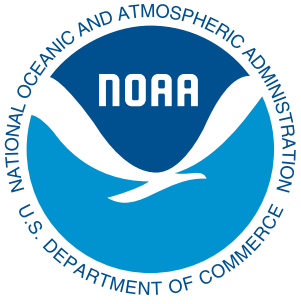

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36th Milford Aquaculture Seminar

January 11-13, 2016

edited by Walter Blogoslawski and Lisa Milke

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NOAA National Marine Fisheries Service
Northeast Fisheries Science Center
212 Rogers Ave, Milford, CT 06460

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OVERVIEW OF THE 36TH MILFORD AQUACULTURE SEMINAR

It was a great pleasure to welcome 175 attendees from 14 coastal states, 18 commercial shellfish and finfish companies, 16 colleges or universities, 3 aquaculture magnet high schools, and 7 federal marine laboratories to the 36th Milford Aquaculture Seminar (MAS) held at the Courtyard Marriott Shelton from January 11-13, 2016. This distribution showcases the scope of these seminars that since 1975 have brought together persons from all aspects of aquaculture.

Our scientific sessions at the 36th MAS included ten posters and 42 oral presentations covering topics such as ocean acidification, nutritional effects of harmful algal blooms, Vibrio pathogen management, probiotic use in hatcheries, kelp farming, impacts from exotic shellfish species, and methods to improve hatchery production.

From its inception, the Milford Aquaculture Seminar has had as its mission to bring together the scientists and practitioners of aquaculture to share the latest advances and the practical applications of this important industry. Over the years, the meeting has grown to include students, those experts in the legislation surrounding aquaculture, those that supply innovative support to the industry in terms of materials, components, and systems, computer experts that provide modeling and software programs to assist in running and improving the facilities, and insurers to protect the investments made in aquaculture. We collectively enjoy a forum where all these ideas, technologies, legal and all other aspects that touch the practice of aquaculture come together. It has proved a valuable venue for learning, debate, and for noting our successes and challenges.

That this seminar has continued to grow in scope and attendance for 36 years speaks to the need for such a forum and to the fact that aquaculture itself, though ancient in origin, has become more and more necessary as our world expands in population and, sadly, continues to impact adversely our water resources and the natural populations of desired food from the waters of the world, be they fresh or marine.

As we have heard at this Seminar over the years, the demand world-wide for water-borne sources of protein that are safe and appealing has increased dramatically. Concurrently, the wild fisheries have become nearly fully exploited. Nearly 60 years ago, the famous ocean explorer Jacques Cousteau sounded a warning that our water habitat was being degraded very quickly in the undersea world. He said, “We must plant the sea and raise its animals as farmers, not hunters.” How true we now know his words to be. The United Nations Food and Agriculture Organisation has urgently stated that we must put major effort into more reliance on farming than wild harvest of our waters.

Thus, aquaculture finds its place in the food supply for our world to meet the need for protein sources that are nutritious, safe to eat, and that appeal to the palate. There are many challenges to achieving this goal, but raising successful crops can contribute to a basic and vital need for our fellow members on this fragile planet. Our work carries a purpose beyond being able to provide for ourselves and our families, beyond letting us do something we enjoy for our job, and allows us to make a real and positive contribution to a world that finds its food supply buffeted by severe natural and man-made pressures. This satisfaction may not be tangible in terms of dollars and cents or measurement of production quantity but is an extremely valuable human benefit in that it provides the knowledge that we are making a very positive contribution to society every day. And that is something that no money or award can provide.

At this Seminar over the years we have learned of means to mitigate many of the challenges facing aquaculture. By including legislators and their staff members, insurers, bankers, and senior fishery policy makers at these meetings, your voice has been provided a forum to make known these challenges so that action can be taken to remove or mitigate some of the legal and financial obstacles that aquaculture faces. Over the years, we have been privileged to have present at the MAS people who have been true innovators in the field. By including providers of the latest technology and software, we've learned how to take advantage of the best means to produce crops without causing damage to the environment. By including the academics and scientists devoted to the study of subjects affecting aquaculture, we have learned of the latest defenses against disease and the proper methods to combat them, as cutting edge science helps to produce prime product. By having the students with us, we have exposed them to the hands-on world of aquaculture, an invaluable experience for those who will succeed us. By having all these persons at this one meeting, we have been able to make contacts outside of our own area of expertise so that we can call on them when we have a question or issue. That is why it is so important that we have this meeting. Finally, by publishing the work and advice we learn at these meetings, an even larger audience is exposed to the benefit of our gathering and to aquaculture in general -and I am grateful that the little experiment to bring diverse groups with ties to aquaculture together I first tried 36 years ago has blossomed into the large and useful meeting that continues to this day.

Your gathering at the MAS has enabled continuity in the line of industry leaders and practitioners who have met over the years in an effort to improve and promote this important industry. For that I thank you for allowing me the privilege of bringing you together for these meetings, for all the information shared, and for the friendships made. We now look forward to the MAS carrying on its informative and valuable exchange of ideas for many years to come.

Walter Blogoslawski

Founder and Convener, Milford Aquaculture Seminar

Agenda for the 36th Milford Aquaculture Seminar

Posters, Monday January 11th

p.1	Joseph Choromanski	Initial observations of blue mussel, *Mytilus edulis*, hatchery culture procedures in Long Island Sound	NOAA, Milford Laboratory
p.2	Christopher Edwards	Remote-setting eyed larvae of the blue mussel, *Mytilus edulis*	Martha's Vineyard Shellfish Group
p.3	James Elliott	A new outlook to solve an old problem: Using hormones and ventral coloration to anticipate ecdysis in the European Green Crab (*Carcinus maenus*)	Salem State University
p.4	Kylie Fawcett	Analysis of *Aurelia aurita* collagen as a viable alternative in medical applications	Bridgeport Regional Aquaculture Science and Technology Education Center
p.5	Brittany Flittner	Assessment of a high throughput microplate method for the determination of larval bivalve respiration rates in ocean acidification studies	Rochester University
p.6	Tessa Getchis	Maps matter for marine aquaculture	CT Sea Grant
p.7	Julia Lanoue	Assessing the potential effects of channel deepening on oyster restoration in the Hudson River estuary	Brown University
p.8	James Parente	Observations on different shell phenotypes of bay scallops (*Argopecten irradians*) from genetic lines	Roger Williams University
p.9	Cassie Stymiest	The Necan story-Linking Ocean and Coastal Acidification science to managers, policymakers, and coastal communities in the northeast United States and Canadian Maritimes	NECAN
p.10	Holly Turner	Development of a secondary school curriculum for *Saccharina latissima* (sugar kelp) production	Bridgeport Regional Aquaculture Science and Technology Education Center

Tuesday, January 12th

8:00-9:00		Continental Breakfast and Registration Open		
9:00		Walter Blogoslawski, Thomas Noji, Michael Rust and Kevin Chu	Welcome and opening remarks	NOAA: Milford Laboratory, Office of Aquaculture and GARFO
9:30	p.11	Tessa Getchis	Key players inform plan to grow Connecticut shellfish sectors	CT SeaGrant
9:45	p.12	Cassie Stymiest	CT stakeholder workshop update on ocean and coastal acidification	NECAN
10:00	p.13	Doris Hicks	Seafood health facts.org: a valuable resource for aquaculture and the seafood industry	Delaware Sea Grant Marine Advisory Service
10:15	p.14	Gef Flimlin	Investing in new market paradigms for shellfish farmers	Rutgers Cooperative Extension
10:30-10:45		Break (15 min)		
10:45	p.15	Sixto Portilla	Distinguishing the effects of toxicity and the nutritional value of the brown tide alga, *Aureococcus anophagefferens*, in homeoviscous adaptation of juvenile northern quahogs, *Mercenaria mercenaria*	City University of New York
11:00	p.16	Gary Wikfors	Evidence for a primary role of hemocytes in oyster shell construction	NOAA, Milford Laboratory
11:15	p.17	Wa Iba	Survival and growth of white shrimp (*Litopenaeus vannamei*) larvae were affected by feeding on Indonesian strain of microalgae	URI
11:30	p.18	Keomelys Gloss	Issues with bugs; Fifteen years of lobster hatching	Sound School
11:45	p.19	John Roy	Educational enhancement; Teaching in a fish production laboratory	Sound School
12:00-1:30		Lunch (1 hour 30 minutes)		
		Special Session: Eco-Forecasting for Shellfish Management Chair: Kristin DeRosia-Banick		
1:30	p.20	Robert M. Daniels	NOAA/FDA ecological forecasting: New tools for *Vibrio* management	National Center for Coastal Ocean Science, NOAA
1:45	p.21	Stephen Jones	Empirical modeling of *Vibrio parahaemolyticus* presence and concentration in New Hampshire shellfish	University of New Hampshire

2:00	p.22	Chris Schillaci	*Vibrio parahaemolyticus*: Management for oysters in Massachusetts	Massachusetts Department of Marine Fisheries
2:15	p.23	Michael Whitney	Forecasting *Vibrio parahaemolyticus* in Long Island Sound	University of Connecticut
2:30	p.24	Kristin DeRosia-Banick	Connecticut's response to the management of pathogenic *Vibrio parahaemolyticus*	CT Department of Agriculture Bureau of Aquaculture
2:45	p.25	Greg Goblick	Application of raft-map to ensure safe management of shellfish growing areas from viral pathogens in sewage sources	FDA Center for Food Safety and Applied Nutrition
3:00-3:15		Break (15min)		
3:15	p.26	Bryan Hurlburt	Noninsured Crop Disaster Assistance Program	Connecticut State Farm Service Agency
3:30	p.27	Diane Kapareiko	Discriminant analysis of oyster hemocyte immune functions as a screening method for predicting potential probiotic candidates	NOAA, Milford Laboratory
3:45	p.28	Marta Gomez-Chiarri	Probiotics for bivalve shellfish hatcheries: challenges and opportunities	URI
4:00	p.29	Tal Ben-Horin	The performance of oyster families exposed to Dermo disease is contingent on the source of pathogen exposure	URI
4:15	p.30	Roxanna Smolowitz	The effects of trematode infection on the life history of *Mytilus edulis* in the Northeast U.S.	Roger Williams University
4:30	p.31	Kelly Markowitz	The blue mussel parasite *Proctoeces maculatus*: A northward expansion?	Hofstra University
4:45		Adjourn (Dinner on your own)		

Wednesday, January 13th

8:00-9:00		Continental Breakfast and Registration Open		
9:00	p.32	Emma Green-Beach	Broodstock selection for higher meat yield in the bay scallop, *Argopecten irradians*	Martha's Vineyard Shellfish Group
9:15	p.33	Kim Tetrault	Development of small, local shellfish hatcheries and increasing hatchery production methods for existing hatcheries culturing the eastern oyster, *Crassostrea virginica*	Cornell Cooperative Extension
9:30	p.34	Eric Henry	High-density bivalve larviculture--Increasing hatchery production by growing larvae more efficiently	Reed Mariculture Inc.
9:45	p.35	Richard Karney	Initial investigations into the wild collection and hatchery production of seed of the ribbed mussel, *Geukensia demiss*a	Martha's Vineyard Shellfish Group
10:00	p.36	Mira Patel	A comparison of three configurations of floating upweller systems (FLUPSYs) and their effect on the growth rate of seed oysters (*Crassostrea virginica*)	Westhampton Beach High School
10:15	p.37	Barry C. Smith	Electrolytic flocculation to concentrate algae from liquid	NOAA, Milford Laboratory
10:30-10:45		Break (15 min)		
		Special Session: An Update Of The Status Of Sugar Kelp Aquaculture In Southern New England: From Seed To Market Chair: Charles Yarish		
10:45	p.38	Clifford Goudey	Advances in kelp farm design.	C.A. Goudey & Associates
11:00	p.39	Sarah Redmond	The development of sea vegetable aquaculture in Maine	University of Maine Sea Grant
11:15	p.40	Simona Augyte	Insights into the cultivation of morphologically distinct strain of the sugar kelp, *Saccharina latissima* forma Angustissima from Southern Maine	UCONN
11:30	p.41	Jang Kim	Development of a mobile kelp processing facility in New England	Incheon National University
11:45	p.42	Hauke Kite-Powell	Economics of seaweed farming in New England	WHOI
12:00	p.43	Bren Smith	GreenWave farmer training program	GreenWave
12:15	p.44	Jeff Trombetta	"Kelping Today", culinary attributes and practical application of kelp	Norwalk Community College
12:30-1:30		Lunch (1 hour)		

1:30	45	Michael Rice	Notes on the identification and distribution of the exotic western hemisphere mussel, *Mytella charruana* D'Orbigny 1846 in the estuaries of Pangasinan, Philippines	URI
1:45	46	Thomas Noji	Hard-clam (*Mercenaria mercenaria*) recruitment as a function of amphipod (*Ampelisca abdita*) abundance in fine-grained sediments	NOAA, Howard Laboratory
2:00	47	Shannon Meseck	Is there a link between sediment porewater chemistry and bivalve settlement?	NOAA, Milford Laboratory
2:15	48	"Barley" John Dunne	A tale of two harbors: Utilizing scallop spawner sanctuaries as a stock enhancement tool in East Hampton, NY	East Hampton Town Shellfish Hatchery
2:30-2:45		Break (15 min)		
2:45	49	Lisa Piastuch	Living shorelines: Reef balls as shellfish habitat, remediation and erosion control?	Sacred Heart University
3:00	50	Mark Dixon	A comparison of filtration and assimilation rates of ribbed mussels, *Guekensia demissa*, and spat-sized oysters, *Crassostrea virginica*, in the lower Providence River.	NOAA, Milford Laboratory
3:15	51	Yuan Liu	Effects of CO2 on planktonic microbial community structure	NOAA, Milford Laboratory
3:30	52	Judy Yaqin Li	Temporal and spatial variability in phytoplankton physiology in Long Island Sound – relevance to shellfish aquaculture activities	NOAA, Milford Laboratory
3:45		Walter Blogoslawski	Closing Remarks	NOAA, Milford Laboratory
4:00		Adjourn		

INITIAL OBSERVATIONS OF BLUE MUSSEL, *MYTILUS EDULIS*, HATCHERY CULTURE PROCEDURES IN LONG ISLAND SOUND

Joseph Choromanski, Sheila Stiles, and Dorothy Jeffress. USDOC, NOAA, NMFS, NEFSC, Milford Laboratory, 212 Rogers Avenue, Milford, CT 06460. joseph.choromanski@noaa.gov

To accommodate an anticipated need for blue mussel seed for aquaculture ventures, both near shore and offshore, studies have begun at the NMFS Milford Lab to evaluate efficient and effective hatchery techniques. Wild set harvests can be sporadic and speculative. Contributing to population fluctuations are several factors such as overharvesting, disease, anthropogenic effects such as pollution, climate change and habitat loss in certain areas. This has spurred an increased interest in hatchery culture of shellfish, which affords the potential for stabilization of seed availability and aquaculture production.

Hatchery protocols for blue mussels were developed from a combination of regular shellfish practices at the lab, examination of references and personal communications with other researchers. Broodstock blue mussels were gathered from the general area of Milford, CT for our first attempts and conditioned at 14 - 16°C with a supplemental algal diet of diatoms and flagellates. Spawning was induced by intermittently raising the seawater temperature to 22°C and lowering back down to 15°C. The initial spawning produced approximately $18x10^6$ eggs of which 95% developed into normal 2 day veliger larvae. Static cultures of the larvae were maintained for 21-28 days when setting material showed evidence of pediveliger attachment. Future studies of larval rearing will include algal and temperature preferences along with investigating properties of set material. In pre-investigation trials, 5/8" polypropylene rope provided adequate substrate for setting purposes, but other materials will also be examined and evaluated for grow-out.

REMOTE-SETTING EYED LARVAE OF THE BLUE MUSSEL, *MYTILUS EDULIS*

Christopher Edwards[1], Emma Green-Beach[1], Amandine Hall[1], Richard Karney[1], Stanley Larsen[2], Dale Leavitt[3], Matthew Griffin[3], David Bailey[4], and Scott Lindell[4]. [1]Martha's Vineyard Shellfish Group, Inc., PO Box 1552, Oak Bluffs, MA 02557; [2]Menemsha Fish Market, Chilmark, MA 02535;[3] Roger Williams University, One Old Ferry Road, Bristol, RI 02809; [4]Marine Biological Laboratory, 7 MBL Street, Woods Hole, MA 02543. puck5976@hotmail.com

Remote-setting technology for hatchery-produced eyed oyster larvae has enabled the efficient setting of larvae close to the grow-out sites. This methodology eliminates the hassle and expense of transporting spat on shell and frees the hatchery from the space and time requirements of nursery culture. The hatchery production of blue mussels would likewise benefit from the development of methods that would provide for the setting of eyed larvae on grow-out ropes near grow-out sites remote from the hatchery.

To determine whether mussels, like oysters, would be amenable to remote setting, about 4 million eyed mussel larvae produced in the Martha's Vineyard Shellfish Group Hatchery were transported to four sites away from the hatchery -- two outside tanks on docks at the Marine Biological Laboratory and the Menemsha Fish Market; one inside tank at the Hughes Hatchery, and two indoor tanks at Roger Williams University (RWU). They successively attached to rope collectors at all sites and have been cultured on a diet of both live and preserved phytoplankton. One group of eyed larvae set at RWU tolerated being refrigerated out of water for about 18 hours prior to placement in the set tank.

A NEW OUTLOOK TO SOLVE AN OLD PROBLEM: USING HORMONES AND VENTRAL COLORATION TO ANTICIPATE ECDYSIS IN THE EUROPEAN GREEN CRAB (*CARCINUS MAENUS)*

James A. Elliott, Alan M. Young, Mae L. Taylor, Joseph M. Incatasciato, and Alex V. Cintolo. Salem State University, Biology Department, 352 Lafayette Street, Salem, MA 01970. j_elliott4@salemstate.edu

The European green crab (*Carcinus maenus)* is a universal problem for the New England shellfish industry. Ways to decrease the green crab population throughout New England are being considered and one suggestion proposes to create a soft-shell crab market for human consumption, an option that is preferred due to the economic advantage. Therefore there must be a way to observe and accurately predict molting behavior. Results of a trapping survey measuring the natural variability of green crabs in Salem Sound, MA have recently prompted a new study that focuses on molting patterns, physiology, and the feasibility of keeping the invasive crustacean in a closed aquaculture system. This study explores the possibility that ventral coloration can assist as a bioindicator for molting. To measure this, crabs were monitored biweekly for ventral color changes and the temperature of the water was being manipulated to stimulate molting. Hemolymph samples will be collected and analyzed via high performance liquid chromatography to quantify methyl farnesoate (MF), the crustacean juvenile hormone. Red-pigmented crabs are predicted to have higher levels of MF. Crabs with this coloration prioritize molting only for reproduction rather than for growth. Crabs that are qualified without red pigmentation are anticipated to show the inverse, in that they will exhibit normal molting patterns relative to their size.

ANALYSIS OF *AURELIA AURITA* COLLAGEN AS A VIABLE ALTERNATIVE IN MEDICAL APPLICATIONS

Kylie Fawcett, Holly Turner, and Kirk Shadle. Bridgeport Regional Aquaculture Science and Technology Education Center, 60 Saint Stephens Rd, Bridgeport, CT 06605. kshadle@bridgeportedu.net

Dissolvable sutures can be used on both external and internal wounds. These sutures are made from natural materials, such as collagen, which allows the body to breakdown the stitches over time. The majority of these dissolvable sutures are made out of the collagen extracted from the serosal layer of beef, bovine collagen. However, 3% of the population, about 203,257,072 people, is allergic to this specific collagen. Additionally, the cows from which this collagen is extracted are potential carriers of black skin disease (BSD), Tay-Sachs disease (TSD), foot-and-mouth disease (FMD), and especially mad cow disease that is transferable to humans. A potential alternate to the bovine collagen is jellyfish collagen. They are both Type 1 collagens, so they have the same structure; however, the jellyfish is not a known allergen and will eliminate disease transmission risk.

It is proposed that, jellyfish collagen would be extracted from moon jellyfish, *Aurelia aurita*, and then compared to a sample of bovine collagen to assure comparable profiles. After, the jellyfish collagen will be processed into thin fibrillar collagen matrices. These matrices will then be rolled into threads to be applied as a surgical suture. These sutures will be evaluated to determine tensile strength and rate of dissolution. At the end of this project, a suture made out of jellyfish collagen will be developed.

ASSESSMENT OF A HIGH THROUGHPUT MICROPLATE METHOD FOR THE DETERMINATION OF LARVAL BIVALVE RESPIRATION RATES IN OCEAN ACIDIFICATION STUDIES

Brittany Flittner, Lisa Milke, and Renee Mercaldo-Allen. USDOC, NOAA, NMFS, NEFSC, Milford Laboratory, 212 Rogers Avenue, Milford, CT 06460. renee.mercaldo-allen@noaa.gov

Ocean acidification can limit the availability of carbonate ions, reducing calcification, shell growth, and survival rate of calcifying organisms including larval shellfish. While numerous studies have shown this impact, research concerning effects of ocean acidification on respiration rates of bivalve larvae remains limited. This project aims to develop a simple, high throughput assay to determine larval respiration rates and to apply this method to assess impacts of ocean acidification on bivalve health. Oxygen consumption by bivalve larvae held in 96 well microplates was measured using the MitoXpress® Xtra probe. This probe binds with extracellular oxygen, creating a fluorescence signal which varies in response to oxygen concentration. Relative fluorescence units, measured at intervals during the assay with a Molecular Devices SpectraMax® M2 Microplate Reader, were used to calculate oxygen consumption rate. Two different species of shellfish larvae, *Crassostrea virginica* (eastern oyster) and *Argopecten irradians* (bay scallop) were tested in initial assay runs. Trials have been conducted to optimize assay parameters such as fluorescence reading interval, assay duration, oil type and delivery, reagent dispensing techniques, and use of an inverted microscope to determine larval number in the plate wells. Further studies using oyster larvae will be conducted this spring to identify optimal larval densities and finalize methodology. Although still under development, this micro-respiration assay shows promise as a condition index for assessing physiological impacts of ocean acidification, or other stressors, on bivalve larvae under laboratory conditions. ® The use of trade names is to facilitate identification of products; but not an endorsement by the USDOC or NOAA,

MAPS MATTER FOR MARINE AQUACULTURE

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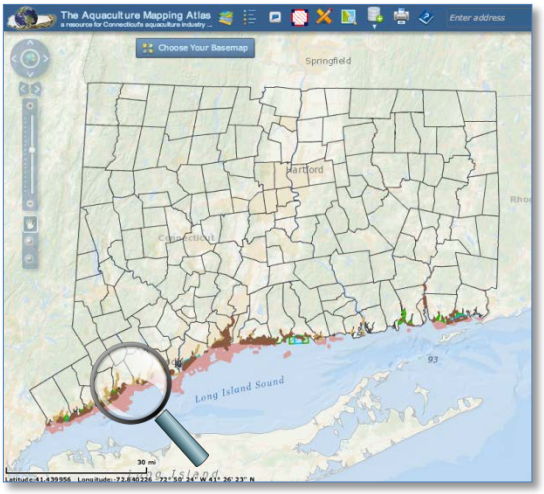
Geographic Information System (GIS) technology is being increasingly used for aquaculture site selection. These tools allow users to view, overlay and analyze a variety of spatial data necessary for aquaculture decision-making. Desktop GIS has been relied upon by resource management and planning agencies but because of the relatively high cost and steep learning curve required to master the technology, it is often of little value to the general public. Web-based mapping applications are typically free and designed to be more user-friendly. Additionally the burden of handling, processing and updating spatial data is on the provider rather than the user which allows the public to access accurate and updated information on the Web.

The Aquaculture Mapping Atlas is one example of a free, web-based mapping application built for aquaculture site selection. The Atlas provides a number of basemap layers including street maps, satellite imagery, topography, bathymetry, and navigational charts. Other "feature" map layers can be overlaid on the base map. These include commercial and recreational harvest areas, aquaculture gear areas, and a variety of other environmental data. One of the key features of the Atlas is that it provides the ability for aquaculture producers to develop spatial data in addition to allowing them to produce maps for the aquaculture application process. The Atlas is used by local, state and federal managers during the coastal permit review process to assess potential conflicts with shellfish resources in the area.



Figures 1a. Aquaculture Mapping Atlas

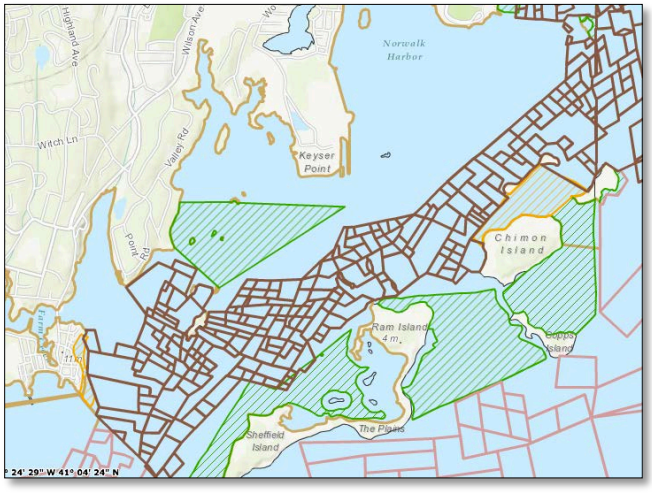


Figure 1b. Shellfish harvest areas in Norwalk.

http://clear3.uconn.edu/aquaculture.

ASSESSING THE POTENTIAL EFFECTS OF CHANNEL DEEPENING ON OYSTER RESTORATION IN THE HUDSON RIVER ESTUARY

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Oysters provide essential ecosystem services for coastal environments. Modern oyster reef restoration efforts are frequently designed to improve water quality, increase biodiversity, and provide opportunities for commercial and recreational harvest in areas where oyster reefs once flourished. In the Hudson River Estuary, located between New York City and New Jersey, restoration efforts are now being implemented to replenish Eastern oyster (*Crassostrea virginica*) populations to improve water quality and enhance regional biodiversity. However, oyster growth rates are sensitive to salinity, and recent ship channel deepening in the estuary may change the salinity distribution spatially and temporally, thereby potentially shifting the optimal sites for restoration. Using previous oyster growth studies from locations along the Atlantic and Gulf coasts, we model post-settlement growth as a function of salinity, temperature, turbidity, and chlorophyll. Applying environmental measurements collected from a recent sampling effort, the model assesses the growth rate of a single oyster in one location, Hastings-on-Hudson. Our results provide further evidence for the close link between growth rate and salinity fluctuations, and periods of low salinity may result in negative growth. Because Hasting-on-Hudson is a low-salinity environment, an increase in salinity from channel deepening may increase oyster growth rates in the area, thereby increasing the site's potential for reef restoration. Further research will involve extending the model to a population of oysters to simulate the growth of an entire reef and to incorporate the output from a regional hydrodynamic model (ROMS) to compare growth rates before and after channel deepening.

OBSERVATIONS ON DIFFERENT SHELL PHENOTYPES OF BAY SCALLOPS (*ARGOPECTEN IRRADIANS*) FROM GENETIC LINES

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The bay scallop (*Argopecten irradians*), an economically and ecologically valuable bivalve mollusk, is polymorphic for shell color. Shells can be yellow, white, bicolor, orange, pink, brown, gray, and other colors. Scallops can be selectively bred to increase the frequency of particular shell phenotypes for stock identification in enhancement and restoration efforts. For this purpose, scallops from two genetic lines were evaluated to determine if shell color and pattern were related to size and abundance. In one line, 5-month old juvenile scallops from a first generation of wild scallops were found to possess half white and brown, yellow, white, brown, and dark-banded shells. Another line of year-old scallops with striped shells that were selectively bred for several generations was found to have brown, tricolored, half tricolored-half brown, and varying striping on their shells. One hundred scallops were sampled at random from each line, sorted into respective colors, then weighed and measured for length, width and height. Color and size frequencies were determined to identify if shell coloration had any correlation with size and if any colors were dominant. Results showed that the scallops with light colors on both valves such as yellow (9%) and white (8%) were on average smaller (24mm) and less frequent than scallops with darker colors (12%-47%, 27mm, respectively) from the same age groups. Additionally, a darker-shelled striped phenotype was the overall preference in a small survey of persons asked to identify which shells were the most aesthetically attractive, with the idea of shells from cultured scallops being sold for ornamental purposes as a supplemental product. Additional investigations would involve larger sample sizes.

THE NECAN STORY – LINKING OCEAN AND COASTAL ACIDIFICATION SCIENCE TO MANAGERS, POLICMAKERS, AND COASTAL COMMUNTIES IN THE NORTHEAST UNITED STATES AND CANADIAN MARITIMES

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Public awareness and concern about Ocean Acidification (OA) is growing at the same time as the science is still maturing. In addition to the trend in global OA, near-coastal areas experience Coastal Acidification that is highly dependent on factors such as freshwater and nutrient delivery which are beyond the general increase in atmospheric CO2, but may be influenced by other human use and climate trends. Addressing these interacting stresses, their influences on Ocean and Coastal Acidification (OCA), and impacts to coastal resources is complex and challenging, both due to the relative paucity of OCA studies and communication gaps between scientists and stakeholders. The Northeast Coastal Acidification Network (NECAN) is a cross border collaboration of scientists, agency representatives, industry and non-governmental organizations that seek to provide relevant information about OCA to stakeholders in the Canadian Maritimes, Gulf of Maine and Long Island Sound. Efforts to date include a webinar series, state-of-the-science meeting and publications, web-based translation materials and face-to-face interactive stakeholder engagement workshops. The ultimate goal is to develop a regional implementation plan that will outline the information needed by stakeholders, including managers, policymakers, and industry, as well as the required observations, research, and communication mechanisms.

DEVELOPMENT OF A SECONDARY SCHOOL CURRICULUM FOR *SACCHARINA LATISSIMA* (SUGAR KELP) PRODUCTION

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The students and the staff Bridgeport Regional Aquaculture Science and Technology Education Center (BRASTEC) have been involved in a hands-on seaweed research project for the past five years. Throughout this time, the collaborative team has assisted in the development of: techniques to seed seaweed (*Saccharina latissima*) line; design a farm site and gain appropriate permits for the site on Long Island Sound; grow, harvest, and process the sugar kelp according to a Hazard Analysis Critical Control Point (HACCP) plan created and implemented by the team. The kelp, which was grown, harvested and processed by the students and staff has been available for sale at BRASTEC's market, Angie's at Aqua. To provide a model for possible expansion of these techniques, a secondary school level curriculum was developed to facilitate student awareness of environmental function and potential anthropogenic impacts of coastal human development. Additionally, a cost effective and potentially high yield growth industry, sugar kelp production, was integrated as a measure for long term ecosystem sustainability. Coupled with the sugar kelp cultivation methodology throughout this STEM, Science Technology Engineering Mathematics, based curriculum students were instructed on the environmental functionality of the nitrogen cycle as it pertains to coastal ecosystems. Students then implemented this background knowledge into a community awareness/action plan. This extension beyond the initial sugar kelp production immersed the students into the sugar kelp production industry and encouraged them to develop skill sets for policy development as it directly relates to their community.

KEY PLAYERS INFORM PLAN TO GROW CONNECTICUT SHELLFISH SECTORS

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The Connecticut Shellfish Initiative (CSI) is a multi-year planning effort to grow commercial and recreational shellfisheries and natural shellfish populations. The primary product is a vision plan that identifies specific recommendations to achieve this growth. The Initiative is stakeholder-based with individuals identifying and prioritizing needs within and across sectors. Three initial scoping workshops resulted in a list of nearly 100 items that participants identified as important for growth or limiting sector growth. From that list, recommendations were proposed, distributed widely and then revised based on comments received. The next step in the process involved priority-setting workshops. Stakeholders (n=81) voted on each recommendation with four possible choices: high priority, low priority, needs discussion, or do not know. Several recommendations rose to the top, being identified as "high priority" across all sectors. Those included engaging targeted groups about the effects of land-based practices that affect shellfish resources; developing strategies to address water quality issues that adversely affect shellfish and human health; and fully funding the state agency that collects and analyzes water quality samples to maintain and expand safe shellfish harvest areas. A steering committee comprised of shellfish interest groups across the state is considering forty additional recommendations and specific actions proposed by sector groups for inclusion in the vision plan.

To garner public support for shellfish sector growth, an important goal of the Initiative is to measurably enhance the public visibility of Connecticut's shellfish sectors and resources. A pilot-scale study was developed to inform the development of a public engagement program. Survey participants (n=296) were asked to answer four multiple choice questions about Connecticut shellfish sectors. The majority of respondents received an average score of 64.5%. Respondents from towns with an industry presence had the highest scores with an average of 85.7%. Overall, respondents were least familiar with recreational shellfishing with 40% selecting the appropriate answer to the question on this topic. This information in concert with data from a planned comprehensive public survey will allow us to create a public engagement program with targeted information and audiences.

Learn more: http://shellfish.uconn.edu.

CT STAKEHOLDER WORKSHOP UPDATE ON OCEAN AND COASTAL ACIDIFICATION

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Public awareness and concern about Ocean Acidification (OA) is growing at the same time as the science is still maturing. In addition to the trend in global OA, near-coastal areas experience Coastal Acidification (CA) that is highly dependent on factors such as freshwater and nutrient delivery, which are beyond the general increase in atmospheric CO2, but may be influenced by other climate trends. The Northeast Coastal Acidification Network (NECAN) is a collaboration of scientists, agency representatives, industry and non-governmental organizations that seek to provide relevant information about coastal acidification to stakeholders in the Canadian Maritimes, Gulf of Maine, and Long Island Sound.

The Northeast Coastal Acidification Network (NECAN) assisted CT Sea Grant in organizing a stakeholder workshop involving presentations on Ocean and Coastal Acidification (OCA) from scientists, fishermen, aquaculturists, and NECAN, along with facilitated conversations among participants. This session will provide an overview of the stakeholder workshop which included presentations on the science behind OCA, local environmental and economic issues linked to OCA, research and monitoring efforts, and communication and outreach. The participants' conversations focused on their questions, observations and concerns related to OCA; their ideas on research needs and focus; and their feedback on communication and outreach needs and opportunities. This workshop, among five others held in other states in the Northeast region and Nova Scotia, Canada, will assist the NECAN process leading to an implementation plan for determining research, monitoring, and outreach and education. Questions and discussion time will be provided during this session.

SEAFOOD HEALTH FACTS.ORG: A VALUABLE RESOURCE FOR AQUACULTURE AND THE SEAFOOD INDUSTRY

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The Seafood Health Facts website (SFH) provides healthcare, seafood industry professionals and consumers with straightforward, science-based information about the pros and cons of including seafood in a balanced diet and current media issues. The website, developed by Cornell University and the New York Sea Grant Extension Program in collaboration with Oregon State University and the Universities of Rhode Island, Delaware, Florida and California in 2011, is currently hosted and managed by the University of Delaware Sea Grant Program. According to a Google Analytics review (2/1/14 to 1/31/15), SHF is directly linked to or receives search engine referrals from more than 840 sources, most notably NOAA FishWatch, the Seafood Network Information Center (SeafoodNIC) hosted by Oregon State University, NOAA Office of Aquaculture, the National Fisheries Institute (NFI), SeafoodSource.com, Monterey Bay Aquarium SeaWatch, Google, Yahoo, eXtension, several state Sea Grant programs and others. Seafood Health Facts received more than 610,000 page views from 50,845 unique visitors (89.8% new and 10.2% returning).The majority of visitors were from the US, representing all 50 states, and the District of Columbia. The United Kingdom, Canada, Australia and India led international visitation from a total of 137 countries. Website managers Doris Hicks and John Ewart are expanding the format and scope of the website and encourage aquaculture businesses and industry associations to include a link to Seafood Health Facts on their websites as a reliable and impartial “go to” resource for seafood information. The presentation includes a review of current and future website subject categories and content.

INVESTING IN NEW MARKET PARADIGMS FOR SHELLFISH FARMERS

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Hard clam, *Mercenaria mercenaria,* growers in NJ have been farming clams for 45 years. The dock price has not essentially changed in 25 years. Growers decided to start a clam growers' cooperative.

Working with a cooperative developer, Heritage Shellfish Cooperative, Inc. (HSC) was formed. The goal is to bypass typical commodity clam market venues, and look to food cooperatives and upscale venues (markets and restaurants) in the Philadelphia and northern NJ markets. These places don't buy a lot of clams but understand the "fresh, local, farm to table, harvested to order, and photos of real working people" marketing style. The clams are packaged in clear plastic 3 pound "clam shell" packages, with a brand label of "Eventide Littlenecks." The result is greater returns to the grower. The members of HSC get more money upfront and receive a dividend at year's end.

To expand market, members looked at the Community Supported Agriculture (CSA) farms and evaluated a project by Rutgers Cooperative Extension that infused seafood into a CSA. Members pursued a Community Supported Fishery (CSF) to sell Eventide Littlenecks and locally sourced seafood from NJ docks or dealers. In the first year, the CSF was established at a local CSA, an upscale culinary store, and at the Rutgers University Gardens Farmers' Market. Reviews of the bi-weekly seafood shares have been excellent, and it is returning more funds to the clammers.

DISTINGUISHING THE EFFECTS OF TOXICITY AND THE NUTRITIONAL VALUE OF THE BROWN TIDE ALGA, *AUREOCOCCUS ANOPHAGEFFERENS*, IN HOMEOVISCOUS ADAPTATION OF JUVENILE NORTHERN QUAHOGS, *MERCENARIA MERCENARIA*

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A persistent, randomly occurring brown tide bloom, *Aureococcus anophagefferens*, during a fall 2011 study provided a unique opportunity to analyze its effect on low temperature acclimation of juvenile northern quahogs during the approach to winter lows. Prior research efforts have articulated the degree to which feeding in juvenile quahogs, *Mercenaria. mercenaria,* is inhibited by the presence and density of brown tide. However, changes to the fatty acid profiles of our experimental subgroups of two genetic varieties, indigenous and *notata* (selected for fast growth), reflected the nutritional attributes of *A. anophagefferens* distinguishable from those subjected to controlled diets. These distinctions suggest ample feeding occurred for successful homeoviscous adaptation as temperature decreased from 18°C to 6°C. Compared with the 4 control groups which were administered cultured diets, the groups feeding on environmental seston dominated by *A. anophagefferens* enjoyed best overall survival. High survival of these groups, according to a linear regression of mortality and fatty acid content, is attributed to the high DHA content found in brown tide, which has been identified as an important component of homeoviscous adaptation at low temperatures. Mean shell length measurements revealed a steady, statistically significant shrinking of the survivor pool over time, suggesting the toxic aspect of *A. anophagefferens* selectively targeted mortality of larger, faster growing individuals of both wild and *notata* strains.

EVIDENCE FOR A PRIMARY ROLE OF HEMOCYTES IN OYSTER SHELL CONSTRUCTION

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The primary requirement for calcification in any marine invertebrate, including the Eastern oyster, *Crassostrea virginica*, is the existence of a specialized compartment in which reaction conditions favor calcium carbonate formation. To meet these conditions, this space must be regulated with respect to the supply of calcium and bicarbonate ions and must be capable of maintaining a suitably-alkaline pH through removal of hydrogen ions generated during calcite and aragonite crystallization. In oysters, a class of circulating hemocytes that contain this intracellular mineralization compartment has been discovered. These motile, adherent, mineralizing hemocytes migrate to the mineralization front, attach to a substrate produced by the mantle epithelium, and deposit crystals. Accordingly, shell formation is a cellular-driven process that is physiologically regulated and controlled. Several independent lines of evidence support this emerging model of bivalve biomineralization: 1) microscopic imaging shows intracellular calcium carbonate crystallization within hemocytes and participation of hemocytes in shell repair, 2) oysters regulate intracellular pH of hemocytes, but do not regulate extracellular (serum) pH, 3) genomic data for the Pacific oyster show expression of chitin synthase and fibronection genes during the earliest stage of larval shell formation and the existence of mineralizing exosomes, and 4) specialized granular hemocytes (putative ‘osteoclasts’) are induced by shell damage. Further confirmation of this new model of shell building, coupled with recent results showing that carbon in shell minerals has an isotopic signature matching respiratory sources rather than surrounding seawater, will help to assess potential resilience of oysters to acidifying environments.

SURVIVAL AND GROWTH OF WHITE SHRIMP (*LITOPENAEUS VANNAMEI*) LARVAE WERE AFFECTED BY FEEDING ON INDONESIAN STRAINS OF MICROALGAE

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Feeding experiments at the laboratory investigated the effect of two Indonesian strains of microalgae (Kb1-2 and Kb1-3) on survival and growth of white shrimp (*L. vannamei*) larvae. Microalgae were cultured in 30 psu to match the salinity of the larval flask cultures, which wewere under natural, tropical conditions. 25 individual larvae were cultured during PZ_I stage in 1-L Erlenmeyer flasks containing 250 mL 0.2-µm-filtered seawater in triplicate for each microalgal diet. After 8 days, more than 80 % of the shrimp larvae had metamorphosed into the mysis stage in all microalgae tested except for Kb1-2 lines and the non-fed control treatments. All larvae in the control and Kb1-2 treatments died on day 3 and day 4 when most of the larvae were still in PZ_I and $PZ_{II,}$ respectively. Significant differences were found in total mean weight gain ($p<0.0001$), percentage increase of weight ($p=0.0001$), gross growth efficiency (k1) ($p=<0.0001$) and food conversion index (FCI) ($p=0.0061$), but not with survival, growth rate, weight gain per larvae, or percentage of food ingested comparing microalgae tested. The highest mean weight gain was observed in larvae feed on Kb1-3 but larvae fed this line had a lower mean survival rate of 11% compared to those fed *T. lutea* and *T. chui*, which had the same 32% mean survival at the end of the experiment. Indonesian microalgae may be suitable as food for white shrimp larvae with performance similar to that of well-established strains; however, further studies with mixed algal diets may reveal even greater performance than any single strain alone.

ISSUES WITH BUGS; FIFTEEN YEARS OF LOBSTER HATCHING

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Students at the Sound School Regional Aquaculture Center began their efforts to hatch and raise American Lobsters, *Homarus americanus*, fifteen years ago. Mortalities are naturally high in lobster husbandry; lobsters grow slowly and by definition students make mistakes as they learn. The hurricanes, Irene and Sandy, took their toll as well; causing mechanical failures that killed all but the youngest year classes. As time has passed methods have been developed and refined or discarded. Each advancement in culturing technique brings with it another challenge to be overcome. As survival increases so do space requirements; as cohorts age, new types of culturing vessels must be developed, food types vary with animal size and the demand for constant, hands-on care rises. Still the numbers of animals in culture has grown; there are more lobsters per hatch and they are living longer. We have provided lobsters to a number of researchers. The National Marine Fisheries Services' laboratories in Milford, Connecticut and Sandy Hook, New Jersey have both used our lobsters. Woods Hole Oceanographic Institute, Southern Connecticut State University, and the University of Rhode Island have also taken animals. Small scale stock enhancement efforts have been done cooperatively with the Bridgeport Aquaculture Center. Every new class of students has added to the skill sets and knowledge base used to grow the animals; progress continues despite the issues that occur when growing "bugs".

EDUCATIONAL ENHANCEMENT: TEACHING IN A FISH PRODUCTION LABORATORY

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The Sound School Regional Aquaculture Center is a New Haven Public School of choice. The school is the largest comprehensive Vocational Aquaculture Center in the world. There are approximately three hundred forty students enrolled at the school, ninety percent of those have opted to study Aquaculture or other Marine related topics. Being a member school of the State of Connecticut's Vocational Agriculture Program we are deeply invested in both Career and Technical Education as well as preparing our students for competitiveness in post-secondary education. Those students who choose to follow the Aquaculture Strand have an opportunity, as high school students, to work in a fully functioning fish production laboratory. While actively participating in the husbandry of aquatic life has a uniqueness of its own; when viewed from an educator's stand-point the fish production laboratory has vast potential for teaching. Learning occurs in a variety of subject areas and on several tiers. In the laboratory attendance and commitment are viewed as gradable objectives; mathematics and data collection are seen as tools that are used on a daily basis. Those students who follow aquatic career pathways are well prepared; however, our graduates are not all destined to work in the Aquaculture Industry. The commonality between all of our students is the experience of hands-on learning, the understanding that investment of self in projects produces results and their exposure to problem solving.

NOAA/FDA ECOLOGICAL FORECASTING: NEW TOOLS FOR *VIBRIO* MANAGEMENT

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Through the Ecological Forecasting Roadmap, NOAA has embarked on an effort to harness existing NOAA infrastructure (i.e.; observational platforms, ecosystem models, operational framework) for application to ecological issues. One focus area has been the distribution and concentration of *Vibrio parahaemolyticus* bacteria in surface waters and oysters. The latter has been explored through a strong partnership with FDA and the states, where NOAA is using output of environmental variables from operational hydrodynamic models throughout the country to force FDA algorithms for growth of *Vibrio* spp. in oyster and post-harvest. The result is a spatially explicit graphical forecast system that predicts total *Vp.* at time of harvest, and each hour post-harvest up to 48 hours in advance. Other tools have also been developed to demonstrate doubling time of *Vp.* in oysters, growing area scale best harvest window calculators, hindcasts to examine environmental trends in relation to illness patterns, and an assortment of weather tools of relevance to harvest management. Through regional workshops, stakeholder driven teams are being assembled to improve risk assessment and risk communication in the interest of protection of commerce and human health.

EMPIRICAL MODELING OF *VIBRIO PARAHAEMOLYTICUS* PRESENCE AND CONCENTRATION IN NEW HAMPSHIRE SHELLFISH

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Vibrio parahaemolyticus (*Vp.*) has become an increasingly important public health threat to shellfish consumers in the Northeast US. This increase has occurred mainly over the past five years during which significant sea surface temperatures have also increased in regional coastal waters. Shellfish-borne illnesses caused by *Vp.* have mainly occurred in southern New England states, while illnesses are much less frequent in New Hampshire and Maine. Knowing more about risk conditions for managing *Vp.* in shellfish harvesting waters. Environmental and climatic factor data can help improve accuracy in capturing the temporal changes in *Vp.* concentrations. With widely varying conditions in coastal and estuarine ecosystem conditions and reported regional variations in Vibrio concentrations, the scale at which modeling of *Vp.* levels can be accurate is a significant consideration.

Surveillance of *Vp.* levels in the Great Bay estuary of New Hampshire and Maine has occurred over an extended time period (2007-15). The surveillance includes measures of *Vp.* concentrations in oysters by MPN-PCR detection, water temperature, salinity, dissolved oxygen, pH, turbidity, chlorophyll *a*, dissolved nutrients and rainfall. Several predictive modeling approaches capable of estimating *Vp.* concentrations in oysters from April to December, 2007 to 2013, were developed and compared. Multiple regression analysis revealed that temperature and salinity resulted in the best fit to *Vp.* concentration data and were the only parameters used for the models. Differences in these parameters between the two main surveillance sites resulted in modeling of data for the site most representative of the estuary and not for the tributary site. Temperature and salinity had seasonally varying influences on *Vp.* levels, so a model of the full, undifferentiated dataset and one reflecting seasonal data were tested. Both models provided relatively accurate fits to summertime *Vp.* levels, but the seasonal model better reflected *Vp.* levels in spring and fall, resulting in lower mean error and root mean square error values. A published seasonally segmented model developed for the Neuse River in NC, with a wider and higher range of *Vp.* concentrations and higher salinity and temperature values over a single year, provided a less accurate fit to the Great Bay *Vp.* data, especially during warm summer months. This illustrates the variation in estuarine conditions in different regions, the need for caution in adopting models from areas differing in environmental conditions, and the benefit of local-scale modeling for accurate risk forecasting.

VIBRIO PARAHAEMOLYTICUS: MANAGEMENT FOR OYSTERS IN MASSACHUSETTS

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To meet National Shellfish Sanitation Program and federal Food and Drug Administration standards pertaining to the harvest and handling of oysters and *Vibrio parahaemolyticus* (*Vp.*), the Massachusetts Division of Marine Fisheries (DMF) and Massachusetts Department of Public Health (DPH) adopted control measures in 2012 intended to deter the post-harvest growth of *Vp*. in oysters. Historically, *Vp*. cases in Massachusetts (MA) have been rare and the relatively cool waters and high salinities in MA harvest areas have not been considered particularly conducive to high level of *Vp*. in shellfish. As a result of increased oyster production, warming air and water temperatures, and the introduction of a highly pathogenic strain of *Vp.* into MA waters this is no longer true. Since 2001, MA has experienced a significant increase in the occurrence of *Vp.* illness related to the consumption of raw oysters resulting in harvest area closures, recalls and considerable economic loss to the oyster industry. We conducted field studies to validate existing *Vp.* control measures and aquaculture industry practices in MA to determine their impact on *Vp*. levels in oysters. We also reviewed environmental conditions, background *Vp*. levels, harvest practices, and production levels in areas implicated in *Vp*. cases in efforts to develop proactive management strategies for *Vp.* in Massachusetts.

FORECASTING *VIBRIO PARAHAEMOLYTICUS* IN LONG ISLAND SOUND

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Vibrio parahaemolyticus (*Vp*.) is a marine bacterium that occurs naturally in brackish and saltwater environments and may be found in higher concentrations in the warmest months. *Vp*. is a growing threat to producing safe seafood. Consumption of shellfish with high *Vp*. levels can result in gastrointestinal human illnesses. Management response to *Vp*.-related illness outbreaks includes closure of shellfish growing areas. Water quality observations, *Vp*. measurements, and model forecasts are key components to effective management of shellfish growing areas. There is a clear need for observations within the growing area themselves. These areas are offshore of coastal stations and typically inshore of the observing system moorings. New field observations in Long Island Sound (LIS) shellfish growing areas are described and their agreement with high-resolution satellite sea surface temperature data is discussed. A new dataset of *Vp*. concentrations in shellfish tissue is used to determine the LIS-specific *Vp*. vs. temperature relationship following methods in the FDA pre-harvest *Vp*. risk model. This information is combined with output from a high-resolution hydrodynamic model of LIS to make daily forecasts of *Vp*. levels. The influence of river inflows, the role of heat waves, and predictions for future warmer climates are discussed. The key elements of this observational-modeling approach to pathogen forecasting are extendable to other coastal systems.

CONNECTICUT'S RESPONSE TO THE MANAGEMENT OF PATHOGENIC *VIBRIO PARAHAEMOLYTICUS*

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Vibrio parahaemolyticus is a naturally occurring marine bacterium in the same family as those that cause cholera and *Vibrio vulnificus.* Since 2012, the Northeast region of the U.S. has experienced a sharp increase in the number of illnesses linked to *Vibrio parahaemolyticus.* During 2013 the State of Connecticut shellfish control authority closed shellfish harvest areas after an outbreak of illness was linked to oysters harvested from growing areas in Norwalk and Westport. Beginning in 2014, Connecticut's *Vibrio parahaemolyticus* control program managers have worked with industry to incorporate more stringent time to temperature requirements in order to minimize the proliferation of this virulent strain of bacteria, and reduce the risk of consumer illness associated with molluscan shellfish. Post-harvest time and temperature controls as required by Connecticut's *Vibrio parahaemolyticus* Control Plans are evaluated by using continuous temperature data loggers to determine the effectiveness of post-harvest temperature controls, and correlated to impacts on Vibrio levels in shellfish and the associated risk of consumer illness.

In order to gain a better understanding of *Vibrio parahaemolyticus* levels in Connecticut shellfish, the State's monitoring plan includes the collection of environmental parameters such as water temperature, air temperature, salinity and depth that may correlate to levels of Vibrio bacteria in shellfish. Program managers are working with UCONN researchers to analyze this expanded dataset of environmental variables and *Vibrio parahaemolyticus* concentrations in shellfish tissue, to determine the Long Island Sound-specific *Vibrio parahaemolyticus* vs. temperature relationship following methods in the FDA pre-harvest risk model. This information is combined with output from a high-resolution hydrodynamic model of LIS to make daily forecasts of *Vibrio parahaemolyticus* levels available to industry and managers.

APPLICATION OF RAFT-MAP TO ENSURE SAFE MANAGEMENT OF SHELLFISH GROWING AREAS FROM VIRAL PATHOGENS IN SEWAGE SOURCES

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Since the beginning of the National Shellfish Certification Program in 1925, now referred to as the National Shellfish Sanitation Program (NSSP), dilution analysis has been used as a means to minimize pathogenic impacts to bivalve molluscan shellfish growing areas. Of particular significance to public health officials are wastewater treatment plant (WWTP) failures, bypasses, and combined sewer overflows (CSOs) that release untreated or minimally treated sewage into shellfish receiving waters. To assess the risk posed by sewage effluents, FDA's Field Engineering and Data Analysis Team (FED-A Team) has conducted hydrographic dye studies in conjunction with studies of the bioaccumulation of pathogens in shellfish to quantitatively demonstrate the risk of viral pathogens on shellfish growing areas. Field data was collected on a novel Mobile GIS application developed by the FED-A Team that displays in real-time on a GIS map the dilution and transport of sewage discharged. The results of these studies provided the scientific basis behind FDA's Dilution Guidance that was recently adopted by the ISSC. The results also have proven valuable for a joint U.S./Canada quantitative norovirus risk assessment for molluscan shellfish as well as calibration and validation of hydrodynamic models of WWTP discharges to growing areas currently being developed by the FED-A Team. RAFT-MAP may additionally support future forecasting models used to predict the sanitary impacts to growing areas attributed to forecasted storm related events.

NONINSURED CROP DISASTER ASSISTANCE PROGRAM

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The farm service agency 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 industry about the availability of the program and the new buy up options. This will include information about eligible species, calculating a loss, and 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.

If additional information is needed, please contact us at 860.871.4090 or
Devon Marsden (Devon.Marsden@ct.usda.gov) Program Specialist or
Bryan Hurlburt (bryan.hurlburt@ct.usda.gov), State Executive Director or
Ronald Clark (ronald.clark@ct.usda.gov), Farm Loan Manager.

DISCRIMINANT ANALYSIS OF OYSTER HEMOCYTE IMMUNE FUNCTIONS AS A SCREENING METHOD FOR PREDICTING POTENTIAL PROBIOTIC CANDIDATES

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Use of beneficial bacterial probiotics to control microbial pathogens in aquaculture is becoming increasingly popular as an environmentally-friendly, alternative management practice for disease prevention. In an effort to improve hatchery production of Eastern oyster (*Crassostrea virginica*) seed for aquaculture and restoration, the Milford Laboratory has isolated and evaluated a naturally-occurring bacterial probiotic isolate (Milford probiotic strain OY15) from the digestive glands of adult Eastern oysters, that has demonstrated significant protective effects against a shellfish larval pathogen, *Vibrio* sp. B183, in experimental larval trials. Sequence analysis of Milford probiotic strain OY15 revealed the closest matches to *Vibrio* sp. EX25 and a benign strain of *Vibrio alginolyticus* and shellfish-larval pathogen B183 to *Vibrio corallyliticus.* Utilizing flow-cytometric techniques to analyze the effects of OY15 on hemocyte functions involved in the innate immune response in oysters (viability, adhesion, phagocytosis, and reactive oxygen species release (ROS)), *in vitro* exposure of hemocytes from adult oysters to OY15 suggested that immune stimulation is a mechanism for the probiotic effects on oyster larvae. We employed these flow-cytometric, immune-function assays as a potential method for screening unknown bacterial isolates for probiotic candidates. Previously, we have shown that Discriminant Analysis can characterize and separate unknown bacterial isolates into groups or classes, based upon linear combinations of their immune function results. This analysis compares the hemocyte response profiles of several unknown bacterial strains, also isolated from oyster digestive glands, to the hemocyte response profile for OY15 as a “probiotic indicator” and the immune-suppressive profile of pathogen B183 as a “pathogen indicator”.

PROBIOTICS FOR BIVALVE SHELLFISH HATCHERIES: CHALLENGES AND OPPORTUNITIES

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Bacterial diseases are an important concern for bivalve shellfish hatchery managers, since they can lead at times to high levels of larval mortality. The use of probiotics (live microorganism that provide a beneficial effect to the larvae) has been suggested as an inexpensive, safe, and effective tool for preventing disease outbreaks in hatcheries. Using laboratory and hatchery trials, we have evaluated the use of two candidate probiotic bacterial isolates, S4 and RI06-95 to prevent diseases in bivalve shellfish. In order to improve efficacy of these probiotics, we have also studied the potential mechanisms of action of these probiotics. Our results indicate that probiotics can be an effective tool to prevent mortality caused by bacterial pathogens in bivalve larvae. These probiotics appear to have species-specific protective effects for shellfish larvae, protecting oysters and bay scallops against mortality caused by a *vibrio*, but not blue mussels, hard clams, or razor clams. Mechanisms of action are multifactorial, including at least antibiotic production, the ability to form biofilms on surfaces, the ability to inhibit the production of virulence factors by bacterial pathogens, and the ability to modulate the immune system of bivalves. Challenges to the development of effective and safe probiotics for commercial use in hatcheries include: 1) the development of stable formulations of probiotics for easy storage and delivery in commercial settings; and 2) how to ensure consistent efficacy in variable environmental conditions in hatcheries. This research has been funded by awards from the USDA NRAC, the Rhode Island Research Alliance, and Rhode Island Sea Grant.

THE PERFORMANCE OF OYSTER FAMILIES EXPOSED TO DERMO DISEASE IS CONTINGENT ON THE SOURCE OF PATHOGEN EXPOSURE

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Here we report preliminary results from a course of research integrating pathology, feeding ecology, genetics and genomics to address resistance to Dermo disease in eastern oysters. We challenged six oyster families with *Perkinsus marinus*, the etiological agent of Dermo disease, through either direct injection or feeding. These families were derived from dams determined to be either resistant or susceptible to the parasite in a previous study crossed with sires from either selected lines (hANA, CROSBreed) or the unselected line (WTS). We sampled mortality daily, and to explore variability in the host immune response and disease progression, we censored oysters for transcriptome and disease analyses at four time points (6hr, 36hr, 7d, 28d) following initial exposure. All animals were sacrificed on day 42 of the experiment. As expected, we found the mortality hazard was greatest in oysters exposed to *P. marinus* through direct injection. In this group, the mortality hazard was greatest in families with sires originating from CROSBreed and WTS lines while predicted dam susceptibility had no effect. In contrast, when exposed to *P. marinus* occurred through feeding sire had no effect on mortality. Here, mortality in families with Dermo-susceptible dams was over four times that of families with a resistant dam. These counterintuitive results implicate a range of processes that are likely to vary among individuals and collectively shape the ability for oyster hosts to resist and/or tolerate pathogens. Our upcoming analysis of transcriptomic and disease progression data will yield crucial insights into these complex patterns of Dermo resistance in oysters.

THE EFFECTS OF TREMETODE INFECTION ON THE LIFE HISTORY OF *MYTILUS EDULIS* IN THE NORTHEAST U.S.

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The blue mussel, *Mytilus edulis*, is commercial important as both a wild harvested bivalve and more recently as a cultured bivalve. This monthly study examined blue mussels from 5 locations in Rhode Island to determine common diseases that may be important in aquaculture and potential connections to die offs noted in wild populations. Squash preparations of mantle tissue containing gonadal tubules was used effectively to identify trematode infection caused by *Proctoeces maculatus* and to rate the severity of infections. Condition index and histological examination were used to identify any visible disease and severity of infections. Infectious agents that contribute to disease and mortality in wild blue mussels on the northeast coast included *Steinhausia mytilovum*, trematodes and *Chlamydia* sp. To ensure that aquaculture of the blue mussels becomes a profitable enterprise, it is important to understand the causes of blue mussel mortality and develop preventative and management methods for their diseases. This work was supported by Rhode Island Sea Grant (R/F-1416-42-1).

THE BLUE MUSSEL PARASITE *PROCTOECES MACULATUS*: A NORTHWARD EXPANSION?

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The digenean trematode *Proctoeces maculatus* is a parasite of numerous molluscs including the blue mussel, *Mytilus edulis.* Presence of this parasite reduces mussel quality and yield, and may negatively impact mussel aquaculture efforts. The trematodes are predominately found in the mantle tissue of bivalves where they cause partial or complete castration of the host. The prevalence of *P. maculatus* was visually determined at sites in New York, Massachusetts, New Hampshire and Maine. Additionally, we designed a species-specific molecular assay provide a better diagnostic tool able to detect *P. maculatus* at any life stage and at low intensities. Primers targeting the 18S nuclear ribosomal DNA (rDNA) were used to develop an end-point polymerase chain reaction assay and a quantitative polymerase chain reaction (qPCR) assay. Both end-point and quantitative PCR were performed on DNA extracted from samples of mussel tissue for which presence or absence of the parasite had been visually assessed through microscopy. The molecular methods showed high sensitivity, detecting the parasite in mussels that were found to be uninfested through microscopy. Using both microscopy and molecular methods, we found that *P. maculatus* was present in mussels from New York, Massachusetts, and New Hampshire, extending the previously described northern limit of the species.

BROODSTOCK SELECTION FOR HIGHER MEAT YIELD IN THE BAY SCALLOP, *ARGOPECTEN IRRADIANS*

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Working waterfronts and the fishing culture are threatened in much of New England due to diminished ground fish populations, the high price of fuel and the high demand for marina space by recreational boating. On Martha's Vineyard, Massachusetts this culture is kept alive in part by the wild bay scallop *Argopecten irradians* fishery. In an effort to support the bay scallop fishery and the significant economic supplement it provides to island towns, we propose to selectively breed bay scallops for larger adductor muscles, and therefore a higher meat yield per harvested bushel of scallops.

Predictive criteria for large adductor muscles were established in late winter of 2015 and broodstock were selected and spawned in the summer of 2015. Currently, several hundred of each treatment and control group are being grown in the Edgartown and Chilmark waters by the Town Shellfish Departments. The selection process and rationale will be discussed, as well as plans to evaluate the results of selection when the experimental seed is of harvestable size in early winter 2016.

DEVELOPMENT OF SMALL, LOCAL SHELLFISH HATCHERIES AND INCREASING HATCHERY PRODUCTION METHODS FOR EXISTING HATCHERIES CULTURING THE EASTERN OYSTER, *CRASSOSTREA VIRGINICA*

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The Suffolk County Marine Environmental Learning Center, a facility of Cornell Cooperative Extension of Suffolk County, New York, has operated a shellfish hatchery on Long Island since 1991, with two additional hatcheries being added in later years. Over the past two decades, many inquiries have been made by commercial enterprises regarding shellfish culture methods. In an attempt to make hatchery techniques and protocol more accessible to prospective ventures, CCE-Suffolk has secured a research grant with New York Sea Grant to examine the use of algae paste as a sole food source for larval rearing and to evaluate high-density larval culture for eastern oysters. One goal is to determine the viability of small-scale "pocket" hatcheries and their ability to produce eyed pediveligers without using expensive resources such as live cultured micro-algae and large volumes of heated seawater. This presentation will outline the project design and will offer preliminary results to date.

HIGH-DENSITY BIVALVE LARVICULTURE-- INCREASING HATCHERY PRODUCTION BY GROWING LARVAE MORE EFFICIENTLY

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Methods of High Density Larviculture have been adopted by an increasing number of bivalve hatcheries during recent years. These methods employ larval densities from 40 to 1,000 larvae/mL, far higher than the 1 to 5 larvae/mL used in conventional low-density larviculture. High larval densities provide several advantages, including use of much smaller larviculture tanks, and decreased water and energy requirements. Decreased water requirements enable culture water to be more easily and more economically treated to optimize temperature and water chemistry, and to eliminate pathogens that can devastate hatchery production. Hatchery production can be increased without increasing the “footprint” of the hatchery, and new hatcheries can be established more easily and at lower cost. The primary limiting factor for larval density is food supply. Algae concentrates can enable food to be delivered to larval cultures at high rates that are easily controlled.

INITIAL INVESTIGATIONS INTO THE WILD COLLECTION AND HATCHERY PRODUCTION OF SEED OF THE RIBBED MUSSEL, *GEUKENSIA DEMISSA*

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The under-appreciated ribbed mussel, *Geukensia demissa,* is gaining recognition for its application in coastal marsh restoration and water quality bioremediation. It is a critical component of coastal marsh habitat. Its excellent filtration capabilities make it a prime candidate for water quality bioremediation. Further, because it is not considered desirable for human consumption, it can be deployed in waters prohibited to shellfish harvest without the problem of it creating an "attractive nuisance" to public health. Presently there is no reliable source of large quantities of ribbed mussel seed for coastal resiliency and bioremediation applications.

To address this shortage of seed *Geukensia,* we tested various ways to collect wild ribbed mussel spat and investigated methods for hatchery seed production and nursey culture. We had no success collecting wild spat. Despite progress in getting the mussels to spawn, larval survival to setting was poor. Most discouraging was the very slow growth of the seed we did produce.

A COMPARISON OF THREE CONFIGURATIONS OF FLOATING UPWELLER SYSTEMS (FLUPSYS) AND THEIR EFFECT ON THE GROWTH RATE OF SEED OYSTERS (*CRASSOSTREA VIRGINICA)*

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Floating Upwellers (FLUPSY), are specialized nursery units that efficiently direct the flow of nutrient rich water upwards through oyster seed resting on mesh. FLUPSYs have been proven to increase oyster growth rates and are important features in shellfish culture facilities around the world. The three FLUPSYs used in this experiment employ pumps to create the flow of water; however, the design of each system is different in a number of respects. The three designs used are the R. Rheault design (F/A) with an open trough and ¾ hp ice-eater, a modified Cornell design (F/B) with a centrally located electric motor mounted out of the water and the Cornell low-cost FLUPSY (F/C) based on a 12" sewer pipe center trunk with a ¾ hp ice-eater pump.

The main objective was to determine if the different configurations of FLUPSYs affect the growth rate of the eastern oyster (*Crassostrea virginica*). Nine silos total were sampled; three silos for each FLUPSY placed at locations 1,5, and 9. The volumes of the oysters were measured every week for six weeks in two separate trials that occurred over the course of two consecutive summers.

In the first trial, FLUPSY C obtained the highest growth rate (.1102x), followed by FLUPSY A (.0728x), and then FLUPSY B (.0719x). The difference between the growth rates of FLUPSY A and C was found to be significant. In the second trial, FLUPSY C obtained the highest growth rate (.2897x), followed by FLUPSY B (.2807x), and then FLUPSY A (.2199x).

ELECTROLYTIC FLOCCULATION TO CONCENTRATE ALGAE FROM LIQUID

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Electrolytic-flocculation can separate microalgae from liquid very effectively. This allows the algae to be used for such things as fish food, nutraceuticals or bio-extractable compounds. Also, microalgae may be stored and re-suspended to feed shellfish similar to how brine shrimp and rotifers can be fed. Further, with increasing environmental regulations, retaining culture water for treatment or even re-use has become important to evaluate.

Electrolytic-flocculation uses less energy and labor than centrifugation. A system using about 300 Watts of electricity can dewater *Tetraselmis* cultures to paste at over 9 liters per minute; leaving 12 to 28 ppt seawater with less than 51 mg/L solids (Dry weight). Labor beyond attaching culture hoses and changing the collected paste buckets is minimal. Concentration ratios can be 800 L algal culture to 1 L concentrate.

Adapted from oil recovery and other separation technologies, electrolytic-flocculation uses an electric field to induce a surface charge on particles such as algae which then form aggregates. Gas bubbles are also formed and attach to the aggregating flocculates, bringing them to the surface. Once at the surface a set of rotating brushes pushes the aggregated algae toward a partially submerged conveyor belt which lifts the algae out of the water; depositing the paste in a container.

ADVANCEMENTS IN KELP FARM DESIGN

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The growth of marine aquaculture in the US will require an enabling regulatory framework and the development of economically viable grow out systems. Important to that viability is the system cost, the infrastructure needed to deploy and service it, and its reliability while in use and in the face of extreme weather events. In addition, due to competing uses of near-shore waters and the importance of scale, technologies are needed that are suitable for exposed or open-ocean locations.

The biological potential for the expansion of the macroalgae culture sector has been demonstrated and the potential role of this activity in energy production and in sequestering carbon has attracted attention. An affordable and reliable approach to building and operating a farm for macroalgae has been developed for use in Long Island Sound with the support of the University of Connecticut that may have application in more exposed locations. Methods of anchoring and array installation with limited vessel capacity will be presented.

The design of a kelp farm is a balance between the desire for stable and predictable performance of the long-line array and the need to bring the kelp crop to the surface for growth monitoring and harvesting. Catenary support lines are introduced as a way to provide array stability and reduce the overall cost of the installation. Other, more easily scaled configurations will be presented including systems that can be supported by single-point moorings.

THE DEVELOPMENT OF SEA VEGETABLE AQUACULTURE IN MAINE

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With a well-established traditional seaweed fishery, the first commercial kelp farm in the country, and the development of new seaweed aquaculture crops, Maine is leading the nation in the production of high quality sea vegetables. Collaborative partnerships between research, industry, and extension are working to develop new species, farms, products, and infrastructure for all aspects of the production-to-market chain. The macroalgal research nursery at the University of Maine's Center for Cooperative Aquaculture Research (CCAR) in Franklin, ME, is developing culture techniques for sugar kelp (*Saccharina latissima*), skinny kelp (*Saccharina latissima forma angustissima*), horsetail kelp (*Laminaria digitata*), winged kelp (*Alaria esculenta*), laver (*Porphyra umbilicalis*), and dulse (*Palmaria palmata*). Educational, research, and industry-based kelp nurseries are providing seed to new and existing sea farms, and significant research and outreach investments are being made in seaweed aquaculture in the state and region. As awareness and demand for domestic sea vegetables increases, the development of a sea vegetable aquaculture industry has great potential to provide economic opportunity and high-quality local seafood. As we enter our sixth season of cultivation, we will review challenges, accomplishments, and opportunities.

INSIGHTS INTO THE CULTIVATION OF A MORPHOLOGICALLY DISTINCT STRAIN OF THE SUGAR KELP, *SACCHARINA LATISSIMA* FORMA *ANGUSTISSIMA* FROM SOUTHERN MAINE

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We have used environmentally sustainable technology to successfully domesticate a narrow bladed form of sugar kelp (*Saccharina latissima*). In the wild, the kelp grows on ledges exposed to high ocean swells and the blades grow long, narrow and thick. We grew the kelp in collaboration with two Maine seaweed aquaculture farms: Maine Coast Sea Vegetables, Sorrento and Maine Fresh Sea Farms, Bristol. The environmental conditions at the open water farm sites were sheltered with low wave energy. This strain of kelp was outplanted around October/November. Harvest was initiated in May through June. Based on harvest results from the first growing season, kelp biomass yields were high and comparable to the broad form of sugar kelp. The wet weight of the yield biomass was on average 17 (± 4.4) kg m^{-1} and plant density was 330 plants m^{-1}. The average wet to dry weight ratio for kelp plants was 1:10. The morphology of the kelp was found to be stable as it grew long and narrow. Unlike its wild parental population however, the farmed kelp grew thinner with undulations in the blades. Our meristematic growth data show that highest growth rates occurred from mid-March to the end of April. We will present data on tissue content coupled with water column nutrient availability at each of the farms. This unique form of kelp has potential as a new cash crop for the Gulf of Maine farmers with applications in the culinary and other industries.

DEVELOPMENT OF A MOBILE KELP PROCESSING FACILITY IN NEW ENGLAND

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Open water kelp aquaculture has become a fast growing industry in New England. Currently, more than 10 growers are operating kelp farms from Connecticut to Maine. In addition, many shellfish growers, commercial fishermen and lobstermen have showed interest in growing several species of kelp. Beyond the biological challenges of growing kelp in open water systems is the quagmire of how to process kelp and prolong its shelf life for high value products in the culinary marketplace. The UCONN seaweed team has recently developed a mobile kelp processing machine with a Korean manufacturer (GAYA SKINNER Co., Busan, Korea) at a HACCP certified facility at Bridgeport Regional Aquaculture Science and Technology Education Center (BRASTEC). Up to 550 kg hr^{-1} of kelp biomass can be processed by the mobile kelp processing unit. This mobile processing unit has successfully processed both fresh and dried species of kelp. To date, this processing unit has been introduced to kelp growers in New England as well as to the students, faculty and staff at BRASTEC and Norwalk Community College. As the kelp aquaculture industry grows, we expect that kelp growers may set up additional processing facilities that use the mobile processing unit that was developed by UCONN personnel at HACCP certified facilities.

ECONOMICS OF SEAWEED FARMING IN NEW ENGLAND

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Seaweed farming represents a promising new direction for the production of useful food and feedstock products from the sea. Based on experience with prototype nursery, farming, harvesting, and processing activities, and models of commercial scale operations that these may evolve to, we have developed an economic model of seaweed farming operations off the coast of New England. For a commercial scale sugar kelp farm that achieves a yield of 10 kg/m of seed string and produces 250 metric tons of kelp/year, our model suggests farm-gate production cost of about $1.00/kg. Processing, marketing, and distribution could add another $2.00-2.50/kg, and management overhead another $0.50/kg, for a preliminary total delivered cost of packaged product of about $4.00/kg. We consider the farm production cost estimates to be fairly robust. Post-farm cost components require significant additional refinement.

GREENWAVE FARMER TRAINING PROGRAM

Bren Smith. 43 East Pearl Street, New Haven, CT 06513. bren@greenwave.org

What skills and resources do new ocean farmers need to succeed?

Bren Smith, owner of Thimble Island Ocean Farm and Executive Director of GreenWave, will discuss his farm replication program, designed to train a new generation of restorative ocean farmers. GreenWave's seed-to-market model supports new farmers throughout the entire farming process, including hands-on training, navigation of complex state regulatory regimes, access to low cost processing infrastructure and opening up new local and national markets.

“KELPING TODAY”, CULINARY ATTRIBUTES AND PRACTICAL APPLICATIONS OF KELP

Jeff Trombetta. Norwalk Community College, 188 Richards Avenue, Norwalk, CT 06854. jcakes1@msn.com

Studying cultivated kelp from a culinary perspective has given vast options to utilize this wonderful sea vegetable in versatile and multiple formats. Included in “Kelping Today” are 60 plus diverse recipes that are codified for a methodology and technique cookbook utilizing kelp. Although the primary focus is on “sugar kelp” specifically, there are multiple varieties of edible seaweed that can be used interchangeably in these recipe applications calling for slightly different cooking techniques (other varieties such as alaria, dulse and skinny kelp may be substituted upon need and availability). Kelp is sturdy enough to handle all forms of culinary preparations, yet sophisticated enough to present itself with elegance, desirability and palatability. This recipe development concentrates on technical, practical uses, plus inherent taste and appearance qualities. Regard is given to storage and shelf life of edible seaweed’s various marketing forms. The scope of this culinary exploration includes kelp’s versatility and food compatibility beyond Japanese cuisine and seafood applications.

NOTES ON THE IDENTIFICATION AND DISTRIBUTION OF THE EXOTIC WESTERN HEMISPHERE MUSSEL, *MYTELLA CHARRUANA* D'ORBIGNY 1846, IN THE ESTUARIES OF PANGASINAN, PHILIPPINES

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In February 2015, mussels were found in Pangasinan different from native mytilids, *Perna viridis, Modiolus philippinarum* and *M. modulaides (=M. metcalfei).* These mussels with a thick black periostracum were first reported in the Calmay River 16.0272^{o}N, 120.3147^{o}E near the village of Tucok (Dagupan City). Samples of ~50 mussels were preserved in 95% ethanol and sent to Maine for genetic evaluation using amplified mtDNA sequences coding for cytochrome oxidase 1 (mtCO1) using universal LCO and HCO primers, and then sequenced with LCO primers. *P. viridis* and *Modiolus brasiliensis* are the closest cladistic outgroups to the *Mytella* phylogeny, with the latter showing the closest sequences. Comparison was made to sequences from deSouza et al. (2015) of two divergent sequences of female mtCO1 lineages in *Mytella* that are distinct from another divergent male lineage using *M. brasiliensis* as the outgroup. Using Basic Local Alignment Search Tool (BLAST), there is a 100% identity match over ~600 bases to Haplotype B of *Mytella charruana*, the Charru mussel, with a native range on the Pacific coast of the Americas from Guaymas, Mexico to Ecuador, and introduced to the Atlantic coast of Florida in 2009. Mussels are spreading rapidly in Pangasinan. In July 2015 freshly set mussels were found in Western Tambac Bay (approx 16.28^{o}N, 119.92^{o}E), and in September, mussels were found in the Limahong Channel near Lingayen (approx 16.01^{o}N, 120.23^{o}E), an estuary contiguous with the original Tucok site. All sites with Charru have considerable seasonal salinity fluctuations and stratification during the dry season, but are primarily within the polyhaline salinity regime. Charru mussels are now fished and sold, and they set on traditional mussel spat collectors, suggesting good potential for aquaculture.

HARD-CLAM (*MERCENARIA MERCENARIA*) RECRUITMENT AS A FUNCTION OF AMPHIPOD (*AMPELISCA ABDITA*) ABUNDANCE IN FINE-GRAINED SEDIMENTS

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Stocks of hard clams or quahogs (*Mercenaria mercenaria*) in Sandy Hook in the early 1970s were predominantly located on sandy bottoms in the bay; during this period mud tubes of the amphipod *Ampelisca abdita* were largely absent in areas characterized by fine sediments. By 1986 hard clams were being harvested from the muddy sediments in the bay, where they co-occurred with *Ampelisca* tubes. The abundance of hard clams and of amphipod tubes remained high in areas with fine sediments through the early 2000s. Nearly monthly surveys since 2005 in the Sandy Hook bay has shown that the tubes were associated with large deposits of bivalve fecal pellets in the muddy areas. These pellets are oval in shape and largely in the sandy sediment size range. The tubes almost entirely disappeared in 2011, and have not reappeared to date. Since 2014, little or no hard clam seed has been observed by clammers in the area; this has been accompanied by progressively smaller harvests of littleneck hard clams. A positive correlation between hard clam recruitment and *Ampelisca* appears to exist. In this presentation, we describe the patterns in occurrence of these species based on benthic surveys as well as reported catch. Along with earlier reports by the first author that the presence of tubes likely improved settlement of hard clam larvae and reduced predation on the larvae, we discuss how the so-called muddy habitats identified by standard grain size analyses may have been biologically modified by amphipods to have functional properties similar to sandy habitats, thereby creating favorable recruitment and growth conditions for hard clams.

IS THERE A LINK BETWEEN SEDIMENT POREWATER CHEMISTRY AND BIVALVE SETTLEMENT?

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In Long Island Sound, northern quahogs, *Mercenaria mercenaria*, typically are harvested by hydraulic dredging. Over a 5-year period (2009-2013), we conducted a series of experiments comparing ecological and chemical variables between dredged and non-dredged sites on clam beds in Long Island Sound. Generally, these studies found minor, short-term, and no long-term, differences between harvested and unharvested clam beds. As most of the Connecticut shellfish industry relies upon natural clam set, we also sought to identify factors that might influence bivalve species abundance. We used a distance-based redundancy analysis to investigate relationships between sediment porewater chemistry and bivalve community abundance. Model analysis suggested that some bivalve species were sensitive to dissolved-oxygen concentrations, others were more sensitive to grain size, and one bivalve species varied in abundance with aragonite saturation state. There appears to be no known or observable, universal, chemical variable (e.g., low oxygen) that predicts general bivalve abundance. These results suggest that chemical factors which drive bivalve abundance in Long Island Sound are different for each species and therefore at least partially responsible for bivalve species distribution patterns.

A TALE OF TWO HARBORS: UTILIZING SCALLOP SPAWNER SANCTUARIES AS A STOCK ENHANCEMENT TOOL IN EAST HAMPTON, NY

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From 2008 through 2012, bay scallops (~300,000/year) were spawned and reared by the East Hampton Shellfish Hatchery and overwintered in a sheltered pond. In early spring of the following year, the scallops were compactly dispersed (target density of 100/m^2) in two low traffic sanctuary areas in Three Mile and Napeague Harbors. Each year, on a bi-weekly basis from May through October, scallop growth and gonad index (documenting spawning) were monitored. Spawning success was also assessed using spat collectors deployed in surrounding areas within sanctuary harbors and evaluated for spat on a regular basis. Concurrently, spat collectors were deployed at a third embayment for purposes of comparison. Scallop survival in the sanctuaries was documented on a monthly basis from May to November. Annual water temperatures were also monitored at the sanctuary sites.

Gonad indices presented an intuitive pattern in that gonad maturation peaked when temperatures approached 20°C, and then decreased thereafter. Spat collection numbers increased substantially from the beginning of the project in 2008 (baseline year, no sanctuaries) through 2012 (from 876 total spat to 165,360 total spat, an increase of 18,777%), followed by a decrease to 58,168 total spat in 2013, an increase of 6540% over 2008. Statistical analysis showed that sanctuary seeding efforts elevated spat densities over ambient conditions beginning as early as 2011.

Anecdotally speaking, the introduction of scallop sanctuaries enhanced local harvests. East Hampton bay scallop harvests began to show signs of recovery in 2010, with viable harvests only seen in the two harbors containing scallop sanctuaries.

LIVING SHORELINES: REEF BALLS AS SHELLFISH HABITAT, REMEDIATION AND EROSION CONTROL?

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Historically, Stratford Point has supported extensive coastal habitats including: oyster beds, fringing tidal marsh, and upland meadow/woodland. From 1926 to 1986, the Remington Arms Gun Club operated a trap and skeet shooting range resulting in lead shot accumulation and contamination of the intertidal zone. In 2000, a large-scale remediation project was undertaken that included dredging and separation of lead shot from the sediments and intertidal marsh. Restoration activities were unsuccessful due to a variety of reasons including Hurricane Sandy.

In 2014, 49 meters of artificial reef was installed at mean tide using 64 Reef Balls in two parallel rows as a pilot study to test wave abatement, shoreline stabilization and habitat enhancement. In 2015, over 3,500 Spartina alterniflora plugs were planted behind the reef. The distribution and settlement patterns of invertebrates and macroalgae on the artificial reef were monitored and the growth rate of S. alterniflora. Eight different invertebrate species and four macroalgae species have been identified. The living shoreline has the potential to become an oyster and mussel habitat however the Reef Balls are fully exposed at low tide causing the spat to freeze in winter and subsequently desiccate in the summer. The eastern oyster, Crassostrea virginica, spat initially settled on the Reef Balls but only 10% survived from November 2014 to April 2015. Nonetheless, 131 juvenile and adult oysters washed in with the tides settled in and on the Reef Balls in October of 2015. The blue mussel, Mytilus edulis, was consistently present within and around the reef.

A COMPARISON OF FILTRATION AND ASSIMILATION RATES OF RIBBED MUSSELS, *GEUKENSIA DEMISSA,* AND SPAT-SIZED OYSTERS, *CRASSOSTREA VIRGINICA,* IN THE LOWER PROVIDENCE RIVER

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There is growing interest in the ecosystem services provided by filter-feeding shellfish in coastal waters. Shellfish assimilate nitrogen from eutrophic coastal waters, and this nitrogen is removed upon harvest. This process, coined nutrient bioextraction, can play a role in the nutrient management strategies of coastal communities. The biodeposition method of measuring shellfish filtration and assimilation provides a mechanism to quantify this contribution.

Published results, and ongoing research, indicate that the ribbed mussel is a good candidate for use as a nutrient bioextraction tool. Quantifying the potential contributions of other shellfish is of interest to resource managers. In parts of the upper Narragansett Bay and lower Providence River, it is permissible to move spat-size oysters, less than 35 mm, from closed and conditional waters to approved waters for grow out and subsequent harvest. This strategy of moving small, fast growing oysters from highly-eutrophic waters to another area for eventual harvest could be a mechanism for nitrogen removal. Additionally, this process could be repeated several times throughout the growing season, potentially employing millions of oysters.

Two experiments were conducted near Fields Point, Rhode Island in the summer of 2015 to measure filtration and assimilation rates of spat-size oysters. Preliminary results will be presented and compared to results from ribbed mussel trials at the same location.

EFFECTS OF CO_2 ON PLANKTONIC MICROBIAL COMMUNITY STRUCTURE

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Phytoplankton and heterotrophic bacteria form the base of the marine food web. Carbon dioxide (CO_2) supplies photosynthetic energy occurring in both eukaryotic and prokaryotic phytoplankton, potentially affecting the compositions of phytoplankton and heterotrophic bacterial communities. In this study, we conducted CO_2 manipulation, mesocosm incubations wherein natural planktonic, microbial communities were subjected to three CO_2 concentrations: 200 ppm, 390 ppm, and 790 ppm for 3 weeks. Microbial community composition was investigated using high-throughput, next-generation sequencing of the conserved regions of 16S and 18S rRNA genes.

After applying the most stringent data-filtration standard to eliminate sequencing errors and ambiguous reads, at least half-a-million sequences remained in both 16S and 18S data sets. At the highest taxonomic level (Phylum), different trends among CO_2 treatments and with time were observed. For example, sequence abundance of photosynthetic cyanobacteria was one of the most abundant throughout the incubation (42%), while the decomposer group, actinobacteria, was sequenced much less frequently beginning on day 16 of the incubation (dropped from 2% at the beginning to background level in the end). Although cyanobacterial sequence abundances did not differ significantly among CO_2 treatments for the majority of the incubation period, sequence abundances of actinobacteria were diminished in the low and high CO_2 treatments compared to the intermediate treatment representing present day CO_2 concentration in the ocean. These observations were based upon preliminary sequence-abundance data. More in-depth investigation using statistical tools is underway.

TEMPORAL AND SPATIAL VARIABILITY IN PHYTOPLANKTON PHYSIOLOGY IN LONG ISLAND SOUND – RELEVANCE TO SHELLFISH AQUACULTURE ACTIVITIES

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Understanding food quantity and quality is essential to the successful practice of aquaculture. Unlike finfish, shellfish aquaculture depends entirely on naturally present phytoplankton; however, phytoplankton communities vary across physical, chemical, and biological factors. Our study tests the hypothesis that physiological status of phytoplankton in the Long Island Sound varies spatially and seasonally in response to external environment.

Variable fluorescence measurements of phytoplankton were taken monthly at 17 stations throughout the Sound along with nutrients and other water quality variables. The maximum quantum yield of PSII, or F_v/F_m, is a measure of photosynthetic efficiency and has been used as an indicator of general physiological stress. F_v/F_m was significantly higher in the winter (median of 0.77) than summer (median of 0.69). Spatial patterns of F_v/F_m were not as prominent. Western stations showed slightly higher F_v/F_m (median of 0.74 at the far western station, A4) than eastern stations (median of 0.69 at station J2) except for the two furthest east stations (K2 and M3) which had similar F_v/F_m values to A4. Patterns of F_v/F_m seemed to follow dissolved inorganic nutrients (nitrogen and phosphorus). Results suggest that inorganic nutrients may limit the photosynthetic potential of phytoplankton in Long Island Sound. Our findings are particularly relevant to shellfish aquaculture during the summer when feeding and growth of shellfish are at high rates but nutrients may be limited.

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