PROGRAM and ABSTRACTS

of the

Northeast Aquaculture Conference & Exposition

33rd Milford Aquaculture Seminar

15th International Conference on Shellfish Restoration

December 12-15, 2012

Mystic Marriott Hotel & Spa

Groton, Connecticut

The 2012 NACE-MAS-ICSR at a Glance

NACE/MAS/ICSR Aquaculture Conference - 2012				
Wednesday, December 12				
	Field Trips Depart at various times (meet in the Hotel Lobby)			
4:00 PM	**Registration opens in the Hotel Lobby**			
7:00 PM	**Opening Reception in the Marriott Ballroom (Trade show opens)**			
Thursday, December 13				
7:00 AM	**Registration in the Hotel Lobby**			
7:00 AM	**Breakfast & Trade show opens in Marriott Ballroom**			
8:00 AM	**Plenary Session in the Marriott Ballroom**			
9:30 AM	**Break in the Marriott Ballroom**			
	Salons A&D	**Salons B&E**	**Salons C&F**	**Conference 3**
10:00 AM	History of Aquaculture in New England	General Finfish & Shellfish Aquaculture I	GIS & Site Selection Workshop	Seaweed Farming 101
12:00 PM	**Lunch in the Marriott Ballroom**			
1:30 PM	Ocean Acidification	NROC Aquaculture Planning I	Use of Instrumentation for Aquaculture Site Selection and Water Quality Monitoring	Finfish Farming 101
3:00 PM	**Break in the Marriott Ballroom**			
3:30 PM	Ocean Acidification Roundtable	NROC Aquaculture Planning II	Diseases of Aquatic Species	Shellfish Farming 101
5:00 PM	**Poster Session in the Marriott Ballroom**			
7:00 PM	**Silent Auction and Dismal Failures Exchange in the Marriott Ballroom**			
Friday, December 14				
7:00AM	**Registration in the Hotel Lobby**			
7:00AM	**Breakfast & Trade show opens in Marriott Ballroom**			
	Salons A&D	**Salons B&E**	**Salons C&F**	**Conference 3**
8:30 AM	Culture of Aquatic Ornamentals	General Finfish & Shellfish Aquaculture II	Water Quality, Public Health, and Bio-Security Issues	Shellfish Production Methods
10:00 AM	**Break in the Marriott Ballroom**			
10:30 AM	Direct Marketing of Shellfish	Integrated Multi-Trophic Aquaculture	Water Quality, Public Health, and Bio-Security Issues	Aquaculture Gear Forum
12:00 PM	**Lunch in the Marriott Ballroom (Trade show closes after lunch)**			
1:30 PM	Farm Risk Management I	Offshore Mussels & Farm Video Exchange	Shellfish Restoration Metrics of Success	Preparation of Shellfish & Finfish for Disease Diagnotics (Conf 2&3)
3::00 PM	**Break in the Foyer**			
3:30 PM	Farm Risk Management II	Climate Change Issues	Shellfish Habitat Restoration I	Preparation of Shellfish & Finfish for Disease Diagnotics (Conf 2&3)
6:00 PM	**Lobster bake at the Mystic Arts Center**			
Saturday, December 15				
7:00AM	**Registration in the Hotel Lobby**			
	Salons A&D	**Salons B&E**	**Salons C&F**	
8:00 AM	Aquaculture Business Management & Marketing Workshop	Aquaculture & High School Education	Shellfish Habitat Restoration II	
10:00 AM	**Break**			
10:30 AM	Aquaculture Business Management & Marketing Workshop	Aquaculture & High School Education	Shellfish Habitat Restoration II	
12:00 PM	**Lunch in Marriott Ballroom**			
1:30 PM			Community-Based Shellfish Restoration	
3:00 PM			Wrap-up of ICSR	

Welcome

The NACE – MAS – ICSR planning committee welcomes you to this joint meeting of our three organizations. Working with a theme of ***Aquaculture and Restoration – a Partnership***, 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 in general and the role aquaculture can play in restoring our shellfish resources around the world. This year's event promises to deliver a quality program with special sessions on finfish, algae and shellfish culture and restoration, very informative workshops, field trips to area aquafarms and a tradeshow including major aquaculture vendors from New Brunswick to California! We hope that you enjoy the meeting and welcome!

NACE-MAS-ICSR Planning Committee

Walter Blogoslawski – NOAA National Marine Fisheries Service Milford Laboratory
Dave Bushek – Rutger's University Haskin Shellfish Research Laboratory
Joe Buttner – Salem State University
Anoushka Concepcion – Connecticut Sea Grant
Chris Davis – Maine Aquaculture Innovation Center
Rick Devoe – South Carolina Sea Grant Consortium
Gef Flimlin – Rutgers Cooperative Extension
Tessa Getchis – Connecticut Sea Grant
Kelly Jurgensen – Rutgers Cooperative Extension
Peter Kingsley-Smith – South Carolina Department of Natural Resources
Dale Leavitt – Roger Williams University
Dorothy Leonard – Ocean Equities
Sandy Macfarlane – Coastal Resource Specialists
Lisa Milke - NOAA National Marine Fisheries Service Milford Laboratory
Dana Morse – Maine Sea Grant & Univ. Maine Cooperative Extension
Jenny Peters – Maine Sea Grant
Bob Rheault – East Coast Shellfish Growers Association
Michael Rice – University of Rhode Island
Gregg Rivara – Cornell Cooperative Extension

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Maine Aquaculture Innovation Center
The Nature Conservancy
National Oceanic and Atmospheric Administration

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National Shellfisheries Association
East Coast Shellfish Growers Association

Thanks to Our Exhibitors

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Thanks to Our Exhibitors!

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Thanks to Our Exhibitors!

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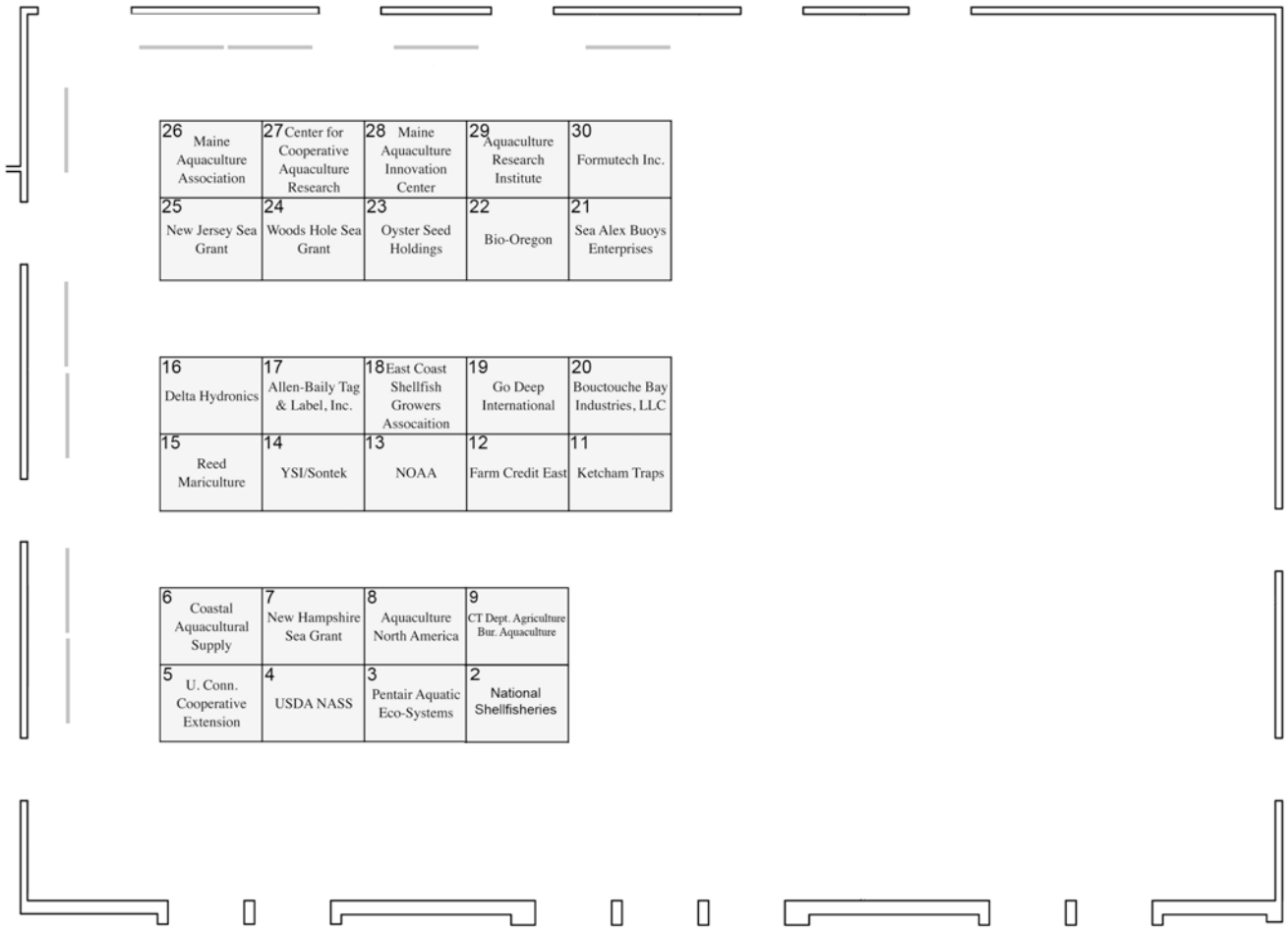

Program for Wednesday & Thursday Morning

NACE/MAS/ICSR Aquaculture Conference - 2012

	Wednesday, December 12			
	Field Trips (meet in the Hotel Lobby) Bridgeport Aquaculture High School & lunch at Miya's Sushi (departs at 9:00 AM) Ocean acidification and aquaculture research at NOAA's NE Fisheries Science Center, Milford Laboratory (departs at 9:00 AM) RWU Aquaculture Facilities tour (departs at 10:00 AM) Noank Aquaculture Cooperative Farm Tour and Lunch at the Mystic Oyster Club (departs at 10:00 AM) American Mussel Harvesters (departs at 10:00 AM) Quinebaug Valley Fish Hatchery (departs at 1:00 PM) Mystic Seaport Special Collections behind the scenes tour (departs at 2:00 PM)			
4:00 PM	**Registration opens in the Hotel Lobby**			
7:00 PM	**Opening Reception in the Marriott Ballroom (trade show opens)**			
	Thursday, December 13			
7:00 AM	**Registration in Hotel Lobby**			
7:00 AM	**Breakfast in Marriott Ballroom**			
8:00 AM	**Plenary Session *The Role of Aquaculture in Fisheries & Restoration (*Marriott Ballroom)** Eric Schwaab, National Oceanic & Atmospheric Administration Sebastian Belle, Maine Aquaculture Association Boze Hancock, The Nature Conservancy			
9:30 AM	**Break & Trade Show Opens**			
	Salons A&D	**Salons B&E**	**Salons C&F**	**Conference 3**
	History of Aquaculture in New England *Chair: David Alves*	**General Finfish & Shellfish Aquaculture I** *Chair: Walter Blogoslawski*	**GIS & Site Selection Workshop** *Chair: Carter Newell*	**Seaweed Farming 101** *Chair: Sarah Redmond*
10:00 AM	The History of Shellfish Culture in New Jersey *Gef Flimlin*	Biofouling ascidians on aquaculture gear as potential vectors of harmful algal introductions *Maria Rosa*	Soil science and oyster aquaculture in Rhode Island – subaqueous soil maps as a tool for spatial planning *Brett Still*	An introduction to the cultivation of seaweeds: new opportunities for integrating seaweeds in Northeast America *Charles Yarish*
10:15 AM	A History of Shellfish Culture on Long Island, NY. *John Holzapfel*	Use of Microalgae Concentrates for Rearing of Oyster Larvae, (*Crassostrea virginica*) *F. Scott Rikard*	Merging modeling and mapping: the integration of ecosystem-based models and interactive web-based visualization tools for improved aquaculture decision making *Tessa Getchis*	Seed production for seaweed aquaculture *Lindsay Green*
10:30 AM	Culture of Bivalve Mollusks – A Milford Laboratory Perspective, 1920s – 1960s *Ronald Goldberg*	The Atlantic Ribbed Mussel, (*Geukensia demissa*), grown using standard aquaculture methods, has potential for use in nutrient bioextraction. *Mark S. Dixon*	ADZ: (*Ā'DĒ'ZĒ*) ACRO. [USA-NJ] – A tool for shaping aquaculture in New Jersey *Joseph J. Myers*	Open water cultivation of *Gracilaria tikvahiae* and *Saccharina latissima* in Long Island Sound and the Bronx River estuary *Jang Kim*
10:45 AM	Conducting Shellfish Aquaculture History Research at the Mystic Seaport *Kelly Drake*	What to do About Nitrogen on Cape Cod: How Much Can Local Oyster and Quahog Harvest Remove? *Joshua Reitsma*	ShellGIS: a GIS software tool for predicting growth and environmental effects of bivalve shellfish according to site selection and culture practice (Demonstration and Training Workshop) *Carter Newell*	Preliminary investigations into the potential of culturing seaweeds on Martha's Vineyard *Rick Karney*
11:00 AM	A Brief History of Shellfish Farming in Maine *Jeff McKeen*	Pollutant nitrogen <=> nutritional protein: the symmetrical, alliterative poetry of bioextraction. *Gary H. Wikfors*		Development of sea vegetable culture technologies in Maine *Sarah Redmond*
11:15 AM	Shellfish in Cape Cod Bay: Centuries of Harvesting Bountiful Bivalves *Sandra Macfarlane*	Hurricanes and Hatcheries: Planning for the worst, hoping for the best. *John Supan*		Challenges and opportunities of kelp farming in New England *Paul Dobbins*
11:30 AM	A History of Connecticut's Shellfishing Industry *Tessa Getchis*	Reproductive pattern and some biological features of *Meretrix casta* (family: Veneroidae) from Pakistan *Shahnaz Rashid*		Market outlets for seaweed production in New England *Anoushka Concepcion*
11:45 AM	Public Funding of Shellfish Restoration: A Case History of Rhode Island's Lobster Restoration Program 1898-1951. *Michael A Rice*	An initial investigation into juvenile lobster, (*Homarus americanus*), benthic habitat preference *Kelsey Brockett*		Seaweed Growers Forum
12:00 PM	**Lunch in the Marriott Ballroom**			

Program for Thursday Afternoon

	Salons A&D	Salons B&E	Salons C&F	Conference 3
	Ocean Acidification *Chair: Brad Warren*	**NROC Aquaculture Planning I** *Chair: John Weber*	**Use of Instrumentation for Aquaculture Site Selection and Water Quality Monitoring** *Co-Chairs: Dale Leavitt & Chris Davis*	**Finfish Farming 101** *Chair: Michael Chambers*
1:30 PM	Ocean acidification causes shell deformities and reduced calcification in Crassostrea virginica larvae *Anne Cohen*	This forum will provide aquaculture stakeholders the opportunity to learn more about the Northeast Regional Ocean Council's work advancing regional ocean planning and provide input on this important initiative. This session will: • Provide an update regarding NROC ocean planning efforts • Discuss current status of data characterizing the aquaculture sector, and potential utility of spatial data (related to other human activities and natural resources) to the industry • Discuss key issues and trends facing the aquaculture sector, and explore the potential role for regional ocean planning to address these issues	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.	A review of fin fish species cultured in the Northeast on land or at sea *George Nardi*
1:45 PM	Ocean acidification impacts on survival and growth of larval surfclams (*Spisula solidissima*) – Environmental conditions (Waquoit Bay, MA) and culture studies *Dan McCorkle*			Hatchery Production of Marine Fish *Nick King*
2:00 PM	Ocean Acidification and the Shellfish Industry: three regional case studies - Gulf of Maine, Chesapeake Bay and Netarts, OR *Mark Green, Joe Salisbury, George Waldbusser and Alan Barton*			Flatfish culture, with an emphasis on species cultivated in the northeastern United States *Elizabeth Fairchild*
2:15 PM				Finfish growout in marine recirculation systems: Challenges and potential solutions *Nick Brown*
2:30 PM				Cage culture of marine fish in New England *Michael Chambers*
2:45 PM				From harvest to plate; getting your fish to the customer *Sebastian Belle*
3:00 PM	**Break at the Trade Show**			
	Salons A&D	**Salons B&E**	**Salons C&F**	**Conference 3**
	Ocean Acidification Roundtable *Chair: Todd Capson*	**NROC Aquaculture Planning II** *Chair: John Weber*	**Diseases of Aquatic Species** *Chair: David Bushek*	**Shellfish Farming 101** *Chair: Robert Rheault*
3:30 PM	Ocean acidification (OA) and the shellfish industry: an introduction to tools to protect production The OA roundtable will feature: 1) forming partnerships between scientists and the shellfish industry 2) training necessary to monitor seawater chemistry in real time 3) Instrumentation needs and costs 4) Current efforts to develop an integrated monitoring network for shellfish aquaculture in the United States *Mark Green, Joe Salisbury, George Waldbusser and Alan Barton*	Continuation of the prior session	Status of oyster diseases in Connecticut *Inke Sunila*	Hatchery & nursery culture of shellfish *Chris Davis*
3:45 PM			QPX epizootiology: ten years of data from a hard clam fishery in Raritan Bay, NY *Soren Dahl*	Growout of shellfish *Will McCormick*
4:00 PM			A look at species-specific and seasonal effects of two probiotic bacteria upon hemocytes of the eastern oyster (*Crassostrea virginica*) and the northern bay scallop (*Argopecten irradians irradians*) *Diane Kapareiko*	Marketing of oysters *Seth Garfield*
4:15 PM			Oyster mortality and disease in Delaware Bay: impact and recovery following Hurricane Irene and Tropical Storm Lee *David Bushek*	Temperature control & *Vibrio* issues related to shellfish *Robert Rheault*
4:30 PM			Does histidine supplementation prevent cataract formation in Atlantic cod (*Gadus morhua*) exposed to elevated levels of dissolved carbon dioxide? *Kevin Neves*	Processing & Shipping of shellfish *Robert Rheault*
4:45 PM			Ichthyophonus species effects on yellowtail flounder in special access areas on Georges Bank *Roxanna Smolowitz*	Record keeping and BMP's for shellfish farmers *Gef Flimlin*
5:00 PM	**Poster Session at the Trade Show**			
7:00 PM	**Silent Auction and Lessons Learned - the Hard Way (a.k.a. Dismal Failures) in the Marriott Ballroom**			

Program for Friday Morning

7:00AM	**Registration in the Hotel Lobby**			
7:00AM	**Breakfast in the Marriott Ballroom**			
	Salons A&D	**Salons B&E**	**Salons C&F**	**Conference 3**
	Culture of Aquatic Ornamentals *Chair: Joe Buttner*	**General Finfish & Shellfish Aquaculture II** *Chair: Lisa Milke*	**Water Quality, Public Health, and Bio-Security Issues** *Chair: William Watkins*	**Shellfish Production Methods** *Co-chairs: Dana Morse & Bill Walton*
8:30 AM	An integrated marine recirculation aquaculture system for abalone production *Robert Bishop*	Experimental fish feed using algal protein for rainbow trout (*Oncorhynchus mykiss*) *Julian Fiorentino*	Shellfish aquaculture, restoration, and harmful algal blooms: a reality check *Sandra Shumway*	Oyster (*Crassostrea virginica*) growth study comparing floating cages and bottom cages in Southeastern MA *Diane Murphy*
8:45 AM	Coral micropropagation technologies and aquaculture for coral reef restoration *Craig Downs*	Developing sustainable egg collection methods for the mummichog: frequency of collection and collector depth *Courtnay Janiak*		Effects of stocking density and basket orientation when using the adjustable longline system for oyster grow-out: measures of product quality *Julie Davis*
9:00 AM	Ornamental fish culture – from fish tanks to fish farms: the evolution of an industry *Neil Greenberg*	Pathological effects of soybean's anti-nutritional factors on summer flounder (*Paralichthys dentatus)* tissues *Rachel Bone*	Health hazards and illness outbreaks – lesson learned *William Watkins*	Effects of ploidy and gear on the performance of farmed oysters *William Walton*
9:15 AM	The importance of the zebrafish for the aquaculture industry *Christian Lawrence*	Potential of white worms *Enchytraeus albidus* as a component for aquaculture and stock enhancement feeds *Michelle Walsh*	*Vibrio* concerns for shallow water and floating aquaculture – what we know and what we don't *William Watkins*	Variation in Settlement and Early Growth of Juvenile Razor Clams (*Ensis directus*) in a Hatchery Setting. *Michael Devin*
9:30 AM	Immunology of red abalone (*Haliotis rufescens*) for aquaculture *Erin Switzer*	Enhancing your outreach portfolio—what are your options for working with NOAA federal labs? *Mike Rust*	Detection methods for pathogenic (*Vibrio*) species *Steve Jones*	East meets west: shellfish aquaculture on the west coast; current culture practices, problems and prospects *Joth Davis*
9:45 AM	Successful aquaculture of ornamental elasmobranchs in captivity *Mae Taylor*	An update of NRAC projects *Reginal Harrell*	Simultaneous enumeration of *Vibrio* species by a multiplex quantitative PCR (BAX) assay *Anita Wright*	
10:00 AM	**Break at the Trade Show**			
	Salons A&D	**Salons B&E**	**Salons C&F**	**Conference 3**
	Direct Marketing of Shellfish *Chair: Anoushka Concepcion*	**Integrated Multi-Trophic Aquaculture** *Chair: Michael Pietrak*	**Water Quality, Public Health, and Bio-Security Issues** *Chair: William Watkins*	**Aquaculture Gear Forum** *Co-chairs: Dana Morse & Bill Walton*
10:30 AM	Community supported agriculture: adding seafood to the recipe *Gef Flimlin*	Moving Forward With Integrated Multi-Trophic Aquaculture as Part of a Sustainable Development Plan for Regional Coastal Zone Development *Shawn Robinson*	Interstate shellfish seed transport: improving regulations to facilitate commerce while enhancing biosecurity *Ryan Carnegie*	This session will examine some of the developments and specifics for successful use of floating cages and graders, and will touch on progress in culture of razor clams and sea scallops, as potential crops for shellfish growers in the northeast US. This session will be informal, and will be interactive. Equipment on hand will be available for examination and handling by members of the audience, and the session is intended to stimulate discussion with producers and others, so that the equipment on the market presently is used to its greatest capacity
10:45 AM	Community supported fisheries summit - building a network, identifying challenges and opportunities, and defining next steps *Erik Chapman*	Multi-cropping seaweed *Gracilaria tikvahiae* with oysters in Waquoit Bay, Massachusetts *Scott Lindell*	Ensuring consumer safety through best practices for post-harvest handling, transportation, and storage *Amy Fitzpatrick*	
11:00 AM	The story of the *Pier to Plate* CSF *Dennis Roebelard*	Deploying a commercial scale mussel raft on a salmon farm: more than just growing fish and mussels *Michael Pietrak*	Best practices for post-harvest rapid cooling *Melissa Evans*	
11:15 AM	Emerging local market mechanisms for shellfish producers - New York City CSF case study *Sean Dixon*	Sustainable aquaculture: economic impact of using integrated multi trophic aquaculture (IMTA) to reduce sea lice in salmon farming *Umi Muawanah*	Depuration & Wet Storage Similarities and Differences *Gary Wolf*	
11:30 AM	Starting a CSA in Connecticut *Jiff Martin*	A land-based integrated multi-trophic aquaculture system: design and initial start-up *John Scarpa*	Best Practices for Depuration & Wet Storage *Gary Wolf*	
11:45 AM	Aquaculture cooperatives and community supported fisheries: how cooperation among competitors contributes to independent business profitability *Lynda Brushett*	Oyster component of a land-based integrated multi-trophic aquaculture system *John Scarpa*	Discussion of Emerging Issues in Public Health	
12:00 PM	**Lunch in the Marriott Ballroom with special guest speaker John Bullard**			

Program for Friday Afternoon

	Salons A&D	Salons B&E	Salons C&F	Conference 3	Conference 2
	Farm Risk Management I *Co-chairs: Tessa Getchis & Gef Flimlin*	**Offshore Mussels & Farm Video Exchange** *Chair: Carter Newell*	**Shellfish Restoration Metrics of Success** *Chair: Boze Hancock*	**Preparation of Shellfish for Disease Diagnotics I** *Co-chairs: Dale Leavitt, Roxanna Smolowitz & Diane Murphy*	**Preparation of Finfish for Disease Diagnotics I** *Co-chairs:Ian Bricknell & Mike Pietrak*
1:30 PM	Aquaculture production hazards – developing outreach services to the region's farmers via extension and aquatic animal professionals using a HACCP approach. *Tessa Getchis*	Research and improved management for offshore mussel farms in southern New England *Scott Lindell*	National guidelines for metrics used for monitoring oyster restoration projects *Boze Hancock*	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.	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	USDA- Farm Service Agency loan program for aquaculture *Ronald Clark*	Establishing an offshore mussel farm in federal waters in the Gulf of Maine *Ted Maney*	New oyster restoration metrics for the Chesapeake Bay *Peter Bergstrom*		
2:00 PM	Overview of USDA's Farm Service Agency Disaster Assistance Program for aquaculture *Devon Marsden*	Farm Video Exchange - Mussel farmers will share with the audience 5-10 minute video clips of their farming activities *Carter Newell*	Measurement of oyster density and size distribution on restored reefs and beds. *Bryan DeAngelis*		
2:15 PM			Definition and measurement of reef area and vertical relief of restored oyster reefs. *Boze Hancock*		
2:30 PM	USDA-NRCS: How Farm Bill programs work with aquaculture *Todd Bobowick*		Evaluating oyster reef restoration: critical ecosystem service-based goals *Loren Coen*		
2:45 PM	SHELLMAN – A production management solution that adds more value to your business *Dave Conley*		Discussion of the universal metrics proposed in the preceding presentations (reef area, reef vertical relief, oyster density size distribution, and critical ecosystem service-based goals) *Bryan DeAngelis*		
3::00 PM	**Break in the Foyer**				
	Salons A&D	**Salons B&E**	**Salons C&F**	**Conference 3**	**Conference 2**
	Farm Risk Management II *Chair: Gef Flimlin*	**Climate Change Issues** *Chair: John Brawley*	**Shellfish Habitat Restoration I** *Chair: Peter Kingsley-Smith*	**Preparation of Shellfish for Disease Diagnotics II** *Co-chairs: Dale Leavitt, Roxanna Smolowitz & Diane Murphy*	**Preparation of Finfish for Disease Diagnotics I** *Co-chairs: Ian Bricknell & Mike Pietrak*
3:30 PM	Developing an individual farm plan For good business planning, shellfish farmers should document what their operation consists of. The Individual Farm Plan allows growers to use the BMP process to build their own plan which can be used for insurance, financial assistance or product marketing	A guide to determining historical climate and habitat indicators from marine resource abundance *Tim Visel*	The use of abandoned and unwanted crab traps as a viable substrate for promoting oyster reef development and creating essential fish habitat. *Peter Kingsley-Smith*	Continuation of the previous session	Continuation of the previous session
3:45 PM		Will climate change alter the prevalence of pathogens of the blue crab (*Callinectes sapidus*) in the Northeast USA? *Eric Schott*	Rebuilding Bay Scallop populations and fisheries in the Peconic Bays, Long Island, New York *Stephen T. Tettelbach*		
4:00 PM		Climate induced acidification of maine soils and impacts upon the new england historical soft shell clam (*Mya arenaria*) and hard shell clam (*Mercenara mercenaria*) shellfisheries *Tim Visel*	The colonization of marine organisms related to a multi-functional, artificial reef designed for the American lobster (*Homarus americanus*) *Christopher Roy*		
4:15 PM		Clams on the run - Climate change and range shifts in the Atlantic surfclam populations: implications for *Daphne Munroe*	Electrical restoration of oysters and saltmarsh at a New York City estuarine wetland *James Cervino*		
4:30 PM		Discussion of impacts of climate change on future aquaculture and restoration efforts	Does the frequency of hydraulic dredging on cultivated shellfish beds influence the sediment chemistry and *Shannon Meseck*		
4:45 PM			Is it time to expand bay scallop, *Argopecten irradians irradians*, culture in the united states *James C. Widman Jr.*		
6:00 PM	**Lobster bake at the Mystic Arts Center**				

Program for Saturday

	Saturday, December 15		
7:00AM	**Registration in the Hotel Lobby**		
	Salons A&D	**Salons B&E**	**Salons C&F**
	Aquaculture Business Management & Marketing Workshop *Co-chairs: Betsy Hart & Linda O'Dierno*	**Aquaculture and High School Education** *Chair: Pete Malinowski*	**Shellfish Habitat Restoration II** *Chair:David Bushek*
8:00 AM	Welcome	A forum for educator and industry feedback into public school curriculum and facilities design	Best management practices for shellfish restoration *Dorothy Leonard*
8:15 AM	Managing your aquaculture business during difficult financial times *Carole Engle*		Using high frequency sidescan sonar to map shellfish habitat and estimate populations on a managed oyster reef: preliminary results *Mark Borrelli*
8:30 AM			Developing remote setting capabilities with disease-resistant triploid oysters for shellfish leases in Delaware Bay *David Bushek*
8:45 AM			Boston harbor softshell clam (*Mya arenaria*) enhancement *Christopher Schillaci*
9:00 AM			Do mud crabs (*Dyspanopeus sayi*) prey upon bay scallops (*Argopecten irradians irradians*) in spat collectors? *Oliver Bender*
9:15 AM			Developing collaborations and metrics for Olympia oyster restoration in Washington state *Joth Davis*
10:00 AM	**Break**		
	Salons A&D	**Salons B&E**	**Salons C&F**
	Aquaculture Business Management & Marketing Workshop continued *Co-chairs: Betsy Hart & Linda O'Dierno*	**Aquaculture and High School Education** *Chair: Pete Malinowski*	**Shellfish Habitat Restoration II continued** *Chair:David Bushek*
10:30 AM	Supermarket sales trends for aquaculture products *Madan Dey*	A forum for educator and industry feedback into public school curriculum and facilities design	Lessons learned: modernizing wild shellfish harvest management as part of a bay-wide shellfish restoration program (hard clams in Great South Bay NY) *Carl LoBue*
10:45 AM			Shellfish restoration, Nelson Bays, New Zealand *Sean Handley*
11:00 AM			Restoration within an urbanized environment: effects of anthropogenic inputs on the health of juvenile (*Crassostrea virginica*) *Allison Fitzgerald*
11:15 AM	Innovative marketing strategies *Linda O'Dierno*		Using aquaculture methods to measure the interactions of restored and existing bivalve populations *Amanda Wenczel*
11:30 AM			The Great Halloween bay scallop seed stranding event of 2011 *Peter Boyce*
11:45 AM			*Wrap-up*
12:00 PM	**Lunch in Marriott Ballroom**		

	Salons C&F
	Community-Based Shellfish Restoration *Chair: Dorothy Leonard*
1:30 PM	Changing public perceptions one oyster at a time *Sandra Macfarlane*
1:45 PM	Martha's Vineyard shell recovery partnership *Jessica Kanozak*
2:00 PM	Incorporating community-based efforts into large-scale oyster (*Crassostrea virginica*) restoration projects in South Carolina estuaries *Michael Hodges*
2:15 PM	Production and performance of living reef blocks as an oyster, (*Crassostrea virginica*) reef substrate: a study of aquaculture and oyster restoration *Peter Malinowski*
2:30 PM	Puyallup tribal treaty rights and shellfish aquaculture in Puget Sound, Washington state *David Winfrey*
2:45 PM	Protective measures for shellfish area support - exploring new water quality standards, watershed management approaches, and closure criteria for Hawaii's coastal systems *David Penn*
3:00 PM	Wrap-up

Aquaculture & Restoration - A Partnership
About our Guest Speakers

We are fortunate to have three distinguished speakers who will present their thoughts on the role aquaculture can play in both meeting world demands for fishery products and in helping to restore shellfish resources around the world.

Eric C. Schwaab was appointed January 17, 2012 as the Acting Assistant Secretary for Conservation and Management for the National Oceanic and Atmospheric Administration. He previously served as the Assistant Administrator for Fisheries for NOAA since February 2010.

As Acting Assistant Secretary, he will drive the policy and program direction for NOAA's stewardship responsibilities, including ocean resource management, coastal management and protected resources. Working closely with the Assistant Secretary for Environmental Observation and Prediction, Mr. Schwaab will ensure the effective integration of activities, information, products and services across NOAA.

As the Assistant Administrator for Fisheries, he focused on rebuilding the Nation's fisheries stocks, ending overfishing, enhancing protection of endangered species, marine mammals and sea turtles and improving aquatic habitat conditions on which these resources depend. He led efforts with the regional fishery management councils and the fishing industry to establish annual catch limits for all commercial fisheries, and to protect the jobs and livelihoods that depend on our nation's fisheries by promoting management approaches that achieve both sustainable fisheries and vibrant coastal communities.

Eric has close to 30 years of experience in a variety of local, state and federal natural resource management positions. He has spent the majority of his career at the Maryland Department of Natural Resources, where he began as a natural resources police law enforcement officer in 1983. During this time, he served as director of the Maryland Forest Service; director of the Maryland Forest, Wildlife and Heritage Service; and director of the Maryland Fisheries Service. In 2003, he left the Maryland Department of Natural Resources to serve as resource director for the Association of Fish and Wildlife Agencies until 2007. He then returned to the Maryland Department of Natural Resources as the agency's Deputy Secretary. He also served as a member of the U.S. Department of Commerce Marine Fisheries Advisory Committee from 2005-2010.

He holds an undergraduate degree in Biology from McDaniel College and a Masters Degree in Environmental Planning from Towson University.

He resides in Catonsville, Maryland with his wife, Valerie, and their 3 daughters.

Sebastian Belle began his career as a commercial fisherman, working his way through university as a mate on offshore lobster boats. Currently, Mr. Belle is the Executive Director of the Maine Aquaculture Association, a private non-profit association representing Maine shellfish and finfish growers. Mr. Belle sits on the National Organics Standards Board Aquaculture Task Force, the Standards Oversight Committee of the Global Aquaculture Alliance and the Boards of Directors for the USDA Northeast Regional Aquaculture Center and the International Salmon Farmers Association. Prior to joining the Maine Aquaculture Association, Mr. Belle was the state aquaculture coordinator working for the Maine Department of Marine Resources and managed commercial salmon and tuna farms. Mr. Belle holds degrees in fisheries biology and agricultural economics and has served as a technical consultant and manager on over twenty commercial aquaculture ventures in nine countries. Mr. Belle has authored numerous articles and several book chapters on the development and implementation of Best Management Practices and Risk Control Programs on commercial aquaculture operations. In addition to his role as the Maine Aquaculture Association's Executive Director, Mr. Belle is President of Econ-Aqua, a consulting firm specializing in aquaculture project design, operations management, financial due diligence and risk analysis and control.

Boze Hancock is the Marine Restoration Scientist for the Nature Conservancy Global Marine Team, based at the University of Rhode Island's Bay Campus. Boze has over 25 years of experience in marine research, working on the ecology, fisheries, management and restoration of coastal marine resources. For many years he worked in the tropical and temperate Indian and Southern Oceans of Western Australia, researching the fisheries ecology of marine invertebrates, primarily molluscs, and advising the fishing industry and fisheries managers. Since 2004 Boze has been involved in marine habitat restoration in the US and territories, with particular emphasis on shellfish restoration. In this position Boze provides technical support to the numerous project managers and teams that undertake marine habitat restoration within TNC. Boze has worked closely with NOAA's Restoration Center and numerous restoration organizations through a National TNC-NOAA Partnership. The position also involves providing the science to support and scale up marine restoration, and promoting marine restoration within TNC and partner organizations internationally.

John K. Bullard assumed the duties of the Regional Administrator for NOAA's Northeast Regional Office on August 6, 2012. As the Regional Administrator, 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.

Oral and Poster Presentations

* indicates the presenting author of oral presentations, those without * designation are poster presentations

Steven Allen, Peter Bergstrom*, A.C. Carpenter, Mark Luckenbach, Kennedy Paynter, Angela Sowers, Eric Weissberger, James Wesson, Stephanie Westby

NEW OYSTER RESTORATION METRICS FOR THE CHESAPEAKE BAY

Steven Allen, Stephanie Westby, Claire O'Neil, Angela Sowers, Eric Weissberger

DEVELOPING A BLUEPRINT FOR TRIBUTARY-WIDE OYSTER RESTORATION IN THE MARYLAND PORTION OF THE CHESAPEAKE BAY

April Bagwell, Mike Rust*

ENHANCING YOUR OUTREACH PORTFOLIO—WHAT ARE YOUR OPTIONS FOR WORKING WITH NOAA FEDERAL LABS?

Allen Barton*

OCEAN ACIDIFICATION ROUND TABLE

Sebastian Belle*

FROM HARVEST TO PLATE; GETTING YOUR FISH TO THE CUSTOMER

Oliver Bender*, Peter Boyce

DO MUD CRABS (*DYSPANOPEUS SAYI*) PREY UPON BAY SCALLOPS (*ARGOPECTEN IRRADIANS IRRADIANS*) IN SPAT COLLECTORS?

Gabriel Betty

IMPACTS OF AQUATIC INVASIVE SPECIES ON RHODE ISLAND SHELLFISH AQUACULTURE

Robert Bishop*

AN INTEGRATED MARINE RECIRCULATION AQUACULTURE SYSTEM FOR ABALONE PRODUCTION

Todd Bobowick*

USDA-NRCS: HOW FARM BILL PROGRAMS WORK WITH AQUACULTURE

Rachel Bone*, Daniel Ward, David Bengtson, Chong Lee, Roxanna Smolowitz, Marta Gomez-Chiarri

PATHOLOGICAL EFFECTS OF SOYBEAN'S ANTI-NUTRITIONAL FACTORS ON SUMMER FLOUNDER (*PARALICHTHYS DENTATUS*) TISSUES

Mark Borrelli*, Anamarija Frankic, Curtis Felix, Jennifer Wilson

USING HIGH FREQUENCY SIDESCAN SONAR TO MAP SHELLFISH HABITAT AND ESTIMATE POPULATIONS ON A MANAGED OYSTER REEF: PRELIMINARY RESULTS

Peter Boyce*, Oliver Bender

THE GREAT HALLOWEEN BAY SCALLOP SEED STRANDING EVENT OF 2011

Suzanne Bricker, Tessa Getchis*, Cary Chadwick, Julie Rose, Cori Rose

MERGING MODELING AND MAPPING: THE INTEGRATION OF ECOSYSTEM-BASED MODELS AND INTERACTIVE WEB-BASED VISUALIZATION TOOLS FOR IMPROVED AQUACULTURE DECISION MAKING

Kelsey Brockett*, Jessica Peterman, John Roy

AN INITIAL INVESTIGATION INTO JUVENILE LOBSTER, (*HOMARUS AMERICANUS*), BENTHIC HABITAT PREFERENCE

Nick Brown*

FINFISH GROWOUT IN MARINE RECIRCULATION SYSTEMS: CHALLENGES AND POTENTIAL SOLUTIONS

Lynda Brushett*

AQUACULTURE COOPERATIVES AND COMMUNITY SUPPORTED FISHERIES: HOW COOPERATION AMONG COMPETITORS CONTRIBUTES TO INDEPENDENT BUSINESS PROFITABILITY

David Bushek*, Daphne Munroe, Eric Powell

OYSTER MORTALITY AND DISEASE IN DELAWARE BAY: IMPACT AND RECOVERY FOLLOWING HURRICANE IRENE AND TROPICAL STORM LEE

Lisa Calvo, Barney Hollinger, William Riggin

IMPROVEMENT AND DEMONSTRATION OF SUBTIDAL CAGE-CULTURE METHODS TO CULTIVATE OYSTERS IN DELAWARE BAY, NEW JERSEY

Lisa Calvo, William ShadelJenny Paterno

SEEDING THE FUTURE: STUDENT CENTERED COMMUNITY-BASED OYSTER RESTORATION EFFORTS IN DELAWARE BAY, NEW JERSEY

Ryan Carnegie*, David Bushek

INTERSTATE SHELLFISH SEED TRANSPORT: IMPROVING REGULATIONS TO FACILITATE COMMERCE WHILE ENHANCING BIOSECURITY

Cyr Carole, Gilmore Solomon Lisandre, Bourque François

MUSSEL LARVAE PRODUCTION ENHANCEMENT BY RESTOCKING MUSSELS BEDS IN BASSIN DU HAVRE-AUBERT, MAGDALEN ISLANDS

Tyler Carrier, Stephen Eddy, Sarah Redmond

COMPARING GROWTH RATES OF JUVENILE GREEN SEA URCHINS, (*STRONGYLOCENTROTUS DROEBACHIENSIS*) ON FOUR DIFFERENT DIETS

James Cervino*

ELECTRICAL RESTORATION OF OYSTERS AND SALTMARSH AT A NEW YORK CITY ESTUARINE WETLAND

Michael Chambers*

CAGE CULTURE OF MARINE FISH IN NEW ENGLAND

Erik Chapman*

COMMUNITY SUPPORTED FISHERIES SUMMIT - BUILDING A NETWORK, IDENTIFYING CHALLENGES AND OPPORTUNITIES, AND DEFINING NEXT STEPS

Derrick Chelikowsky, Diane Kapareiko, Dorothy Jefferess, Gary Wikfors, Carmela Cuomo

THE MICROALGA PAVLOVA CONTAINS AN ANALOG FOR THE HORMONE ECDYSONE THAT PROMOTES METAMORPHOSIS OF LARVAL BAY SCALLOPS (*ARGOPECTEN IRRADIANS IRRADIANS*)

Joseph Choromanski, Sheila Stiles, Dorothy Jeffress, Haley Ladeau
EVALUATION OF BAY SCALLOPS FROM GENETIC LINES OF TWO GEOGRAPHIC POPULATIONS FOR GROWTH AND SURVIVAL IN THE NIANTIC RIVER, CONNECTICUT

Loren Coen*, Boze Hancock, Lesley Baggett, Sean Powers, Rob Brumbaugh, Summer Morlock, Bryan DeAngelis
EVALUATING OYSTER REEF RESTORATION: CRITICAL ECOSYSTEM SERVICE-BASED GOALS

Anne Cohen*, Daniel McKorkle, Gail Schwieterman, Kathryn Rose
OCEAN ACIDIFICATION CAUSES SHELL DEFORMITIES AND REDUCED CALCIFICATION IN *CRASSOSTREA VIRGINICA* LARVAE

Kevin Coles, Dennis McIntosh
PRODUCTION OF MUMMICHOGS (*FUNDULUS HETEROCLITUS*) USING BIOFLOC TECHNOLOGY

Anoushka Concepcion*
MARKET OUTLETS FOR SEAWEED PRODUCTION IN NEW ENGLAND

Dave Conley*, SaiGiridhar Dasika
SHELLMAN – A PRODUCTION MANAGEMENT SOLUTION THAT ADDS MORE VALUE TO YOUR BUSINESS

April Croxton, Gary Wikfors
APOPTOSIS MEASUREMENTS IN SEVERAL BIVALVE SPECIES DURING A SEASONAL CYCLE

Soren Dahl*, Debra Barnes, Bassem Allam
QPX EPIZOOTIOLOGY: TEN YEARS OF DATA FROM A HARD CLAM FISHERY IN RARITAN BAY, NY

Chris Davis, Jeffrey McKeen*
A BRIEF HISTORY OF SHELLFISH FARMING IN MAINE

Chris Davis*
HATCHERY & NURSERY CULTURE OF SHELLFISH

Jonathan Davis*, Brian Allen, Betsy Peabody
DEVELOPING COLLABORATIONS AND METRICS FOR OLYMPIA OYSTER RESTORATION IN WASHINGTON STATE

Jonathan Davis*
EAST MEETS WEST: SHELLFISH AQUACULTURE ON THE WEST COAST; CURRENT CULTURE PRACTICES, PROBLEMS AND PROSPECTS

Julie Davis*, William Walton
EFFECTS OF STOCKING DENSITY AND BASKET ORIENTATION WHEN USING THE ADJUSTABLE LONGLINE SYSTEM FOR OYSTER GROW-OUT: MEASURES OF PRODUCT QUALITY

Bryan DeAngelis*, Summer Morlock, Lesley Baggett, Sean Powers, Loren Coen, Robert Brumbaugh, Boze Hancock

DISCUSSION OF THE UNIVERSAL METRICS PROPOSED IN THE PRECEDING PRESENTATIONS (REEF AREA, REEF VERTICAL RELIEF, OYSTER DENSITY SIZE DISTRIBUTION, AND CRITICAL ECOSYSTEM SERVICE-BASED GOALS)

Bryan DeAngelis*, Lesley Baggett, Sean Powers, Robert Brumbaugh, Loren Coen, Summer Morlock, Boze Hancock

MEASUREMENT OF OYSTER DENSITY AND SIZE DISTRIBUTION ON RESTORED REEFS AND BEDS.

Donatella Del Piero

SOMETIMES THEY COME BACK

Michael Devin*, Molly Flanagan, Paul Rawson, Chauncey Devin, Dana Morse

VARIATION IN SETTLEMENT AND EARLY GROWTH OF JUVENILE RAZOR CLAMS (*ENSIS DIRECTUS*) IN A HATCHERY SETTING.

Maden Dey*

SUPERMARKET SALES TRENDS FOR AQUACULTURE PRODUCTS

Mark S. Dixon*, Genevieve Bernatchez, Kelsey Boeff, Eve Galimany, Yaqin Li, Aynur Lok, Shannon L. Meseck, Marguerite Petit

THE ATLANTIC RIBBED MUSSEL, (*GEUKENSIA DEMISSA*), GROWN USING STANDARD AQUACULTURE METHODS, HAS POTENTIAL FOR USE IN NUTRIENT BIOEXTRACTION

Sean Dixon*, Sam Lee, Dennis O'Connor

EMERGING LOCAL MARKET MECHANISMS FOR SHELLFISH PRODUCERS - NEW YORK CITY CSF CASE STUDY

Paul Dobbins*

CHALLENGES AND OPPORTUNITIES OF KELP FARMING IN NEW ENGLAND

Craig Downs*

CORAL MICROPROPAGATION TECHNOLOGIES AND AQUACULTURE FOR CORAL REEF RESTORATION

Kelly Drake*

CONDUCTING SHELLFISH AQUACULTURE HISTORY RESEARCH AT THE MYSTIC SEAPORT

Shelley Edmundson, Elizabeth Fairchild

EFFECTS OF TEMPERATURE ON INCUBATION PERIOD, SURVIVAL, AND GROWTH RATES OF JUVENILE CHANNELED WHELK (*BUSYCOTYPUS CANALICULATUS*)

Shelley A. Edmundson, Elizabeth A. Fairchild, Warren Doty, Nathan Rennels, John Armstrong, Brett Stearns, Serel Garvin, Danielle Ewart, David Grunden

RESTORING WINTER FLOUNDER (*PSEUDOPLEURONECTES AMERICANUS*) POPULATIONS ON MARTHA'S VINEYARD, MA THROUGH STOCK ENHANCEMENT

Carole Engle*

MANAGING YOUR AQUACULTURE BUSINESS DURING DIFFICULT FINANCIAL TIMES

Melissa Evans*

BEST PRACTICES FOR POST-HARVEST RAPID COOLING

Elizabeth Fairchild*

FLATFISH CULTURE, WITH AN EMPHASIS ON SPECIES CULTIVATED IN THE NORTHEASTERN UNITED STATES

Julian Fiorentino*

EXPERIMENTAL FISH FEED USING ALGAL PROTEIN FOR RAINBOW TROUT (*ONCORHYNCHUS MYKISS*)

Allison Fitzgerald*, Chester Zarnoch, William Wallace

RESTORATION WITHIN AN URBANIZED ENVIRONMENT: EFFECTS OF ANTHROPOGENIC INPUTS ON THE HEALTH OF JUVENILE OYSTERS (*CRASSOSTREA VIRGINICA*)

Amy Fitzpatrick*

ENSURING CONSUMER SAFETY THROUGH BEST PRACTICES FOR POST-HARVEST HANDLING, TRANSPORTATION, AND STORAGE

Gef Flimlin*

RECORD KEEPING AND BMP'S FOR SHELLFISH FARMERS

Gef Flimlin*

THE HISTORY OF SHELLFISH CULTURE IN NEW JERSEY

Gef Flimlin*, Sandra Macfarlane

DEVELOPING AN INDIVIDUAL FARM PLAN FOR EAST COAST SHELLFISH GROWERS

Thomas Foca, David Bushek*

DEVELOPING REMOTE SETTING CAPABILITIES WITH DISEASE-RESISTANT TRIPLOID OYSTERS FOR SHELLFISH LEASES IN DELAWARE BAY

Seth Garfield*

MARKETING OF OYSTERS

Tessa Getchis*, Timothy Visel, Walter Blogoslawski

A HISTORY OF CONNECTICUT'S SHELLFISHING INDUSTRY

Tessa Getchis*

AQUACULTURE PRODUCTION HAZARDS – DEVELOPING OUTREACH SERVICES TO THE REGION'S FARMERS VIA EXTENSION AND AQUATIC ANIMAL PROFESSIONALS USING A HACCP APPROACH.

Tessa Getchis, Cori Rose, David Carey, Shannon Kelly, Kristen Bellantuono, R. Michael Payton, Mark Johnson

HOW TO GET YOUR CONNECTICUT AQUACULTURE PROJECT PERMITTED

Ronald Goldberg*, George Sennefelder

CULTURE OF BIVALVE MOLLUSKS – A MILFORD LABORATORY PERSPECTIVE, 1920s – 1960s

Lindsay Green*

SEED PRODUCTION FOR SEAWEED AQUACULTURE

Mark Green*

OCEAN ACIDIFICATION ROUND TABLE

Neil Greenberg*

ORNAMENTAL FISH CULTURE – FROM FISH TANKS TO FISH FARMS: THE EVOLUTION OF AN INDUSTRY

Boze Hancock*, Lesley Baggett, Sean Powers, Robert Brumbaugh, Loren Coen, Summer Morlock, Bryan DeAngelis

DEFINITION AND MEASUREMENT OF REEF AREA AND VERTICAL RELIEF OF RESTORED OYSTER REEFS.

Boze Hancock*, Sean Powers, Lesley Baggette, Robert Brumbaugh, Loren Coen, Summer Morlock, Bryan DeAngelis

NATIONAL GUIDELINES FOR METRICS USED FOR MONITORING OYSTER RESTORATION PROJECTS

Sean Handley*, Keith Michael, James Williams, Ian Tuck, Alistair Dunn, Rosemary Hurst

SHELLFISH RESTORATION, NELSON BAYS, NEW ZEALAND

Katherine Hladki, Christopher Neefus, Larry Harris

COUPLING URCHINS, SEAWORMS, AND SEAWEED IN A PILOT SCALE INTEGRATED MULTI-TROPHIC AQUACULTURE SYSTEM

Michael Hodges*, Nancy Hadley

INCORPORATING COMMUNITY-BASED EFFORTS INTO LARGE-SCALE OYSTER (*CRASSOSTREA VIRGINICA*) RESTORATION PROJECTS IN SOUTH CAROLINA ESTUARIES

John Holzapfel*

A HISTORY OF SHELLFISH CULTURE ON LONG ISLAND, NY

Scott Hughes, Joseph Hinton, Zachary Schuller

NATURAL SPATFALL COLLECTION FOR AUGMENTATION OF BAY SCALLOP RESTORATION EFFORTS

Rachel Hutchinson

COMPARATIVE GROWTH OF QUAHOG (*MERCENARIA MERCENARIA*) SEED IN VARIOUS GROW-OUT CONDITIONS, CHATHAM, MA

Courtnay Janiak*, Dennis McIntosh

DEVELOPING SUSTAINABLE EGG COLLECTION METHODS FOR THE MUMMICHOG: FREQUENCY OF COLLECTION AND COLLECTOR DEPTH

Jessica L. Jones, William Watkins*

VIBRIO CONCERNS FOR SHALLOW WATER AND FLOATING AQUACULTURE – WHAT WE KNOW AND WHAT WE DON'T.

Steve Jones*

DETECTION METHODS FOR PATHOGENIC (VIBRIO) SPECIES

Jessica Kanozak*, Richard Karney

MARTHA'S VINEYARD SHELL RECOVERY PARTNERSHIP

Diane Kapareiko*, Jennifer Alix, Dorothy Jeffress, Gary Wikfors

A LOOK AT SPECIES-SPECIFIC AND SEASONAL EFFECTS OF TWO PROBIOTIC BACTERIA UPON HEMOCYTES OF THE EASTERN OYSTER (*CRASSOSTREA VIRGINICA*) AND THE NORTHERN BAY SCALLOP (*ARGOPECTEN IRRADIANS IRRADIANS*)

Hillary Kenyon, Tessa Getchis, Kate Blacker, Karen Rivara, Inke Sunila

DEPLOYING REMOTE-SET DISEASE-RESISTANT EASTERN OYSTER, (*CRASSOSTREA VIRGINICA*), IN BIODEGRADABLE NETTING ON A SHELLFISH LEASE IN CONNECTICUT

Jang Kim*, Sarah Redmond, George Kraemer, John Curtis, Charles Yarish

OPEN WATER CULTIVATION OF *GRACILARIA TIKVAHIAE* AND *SACCHARINA LATISSIMA* IN LONG ISLAND SOUND AND THE BRONX RIVER ESTUARY

Nick King*

HATCHERY PRODUCTION OF MARINE FISH

Peter Kingsley-Smith*, John Heinsohn, Katherine Luciano, Kristin Schulte, Benjamin Stone

THE USE OF ABANDONED AND UNWANTED CRAB TRAPS AS A VIABLE SUBSTRATE FOR PROMOTING OYSTER REEF DEVELOPMENT AND CREATING ESSENTIAL FISH HABITAT.

Christian Lawrence*

THE IMPORTANCE OF THE ZEBRAFISH FOR THE AQUACULTURE INDUSTRY

Dale Leavitt*, Chris Davis

USE OF INSTRUMENTATION FOR AQUACULTURE SITE SELECTION AND WATER QUALITY MONITORING

Dorothy Leonard*

BEST MANAGEMENT PRACTICES FOR SHELLFISH RESTORATION

Scott Lindell*, Emma Green-Beach, Molly Peach, Morgan Beal, Charlotta Jornlind, Charles Yarish, Jang Kim

MULTI-CROPPING SEAWEED GRACILARIA TIKVAHIAE WITH OYSTERS IN WAQUOIT BAY, MASSACHUSETTS

Scott Lindell*, Emma Green-Beach, Bill Silkes, Rick Karney, Alec Gale, Mary Carman, Greg Mataronas, Michael Marchetti

RESEARCH AND IMPROVED MANAGEMENT FOR OFFSHORE MUSSEL FARMS IN SOUTHERN NEW ENGLAND

Carl LoBue*

LESSONS LEARNED: MODERNIZING WILD SHELLFISH HARVEST MANAGEMENT AS PART OF A BAY-WIDE SHELLFISH RESTORATION PROGRAM (HARD CLAMS IN GREAT SOUTH BAY NY)

Jim Lodge, Raymond Grizzle, Allison Mass

PHASE 2 OF THE OYSTER RESTORATON RESEARCH PARTNERSHIP, 2012-2014: SCALING UP EFFORTS AT SOUNDVIEW PARK, BRONX, NY TO MAZIMIZE RETENTION OF PLANTED SPAT-ON-SHELL AND THE RECRUITMENT OF WILD OYSTERS

Sandra Macfarlane*

CHANGING PUBLIC PERCEPTIONS ONE OYSTER AT A TIME

Sandra Macfarlane*

SHELLFISH IN CAPE COD BAY: CENTURIES OF HARVESTING BOUNTIFUL BIVALVES

Peter Malinowski*

PRODUCTION AND PERFORMANCE OF LIVING REEF BLOCKS AS AN OYSTER, (*CRASSOSTREA VIRGINICA*) REEF SUBSTRATE: A STUDY OF AQUACULTURE AND OYSTER RESTORATION TECHNIQUES IN NEW YORK HARBOR

Ted Maney*, Mark Fregeau, David Alves, Scott Lindell, Bill Lee, Jim Blake

ESTABLISHING AN OFFSHORE MUSSEL FARM IN FEDERAL WATERS IN THE GULF OF MAINE

Kathryn Markey

LIFE CYCLE OF THE EASTERN OYSTER, (*CRASSOSTREA VIRGINICIA*) (GMELIN, 1791), A PEN AND INK PERSPECTIVE.

Devon Marsden*

USDA- FARM SERVICE AGENCY NAP OVERVIEW

Jiff Martin*

STARTING A CSA IN CONNECTICUT

Daniel McCorkle*, James Widman, Anne Cohen, Lisa Milke, Barbara Ramon

OCEAN ACIDIFICATION IMPACTS ON SURVIVAL AND GROWTH OF LARVAL SURFCLAMS (*SPISULA SOLIDISSIMA*) – ENVIRONMENTAL CONDITIONS (WAQUOIT BAY, MA) AND CULTURE STUDIES.

Will McCormick*

GROWOUT OF SHELLFISH

Caroline McLaughlin, Gef Flimlin*, Jennifer Lamonaca

COMMUNITY SUPPORTED AGRICULTURE: ADDING SEAFOOD TO THE RECIPE

Shannon Meseck*, Paul Clark, Renee Mercaldo-Allen, Julie Rose, Ronald Goldberg

DOES THE FREQUENCY OF HYDRAULIC DREDGING ON CULTIVATED SHELLFISH BEDS INFLUENCE THE SEDIMENT CHEMISTRY AND IS THERE A RELATIONSHIP BETWEEN BENTHIC ORGANISMS PRESENT?

Nicole Messerman, Timothy Bowden

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NEW OYSTER RESTORATION METRICS FOR THE CHESAPEAKE BAY

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While oyster restoration efforts have been under way in the Chesapeake Bay for more than two decades, until recently, varying reporting methods and success criteria made it difficult to determine how much progress had been made. A goal to "Restore native oyster habitat and populations in 20 out of 35 to 40 candidate tributaries by 2025" was set in the 2010 strategy to implement the Chesapeake Bay Protection and Restoration Executive Order (signed by President Obama in 2009). This goal made it a priority for state and federal fishery managers, academics, and scientists working on oyster restoration to collaboratively define a "restored tributary" and a "restored reef" to enable them to track progress. A team of these people, led by NOAA staff, agreed on "oyster metrics" in 2011 (http://preview.tinyurl.com/8kmbdpm) that specify key metrics and target ranges for them, including tributary size, how to determine how much restorable bottom a tributary contains, how much of that restorable bottom needs to be restored, and the minimum oyster density and biomass in that restored bottom to count a tributary as restored. These new metrics enable experts to clearly see how oyster restoration efforts are working and use adaptive management to improve these efforts. These metrics serve as a tool to plan and evaluate oyster restoration consistently across the Chesapeake Bay, and the consensus-based framework used to develop them may have broader application to other restoration activities.

DEVELOPING A BLUEPRINT FOR TRIBUTARY-WIDE OYSTER RESTORATION IN THE MARYLAND PORTION OF THE CHESAPEAKE BAY

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In the past, oyster restoration in Maryland was performed primarily on a bar-by-bar basis, with no concerted focus on whole tributaries. In May 2009, President Obama issued Executive Order 13508, "Chesapeake Bay Protection and Restoration." Subsequently, the Bay's Federal agencies established an oyster outcome of restoring oyster populations in 20 tributaries by 2025. Tributary-based restoration provides an opportunity to concentrate effort and generate a system-wide impact on oyster populations. In response, an interagency team convened to craft specific goals and metrics to evaluate restoration success. Using the newly-minted goals and metrics, the Maryland Interagency Workgroup (a small state-Federal working group) started out on the ambitious task of preparing and implementing tributary-based restoration plans. Drawing on available information, including water quality data, seafloor surveys, sanctuary boundaries, and historical spat set, the Maryland Interagency Workgroup selected Harris Creek as its first tributary for intensive oyster restoration. A restorable bottom analysis was developed using the historical oyster population footprint and seafloor surveys. This led to the establishment of a restoration target of 300 to 600 acres of functioning oyster habitat in Harris Creek. The workgroup's next step was to identify potential reef treatments, including substrate and seeding for individual sites, as well as determine restoration costs. Implementation was started in 2012 and is expected to continue for the next few years. Monitoring of the oyster population

is planned until the success metrics are reached. The workgroup is using this process and lessons learned as a prototype for the remaining tributary plans in Maryland.

ENHANCING YOUR OUTREACH PORTFOLIO—WHAT ARE YOUR OPTIONS FOR WORKING WITH NOAA FEDERAL LABS?

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Outreach and extension have become requirements for many grant applications, but creating opportunities for extending your research into this realm is not always easy. The ultimate goal is to get the best available science out of the lab and into industry's hands to enhance aquaculture technologies. We will give several examples of how the NOAA federal labs are helping and encouraging scientists to create and engage in outreach and technology transfer activities, traditional and non-traditional, leading to a more robust outreach portfolio for grant proposals and to focus on research results that get used by society. In addition, we will discuss collaborating and partnering with NOAA labs, which often have unique facilities and expertise to aid in research outreach and extension. Partnering allows for direct outreach between university researchers, regulatory agencies, labs, and industry. One mechanism for direct extension between NOAA scientists, universities, and industry is Cooperative Research and Development Agreements (CRADA's). CRADA's allow for technology transfer between government and private labs for mutual benefit and allow private industries the chance to use facilities and expertise at National labs. As aquaculture scientists, providing the newest information to industry should be of utmost importance for developing a successful and sustainable seafood supply. As a regulatory agency, we rely on scientists to provide invaluable information about their research so we can use this information to help shape policy and regulation.

DO MUD CRABS (*DYSPANOPEUS SAYI*) PREY UPON BAY SCALLOPS (*ARGOPECTEN IRRADIANS IRRADIANS*) IN SPAT COLLECTORS?

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A study of the spawning and recruitment of Nantucket Bay Scallops (*Argopecten irradians irradians)* has been ongoing since 2006. Spawning and recruitment has been measured by deploying spat collectors at several locations every two weeks from May through December. Each spat line consists of 4 spat bags supported by buoys. The spat bags collect bay scallop larvae as well as the larvae from several different crab species. The most common crab in the bags is Say's Mud Crab *Dyspanopeus sayi*. To measure the effect of these crabs on the bay scallop recruitment in each individual spat bag we compared the population of crabs in each bag with the population of scallops in each bag. There was no correlation between the two. We concluded that the number of crabs had no effect on the number of scallops. We also mapped the spawning patterns of Say's Mud Crab, which show a well-defined seasonal spawning pattern. During most years, the peak of the mud crab spawn came before the peak of the bay scallop spawn. However, the crab spawning patterns vary from year to year. Finally we note that, during the peak of the spawn, a majority of the crabs were found in spat bags at sites outside of the harbor. We assume that tidal currents are flushing out larvae from the harbor, as is the case for the scallop larvae

IMPACTS OF AQUATIC INVASIVE SPECIES ON RHODE ISLAND SHELLFISH AQUACULTURE

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The introduction of intentionally and non-intentional exotic species within Rhode Island has been in occurrence since European explores first began the colonization of New England. The dispersal of exotic species throughout New England over the past few hundred years has led to the alteration of local community structure with the over competition of indigenous species. This investigation of the species and abundance of exotic species was conducted at the Matunuck Oyster Farm 6.9 acre lease within Potters Pond. Starting with the third week of May 2012 (Monday 14th) to the third week of August 2012 (Monday 13), observations were conducted and recorded on overall farmed oysters *Crassostrea virginica*, farm

equipment and the farm's ecological community structure. Measure of species abundance was recorded as small-scale presence (1-30%) common presence (31-60%) and extensive presence (61-100%). A total of fifteen exotic species, along with a total of three cryptogenic species have been identified, representing eight different phyla. The polychaete *Harmithoe imbricata*was found widely in and around farm equipment and oysters but without much observed impact. Most of the sessile species identified were pests on the oyster farm, requiring periodic bag defouling. The main exotic organisms fouling the oyster bags and other equipment included *Botrylus schlosseri*, *Botrylus violaceus*, *Carcinus maenas*and *Codium fragile tomentosoides*. By increasing the need for defouling, these particular species made overall farming operations more demanding and costly.

AN INTEGRATED MARINE RECIRCULATION AQUACULTURE SYSTEM FOR ABALONE PRODUCTION

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With environmental changes taking place around the world, cost of costal land increasing, there is a point in time when all the elements come together to allow next generation technology systems to take over older abalone systems to better the abalone farming industry.

While most abalone farms around the world are still older systems, labor intensive, by the ocean, costly intake systems, ongoing local state rules and regulation changes which makes it harder and more costly to operate in today economical 21st century, this paper will show the difference that an integrated marine recirculation aquaculture system for abalone farming and other seafood products can work today.

Abalone farming in the new system is benefiting in ways of lower electrical cost, lower feed conversation ratios, lower labor cost, better control of the finial product for the market, real time data information, better placed for improved genetics of abalone stock and full control of their environment. This all helps lower the cost of operations as well as a more sustainable environmental outcome both for the farm and local area.

With some current research work being done in-conjunction with the University of Maine, and past work with North Carolina State University and University of Canterbury New Zealand over the past 20 years, integrated marine recirculation aquaculture systems are helping the new generation of abalone farming work smarter and more economically in the 21st century.

USDA-NRCS: HOW FARM BILL PROGRAMS WORK WITH AQUACULTURE

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The USDA-Natural Resources Conservation Service (NRCS) provides both technical and financial assistance for the implementation of conservation practices on private lands. NRCS provides assistance through the conservation provisions of the Farm Bill. Understanding the rules and regulations of Farm Bill Programs, in particular the Environmental Quality Incentives Program (EQIP), as they relate to aquaculture can be confusing. The presentation will explain the role of NRCS and the applicability of the EQIP Program for the implementation of conservation practices for inland finfish and marine bivalve aquaculture. Current Farm Bill policy and available conservation practices will be discussed.

PATHOLOGICAL EFFECTS OF SOYBEAN'S ANTI-NUTRITIONAL FACTORS ON SUMMER FLOUNDER (*PARALICHTHYS DENTATUS*) TISSUES

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Previous research has shown that when summer flounder (*Paralichthys dentatus*) are fed diets in which soybean meal (SBM) replaced ≥ 60% of fish meal (FM), a reduction of growth occurs. However, when summer flounder are fed a soy protein concentrate (SPC) diet, there is little to no reduction in growth. Interestingly, summer flounder fed on SBM diets had better survival when challenged with the pathogenic bacterium *Vibrio harveyi* than fish fed on SPC or FM diets. We hypothesized that compounds found in SBM, but not SPC, are responsible for both reduced growth and increased survival during bacterial challenge. To determine which compounds in SBM are responsible for increased survival during bacterial challenge and reduced growth, four SPC replacement diets were formulated with different concentrations of soybean molasses (the portion of SBM not present in SPC). Increasing concentrations of SBMol(12 – 36%) resulted in reduced growth compared to control FM or SPC diets. Fish fed on diets containing SBMol at levels equivalent to a 12% SBM replacement diet showed the highest levels of survival. In order to understand the mechanisms responsible for the reduction in growth seen in diets containing SBMol, samples of summer flounder tissues involved in nutrient absorption and processing (pyloric cecae, small intestine, liver, and spleen) were prepared for histological examination. The morphological integrity of the intestinal and digestive structures was ranked on a semi-quantitative scale. Our studies will identify which concentrations of SBMol result in minimal tissue damage and optimal growth, while providing increased survival to disease challenge.

USING HIGH FREQUENCY SIDESCAN SONAR TO MAP SHELLFISH HABITAT AND ESTIMATE POPULATIONS ON A MANAGED OYSTER REEF: PRELIMINARY RESULTS

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A test site was established in Wellfleet Harbor, Massachusetts to restore an oyster reef in order to increase wild aquaculture productivity and improve water quality in the harbor. As part of that larger ongoing study, the Provincetown Center for Coastal Studies (PCCS) and the Town of Wellfleet are using two acoustic instruments to map intertidal and subtidal shellfish beds and surrounding areas. The first of two data collection surveys has been completed. A Phase-Measuring Bathymetric Sonar (PMBS) and an ultra-high, dual frequency sidescan sonar have been used to collect data in the summer of 2012. The PMBS has an operating frequency of 200 kHz and collects coincident swath bathymetry and backscatter imagery and the sidescan sonar has two simultaneously operating frequencies of 600/1600 kHz.

Investigators from the Green Harbors Project at the University of Massachusetts-Boston are monitoring oyster reefs in portions of the Harbor as part of this larger study. They, in part, conduct low-tide surveys using quadrats of known coordinates and collect information on shellfish growth rates, biodiversity and shellfish diversity, and oyster density to determine optimal carrying capacity for the test site. Scientists from PCCS then collect acoustic data at the following high tide in those same areas to validate oyster density estimates seen in the sidescan sonar data. The fall/winter 2012-13 surveys will be used to test the ability to estimate oyster density from sidescan sonar data developed in the summer surveys.

THE GREAT HALLOWEEN BAY SCALLOP SEED STRANDING EVENT OF 2011

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Since 2006, we have been surveying the bay scallop, predator, and eelgrass health in Nantucket Harbor each September at up to 48 sites. During the years 2006 – 2010 five of the shallow sites in the present study averaged 1.4 – 18 scallops per $25m^2$ transect. In 2011, the Town of Nantucket Shellfish Biologist released 10 million bay scallop larvae on June 4. Our 2011 September survey showed a uniform size population of seed scallops at all six sites numbering from 24 to 1,111 per 25 m^2 transect. We hoped to use this relatively isolated population for studies of natural survival rates.

On October 30, 2011, north winds of over 60 kph sustained over several hours stranded large numbers of bay scallop seed on the north-facing beaches. Over 400 bushels of seed were returned to deeper water. A resurvey of the five shallow sites on June 11, 2012, showed almost no adult scallops. High winds were apparently effective in removing nearly all the seed scallop population in shallow, near-shore areas. Our one deeper site, 2 m depth, showed a count of 337 adult bay scallops, essentially unchanged from the previous September. Further surveys by the Town of Nantucket also indicated that sites farther from shore and in deeper water still harbored good populations of adult bay scallops. We conclude that strong winds can play a

major role in moving bay scallop seed populations in shallow water, and that management of such populations should include moving them to deeper water whenever practical.

MERGING MODELING AND MAPPING: THE INTEGRATION OF ECOSYSTEM-BASED MODELS AND INTERACTIVE WEB-BASED VISUALIZATION TOOLS FOR IMPROVED AQUACULTURE DECISION MAKING

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Proper site selection is critical to the development and expansion of the marine aquaculture industry. Major considerations for site selection include the potential for competing uses, environmental interactions and animal productivity. Recently two types of site selection tools, mapping and modeling, have proven useful to aquaculture siting and expansion. GIS-based mapping tools provide access to various marine and coastal datasets and allow users to gather information on the availability of land or leases, general site characteristics (e.g. bathymetry, currents, etc.), and to assess potential use conflicts (e.g. commercial fishing, recreational angling, etc.) and environmental interactions (e.g. presence of submerged aquatic vegetation, threatened or endangered species, etc.). In locales where aquaculture is new or expansion is a concern, modeling tools have become important in the decision-making process. Based on physical and biogeochemical parameters these tools allow users to determine animal growth and farm productivity as well as evaluate farm-related effects on benthic processes.

This effort will demonstrate the integration of the Farm Aquaculture Resource Management (FARM) model http://www.farmscale.org into *The Shellfisheries Mapping Atlas* http://clear2.uconn.edu/shellfish. Separately, these two tools have been used successfully in the planning for and siting of aquaculture; integrated they become a powerful tool set for decision-making. The FARM model will be used in this project to evaluate the suitability of three geographically distinct water bodies/ sites within water bodies (locations in Stonington, Milford, and Westport, Connecticut) to support aquaculture.

AN INITIAL INVESTIGATION INTO JUVENILE LOBSTER, (*HOMARUS AMERICANUS*), BENTHIC HABITAT PREFERENCE

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Since 2001 students at the Sound School Regional Aquaculture Center have been engaged in the culture of the American Lobsters, *Homarus americanus*. Questions about the choice of habitat juvenile lobsters prefer have risen. There are a number of anecdotal accounts that link juvenile lobsters with the peat found in tidal marshes. This study was performed as an initial test to see if the juvenile lobsters would prefer a benthic substrate of peat to one of small cobble. In this study 75 lobsters hatched in the 2012 season were equally divided into five 131L kreisals. The kreisals were part of a 4500L recirculating seawater system. The system contained physical and biological filters; was aerated and was thermally regulated. The lobsters were released into each well and allowed to acclimate. Each kreisal contains an equal amount of each substrate. The animals are being fed a gelatin based diet every other day. Water quality is being monitored daily and water changes performed as needed. At the end of two weeks each kreisal will be drained and the location of the lobsters recorded. At the end of the experiment the tanks will be cleared of all lobsters and substrate material. The experiment will be repeated using another 75 individuals from the 2012 hatch. From that point on modifications will be made to the substrates and additional tests performed in an attempt to better understand what type of habitat is most suited for release of the hatchery reared juvenile lobsters.

AQUACULTURE COOPERATIVES AND COMMUNITY SUPPORTED FISHERIES: HOW COOPERATION AMONG COMPETITORS CONTRIBUTES TO INDEPENDENT BUSINESS PROFITABILITY

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The Fishermen's Collective Marketing Act (FCMA) 1934 gave fishermen the right to organize cooperatives to jointly harvest, prepare for market, process, distribute, and price their product without being in violation of anti-trust laws. Aquaculture co-ops are member-owned and controlled businesses that provide as few or as many products and services as growers want in order to reduce costs, increase efficiency, expand sales and improve profitability of each member's independently-owned operation. Co-ops are organized to help growers develop new markets such as Community Supported Fisheries, own hatchery and/or processing facilities, add brand value, and more. Would a co-op advance your business? An overview of cooperative business basics will cover pro's and con's, organizational steps and keys to success.

OYSTER MORTALITY AND DISEASE IN DELAWARE BAY: IMPACT AND RECOVERY FOLLOWING HURRICANE IRENE AND TROPICAL STORM LEE

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The distribution of eastern oysters (*Crassostrea virginica*) and their parasitic disease pathogens depends largely on salinity. Both thrive in intermediate salinity, but oysters have a greater ability to survive lower salinity. Interannual and seasonal patterns of major oyster pathogens, Dermo and MSX, are regularly monitored in Delaware Bay. The native population has developed a high level of resistance to MSX, but not to Dermo. Refugia from both diseases exist in the upper, lower salinity, portion of the Bay, creating a spatial pattern that fluctuates with riverine inputs, runoff and drought conditions. Hurricane Irene and Tropical Storm Lee dumped record levels of precipitation into the Delaware Bay watershed in late summer 2011, dropping salinity for a prolonged period across the natural oyster beds. The reduced salinity pushed oyster pathogens down bay, reducing their impact, but the prolonged low salinity caused extensive freshwater mortality on the upper bay oyster beds. Pre-flood, this region of the bay comprised about 34% of New Jersey's commercial oyster fishery. Flood-related mortality on some beds exceeded 70% by spring of 2012. An individual-based metapopulation model that includes oyster population dynamics, larval dispersal, and population genetic structure was used to hindcast population dynamics preceding and during the flood, and forecast population recovery subsequently. Simulations suggest a minimum of ten years will be required for the upper bay population to recover. This talk will describe impacts to the oyster population, fishery and the local economy, will review recovery during 2012, and outline efforts to expedite the recovery.

IMPROVEMENT AND DEMONSTRATION OF SUBTIDAL CAGE-CULTURE METHODS TO CULTIVATE OYSTERS IN DELAWARE BAY, NEW JERSEY

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The eastern oyster, *Crassostrea virginica*, is a commercially and ecologically important species in the Delaware Bay. However, the Bay's oyster fishery has declined with current harvests representing less than 10% of peak harvest levels. This decline is largely attributed to the emergence of two oyster diseases that have caused significant losses of the resource. The increasing availability of disease resistant hatchery produced oyster seed creates an opportunity for sustainable and profitable aquaculture to occur in the face of disease. In New Jersey, oyster aquaculture has emerged as a viable industry with intertidal areas of the lower Delaware Bay serving as an ideal environment for rack and bag culture of disease resistant oysters.

In 2010, a small group of oystermen began evaluating the production potential of subtidal cage culture of disease resistant oyster stocks as a means to revitalize production on the largely abandoned leased planting grounds of Delaware Bay. Initial evaluations produced promising results. The purpose of this project was to improve culture handling and husbandry methods and further demonstrate the potential of cage- culture as a means to increase oyster production on underutilized leased

grounds of the Delaware Bay. Two types of cages and two maintenance regimes were evaluated in respect to labor costs and production benefits. Oyster growth varied little between the two cage types and two cleaning regimes evaluated; however, a flip-top cage design offered higher oyster survival and reduced labor effort in comparison to a tiered rack and bag system.

SEEDING THE FUTURE: STUDENT CENTERED COMMUNITY-BASED OYSTER RESTORATION EFFORTS IN DELAWARE BAY, NEW JERSEY

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Project PORTS is a unique community-based restoration and education program that provides locally relevant experiential learning in the K-12 environment. The formal education component utilizes the oyster as a vehicle to acquaint school children with the Estuary and scientific concepts. The oyster restoration component gives students and community volunteers an opportunity to experience environmental stewardship first hand as they work to enhance oyster habitat in the Delaware Bay.

Now in its sixth year, Project PORTS has partnered with 20 schools and engaged more than 5000 elementary and middle school students. Shell bags constructed by participating students have collected more than 20 million oyster spat, which have been planted on 5-acres of bottom at the New Jersey Department of Environmental Protection designated Gandy's Beach Oyster Restoration and Enhancement Area. Habitat evaluations of the restored area have included: assessment of oyster abundance based on samples collected by dredge and divers, RoxAnn hydro-acoustic seabed classification survey, and trawl, trap, and hook and line surveys of macro-fauna associated with the reef.

Project PORTS enhancement efforts have demonstrated positive restoration results with post-enhancement oyster abundances ranging from 45 to 81 m^2 on targeted 1 to 2-acre plots as compared to < 5 m^2 on adjacent unmanipulated plots. The education effort has also shown success, with pre- and post- program student surveys demonstrating a 30% increase in content knowledge. A retrospective of Project PORTS will be presented highlighting the successes and challenges of the program during its first 6-years.

INTERSTATE SHELLFISH SEED TRANSPORT: IMPROVING REGULATIONS TO FACILITATE COMMERCE WHILE ENHANCING BIOSECURITY

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Growth of the shellfish aquaculture industry has made interstate broodstock and seed transfers more common, necessitating increasingly frequent health certifications to protect shellfish from the spread of disease. Important shellfish pathogens are widely distributed across the region, often including multiple states, but health certifications are based upon jurisdictional boundaries, typically at the state level regardless of the disease epizootiology. Zero tolerance policies that are often employed prohibit importation if any shellfish pathogen is detected. These policies stretch the limited resources of pathology laboratories and cut sharply into the profits of the small businesses paying for this service while limiting their ability to nimbly take advantage of opportunities for sales. The existing system is poorly organized, expensive for industry, an inefficient and ineffective use of pathology laboratory resources, and difficult to manage. It is a significant impediment to a growing aquaculture sector.

What alternatives exist?

A fresh look at interstate biosecurity regulation, including the appropriate use of tools that support it, is necessary to produce viable recommendations that safeguard shellfish while allowing growth and development of shellfish aquaculture. We suggest a coordinated inter-jurisdictional system based upon epizootiology that takes advantage of advances in technology to detect and quantify infections. We seek input from industry, regulators, and scientists to help design a system that can respond swiftly and appropriately to problems as they arise such as the recent detection of *Bonamia exitiosa* in eastern oyster seed.

MUSSEL LARVAE PRODUCTION ENHANCEMENT BY RESTOCKING MUSSELS BEDS IN BASSIN DU HAVRE-AUBERT, MAGDALEN ISLANDS

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Mussel production is an important part of Magdalen Islands aquaculture business since thirty years. Natural mussels spat capture is made on rope collectors in a shallow bay which is call Bassin du Havre-Aubert (BHA). When grown enough, juvenile mussels are sleeved (place in plastic rope nets) and transferred in one of two mussel company site. Mussel seed collecting in BHA is the first step prior to the whole mussel growing process.

Blue mussels (*Mytilus edulis*) of BHA are known to be more resistant to summer mortality compare to the lagoon ones. There would be some genetic aspects (multiple locus heterozygosity) that are different for these two mussels' populations. For this reason grower depends on mussel supply from this specific site.

Since 2004, mussels' growers have observed three really bad mussels seed collecting years in BHA. Many reasons have been highlighted to explain this drastic decline of spat abundance. One of them concern mussel genitors. Mussel bed was inventoried between 2001 and 2009, and we found that biomass drop off 98 %. Weak mussel genitors' abundance and their wide repartition over the bay could explain larvae decline. This may have an influence on mussel seed collecting success.

Merinov-Centre des Îles have begun a new experimental project on mussel bed restoration in BHA since 2009. Collectors were first installed on grower's installations in this bay. Mussels' seeds were removed from collectors and grown afterward in the same bay for one year. When mussels reached > 65 mm, they were laid down on three specific areas near from growers installations. Results of seed harvesting in the year after the first restocking attempt were really good.

COMPARING GROWTH RATES OF JUVENILE GREEN SEA URCHINS, (*STRONGYLOCENTROTUS DROEBACHIENSIS*) ON FOUR DIFFERENT DIETS

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The green sea urchin [*Strongylocentrotus droebachiensis*] is a high value marine species in Maine, with a continuously declining trend in landings, from a peak of over 18,000 tons in 1993 to just a little over 1,000 tons in 2011. Sea urchin culture and bulking technology has been developed in Maine, but formulated urchin feeds are prohibitory for further growth of the industry. The developing seaweed culture industry of Maine provides a feed source opportunity to lower the cost of culture. A preliminary feeding trial is being conducted with juvenile urchins to compare different types of macroalgae diets on urchin growth. 200 juvenile urchins were fed four different diets: wild harvested fresh sugar kelp [*Saccharina latissima*], dried cultured sugar kelp, tank cultured [*Porphyra umbilicalis*], and the formulated urchin diet (nofima). Juvenile urchins are fed to satiation and weighed once per month at the Center for Cooperative Aquaculture Research in Franklin, ME. Preliminary results suggest higher growth rates of urchins fed on dried kelp than fresh kelp, and similar growth rates for the formulated feed and dried sugar kelp. Results from this study may be important for the development of a dried macroalgal-based diet.

ELECTRICAL RESTORATION OF OYSTERS AND SALTMARSH AT A NEW YORK CITY ESTUARINE WETLAND

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Catastrophic loss of oyster reefs and saltmarshes has removed the major mechanisms of sediment and organic material filtration of estuarine waters, and of shore protection against erosion in the eastern United States and temperate coastal ecosystems worldwide. The Biorock low voltage solar-powered direct current electrical stimulation method has been used to

restore oysters and saltmarsh in a severely polluted New York City estuarine wetland, next to a former navy shipyard and toxic waste dump. Oysters (*Crassostrea virginica*) receiving low amounts of electrical current increased in length 5.82 times faster than controls, and oysters receiving higher amounts of current grew 9.30 times faster than controls over the 2011 summer growing season. Control oysters decreased in size from by 4 mm over Winter 2010-2011 and had chalky dissolved shells, while low electrical current oysters had no change in size, and medium and high current oysters grew by 6 mm and 8 mm respectively, and had shiny shells. Control oysters had more than 91% over-winter mortality in this severely polluted habitat, while mortality of oysters under low, medium, and high electrical currents were 34%, 31% and 0% respectively. Saltmarsh grass (*Spartina alterniflora*) controls grew by 5 cm/week, while those receiving low electrical current grew by 9 cm/week and those receiving higher current grew by 11 cm/week. *Spartina* planted in a seep draining the toxic waste dump, at a site lower in the intertidal than the lowest tolerance limit of *Spartina,* had 100% mortality in two successive winters, while *Spartina* under electrical stimulation had two thirds survival over three winters and sent up new shoots each following spring. Electrified *Spartina* showed much higher growth rates in the summer, greener leaves, more stems per clump, more abundant, thicker, and darker roots. Our results demonstrate that the Biorock method is able to keep oysters and saltmarsh alive and growing under conditions that would otherwise be toxic. The much greater growth and survival even under the most severe water quality conditions therefore make the Biorock method ideally suited to restoring oyster reefs and saltmarshes where all other methods fail, and of greatly increasing oyster mariculture productivity. Biorock methods are even able to extend seaward saltmarshes that are now eroding from global sea level rise and pollution.

COMMUNITY SUPPORTED FISHERIES SUMMIT - BUILDING A NETWORK, IDENTIFYING CHALLENGES AND OPPORTUNITIES, AND DEFINING NEXT STEPS

Erik Chapman
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Community Supported Fisheries (CSFs), based upon the Community Supported Agriculture model, have been one approach that fishermen and fishing communities have explored to direct more money to boats, while achieving a range of other social and environmental goals. Over the last five years CSFs have grown dramatically in number and size. Despite their potential, a variety of technical barriers and overarching questions about their long-term viability have emerged.

The purpose of the *National Summit on Community Supported Fisheries*, hosted in Portsmouth, New Hampshire in June 2012, was to bring together CSFs from across North America to share experiences, learn from each other, and identify challenges and opportunities for supporting the evolution and long-term viability of CSFs. The two-day summit drew participants from 9 states and 2 Canadian provinces, representing 21 CSFs and a small group of government, academic, and non-profit interests. The ideas, points, challenges, questions, answers, and proposed actions from the Summit form the foundation of my talk.

Here, I will provide an overview of the planning, implementation and immediate outcomes of the Summit, highlighting the breadth of information that was gathered and their relevance to aquaculture producers. The needs assessment, recommendations and conclusions captured at the Summit are intended to inform and inspire new and ongoing activities, partnerships, and initiatives that serve to address the needs of fishing communities involved with both wild fisheries and aquaculture.

THE MICROALGA *PAVLOVA* CONTAINS AN ANALOG FOR THE HORMONE ECDYSONE THAT PROMOTES METAMORPHOSIS OF LARVAL BAY SCALLOPS (*ARGOPECTEN IRRADIANS IRRADIANS*)

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Nutritional requirements of bivalve molluscs (oysters, clams, mussels, scallops), especially young stages, must be known for effective hatchery production of “seed” shellfish for subsequent grow-out to market Species in the Genus *Pavlova*, a prymnesiophyte alga, have been used for many years as components in diets mass-cultured and fed to larval shellfish because they are known to contain essential lipids. In this project, we have determined that a *Pavlova* strain also contains an analog for the hormone Ecdysone, and that when added to the diet of Bay Scallops (*Argopecten irradians irradians*) induces

metamorphosis earlier than that obtained feeding a diet with no *Pavlova*. A sterol unique to the Genus *Pavlova*, named ethyl-Pavlovol, with a structure very similar to Ecdysone appears to be the bioactive compound in *Pavlova* cells. Addition of synthetic ecdysone also induced early metamorphosis in scallop larvae, and metamorphosis induction by both *Pavlova* and ecdysone was inhibited by the ecdysone-blocking insecticide Azasol. These findings provide strong evidence that pavlovols have hormonal effects upon mollusk larvae.

EVALUATION OF BAY SCALLOPS FROM GENETIC LINES OF TWO GEOGRAPHIC POPULATIONS FOR GROWTH AND SURVIVAL IN THE NIANTIC RIVER, CONNECTICUT

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Hatchery-reared progeny from two populations of northern bay scallops, *Argopecten irradians irradians*, were tested for survival and growth at a site in Niantic, Connecticut. Stonington, Connecticut and Nantucket, Massachusetts scallops were spawned two weeks apart. Three hundred scallops from each group were placed in two triple tiered cages that were deployed in the Niantic River in Connecticut. Scallop survival and shell height, along with temperature, salinity and DO, were determined periodically. Initial shell height mean for the Stonington scallop line was 11.7 mm. For the Nantucket line the initial shell height mean was 11.1 mm.

After seventy days, shell height for the Stonington line was 42.9 mm and for the Nantucket line was 42.6 mm, yielding an average growth rate in both groups of 0.45 mm. per day. Mortality in five of six cage tiers was under 10%, but bottom tier of the Stonington cage was at 17%. Recent studies have shown that transplanted bivalves may not adapt quickly to new location, showing decreases in growth, survival, and inhibition of certain regulatory processes. In this study, the progeny of transplanted broodstock did not appear to show differences in local adaptation. Results to this point indicate similar good growth and survival rates for both groups, and these variables will be assessed throughout the growing season.

EVALUATING OYSTER REEF RESTORATION: CRITICAL ECOSYSTEM SERVICE-BASED GOALS

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Oyster habitats provide a number of important ecosystem services that often coincide with oyster habitat restoration goals. Here we present suggested metrics, standardized methodologies, and success criteria that are applicable nationwide for judging the success of some critical ecosystem service-based restoration goals.

OCEAN ACIDIFICATION CAUSES SHELL DEFORMITIES AND REDUCED CALCIFICATION IN *CRASSOSTREA VIRGINICA* LARVAE

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In situ measurements reveal that seawater pH and Ω_{ar} in estuaries and coastal embayments along much of the Northeastern US are already significantly different from open ocean values, and that year round aragonite under-saturation ($\Omega_{ar}<1$) will be reached by mid-century, if current CO_2 emissions trends continue. We investigated the impact of ocean acidification (OA) on early development of the eastern oyster, *Crassostrea virginica*, an important reef-building species along the Atlantic coast. We find that growth of the prodissoconch in the first 48 hrs post-fertilization is significantly impaired at $\Omega_{ar}<1$. Average

larval shell length and weight decreased by 5% and 36% respectively, and severe shell deformities increased by 25% relative to larvae reared under ambient conditions (Ω_{ar}~2.6). The scale of impact is consistent with that observed for the same species exposed at different stages of development, from fertilization through metamorphosed juveniles. A switch experiment (super-saturation to under-saturation and visa versa) was performed 24 hrs post-fertilization to identify the stage of growth most vulnerable to OA. We find the prodissoconch I (PDI), secreted by the shell gland, developed normally in all treatments. Conversely, the prodissoconch II (PDII), secreted by the mantle edge, was absent, significantly delayed and/or malformed in larvae exposed to OA during its formation. Our results imply that ocean acidification will have a profound effect on recruitment success of one of the east coasts most important shellfish.

PRODUCTION OF MUMMICHOGS (*FUNDULUS HETEROCLITUS*) USING BIOFLOC TECHNOLOGY

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Fundulus heteroclitus, also known as the mummichog, is found along the eastern seaboard, ranging from Canada to southern Florida. The species is known for their tolerance to a wide range of environmental conditions including low oxygen levels, temperature fluctuations and salinity extremes. In addition, mummichogs have the capacity to adapt to polluted environments. As a result of their adaptability, *F. heteroclitus* are commonly used as both a model lab animal species, and as recreational fishing bait. Techniques to culture mummichogs for the bait market are being developed at the DSU Aquaculture Research and Demonstration Facility. This summer we conducted an eight week experiment in which mummichog fry were grown using biofloc technology. Biofloc production techniques have been shown to be a viable means of improving production in other marine species. The biofloc environment consists of a 'soup' of algae and bacteria which break down the wastes from the target culture species and converts them into a high protein 'floc.' The resultant floc can subsequently be grazed acting as a feed supplement improving overall growth and survival. Mummichog fry were stocked into six 18.9-L experimental tanks at one of two densities (2 or 5 larvae/L). Throughout the experiment, dissolved oxygen levels, temperature, and salinity were checked daily; ammonia and alkalinity were checked weekly. Fry were feed ad libitum on a daily basis. After eight weeks, surviving fry were measured for length and weighed. Survival and growth were compared between treatments. Our poster will discuss our findings.

MARKET OUTLETS FOR SEAWEED PRODUCTION IN NEW ENGLAND

Anoushka Concepcion
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Global seaweed cultivation has produced over 16 million tons of product valuing approximately $ 7 billion worldwide. Products produced from seaweed range from 'sea vegetables' for human consumption, biofuels, as well as extracts for animal feeds, thickening/gelling agents, and nutritional supplements. Although China and other southeast Asian nations dominate the seaweed industry, husbandry methods and technology have been transferred across the globe and to New England where native species are now cultivated on a small-scale.

Seaweed cultivation is gaining attention as the products provide a source of locally-produced and nutritional food, as well as serve as a means to improve water quality. This type of aquaculture is suitable as a stand-alone enterprise. Alternatively, seaweed culture could be incorporated into an existing shellfish aquaculture operation, thus enabling producers to diversify. Municipalities and NGOs can utilize the benefit of seaweed's bioextractive properties toward improving water quality and aid in restoration efforts. An examination of potential products and market outputs available to, and appropriate for, prospective seaweed growers in New England will be addressed. Also to be examined are current issues (ie. permitting, public health guidelines) and barriers (ie. lack of processing facilities) for the commercialization of seaweed aquaculture in New England.

SHELLMAN – A PRODUCTION MANAGEMENT SOLUTION THAT ADDS MORE VALUE TO YOUR BUSINESS

Dave Conley[1], SaiGiridhar Dasika[2]

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SHELLMAN (SHELLfish MANagement software) is a new web-based data management solution for shellfish farmers. Created to simplify routine production data management and record keeping, SHELLMAN is totally online, providing data entry and access from desktop and mobile devices in real time wherever an Internet connection is available. Pro SAAMYA, creator of SHELLMAN, contacted the Aquaculture Communications Group (ACG) to help develop and market the solution in the USA and Canada. Based on interviews with shellfish industry participants, SHELLMAN has been designed with the following features: Inventory Analysis; Production Tracking by culture method (Line, Rack, Cage/Bag, Raft, Tray); Production Activity (Grading, Sorting, Mortality); Seed Source; Sales; Equipment/Gear Inventory & Tracking; and Cost of Goods Calculation. SHELLMAN also runs on popular tablet operating systems, such as the Apple iPad. With increasing demands for seafood traceability in the USA for both domestic and imported products, SHELLMAN is being developed to allow for the exchange of certain data between partners in the value chain to enable farm to fork traceability. This presentation will provide an overview of SHELLMAN's features and discuss how it can add more value to your shellfish business.

APOPTOSIS MEASUREMENTS IN SEVERAL BIVALVE SPECIES DURING A SEASONAL CYCLE

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Apoptosis, or programmed cell death, is a mechanism used by organisms to regulate cell proliferation. In bivalve species, this mechanism can be altered by various factors including pathogens, parasites, and toxins. Previous studies in our laboratory have shown that natural apoptosis rates in eastern oyster hemocytes ranged from 2-5%. Little is known, however, of the possible variability in apoptosis rates in bivalve hemocytes during a seasonal cycle. The current study measures apoptosis rates in several bivalve species including the eastern oyster, northern quahog, soft-shell clam, bay scallop, and blue mussel. The aim of this study is to determine if apoptosis rates are similar among species, and if there is a seasonal cycle. Hemocyte apoptosis is an important component of the immune defense system; therefore, we expect that this information will provide additional insight into the roles of environmental variability and reproductive cycles in modifying the immune function of these bivalve species. Preliminary results from this comparative, seasonal study will be presented.

QPX EPIZOOTIOLOGY: TEN YEARS OF DATA FROM A HARD CLAM FISHERY IN RARITAN BAY, NY

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Earlier QPX reports followed hard clam mortality events and consequently capture a point in time that is late in the infection process. Subsequent hard clam health surveys for QPX have been limited in study duration or frequency of sampled locations. A QPX monitoring program has been conducted in Raritan Bay NY by the Marine Animal Disease Laboratory at Stony Brook University for the Shellfisheries Management Unit of New York State Department of Environmental Conservation since hard clam mortalities were reported in the summer of 2002. Sampling has been conducted for a decade in the same fishery area. Stations have been sampled multiple times a season. This unique data set allows for greater examinations than previously possible of temporal, spatial, and hard clam factors associated with disease development and dynamics. A descriptive overview of the QPX infection pattern in Raritan Bay NY will be presented. Patterns in prevalence, severity, or signs of remission will refine the understanding of infection seasonality. Hard clam cofactors (e.g., host density and size) and environmental data (e.g., temperature and salinity) will be analyzed for potential relationships with QPX infections. This study brings together various data sets, from the same enzootic area, which are being processed and analyzed in order to develop a better understanding of the basic ecology and epizootiology of this infectious disease. Results presented from these endeavors should aid mitigation and improve management of QPX disease risk in both wild and cultured hard clam areas.

DEVELOPING COLLABORATIONS AND METRICS FOR OLYMPIA OYSTER RESTORATION IN WASHINGTON STATE

Jonathan Davis, Brian Allen, Betsy Peabody
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The Olympia oyster (*Ostrea lurida:* Carpenter 1864; = *Ostreola conchaphila*), the only native oyster to the North American west coast remains extant in much of its historic (circa 1850) range though currently in greatly reduced abundance in most places. Exploitation of oysters from 1850 to the early 1900s resulted in the loss of large natural beds, mainly through harvest and conversion to intensive cultivation of other oysters. Restoration efforts in Puget Sound have been largely undertaken over the last 14 years by the Puget Sound Restoration Fund (PSRF) in collaboration with the Washington Department of Fish and Wildlife. This has been a collaborative effort facilitated by PSRF involving shellfish growers, treaty tribes, tideland owners, other government agencies and non-profit organizations. Significant changes in approach to restoration have occurred since 1998: (1) decreased reliance on use of hatchery derived seed with focus on habitat enhancement; (2) development and use of genetic conservation protocols for use of hatchery seed where adult populations are absent either very small in otherwise prime habitat; (3) focus on effective collaboration between resource managers and restoration proponents. Liberty Bay and Dogfish Bays in central Puget Sound are examples of how long-term efforts to increase native oyster abundance have been successful. Metrics associated with oyster restoration efforts have been developed and refined to include better estimates of abundance based on measures of emergent substrate, determination of the biological record of recruitment history. Refinements are critically important to better predict native oyster spatfall, subsequent survival and overall population resilience.

EAST MEETS WEST: SHELLFISH AQUACULTURE ON THE WEST COAST; CURRENT CULTURE PRACTICES, PROBLEMS AND PROSPECTS

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Shellfish aquaculture on the US West Coast is a $117 million industry and remains focused on culturing the Pacific oyster though many farms are increasingly diversified and rearing a widening number of species. Diversification has become increasingly important in light of difficulties rearing adequate amounts of oyster larvae and seed at the hatchery level though additional production is rapidly filling the void in seed availability. Reliable hatchery production of high quality larvae and seed and increased regulatory hurdles, primarily but not exclusively at the local level, remain primary impediments to expanded production. Culture practices for rearing oysters have increasingly relied on using genetically improved larvae and seed and using methods that improve shell shape and increased meat quality. Intensive nursery facilities are commonplace with increasingly large Floating Upwelling Systems being used. Mechanizing grow-out systems for oysters is occurring at a number of sites as well with large-scale production limited only by seed availability. Manila clam culture has changed little in ten years and remains focused on habitat modifications to retain naturally recruiting larvae to intertidal beds augmented with hatchery grown seed. In recent years there has been increased interest in mechanical clam harvesting. Geoduck culture remains a priority species for increased production though there has been no expansion in new geoduck ground in the last six years. Geoduck culture has, however expanded on existing tidelands already dedicated to geoduck culture and represents a significant new revenue stream for growers. Methods have been modified over the years to minimize impacts associated with predator protection gear though use conflicts remain and seed availability remains a major impediment to expanded production on existing ground. Prospects for new culture development are focused on macroalgae, rock scallops and integrated multi-trophic aquaculture systems.

EFFECTS OF STOCKING DENSITY AND BASKET ORIENTATION WHEN USING THE ADJUSTABLE LONGLINE SYSTEM FOR OYSTER GROW-OUT: MEASURES OF PRODUCT QUALITY

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The adjustable long-line system (ALS) can be configured in two ways: with baskets hanging perpendicular to tandem tensioned long-lines (termed 'cross-line'), or hung parallel to the tensioned long-line (termed 'in-line'). The cross-line orientation is enticing to farmers because it can potentially increase production by fifty percent per unit area. We were interested in how having baskets hung cross-line versus in-line would affect oyster quality at harvest. We tested this using two, 91 m runs of ALS gear, each with 34 bays (defined as the space between riser posts). The experiment was replicated on the level of a bay. In addition to basket orientation, we were interested in determining optimum basket stocking density (75, 90, and 105 oysters/basket). Paired with the comparison of orientation, this equated to oysters being grown at densities ranging from 450 to 945 oysters/bay (e.g. 9 baskets X 105 oysters/basket = 945 oysters/bay). Preliminary data suggests differences in growth depending on orientation.

Growing single set oysters in cages off the bottom will allow the Gulf of Mexico oyster industry to diversify into the premium half-shell market. The aesthetic appeal of the product is important to all levels of consumers in this market. Therefore, we examined several aesthetic aspects of the oysters grown in each of the nine density and orientation treatments. In addition to metrics such as shell shape, condition index, and yield, we quantified fouling on the oysters, prevalence of mud worm, *Polydora websterii*, and classified the fullness of each oyster on the half shell.

DISCUSSION OF THE UNIVERSAL METRICS PROPOSED IN THE PRECEDING PRESENTATIONS (REEF AREA, REEF VERTICAL RELIEF, OYSTER DENSITY SIZE DISTRIBUTION, AND CRITICAL ECOSYSTEM SERVICE-BASED GOALS)

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The final time period will be used to convene a discussion of the universal metrics presented (Reef Area, Reef Vertical Relief, and Oyster Density, Size Distribution and Critical Ecosystem Service-Based Goals) and opportunity will be provided for recommendations from the audience.

MEASUREMENT OF OYSTER DENSITY AND SIZE DISTRIBUTION ON RESTORED REEFS AND BEDS

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Reef area is a universal metric for oyster restoration projects and vertical relief is common. Despite the fundamental nature of the measures they have been defined in various ways and measures have not necessarily been comparable between projects. Variations in methods will be described along with recommendations for successful techniques.

SOMETIMES THEY COME BACK

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In the past ten years in the Gulf of Trieste (Italy) the razor clam *Ensis minor* disappeared, reappeared and in 2011 flourished, with at least three successive recruitment events.

This species is difficult to rear and no restocking is possible. The present density is very high and the fishery could restart with quite good economic income, after a similar species, *Solen marginatus,* crashed in January 2008 due to heavy mortality.

On the contrary, the striped venus *Chamelea gallina*, after good results observed in 2007 following restocking activity, suffered mortalities and seems not able to recover and new restocking is planned. The short but severe weather events in February 2012 is expected to interfere in razor clams recruitment but seems to be more detrimental to striped venus survival and the fishery was stopped for long. The current razor clams density is among the highest observed since 30 years and widespread from coastline till at least 4 m depth.

VARIATION IN SETTLEMENT AND EARLY GROWTH OF JUVENILE RAZOR CLAMS (*ENSIS DIRECTUS*) IN A HATCHERY SETTING

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Razor Clams (*Ensis directus*) are a promising new species for aquaculture in the Northeast. Hatchery production of seed, however, has been hampered by high levels of mortality in traditional nursery downwellers. We successfullly spawned broodstock obtained from the Damariscotta River, Maine by manipulating temperature and produced 18-million embryos. After 12 days of culture on a standard larval clam diet, many razor clam larvae appeared competent for settlement. We released 800,000 competent larvae into each of two tanks. The first tank contained a matrix of three sediment choices: natural (N), fine sand (F) and coarse sand (C) with three replicates for each treatment. The second tank contained the same matrix, however, all sediments were autoclaved. Seawater was replaced regularly and animals fed (*ad libitum*).

After ten weeks, all replicates were sieved on 1-mm screens, clam length was measured and biomass estimated volumetrically for each replicate. Animals from non-autoclaved treatments were all slightly longer than animals from the autoclaved sediments (5.1 mm versus 4.5 mm). In contrast, biomass was higher in autoclaved treatments when compared to non-autoclaved treatments. The biomass of clams from fine sand was greater than in the other treatments while the lowest amount of biomass was observed in the natural sediment treatments in each tank. Although we could not directly estimate post-settlement, treatment-specific mortality, all animals in several replicates with autoclaved sediments were lost due to excessive bacterial overgrowth. Our results suggest that sediment-based nursery culture shows promise for reducing post-settlement morality and increasing seed production for razor clams.

SUPERMARKET SALES TRENDS FOR AQUACULTURE PRODUCTS

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The University of Arkansas at Pine Bluff has acquired 7 years of weekly scanner data (2005-2012) for 52 cities across the U.S. Summaries of trends in prices and quantities sold of the most important regional aquaculture products will be presented and reports made available to workshop participants. Prices, promotion, and trends of the most important competing products for the most important markets will also be presented. Individual producers will have the opportunity to request customized reports.

THE ATLANTIC RIBBED MUSSEL, (*GEUKENSIA DEMISSA*), GROWN USING STANDARD AQUACULTURE METHODS, HAS POTENTIAL FOR USE IN NUTRIENT BIOEXTRACTION

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Nutrient bioextraction is gaining interest as a component of nutrient management in nearshore ecosystems. Suspension-feeding bivalves incorporate nutrients within seston into tissue; this process could be used to remove nutrients, especially nitrogen, from the water. Pilot-scale research is needed to determine which species can be used effectively for nutrient bioextraction, assist in site selection, and address scaling.

To evaluate Atlantic ribbed mussel *Geukensia demissa* as a species for nutrient bioextraction, a commercial-scale mussel raft stocked with ribbed mussels was deployed at the confluence of the Bronx and East rivers (New York, USA). Relevant water chemistry and seston measurements, and mussel growth measurements, were coupled with biodeposition feeding experiments to quantify ribbed mussel filtration, assimilation, and return to the environment of seston components.

Dissolved inorganic nitrogen and phosphorous varied tidally at the Bronx site, with ammonia above typical estuary concentrations (<10 μmol l^{-1}). Phytoplankton biomass, however, was low for a eutrophic estuary, with chlorophyll *a* ranging from 1 to 4 μg L^{-1}. PAR measurements indicate that low light penetration, resulting from a high silt load, may account for this discrepancy. Mussel absorption efficiency was maintained at 0.71 -- statistically the same at the Bronx site as in a productive, non-urban environment. Despite the atypical seston profile at the Bronx site, preliminary results indicate that ribbed mussels are capable of extracting nutrients, but the expected path of nutrients to phytoplankton to mussels may not be the dominant one in the Bronx River. Instead, nutrients may have been incorporated through the microbial loop.

EMERGING LOCAL MARKET MECHANISMS FOR SHELLFISH PRODUCERS - NEW YORK CITY CSF CASE STUDY

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Over the history of coastal US fisheries, connections between supplier and consumer have transitioned from the personal to corporate. Once, on Manhattan docks, everyone from chefs to families would head dockside to collect the shellfishermen's landings - harvests of world-renown brands of oysters, clams, and mussels. In the last 50 years, trends in cities like New York have been to replace that historic local connection with warehouses and wholesale trades. In cities, people's access to fresh, local, responsibly harvested seafood is a confusing morass of labeling systems, scorecards, and near complete lack of transparency. More often than not, consumers have no idea where their seafood comes from, or what went into its harvest.

There is a new trend in urban fish markets - that of the re-connected local supplier. Urban seafood enthusiasts are once again able to directly access their fishermen, baymen, and growers, and are willing to pay more for that peace of mind. Consumers are more and more interested in knowing where their clams come from, how their oysters are grown, when their mussels were harvested, and if their food is safe to eat, and we're helping shellfishermen step up to fill that market. In this presentation, we will describe Village Fishmonger NYC's model for making urban seafood markets local, seasonal, and informational. We will also discuss how CSFs are set up, the hurdles shellfishermen face in getting their product, message, and brand to market, and the importance of education and transparency.

CHALLENGES AND OPPORTUNITIES OF KELP FARMING IN NEW ENGLAND

Paul Dobbins
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There is growing demand from chefs and consumers for sustainably harvested and locally produced seaweed food products. New England companies that are creating an industry to meet this demand have many challenges and opportunities. Some of these are in the field of Marine Science, others are societal or business related.

Ocean Approved, a seaweed products company operating four kelp farms in the Gulf of Maine will share insights on how it sees these challenges and opportunities evolving as the industry grows.

CORAL MICROPROPAGATION TECHNOLOGIES AND AQUACULTURE FOR CORAL REEF RESTORATION

Craig Downs
Global Coral Repository, P.O. Box 92, Clifford, VA 24533 USA

We have developed a technology for the micropropagation of corals through two separate methods: (1) explantation using tissue culture and (2) micro-fragmentation of corals using single polyps of colonial tissue with less than a dozen polyps. We have established a method for the successful cryo-preservation and resurrection of coral tissue that can be stored indefinitely, and then when thawed, be used for micro-propagation. Applying formal animal-husbandry research science, we also developed methodologies for the high-density culturing of colonial coral; growing coral to a size that will successfully withstand transport and transplantations stress. Included in these culturing methods is the ability to induce phenotypes in a coral species that will acclimatize specimens for prospering under specific environmental habitats (e.g., strong surge zones, protected bays). With these technologies taken together, we have developed a high-production methodology for the generation of tens of thousands of corals where genetics stocks can be controlled and used for wise-management strategies for coral reef restoration.

CONDUCTING SHELLFISH AQUACULTURE HISTORY RESEARCH AT THE MYSTIC SEAPORT

Kelly Drake
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In 2010 the Census of Marine Life published data and charts detailing whale populations, delineated by specie and by season from 1780-1920. The data for the basis of the study came from a previously unappreciated source, the ships logs and papers of American and British whaling vessels. Similar and still untapped sources of information exist for the study of shellfish history in museums and libraries around the world. One especially rich repository of such information is the Collections and Research Department of Mystic Seaport. Containing thousands of shellfishing related objects, archival documents, rare publications, photographs, representative watercraft, Mystic Seaport's Collection is easily accessible and open for researchers. A sample of interesting items include the business records of Jeremiah Smith & Sons, a Connecticut oyster company in operation from 1883-1911, a 260 minute oral history interview conducted in 1967 with John Thomas, son of Thomas Thomas of the Thomas Thomas Oyster Company, two 1824 oystering dugout canoes, a 1905 double-acting steam engine from the oyster boat ARGUS, and a 19th century advertisement of Howard's Silver Spring Oysters of South Wellfleet, Mass. This talk will highlight these and several other possible sources for further exploration, outline the depth and scope of the collection as it pertains to shellfishing, and provide guidance on how best to research and access the materials.

EFFECTS OF TEMPERATURE ON INCUBATION PERIOD, SURVIVAL, AND GROWTH RATES OF JUVENILE CHANNELED WHELK (*BUSYCOTYPUS CANALICULATUS*)

Shelley Edmundson, Elizabeth Fairchild
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Channeled whelk (*Busycotypus canaliculatus*), a predatory marine gastropod in the family Melongenidae, supports a lucrative (average $1.96/lb; MA DMF, 2011) and growing New England fishery. The whelk fishery used to be a by-catch fishery, but over time, as other fisheries began to decline and the overseas market demand increased, it has become a full-time commercial fishery. Unlike many fisheries, little is known about the biological parameters of channeled whelk making this fishery extremely difficult to regulate. It is surmised that this gastropod is long-lived, slow growing, matures late, may be a protandrous hermaphrodite, and has low fecundity, therefore making it extremely susceptible to overfishing. The early life history of channeled whelks is not fully understood. Female whelks anchor egg strings to sandy substrates and juveniles begin to hatch after some unknown period of incubation. By cultivating the egg strings, much can be learned about whelk early life history.

In an effort to understand more fully the effects of temperature on incubation period, survival, and growth rates of juvenile channeled whelks, six channeled whelk egg strings were collected from Vineyard Haven, MA and cultivated at the University of New Hampshire's Coastal Marine Laboratory. Each egg string was divided and randomly assigned to four water temperature treatments: 10C, 15C, 25C, and ambient. Egg strings were monitored for one year, and incubation length,

hatch rates, and juvenile sizes were documented. Post-hatch juveniles are being grown-out, and different diets tested. Juvenile growth rates and survival are being measured, and current data will be presented.

MANAGING YOUR AQUACULTURE BUSINESS DURING DIFFICULT FINANCIAL TIMES

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Foodfish industries across the U.S. have struggled to cope with the financial effects of high prices of feed and other inputs, competition from imports, and depressed markets in several sectors. Management decisions based on close attention to key financial indicators can make the difference between surviving difficult financial times and business failure. For those segments of aquaculture with fewer financial problems, there is no better time to take steps to avoid the type of financial distress that is being experienced elsewhere in U.S. aquaculture. The presenter has worked with more than 100 catfish farmers to develop comprehensive financial analyses and business plans. The workshop will discuss what steps were taken by the catfish farmers who survived these difficult financial times and what the early warning signs were for farms that did not survive. A simplified system to conduct an annual checkup of financial health will be presented with supporting materials (workbook and flash drive with electronic materials). Hands-on exercises will be included that focus on interpreting financial indicators and how to use them in management decision making for aquaculture businesses to remain successful.

BEST PRACTICES FOR POST-HARVEST RAPID COOLING

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For states implementing a *Vibrio vulnificus* (Vv) or *Vibrio parahaemolyticus* (Vp) control plan, there exist several options for temperature control to limit post-harvest vibrio growth. National Shellfish Sanitation Program (NSSP) recognized methods of temperature control include ice, mechanical refrigeration, or other approved means capable of lowering and maintaining the temperature of shellstock.

Concerns recently have been expressed regarding the efficacy and safety of water and ice slurry dips and icing as a means of controlling the post harvest growth of vibrios. Several states have utilized icing shellstock onboard harvest vessels and at landing as a temperature control measure with documented success.

A new vibrio technical team within FDA developed a research plan to answer specific questions regarding vibrio safety and best management practices. This team examined the potential for microbial contamination when oysters are submerged in cold water or ice slurries. Additionally, the team examined the potential increased risk of producing a microbial rich environment, consisting not just of Vibrio spp. but fecal coliforms and other bacteria resulting from repeated use of the same cold water or slurry.

Data show the icing procedure at or below 50°F (10°C) will inhibit growth and proliferation of bacteria in addition to decreasing internal meat temperature. Additionally, to ensure that cold water and ice slurry dips do not become overloaded with mud, sediment, and debris, in accordance with NSSP Model Ordinance requirements, the team made several recommendations.

RESTORING WINTER FLOUNDER (*PSEUDOPLEURONECTES AMERICANUS*) POPULATIONS ON MARTHA'S VINEYARD, MA THROUGH STOCK ENHANCEMENT

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Biomass of winter flounder, once a popular target species of both recreational and commercial fisheries, is at an all-time low. Winter flounder population recovery could be expedited by enhancement, and experimental restocking studies have been the focus of scientific inquiry at the University of New Hampshire (UNH). Experiments have shown:

1) Winter flounder can be successfully cultured, tagged, conditioned, and released into the wild,
2) Released winter flounder then "behave" like wild fish in their habitat utilization, movements, home range, growth, and diet.

The possibility that restocking winter flounder could help diminished wild stocks has elicited interest from several New England municipalities, especially from commercial fishermen and aquaculture facilities. Joining forces with communities who have the motivation and diligence to take initiatives to try to protect their natural marine resources, are near ecologically important areas (historically high winter flounder populations, high quality winter flounder nursery areas, existing wild spawning winter flounder stock), and are near aquaculture facilities capable of producing enough juvenile fish for releases, can result in unequivocally and scientifically testing winter flounder enhancement strategies.

UNH partnered with the Dukes County/Martha's Vineyard Fishermen's Association and the Wampanoag Tribe of Aquinnah and developed optimal release strategies for stocking winter flounder in Vineyard waters through an extensive yearlong ecosystem analyses, provided aquaculture training to personnel, retrofitted a shellfish hatchery for rearing finfish, and raised and released into Menemsha Pond, Aquinnah, MA in August 2012 approximately 5,000 juvenile winter flounder. An overview of this project along with post-release effects will be presented.

EXPERIMENTAL FISH FEED USING ALGAL PROTEIN FOR RAINBOW TROUT (*ONCORHYNCHUS MYKISS*)

Julian Fiorentino
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Current forms of aquaculture feed use wild caught fishes that are processed into fish meal and fish oil to provide nutrition and protein for livestock. This system taxes the environment and could lead to the collapse of the important foraging fish that transfer planktonic energy to higher order animals. Another potential protein source for aquaculture feed is plant protein but it is not often used because plants produce inhibitory chemicals that affect digestibility. This experiment looked at the prospect of using algal protein as a protein and nutrition source for a species specific fish feed. Initially 150 Rainbow trout (*Oncorhynchus mykiss*) at an initial tank density of 4.5g l-1 were housed in a recirculating aquarium. They were fed an experimental diet consisting of differing concentrations of algal protein. The diets had an initial concentration of algal protein of which the remaining protein from fish meal. This formulation technique was used for a 10% algal protein diet, a 40% algal protein diet and a 70% algal protein diet. The fish were weighed weekly and fed daily for one month then fixed for future protein analysis. The 40% algal protein diet showed a growth rate higher than the control but using an ANCOVA to compare against the control there was no statistical difference. The 10% algal protein diet had a food conversion rate that was 9% better than the control and with a large standard deviation all conversion rates could be considered not statistically different. The results all show algal protein as a suitable replacement for the current protein sources.

RESTORATION WITHIN AN URBANIZED ENVIRONMENT: EFFECTS OF ANTHROPOGENIC INPUTS ON THE HEALTH OF JUVENILE OYSTERS (*CRASSOSTREA VIRGINICA*)

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The Hudson-Raritan Estuary (HRE) has been the focus of recent efforts to restore the ecologically important bivalve, *Crassostrea virginica*. Although, habitat alterations and sewage pollution will prevent restoration of the fishery, it is possible to use restored reefs as a means to improve water quality and gain other ecological benefits of this ecosystem engineer. However, it is important to know how large-scale urbanization of NYC affects the health of the oysters, as non-lethal

subcellular effects could impact population dynamics. It was hypothesized that oysters placed in highly degraded areas within the HRE would have lower overall condition and biochemical stores, and higher body burdens of important metals (Cd and Hg). Juvenile *C. virginica* were placed at 6 sites within the HRE during 2009 and 2010, and at a reference site outside the HRE. Each site was characterized by studying the environmental parameters (chlorophyll, temperature, salinity, TPM). Bimonthly, oysters were subsampled for physiological parameters (condition index, biochemical makeup of tissues, energy usage) and uptake of key heavy metals, Cd and Hg. Site-specific differences between key physiological variables were found between sites (i.e., condition index, biochemistry), as well as differences in metal accumulations. Correlations between the three types of variables (environmental, physiological, anthropogenic) give us insight into the influence of an urbanized environment on benthic filter-feeding bivalves. Additionally, regressions were drawn between several environmental/anthropogenic variables and the physiological responses seen in the oysters. This data will be useful to managers and researchers in understanding the effects of urbanization on these bivalves.

ENSURING CONSUMER SAFETY THROUGH BEST PRACTICES FOR POST-HARVEST HANDLING, TRANSPORTATION, AND STORAGE

Amy Fitzpatrick
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Ensuring consumer safety through best practices in post-harvest handling, transportation, and storage is one of the goals of the National Shellfish Sanitation Program (NSSP). If applied properly, best practices in post-harvest activities are an effective way to control the safety of molluscan shellfish for human consumption by preventing unnecessary growth of bacterial pathogens resulting from improper/ineffective cooling, or from time/ temperature abuse. Several pathogens can cause illness from consumption of molluscan shellfish. Not all known pathogens associated with shellfish consumption will reproduce in the shellfish; however, several multiply under temperature abuse and present a health concern. To minimize illness, the NSSP includes controls to limit exposure to warm temperatures. Additionally, proper handling, transportation, and storage practices prevent cross contamination and preserve the identity of shipments/consignments. Implementing best practices from harvest to table for post-harvest handling and the requirements of the NSSP is vital to enabling trace-back and the undertaking of subsequent appropriate actions whenever consumer complaints or other adverse findings arise.

DEVELOPING AN INDIVIDUAL FARM PLAN FOR EAST COAST SHELLFISH GROWERS

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Over a period of about 3 years, the East Coast Shellfish Growers Association (ECSGA) worked with farmers from Maine to Florida to determine how they were growing their shellfish and how they operated their businesses. After interviewing about 350 people including not only the farmers, but state agency people, academics, environmental group representatives and the public, ECSGA published a document called “Best Management Practices for East Coast Shellfish Growers.” This work was funded by both USDA’s Northeast Regional Aquaculture Center and the NOAA Office of Aquaculture. Part of the impetus for creating this code of practice and BMPs was to have the shellfish growers examine their operations in a business-like manner incorporating parameters that could be examined if the grower applied for financing or insurance.

As part of the BMP process, we developed a template for an Individual Farm Plan for growers to use for whatever need that arose, including financing and marketing strategies. This session will introduce the reasoning behind developing BMPs, show how they can be used by growers to increase consumer confidence in their product and demonstrate how the template can be filled out using data either from a current grower or a fictitious one. The template itself is available at ecsga.org, the website of the East Coast Shellfish Growers Association for free.

THE HISTORY OF SHELLFISH CULTURE IN NEW JERSEY

Gef Flimlin
Rutgers Cooperative Extension of Ocean County, 1623 Whitesville Road, Toms River, NJ 08755 USA

Harvesting of shellfish in New Jersey goes back to the Lenape tribe. The shellfish abundance in coastal bays and the Delaware shore was tremendous. The oysters (Eastern oyster, *Crassostrea virginica*) from Delaware Bay started to diminish and Rutgers University began to work with industry to improve the oyster populations about 100 years ago. Simple husbandry methods described in farming terms were first used to describe the process of planting, seeding, and cultivating; typical terms that describe both agriculture and aquaculture.

The hard clam (Northern Quahog, *Mercenaria mercenaria*) aquaculture process began after a massive set fell in a coastal bay in the early 1970s. Clammers took up these little seed and replant them on their leases where natural predation decimated the seed. At that point, wild harvest was also falling. Three enterprising clammers sought assistance from the Virginia Institute of Marine Science Laboratory in Wachapreague, VA. In 1975, the first clam hatchery began in Atlantic City, and the process of spawning, culturing and growing out of these shellfish has continued since.

The hatchery produced culture of oysters is more recent. Beginning with seed produced at the Rutgers Haskin Shellfish Research Lab, a small group has been culturing oysters on the flats of Delaware Bay since 1997. They use selectively- bred, disease-resistant oysters and use an old brand name called Cape May Salt Oysters. A small contingent now grows oysters in the Atlantic Coastal bays. Presently both the clam grower and the oyster growers are evaluating the concept of forming cooperatives to improve their return on their products.

DEVELOPING REMOTE SETTING CAPABILITIES WITH DISEASE-RESISTANT TRIPLOID OYSTERS FOR SHELLFISH LEASES IN DELAWARE BAY

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The lower Delaware Bay contains about 33,000 acres of bottom leased by the state of New Jersey for the production of shellfish, specifically oysters. Much of this bottom has been out of production for many years due to MSX and Dermo disease. Oysters that survive still produce a high quality product. Intensive aquaculture methods (e.g., cage culture) are being adapted or developed for these leases. Such methods are expensive and target the higher value half shell market by necessity. Harbor House Seafood, LLC., operates the last remaining shucking house in New Jersey. To enhance shellfish production for the shucked product market a less expensive production method is required. Presently, virtually all shucked product comes from wild fishery harvests. Following success in other areas, Harbor House invested in building a remote setting facility to begin developing spat-on-shell on bottom culture as an alternative method to revitalize production on these beds. Eyed triploid disease-resistant larvae (23 million total) were obtained from Rutgers NJ Aquaculture Innovation Center and set on oyster shell in three batches producing nearly 2 million spat that were planted on a commercial lease and tracked for growth and mortality. Despite the impacts of Hurricane Irene and Tropical Storm Lee, box count estimates of mortality indicated survival of about 40%. Surviving oysters averaged 15.9 mm with a range of 7.3 – 39.5 mm in November. An earlier production schedule should increase survival and growth and holds promise for this technology in Delaware Bay.

A HISTORY OF CONNECTICUT'S SHELLFISHING INDUSTRY

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Records from archaeological surveys show that Native Americans harvested oysters in southern New England as early as 4,000 years ago. As colonist populations expanded along Connecticut's coast, shellfish populations close to shore quickly became depleted, leading to interest in aquaculture. By the 1700s, shoreline towns began granting individuals the right to cultivate oysters. These grants resulted in private ownership of underwater shellfish beds. This perpetual franchise system was abolished in 1915 and replaced with a leasing program that exists today. Northern quahog production became increasingly popular with the introduction of bull-rakes in the 1920s, and later hydraulic dredges in the 1950s. The industry has and continues to benefit greatly from federal and state research and development support. Molluscan shellfish currently

represents the largest segment of the aquaculture industry in Connecticut with over 77,000 acres of leased and franchised shellfish grounds.

AQUACULTURE PRODUCTION HAZARDS – DEVELOPING OUTREACH SERVICES TO THE REGION'S FARMERS VIA EXTENSION AND AQUATIC ANIMAL PROFESSIONALS USING A HACCP APPROACH.

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Each year, the aquaculture industry experiences significant economic losses as a result of disease, and pests, predators and adverse environmental conditions that render product unmarketable. Massive mortality or deformation of farmed product adversely impacts profitability, trade, and public perception. Inadequate farm level monitoring, record keeping, and producer knowledge of risk factors can confound experts' abilities to properly identify, diagnose and/or respond to the threat of aquaculture production hazard issues. Frequently, the cause of mortality events remains unknown or is identified only when it is too late to control or correct. Often, key pieces of information are missing from farmers' requests to identify and correct the hazard making the response from the Extension and aquatic health professional community, at best, highly speculative. Additionally, Extension and outreach practitioners lack comprehensive guidelines, tools, and training to assist aquaculture farmers with implementing a plan to prevent and/or control production hazards.

To address this problem, the Northeast Aquaculture Extension Network in collaboration with industry representatives and technical advisors from the research community and aquatic animal health professionals, are developing a comprehensive manual that will identify the production hazards associated with shellfish and finfish species commercially cultivated in the Northeast U.S. The manual will include industry guidelines for monitoring, recording, evaluating and sampling of stocks at the farm level, as well as a response plan for Extension professionals who receive 'disaster' calls from industry. A train-the-trainer workshop will inform first responders how to work with individual industry members to development a plan to prevent and/or control aquatic production hazards. Finally, to assess the value of these tools, a cost-benefit analysis will be conducted for four aquaculture operations. Initial enterprise budgets have been developed and will be recalculated considering the costs of implementing this new hazard analysis and management plan.

HOW TO GET YOUR CONNECTICUT AQUACULTURE PROJECT PERMITTED

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The Connecticut Aquaculture Permitting Workgroup, a partnership among Connecticut Sea Grant, the Connecticut Department of Agriculture/Bureau of Aquaculture (DA/BA), Connecticut Department of Energy and Environmental Protection and the U.S. Army Corps of Engineers/New England District, establishes guidance for the permitting of all aquaculture activities sited in the state. Though one or more permits are required for any type (e.g. commercial, recreational, research, demonstration, stock enhancement) of activity, the application and review process has been streamlined and all applications are now routed through the State Aquaculture Coordinator located at the DA/BA office.

Another recent improvement to the permitting process is a new and brief pre-application screening form. This form allows the agencies to quickly review a project outline to determine if the location and activity place the project within the guidelines for the general aquaculture permitting process or if it will require a more extensive application and review process. This screening tool results in a rapid written response to the applicant that identifies the necessary application(s) to complete and an expected timeframe from application submittal to final project approval. The pre-application screening process is meant to provide the prospective producer with better information and the flexibility to adapt project plans without first completing an extensive application. This information is laid out in the most recent version of "A Guide to Permitting Marine Aquaculture in Connecticut" which can be located at: http://web2.uconn.edu/seagrant/publications/aquaculture/permitguide.pdf, as well as on the sites of the State and federal regulatory agencies.

CULTURE OF BIVALVE MOLLUSKS – A MILFORD LABORATORY PERSPECTIVE, 1920S – 1960S

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Although the concept of farming bivalves was envisioned by the early 1920s, important scientific investigations began on the artificial propagation of oysters, which eventually led to today's aquaculture industry. At this time Dr. Herbert Prytherch, a scientist with the United States Bureau of Fisheries, began oyster studies at a field station in Milford, Connecticut. Under Dr. Paul Galtsoff, at Woods Hole, Massachusetts the Bureau focused on oyster biology and addressed issues of concern to the oyster industry. In 1932, Dr. Galtsoff hired Dr. Victor Loosanoff, who in a long career, led Milford Laboratory scientists in productive research that provided a foundation for modern shellfish aquaculture. Advances in bivalve conditioning, spawning, and larval rearing were all pioneered at Milford Laboratory. Methods for axenic mass culture of phytoplankton, essential to modern hatcheries, were described in 1961 by Harry Davis and Dr. Ravenna Ukeles. The "Milford Method" added more control and predictability to bivalve larval culture than had been achieved previously.

Research from Milford Laboratory from this period still remains relevant today. For example, recent mortalities in west coast bivalve hatcheries focused initially on *Vibrio tubiashii*, first described by Dr. Haskell Tubiash in 1965. A paper on pH tolerances of bivalves (Calabrese and Davis 1966) is relevant to today's ocean acidification studies. Research on pesticide effects (Davis and Hidu 1969) and Clyde Mackenzie's many field studies are still often cited. Collectively, these scientific contributions accelerated greatly the state of the art of modern shellfish aquaculture.

SEED PRODUCTION FOR SEAWEED AQUACULTURE

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Humans worldwide utilize over 200 species of seaweed with intense cultivation focusing on ten genera. The worldwide top aquaculture product by weight is the kelp *Laminaria japonica* that is extensively cultivated in China and other Asian countries. One of the requirements for establishing commercial seaweed cultivation is the technology to produce seed for grow-out. Many seaweeds have complex and complicated life histories with different environmental triggers for different stages. Understanding how to control and manipulate the life history of seaweeds is vital from an aquaculture standpoint. The technology behind seed production for several commercially farmed seaweeds including browns *(Laminaria)* and reds (*Porphyra, Euchema*, and *Gracilaria*) has been optimized since the 1950s in several Asian countries. However these technologies can also be applied to many native and local seaweeds of interest. Many studies have addressed the desire to expand seaweed aquaculture in the Northeast by completing life histories of local seaweeds in culture and determining environmental triggers to control or manipulate the life history. Utilizing this breadth of biological knowledge and developed technologies, seaweed cultivation may be more possible than ever in the Northeast. Additionally, growing awareness of the environmental impacts of finfish aquaculture has lead to the desire to mitigate nutrient loading and sedimentation. Seaweed and bivalves can be integrated into systems to reduce these environmental impacts and serve as additional crops. These secondary crops can be utilized to diversify products, substitute protein in fishmeal, and provide an overall more sustainable approach to farming fish.

ORNAMENTAL FISH CULTURE – FROM FISH TANKS TO FISH FARMS: THE EVOLUTION OF AN INDUSTRY

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Ornamental fish, whether freshwater or marine, have been bred and raised by aquarists for more than 60 years. In basements and garages, these self-taught aquaculturists have developed culture methods that often rival some of the best, most well funded research institutions. Is this a hobby? Is it an industry? How has technology transformed the simple goldfish bowl into a multi-million dollar industry?

Early ornamental systems often consisted of simple glass tanks with minimal filtration and average water quality. As the technology developed to breed many new species of fish, including valuable marine species with long planktonic larval stages, these primitive systems simply did not provide appropriate life support. This has resulted in the development of new systems that mimic the planktonic environment while removing the major risks to life in the planktonic stages, such as predation. Low cost, high efficiency upwelling incubators, and sophisticated live feed systems have allowed both hobbyists and professional aquaculturists to rear larval fish through these difficult larval stages.

This presentation will outline the history of ornamental production in the USA over the last 50 years. It will explain why we are slowly seeing the replacement of wild caught exotic ornamentals with captive bred specimens, which will provide sustainable solutions that this industry will need to survive and thrive.

DEFINITION AND MEASUREMENT OF REEF AREA AND VERTICAL RELIEF OF RESTORED OYSTER REEFS.

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Reef area is a universal metric for oyster restoration projects and vertical relief is common. Despite the fundamental nature of the measures they have been defined in various ways and measures have not necessarily been comparable between projects. Variations in methods will be described along with recommendations for successful techniques.

NATIONAL GUIDELINES FOR METRICS USED FOR MONITORING OYSTER RESTORATION PROJECTS

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Oyster reefs and beds are among the most imperiled marine habitats with approximately 85% loss from historic extents on a global basis. In the US the restoration of oyster reef has developed from a proof of concept exercise to one that now includes large scale restoration for the enhancement of many ecosystem services. Despite this maturing of oyster restoration there remains a diversity of techniques and metrics chosen to demonstrate the success or failure of an individual project or technique. The diversity of techniques and metrics employed has made it difficult or impossible to compare the success of many different approaches to oyster restoration around the US.

A coalition of oyster restoration practitioners has established metrics for monitoring the success of oyster restoration nationwide allowing comparisons between habitats and techniques, and suggested metrics, standardized methodologies, and success criteria applicable for judging the success of some critical ecosystem service-based restoration goals. The scope of the manual and intended outcomes will be introduced.

SHELLFISH RESTORATION, NELSON BAYS, NEW ZEALAND

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Shellfish, including green-lipped mussels (*Perna canaliculus*), dredge oysters (*Tiostrea chilensis*) and scallops (*Pecten novaezelandiae*) have been an important resource in the Nelson region since European colonisation of New Zealand in the 1850s. Significant shellfish beds have been exploited over time, but re-colonisation of populations has had a chequered history. The most valuable fishery for scallops formed the basis of a thriving enhancement operation in the 1980s that has dwindled recently to very low levels in Nelson Bays. The largest changes since formal records began in the 1960s in the seabed communities in Nelson Bays is the removal by dredging of significant quantities of shellfish including green-lipped mussels, flat oysters and scallops. The lack of re-colonisation of shellfish is most likely caused by lack of settlement substrata. Mussel and scallop larvae will not settle on bare mud, and prefer to settle on filamentous or fibrous material, a role historically provided by red algae, seagrass detritus, hydroids and bryozoans. Flat oysters also require hard surfaces, historically shell-gravels, on which to settle. Comparisons of sediment characteristics inside and outside a 28-year old fisheries exclusion zone show that fished sediments appear to have been homogenised by removing, eroding or burying shell content once available for shellfish settlement. A thorough review of factors affecting shellfish production, including a stakeholder engagement process is currently underway to form the basis for developing an ecosystem approach to fisheries management for these shellfish fisheries.

COUPLING URCHINS, SEAWORMS, AND SEAWEED IN A PILOT SCALE INTEGRATED MULTI-TROPHIC AQUACULTURE SYSTEM

Katherine Hladki, Christopher Neefus, Larry Harris
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Aquaculture produces nearly half the world's seafood. Most current aquaculture production comes from monoculture systems that are often associated with negative environmental impacts. Moving aquaculture onto land in recirculating aquaculture systems (RAS) can eliminate some of the negative impacts of aquaculture such as escapes and disease, but waste removal remains an issue. Integrated multi-trophic aquaculture (IMTA) systems utilize extractive crops such as urchins, seaworms, and seaweeds to remove solid and dissolved wastes, stabilize water quality, and increase economic viability throught product diversification. Urchins command a high price in Asian markets; however, many urchin fisheries are in decline. Urchin aquaculture can help provide a consistent supply to markets while relieving pressure on wild populations. Seaworms produced from aquaculture can be used as live bait in recreational fishing as well as an alternative to fishmeal in aquaculture feeds. Urchins and seaworms can be used in IMTA systems to remove particulate waste and uneaten feed from finfish culture systems but produce their own waste products including inorganic nitrogen (namely ammonium) which can be detrimental to fish health. Seaweeds can thus be used to remove nitrogen in IMTA systems and balance water quality. This study will examine the ammonium production of seaworms and urchins and uptake abilities of red seaweeds under a range of environmental factors. The ultimate goal of this study is to identify the appropriate biomass ratio of the three organisms in IMTA.

INCORPORATING COMMUNITY-BASED EFFORTS INTO LARGE-SCALE OYSTER (*CRASSOSTREA VIRGINICA*) RESTORATION PROJECTS IN SOUTH CAROLINA ESTUARIES

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Oyster restoration has become an effective method of establishing living shorelines in coastal South Carolina waters over the past decade. The South Carolina Department of Natural Resources and its South Carolina Oyster Restoration and Enhancement (SCORE) program have developed methodology for both large and small-scale habitat restoration projects that can be implemented in varying types of intertidal estuarine conditions. Obtaining funding for one or the other can be challenging since funds for habitat restoration are in short supply, particularly in impacted areas. Combining these methods provides an avenue for leveraging funding on both scales. Large-scale restoration provides a cost effective method of restoring acreages that are not achievable with small scale projects while small-scale efforts provide an opportunity for the community to become involved in hands on restoration activities that may not be suitable with the large-scale process. Community involvement provides stewardship opportunities to participants and allows them to gain a vested interest in oyster resources and habitat restoration. Furthermore, volunteer hours provide a source of matching funds. Large-scale restoration also provides an opportunity to establish working relationships with industry professionals, who have the equipment required for the job. Neither large-scale nor community-scale oyster restoration methods are suitable at all sites, so a combined project can often result in a more complete shoreline restoration by siting the methods where they will work best. A project combining large-scale and community-based efforts appeals to a wider array of grant sources than either project would alone.

A HISTORY OF SHELLFISH CULTURE ON LONG ISLAND, NY

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This presentation will concern itself with the history of shellfish culture on Long Island with a special emphasis on the Peconic Bay system.

It will describe the historic taking of shellfish, the advent and evolution of government grants and leases for private bottom culture of shellfish which put new life into the shellfish industry and led to the rise of the local industry from the middle 1800's to the early 1930's and will include the interaction between the companies of Connecticut and New York to spawn, set, grow, transplant and sell oysters and how this influenced the growth of the oyster industry particularly in the Peconics.

Next, the early science and the advent of shellfish hatcheries and their necessity and influence on the industry will be described.

Finally, the state of the present industry will be described along with the most recent actions of NYS and the Suffolk County Legislature which have encouraged the new leasing of underwater lands in the Peconics and allowed the sale of an undersized or "in the shell" scallop which could result in a new industry.

NATURAL SPATFALL COLLECTION FOR AUGMENTATION OF BAY SCALLOP RESTORATION EFFORTS

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Intensive Peconic Bay Scallop (*Argopecten irradians*) restoration efforts in eastern Long Island, New York waters are being conducted in response to the decimation of natural populations by "brown tide" algal blooms. Our scallop restoration methods predominately utilize hatchery reared animals. This project augments these restoration methods by capturing, growing-out, and releasing natural spat. In the spring/summer of 2012, 400 "spat collector" bags were deployed with the goal of capturing 100,000 scallop spat. Settled scallops were allowed to grow in the field for several (9-14) weeks before being collected; they were then sorted, counted, and transferred into lantern nets suspended from long lines in our spawner sanctuary. Some will be 'free-planted' in the Fall of 2012 while the rest will be over-wintered and then released after spawning in spring 2013. Spat collection results (~464,000 scallops) were far better than expected, surpassing our goal by over 4 1/2 times. These numbers suggest natural spat collection is a viable, and maybe less expensive, method for bay scallop restoration projects.

COMPARATIVE GROWTH OF QUAHOG (*MERCENARIA MERCENARIA*) SEED IN VARIOUS GROW-OUT CONDITIONS, CHATHAM, MA

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Every year the Town of Chatham receives Quahog Seed from Aquaculture Research Corporation (ARC) at size R1. The Town of Chatham uses this seed to enhance the natural stocks of quahogs in the wild fisheries. The goal of the town is to raise this seed to approximately 25mm at which point it can be broadcast into the wild fishery.

This presentation aims to compare various methods that were used by the Town of Chatham in the summer of 2012 and evaluate the growth rate of each method. Once Quahogs are received they are placed in the Land Based Upweller where they are grown until they reach field plant size (~10-15mm). Traditionally these Quahogs are then moved under predator screen net to complete their growth and are over wintered.

In the summer of 2012 multiple methods were experimented with. Once they reach field plant size the quahogs were divided between multiple methods. These methods were: 1) remaining in the upweller, 2) planted under nets, 3) placed in grow-out trays/ cages. In October 2012 all the Quahogs will be measured and those above 25mm can be broadcast, those below must be overwintered. Methods will be evaluated based on growth rate and mortality as well as time and money spent.

DEVELOPING SUSTAINABLE EGG COLLECTION METHODS FOR THE MUMMICHOG: FREQUENCY OF COLLECTION AND COLLECTOR DEPTH

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The mummichog, *Fundulus heteroclitus*, is a popular marine baitfish along the Atlantic coastline. At present, this species is primarily wild caught and bait fishermen, bait shops, and inevitably anglers suffer from seasonal lulls when demand is high

and natural supply is low. Of all the marine baitfish, *Fundulus* has great culture potential due to its durability but has yet to break through owing to a lack of profitable methods. Since *Fundulus* also has a relatively low fecundity, methods that focus on maximizing egg production and minimizing labor costs should be investigated. To address these issues, we examined egg production of mummichogs over an eight week period in a small-scale production setting, focusing on effects of egg collector depth and frequency of collection. Egg collectors were placed at three different depths below the water surface (8, 16, and 14 cm) to identify the ideal depth of egg deposition in the absence of tidal cues. Eggs were also collected simultaneously at two different frequencies (two or three times per week) to determine a cost-efficient labor regime that maximized yield. Mummichogs exhibited a significant preference for egg deposition at the shallowest depth. The number of eggs collected and fry that hatched were not statistically different between collection regimes, yet labor was significantly higher for increased collection frequency. Accordingly, a sustainable business model for indoor mummichog egg production should include bi-weekly egg collection using collectors placed 8 cm below the surface.

VIBRIO CONCERNS FOR SHALLOW WATER AND FLOATING AQUACULTURE – WHAT WE KNOW AND WHAT WE DON'T

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Vibrio spp. are a leading causes of seafood associated illnesses in the United States. Warm estuarine temperatures have long been established as a key factor in elevation of *Vibrio* populations in the environment and seafood, which also correlates with the peak incidence of *Vibrio*-related illnesses in July and August. As new and innovative aquaculture practices arise, concerns about potential impact of farming conditions on *Vibrio* levels should be addressed. Based on current knowledge, it is feasible that some aquaculture practices may promote *Vibrio* proliferation. Shallow water areas generally have warmer water temperatures than deep water areas. Additionally, aquaculture floats position the shellstock near the top of the water, where temperatures are warmest and more directly impacted by the sunlight. Based on water temperature, there is an increased concern of *Vibrio* levels with these types of practices and additional mitigation strategies may be needed to address the potential risk of illness associated with these products. Site selection for aquaculture farms, examination of current practices, and potential mitigation strategies will be discussed.

DETECTION METHODS FOR PATHOGENIC (*VIBRIO*) SPECIES

Steve Jones
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The Northeast shellfishing industry is facing an emerging challenge as pathogenic [*Vibrio*] species are causing disease in areas where infections have been rare. The detection of [*Vibrio parahaemolyticus*] and [*Vibrio vulnificus*] has been well established for decades, yet new molecular biological modifications have made detection more straightforward. Not all strains of these pathogens are virulent, and the detection of pathogenic strains has complicated shellfish harvest and public health management. There is a range of options available for use in detecting pathogenic [*Vibrio*] species and strains, depending on the management or scientific question being addressed. The detection options will be presented in a tiered fashion, with increasing details and sophistication. Recently developed methods will be discussed, as will more complex scientific research related approaches that relate to critical shellfish industry issues.

MARTHA'S VINEYARD SHELL RECOVERY PARTNERSHIP

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Shell is a necessary component of oyster habitat providing hard substrate for setting oyster spat; and of increasing importance as a buffering agent for acidified waters which can inhibit shell formation in bivalves and other marine organisms. Each year

hundreds of cubic yards of shell are brought to the island and planted in the ponds in an effort to replace shell that is removed during the harvest of bivalve shellfish. At the same time, dumpsters outside restaurants are filled with discarded shells destined for removal to off-island landfills.

During the summers of 2011 -2012 with funding from the local Edey Foundation & Vineyard Vision Fellowship, the Martha's Vineyard Shell Recovery Partnership was initiated to recover and recycle shell from the waste stream; thereby, reducing bulk waste and providing a local source of shell to protect and maintain shellfish habitat. Efforts are underway to expand the program and make it economically sustainable.

A LOOK AT SPECIES-SPECIFIC AND SEASONAL EFFECTS OF TWO PROBIOTIC BACTERIA UPON HEMOCYTES OF THE EASTERN OYSTER (*CRASSOSTREA VIRGINICA*) AND THE NORTHERN BAY SCALLOP (*ARGOPECTEN IRRADIANS IRRADIANS*)

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Use of probiotic bacteria as an environmentally-friendly method for controlling microbial pathogenesis in aquaculture is becoming increasingly preferred over use of chemical antimicrobials, which can lead to the development of resistant strains of bacterial pathogens. Research at the Milford Laboratory has identified a naturally-occurring *Vibrio* sp. bacterium (OY15), isolated from Eastern oysters (*Crassostrea virginica*), that significantly improved survival ($p<0.014$) of oyster larvae in pilot-scale trials when challenged with *Vibrio* sp. shellfish-larval pathogen B183. *In vitro* studies on the immune functions of adult oyster hemocytes suggested immune-stimulation as a possible mechanism of OY15's probiotic effects. Another probiotic candidate, a *Bacillus* sp. bacterium (S1), isolated from bay scallops (*Argopecten irradians irradians)*, was not effective in improving survival of oyster larvae challenged with B183 in pilot-scale trials, possibly attributable to significant immune-suppression of oxidative burst as indicated by adult oyster hemocytes. *In vitro* exposures comparing immune functions of adult oyster and bay scallop hemocytes to probiotic candidates OY15 and S1 to determine possible bacterial-strain species specificity suggested that significant immune-suppression of oxidative burst occurred for both oyster and bay scallop hemocytes by both probiotic candidates, contrary to previous immune-function assays showing significant stimulation of oxidative burst in oyster hemocytes by OY15. This study will compare immune functions of both adult oyster and bay scallop hemocytes to determine if seasonal differences in metabolism activity can cause these immune-function differences, and confirm the possibility of species-specific probiotic effects of OY15 and S1.

DEPLOYING REMOTE-SET DISEASE-RESISTANT EASTERN OYSTER, (*CRASSOSTREA VIRGINICA*), IN BIODEGRADABLE NETTING ON A SHELLFISH LEASE IN CONNECTICUT

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The Connecticut oyster industry is subject to large production fluctuations due to two salient issues: epizootics caused by the parasite *Haplosporidium nelsoni* (MSX*)* and gap years between successful natural sets. Experiments aim to develop a method to restock Connecticut's natural oyster beds via disease-resistant remote set *Crassostrea virginica* seed-on-shell in biodegradable netting. Traditional bottom culture in Long Island Sound relies on natural oyster set for commercial harvest. Deploying hatchery-raised oysters on seed beds may compensate economically and ecologically for future MSX epizootics and/or insufficient natural sets. Hatchery reared, disease-resistant oysters were deployed on a shellfish lease off Westport, CT. Before deployment, the lease was dredged and species of local fauna recorded. Following remote setting techniques, oyster seed-on-shell was released with, and without, biodegradable New Zealand mussel socking. Seedless cultch for natural recruitment was deployed as the control. Oysters were sampled monthly during low tide. Oyster shells from each specimen group (n=30) were collected and counted to evaluate average survival and mortality of the set. One-hundred oysters were then measured to determine growth, and predators and fouling organisms were recorded. Preliminary results indicate lower initial mortality and greater growth in oyster set deployed in biodegradable netting. Netted, un-netted, and cultch samples exhibited substantial sets of fouling organisms such as *Crepidula fornicata, C. plana, Balanus balanus,* and *Anomia simplex*.

Predators include *Urosalpinx cinera, Eupleura caudata,* and *Panopeus herbstii*. Early results demonstrate the potential of biodegradable netting as an effective predator control and offset to disease outbreaks or lack of natural recruitment.

OPEN WATER CULTIVATION OF *GRACILARIA TIKVAHIAE* AND *SACCHARINA LATISSIMA* IN LONG ISLAND SOUND AND THE BRONX RIVER ESTUARY

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Two native seaweeds, *Gracilaria tikvahiae* and *Saccharina latissima* were cultivated on longlines in Long Island Sound (LIS) and the Bronx River Estuary (BRE). *Gracilaria* bundles were attached to the longline by entwining before ouplanting the longlines. As biomass increases, fronds were harvested by 'trimming' the fronds and leaving fronds to re-grow to cut again every two to four weeks. *Gracilaria* at BRE grew ~11.8% d^{-1}, in Aug. 2011 and ~16.5% d^{-1} in July, 2012. Growth rate in LIS was ~6.0% d^{-1} in Aug. 2011 and July 2012. The *Gracilaria* yield varied depending on the nutrient availability. In LIS (nutrient limited), the yield was ~72.9kg mon^{-1} on a 100m longline in July while the highest yield at BRE (nutrient enriched) was 365.1kg mon^{-1} at the same time. Sugar kelp (*Saccharina)* was farmed in LIS during the winter of 2012. After outplanting juvenile kelp (<1mm), our aquacultured kelp grew as much as 3.0 m in length and had a yield of 1,752 kg per a 100 m longline after 5 months (Dec.-May). Our *hypothetical* one hectare nutrient bioextraction *Gracilaria* farm system in LIS with 4m spacing between longlines could remove 2.6 kg N ha^{-1} mon^{-1} while nitrogen removal at BRE could be 5.5-10.3 kg N ha^{-1} mon^{-1}. One hectare sugar kelp farm system in LIS (with 5-10 m spacing) could remove 46-87 kg N ha^{-1} during the winter-spring growing season. These results suggest that seaweed aquaculture can be a useful technique for nutrient bioextraction in urbanized coastal waters while producing significant biomass for other uses (e.g. human food, hydrocolloids, animal feed or biofuel).

THE USE OF ABANDONED AND UNWANTED CRAB TRAPS AS A VIABLE SUBSTRATE FOR PROMOTING OYSTER REEF DEVELOPMENT AND CREATING ESSENTIAL FISH HABITAT.

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In the coastal waters of the southeastern United States, abandoned crab traps are a major source of marine debris that cause the "ghost fishing" mortality of target and non-target species. Recent work at the SCDNR has shown that crab traps represent an effective substrate for establishing new oyster reef habitat, particularly in "pluff mud" environments where more traditional approaches to restoration are less effective. Through funding from the Southeast Aquatic Resources Partnership (SARP) and the State Wildlife Grant (SWG) program, researchers at the SCDNR have established a crab trap revitalization program. The primary goals of this program are: 1) to facilitate the reporting and removal of abandoned crab traps from marine and estuarine habitats; 2) to provide opportunities for the donation of unwanted crab traps; and 3) to use recovered and donated crab traps as substrate to establish new oyster reefs that serve as essential fish habitat. As part of these projects, a variety of outreach products have been developed including a web-based survey to gather information on the distribution of abandoned crab traps. More than 500 traps have been collected so far, with more than half of these traps having been deployed as reef substrate. Further crab trap-based reef building is planned for the spring of 2013 as part of a NERRS Science Collaborative project. This presentation will provide an overview of the reef building efforts completed over the past three years and the monitoring data that has been collected on oyster reef development and the associated nekton communities.

THE IMPORTANCE OF THE ZEBRAFISH FOR THE AQUACULTURE INDUSTRY

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The zebrafish (*Danio rerio*) is a venerable aquatic ornamental that also happens to be a pre-eminent experimental model animal used in an ever-growing number of scientific disciplines, including human health and disease, environmental toxicology, behavior, drug discovery, and commercial aquaculture. While the continued growth of both publicly and privately funded zebrafish research will have important implications for many economic sectors, some of the most profound impacts of this movement will be felt in the aquaculture industry. After all, *all* research done on zebrafish is predicated upon the ability to grow and maintain hundreds, if not thousands of fish under tightly controlled conditions. This universal requirement has led to an increasingly robust demand for sophisticated life support equipment, feed, therapeutics, supplies, and, perhaps most importantly, people with education and experience in culturing aquatic animals. Each of these cases represents an opportunity for different segments of the aquaculture industry that can be capitalized upon going forward.

USE OF INSTRUMENTATION FOR AQUACULTURE SITE SELECTION AND WATER QUALITY MONITORING

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Identification of optimal aquaculture sites and monitoring the water quality on those sites depend 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. Topics to be covered will include: measuring bathymetry, tidal heights and currents, sources of aerial imagery, sources of weather data, underwater video options, production modeling packages, use of CTD's and multi-parameter data loggers, measurement of chlorophyll *a*, dissolve oxygen, turbidity and nitrogen compounds.

BEST MANAGEMENT PRACTICES FOR SHELLFISH RESTORATION

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The objectives of the Best Practices for Shellfish Restoration (BMPs) project are to establish methods which include protocols for educational programs and safeguards to ensure that shellfish grown in unapproved areas do not reach the market The project was designed around seven workshops at regional ISSC and other professional shellfish management meetings, drawing together stakeholders representing state regulatory agencies and public health officials, extension specialists, shellfish industry, non-government organizations, representatives of shellfish gardening programs to identify critical issues and solutions. The goal was to use workshop results to provide guidelines that address the needs of stakeholders while establishing protocols for the biosecurity of restoration projects, including educational outreach, and to encourage consistency from state to state.

A theme identified throughout the workshop sessions was the need for better planning and earlier communication. Participants suggested forming partnerships among restoration proposers, regulators, funding agencies, academic institutions and non-government organizations to promote restoration of native shellfish and ecosystem services and to conserve and restore coastal water quality. Although most regulators preferred that restoration activities were only sited in approved waters it was agreed that activities could occur in unapproved waters but would require additional plans for the biosecurity of projects and an education component (biology, growing methods, pests competitors, diseases and public health) for restoration programs using volunteers.

MULTI-CROPPING SEAWEED *GRACILARIA TIKVAHIAE* WITH OYSTERS IN WAQUOIT BAY, MASSACHUSETTS

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A native species of seaweed, *Gracilaria tikvahiae*, was selected and cultivated on an oyster farm to investigate the dual purposes of nutrient bioextraction and production of edible sea vegetables.

Starting from laboratory cultures, stock cultures were grown in the spring of 2012 to facilitate a first planting in June 2012. *G. tikvahiae* was planted at two sites (with and without oyster cages) at two depths (0.2 m and 0.6 m), at two stocking densities (20g bundles planted every 10 cm and 20 cm), and at two harvest intervals (every 2 weeks and every 4 weeks).

G. tikvahiae grew well at both locations, and produced the best yield per unit area at shallower depths, closer stocking densities, and shorter harvest intervals. These more favorable culture characteristics also helped reduce fouling problems. We will present results from our first growing season and plans for the second year.

RESEARCH AND IMPROVED MANAGEMENT FOR OFFSHORE MUSSEL FARMS IN SOUTHERN NEW ENGLAND

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Fishermen in MA and RI expanded their leases and longline installations in 2011, and now manage 8 longlines. Experiments with socking (Canadian cotton bi-sected vs. NZ and Spanish rope types), seed size (5 mm to 35 mm) and density (600/m and 900/m) were conducted in 2011 and 2012. Equipment for grading and socking seed was imported from New Zealand, Spain and Canada for comparison, and results will be presented. Experiments were conducted to develop protocols for eradicating invasive tunicates on wild-collected mussel seed to reduce the likelihood of introducing fouling problems on offshore lines. Results of our experiments and of our stocking and harvests will be presented.

LESSONS LEARNED: MODERNIZING WILD SHELLFISH HARVEST MANAGEMENT AS PART OF A BAY-WIDE SHELLFISH RESTORATION PROGRAM (HARD CLAMS IN GREAT SOUTH BAY NY)

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In the last decade there's been marked increase in the number of US efforts aimed at restoring native estuarine shellfish as a tool to resurrect ecosystem functions that were disrupted by historic declines in wild shellfish populations. Unsustainable harvest practices are major factor linked to the initial shellfish declines in many of the estuaries that currently have shellfish restoration goals. This is the case for Great South Bay NY, which less than four decades ago supported the largest hard clam fishery in the US. The complete boom and bust of the Great South Bay clam fishery occurred over decades without any notable changes to the rules governing open access commercial harvest. IN 2004, following The Nature Conservancy's acquisition of 13,400 acres of privately held submerged lands, a coalition of agencies and stakeholders developed and endorsed an adaptive hard clam restoration framework with both ecosystem and human use objectives. During implementation, restoration approaches were well supported by the commercial and recreational shellfishing communities. Unfortunately, once attention became focused on implementing changes to the long-standing shellfish codes, coalitions became fractured, opposition grew, and personal and professional relationships were strained. This presentation highlights

where and how mistakes were made, as well as approaches that were used to eventually mend some relationships, find some common ground, and ultimately gain political support for implementing code changes aimed at aligning harvest management rules with the broadly accepted restoration and sustainability objectives in a way that tries to strike a fair balance between extraction and restoration goals.

PHASE 2 OF THE OYSTER RESTORATON RESEARCH PARTNERSHIP, 2012-2014: SCALING UP EFFORTS AT SOUNDVIEW PARK, BRONX, NY TO MAZIMIZE RETENTION OF PLANTED SPAT-ON-SHELL AND THE RECRUITMENT OF WILD OYSTERS

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Restoration of oysters is a major component in the Hudson-Raritan Estuary Comprehensive Restoration Plan which calls for establishing 200 acres of oyster (*Crassostrea virginica*) reef habitat by 2050. In 2009, the Hudson River Foundation, New York/New Jersey Baykeeper, NY Harbor School, US Army Corps of Engineers, University of New Hampshire, and other partners formed the Oyster Restoration Research Partnership (ORRP) and in 2010 initiated a study to investigate appropriate methods and locations to restore native oyster populations to the New York Harbor region. Five experimental reefs (each 30m^2) consisting of a rock base overlain with surf clam shell 'seeded' with juvenile oyster spat on shell (SOS) were constructed in fall 2010, and monitored during 2010-2012. SOS survival and growth, retention of SOS on reef areas and natural spat recruitment varied widely across the experimental reef sites. Phase II of the project will restore ½ acre of subtidal oyster reef habitat within a 1-acre footprint at the confluence of the East and Bronx Rivers near Soundview Park's shoreline. 400 cubic yards of clam shell will be placed directly adjacent to existing rock outcroppings within the 1 acre footprint, and SOS will be added. Placement methods, groupings and density of the spat-on-shell will be manipulated to examine the factors controlling SOS loss and the recruitment of wild oysters. Development of the constructed reefs will be monitored for 20 months post-construction.

CHANGING PUBLIC PERCEPTIONS ONE OYSTER AT A TIME

Sandra Macfarlane
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Shellfish restoration has become a growth industry in the last two decades with many communities, research institutions and non-profit organizations combining a desire to execute a particular project with volunteer energy to accomplish the task. In the process, everyone gains an education. For the project proponents it can be the joys and frustrations of working with volunteers; for academics it can be imparting text-book knowledge to people with practical knowledge and life-experience; for the volunteers it can be gaining a completely new perspective of marine ecology and what it takes to grow shellfish or build a reef. For communities dealing with the effects of estuarine nutrient loading, shellfish can act as partial ameliorators at least until such time as land-based solutions are put in place though restoration projects are not usually framed in that manner, but rather as projects to increase the supply of shellfish, the filtering capacity of the shellfish an added bonus. A pilot project begun in Orleans, MA through the Orleans Pond Coalition proves the point as volunteers embarked on a voyage of discovery to grow a small number of oysters at a land-based upweller facility. As the oysters grew and the need for field grow-out became apparent, the group learned about best practices for shellfish restoration and the issues surrounding shellfish aquaculture on a larger scale.

SHELLFISH IN CAPE COD BAY: CENTURIES OF HARVESTING BOUNTIFUL BIVALVES

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Shellfish harvesting has a long history in Cape Cod Bay. Native Americans harvested shellfish leaving shell middens as testimony to the value of shellfish collected and early European settlers survived on fish and shellfish from the bay. Later there were fishermen bullraking for quahaugs (*Mercenaria mercenaria*) with forty-foot poles while balancing on the decks of beamy catboats; harvesting oysters (*Crassostrea virginica*) from the flats and waters of Wellfleet Harbor with hand rakes and dredges; hydraulic harvesting seaclams (*Spissula solidissima*) off Billingsgate Shoals; dragging for scallops (*Argopecten irradians*); and the more recent explosion of aquaculture entrepreneurs – all of these activities maintained shellfishing as a maritime industry tied to the region and emblematic of an evolving seascape and changing resident attitudes. Fishermen have had to find other ways to stay on the water, many turning to part-time or full time aquaculture, since shellfish harvest has not been immune to the general trend of fisheries decline. The change from hunter-gatherer to farmer has been dramatic. Water quality is generally favorable for shellfish growth, survival and harvest, due, in part, to the tidal amplitude and exchange of water within the bay. Aquaculture in Cape Cod Bay is not without challenges, the most important being winter ice.

PRODUCTION AND PERFORMANCE OF LIVING REEF BLOCKS AS AN OYSTER, (*CRASSOSTREA VIRGINICA*) REEF SUBSTRATE: A STUDY OF AQUACULTURE AND OYSTER RESTORATION TECHNIQUES IN NEW YORK HARBOR

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In an attempt to prevent transport of live animals off of restoration reefs, The New York Harbor School (NYHS), has developed culture techniques that will allow for spat-on-shell aggregation in oyster trays. Oyster trays have been modified to take advantage of the animals' natural tendency to grow together. These techniques are designed to produce, large spat-on-shell blocks comprised of 800-1500 live animals. The study, attempts to evaluate the effectiveness of these culture techniques. Performance will be evaluated based on the structural integrity and total dry weight of the reef blocks as well as the average size and survivability of individual oysters. Currently two tray systems, sets of handling procedures and nursery locations are under evaluation on Governors Island and in the Brooklyn Navy Yard. One million live oysters from three northeast hatcheries are the test population. The reef blocks are scheduled for deployment on restoration reefs during the summers of 2013 and 2014.

ESTABLISHING AN OFFSHORE MUSSEL FARM IN FEDERAL WATERS IN THE GULF OF MAINE

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This year, NOAA Fisheries contracted with researchers at the Salem State University's Northeastern Massachusetts Aquaculture Center to support a demonstration mussel farm in federal waters off the coast of Massachusetts. We are currently working to obtain permits for establishing a commercial scale (33 acre) offshore mussel farm off the coast of Cape Ann Massachusetts. Our primary objective is to define the permitting process in federal waters and to investigate offshore mussel culture as an alternative fishing option for fishermen and lobstermen currently displaced or negatively impacted by current fishery restrictions.

Working with NOAA personnel we are defining the permitting process for offshore deployment of mussel gear in federal waters. Once permitted, we will establish long-lines and begin culturing. Our project involves an evaluation of gear options focusing on user-friendly designs, specifically for stocking, deployment and harvesting of mussel lines. The project will also develop stocking protocols to maximize mussel yields through refinements of seed density and line placement within culturing systems.. Finally, the project will compare results with similar southern initiatives currently underway off Martha's Vineyard, MA and in Narragansett Bay, RI, examining techniques for seed collection, gear design and harvesting procedure, all essential components to developing a sustainable aquaculture industry.

Open ocean mussel culture would avoid conflicts with other coastal fishing activities while providing new sources of income to fishermen and other fishing-related businesses in the ports along the New England coast. Once established, we hope to engage and train local fishermen in long-line mussel farming.

LIFE CYCLE OF THE EASTERN OYSTER, (*CRASSOSTREA VIRGINICIA*) (GMELIN, 1791), A PEN AND INK PERSPECTIVE

Kathryn Markey
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A pen and ink illustration of the life cycle of the Eastern oyster, *Crassostrea virginica* was created at Roger Williams University in the Aquatic Diagnostic Laboratory. This illustration, based on published literature and photographs, was designed to broaden the archive of illustrations that currently exist and is a work in progress. The Luther H. Blount Shellfish Hatchery at RWU allows for a direct source of shellfish larvae for photographing. What follows is a brief description of the oyster life cycle geared toward both public and scientific persons. Development times and sizes depend greatly on temperature, broodstock, food availability, and food quality. Oysters are broadcast spawners, releasing their gametes (a) into the water column where fertilization (b) occurs. Embryogenesis follows with formation of the first polar body (c) and continuous cell divisions (d,e,f,g,h). A pelagic trochophore (i,j) then immerges. Trochophores develop into D-hinge veligers (k) after 12-24 hours. As the veligers grow they develop an umbo (l) and then over the next few days a foot and eye spot (m). Once the foot and eye spot are developed (12-20 days) the veliger is a pediveliger (n) (*ped*=foot) and is now looking to "settle" and metamorphose (200-300+ µm). Pediveligers use their foot to attach to "suitable settling substrate", i.e. rocks, shells. This sessile stage is called "spat" (o, p). In a hatchery oysters can be "single-set" (o), where each oyster attaches to one piece of micro-cultch, or they can be "remote-set" (p), where multiple oysters settle on one piece of substrate.

USDA- FARM SERVICE AGENCY NAP OVERVIEW

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FSA will present an overview of the Noninsured Crop Disaster Program (NAP) and Farm Loan Program. NAP provides financial assistance to producers of noninsurable crops when loss of inventory occurs due to a natural disaster. The objective will be to educate the producers about the availability of the program. This will include information about eligible species, calculating a loss, and growing in a controlled environment. Additional remarks may include an update from Tessa Getchis on growing in a controlled environment.

The short overview of the farm loan program will include the types of loans available and contact information for additional information.

STARTING A CSA IN CONNECTICUT

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In November 2012 UConn Extension will be hosting a day long program titled CSA School: By Farmers, For Farmers. The program is designed for new and existing CSA farmers, with a focus on sharing models, tools, and research. Topics on the agenda include: considerations when starting a CSA, model CSA contract, insuring a CSA, accepting SNAP at a CSA, case studies (multi-farmer CSA, multi-season CSA, meat CSA, etc), CSA innovations, and research on pricing for summer CSA shares in 2012 season. In the context of growing consumer demand for sustainable and local food, CSAs are an important business model for farms to consider that combines production under contract with a unique distribution approach and direct retail to customers. This business model seems to have an ever-widening application, broadening from the traditional vegetable CSA to include fruit, eggs, meat, flowers, value-added products, baked goods, and of course aquaculture.

OCEAN ACIDIFICATION IMPACTS ON SURVIVAL AND GROWTH OF LARVAL SURFCLAMS (*SPISULA SOLIDISSIMA*) – ENVIRONMENTAL CONDITIONS (WAQUOIT BAY, MA) AND CULTURE STUDIES.

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As atmospheric pCO_2 rises, shellfish will be exposed to lower pH conditions, which may affect both survival and early shell formation, and thus impact recruitment. Water chemistry data from Waquoit Bay, MA, illustrate the dramatic range in the carbonate chemistry of nearshore waters, which often show lower and more variable pH and aragonite saturation state values (Ω) than are observed in the open ocean. Summer Ω values are below 1.8 throughout Waqouit Bay, and are below 0.5 in areas with restricted circulation. In laboratory experiments conducted over two years, eggs of the surfclam *Spissula solidissima* were introduced, within four hours post-fertilization, to seawater bubbled with air-CO_2 mixtures to yield Ω values over a similar range, from ambient (2.2) to substantially undersaturated (0.5 to 0.7). In both years the initial larval surfclam growth was negatively impacted by elevated pCO_2, but this effect was small – less than a 5% decrease in average shell size relative to ambient at three days post-fertilization, even at the highest pCO_2 level, with Ω less than 0.7.

COMMUNITY SUPPORTED AGRICULTURE: ADDING SEAFOOD TO THE RECIPE

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New Jersey Sea Grant Consortium and Rutgers Cooperative Extension of Ocean County partnered with Sea Salt Community Supported Agriculture (CSA) program, a Certified Organic operation located at B&B Farms in Galloway Township, New Jersey, to develop and implement a small-scale pilot program offering current CSA shareholders the option to buy biweekly local seafood shares in addition to farm produce. Twenty six opted to participate in the pilot project out of sixty five produce shareholders.

The program hopes to expand regional markets for local New Jersey seafood by adapting the success of community supported fishery (CSF) models to the popularity of the local foods movement in New Jersey. Due to legal and regulatory requirements associated with seafood distribution in the New Jersey, the program coordinators chose to source all shares from certified seafood distributors that sell local, responsibly harvested or grown seafood. Every two weeks, seafood shares were distributed out of the CSA Farm Shop at B&B Farms, accompanied by a packet that includes information about the product suppliers, methods of catch or harvest, a brief natural history of the featured species, instructions for handling and preparation, and recipe suggestions.

Customer and producer satisfaction surveys will be administered at the end of the season (October 27, 2012) to gauge the program's success among customers and identify areas for improvement when the program hopefully expands to other CSAs next season.

DOES THE FREQUENCY OF HYDRAULIC DREDGING ON CULTIVATED SHELLFISH BEDS INFLUENCE THE SEDIMENT CHEMISTRY AND IS THERE A RELATIONSHIP BETWEEN BENTHIC ORGANISMS PRESENT?

Shannon Meseck, Paul Clark, Renee Mercaldo-Allen, Julie Rose, Ronald Goldberg
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Numerous studies designed to investigate effects of dredge harvesting focus on benthic organisms, however little research has been done to examine the biogeochemical effects that dredging has on the habitat. A field experiment was conducted in Long Island Sound with an industry partner on three leased shellfish beds with different dredging histories (2, 3 and +5 years since last dredged), where hard clams, *Mercenaria mercenaria,* are cultivated. Each of the plots was split into two 15.6 ha areas with half hydraulically dredged and the other half left not dredged. Three sediment core samples were collected

biweekly from each site from July to October (n=18 for each sampling period). Sediment pore water hydrogen sulfide concentrations, pH, and dissolved oxygen were measured. We also collected particulate samples for grain-size analysis and particulate carbon, nitrogen, and sulfur. Preliminary results suggest that there appear to be differences between sites that were dredged and those that were not dredged and between the numbers of years since it was last dredged for pH, dissolved oxygen, and hydrogen sulfide concentrations. This will be subjected to statistical analysis at the end of the season. Data show that throughout the season, the number of benthic organisms has varied. These findings will help determine whether there are distinct biogeochemical signatures related to dredging history that may influence benthic communities.

THE SEARCH FOR THE INTERMEDIATE HOST OF THE OYSTER PARASITE, (*HAPLOSPORIDIUM NELSONI*)

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The Eastern oyster, *Crassostrea virginica,* makes up an important commercial fishery along the East and Gulf coast of North America. As a result of overharvesting and disease, the oyster populations are dwindling and can no longer meet the demands of consumers. This has led to expansion of the oyster aquaculture industry. Unfortunately disease among cultured Eastern oyster in many areas along the east coast of the United States has become a major concern. One disease of concern affecting the eastern oyster is known as MSX (Multinucleated sphere unknown). MSX is caused by the protozoan parasite *Haplosporidium nelsoni*. MSX has devastating effects on cultured and wild oysters, killing 90-95% of the oysters it infects. The complete lifecycle is unknown. It is not possible to transmit the disease from infected to naïve oysters. Consequently, it is believed that there is an intermediate host. In the summer of 2010 MSX was identified in commercial operations in the Damariscotta River Estuary for the first time in Maine. This resulted in significant mortality among the cultured oysters in the river. The current study aims to conduct a search for potential intermediate hosts of *H.nelsoni* in the Damariscotta River with the use of a TaqMan assay. In addition, it is hoped to complete a study of the changes in prevalence of the parasite within the estuary following the mild winter. These studies will provide more detailed understanding of the parasite and it's interactions with the eastern oyster and so contribute to better management strategies.

CULTURE AND MAINTENANCE OF PARALARVAL LONGFIN SQUID ([*DORYTEUTHIS (*LOLIGO*) PEALEII*]) IN A LABORATORY

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Native to the northwest Atlantic, the longfin squid, *Doryteuthis* (Loligo) *pealeii*, supports a multimillion dollar scientific, commercial and recreational industry. Although adults can live for several months and reproduce in a tank, maintaining the paralarval stage is difficult due to their planktonic nature and their susceptibility to fatal injury from hitting solid objects such as tank walls. Building upon techniques used to successfully culture other cephalopods (such as the common cuttlefish, *Sepia officanalis)*, a system and management protocol was developed that maintained large numbers of paralarval longfin squid at the Cat Cove Marine Laboratory in Salem, MA. The system included a 200L conical tank, an inflow pipe with a 1μ filter, an aeration ring, and a centered outflow standpipe with a 150μm mesh outflow filter. Cleaning and maintenance protocols involved siphoning tanks, periodic partial draining, and transfer of squid from a used to a clean tank; the protocols maintained a healthy environment. Paralarval squid were fed brine shrimp and, appeared to ingest commercial rations; however, this could not be verified due to a disruption that prematurely ended the experiment. The system and its operation demonstrated for the first time that large numbers of paralarvae longfin squid can be maintained in tanks. Although more work is needed to extend the life of paralarval squid on to adulthood within a laboratory setting, this study provides insight necessary to achieve successful culture of longfin squid for both commercial and scientific purposes.

FLOATING OYSTER CAGES AND OTHER ADVANCEMENTS: A SHELLFISH GEAR REVIEW

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The shellfish aquaculture industry in the northeast is maturing, with an increasing emphasis on mechanization, product diversity, and farm management. Particular attention has been paid by the industry in recent years to floating cage systems, and graders for oyster producers. This session will examine some of the developments and specifics for successful use of floating cages and graders, and will cover progress in culture of razor clams and sea scallops, as potential crops for shellfish growers in the northeast US. In addition, we will cover the emerging field of farm management software, and the potential for software to track inventory and help in efficient production.

This session will be informal, and will be interactive. Equipment on hand will be available for examination and handling by members of the audience, and the session is intended to stimulate discussion with producers and others, so that the equipment on the market presently is used to its greatest capacity.

SUSTAINABLE AQUACULTURE: ECONOMIC IMPACT OF USING INTEGRATED MULTI TROPHIC AQUACULTURE (IMTA) TO REDUCE SEA LICE IN SALMON FARMING

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Salmon aquaculture is a growing industry in Maine. Recently, there has been an outbreak of sea louse disease. This disease outbreak has adversely impacted the salmon aquaculture industry. IMTA is Integrated Multi Tropic Aquaculture where extractive species such as mussels is incorporated into the farm. Utilization of IMTA technology is a potential way to reduce lice pressure through mussels' ability to digest copepods, the parasitic stage of lice, and add revenues for farmers. This paper studied the potential of utilizing IMTA technology to reduce economic impact from sea lice. Financial analysis and bioeconomic models were carried out. Financial analysis measure the profitability of different farming options and the bioeconomic models determine the optimal harvesting schedule that maximizes profits for these options.

Several IMTA arrangements are examined. Financial analysis shows that IMTA2 (converting one salmon cage into mussel cage) is the least-cost option for growing salmon and has the highest returns to risk and management. However, under IMTA1 (adding 3 mussel cages in addition to 15 salmon cages), mussels add small marginal net revenues compared to salmon only. Bioeconomic model results are similar to the financial analysis, where the most profitable farming is IMTA1. This is followed by salmon only and the least profitable is IMTA2. Thus, the mussels do address sea lice and water quality issues (not the focus of our study), and they provide both economic benefits and environmental benefits to the farmer.

CLAMS ON THE RUN - CLIMATE CHANGE AND RANGE SHIFTS IN THE ATLANTIC SURFCLAM POPULATIONS: IMPLICATIONS FOR FISHERY AND MANAGEMENT

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The Atlantic surfclam (*Spisula solidissima*) fishery lands 22,000 metric tons annually, (worth $39 million), making it one of the most valuable single species commercial fisheries in the US. Since 1997, populations from southern inshore regions of the clam's range have experienced significant mortality co-incident with warm bottom water temperatures (reaching 21-24°C in September). Resulting changes in population distribution have major implications for the clam fishery. The processes

underlying this ongoing range shift are being investigated using a multi-disciplinary approach that includes an individual-based population model that simulates the growth of post-settlement surfclams. The individual-based biological model includes phenotypic variability and individual adaptation to environmental conditions. Hindcast simulations using this model reproduced observed mortality events from southern inshore regions of Virginia through New Jersey, consistent with the northward range shift. In simulations, higher temperatures decreased ingestion, caused stunted growth, reproductive failure, and eventual starvation and death. Additional simulations examining changes in population range and demographics resulting from climate warming will be discussed. Integrating predictions from the biological model with those of other disciplines (physical oceanography, economics and anthropology) will provide comprehensive guidance for a proactive approach to Atlantic surfclam management in the face of climate-driven shifts in resource distribution.

OYSTER (*CRASSOSTREA VIRGINICA*) GROWTH STUDY COMPARING FLOATING CAGES AND BOTTOM CAGES IN SOUTHEASTERN MA

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Efforts to improve shellfish aquaculture productivity include testing of gear modifications and new gear types. In recent years various methods to suspend or float oysters have been explored; these include the use of floating bags and cages. One system in particular, the OysterGro™ floating cage system (FCS), has gained popularity among many farmers seeking improved growth, enhanced fouling control, and/or relief from predation pressures such as those encountered by oyster drills (*Urosalpinx cinerea*).

This study utilizes the collaboration of shellfish farmers in the region to field test the use of the OysterGro™ floating cage system in contrast to on-bottom cage and bag systems. In 2011 six participating oyster farmers, representing six disparate growing locales, were furnished with appropriate size mesh ADPI bags to complete an array of OysterGro™ cages, as well as on-bottom cages. All participants were also given locally produced oyster seed from the same spawn to stock floating and bottom gear. Data collection visits thus far have occurred through fall 2011, spring 2012, and summer 2012 to record oyster measurements in both systems. Results indicate early oyster growth advantages at most sites in the floating cages versus the bottom cages but those differences tend to reduce during the second year at some sites.

ADZ: (Ā'DĒ'ZĒ) ACRO. [USA-NJ] – 1. A TOOL FOR SHAPING AQUACULTURE IN NEW JERSEY

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The Aquaculture Development Zone (ADZ) concept was introduced into aquaculture policy in New Jersey not long after the passage of the 1998 Aquaculture Development Act. With what was, at the time, agreed by most to be a complex regulatory path with excessive delays for the development of off-bottom shellfish aquaculture, the State proposed to obtain all required State and federal permitting on behalf of the leasees.

The concept matured and four ADZ areas were proposed in the Delaware Bay in 2005. This included two nearshore, intertidal sites and two offshore sites in the middle of the bay. The groundwork began in 2006 to survey the sites and obtain the various permits. As this work progressed, issues emerged surrounding existing regulatory framework, shorebird and horseshoe crab disturbance, updating navigational charts, Nationwide Permit 48, waterfront development permitting, archaeological artifact preservation, tidelands licensing, riparian landowner rights, water quality classification, shorefront access, and in some cases simply intolerance to change.

Through the commitment of NJDEP's Bureau of Shellfisheries, the NJDA and the Shellfisheries Council, much of the regulatory uncertainty created by these aforementioned issues have been resolved. These solutions resulted in changes and reconfigurations to the original ADZ concept. Allocation of lease tracts within the ADZs began in the spring of 2012.

The presentation will cover each of the regulatory challenges in greater detail to aid others who work in aquaculture policy development. The presentation will also cover the application requirements and discuss logistics and infrastructure of New Jersey's working waterfronts.

DOES HISTIDINE SUPPLEMENTATION PREVENT CATARACT FORMATION IN ATLANTIC COD (*GADUS MORHUA*) EXPOSED TO ELEVATED LEVELS OF DISSOLVED CARBON DIOXIDE?

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One of the challenges for commercial production of Atlantic cod (*Gadus morhua*) is the sometimes high prevalence of cataracts, which affect growth, survival, and ultimately profitability. We investigated two specific factors that have been implicated in cataract formation in farmed fish; histidine deficiency in the diet and dissolved carbon dioxide levels. Triplicate groups of cod were fed diets containing one of three histidine levels (Low = 1.7%, Mid = 2.3%, and High = 2.9% HIS as protein) and exposed to one of three carbon dioxide levels (Low = 7.00 ± 1.13ppm; Mid = 12.20 ± 0.79ppm; High = 19.66 ± 1.82ppm) in a 3x3 factorial design for 5 months. Weight (g), length (mm), cataract prevalence, and cataract severity were monitored every four weeks. Blood pH and eye pH were measured at the start, midpoint, and end of the trial. Results show that increasing CO_2 levels significantly affected growth, feed conversion, cataract prevalence, cataract severity, eye pH, and blood pH values. Histidine did not have a significant effect on any of the measured parameters in cod, which suggests that histidine does not help prevent cataract formation, as demonstrated with salmonids. Our findings implicate high dissolved carbon dioxide as a causative agent of cataract formation in Atlantic cod and suggest the optimum range for good growth and health is lower than previously recommended.

SHELLGIS: A GIS SOFTWARE TOOL FOR PREDICTING GROWTH AND ENVIRONMENTAL EFFECTS OF BIVALVE SHELLFISH ACCORDING TO SITE SELECTION AND CULTURE PRACTICE

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Hydrodynamic flow models and shellfish growth models are important elements of integrated applications helping to manage aquaculture production, including internalization of wastes within multi-trophic systems and effects of aquaculture on wider ecosystem services. However, many of these models lack a detailed representation of the hydrodynamics in and around aquaculture, whether suspended or on the bottom, thus without sufficient spatial resolution to be useful on an individual farm scale. In addition, inadequate representation of the drivers of shellfish growth, especially the detrital component of suspended particulate matter, limits the predictability of such models. ShellGIS™ is being developed as a transferable software tool which redresses previous shortcomings by integrating state-of-the-art models of flow and shellfish biology within geographic information system (GIS) that handles additional dimensions of time and depth, thereby enabling dynamic three-dimensional predictions of growth and environmental effects in bivalve shellfish at both fine (farm) and course (system) scales according to both site selection and culture practice.

INNOVATIVE MARKETING STRATEGIES

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Marketing strategies to help the small grower survive in difficult economic times will be the focus of this session. Diversification strategies including e-marketing, Community Supported Agriculture (CSA), niche marketing, farmers markets, product branding, and exporting will be discussed. Product placement, pricing, and cost-effective distribution schemes will be emphasized. Organizational structures that include vertical and horizontal integration (i.e. forming producer organizations for meeting product demand, processing specifications, distribution and/or marketing), contract growing and multi-level marketing will be covered. The goal will be to provide tactics that can reduce costs and increase profits.

ONGOING *VIBRIO* MONITORING IN DELAWARE INLAND BAYS

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The biological, chemical, and ecological status of the Delaware Inland Bays have changed dramatically in the last few decades. Increased pressure from agriculture, coastal tourism, and local populations has resulted in increased nutrient inputs into the shallow coastal bays. In addition, the constructed canals have exacerbated conditions within the Bays. Eutrophication within the bays and the resulting decline in water quality conditions have led to the Delaware Inland Bays being listed as 'impaired waters' under the Delaware 1996 Clean Water Act Section 303(d).

Recent efforts to re-establish oyster reefs in the Delaware Inland Bays have had some success but little is known about the bacteria interacting with these oysters. It is unclear whether these oysters accumulate bacteria, such as *Vibrionaceae*, as has been noted in studies of other areas. The purpose of this ongoing five year monitoring effort is to identify physical and chemical parameters, including temperature, salinity, pH, dissolved oxygen, total suspended solids, and nitrate and phosphate levels, that may affect total bacteria and *Vibrionacae* in Delaware's Inland Bays and canals. Oyster growth and mortality rates have also been examined to determine locations ideal for oyster restoration. Late summer and early fall total bacteria and *Vibrio* levels were high, with a strong relationship between both salinity and dissolved oxygen with *Vibrio* levels. Also, *Vibrio* densities in oysters spiked just after Hurricane Irene in 2011.

PROTECTIVE MEASURES FOR SHELLFISH AREA SUPPORT - EXPLORING NEW WATER QUALITY STANDARDS, WATERSHED MANAGEMENT APPROACHES, AND CLOSURE CRITERIA FOR HAWAII'S COASTAL SYSTEMS

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Hawaii's shellfish industry is gaining momentum towards state administration of a sanitation program that will manage the classification and operation of shellfish growing areas. In conjunction with that effort, we are investigating ways to assure that existing coastal water quality can be maintained and improved to facilitate growing area compliance with ambient water quality standards and shellfish sanitary requirements. However, some of the state's existing water quality criteria are antiquated and difficult to achieve in aquacultural and maricultural settings, and others may be inadequate for protecting shellfish health. Thus we strive to use new knowledge of fishpond and marine ecosystem dynamics, community food security needs, and economic opportunity as drivers for standards development, rather than as slaves to the regulatory status quo.

Efforts to repair, reconstruct, and operate shellfish grounds in Hawaii—in a traditional manner that respects native Hawaiian beliefs, values, and practices—may benefit from new modifications to the institutional framework. In order to help reshape water quality standards for shellfish grounds, we propose that industry, regulators, and communities consider four key changes: establish regulatory distinctions between coastal fishponds, shellfish grounds, and existing marine waterbody types; establish traditional and customary fishpond aquaculture, and open water shellfish production, as uses to be protected, by regulation, in certain waters of the state; develop biological monitoring and assessment methodologies for determining if shellfish uses are attained in state waters; and establish type-specific and site-specific water quality criteria to better protect coastal fishponds and shellfish grounds from point and nonpoint source pollution.

DEVELOPMENT OF A MULTIPLEX QPCR FOR THE QUANTIFICATION OF THE CAUSATIVE AGENTS OF DERMO, MSX, AND SSO DISEASES IN OYSTERS

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The protozoan parasites, *Perkinsus marinus*, *Haplosporidium nelsoni*, and *Haplosporidium costale,* causative agents of Dermo, MSX, and SSO diseases respectively, are responsible for severe mortalities in wild and farmed Eastern oysters,

Crassostreae virginica. Traditional diagnostic methods used to monitor oyster health and assess pathogen prevalence and intensity are time consuming and costly. To improve workflow and allow for high-throughput processing of oyster samples, we developed a multiplex real-time PCR (qPCR) for the simultaneous detection of all three oyster pathogens. Three hydrolysis probes were designed and tested *in silico* for specificity against *P. marinus*, *H. nelsoni*, and *H. costale*. Standard curves were prepared using genomic DNA (*P. marinus*) or plasmid DNA containing a fragment of ribosomal DNA (*H. nelsoni and H. costale*). Linear regression analysis of standard curves showed that our assay was efficient (values ranging from 93-104%) and precise (R^2 values ranging from 0.98 – 1.00). The detection limit was 10 cells/ml for *P. marinus* and 100 plasmid copies for *H. costale* and *H. nelsoni*. Genomic DNA from oysters known to have low and high levels of pathogens in the tissues as shown by histological examination was used to test the specificity and sensitivity of the assay. Results showed good concordance between histology and qPCR. Our multiplex qPCR provides an efficient and quantitative method of detecting three oyster pathogens in one single reaction. This assay will help improve implementation of management practices at oyster farm, wild, and restoration sites by providing a quick and low cost alternative to pathogen detection and quantification.

DEPLOYING A COMMERCIAL SCALE MUSSEL RAFT ON A SALMON FARM: MORE THAN JUST GROWING FISH AND MUSSELS

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Integrated multi-trophic aquaculture systems (IMTA) have been demonstrated for at least the last decade. Despite this there remain relatively few commercial IMTA operations that incorporate marine net pen fish culture with the culture of other species. Since Maine has both commercial scale salmon farms and mussel raft growers, our project attempts to integrate these two culture technologies by deploying a commercial scale mussel raft on an existing commercial salmon farm. Integrating the two existing systems is proving more challenging than expected. Some challenges such as educating salmon growers about mussel culture are relatively straightforward, while other challenges such as acquiring equipment and mussel seed pose more difficulty. This experience helps to illustrate some of the challenges associated with integrating multiple systems.

REPRODUCTIVE PATTERN AND SOME BIOLOGICAL FEATURES OF *MERETRIX CASTA* (FAMILY: VENEROIDAE) FROM PAKISTAN.

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This study is the first to describe the reproductive pattern of *M. casta* based on the histological examination of male and female gonads. The overall sex-ratio was closed to 1:1 ratio. The four stages of gonad development in females are: developing, ripe, spawned out and resorbing were identified. The female and male specimens in ripe and spawning were considered to be in spawning condition. The ripe females were present throughout the study period except, August, October, November and April. They were abundant during June and January with peak in January while their lowest value was in February. The ripe males were found in July, August October January, March and April with highest peak encountered in August. A proportion of individual was reproducing throughout the year, although there was increased spawning activity in females was observed in May, June, September to November,-04and January -05 with the highest in September to November., however, there lowest percentage was in June. While the spawned out males were encountered in five months with there maximum number was in June followed by July. No indifferent clam was found in this species

DEVELOPMENT OF SEA VEGETABLE CULTURE TECHNOLOGIES IN MAINE

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Biological integration is important to achieve environmental sustainability and multiple crops in aquaculture. We are building infrastructure in Maine to encourage use of sea vegetables in integrated polytrophic aquaculture (IMTA or IPTA) with field trials of the kelp *Saccharina latissima* on shellfish lease sites and by establishing a spore seed-stock nursery for multiple species (e.g., laver, dulse, kelps) at the Center for Cooperative Aquaculture (University of Maine, Franklin, ME). A pilot project in integrated aquaculture was initiated in December 2011 by seeding seven different shellfish lease sites from Casco Bay to Lamoine with juvenile sugar kelp plants. Information on site characteristics, growth and yield were collected throughout the growing period, and results from this pilot project will be used to inform further work in integrated systems, to build relationships between growers and potential buyers, and to encourage diversification. Our seed stock system for *Porphyra umbilicalis* was started in January 2012 from a unialgal culture from the Maine coast. Mature, spore-producing plants were produced from juveniles within 6 weeks. Net seeding with wild and laboratory raised seed stock is in progress. Seeded nets will be incubated in a recirculating fish aquaculture system, and preliminary trials show blades retain their deep reddish-brown color without any other nutrient additions. These studies should expand interest among Maine aquaculturists in sea vegetable crops for the development of a sustainable seaweed aquaculture industry in Maine.

WHAT TO DO ABOUT NITROGEN ON CAPE COD: HOW MUCH CAN LOCAL OYSTER AND QUAHOG HARVEST REMOVE?

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The negative impacts of excess nutrient loading to coastal water bodies are readily seen around Cape Cod, prompting many municipalities to explore options to reduce the amount of nitrogen impacting these waters. While land based options to reduce the amount of nitrogen reaching the marine environment are being discussed, the shellfish harvest operations common throughout this region may be another tool to augment certain nitrogen management plans. Shellfish are known to pull nutrients from the surrounding water through their feeding activity and numerous studies have documented this effect. However, quantifying nutrients such as the nitrogen accumulated in shellfish tissue for potential removal through harvest may vary by growing conditions or morphology. To obtain actual values specific to the Cape Cod region, especially for those who may consider shellfish as part of a nitrogen management plan, quahogs of wild and cultured origin, as well as oysters from the wild or of several different culture methods were collected from a number of water bodies in late spring and early fall of 2012 to be assayed for nitrogen and carbon content of the shell and soft tissue. Values will be discussed in relation to species, water body, growing method and time of year.

PUBLIC FUNDING OF SHELLFISH RESTORATION: A CASE HISTORY OF RHODE ISLAND'S LOBSTER RESTORATION PROGRAM 1898-1951.

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Aquaculture of lobsters was begun in Rhode Island in 1898 by Hermon Carey Bumpus (1862-1943) a Brown Professor and Scientific director of the U.S. Fish Commission lab in Woods Hole. Initial work began hatching eggs and rearing larvae in static tanks at a laboratory at Mill Cove, in Wickford. It was quickly discovered that the vast majority of larval losses were due to cannibalism, so that by the summer of 1899, they started culturing lobsters in buoyed canvas bags from a barge in the cove, with larvae kept in motion by hatchery workers using canoe paddles. By 1901, Brown Professor Albert D. Meade and his graduate student George H. Sherwood developed a mechanical paddle system reminiscent of an inverted ceiling fan that allowed lobster larvae in the canvas rearing bags to be kept in constant motion. The earliest lobster feeds consisted of ground fish offal and slaughterhouse by-products fed manually to the larvae. The main purpose of the state-funded hatchery was to produce Stage IV and Stage V larvae for stocking into Narragansett Bay, but they explored rearing lobsters from egg to adult. By 1906, hatchery superintendent Ernest H. Barnes demonstrated the biological feasibility of lobster culture to adult, with greatest growth rates occurring when lobsters were held in low densities. But he also discovered the life-long lobster cannibalism was a major impediment to commercial viability. Buy 1936, 1.7 million Stage IV & V lobsters were being released annually, and by 1939, Barnes was assisting Massachusetts in establishing their own lobster hatchery on Martha's Vineyard. Beginning in the mid-1930s, socio-economic changes and government reorganization in Rhode Island contributed to the decline of the hatchery program. Ultimately the failure to convincingly demonstrate that the hatchery program had any demonstrable effect on lobster fisheries led to the state discontinuing funding in 1949. The last year that the then new RI Department of Fish and Wildlife put out lobster larvae was in 1951.

USE OF MICROALGAE CONCENTRATES FOR REARING OF OYSTER LARVAE, (*CRASSOSTREA VIRGINICA*)

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Shellfish hatcheries typically use large quantities of single-cell phytoplankton (microalgae) to feed shellfish larvae. In the past, the need for algae required hatcheries to commit large square footage and equipment cost to rearing phytoplankton. Additionally, rearing algae requires significant labor cost to maintain algal cultures and equipment. The development of microalgae concentrates for feeding shellfish larvae provides the opportunity to mitigate significant capital and operating costs. The Auburn University Shellfish Laboratory (AUSL) has been using only microalgae concentrates for rearing oyster larvae, *Crassostrea virginica*, for approximately 10 years and is currently working with Reed Mariculture Inc. to develop best management practices for use of this type of product in shellfish hatcheries. This study compares the effect of three microalgae concentrate feeding protocols on the survival and growth of oyster larvae to the "eyed" stage. The feeding protocols (assigned to replicate larval rearing tanks, n=3) consisted of 1) batch feeding twice daily (existing AUSL protocol), 2) continuous feeding via peristaltic pump, and 3) continuous feeding plus ChlorAm-X™ additive for ammonia control. Survival and growth were similar among the feeding treatments across two separate trials. Survival in general ranged from 80 to 100% between tank drainings that occurred every other day. In the two trials, larvae began reaching the "eyed" stage in 14 days and 10 days, respectively. Though not significantly different, there was a tendency for the treatment with the ChlorAm-X™ addition to produce more harvestable "eyed" larvae. Current best management recommendations will be presented.

MOVING FORWARD WITH INTEGRATED MULTI-TROPHIC AQUACULTURE AS PART OF A SUSTAINABLE DEVELOPMENT PLAN FOR REGIONAL COASTAL ZONE DEVELOPMENT

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The coastal marine environment is under constant development from various anthropogenic sources including: development of the coastal shoreline for human habitation, wild harvest fisheries, aquaculture, extraction of natural resources and recreational uses of the waterfront for tourism and generally "wasting time" in boats and boots. These seemingly disparate activities all have a common effect; they impact on processes within the natural ecosystem. The silo-nature of these activities makes coastal zone management efforts difficult for those individuals that attempt the challenge. Part of the reason for that difficulty may be the lack of a unifying concept that the parties can buy into.

One unifying concept we are studying for the aquaculture industry is Integrated Multi-Trophic Aquaculture (IMTA), an ecological engineering technique based on the concept of recycling nutrients from a fed trophic level through extractive trophic levels where nutrients are converted, accumulated and removed from the ecosystem. This results in less nutrient loading than the *status quo*, higher economic returns and more socially acceptable forms of aquaculture. While not a panacea for all ills, it does create a new paradigm for the industry where the participants are required to be more aware of the ecological interactions occurring and the fact that excess nutrients generated are more of a resource than a waste product. This approach is gaining acceptance worldwide and may have the potential to bridge the wild harvest and aquaculture industries in coastal communities creating a more unified and sustainable coastal zone for the production of seafood.

BIOFOULING ASCIDIANS ON AQUACULTURE GEAR AS POTENTIAL VECTORS OF HARMFUL ALGAL INTRODUCTIONS

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Biofouling ascidians are ubiquitous in coastal ecosystems and are among the main colonizers of aquaculture gear. Our study tested the hypothesis that the transport, removal, and transfer of fouling ascidian species by aquaculturists provide a mechanism for concentration and distribution of harmful-algal cells to new areas. Wild-caught specimens of common, biofouling ascidian species (*Styela clava*, *Ciona intestinalis, Molgula manhattensis, Bottryloides violaceus, Didemnum vexillum,* and *Botryllus schlosseri*) were exposed individually to cultured strains of co-occuring harmful algae (*Prorocentrum minimum, Alexandrium fundyense, Alexandrium monilatum, Karenia brevis, Aureococcus anophagefferens,* or *Heterosigma akashiwo*) at simulated bloom cell densities of each HAB species. After feeding, ascidians were transferred to ultrafiltered seawater. Immediately after exposure, and after 24 and 48 h in ultrafiltered seawater, biodeposits were collected and observed microscopically for the presence of intact, potentially-viable cells. Subsamples of biodeposits were transferred into culture tubes with ultrafiltered seawater and monitored for algal growth during 8 weeks. Cells of all HAB species were found to pass intact through the ascidian digestive system, remained viable, and in many cases were capable of re-establishing populations at least 48 h post-ingestion. The results of our study will inform industry and managers as to the potential threat and ecological impact of spreading biofouling ascidians, and practices to mitigate adverse impacts. Additionally, these management practices have been formally incorporated into a new cost-share program developed to help shellfish producers implement management practices to prevent the further spread of ascidians and associated HAB species.

THE COLONIZATION OF MARINE ORGANISMS RELATED TO A MULTI-FUNCTIONAL, ARTIFICIAL REEF DESIGNED FOR THE AMERICAN LOBSTER (*HOMARUS AMERICANUS*)

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In the recent past, American lobster landings in Maine have been increasing with every year. The lobster fishery is by far the most valuable fishery in the state and is accountable for 80 percent of U.S. commercial landings. In an effort to support the sustainability of this fishery, Habitat Mooring Systems™ designed a multifunctional artificial reef, which serves as both a marine mooring system and as a potential lobster habitat. The purpose of this project is to test the design of this system on its effectiveness to encourage the colonization of vertebrate and invertebrate species, with a focus on providing habitat for the American lobster, *Homarus americanus*. The success of these habitats in increasing biodiversity around each mooring is assessed through the use of self-contained underwater breathing apparatus (SCUBA). The biodiversity of the habitat

mooring system versus a traditional granite mooring is compared at two locations: Sand Cove, South Bristol, Maine and Seal Harbor, Mount Desert Island, Maine. Abundance and species of all vertebrate, invertebrate, and vegetative colonization observed on each mooring is being recorded, as well as the size and sex of all lobsters. Preliminary data suggests that the habitat mooring is a highly favorable environment for marine organisms. Overall, we expect the habitat mooring will have a higher biological diversity and lobster density than the traditional mooring. This new mooring design could possibly help alleviate the negative ecological impact of current mooring use while encouraging the sustainability of the lobster fishery.

A LAND-BASED INTEGRATED MULTI-TROPHIC AQUACULTURE SYSTEM: DESIGN AND INITIAL START-UP

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Integrated multi-trophic aquaculture (IMTA) is typically associated with open water aquaculture. IMTA is distinguished from traditional polyculture in that the species being cultured do not share the same living space, but rather requires the transport of nutrients between fed and extractive species. In an IMTA system, extractive species provide biomitigating functions for the waste generated by the fed species, thereby reducing nutrient pollution. Closed recirculating aquaculture systems (RAS) provide a level of control of nutrient discharge unavailable in most other aquaculture systems. A logical advancement in RAS design is the adaptation of the IMTA scheme whereby the nutritive waste stream produces additional crops rather than being discharged. Typical land-based IMTA (LB-IMTA) systems have used a single-loop serial flow regime whereby all of the culture water flows to each culture species with ammonia reduction accomplished through plant culture. This design presents potential difficulties for integration. For instance, waste water with high ammonia concentrations is delivered to organisms in the extractive culture component, likely reducing productivity. Solids move through the plant culture component, which may cause fouling, and full water flow potentially reduces nitrogen uptake efficiency by the plants. The design and initial prototype start-up for a new concept in LB-IMTA being investigated by researchers at HBOI-FAU will be presented. The major design difference is the use of a centralized filtration system that delivers controlled volumes of selected pretreated waste streams to each system component, which potentially resolves water quality and flow distribution issues related to a single-loop closed system IMTA design.

OYSTER COMPONENT OF A LAND-BASED INTEGRATED MULTI-TROPHIC AQUACULTURE SYSTEM

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The objective of this study was to determine the ability of the American oyster *Crassostrea virginica* to remove and utilize fine suspended solids (FSS, ≤40 μm) produced by a fed-component of the prototype HBOI-FAU land-based integrated multi-trophic aquaculture (LB-IMTA) system. A series of experiments were conducted with juvenile oysters (~20 mm shell height) exposed in 15L seawater to FSS (~3 mg/L) from a surrogate system, a microalgae control (~6 mg/L), or no FSS. Results of these static-tank experiments were mixed as FSS increased unexpectedly (potentially fecal material) in some treatments. Therefore, a two week growth experiment was conducted using ten oysters (mean wt = 1.7 g) in triplicate tanks of 15L seawater changed daily with 100% FSS water, 50% FSS water, 100% microalgae, 50% microalgae, 50% FSS water + 50% microalgae, or 1-μm filtered seawater (i.e., no food control). After two weeks, the 100% microalgae treatment had the greatest mean weight gain (33.8%), followed by the 50% FSS + 50% microalgae treatment (27.6%), 50% microalgae treatment (20.4%), 50% FSS treatment (2.4%), 100% FSS treatment (2.2%), and no food treatment (1.1%). These data indicate that FSS alone is not sufficient for oyster growth, although there may be interactions when paired with microalgae or with greater water volume as in the LB-IMTA. Oysters (n=500 in duplicate) in the prototype LB-IMTA system for 30-days increased in volume 23.8%. Other components (e.g., microalgae, bacteria) in the waste stream of the prototype system need to be characterized to assist in determining food value to oysters.

BOSTON HARBOR SOFTSHELL CLAM (*MYA ARENARIA*) ENHANCEMENT

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Since 2006, The Massachusetts Division of Marine Fisheries *(MarineFisheries)* has been collaborating with a broad base of partners to restore Boston Harbor clam beds decimated by poor recruitment, disease, habitat degradation, and overfishing. The main goal of the project is to enhance populations of soft shell clams in Boston Harbor through cooperative programs with local municipalities, industry, volunteers, and the Northeast Massachusetts Aquaculture Center. *MarineFisheries* and its partners began the project on a pilot scale and gradually expanded as the team gained familiarity with the technology and processes of softshell clam aquaculture. Adaptive restoration methods have been developed to fit the specific coastal regions of Boston Harbor with special considerations made to protect public health and ensure success across a wide range of site characteristics. To date, approximately 7 million clams have been planted at over 35 restoration sites throughout Boston Harbor. *MarineFisheries* has been monitoring clam growth and the long term survival of restoration sites 35 as well as the economic impact of enhancement activities.

WILL CLIMATE CHANGE ALTER THE PREVALENCE OF PATHOGENS OF THE BLUE CRAB (*CALLINECTES SAPIDUS*) IN THE NORTHEAST USA?

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Ongoing climate is already warming southern New England waters, whose temperature by 2100 may resemble the current mid-Atlantic coastal zone. Accordingly, there is anecdotal evidence of an expansion of blue crab (*Callinectes sapidus*) populations from Delaware to Massachusetts. It is of interest whether this range expansion will be mirrored by an expansion of blue crab pathogens. A coalition of academic, state and federal partners is collaborating to assess disease prevalence in blue crabs from between Delaware Bay and the south shore of Massachusetts. Using quantitative molecular (qPCR) methods, crabs collected at 5 stations are being tested for two lethal crab diseases that are exacerbated by high temperatures: *Hematodinium perezi* is a protozoan that affects crabs in coastal bays of the Southeast, and CsRV is a reovirus recently discovered to be prevalent in captive crabs. Initial analyses indicate that *H. perezi* is present at least as far north as Barnegat Bay, New Jersey, and CsRV virus as far north as Long Island, New York. There is a critical data gap on crab abundance in the Northeast, even as recreational and commercial harvests grow. Crab population data would be helpful in understanding the geographic distribution and possible changes in disease prevalence, and is crucial for development of recreational and commercial fishery regulations. The field and laboratory science that this project involves is excellent for training students in skills and approaches needed in coming decades, and may provide opportunities for collaborations to establish a multi-year crab and disease survey.

SHELLFISH AQUACULTURE, RESTORATION, AND HARMFUL ALGAL BLOOMS: A REALITY CHECK

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Shellfish aquaculture and restoration continue to expand globally, as do eutrophication and harmful algal blooms. Molluscan shellfish are among the most important of ecosystem engineers and providers of ecosystem services. As such, restoration and aquaculture are both increasingly touted as means of habitat restoration, and as potential sources of mitigation for coastal degradation including eutrophication and erosion. At some scales, shellfish restoration and establishment of sustainable molluscan shellfish aquaculture operations can mitigate effects of coastal development and eutrophication; however, the expectations and publicity are reaching unrealistic levels. Harmful algal blooms impact coastal resources globally and their impacts can be devastating to local economies and environments. In addition, the impacts of harmful algae on shellfish are highly species-specific and critical data regarding impacts of these toxic algae on critical life stages of the shellfish, and which will impact the potential for success of any restoration effort in the long term, are lacking. This presentation will open

a discussion of the realistic expectations that could result from exploitation of bivalve molluscs, whether in restored reefs or in aquaculture farms, as long-term ecosystem engineers and mitigators of coastal degradation, and discuss the importance of strong and meaningful collaboration between scientists and industry.

ICHTHYOPHONUS SPECIES EFFECTS ON YELLOWTAIL FLOUNDER IN SPECIAL ACCESS AREAS ON GEORGES BANK

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Required reductions in yellowtail flounder, [*Limanda ferruginea*], bycatch due to low stock abundance severely limits the catch of other fished species, including sea scallops. While conducting experiments on scallop dredges modified to eliminate yellowtail bycatch, Coonamessett Farm Foundation researchers noted significant numbers of yellowtail with multifocal, 2 to 5 mm, white/tan nodules in the parenchyma of the liver, mesentery and other organs. Histologically, most of these nodules were caused by infection with [Ichthyophonus] species organisms. Infection with [Ichthyophonus] sp. can be considered an incidental finding, but when noted in large numbers and/or in prey species of fish, such as herring, they can cause morbidity and mortality. The low stock abundance of yellowtail has not been associated with any known sources of high fishing mortality. It is possible one reason for the lack of population increase, even with the conservation efforts, is morbidity and mortality associated with this chronic disease.

EVALUATION OF THE EFFICACY OF TWO PROBIOTIC STRAINS IN AN OYSTER HATCHERY

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Vibriosis is a major disease affecting larval Eastern oysters, *Crassostrea virginica,* which could lead to shortages in the supply of oyster seed for the industry when oyster hatcheries are impacted. Probiotics are one of the tools available to manage the impact of bacterial disease in shellfish and finfish hatcheries. The objective of this study was to evaluate the effect of two candidate probiotics previously characterized in our laboratories, *Phaeobacter* sp. S4 and *Bacillus* sp. RI06-95, on the growth and survival of oyster larvae in a shellfish hatchery.

Larval oysters (80 - 300 microns in size) maintained in triplicate (trial 1) or quadruplicate (trial 2) 100L conical tanks per treatment in static conditions were treated every other day (trial 1) or daily (trial 2) with 10^4 cfu per ml of probiotics (S4, RI, or a mix of S4 and RI) or no probiotic (control). Tanks were drained every other day to evaluate larval growth and survival. Samples of water, tank surfaces, and oysters were taken from each tank at selected time points for evaluation of levels of total vibrios (colony counts on TCBS) and probiotics (counts on selective media). Samples of larvae (about 200) from each tank were collected, placed in wells of a multi-well plate, and exposed to 10^5 cfu/ml of *Vibrio tubiashii* (RE22) for 24 - 48 hours for evaluation of the impact of probiotic treatment on larval survival to bacterial challenge.

Exposure of oyster larvae to *Phaeobacter* sp. S4 and *Bacillus* sp. RI06-95 in the hatchery resulted in a significant decrease in the levels of total vibrio in water (i.e. 4.59×10^3 cells/ml for control and 1.67×10^1 cells/ml for S4, $P = 0.002$), tank surfaces (8.18×10^4 cells/ml for control and 2.78×10^2 cells/ml for S4, $P = 0.011$), but not in oysters ($P > 0.05$). Exposure to probiotics did not lead to significant changes in the growth or survival of larval oysters in the hatchery, but significantly improved survival of larval oysters exposed to bacterial challenge (i.e. from 50 – 70% survival for larvae exposed to probiotics compared to 33% in control larvae, $p<0.05$). These results suggest that *Phaeobacter* sp. S4 and *Bacillus* sp. RI06-95 are good candidates for use as a probiotic in shellfish hatcheries.

OPTIMIZATION OF PRODUCTIVITY BY THE CO_2 INJECTION FOR *GRACILARIA TIKVAHIAE* NURSERY SYSTEMS

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The productivity of *Gracilaria tikivahiae* was studied in von Stosch's enriched (VSE) seawater at two different stocking densities (0.5 $g \cdot L^{-1}$ and 10 $g \cdot L^{-1}$), two different light levels (100 $\mu mol \cdot m^{-2} \cdot s^{-1}$ and 250 $\mu mol \cdot m^{-2} \cdot s^{-1}$), and in the presence or absence of CO_2 injection. When CO_2 was added, the pH was regulated in the range of 8.0±0.2. The growth rates of *G. tikivahiae* were affected by CO_2 injection most significantly at the high irradiance (250 $\mu mol \cdot m^{-2} \cdot s^{-1}$) and at high stocking density (10 $g \cdot L^{-1}$). Cultures with CO_2 injection had an average growth rate of 8.1 % $FW \cdot d^{-1}$ versus ones without any CO_2 injection had an average growth rate of 2.8 % $FW \cdot d^{-1}$. *Gracilaria* at the low stocking density was not significantly affected by CO_2 injection. These cultures had higher growth rates of 18.3 % $FW \cdot d^{-1}$ with CO_2 injection and 17.8 % $FW \cdot d^{-1}$ without CO_2 injection at 250 $\mu mol \cdot m^{-2} \cdot s^{-1}$. However, at the high stocking density, the productivity of *G. tikivahiae* was the highest (1.10 g $FW \cdot L^{-1} \cdot d^{-1}$) at 250 $\mu mol \cdot m^{-2} \cdot s^{-1}$ with CO_2, while the productivity without CO_2 addition remained at 0.31 g $FW \cdot L^{-1} \cdot d^{-1}$. The productivity at lower stocking density was even lower, 0.19 g $FW \cdot L^{-1} \cdot d^{-1}$ with and without CO_2 addition. These results suggest that CO_2 addition could be an effective and useful way to maximize productivity in *G. tikivahiae* nursery systems.

GENETIC APPLICATIONS FOR SHELLFISH RESTORATION

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Genetic technology is being investigated to determine various applications for restoration of economically valuable bivalve mollusk populations which have declined, such as oysters, clams and scallops. These bivalves also are ecologically significant as filter feeders in recycling organic material which improves water quality in ecosystems. One area where genetics can make a significant contribution is in understanding and assessing diversity. Another area involves understanding how populations respond to environmental and habitat changes with regard to reproduction, recruitment and other stock characteristics. A multifaceted approach is being explored encompassing breeding, population genetics or molecular technology and performance trials. For example, selective breeding is underway for bay scallops to improve growth and survival. Results from a long-term multi-generational study indicate a positive response overall to selection for growth. Other technology includes molecular approaches which have shown mtDNA polymorphisms and genetic diversity in bay scallops from Northeastern U.S. populations used in reseeding efforts for stock enhancement and restoration. In addition, a phenotypic shell marker of striped shells is being employed successfully to identify, distinguish and monitor stocks transplanted for restoration. Experiments also have been conducted on chromosomal manipulation for the induction of triploidy and tetraploidy to induce sterility and increase growth rate. Other genetic applications include hybridization and induction of transgenesis for improving traits. Results from such studies with some commercial species can have implications for other bivalves in restoration efforts.

DEVELOPING USE AND INTERPRETATIONS FOR SUBAQUEOUS SOIL MAPS – SOIL PH MAY HAVE IMPLICATIONS FOR INFAUNAL BIVALVE RESTORATION AND AQUACULTURE SITE SELECTION

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As global atmospheric CO_2 concentrations increase, the partial pressure of CO_2 in the ocean surface also increases, lowering the surface ocean pH and calcium ion saturation. Under existing CO_2 emission projections, the ocean surface pH is estimated to decline up to 0.35 units in the 21 century. Several recent studies have documented physiological stress, declines in growth, and reduced survival of several infaunal bivalve species under such projections.

Estuarine and coastal systems experience greater variation in pH when compared to the open ocean. In addition to atmospheric CO_2, freshwater inputs, nutrient enrichment, organic matter decomposition, and sulfide oxidation also contribute to declines in pH within coastal systems. Existing measured pH values within coastal systems can be well below projected

open ocean pH. Therefore, calcifying organisms within coastal systems are currently subject to pH and calcium saturation states that increase physiological stress leading to reduced growth, shell dissolution, and increased mortality.

In-situ measurements of pore-water pH within the upper 5-cm of mapped subaqueous soils in southern Rhode Island are highly variable based on soil type, and can be 100 times more acidic than preferred ranges for infaunal bivalves. Growth rates and condition of infaunal bivalves may be greater at sites with soils that have optimal pH ranges. Subaqueous soil maps that provide spatial information on pH and calcium ion saturation states may be useful for prioritizing sites for restoration and aquaculture.

SOIL SCIENCE AND OYSTER AQUACULTURE IN RHODE ISLAND – SUBAQUEOUS SOIL MAPS AS A TOOL FOR SPATIAL PLANNING

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For over a decade, soil scientists have been mapping estuarine habitats throughout Rhode Island as subaqueous soils. These subaqueous soil maps incorporate USDA-NRCS soil mapping and characterization standards to stratify coastal estuaries into dominant soil landscapes. The soils approach to classify shallow subtidal-habitats is now recommended in the national Classification of Marine and Estuarine Standards (CMECS) when use and management interpretations are the goal.

Since 2008, the Laboratory of Pedology and Soil Environmental Science at URI has been conducting field experiments to test the effect of soil type on the growth rates and survival of eastern oysters [*Crassostrea virginica*] within coastal lagoons and embayments. These experiments are revealing significant differences in growth rates and survival among soil landscapes, indicating that soil landscapes are important when considering economic return associated with aquaculture development.

Oyster aquaculture within the state of Rhode Island is expanding, and has proven to be an economically viable alternative to wild oyster harvest. In 2011, Rhode Island aquaculturists produced over 4 million oysters, valued at nearly $2.5 million dollars, or over $17,000 per acre under production. A majority of these farms are located on a select few soil landscapes demonstrating the high ecological and economic value of these soils. Given the increasing use of the coastal zone, and the associated anthropogenic stressors to coastal habitats, further characterization and study of these soil landscapes will provide managers with a valuable suite of tools for spatial planning and resource utilization from ecological and economic perspectives.

STATUS OF OYSTER DISEASES IN CONNECTICUT

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The population size of eastern oysters, [*Crassostrea virginica*], which directly effects the market harvest in Connecticut, depends principally on two biological factors; input of juvenile oysters via annual spatfalls and output through mortality caused by a protozoan parasite, [*Haplosporidium nelsoni*], the causative agent of MSX-disease. A major MSX-epizootic in 1997, with an average prevalence of 47%, caused significant mortalities in oysters and the consequent lag in successful commercial sets for several years until 2004 caused persistent low production. The next, smaller, MSX-epizootics occurred in 2009 when the average prevalence of [*H. nelsoni*] along CT's shoreline was 22%. Prevalences up to 53% were recorded and heavy mortalities were observed at some shellfish leases. However, the exceptionally abundant oyster sets of 2008 and 2010 provided new oyster stock to replace those lost to MSX-associated mortalities. [*Perkinsus marinus*], the oyster pathogen causing Dermo-disease, is present with high-prevalence, low-intensity infection in CT. The intensity of infection, which increases annually as the oysters age, does not cause significant mortalities in market size oysters (3 to 4 year-old), but may cause mortalities in older oysters in non-harvest areas. In agreement with reports from other East Coast estuaries, the decreasing long term trend in MSX-prevalences in CT demonstrates the evolutionary force of continuous MSX-disease pressure toward increased disease resistance in the natural oyster population.

HURRICANES AND HATCHERIES: PLANNING FOR THE WORST, HOPING FOR THE BEST

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It is necessary to locate shellfish hatcheries near sources of superior coastal water quality. This, however, also exposes hatcheries, staff and investments to increased risk of tropical cyclones in the Atlantic and Gulf regions. Climate change is real and the predicted increase in future hurricane strength and frequency is real as well.

Thoughtful hatchery design, construction, and operation can help reduce repetitive loss of equipment and supplies to tropical cyclones, while also reducing lost time in shutdown and restart of operations. Response to 16 tropical cyclones over 23 years at the Sea Grant Oyster Hatchery on Grand Isle, Louisiana is a useful summary to demonstrate practical applications in hurricane preparedness, response and recovery, including planning, execution, and evaluation. Post disaster interaction with federal and state emergency management agencies is challenging and vital to successful recovery.

PRELIMINARY INVESTIGATIONS INTO THE POTENTIAL OF CULTURING SEAWEEDS ON MARTHA'S VINEYARD

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In recent decades, the water quality in the Island's ponds has declined significantly and resulted in a damaged local marine ecosystem, compromised marine habitats and a decline in fish and shellfish populations. Recent results from studies conducted under the Massachusetts Estuaries Program ((MEP) in Lagoon Pond confirm that the major cause for this environmental decline is nutrient enrichment in the form of excess nitrogen entering the ponds primarily from residential septic systems. Initial steps have begun to investigate the potential of culturing seaweeds (macroalgae) to help reduce the nitrogen.

Specifically, efforts have begun to grow a local (*Aghardiella sp*.) vegetatively from cuttings during the summer and sugar kelp, (*Laminaria saccharina*), on rope lines seeded with young sporophytes during the winter. Our initial culture attempts have identified the following obstacles: need for a culture permit policy; requirement to produce sporophytes from local brood stock; need to easily access local populations for both vegetative cuttings and spores; need for better methods to secure cuttings to growing ropes, and excessive biofouling on cultures. Despite these difficulties, local consumer interest for an edible local seaweed product is high, and is reason enough to forge ahead with the culture efforts.

IMMUNOLOGY OF RED ABALONE (*HALIOTIS RUFESCENS*) FOR AQUACULTURE

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The red abalone *Haliotis rufescens* is the largest species of the 20 commercially important abalone species fished, cultured, and consumed around the world. This species is susceptible to disease issues such as Withering Foot Syndrome both in aquaculture and wild settings that can rapidly diminish populations. In order to improve husbandry techniques including prevention and treatment of disease a clear understanding of abalone immunology is needed.

The defense mechanisms of this marine gastropod against pathogens are still in the early stages of understanding. It is currently believed that abalone like most other invertebrates do not produce antibodies; therefore they would not have adaptive immune response to repeated infections. This study is of innate cellular and humoral factors of the red abalone. It is an initial attempt to establish baseline parameters of healthy abalone. These parameters are all components of the abalone hemolymph, blood equivalent, which can be collected non-destructively. The number, type, and phagocytic activity of circulating hemocytes, hemolymph cells, along with the presence of the bacteria rupturing enzyme lysozyme are the parameters being examined in this initial test. If consistent ranges for each of these immune factors can be established in healthy abalone a rapid diagnostic evaluation of animal health can be developed.

Preliminary results from this study show that the hemocytes range between 2.19 x 10^6 and 1.26 x 10^7 cells/ml. 6-36% of adherent cells demonstrated phagocytic ability upon latex beads. The hemolymph lysozyme ranged from not detectable to less than 100 units/ml.

SUCCESSFUL AQUACULTURE OF ORNAMENTAL ELASMOBRANCHS IN CAPTIVITY

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Ornamental elasmobranchs are popular additions to saltwater aquariums. These tanks are housed in restaurants, pet stores, public settings such as Universities, and in private homes. Many Oceanographic facilities across the world maintain ornamental elasmobranchs on display for visitors to view. Although popular, elasmobranchs can be difficult to obtain and maintain as they are more sensitive to external changes than teleosts. Popular ornamental elasmobranchs include Whitespotted Bambooshark (*Chiloscyllium plagiosum*), Brownbanded Bamboo Sharks (*Chiloscyllium punctatum*), Epaulette Sharks (*Hemiscyllium ocellatum*), and Coral Catsharks (*Atelomycterus marmoratus*). Specimens produced by aquaculture, which are available, are preferred to ensure that they are not removed from wild populations. Fishing regulations for these species are heavily enforced, there have been offenders prosecuted for being in possession of undersized individuals obtained for the purpose of selling them for ornamental aquariums. Elasmobranchs must be maintained in closely monitored and managed systems. Temperature and salinity changes may stress elasmobranchs, potentially altering their behavior and feeding patterns. Acute or prolonged stress may lead to death. Another problem faced is the refusal by many sharks in aquarium settings to ingest pelleted feed. A readily available supply of fresh or frozen mollusks, finfish, and crustaceans is essential to ensure good ingestion and nutrition. Another often overlooked concern is the compatibility of species in the tank. When larger sharks are placed into a tank with smaller species, they may view their tank mates as potential food sources. Animals of the same relative size should be housed in the aquarium.

REBUILDING BAY SCALLOP POPULATIONS AND FISHERIES IN THE PECONIC BAYS, LONG ISLAND, NEW YORK

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Bay scallops (*Argopecten irradians irradians*) in the Peconic Bays of eastern Long Island, New York were decimated by 'brown tide' algal blooms from 1985-1995. Scallop populations did not recover on their own over the next 11 years and commercial fishery landings remained at 1-2% of historical levels. We hypothesized that populations were recruitment limited and, starting in 2006, initiated an intensive restoration program to jump-start populations by planting >5 million hatchery-reared scallops at high densities, in lantern nets or directly to the bottom, to ensure a high probability of fertilization of spawned eggs. In the 6 years following restoration, compared to the 2 years prior, we have documented increases in larval recruitment and benthic juvenile and spawning adult populations of >75x, >120x and 14x higher, respectively, in Orient Harbor – where we have focused our restoration efforts. Populations are now rebuilding throughout the Peconic bays and commercial scallop landings in 2010 were >13x greater than mean annual harvests recorded from 1996-2007. Increased revenues resulting from higher commercial harvests have now exceeded the total spent on our restoration efforts.

A GUIDE TO DETERMINING HISTORICAL CLIMATE AND HABITAT INDICATORS FROM MARINE RESOURCE ABUNDANCE

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Native Americans may have left a record of past environmental conditions - an "environmental history" based upon seafood remains in disposal pits and refuse. Shell middens have long been a source of rich and reliable information for dietary preference and seasonal use. Examination of middens for species and especially bivalve shell condition may provide clues for environmental habitat histories. Two of the largest indicators for habitat quality appear to be climate (temperature) and energy (storms).

Temperature and energy pathways can change habitat quality and record changes in species dominance. For example, colder storm filled periods in southern New England provided a habitat suitability index that favored bay scallops (*Argopecten irradians*) and less for the soft shell clam (*Mya arenaria)*. The hard clam (*Mercenaria Mercenaria)* has widespread and intense natural sets after hurricanes, and oysters (*Crassostrea virginica*) sets follow stormy periods with higher temperatures. Razor clam (*Ensis directus)* populations follow long periods of intense heat and few storms.

A review of past archaeological examinations highlighting the presence of bivalve shell may indicate past habitat suitability. In addition, characteristics shell shape, growth patterns, relative abundance and age provide aqua culturists a look at previous site specific habitat conditions.

Shell middens may have left a habitat history reflecting climate changes spanning centuries here in New England and in other parts of the United States as well. These key habitat parameters will assist aqua culturists with species selection and guide possible shellfish restoration efforts.

CLIMATE INDUCED ACIDIFICATION OF MAINE SOILS AND IMPACTS UPON THE NEW ENGLAND HISTORICAL SOFT SHELL CLAM (*MYA ARENARIA*) AND HARD SHELL CLAM (*MERCENARA MERCENARIA*) SHELLFISHERIES

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As New England's summer temperatures moderated in the late 1870s, a time when New England residents were worried about the possible return of glaciers, storms raked the coast as extreme cold and hot periods created climate instability. Then the powerful storms ceased and temperatures increased.

One of the first indicators of changed marine soil conditions was seen in the soft shell clam (Mya arenaria) fishery. A small community in Cape Cod, Chatham, was perhaps the most exposed coast to the Atlantic Ocean's energy pathway. As summers warmed, the soft shell clam populations were immense in its recently cultivated, and therefore alkaline, bay and cove marine soils. Chatham's soft shell clam fisheries soared, and the area would soon become a leading soft shell clam producer.

As the heat intensified, marine vegetation, especially eelgrass (Zostera marina), grew to immense densities and formed meadows which extended out off the Cape to the depth up to ninety feet. As sea grasses grew in the intensifying heat, flushing rates in near-shore areas decreased, organic matter filled soil spaces, and these sub-tidal marine soils acidified. Although the industry was blamed (over-harvesting was often stated), the fact was it was a climate-induced habitat failure as marine soils acidified and became unsuitable for clam sets.

Today, a century later, the shellfish industry again is witnessing acidification of marine soils after a similar prolonged period of high heat and low energy (storms).

Climate and energy pathways have huge implications for shellfish aquaculture industries worldwide.

POTENTIAL OF WHITE WORMS *ENCHYTRAEUS ALBIDUS* AS A COMPONENT FOR AQUACULTURE AND STOCK ENHANCEMENT FEEDS

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The increased use of invertebrates in formulated fish diets may lessen the demand for fish species used to produce aquaculture feeds. Large-scale production of white worms, *Enchytraeus albidus*, may be valuable for stock enhancement, as well as for aquarium, laboratory and personal maintenance of fishes. White worms are an intertidal oligochaete with high

protein and lipid but low mineral content. White worm cultivation was developed in the USSR in the 1940s. Studies on the biology, nutrition and cultivation are reported in a number of Russian publications, but few are available to English-speaking audiences. The reviews that exist describe the production of 100-500 kg of worms for feeding juvenile sturgeon. To our knowledge, production on this scale has never been attempted in the US. Our objectives are to describe the potential of white worms for aquaculture and stock enhancement feeds and to present preliminary work we have conducted rearing white worms for hatchery-reared juvenile winter flounder. The potential economic benefits for commercial aquaculture might include incorporation into formulated diets or development of alternative diets. The mass culture of invertebrates as advanced live diets for marine stock enhancement may increase stocking effectiveness, survival and recruitment of released fish, translating to higher landings for fishermen and an economic boost for fishing communities. Identification of live diets (and formulated feed components) that are reared and harvested easily, thrive with minimal maintenance, and survive in salt/brackish water for prolonged periods also may decrease overall feed costs by reducing feed waste and water quality maintenance.

EFFECTS OF PLOIDY AND GEAR ON THE PERFORMANCE OF FARMED OYSTERS

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In 2011 at a commercial oyster farm in Grand Bay, Alabama, we conducted an experimental field test of ploidy (triploids and half-sibling diploids) and gear type (LowPro bottom cages, adjustable long-line baskets, floating cages and floating bags) as two potentially interacting means of improving performance. Eastern oysters, *Crassostrea virginica*, were deployed in the four gear types from May 5 to October 11 (166 days), with replicate bags of each ploidy assigned to each gear type ($n \geq 3$). Survival was equivalent between ploidies, but differed significantly among gear types with poor survival in the bottom. Triploids grew better than diploids for almost all metrics. Among gear types, growth was poorest in the bottom cages. For dry tissue weight, there was a significant ploidy by gear interaction; within floating bags, there was no difference between triploids and diploids, but triploids had higher dry tissue weight than the diploids in all other gear types. Triploids had significantly higher cup ratios than diploids. For condition index, there was no clear effect of ploidy in the August sample. In October, however, triploid condition index exceeded the diploid condition index. Finally, there was no significant effect of gear or ploidy on the abundances of the two *Vibrio* spp. assessed, but there was a tendency for these abundances to be lower in triploids than diploids. We suggest that oyster farmers could expect to benefit from raising triploid oysters, but that the magnitude of these benefits will depend on the type of gear selected.

SUBTIDAL OYSTER AQUACULTURE: CREATING SAFE AND EFFICIENT PRODUCTION TECHNIQUES THROUGH TECHNOLOGICAL INNOVATION

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The rapidly expanding oyster aquaculture industry in the Northeast requires that farmers move farther out from intertidal areas, and into deeper subtidal waters. In Falmouth, MA all new leases (and 5 out of the current 6 leases) are located in subtidal waters. This requires either great investment to buy a boat capable of lifting the heavy cages and oysters out of the water, or utilizing SCUBA to bring the oysters to the surface. Both of these methods can are inefficient, expensive, labor intensive, as well as dangerous. A new way to bring cages to the surface was designed, using air to lift the cages instead of using SCUBA or a hauler to drag them out of the water. Using air to lift the cages is safer and less labor intensive than SCUBA, and less expensive than using a larger boat and getting a mooring. Other than the added material costs to build the cages, the only additional equipment a farmer needs is an air compressor and tank to be able to work their farm in a safer and more efficient method. Subtidal aquaculture shellfish farmers also need a method to keep their small juvenile oysters predator free, and supplied with food similar to the “upweller” technique utilized by inshore farmers. Through a novel “bottom-upweller” technique utilizing the same principle, farmers can keep their immature shellfish free from predators while they grow quickly and increase the amount of food passing by the juvenile oysters, while complying with current regulations.

THE OYSTER RESTORATON RESEARCH PARTNERSHIP 2010-2012: INITIATION OF A LONG-TERM PROGRAM TO RESTORE OYSTER POPULATIONS IN THE NEW YORK HARBOR REGION

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The Hudson River Foundation, New York/New Jersey Baykeeper, US Army Corps of Engineers, University of New Hampshire, and other partners initiated in 2010 an Oyster Restoration Research Partnership (ORRP) to investigate appropriate methods and locations in restoring native eastern oyster (*Crassostrea virginica*) populations to the New York Harbor region. Restoration of oysters is a major component in the Hudson-Raritan Estuary Comprehensive Restoration Plan which calls for 20 acres of new oyster reef habitat by 2020 and 200 acres of established reef habitat by 2050. The major focus of the program is on ecosystem services by the oyster reefs rather than human harvest and consumption. Five small experimental reefs (each $30m^2$) consisting of a rock base overlain with surf clam shell then 'seeded' with juvenile oyster spat on shell (SOS) were constructed in fall 2010, and monitored during 2010, 2011 and 2012. Throughout the duration of the project only one of the five constructed reefs showed consistent SOS survival and growth, natural spat recruitment, and adequate retention of SOS on reef area. The remaining four reefs were affected by either sedimentation, SOS transport off reef or unusually low salinity levels. Ultimately, the Governor's Island reef will act as an educational platform for Harbor School dive and aquaculture classes. Phase II of the project seeks to expand the site that has shown the most promise to become a self-sustaining oyster reef. The site located at the confluence of the Bronx and East Rivers (Soundview Park) will be expanded to 0.5 acre reef area.

HEALTH HAZARDS AND ILLNESS OUTBREAKS – LESSON LEARNED

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Throughout history bivalve molluscan shellfish have been associated with human infectious illnesses, many debilitating and some fatal. One important reason for such events is that by custom people often consume shellfish with little or no cooking to kill infectious agents. Another factor is that shellfish feed on algae and uniquely concentrate materials from surrounding waters at levels far greater than those in their aquatic habitats. Since bivalve molluscan shellfish are essentially sessile, the quality and safety of shellfish depend first and foremost on the cleanliness of their environment. To protect consumers, many nations implement shellfish safety systems that classify shellfish areas to designate where safe shellfish may be harvested. Properly implemented, the U.S. National Shellfish Sanitation Program (NSSP) has proven highly effective in minimizing shellfish-borne illnesses. Still, illness outbreaks do periodically occur. Whenever this happens, it undermines consumer confidence in shellfish, forces closures of implicated harvest areas, triggers costly regulatory recalls, damages the reputations of both the shellfish industry and its regulators, and calls into question the effectiveness of the controls being followed. Brief reviews of the hazards, some recent shellfish-borne illness cases and outbreaks, and the factors involved are presented. Information gaps and several remaining needs in the NSSP to improve the prevention of shellfish-borne illnesses are described.

NROC OCEAN PLANNING FORUM

John Weber
Northeast Regional Ocean Council, http://collaborate.csc.noaa.gov/nroc/default.aspx

The Northeast Regional Ocean Council (NROC) is a partnership of state and federal agencies convened by New England's Governors in 2005 to address certain ocean-related issues that require a regional response. In 2010, NROC developed a work plan to advance regional ocean planning, which focuses on developing better information and convening people to discuss ocean use issues in New England. In 2011, NROC obtained funds from federal and foundation sources to implement its work plan, which is underway now.

This work plan includes a project to engage representatives from existing and potentially new ocean uses, including aquaculture. Beginning in summer of 2012, NROC reached out to diverse representatives involved in aquaculture, including growers (shellfish and finfish), government, and academia. This engagement occurred through a series of phone interviews, surveys, and similar requests for information, through which NROC received input on potential issues for regional ocean planning in New England. NROC also asked about the most practical ways to convene members of the aquaculture industry, and was recommended to explore co-locating with existing events where possible, such as the Northeast Aquaculture Conference and Exposition. NROC is now convening a series of work sessions in New England, with growers, government, and academia, to further refine the issues identified through this summer's initial engagement, discuss potential next-steps, and ensure it is not replicating other efforts.

This session at NACE will 1) provide an update regarding NROC ocean planning efforts, 2) discuss current status of data characterizing the aquaculture sector, and potential utility of spatial data (related to other human activities and natural resources) to the industry, and 3) discuss key issues and trends facing the aquaculture sector, and explore the potential role for regional ocean planning to address these issues.

USING AQUACULTURE METHODS TO MEASURE THE INTERACTIONS OF RESTORED AND EXISTING BIVALVE POPULATIONS

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Shellfish restoration efforts have historically focused on the enhancement of a single, commercially important species. Recently, however, shellfish are being recognized for their biofiltration and shore stabilization properties. In Delaware Bay, for instance, the use of *Geukensia demissa* along the fringe of a marsh rehabilitation site has been increasingly popular and effective in low energy zones. Since these initiatives are relative new, little is known about how a newly established or augmented population of *G. demissa* may affect the already present populations of bivalve mollusks. To that end, this research examines the interactions of bivalves native to New Jersey waters— *Crassostrea virginica*, *Mercenaria mercenaria*, and *G. demissa*— to determine what impact augmenting the population of a single species may have on the food availability for a community of bivalve filter feeders. Based on equipment common to the bivalve mollusk aquaculture industry, a portable upweller system was developed. Useful under laboratory and field conditions, the upweller design allowed for concurrent trials of monoculture and mixed species experimental units. Water samples extracted from the basin inflow and the outflow of each silo were run through a Fluid Imaging FlowCAM IV to quantify number of particles present as well as provide characteristics of each particle (e.g. diameter, elongation, circularity, etc.). Comparisons of phytoplankton removal rates were made between the bivalve species as well as between the single and mixed bivalve species trials. Where possible, phytoplankton genus and species were identified to better determine food preferences of the study bivalves.

IS IT TIME TO EXPAND BAY SCALLOP, *ARGOPECTEN IRRADIANS IRRADIANS*, CULTURE IN THE USA

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Bay scallops are highly prized for their delicious adductor muscles, commanding a premium price in the retail markets. A decline in natural populations can be contributed to multiple factors such as harmful phytoplankton blooms, climate change, pollution, and decreasing habitat. The majority of bay scallops spawn once in their life time, which can severely impact the population if favorable rearing conditions are not met.

Due to its rapid growth rate, premium market value and unstable supply, the scallop is a prime aquaculture candidate, as China has demonstrated. In 2011 the United State imported 25,167 metric tons of bay/sea scallops worth over $294 million. Larval culture techniques for the bay scallop are established and similar to the methods used for both the hard clam and oyster. Nursery rearing is also similar, with requirements for warm culture temperatures and phytoplankton as a food source. However, scallops can swim and care must be taken to constrain both juveniles and adults. Therefore scallop farmers must rely on nets, cages, or pens during their grow-out phase at an additional expense. One advantage to scallop culture, in comparison to other shellfish species, is the ability to harvest a crop within a year.

POLLUTANT NITROGEN <=> NUTRITIONAL PROTEIN: THE SYMMETRICAL, ALLITERATIVE POETRY OF BIOEXTRACTION.

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The inert gas diatomic nitrogen constitutes 70% of the earth's atmosphere. In all living cells, nitrogen constitutes 16% of proteins, both structural and enzymatic. Recently, however, nitrogen has acquired a sinister reputation as a pollutant causing environmental degradation in coastal seas. We have demonized this essential element by over-fertilizing industrial agriculture and by concentrating human waste streams in coastal cities that use estuaries as convenient waste dumps. The so-called eutrophication of coastal seas, however, can be viewed as an opportunity; there is potentially-useful primary productivity going to waste. At a time when large investments are being made to cultivate microalgae for biofuel, we also are spending billions to prevent microalgae from growing in natural waters. Capturing the primary productivity of eutrophic coastal ecosystems would return the nitrogen in coastal seas to its rightful status as a precious resource.

Nutrient bioextraction is a technology to recover and recycle *pollutant* nitrogen into useful *protein* nitrogen for human food or animal feed. Cultivation of macroalgae that absorb dissolved nitrogen directly and molluscan shellfish that efficiently separate phytoplankton from the vast quantities of water in which they grow – a feat un-matched by any man-made machine -- for the main purpose of removing nutrients, especially nitrogen, from eutrophic waters is just beginning. Attention to toxic contaminants obviously is necessary for many applications, but with proper controls, nutrient bioextraction has the potential to address three problems simultaneously: eutrophication, the need for microalgal biomass to supplement agricultural plant production, and the harvest of fish to feed fish.

PUYALLUP TRIBAL TREATY RIGHTS AND SHELLFISH AQUACULTURE IN PUGET SOUND, WASHINGTON STATE

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The Puyallup Tribe of Indians is among the signatories to the Treaty of Medicine Creek, 1854. Part of the treaty guarantees "The right of taking fish, at all usual and accustomed grounds and stations", "*Provided, however*, that they shall not take shellfish from any beds staked or cultivated by citizens". The court case "*U.S. vs. State of Washington*" further defined the treaty right to 50% of the natural shellfish resource. The Tribe actively co-manages wild shellfish with the State of Washington and other tribes. The Tribe also cultivates clams and oysters to provide ceremonial and subsistence shellfish to members. The Tribe is acquiring tidelands to expand to potential commercial scale cultivation opportunities. The Tribe participates in restoration activities such as clean growing water and substrate protection. The Olympia Oyster, *Ostrea lurida* is the native oyster of Puget Sound and is in need of restoration due to over exploitation and water quality. The Tribe will partner with agencies and NGOs to facilitate the reintroduction of the Olympia Oyster.

DEPURATION & WET STORAGE SIMILARITIES AND DIFFERENCES - BEST PRACTICES FOR DEPURATION & WET STORAGE

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Commercial Depuration and Wet Storage of Bivalve Mollusks has been in existence in New Jersey as a licensed activity primarily for *Merceneria merceneria* and occasionally for *Mya arenaria* clam species since the 1970's. Also wet storage in New Jersey was practiced These processes have similar designs and typically utilize ultra-violet radiation as disinfection for systems which in New Jersey have been recirculating seawater systems. The seawater utilized has come from waters classified by the State as "Restricted" category water. In addition mussels have been wet stored in a seawater re-circulating system using potable water and sea salt made on-site. Although both have similar equipment as well as disinfection capability the purpose and public health risks are different. There are also plants in the U.S. that conduct both depuration and wet storage within the same systems and that use either a pass thru or re-circulating process waters. Also there have been plants that have used salt water wells for process waters or fresh waters with potable municipal water and sea salt added. Wet storage can occur in both tanks in buildings or in open natural bodies of water.

In the case of depuration we must consider that the shellfish originate in waters that have been classified by the state authority as "Restricted". There are variable non-point sources of bacterial pollution that would not allow these shellfish to be harvested and directly marketed for consumption. The 44 + hour depuration process allows the animals to pump at their most effective levels by controlling the systems water temperature, dissolved oxygen, salinity and Ph in order to purge them of any potential pathogenic bacteria and reduce the overall bacterial load. This requires a HACCP approach to monitoring and recording these "Critical' physical water quality parameters during the entire depuration process. Also critical to these depuration operations are the monitoring of the UV or other disinfection system outputs and the process water turbidity, cleaning of the UV light tubes and proper timing of replacement of bulbs all to assure adequate disinfection of the depuration process waters. There are requirements for daily analysis for absence of coliforms in the disinfected process water and a final fecal coliform analysis of the depurated shellfish meats to determine the post-depuration bacterial load based on fecal coliforms.

SIMULTANEOUS ENUMERATION OF *VIBRIO* SPECIES BY A MULTIPLEX QUANTITATIVE PCR (BAX) ASSAY

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Vibrio vulnificus (Vv), *V. parahaemolyticus* (Vp) and *V. cholerae* (Vc) cause over 75% of seafood-borne bacterial infections. Simultaneously enumeration of these species is needed for evaluation of post-harvest processed (PHP) oysters and for environmental surveillance. This study used a multiplex real-time PCR method (DuPont BAX ® Real Time *Vibrio* Test Kit) for direct enumeration of Vibrios and to determine most probable number (MPN). Growth of individual and co-inoculated species was evaluated in broth culture (Luria Burtani with 5, 10, 20, 30, 35 ppt artificial seawater, LB-ASW) and in live oysters, using environmental samples from in Apalachicola Bay, FL and PHP oysters. Close agreement was observed between QPCR and plate counts for Vv, Vp, and Vc (R^2=0.89-0.97) for individual culture, although Vv was not always detected at 35ppt by qPCR. Relative to Vp the other species showed growth inhibition at 30 and 35 ppt in individual culture. Co-cultures were similar to individual culture except Vp showed significantly more growth in co-culture than it did in individual cultures at 35 ppt, suggesting a competitive advantage. Detection by qPCR increased recovery from seeded oyster homogenates compared to standard assay for Vc and Vv. The qPCR-based MPN assays also showed close agreement with the standard assay for recovery of Vibrios (R^2= 0.99) from environmental samples and PHP oysters. Application of qPCR for simultaneous assessement of *Vibrio* spp. will facilitate evaluation of environmental parameters that promote growth, as well as validation of processing protocols for elimination of Vibrios in oysters.

AN INTRODUCTION TO THE CULTIVATION OF SEAWEEDS: NEW OPPORTUNITIES FOR INTEGRATING SEAWEEDS IN NORTHEAST AMERICA

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The value of aquacultured seaweeds according to estimates of the FAO exceeds over $U.S. 5.65 billion. The most valued of the maricultured seaweeds is the red alga *Porphyra*, or nori. It is a major source of food for humans throughout the world, although it is primarily cultivated in Asia (China, Japan and South Korea). Worldwide production is approximately 14 billion sheets, with an annual value of over $U.S. 1.2 billion. In addition to *Porphyra*, other edible and cultivated seaweeds include *Saccharina, Gracilaria and Undaria* with their collective value exceeding $U.S. 4.0 billion. Seaweeds are also the industrial sources of colloids including carrageenans (*Chondrus* and *Kappaphycus*), alginates (*Ascophyllum* and *Saccharina*) and agars (*Gelidium* and *Gracilaria*). These important polysaccharides are used in the food, textile, paint, biotechnological and biomedical industries having a global value of over U.S. $1 billion. Seaweeds have significant value in US agriculture as organic fertilizers, livestock feeds and as a food for abalone and sea urchins. The increasing demand for safe, healthy, and minimally processed foods is creating an opportunity for seaweed products as functional foods, nutraceuticals, and alternative medicinal products. There is now

interest in using seaweeds as the extractive component in integrated multi-trophic aquaculture (IMTA) and nutrient bioextraction systems. Properly planned seaweed aquaculture will enhance the health of coastal waters, provide biomass for biofuels and will benefit other maritime industries in need of new revenue streams. This presentation will be an introduction to seaweed aquaculture systems that are relevant to meeting market demands in Northeast America.

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