various levels of pCO_2 in the system. For monitoring the pH levels we have constructed an automated sampling system that utilizes an Ocean Optics USB 2000+® spectrophotometer connected to a rotary and a syringe pump. The monitoring system uses National Instruments LabVIEW 2010® as an operating platform. Future plans include exposing other species indigenous to Long Island Sound and also some of same species but at different life stages.

SEAWEED FARMING IN THE NORTHWEST ATLANTIC: A ROUNDTABLE DISCUSSION

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The developing seaweed aquaculture industry in the US and Canada has great potential to provide new products, technologies, and opportunities for our coastal and inland communities. The unique combination of people with diverse backgrounds and experience along with a long history of traditional use of native seaweeds gives the Northeast US and Atlantic Canada an advantage and an opportunity to create a viable and thriving new industry. Join us in a roundtable discussion about macroalgal cultivation as we share experiences and ideas in order to create a stronger network of farmers, researchers, and entrepreneurs in the US and Canada.

INTRODUCTION TO THE KELP FARMING TECHNOLOGIES: OPEN WATER FARMING

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The development of a commercially viable seaweed aquaculture industry in the Northeast is providing new opportunities for coastal communities, supplying healthy sustainable seafood, and contributing to resilient waterfront economies. Kelp aquaculture, in particular, is promising in the Northeast, given its winter growing season, fast growth rates, and its coastal integration potential. Kelp is cultivated on leased sea farms on simple horizontal long lines with minimal impact to other coastal zone users, and can be grown alone or as the inorganic extractive component of integrated aquaculture systems. The submerged long line system currently in use in the Northeast has been developed to minimize navigational impacts in the coastal zone, but there are many different designs for farming systems in use in other countries. We will review kelp farm designs used around the world, and include some discussion on seeding, husbandry, and harvesting technologies.

FRESH LOCAL SHRIMP IN THE NORTHEAST: CAN RECIRCULATING SYSTEMS MAKE IT HAPPEN?

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The United States imports about 90% of the shrimp consumed, creating a trade deficit of greater than $5 billion directly related to shrimp products. The average American consumes 4.2 pounds of shrimp annually, and with such demand a consistent local source of quality shrimp should be an easily marketed high value product in the Northeast. While successful culture of *Litopenaeus vannamei* has been demonstrated in ponds in the southern US, recirculating aquaculture systems offer the needed environmental control to allow warm water species to be grown in the Northeast. Recent work has shown super-intensive shrimp culture systems with biofloc management to have potential, but less is known about culture potential for shrimp in more traditional recirculating systems in the Northeast. A series of trials were conducted in retrofitted tilapia and koi production recirculating systems to see if *L. vannamei* could be grown cost effectively in low salinity water. A nursery system was employed to gradually acclimate post larvae (PL_{12}) to low salinity water and advance growth. Survival and growth suffered in the first nursery trial due to poor water quality, though in a second trial survival improved from 7% to 86%, with growth improved as well. Grow out trials are nearing completion and will be discussed in relation to other forms of production in the literature.

COMMON MISTAKES FOR NEW GROWERS TO AVOID

Robert Rheault
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Veteran growers have typically experienced a number of costly pitfalls that might have been avoided, but for ignorance, arrogance or a lack of capitol. This presentation will describe a variety of common and expensive errors often made by new growers, along with preventative tips, best management guidelines and advice so that prospective new growers can avoid repeating them.

NICHE MARKETING CULTURED OYSTERS

Robert Rheault
East Coast Shellfish Growers Association, 1121 Mooresfield Rd., Wakefield, RI 02879 USA

There are several key factors that go into the development of a brand and successfully marketing that brand. The author will describe key steps in developing a brand, separating one's product from the competition, identifying one's customers and communicating the virtues of that brand to the buyers. Important subjects will be discussed including: quality control, sorting, packaging and guerilla marketing on a budget. The author will discuss how to identify new customers and how to deliver your product affordably. Following these steps will help new growers compete with established brands in the various segments of the retail and wholesale market chain.

WHY OCEAN ACIDIFICATION MAY NOT BE THE END OF SHELLFISH

Robert Rheault
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Ocean acidification (the result of anthropogenic carbon dioxide emissions) is often conflated with other phenomena that also cause corrosive conditions, such as the upwelling of deep acidic ocean waters and eutrophication-induced acidification of estuarine waters and sediments. The author will describe the similarities and differences between these conditions, making the case that some are issues of immediate and pressing concern, while others are unlikely to be major factors for shellfish farmers on the east coast. Drawing on several lines of evidence the author will point out why he is less concerned about the impacts of ocean acidification and

more concerned about the impacts of eutrophication-induced acidification. He will point to the need for better scientific experimentation to determine how these processes will impact both wild shellfish populations and shellfish aquaculture so that we can mitigate and adapt to acidic conditions in the decades ahead.

SHELLFISH FARMING 101

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Initiating a shellfish culture operation can be quite challenging. This workshop will focus on several of the basic concepts that new growers must face when starting a shellfish aquaculture business. The session will cover the basics of shellfish animal husbandry; an overview of nursery and growout techniques for clams and oysters; common mistakes for new growers to avoid; recordkeeping makes good business sense; addressing hazards in shellfish farming/biosecurity; and niche marketing for oyster growers.

MODELING FLOW THROUGH AQUACULTURE FARMS

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Increasing the productive capacity of aquaculture farms requires a thorough understanding of flows that are affected by the design of gear used in culture operations. This talk will explain the application of Computational Fluid Dynamics (CFD) modeling techniques used to solve problems related to the siting and design of aquaculture operations. At several locations in Maine, the results of CFD analyses have been used to determine the optimal number of ropes suspended from rafts used to grow mussels and to aid in the design of mooring systems used to keep the rafts in place. At other locations, the results of these studies have been used to determine the best placement of gear within a given lease site.

HIGH BRIGHTNESS LEDS DETER EIDER PREDATION AT MUSSEL RAFTS

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Predation by Common Eiders (*Somateria mollissima*) is a significant limiting factor for blue mussel (Mytilus edulis) aquaculture, and is a particularly challenging problem along the Maine coast, which supports one of the world's largest wintering eider populations. We deployed high brightness blue and violet light-emitting diodes (LEDs) on two sides of a mussel raft in Casco Bay during August and September 2014. Nine, six-stone plastic fish baskets containing 500 seed mussels each were submerged from each of the two illuminated sides and from one side of a nearby, control raft in mid-August. When inspected on 3 October, baskets at the illuminated raft showed minimal signs of predation, while those at the control raft contained a maximum of about three dozen mussels. Further studies are needed to assess the relative effectiveness of above and below water and blue vs. violet lights, and the added value of combining lights with acoustic deterrents.

MERGING, MODELING AND MAPPING TO IMPROVE SHELLFISH AQUACULTURE SITE SELECTION

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Informed site selection is essential to the successful expansion of the marine shellfish aquaculture industry. GIS-based mapping tools are becoming well-established as regulatory tools to assess potential use conflicts and environmental interactions, and industry tools to gather information on site characteristics, and the availability of land or leases. Shellfish farm models have also been used separately to optimize farm productivity, predict shellfish growth and assess farm-environment interactions. Spatial data and tools from the Connecticut Shellfisheries Mapping Atlas were integrated with the Farm Aquaculture Resource Management model at three nearshore locations in Long Island Sound. Local embayment monitoring groups assisted in sample collection. Site quality for *Crassostrea virginica* was based on time to harvest from one inch seed. All three sites were deemed suitable, with time to harvest varying from 278 days (high growth) to 645 days (moderate growth). Data from two long-term sampling stations, near existing shellfish leases, were used for model validation and to examine interannual variability. Both sites averaged moderate growth over the time series, 764 and 956 days to harvest, but interannual variability was high, from 308 to >1500 days to harvest. Comparison of the two sites by year consistently resulted in one station yielding faster growth than the other, likely due to higher food availability and delivery at that site. These results underscore the importance of comparing sites only using data from the same time period. Combining mapping and modeling could strengthen the site selection process, particularly in locations where shellfish aquaculture is not well-established.

VIBRIO PARAHAEMOLYTICUS CONTROL FOR OYSTERS IN MASSACHUSETTS

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To meet federal Food and Drug Administration mandates pertaining to the consumption of raw oysters and *Vibrio parahaemolyticus* (*V.p.)*, The Massachusetts Division of Marine Fisheries (DMF) and Massachusetts Department of Public Health (DPH) adopted control measures for shellfish harvesters and dealers intended to deter the post-harvest growth of *V.p* in oysters. Historically Massachusetts had not been subject to temperatures high enough to create a significant risk of *V.p*. However, due to warming air and water temperatures, this is no longer true and since 2011 Massachusetts has experienced an increasing occurrence of *V.p* illness related to raw oysters harvested in Massachusetts (2011-2, 2012-11, 2013-33, 2014-12). To address this risk DMF and DPH have designed a series of time-cooling, re-submergence, and record keeping requirements to minimize the risk of *V.p* infection from oyster consumption. Initially control efforts were focused in Eastern Cape Cod Bay as exposure of oysters to the air and direct sunlight during low tide was expected to substantially increase the risk of infection. However, controls were expanded state wide as the illness pattern over the subsequent 3 years showed a significant

incidence of vibrio illness associated with harvest areas in Western Cape Cod Bay and Martha's Vineyard resulting in costly area closures and recalls. A review of *V.p.* cases associated with Massachusetts harvest areas since 2011 shows a trend toward increased incidence in specific harvest areas and specific harvest practices, and has resulted in the development of management methodologies specific to Massachusetts industry practices.

APPLICATION OF INEXPENSIVE TILT LOGGERS FOR MONITORING CURRENTS FROM FISHERMEN AND AQUACULTURE GEAR

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The SeaHorse Tilt Current Meter designed and manufactured by Okeanolog is a low cost instrument for measuring currents. Its operation is based on the drag principle of a buoyant cylindrical pipe tilted by the ambient current. The tilt is measured by a three axis accelerometer and converted to the flow magnitude and direction. The instrument has been employed in several field studies including deployments on lobster traps, oyster cages, kelp growing long-lines. The instrument has a robust design withstanding typical fishing activities, minimizing trapping seaweed. The measurements can be used for a variety of academics problems and applied tasks such as validation of ocean circulation models, oyster farm site assessments, seaweed growth modeling, sediment resuspension studies, etc. During eMOLT (Environmental Monitors on Lobster Traps) we deployed 50 instruments for 9 months with the help of lobstermen volunteers in the Gulf of Maine in the depth range from 10 to 300m. The instruments were also equipped with a sensor measuring the tilt of the trap on the bottom thus allowing us to detect its movement. On average 6% of time the traps were on a side or upside down with Tilt > 45 deg. Comparison with meteo-data from the National Data Buoy Center showed the movements of the traps in response to high wind and wave events. In some cases lobster traps rolled every 12h in response to tidal currents. We present comparison of our observations with the FVCOM GOM3 30 year hindcast simulations.

SCALLOPS AND ALGAL TOXINS – SAME THREAT DIFFERENT DAY

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Harmful and toxic algal blooms are a global issue, threats to human health, and they continue to plague shellfisheries and aquaculture activities. Like other filter-feeding molluscs, scallops readily accumulate algal toxins and some species sequester these toxins in specific tissues for extended periods of time. Further, there is strong spatial variability in toxin levels among geographic regions coupled with high individual variability of toxin accumulation and depuration among individual scallops. There is a continued quest to market whole or 'roe-on' scallops from regions impacted by toxic algae poses a serious threat to both human health and the industry overall. While there are outstanding monitoring programs in place to ensure safe seafood, there are constraints on how much product can be tested. Because of these highly variable factors, the numbers of animals sampled to guarantee statistically sound testing protocols to safeguard the public can be unrealistically high or even impossible to monitor. A brief overview of relationships between scallops and algal toxins will be presented along with information on variability of toxin accumulation and retention between individual animals, distribution of toxins among scallop tissues, and a discussion of the dangers associated with marketing or consuming whole or 'roe-on' scallops from regions prone to toxic algal blooms.

FIELD TESTING OF NOVEL ANTIFOULING COATINGS FOR THE AQUACULTURE INDUSTRY – PRELIMINARY RESULTS

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Biofouling is ubiquitous in the marine environment and inarguably one of the most serious problems facing aquaculture. Considerable research has been carried out during the past several decades to develop means of prevention and control of biofouling, yet most methods are designed to remove fouling once established. Currently no cost-effective means of eradication or control are available. Novel non-toxic antifouling coating technology developed for the aquaculture industry is presented which relies on the photoactive generation of hydrogen peroxide to reduce the settlement of biofouling organisms rather than the leaching of pesticides. Traditional antifouling paints used for boat hulls are based on copper, and often contain booster biocides. Copper is toxic to shellfish, impairs olfactory organs of anadromous fish, and persists in the environment. Photoactive release coatings provide a viable solution for minimizing biofouling on aquaculture netting, cages, and tanks. Biofouling resistance of photoactive coatings was evaluated at the University of Connecticut (Avery Point) for 12 months. Biofouling weight and percent coverage of test surfaces is reported. Antifouling efficacy of photoactive coatings on nylon and HDPE netting, PVC-coated cage used for shellfish and finfish aquaculture, and experimental panels was determined over 6 months in several geographic regions globally through a controlled series of biofouling settlement assays. Toxicity of coating materials to scallop and oyster larvae at concentrations of 0.02, 0.2 and 2.0 ppm is reported and compared to the toxicity of copper-based antifouling paint. Results from antifouling resistance testing demonstrate the promise of photoactive coatings for biofouling control.

ADVANCING BLUE MUSSEL LONGLINE AQUACULTURE TECHNIQUES IN RHODE ISLAND

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Due to the increased demand for sustainable, domestic seafood supply, American Mussel Harvesters and research partners at the MBL are striving to make submerged longline aquaculture of *M. edulis* economically feasible in Southern New England. American Mussel has chosen to model their mussel farms after New Zealand's continuous loop approach. Details of our endeavors in 2014 will be presented using photographs and short movies. Information about planting seasons, seeding density, longline tension, and flotation will be covered. We will explain the Hafbor anchoring system used for all of our aquaculture sites; these screw anchors do not move once installed, are economical, and have a low environmental impact. Our experience with new harvesting and seeding equipment from Ansco LTD. NZ will be presented. This equipment design is based on 30 years of mussel farming experience, and it allows us to work faster, and more consistently, both of which are a necessity when it comes to scaling up. We will describe farm locations and set ups including at an exposed Newport, RI site. We will discuss our plans for a workboat (including retrofits) and possible farming expansion.

TRAINING GUIDANCE TO NEW KELP GROWERS

Bren Smith
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What skills and resources do new ocean farmers need to succeed? The GreenWave apprenticeship program will be introduced, which was designed to train a new generation of seaweed farmers. Greenwave provides education and technical assistance for growers to: 1) navigate complex state regulatory processes; 2) install open-source ocean farming systems; 3) access community-based funding sources; 4) develop local markets for products; and 5) leverage "storied food" marketing strategies. GreenWave's goal is to graduate new growers with the hands-on skills needed to launch and finance their own restorative integrated shellfish and seaweed farms. Beyond gaining the core knowledge and skills to set up and operate farms, they learn how to launch crowdsourcing campaigns, community supported fisheries programs, and farm-to-table "storied food." Farmers are also equipped with "lessons learned" from other growers, ranging from quality control, to shipping pricing and logistics. Finally in an effort to expand the industry as a whole, GreenWave works with farmers to aggregate their harvests and connect them with large buyers who need a stable and durable supply of product.

RESEARCH AND DEVELOPMENT CHALLENGES LEADING TO VIABLE FARMING OF *ANGUILLA ROSTRA*TA IN NORTH AMERICA

Paul Smith
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NovaEel has embarked on a business development strategy with investment from glass eel quota holders. The presentation will touch on a range of subjects from the history of farming *Anguilla .rostrata* in North America and abroad, recent experiences weaning, feeding and maintaining *Anguilla rostrata* glass eels in RAS, early experimental plans and results.

THE EFFECTS OF CANDIDATE PROBIOTICS ON SEVERAL SEPECIES OF CULTURED LARVAL SHELLFISH

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Shellfish aquaculture is an important industry in many countries, especially in coastal and estuarine environments. Hatcheries are the main source of seed for bivalve mollusk culture. However, these facilities can experience disease outbreaks that result in high loss of production stocks. In a previous study, we demonstrated the significant protective effects of two candidate probiotic bacteria, *Phaeobacter gallaeciensis* S4 and *Bacillus pumilus* RI06-95, against fatal infections caused by the bacterial pathogen *Vibrio tubiashii* in larvae of *Crassostreae virginica*. Here, we investigated the effectiveness of these probiotic bacteria in the treatment of larval hard clams, *Mercenaria mercenaria,* and bay scallops, *Argopecten irradians*. Molluscan larvae in 5 mL of filtered sterile seawater were treated with either a probiont (10^4 CFU/mL) or control for 24 h, washed with sterile seawater, and then exposed to *V. tubiashii* RE22 (10^5 CFU/mL). The cultures were incubated at 22-23 °C for 24 h with gentle rocking. Larval survival was determined after 24 and 72 h exposures to the pathogen. Both candidate probiotics provided significant protection to hard clams, but not bay scallops. Relative Percent Survival (RPS) compared to non-treated controls on hard clams was 70 ± 9 % for S4 and 92 ± 3 % for RI06-95. In addition, the protection of probiotics on hard clam lasted up to 72 hours after addition of the pathogen. Neither showed

significant differences with non-treated controls for bay scallops. Thus, these probiotics appear to have species-specific protective effects for shellfish larvae.

ECONOMIC ASSESSMENT OF USING A COMMERCIAL FISHERY TO CONTROL THE INVASIVE GREEN CRAB IN PEI

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The European green crab is an aggressive invasive aquatic species on the Atlantic coast of Canada. The precise economic impact of this species on local ecosystems is unknown but it has had substantial direct and indirect negative effects on local species and their habit. Short-term, experimental harvests of the green crab in Atlantic Canada and the U.S. have only been temporarily successful at reducing local populations. However, this suggests that a continuous fishery on the green crab may be a viable option for managing the invasive species. For a commercial fishery to persist it would need to be profitable for the fishermen. We developed an economic model to look at the break-even point for a green crab fishery under different conditions. We explored the effect of using different fishing techniques, varying the number of crabs per trap, and changing the price of crabs on the profitability of this fishery. Our model suggests if the price for green crab is sufficiently high we should be able to control this species with a commercial fishery.

STUDENT RUN RECIRCULATING AQUACULTURE SYSTEM FOR AQUACULTURE OF THE KAMLOOPS VARIETY OF STEELHEAD TROUT (*OXYRYNCHUS MYKISS*)

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Increasingly, due to public concerns over contamination (PCB's, mercury, heavy metals, etc) sustainability, and lack of traceability consumer confidence regarding the consumption of locally grown salmonid fish has been questioned. Concurrently, industry consolidation and a disparate and oftentimes confusing regulatory environment have led to a decreased market share of salmonid finfish from local farms d in the USA. Consumer demand for sustainable, healthy, traceable seafood sources in the Northeast USA has increased in recent years, with a particularly robust interest in Maine. While local and sustainable foods represent discrete niche markets, they are expanding, and producers are able to charge a premium for their products. Small scale production of steelhead trout (*Onchorhyncus mykiss*) in land based marine recirculating aquaculture systems (RAS) has the potential to fill local demands for sustainable and traceable food fish in our cold temperate bioregion. The Marine Science Center (MSC) at the University of New England (UNE) in Biddeford, Maine has developed a new strategic plan with one priority being the formation of a Sustainable Ecological Aquaculture and Fisheries (SEAFISH) Programme. UNE SEAFISH have implemented an aquaculture demonstration project rearing the Kamloops variety of steelhead trout (*O. mykiss*), and now engage our 200+ undergraduate student body in this effort. Students involved in the steelhead project gain hands on experience in aquatic systems engineering, applied mathemetics, water quality monitoring, animal health and husbandry, and product preparation on a pseudo-commercial scale.

RESEARCH TO SUPPORT AQUACULTURE AND FISHERIES: THE SUSTAINABLE ECOLOGICAL AQUACULTURE AND FISHERIES (SEAFISH) PROGRAMME AT THE UNIVERSITY OF NEW ENGLAND

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Modern, sustainable aquaculture remains a developing, but growing sector of the marine economy in Maine. Development of marine aquaculture in Maine however has not been uniform, and clusters of higher intensity aquaculture have been centered on the midcoast and downeast areas of the state. Southern portions of Maine have huge biophysical potential, but remain underdeveloped and underserved by aquaculture industry, research, and development communities. The Marine Science Center (MSC) at the University of New England (UNE) in Biddeford Maine has developed a new strategic plan, repurposed its MSC facilities, and hired the experts to play a leading role in the development of collaborative aquaculture and fisheries research in Southern Maine. Through industry and institutional partnerships, applied research, and our 200+ student engagement, the UNE Sustainable Ecological Aquaculture and Fisheries (SEAFISH) Programme will pursue responsible and sustainable expansion of aquaculture from a regional to global scale. We detail in this talk several ongoing projects which form the foundation for expansion, innovation, and integration of SEAFISH related research at UNE and our surrounding communities. SEAFISH Projects include; high volume microalgae culture facility, macroalgae sporing and nursery, oyster spawning; breeding and broodstock development, student run recirculating steelhead aquaculture, aquaponics, and wild sturgeon domestication and husbandry.

GENETIC AND VIABILITY EFFECTS OF pH ON EARLY STAGES OF BAY SCALLOPS FOR RESTORATION

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Increased acidity in seawater, which lowers pH, can affect the development of economically and ecologically valuable marine bivalves, such as oysters, clams, and scallops. Early stages of these shellfish are particularly vulnerable to low pH. To evaluate and determine which pH levels have the greatest effects, experiments are being conducted on early stages of bay scallops *(Argopecten irradians irradians)* from various genetic lines for restoration. For this purpose, bay scallops were cultured in triplicate beakers, and sampled at 3 and 48 hours, after exposure to different pH levels. Results demonstrated no development at all at 48 hours in a reduced pH of 7.2, low development with a mean of 5% to the veliger larval stage at a high pH of 8.5, and a mean of 38.4% development in a control pH of 8.1. Three hour samples taken for cytogenetic examination to determine chromosomal and cellular abnormalities also indicated adverse effects at very early stages. For example, fewer mitoses were observed in embryos from low pH cultures, which suggested delayed or arrested development. There was a significant difference among the groups at 3 hours with a mean of 49.7% normal cleaving embryos at the low pH, compared with 67% normal embryos in the high pH and 79% in the control cultures. Additional studies are planned for various genetic lines to determine any differences in responses possibly attributable to adaptation to different levels of pH or overall to a changing climate.

LESSONS LEARNED FROM STAKEHOLDERS AT MAINE'S OCEAN ACIDIFICATION WORKSHOP TOWARDS AN IMPLEMENTATION PLAN

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Public awareness and concern about Ocean Acidification (OA) is growing at the same time as the science is still maturing. In addition to the trend in global OA, near-coastal areas experience Coastal Acidification (CA) that is highly dependent on factors such as freshwater and nutrient delivery which are beyond the general increase in atmospheric CO2, but may be influenced by other climate trends. Communicating these interacting stresses, their influences on Ocean and Coastal Acidification (OCA), and impacts to coastal resources is complex and challenging, both due to the relative paucity of OCA studies and communication gaps between scientists and stakeholders. The Northeast Coastal Acidification Network (NECAN) is a collaboration of scientists, agency representatives, industry and non-governmental organizations that seeks to provide relevant information about OCA to stakeholders in the Canadian Maritimes, Gulf of Maine, and Long Island Sound. Communication methods include state-of-the-science webinar series and publications, web-based translation materials and interactive stakeholder workshops in NECAN sub-regions. The purpose of these workshops is to inform and learn from fishermen, shellfish harvesters, aquaculturists, and coastal water quality volunteer programs their concerns and state of knowledge about OCA. This presentation will focus on the results from the first stakeholder workshop on December 10, 2014 for Maine Stakeholders.

SUBAQUEOUS SOILS AND COASTAL ACIDIFICATION: A HYDROPEDOLOGY PERSPECTIVE

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In the coastal zone, biological and biogeochemical processes, often coupled with anthropogenic inputs, drive pH variability and contribute to coastal acidity. Spatial patterns of these processes across shallow coastal estuaries are unknown. In this study, we used a hydropedological approach to assess the spatial variability of coastal acidity within two coastal lagoons and embayments in Rhode Island by measuring oyster shell dissolution, and pore water pH within the water column and upper 5-cm of the underlying subaqueous soils. Sampling and monitoring sites were stratified based on soil-landscape types mapped at the great group level as Haplowassents, Sulfiwassents, and Psammowassents. We found that pore water pH varied significantly among soils and with depth. Median pore water pH was significantly greater in sandy, low organic matter content Psammowassents (7.97) than the finer textured higher soil organic matter content Sulfiwassents (7.35) and the Haplowassents (6.57) that receive groundwater discharge from the surrounding subaerial soils. Juvenile calcifying organisms can experience acidic stress at pH values below 7.6; thus, current acidity levels within the upper few centimeters of Sulfiwassents and Haplowassents may be low enough to impact recently set juvenile calcifying organisms inhabiting these soils. Consequently, mean shell loss over a 4-week period was significantly greater in the Sulfiwassents (1.58%) than the Psammowassents (0.96%), with the greatest shell loss (24.18%) in one of our

Haplowassents sites with groundwater discharge. Our research suggests that measures of pore water pH and shell dissolution may be helpful in developing soil interpretations regarding the effects of coastal acidity on calcifying organisms.

INVESTIGATING FACTORS CONTRIBUTING TO REDUCED EMBRYO SURVIVAL IN FARM-RAISED ATLANTIC SALMON, *SALMO SALAR*

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Embryo mortality of Atlantic salmon, *Salmo salar*, has been increasing for more than a decade in the State of Maine, a leading producer of this species in the U.S. Increasing embryo mortality not only creates a financial bottleneck for farms, but also prevents the sale of surplus eggs as an additional source of revenue. Blood and egg samples were collected at three Maine Atlantic salmon farms from female broodstock at the time of spawning over a two year period. Correlative factors for reduced embryo survival were investigated by measuring egg and maternal plasma concentrations of 17β-estradiol (E2), 11-ketotestosterone (11-KT), testosterone (T) and calcium, as well as maternal hepatic ethoxyresorufin-*O*-deethylase (EROD) activity and fork length. Significant positive correlations were found between maternal plasma concentrations of E2 and 11-KT and embryo survival. Interestingly, there was no correlation with egg concentrations of sex steroids and embryo survival, suggesting that embryo mortality does not likely rest with the maternal deposition of sex steroids into the egg, but with another hormone regulated process related to egg assembly, ovulation or post-ovulatory aging.

A PROACTIVE GIS ASSESSMENT OF SUITABLE OFFSHORE AQUACULTURE SITES IN THE GULF OF MAINE INTEGRATING SOCIAL, BIOLOGICAL, AND ECONOMIC FACTORS

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In anticipating the challenge of increasing offshore aquaculture, it needs to be balanced against other spatially competing activities. The occurrence of multiple users and uses of coastal environments may severely limit the potential sites where aquaculture development can occur. Because of these competing uses for space in the oceans, it is imperative to apply marine spatial planning principles including assessment of the co-occurrence of spatially explicit industries and their compatibility. This will function to demonstrate up-front that there is adequate space available for aquaculture in suitable areas, and also have a solid understanding of the space, economic, human and ecosystem services tradeoffs that will occur through appropriate aquaculture siting. By reducing or eliminating the concerns over competition for space, a significant hurdle against the implementation of aquaculture will be removed, and this will help attract new ventures to the region. Here, the available space for aquaculture development in the Gulf of Maine was assessed by concurrently assessing the requirements of three disparate users; fishers, commercial shipping, and large pelagic animals (whales and turtles). Location and intensity of each user was charted, and used to tabulate the economic value opportunity costs (displacement of current shipping lanes, loss of whale watching or fishing activity) across the Gulf of Maine. These data were combined to provide the cumulative use assessment, identifying the areas with the least disruption to the identified user groups, and thus the greatest potential for aquaculture siting.

WHY SEADUCKS FORAGE IN MUSSEL FARMS? PREFERRENCES AND EFFICIENCIES WHEN FORAGING ON CULTIVATED OR INTERTIDAL MUSSELS

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The blue mussel *Mytilus edulis* is the primary farmed shellfish, but it is also a main prey for various species of seaducks. Thus, seaduck depredation in mussel farms represents a substantial economic loss among mussel growers worldwide. However, the attractiveness of aquacultures for these predators is not well understood, neither are their benefits when foraging in this habitat compared to intertidal wild zones, nor the extent of losses they can cause. To explore these issues, we conducted a series of experiments in controlled conditions with captive common eiders (*Somateria mollissima*) foraging on mussels from the two habitats (aquaculture and intertidal zone). We compared eiders' ingestion and digestion rates while foraging on both mussel types. Finally, we measured losses due to eiders' direct ingestion and fall off when foraging on a mussel collector. Eiders recognized and preferred cultivated over intertidal mussels, allowing higher ingestion rates and shorter digestion times. Moreover, underwater videos showed that one individual can clean up completely a 50 cm-rope in approximately 3 hours (corresponding to only 4 min spent underwater). Because foraging in mussel farms represents such an energetic advantage, growers need to actively deal with their depredation problem. With this in mind, we can give some advices based on seaduck foraging behaviors seen in these experiments.

SEA DUCK PREDATION IN MUSSEL FARMS: THE BEST NETS FOR EXCLUDING COMMON EIDERS SAFELY AND EFFICIENTLY

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Shellfish aquaculture is a growing food-producing sector. The blue mussel *Mytilus edulis* is the primary farmed shellfish and is also a main prey for various species of sea ducks. With their large density of high-quality mussels, mussel farms attract these predators, and consequent depredation by ducks represents a substantial economic loss among mussel growers worldwide. Total exclusion with nets seems to be the only method that provides complete and long-term control of bird predation. The best nets for duck exclusion must be cost effective, efficient, easy to handle, and safe for bird populations. In order to identify the best net type, we tested 8 different nets under controlled conditions using captive common eiders *Somateria mollissima*, the largest sea duck species in the Northern Hemisphere. We identified a net with a maximum mesh size of 6 inches (~15 cm) and large twine size to be best in excluding common eiders considering the above-mentioned criteria. Nets with thin twine and large mesh size were more likely to cause bird entanglement. In addition to using the best nets for sea duck exclusion, it is necessary to identify a target zone where such nets are the most effective. Good knowledge of the predation problem as well as collaboration among mussel growers, bird specialists, and government authorities are essential to reduce the costs and effort of installing and maintaining exclusion nets.

AN INITIAL LOOK AT BATCH CULTURE OF JUVENILE AMERICAN LOBSTERS, *HOMARUS AMERICANUS*, AT THE SOUND SCHOOL AQUACULTURE CENTER

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Students at the Sound School Regional Aquaculture Center in New Haven, Connecticut have been engaged in hatching American Lobsters, *Homarus americanus*, for over a decade. During the spring of 2014 both the initial hatch and the number of animals that reached the fourth instar surpassed all of the previous efforts. An attempt was made to batch culture a group of these newly settled benthic forms. One hundred and twenty fourth instar lobsters were selected for the study. Only lobsters that were not damaged from fighting in the planktonic stages were chosen. A 440 liter recirculating system that contained three 97 liter glass tanks (120cmx33cmx33cm) was used for the study; salinity was maintained at 24 ppt +/- 2ppt; water temperature was 20ºC +/- 2ºC and nitrogenous product was controlled through water changes (<.05ppm). Each of the three tanks was stocked with 40 lobsters. One of the tanks was maintained as "bare glass" and held only the lobsters and water. Structure was added to the second tank in the form of 40 assorted PVC pipe fittings < / = to 2.54 cm interior diameter. The third tank was stocked with matching PVC couplings and a substrate of aquarium gravel 1.5 cm deep. The trial ran from May 13th until July 9th. At the close of the study 8 lobsters remained from the original 120 animals; 3 lobsters were alive in the bare glass tank; 2 lobsters were in the PVC tank and 3 lobsters were alive in the PVC/ gravel tank.

COMPARISON OF GROWTH AND SURVIVAL OF THE LARVAL EASTERN OYSTER (*CRASSOSTREA VIRGINICA*) FED BY DIFFERENT METHODS

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Different methodologies have been developed at the Milford Laboratory to feed larval bivalves, using calculated batch feeding rations, and pulse feeding using fluorometers to maintain constant food rations. This experiment was designed to directly compare growth and survival of larvae fed by these differing methods. Two day old larval oysters (*Crassostrea virginica*) were placed in 15 liters of static 1 μm filtered seawater at a concentration of10 ml^{-1}, and were exposed to *Tisochrysis lutea* (T-iso) via one of four different feeding methods: (1) demand feed using fluorometry to maintain constant T-iso concentrations at 2,333 cells per ml of culture water; (2) incremental feeding, which increases the amount of algal cells using calculations based on growth; (3) modified batch feeding; and (4) an unfed control. At the end of the experiment on day 8 (10 day old larvae), there was no significant difference in number of live animals remaining per treatment. There was also no significant difference in shell height among the feed delivery methods, although all fed treatments were significantly larger than unfed ($p<0.05$). It appears that the three feeding methods discussed do not significantly impact growth or survival of larval oysters during the first 8 days of feeding.

APPLYING LAGRANGIAN DRIFTERS AND HYDRODYNAMIC MODELING TO SITE SELECTION IN SHELLFISH AQUACULTURE

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The success of a shellfish farm depends to a large degree on the selection of a proper site. A suitable site is dependent on water circulation in the area and knowledge of the circulation patterns can improve the efficiency of site selection. In Narragansett Bay, determining water circulation patterns can help identify sites with high water flow or help reject sites prone to biofouling. Additionally, the ability to predict the abundance of larvae at the site through water circulation patterns will benefit farms that rely on spat collectors for seed procurement. To track hydrodynamic conditions and larval dispersal, Lagrangian subsurface drifters were deployed at six locations throughout Narragansett Bay during May to October. The resulting drifter tracks showed unique hydrodynamic patterns at each deployment site and implied differences in the rate of water exchange and invertebrate larval

dispersal. At the primary convergence site between the East and West passages of Narragansett Bay, the drifter tracks indicated the mixing pattern was random. At other deployment sites, the drifter tracks either showed widespread larval dispersal and extensive water exchange, or remained in the vicinity of the site and suggested high larval settlement and/or limited water exchange. The *in situ* drifter tracks were also compared to passive particle transport simulated by a Regional Ocean Modeling System (ROMS) applied to Narragansett Bay. The comparability between the modeling system and the drifter deployments varied greatly among sites. With adequate verification, hydrodynamic characterization of local waters can contribute to the site selection process for shellfish aquaculture.

DEVELOPMENT OF NOVEL ANTIFOULING COATINGS FOR THE AQUACULTURE INDUSTRY

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Biofouling is ubiquitous in the marine environment and inarguably one of the most serious problems facing aquaculture. Considerable research has been carried out during the past several decades to develop means of prevention and control of biofouling, yet most methods are designed to remove fouling once established. Currently no cost-effective means of eradication or control are available. Novel non-toxic antifouling coating technology developed for the aquaculture industry is presented which relies on the photoactive generation of hydrogen peroxide to reduce the settlement of biofouling organisms rather than the leaching of pesticides. Traditional antifouling paints used for boat hulls are based on copper, and often contain booster biocides. Copper is toxic to shellfish, impairs olfactory organs of anadromous fish, and persists in the environment. Photoactive release coatings provide a viable solution for minimizing biofouling on aquaculture netting, cages, and tanks. Biofouling resistance of photoactive coatings was evaluated at the University of Connecticut (Avery Point) for 12 months. Biofouling weight and percent coverage of test surfaces is reported. Antifouling efficacy of photoactive coatings on nylon and HDPE netting, PVC-coated cage used for shellfish and finfish aquaculture, and experimental panels was determined over 6 months in several geographic regions globally through a controlled series of biofouling settlement assays. Toxicity of coating materials to scallop and oyster larvae at concentrations of 0.02, 0.2 and 2.0 ppm is reported and compared to the toxicity of copper-based antifouling paint. Results from antifouling resistance testing demonstrate the promise of photoactive coatings for biofouling control.

NOVEL ANTI-PREDATOR COATINGS FOR SHELLFISH AQUACULTURE

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In the northeastern United States, one of the most pressing issues for shellfish aquaculturists is the constant threat of predation. In different environments, the issue may be oyster drills (*Urosalpinx cinerea), sea stars (Asterias vulgaris*), moon snails (*Euspira heros*) in addition to many others. When culturing species which reside in cages or bags above the sea floor (i.e., eastern oyster, *Crassostrea virginica*), despite decades of research, there remain no environmentally sustainable methods to control invertebrate predators. The use of copper anti-fouling agents is not recommended near shellfish aquaculture operations because the metal can leach into the environment and have unintended consequences. Therefore, aquaculturists are currently forced to include losses from predators in their economic calculations, and remove predators manually which is both labor and cost intensive. Several commercially available active compounds were evaluated which could be integrated into coatings for aquaculture

gear: ECONEA, capsaicin, and menthol. The efficacy of each compound was determined within different coating matrices and in mesocosm experiments. ECONEA reduced oyster drill prevalence on the coated surfaces by 48.2% compared to controls. Capsaicin and menthol reduced oyster drills on the coated surfaces by 22.2% and 33.3%, respectively; ECONEA was proven to be lethal to invertebrates throughout the trials and is not a viable anti-predator compound to be used near commercial shellfish farms. Capsaicin and menthol each reduced predator movement, though the exact concentration and precise carrier formulation still requires further investigation.

SUGAR KELP AQUACULTURE IN SOUTHEASTERN MASSACHUSETTS

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There are no marine aquaculture farms in Massachusetts, and very few farms in the country that culture multiple species at different trophic levels on the same farm, despite the known synergistic benefits to both the farm and the environment. Sugar kelp (*Laminaria saccharina*) has been grown in Maine for several years, and has been supplementing wild harvest for commercial macroalgae businesses. In this project a sugar kelp nursery was developed, and then sugar kelp growout was added to the existing oyster and bay scallop farm to; 1) take advantage of the known culture technique, 2) utilize an established market with great demand for the product, and 3) collaborate with other farmers in northern New England culturing the macroalgae who are very willing to assist in establishing new farms. The water temperature, climate and environmental characteristics of our farm are conducive to sugar kelp culture, as there are already natural beds found nearby. The nursery phase was very successful, and the seed string was installed at the site in December 2013. At the growout site however, the kelp did not grow to harvestable size, and therefore research is ongoing to determine why the kelp stayed small throughout the entire culture period. One potential factor may have been the late planting, and the fact that the winter of 2013/2014 was unusually cold, and therefore water temperatures were colder than average. Sugar kelp lines were again installed in 2014, and protocols to improve sugar kelp culture in Massachusetts are currently being evaluated.

AN OVERVIEW OF THE PEI CULTURED MUSSEL INDUSTRY: ONGOING CHALLENGES AND RECENT DEVELOPMENTS

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Mussel aquaculture began in PEI in the mid-1980s and has expanded rapidly to become the largest producer of cultured blue mussels in North America (77% of current Canadian production, 2012 data). The presenter will review ongoing challenges being faced by the industry such as aquatic invasive species, sea duck predation and access to new leases, and discuss recent and potential future developments to address these issues.

SPATIAL PLANNING FOR AQUACULTURE

John Weber
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The New England regional ocean planning effort is well underway (see www.neoceanplanning.org for background information). This session will provide an overall update on the progress since the last discussion at the NACE meeting in Mystic in 2012, including the results of discussions with industry, government, and non-

governmental organizations about ways in which regional plan data and guidance can enhance the regulatory process. In particular, we will focus on aquaculture in federal waters (more than three miles offshore). There will be ample time for discussion to help identify specific needs for work going forward.

REMOTE SETTING TRAINING PROGRAM: SUPPORTING SEED PRODUCTION FOR MARYLAND OYSTER GROWERS

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Remote setting is a form of oyster seed production originating on the US West Coast and transferred to the Mid Atlantic in 1982. It is used for spat on shell seed for planting bottom leases. Early adaptation of the process was carried out with leaseholders through extension programs. Disease epizootics during the late 1980s led to severe decline of the resource and industry. In 2010, reopening of leasing occurred with laws mandating the use or surrender of grounds. To support the new industry, a series of programs were developed. The Remote Setting Training Program was funded by NOAA and the Maryland Department of Natural Resources and teamed the Oyster Recovery Partnership with University of Maryland (UM) units to provide setting systems in areas surrounding the bay including tanks, pumps and blowers. Growers reserved systems on a two-week basis, providing containerized cultch and labor for setting and cleaning the units at completion. Larvae was provided at no cost to those in the program with statewide and individual training provided, as well as assessment of setting success by hatchery personnel. During four years of operation, over thirty tanks were operated in ten locations. Production grew from 32 million seed in 2011 to over 300 million annually in recent years. After learning the process, four growers built their own systems. An overview of production increases is provided as well as an historical perspective of development of the process and assessment of future directions.

DEVELOPMENT OF MARYLAND SHELLFISH AQUACULTURE: A TEN-YEAR ASSESSMENT

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The decade ending in 2014 brought many changes to Maryland shellfish aquaculture. A task force concluding in 2004 recommended creation of an Aquaculture Review Board for tracking applications, making that process faster. It created the Aquaculture Coordinating Council (ACC), a policy group providing input to government on ways to advance all aquaculture. The ACC was instrumental in making recommendations for revision of leasing laws which began a new program in 2010 designed with minimal restrictions but with a “use or lose” concept to ensure continued production. Legislative action in 2012 consolidated aquaculture permitting in a single state agency with adequate personnel for effective operations and a negotiated Regional General Permit with federal agencies reduced oversight on limited size leases. Support programs were developed to encourage industry growth including multi-year projects for extension education programs for training new growers, low-interest loans through an agricultural lending agency for capital, emplacement of remote setting equipment in multiple locations for growers to use to produce seed for their grounds, and grants for bottom habitat development. Additionally, a program partnering university researchers with industry to develop new systems has been used successfully by several growers. Currently the industry comprises over 4,000 acres of active leases with traditional spat on shell and water column methods being used by growers. Market expansion has been strong and annual industry growth has been documented. Examples are provided to highlight successes with a discussion of future modifications to regulations and support programs.

BIOLOGICAL RESPONSES OF MULTIPLE NORTHEAST TAXA TO OCEAN ACIDIFICATION

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The number of studies on ocean acidification (OA) effects in marine organisms has greatly increased during the last decade. Most are laboratory experiments that consider responses of only a single species to the single stressor of elevated pCO_2. These studies show OA effects but they underscore the need for experiments that realistically capture the conditions that future marine organisms are expected to experience. Features likely to be important in nature include variable pH conditions, multiple co-occurring stressors, and the role of species interactions in determining outcomes. The number of single-species, single-stressor experiments is sufficiently large, however, to draw tentative generalizations about biological responses to elevated pCO_2 among populations and taxa including phytoplankton, macrophytes, mollusks, crustaceans, echinoderms, and fish. Patterns of biological response to OA among Northeast organisms are consistent with global trends. For both flora and fauna, calcifying taxa appear to be more vulnerable than non-calcifying ones to OA. Among mollusks, a widely studied group with respect to OA, early life-stages are more sensitive than adults to OA. For multiple taxa, experimental data suggest that an organism's response to OA will depend in part on food (energy) availability, with impairment increasing as energy supply is reduced. Furthermore, some responses appear to be population-specific, with populations from more elevated or highly variable pCO_2 conditions being less vulnerable to simulated future pCO_2 levels than those from stable habitats. These early generalities highlight the importance of considering the features and variability of an organism's natural environment when designing laboratory OA experiments.

NEW INSIGHTS INTO THE DEVELOPMENT AND FUNCTION OF HEMOCYTE TYPES IN OYSTERS

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One-hundred and thirty years after the first discovery of circulating defense cells in an invertebrate animal, origins and developmental sequences in invertebrate hemocytes retain elements of mystery. In the last decade, wide availability of bench-top flow cytometers and recognition that physiology and function of "white blood cells" (specifically neutrophils) in the human, innate immune system and hemocytes in invertebrates are highly conserved have enabled application of advanced, clinical tools to invertebrate immunology. Clinical methods have been adapted to categorize and quantify hemocytes in oysters and other bivalves in terms of morphology, defense function, and intracellular physiology. These methods have revealed bivalve hemocyte defense functions to be extremely robust in the face of various environmental and biological challenges. Accordingly, stresses that do cause immunomodulation are thought to be relatively severe. Beyond serving as a tool to evaluate resilience of bivalves to environmental challenges, flow cytometry has provided insights into fundamental developmental and functional relationships between sub-categories of hemocytes, chiefly agranular and granular cells. Combined with advanced imaging techniques and molecular methods, flow cytometry is providing growing evidence of a unified model of hemocyte development and regulation in oysters and other bivalves. Ten years of primary research in the Milford Laboratory, and some ground-breaking recent publications of others, provide

evidence stimulating an evolving view of how hemocytes work in oysters and other bivalve mollusks. A more thorough understanding of relationships between different hemocyte types and their functions will improve interpretation of flow-cytometric data in terms of molluscan health and resistance to disease.

EUROPEAN GREEN CRABS IN SOUTHERN MAINE MARSHES: TRENDS IN ABUNDANCE AND MARSH IMPACTS

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Recent studies indicate that intertidal crabs contribute to marsh erosion and loss through foraging and burrowing activities. The European green crab, *Carcinus maenas*, is a highly-successful invader established in Maine since the 1890s. In the mid-coast region, green crabs are implicated in the destruction of softshell clam flats, eelgrass beds, and salt marshes since 2012. This study quantifies green crab abundances at salt marshes in Damariscotta, Yarmouth, and Wells using two methods that sample different marsh habitats: fyke nets (marsh surface, fished for one full tidal cycle) and baited, modified eel traps (subtidal creeks, round traps, approximately 90 cm long, 1 cm mesh, 24-hour set). Concurrent sampling of these methods in late June and early August revealed much greater green crab activity in the tidal channel compared to the marsh surface and/or greater trap efficiency. Crab densities ranged from 0-0.5 crabs/m^2 with greater densities observed during the day for most sites and the lowest densities at Yarmouth, until September when abundances grew which may be correlated with cooling water temperatures. Trapping data from June, July, and August agree with the fyke net data and reveal that Yarmouth had many fewer crabs captured (0.2-3.0 crabs/hour) compared to Damariscotta (24.4-30.0 crabs/hour) or Wells (26.3-46.3 crabs/hour). The greatest sampling event to-date was Wells in early August, where 1,110 crabs were captured. CT scans of marsh cores reveal crab burrows in Yarmouth and Wells. Understanding spatial differences in population trends and direct impacts to marshes, may help inform management options in Maine.

SELECTION RESPONSES FOR CARCASS WEIGHT IN FOUR ATLANTIC SALMON YEAR CLASSES

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Atlantic salmon, *Salmo salar*, aquaculture is one of the most successful global aquaculture enterprises, and has wide acceptance as a seafood item by American consumers. US production of Atlantic salmon is concentrated in Maine and Washington. The initial focus of the USDA applied Atlantic salmon breeding program has been on growth or carcass weight utilizing certified North American stocks. Additional traits such as fillet color, fillet fat, susceptibility to sea lice, and resistance to superchill are currently being selected. Sexual maturity is not evaluated in net pen fish as they are cultured under lights, however, sexual maturation is recorded on captive broodfish for each generation. Smolts from each year class were stocked into net pens and growth data collected at a processing plant along with tissue samples for fillet quality analysis. Performance of salmon from each year class is compared to a control line of non-selected wild fish. There has been significant variation in growth between fish from the breeding program, control fish, and growth of the different year classes. Carcass weight of salmon from the breeding program ranged from 3.7 to 5.7 kg depending on length of the culture period and was 57% to 141% larger than wild control fish. Estimated breeding values for carcass weight in the breeding nucleus (all families in the breeding program) ranged from 0.33 kg to 0.52 kg. Estimated breeding values for carcass weight in multipliers (future industry broodfish) ranged from 0.61 to 0.77. Carcass weights of fish produced from multiplier families were significantly higher than fish in the breeding nucleus and ranged from 4.9 to 5.8 kg. Additional traits are also being evaluated in the salmon breeding program. Susceptibility to sea lice has been

evaluated with tank challenges and natural infections in sea cages. Fillet pigment has been measured with HPLC extraction, from the red a* value from a colorimeter, and VIS/NIR spectroscopy. Fillet fat has been measured with VIS/NIR spectroscopy and automated fat extraction. Future plans are to evaluate markers and for disease resistance traits (IPN, sea lice), and develop a selection index for traits of economic importance as determined by industry priorities.

GENETIC CHARACTERIZATION OF CLINICAL AND ENVIRONMENTAL *VIBRIO PARAHAEMOLYTICUS* FROM THE NORTHEASTERN US REVEALS EMERGING RESIDENT AND INVASIVE PATHOGEN LINEAGES

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Even as gastric infections caused by the environmentally-transmitted pathogen, *Vibrio parahaemolyticus* have increased over the last two decades, until recently, infections linked to shellfish from the Northeastern US were rare. Cases have risen recently in New England, suggesting *V. parahaemolyticus* populations are changing. We examined clinical strains collected during a period of unprecedented disease in the region and compared them to environmental counterparts to identify resident and invasive lineages and to gain insight into the evolution of emergent pathogenic strains present in local waters. Genotyping and multi-locus sequence analysis of clinical isolates collected between 2010-2013 in Massachusetts, New Hampshire and Maine reveal the polyphyletic nature of pathogens. Although 80% of the clinical strains harbored the *trh* hemolysin either alone or with *tdh*, 14% harbored neither hemolysin emphasizing a limitation for this trait in pathogen discrimination. Resident sequence type (ST)631 strains caused multiple infections, and also show a dramatic, recent history of recombination with other clinical and with environmental lineages present in the region. ST34 and ST674 strains were linked to fewer infections but were also found as environmental isolates harboring hemolysin genes. Whole-genome phylogenies indicate ST36 strains that caused a rise in regional infections starting in 2012 following an atypically mild winter are derived from the Pacific Northwest population. This study lays the foundation for more accurate pathogenic strain detection as well as future work aimed at understanding dynamics within natural populations associated with emergence and invasion of pathogenic strain types in the region.

TRAPPING GREEN CRABS (*CARCINUS MAENAS*) IN SALEM SOUND, MASSACHUSETTS

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Since the arrival of the invasive European green crab (*Carcinus maenas*) in Massachusetts waters in the 1880's the species has had a significant negative impact on the soft-shell clam (*Mya arenaria*) industry. Various locations in New England have noted a recent increase in the numbers of green crabs with a concurrent decline in soft-shell clams. To get a better picture of the current green crab population in Salem Sound, Massachusetts, an ongoing trapping survey was initiated in July 2013 using baited traps deployed off docks once per month at several locations in Salem and Beverly harbors and the Danvers River and Bass River estuaries within Salem Sound. An additional study of bait preferences and a comparison of various commercially available traps have been

conducted to assist the Massachusetts Division of Marine Fisheries in coordinating a trapping program involving several communities in an effort to reduce the density of crabs in local waters. To date nearly 4000 green crabs have been collected in our survey, with the highest catch per unit effort (CPUE) during the months of September, October and November. Very few crabs have exceeded 2.75" and none have exceeded 3" carapace width. Over 75% of caught crabs have been females but only 13 out of over 2900 females were gravid. Herring proved to be the most effective bait of those tested. Features and effectiveness of a variety of traps will be presented.

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