THERMAL TOLERANCE OF JUVENILE ATLANTIC SURFCLAMS (*SPISULA SOLIDISSIMA*): A STEP TOWARDS DIVERSIFYING THE NEW JERSEY SHELLFISH AQUACULTURE SECTOR

Michael P. Acquafredda*, Daphne Munroe, Lisa M. Calvo, Michael P. De Luca
Rutgers, The State University of New Jersey, Haskin Shellfish Research Laboratory, 6959 Miller Avenue, Port Norris, New Jersey 08349
Michael.Acquafredda@rutgers.edu

New Jersey shellfish aquaculture is currently limited to two species: the northern quahog (=hard clam) (*Mercenaria mercenaria*) and the eastern oyster (*Crassostrea virginica*); however, shellfish farmers eager to diversify have expressed interest in culturing new species. The Atlantic surfclam (*Spisula solidissima*) represents an ideal target species for diversification because it is native, grows rapidly, and fits into the established farming framework. To optimize the husbandry techniques required for sustainable and profitable farming, it is necessary to gain a thorough understanding of how temperature impacts the performance of the surfclam throughout its different developmental stages. This study examined the effects of five different temperatures (≈18˚C, 20˚C, 23˚C, 24˚C, and 26˚C) on the growth and survival of juvenile surfclams (shell length = 0.69–3.00 mm). Three independent cohorts were tracked for several weeks and cultured using downweller and upweller systems. Shell length and survival estimates were collected 2–3 times per week. Results suggest that colder temperatures reduce clam mortality, while temperatures between 20 and 24˚C promote the greatest growth. The parentage of each cohort also had a significant impact on growth and survival, suggesting there is a genetic component to surf clam thermal tolerance. These findings and the results from our on-going surfclam aquaculture optimization studies will be incorporated into a manual of best practices. This manual will be made accessible to the state's local shellfish farmers. Moreover, these results can be incorporated into species distribution models, and further refine the management of the lucrative wild surfclam fishery.

A HIERARCHICAL BAYESIAN MODEL ESTIMATING MICROBIAL CONCENTRATIONS FROM MOST PROBABLE NUMBER DATA

Tal Ben-Horin[1*], Corinne Audemard[2], David Bushek[3], Lisa M. Calvo[3], and Kimberly S. Reece[2]
[1]University of Rhode Island, Department of Fisheries, Animal and Veterinary Sciences, College of the Environment and Life Sciences, Kingston, RI 02881, United States of America
[2]Virginia Institute of Marine Sciences, College of William and Mary, Gloucester Point, VA 23062, United States of America
[3]Rutgers University, Haskin Shellfish Research Laboratory, 6959 Miller Ave, Port Norris, NJ 08349
tbenhorin@uri.edu

The most probable number (MPN) method is an effective tool for quantifying low concentrations of microbial contamination in food and water; however, it requires often prohibitively large numbers of replicates, subsamples within replicates, and dilutions of each subsample to sufficiently narrow the confidence intervals of estimated microbial concentrations, particularly when testing for differences across predictor variables. A hierarchical Bayesian model that combines data from replicates collected using the MPN method to increase the precision of estimated microbial concentrations will be presented. This model was applied to data collected from an ongoing project investigating the effects of intertidal exposure on concentrations of *Vibrio parahaemolyticus* in oysters grown across a salinity gradient in Delaware and Chesapeake Bays. The hierarchical model decreases uncertainty and improves inference of the effects of ecologically-relevant predictor variables such intertidal exposure, salinity and region on estimates of microbial concentration.

WAVED WHELK (*BUCCINUM UNDATUM*) IN THE MID-ATLANTIC BIGHT: LIFE HISTORY TRAITS AND POPULATION STRUCTURE

Sarah Borsetti[1]*, Daphne Munroe[1], Eleanor Bochenek[1], David Rudders[2], Collin Dobson[3]
[1]Rutgers University, Haskin Shellfish Research Laboratory, 6959 Miller Avenue, Port Norris, NJ 08349
[2]Virginia Institute of Marine Science, Rt. 1208 Greate Rd., P.O. Box 1346, Gloucester Pt., VA 23062
[3]Woods Hole Oceanographic Institution, 86 Water Street, MS 57, Woods Hole, MA 02543
sarahbor@hsrl.rutgers.edu

Recent expansion of the unmanaged waved whelk (*Buccinum undatum*) fishery in the Mid Atlantic Bight has initiated investigation into local life history parameters of this species, which vary with location. Limited adult dispersal and a lack of planktonic larval stage create spatially distinct populations with regional variation in size at sexual maturity and shell morphology. This current study presents the distribution and density of the stock in the Mid Atlantic, size at onset of sexual maturity, and an age length curve for the south portion of the population. In the summer of 2015, waved whelk samples (n = 231) were collect in the mid-Atlantic, from Georges Bank to DelMarVa, using a modified scallop dredge. All whelk (n = 3877) were sexed, weighed, measured, and assessed for maturity. Size at maturity varied between sexes and sites and ranged from 54 to 72 mm. The largest whelk measured 103 mm shell length (SL) (mean = 69 mm) from the Georges Bank region with the smallest animal from the New Jersey region, measuring 15 mm SL (mean = 65 mm). Abundance estimates of whelk were also made from counts of bottom images taken in the HabCam survey conducted by NEFSC. Driving forces behind local adaption might include, depth, temperature, habitat, predation, and prey availability. This evidence for local adaptation in whelk means that if fishing was to continue and management necessary, regional management rather than national management would best protect the Mid Atlantic whelk fishery.

PATHOGEN SOURCE OR SINK: THE POTENTIAL ROLE OF BIVALVE AQUACULTURE IN MITIGATING DISEASE RISK

Colleen A. Burge[1], Tal Ben-Horin*[2], Maya L. Groner[3], Ryan Carnegie[3], Dave Bushek[4], and Eileen E. Hofmann[5]

[1]University of Maryland Baltimore County, Institute of Marine and Environmental Technology, 701 E Pratt Street, Baltimore, MD 21202

[2]University of Rhode Island, Department of Fisheries, Animal and Veterinary Science, 462 Center for Biotechnology and Life Sciences, Kingston, RI 02881

[3]Virginia Institute of Marine Science, College of William & Mary, P.O. Box 1346, Gloucester Point, VA 23062

[4]Rutgers University, Haskin Shellfish Research Laboratory, 6959 Miller Ave, Port Norris, NJ 08349

[5]Old Dominion University, Center for Coastal Physical Oceanography, 4111 Monarch Way, Norfolk, VA 23508

tbenhorin@uri.edu

Rapid anthropogenic change has intensified disease impacts on marine and freshwater environments. Understanding the ecology of these diseases is essential to mitigating their effects, and is particularly urgent for diseases related to aquaculture, which is growing rapidly worldwide and important for the sustainability of human coastal communities. Intensive aquaculture can exacerbate disease impacts on nearby natural host populations. However, it is far from certain that this is universally the case, and we question whether aquaculture may on the contrary be a sink for some directly transmitted pathogens. *Perkinsus marinus* is a major pathogen of the oyster *Crassostrea virginica* along the Atlantic and Gulf coasts. Dermo disease caused by *P. marinus* typically reaches peak severity after two growing seasons, and in areas where this disease is prevalent aquaculturists hedge against disease risks by getting oysters to market before large losses occur. Parasite transmission occurs when infected oysters die and release infective parasite stages into the water column, which are then filtered by uninfected oysters nearby. Oyster aquaculture may be a sink for *P. marinus* given that cultured oysters are growing and filtering parasites from water bodies shared with wild populations but harvested before large numbers die and release parasite stages into the environment. Here we modeled interactions between oyster aquaculture and wild populations, showing how the scale of aquaculture and the extent of harvest can be optimized to minimize disease impacts on surrounding wild populations. The results are immediately relevant to oyster aquaculture in areas where wild oysters are present.

INTERANNUAL SEASONAL PATTERNS OF *PERKINSUS MARINUS* INFECTIONS AND OYSTER MORTALITY IN DELAWARE BAY

David Bushek*, Iris Burt, and Susan Ford
Haskin Shellfish Research Laboratory, Rutgers, The State University of NJ
6959 Miller Avenue Port Norris, NJ 08349
bushek@hsrl.rutgers.edu

The etiological agent of Dermo disease, *Perkinsus marinus*, has been a major source of oyster mortality in Delaware Bay since 1990. The oyster population is also challenged by *Haplosporidium nelsoni* (the etiological agent of MSX disease) but MSX disease has not been a problem since the late 1980s following the spread of resistant oysters throughout most of the bay. The MSX parasite is still widely prevalent in the Bay and quickly attacks naïve oysters whereas native oysters survive well. Monthly monitoring of *P. marinus* infection prevalence and intensity has occurred since 1999 with corresponding levels of mortality, temperature and salinity and provides a unique opportunity. Temporal (seasonal) and spatial patterns show the typical cycle of infection intensification during summer followed by remission over the winter and spring with a gradient of increasing infection intensity as salinity increases. Interannual variation in the time series includes periods of drought contrasted by periods of flooding, as well as periods of varying duration of temperature threasholds. These data provide a unique opportunity to investigate relationships of environmental controls on disease status and impact which will be explored in this presentation.

THREATENED BIRDS ENDANGER OYSTER FARMS

Lisa M. Calvo*, Michael P. De Luca, David Bushek
Rutgers University, Haskin Shellfish Research Laboratory, 6959 Miller Avenue, Port Norris, NJ 08349
lcalvo@hsrl.rutgers.edu

The lower Delaware Bay shoreline in Cape May County, New Jersey, provides important habitat for migratory shore birds including the Red Knot (*Calidris canutus rufa*), which was recently listed as Threatened under the Endangered Species Act (ESA). This shoreline also serves as the center of the New Jersey oyster aquaculture industry. Since the listing, the interplay between conservation measures aimed at protecting the red knot and their effect on the oyster aquaculture industry has taken on critical focus. Several non-governmental conservation organizations have petitioned state and federal agencies to stop shellfish aquaculture growth and curtail existing activities as they are apprehensive that oyster farming may pose disturbances to Red Knots during their annual spring migration to arctic breeding grounds. Concern has also been expressed that intertidal oyster farms may negatively impact horseshoe crabs, whose eggs serve as the primary food source for the red knot during its Delaware Bay stopover. As required by ESA consultation provisions, the U.S. Fish and Wildlife Service has developed a *Programmatic Biological Opinion for Structural Aquaculture* (PBO). The PBO prescribes risk-averse conservation measures to reduce potential impacts of oyster farming activities in the lower Delaware Bay, NJ on the Red Knot population and their critical habitats. Outcomes of this process will likely be precedent setting. An overview of the ESA experience with respect to Red Knots and oyster farms in Delaware Bay will be discussed.

DESIGN, BUILDING, AND PERFORMANCE OF A SIMPLE YET FUNCTIONAL AMPHIBIOUS FARM VEHICLE

Lisa M. Calvo[1]*, Gustavo Calvo[2], David Bosco[3]
[1]Rutgers University, Haskin Shellfish Research Laboratory, 6959 Miller Avenue, Port Norris, NJ 08349
[2] Sweet Amalia Oyster Farm, PO Box 475, Newfield, NJ 08344
[3]Bosco Architects, PO Box 44, Newfield, NJ 08344
lcalvo@hsrl.rutgers.edu

Near-shore intertidal environments often present ideal conditions for cultivating shellfish, providing both the appropriate environmental conditions and reducing travel time and costs to access farms; however, the dynamic topographies of alternating sand bars and sloughs, tide-dependent work windows, and environmentally sensitive habitats characteristic of intertidal locations also present challenges to developing environmentally sound, optimal and efficient farm operations. Focusing their efforts during the low tide, many oyster farmers who operate intertidal farms have at best two hours on either side of a low tide to carry out daily husbandry and harvest tasks. This limited period heightens the need for equipment and practices that maximize efficiencies while minimizing environmental impacts. A critical problem is the lack of a low impact versatile vehicle that allows oyster growers to efficiently transport oysters and gear to and from, and within the farm, and provides a platform for production activities, such as harvesting and sorting stocks. An Amphibious Farm Vehicle (AFV) was developed for working an intertidal oyster farm. Central to the design was the desire for the vehicle to be low impact—quiet and environmentally friendly. The resultant manually operated amphibious farm vehicle has increased the efficiency of farm operations, while minimizing environmental impacts on a small scale oyster farm in the lower Delaware Bay, NJ.

MATERNAL AND SALINITY EFFECTS ON BLUE CRAB (*CALLINECTES SAPIDUS*) LARVAL MORPHOLOGY: IMPLICATIONS FOR BIOPHYSICAL INTERACTIONS

Joseph Caracappa*, Daphne Munroe
Rutgers University, Haskin Shellfish Research Laboratory, 6959 Miller Avenue, Port Norris, NJ 08349
jcc290@hsrl.rutgers.edu

Adult blue crab (*Callinectes sapidus*) population abundance is highly variable, and may be related to variability in larval recruitment. Larval success partially depends on morphology, as it affects predation risk, feeding and swimming ability, and ultimately dispersal capability. The purpose of this experiment was twofold: 1) To determine the degree of inter-brood and intra-brood variability in morphology in blue crab larvae, and 2) to determine whether maternal effects or salinity influence the morphological development of larvae. Salinity varies in coastal environments, and is a key environmental parameter in crab larval development. To test maternal effects, larvae from six ripe adult female Delaware Bay crabs were reared in laboratory cultures. Larvae were sampled at hatching and the morphology of 125 individuals was measured microscopically. Additionally, larvae from two females were split and reared two separate salinity treatments (28 and 33), and sampled regularly for morphological measurements (348 larvae overall). Measurements for all larvae included size, shape, spine, and swimming appendage dimensions. Reynolds number and drag were estimated from measured morphology. Morphology was highly variable both within and between broods, and most metrics were significantly influenced by maternal identity. Therefore, maternal effects should be controlled for in future developmental studies, and morphological variability should be considered in biophysical modeling. After 22 days of culture, larvae from lower salinity (28) were larger, experienced higher drag force, and had longer swimming appendages. This suggests that morphological development is sensitive to abiotic factors. Additionally, larvae may be triggered by an estuarine environment to accelerate their development.

PROGRESS TOWARD STREAMLINING SHELLFISH HEALTH MANAGEMENT

Ryan B. Carnegie[1]*, David Bushek[2]
[1]Virginia Institute of Marine Science, College of William & Mary, P.O. Box 1346, Gloucester Point, Virginia 23062, USA
[2]Rutgers University, Haskin Shellfish Research Laboratory, 6959 Miller Avenue, Port Norris, New Jersey 08349
carnegie@vims.edu

The rapid expansion of shellfish aquaculture along the US East Coast has occurred against a significant backdrop of parasitic diseases, and generally reflects successful management of these diseases. Nonetheless, difficulties remain with regard to shellfish health management. Uncertainty concerning pathogen distributions, prevalences and impacts challenges state regulators to make informed decisions quickly regarding interstate seed transfers. This has contributed to establishment of zero-tolerance policies with regard to pathogens in seed proposed for transport, to the detriment of aquaculture commerce and, potentially, regional biosecurity of the industry. The increasing numbers of disease analyses required with increasing volume of interstate transfers stresses limited diagnostic resources and produces additional expenses for industry in both time and the cost of these analyses. With collaborators from industry, regulation, and the extension and scientific communities coastwide and with support from the NOAA Aquaculture Research Program, NJ and VA Sea Grant, and the USDA APHIS Veterinary Services, we have been working to streamline disease management by making improvements in several areas, including the resolution of pathogen distributions and guidelines for hatchery certification for expedited transport of seed. An update will be provided on progress on these fronts and perspective on the future directions of this initiative.

CALCULATING TIME-DEPENDENT CONNECTIVITY OF NORTHERN QUAHOG (*MERCENARIA MERCENARIA*) AND EASTERN OYSTER (*CRASSOSTREA VIRGINICA*) LARVAE IN BARNEGAT BAY LITTLE EGG HARBOR ESTUARY

Jacob D. Goodwin*[1,2], Zafer Defne[3], Daphne Munroe[1], Neil K. Ganju[3], and James Vasslides[4]
[1]Haskin Shellfish Research Laboratory, Rutgers University, Port Norris, NJ
[2]Woods Hole Oceanographic Institution, 266 Woods Hole Rd, MA 02543
[3]U.S. Geological Survey, Woods Hole, MA, USA
[4]Barnegat Bay Partnership, College Drive, Toms River, NJ, USA
jgoodwin@whoi.edu

Understanding bivalve larval connectivity can improve management of bivalves by identifying areas best suited for sanctuaries and harvest. Modeling that combines particle attributes (e.g. buoyancy or behavior) coupled with physical processes of water movement has been used to estimate the transport and connectivity of marine species; however, until recently, these types of models were used to evaluate connectivity in only two dimensions. Recently, a retention clock matrix (RCM) concept was introduced to add the temporal dimension to the evaluation of connectivity between user-defined areas. Numerical particles simulating the behavior of *Mercenaria mercenaria* and *Crassostrea virginica* populations were released from points in Barnegat Bay Little Egg Harbor (BBLEH) and connectivity was estimated using a Lagrangian particle-tracking model (LTRANS), offline ROMS output, and RCM. Results show similar transport patterns for both species despite behavioral differences of particles. The RCM connectivity matrices provide management guides for the larval connectivity of both *C. virginica* and *M. mercenaria* populations in BBLEH for various pelagic larval durations that could vary annually or during decadal oscillations of climate.

SUPERIOR TRIPLOID EASTERN OYSTERS PRODUCED BY SELECTING TETRAPLOIDS

Ximing Guo[1]*, Ming Liu[1], Baohong Xu[1,2,3], Yun Chen[1,4], Yinghui Dong[1,5], Linlan Lv[1,6], Michael Whiteside[1] and Gregory DeBrosse[1]

[1]Rutgers University, Department of Marine and Coastal Sciences, Haskin Shellfish Research Laboratory, 6959 Miller Avenue, Port Norris, NJ 08349, USA.

[2]Hunan Agricultural University, Department of Fishery, 1 Nongda Road, Furong District, Changsha, Hunan 410128, China.

[3]Collaborative Innovation Center for Efficient and Health Production of Fisheries in Hunan Province, Changde, Hunan 415000, China.

[4]Jimei University, Fisheries College, 43 Yindou Rd., Jimei, Xiamen, Fujian 361021, China.

[5]Wanli University, Zhejiang Key Laboratory of Aquatic Germplasm Resources, 8 Qianhu South Road, Ningbo, Zhejiang 315100, China.

[6]Yancheng Institute of Technology, Department of Marine and Biological Engineering, 211 Jianjun Road, Yancheng, Jiangsu 224051, China.

xguo@hsrl.rutgers.edu

Because of their sterility, superior growth, and improved summer meat quality, triploid oysters have become an important part of oyster aquaculture, accounting for 30-50% of productions in the US and France. Triploids are produced by crossing diploids and tetraploids, and the sterility of triploids, while beneficial for aquaculture, poses a challenge to further improvements. Tetraploid genomes are unstable, and it is unclear whether superior characteristics in tetraploids can be faithfully transmitted to their triploid progeny.

To determine if triploid eastern oysters (*Crassostrea virginica*) can be improved by selecting tetraploids, two classes of triploids were produced by crossing the same diploid females with the largest (L) or smallest (S) tetraploid males from the same cohort. Two experiments were conducted with two different sets of parents. The two classes of triploids and control diploids from each experiment were deployed in triplicate for field evaluation.

At 6-month post-fertilization and in both experiments, L-triploids were significantly ($p<0.001$) larger than S-triploids, and both triploids were significantly ($p<0.001$) larger than diploids. In Experiment 1 where the largest and smallest 10% tetraploids were used, L-triploids were 79% heavier than S-triploids, which in turn were 50% heavier than diploids. In Experiment 2 where the largest and smallest 20% tetraploids were used, L-triploids were 21% heavier than S-triploids, and the latter were 54% heavier than diploids. These results show that despite genome instability tetraploids have a large influence on the performance of their triploid progeny, and superior triploids can be produced by selecting and using the best-performing tetraploids.

FACTORS AFFECTING DISTRIBUTION OF THE ATLANTIC SURFCLAM (*SPISULA SOLIDISSIMA*), A CONTINENTAL SHELF BIOMASS DOMINANT, DURING A PERIOD OF CLIMATE CHANGE

Eileen E. Hofmann*[1], Eric N. Powell[2], John M. Klinck[1], Daphne M. Munroe[3], Roger Mann[4], Dale B. Haidvogel[5], Diego A. Narváez[1,6], Xinzhong Zhang[5], Kelsey M. Kuykendall[2]
[1]Old Dominion University, Center for Coastal Physical Oceanography, Norfolk, VA
[2]University of Southern Mississippi, Gulf Coast Research Laboratory, Ocean Springs, MS
[3]Rutgers University, Haskin Shellfish Research Laboratory, Port Norris, NJ
[4]Virginia Institute of Marine Science, College of William & Mary, Gloucester Point, VA
[5]Rutgers University, Dept. Marine and Coastal Sciences, New Brunswick, NJ
[6]Universidad de Concepción, Departmento de Oceanografia, Concepción, Chile
hofmann@ccpo.odu.edu

The Atlantic surfclam (*Spisula solidissima*) is a dominant member of the biological community of the Middle Atlantic Bight continental shelf and also a commercially harvested species. Climate warming is affecting the biology and distribution of this species, which provides an opportunity to investigate the processes and conditions that are restructuring this fishery and the implications for ecological and socio-economic systems. The Management Strategy Evaluation (MSE), which is a system of linked models, developed for the surfclam fishery is an attempt to provide a comprehensive mechanistic description of the surfclam's response to climate change and understand the cascade of effects initiated by changes in oceanographic conditions that ultimately appear as social and economic effects, which in turn inform development of management policies for the resource. This study provides an overview of the components of the surfclam MSE, relevant results, and implications for management and policy. The lessons learned from the surfclam MSE provide a basis for applying similar approaches to other ecologically important species that are also commercially exploitable resources.

IDENTIFICATION OF CANDIDATE DISEASE-RESISTANCE GENES IN THE EASTERN OYSTER UTILIZING GENOMIC RESOURCES FROM THE PACIFIC OYSTER

Ming Liu* and Ximing Guo
Rutgers University, Haskin Shellfish Research Laboratory, Department of Marine and Coastal Sciences
mliu@hsrl.rutgers.edu

The Pacific oyster (*Crassostrea gigas*) genome project has generated rich genomic resources including a reference assembly and extensive transcriptomes that provide expression profiles of all genes at all developmental stages, in different adult organs and under various environmental conditions. These resources are useful for inferring gene function and comparative genomics. In this study, *C. gigas* genomic resources were explored to identify candidate disease-resistance genes in the eastern oyster (*Crassostrea virginica*), a sister species that was separated from *C. gigas* 83 mya. Despite extensive divergence in nucleotide sequences, protein sequences and gene structure are highly conserved between them allowing easy identification of homologs. A set of 1002 *C. virginica* genes potentially involved in immune and stress responses were identified based on annotation and transcriptome profile in *C. gigas* and sequenced in 7 pairs of before- and after-mortality *C. virginica* samples with AmpliSeq™ to detect single-nucleotide polymorphism (SNP) frequency shifts. The 7 populations were Rutgers NEH™ disease-resistant lines where mortalities were caused by *Perkinsus marinus* and/or environmental stress. Consistent SNP frequency shifts were found in several genes including a Death-associated protein related to apoptosis and up-regulated by stress in *C. gigas*, a heat shock protein and a G-protein coupled receptor that are up-regulated by stress and OsHV-1 infection in *C. gigas*, and an acetylcholine receptor that is down-regulated by stress and OsHV-1 infection in *C. gigas*. These and other genes provide good candidates for further functional studies and as target genes for editing or marker-assisted selection for disease/stress resistance in oysters.

DETERMINING INCIDENTAL DISCARD MORTALITY OF SEA SCALLOPS IN THE DREDGE FISHERY IN THE MID-ATLANTIC BIGHT

Jason M. Morson* and Eleanor A. Bochenek
Rutgers University, Haskin Shellfish Research Laboratory, 6959 Miller Avenue, Port Norris, NJ 08349
jmorson@hsrl.rutgers.edu

Incidental fishing mortality, also known as non-capture mortality, is the mortality associated with individuals contacted by the fishing gear, but not caught. The most recent sea scallop assessment set this rate at 10% and 20% of the fully recruited fishing mortality in the Mid-Atlantic region and on Georges Bank, respectively; however, these rates are based on experiments conducted in the 1970s and 1980s using a dredge configuration that longer complies with regulations in the commercial fishery. To obtain up-to-date estimates on incidental mortality, we sewed a twine mesh bag (1 7/8″) into the top a dredge configured to current regulations and conducted a total of thirty-nine tows with this gear near the Hudson canyon access area. For all scallops collected in the twine mesh bag that would have normally passed through the dredge rings, shell damage was assessed, and for a subset of scallops in each injury category, post-release mortality was monitored. No scallops categorized as undamaged died after being returned to the sea floor and monitored at one- and two-week intervals. A large fraction of those scallops categorized as having sub-lethal and lethal damage were still alive after two weeks of post-release monitoring. When mortality rates by injury category, from the sub-sample of scallops that were monitored post-release, were applied to the entire incidental catch, total incidental mortality rate was low in both 2015 (3%) and 2016 (1%). These results are consistent with previous estimates from the same region, but lower than what is currently assumed in the assessment.

THE ROLE OF FISHERY ENHANCEMENT IN THE SUSTAINABLE OYSTER FISHERY IN DELAWARE BAY

Daphne Munroe*, Kathy Ashton-Alcox, Jason Morson, David Bushek
Rutgers University, Haskin Shellfish Research Laboratory, 6959 Miller Ave. Port Norris, NJ 08349
dmunroe@hsrl.rutgers.edu

Wild harvest of Eastern oysters (*Crassostrea virginica*) has been culturally and economically important to the Delaware Bay for well over a century. This fishery has remained relatively stable over the past two decades with an average of 76,085 bushels (1 NJ bushel = 35 L and yields about five pounds [2.27 kg] of meat) of oysters harvested annually since 1996. Quotas are set using an exploitation-based reference point system that uses data from catch and annual assessment of oyster abundance. Additionally, fishery management employs enhancement strategies that include habitat improvement (planting shell) and transplanting of oysters from lower to higher productivity regions. The effect of these strategies was analyzed using repeat observations in space and time of oyster abundance on these areas relative to adjacent unenhanced areas in the central region of the stock. Results show that on average, without enhancement, oyster abundance remains constant; however, with enhancement, oyster abundance is significantly increased. On average, enhanced grids (~25 acres each) saw an increase of 20 oyster/m^2 (> 2 million oysters per grid) over a three-year period following the enhancement activity. Oyster enhancement on a scale of relevance to the fishery not only contributes to the sustainability of the stock, but is also of great importance to the ecology of the bay.

HORSESHOE CRAB ACTIVITY AND INTERACTIONS ON RACK-AND-BAG OYSTER FARMS

Daphne Munroe*, David Bushek, Lisa Calvo
Rutgers University, Haskin Shellfish Research Laboratory, 6959 Miller Ave. Port Norris, NJ 08349
dmunroe@hsrl.rutgers.edu

Concern has recently been raised about the ability of horseshoe crabs (*Limulus polyphemus*) to navigate safely in and around intertidal oyster farm gear, and how farms may change shorebird foraging activity. During the 2016 crab spawning season, a series of experiments were conducted in the Delaware Bayshore region to assess the ability of crabs to move around and among oyster farms to mate and spawn, and to survey the spatial distribution of dislodged eggs upon which Red Knots feed. These experiments included (1) testing rack heights for impairment of crab passage, (2) repeated crab census on paired farm/control sites to test if crabs avoid farms, and (3) spatial survey of dislodged egg distribution along the wrack zone. All crabs, regardless of size, passed easily beneath racks 10 cm (4 inches) or more above the bottom. Thus, regulated rack height of 30.5 cm (12") should be sufficiently precautious to allow crab movement beneath racks. The crab census observed 853 crabs total, with no evidence of a difference in crab numbers among farmed and control transects ($p=0.3$, paired Wilcox signed-rank test). In total, 2 out of 853 (<0.5%) crabs were observed to be impeded by racks. Crab eggs washed up in the wrack zone were distributed unevenly throughout the survey region. Dislodged eggs were observed most frequently in the central portion of the survey area, and were not concentrated in the area of farms suggesting that in 2016, Red Knot foraging opportunities were not spatially coincident with farm locations.

ANCIENT CLAM GARDENS AS NURSERY GROUNDS: HOW DO SHELL HASH ADDITIONS AFFECT SETTLEMENT AND SURVIVAL?

Daphne Munroe[1*], Laura Gray[2], Amy Groesbeck[2], Anne Solomon[3], Dana Lepofsky [3], and Kirsten Rowell[2]
[1]Rutgers University, Haskin Shellfish Research Laboratory, 6959 Miller Ave., Port Norris, NJ 08349
[2]University of Washington, Biology Department, 24 Kincaid Hall, Seattle, WA 9810
[3]Simon Fraser University, 8888 University Dr., Burnaby, BC V5A 1S6, Canada
dmunroe@hsrl.rutgers.edu

At least 2000 years ago, coastal First Peoples from the North Pacific began constructing and actively managing "clam gardens". These features are characterized by rock walls built at the lower tidal limit of beaches, which effectively back-filled the intertidal, decreased beach slope, and extended the area of optimal clam habitat. In intertidal surface sediments, grain size and inorganic carbon content are important characteristics controlling settlement and post-settlement survival. These sediment characteristics were tested as a driving mechanism for increased clam productivity observed today in clam gardens relative to non-walled beaches. Survey data from Quadra Island, British Columbia, reveal that clam gardens have (1) on average four times more calcium carbonate, which likely buffers pH at the sediment-water interface and increases the chances of settlement, and (2) more coarse-grained sediment (particles >1mm), which may increase post-settlement survival. These qualities correlate positively with surveyed abundance of adult clams. Furthermore, a sediment transplant experiment was run to test how changes in sediment characteristics may alter settlement and early survival. Three treatments (clam garden sediment, non-clam garden sediment, 100% shell hash) were deployed at randomly stratified intertidal plots on a clam garden site. Plots were sampled over 14 months and examined for differences in larval settlement and juvenile survival. Early results suggest an ontogenic trend such that larger juveniles (>1000µm) are found in higher abundance in clam garden sediments.