INTERNATIONAL CONFERENCE ON SHELLFISH RESTORATION

ICSR/2008

11th International Conference on Shellfish Restoration

NO. 11

ABSTRACTS & SELECTED PRESENTATIONS

ICSR/2008

Oral & Poster

PRESENTATION ABSTRACTS

▶ **LARGE SCALE OYSTER RESTORATION IN THE MARYLAND PORTION OF THE CHESAPEAKE BAY: ADAPTIVE MANAGEMENT FROM SITE SELECTION AND PLANTING TO MONITORING.** Allen, S. M. (1), S. Abel (2), (1, 2) Oyster Recovery Partnership, 1805 A Virginia Street, Annapolis, MD, 21401, USA.

Oyster restoration in the Maryland portion of the Chesapeake Bay is a controversial topic often subject to public scrutiny. Each tributary of the Chesapeake has its own set of challenges that need to be surmounted for a restoration strategy to prove successful. Unfortunately, there is no manual or set of BMPs to guide our efforts. Most of the current restoration effort has focused in areas of lower salinity (5-12ppt). The goal of this strategy is to maximize survival and ecosystem services. Future restoration practices aim to focus on areas that have a higher likelihood of receiving natural spat sets. The ideal outcome is a self-sustaining natural system; to reach that goal, hatchery produced seed will be needed to jumpstart populations. The Oyster Recovery Partnership (ORP) is a non-profit organization founded in 1994 to accomplish the goals set forth by Maryland's Oyster Roundtable Action Plan. We currently use adaptive management practices to enhance restoration efficiencies. With our partners, NOAA, MDDNR, ACOE, MWA and UMD, we are continuously refining our techniques to restore areas with the best potential of success. In recent years, we have combined the practical knowledge of watermen with side scan sonar profiles of the bay bottom and SCUBA diver surveys to determine optimal restoration sites. Our efforts have contributed to the restoration of over 1,000 acres of oyster habitat.

▶ **CONDITION AND SIZE DISTRIBUTION OF OYSTERS (*CRASSOSTREA VIRGINICA*) IN INTER-CONNECTED, MODERATELY IMPACTED TIDAL CREEK ESTUARIES.** Alphin, T. D. (1), M. H. Posey (2), S. M. Colosimo (3), A. L. Markwith (4), (1) University of North Carolina Wilmington, Center for Marine Science, Wilmington, NC, 28409, USA, (2) University of North Carolina Wilmington, Dept. of Biology and Marine Biology, Wilmington, NC, 28409, USA, (3, 4) University of North Carolina Wilmington, Center for Marine Science, Wilmington, NC, 28409, USA.

Oysters, *Crassostrea virginica*, are the dominant structure in the intertidal portion of tidal creek systems in southeastern North Carolina and much of South Carolina and Georgia. Over the last four decades, development (residential and commercial) in the areas surrounding these estuaries has accelerated. Runoff from increasing expanses of impervious surface and active construction impacts these tidal creeks in both chronic and acute ways. Resulting changes in water quality may, in turn, significantly impact the oyster populations in these systems. Here we present data from three tidal creeks in southeastern North Carolina (Hewlett, Howe, and Pages) that have experienced moderate impacts to water quality. These creek systems are similar in size and drainage basin but differ in the amount of impervious surface within each watershed and are currently experiencing different amounts of active development. All of these creeks are interconnected via the intercoastal waterway, with Howe and Pages Creeks located north of Mason Inlet (2 km and 4 km respectively) and Hewletts Creek located south of Masonboro Inlet (~ 3 km). Here we compare data on size distribution of oysters, condition and overall oyster coverage. Some seasonal and creek differences are evident with winter samples showing higher condition levels overall.

▶ **THE DELAWARE BAY OYSTER (*CRASSOSTREA VIRGINICA*) RESTORATION PROGRAM.** Babb, R. M. (1), J. Hearon (2), E. Powell (3), D. Bushek (4), C. Tomlin (5), (1, 2) NJ Division Of Fish & Wildlife, Marine Fisheries Administration, Shellfisheries, 1672 E. Buckshutem Rd., Millville, NJ, 08332, USA, (3, 4) Rutgers University - Haskin Shellfish Research Laboratory, 6959 Miller Ave., Port Norris, NJ, 08349, USA, (5) NJ Division Of Fish & Wildlife, Marine Fisheries Administration, Shellfisheries, 1672 E. Buckshutem Rd., Millville, NJ, 08349, USA.

Initiated in 2005, the Delaware Bay shell-planting program was designed specifically to address the issue of inadequate oyster recruitment across the natural oyster beds and to improve habitat sustainability. Shell is the basic material required for oyster recruitment and the formation of beds and reefs. New Jersey's oyster beds were losing shell at a rate of hundreds of thousands of bushels annually. Without increased recruitment, this loss would result in the deterioration of oyster habitat and accelerate declines in oyster abundance. As oyster abundance and oyster shell decline, so will oyster reef associated fauna and the ecosystem services provided by the oysters and the habitat they create. Using federal funding obtained for activities in 2005, 2006 and 2007 by the Oyster Industry Revitalization Working Group and the State's Congressional delegations, the objectives of this program are being achieved. Shell planting has had a positive influence on habitat sustainability. In 2007, the shell budget of the New Jersey oyster beds was in relative balance for the first time in nearly a decade. Furthermore, oyster abundance has risen significantly on a number of major oyster producing beds. For example, on the Shell Rock seed bed in New Jersey (a bed that accounts for approximately 25% of the annual harvest) oyster abundance has increased by a factor of 1.75, with a significant increase in the number of juvenile oysters (0.75-2.5") on this critical bed. Continued attention is necessary to maintain production of commercially fished oyster beds. The success of this project to date results from multi-agency and multi-state partnerships working collaboratively with the industry in a uniform effort to restore a valuable natural resource.

▸ **ECOLOGICAL CONSIDERATIONS FOR OYSTER RESTORATION: INTERACTIONS BETWEEN OYSTER LARVAE AND REEF-ASSOCIATED FAUNA.** Barnes, B. B. (1), M. W. Luckenbach (2), P. R. Kingsley-Smith (3), (1, 2) Virginia Institute of Marine Science, PO Box 350, Wachapreague, Virginia, 23480, USA, (3), SC Dept of Natural Resources, 217 Fort Johnson Road, Charleston, SC, 29412, USA.

Oyster restoration efforts typically involve the addition of hard substrates to increase the opportunities for oyster larvae to settle. This approach is often employed without regard to how other organisms may utilize the new substrate, and how these organisms may affect the recruitment of oyster larvae. Fouling epifauna are generally believed to reduce the recruitment of interspecific larvae through competitive exclusion and predation. Studies of these interactions, however, often utilize artificial settlement panels, which can exhibit different recruitment patterns to those observed on natural substrates. We therefore investigated the interactions between reef-associated fauna and settling oyster larvae on natural shell substrates. Over a series of laboratory microcosm studies, native (*Crassostrea virginica*) and non-native (*Crassostrea ariakensis*) larvae were exposed to reef-collected shells, each supporting a single species of reef-associated fauna. While the presence of adult bryozoans (*Membranipora tenuis*) and the boring sponge (*Cliona* sp.) had no significant effect on oyster larval settlement, barnacles (*Balanus improvisus*) significantly facilitated settlement. Increased settlement was proportional to barnacle density for *C. ariakensis* larvae, but independent of barnacle density for *C. virginica* larvae. Barnacle molds and empty barnacle tests, intended to mimic the surface area and rugosity of live barnacles, did not significantly affect settlement. Adult barnacle bathwater, however, enhanced settlement of both oyster species, implicating the role of waterborne cues. Predation by clamworms (*Neanthes succinea*), which were found at high densities on field-collected oyster shells, caused significant oyster larval mortality in our experiments. The combined roles of both positive and negative interactions between oyster larvae and reef fauna require enumeration under field conditions. Our results highlight the need for the clarification of these roles in order to optimize our restoration efforts.

▸ **TREATY FISHERIES CHALLENGES AND OPPORTUNITIES IN PUGET SOUND, WASHINGTON.** Barry, V., Suquamish Tribal Fisheries Department, P.O. Box 498, Suquamish, Washington, 98392, USA.

Fisheries management in Washington State presents unique concepts not shared by other states or provinces in North America. After more than a century of state policies ignoring treaty rights, a consortium of Washington Tribes that had signed federal treaties in the 19th century took legal action against the state. Litigations occurred in the Supreme Court twice; once in 1974 for salmon and again in 1994 for shellfish and other finfish species. The court ruled in favor of the Tribes in both instances, reaffirming their treaty rights which entitle them to fish and hunt for subsistence and commerce on traditional lands and water. Following this ruling the court ordered specific co-management directives to all parties involved. These directives are based on equal sharing of fishing opportunities, determined by the total annual allowable catch for each species. Annual harvest rates are determined for all species in the state waters through a series of co-management principles. The 1994 court case also reiterated the right to harvest half of the biomass of naturally occurring bivalves on privately owned tidelands. Along with some state-tribal disagreement on management principles, much of the challenge experienced by treaty co-managers resides with many tribes' overlapping Usual and Accustomed Areas (U&A), and exercising their rights to harvest shellfish on private tidelands. However, tribes play a crucial role as environmental stewards and hold a tremendous potential to help improve environmental standards. This presentation will depict an overview of the schematic and role of treaty fisheries management in resource conservation through current and historical practices as experienced by the Suquamish Tribe.

SHELLFISH REEFS AT RISK: A GLOBAL ASSESSMENT OF CONDITION AND THREATS. Beck, M. W. (1), R. Brumbaugh (2), L. Airoldi (3), A. Carranza (4), O. Defeo (5), B. Hancock (6), H. Lenihan (7), L. Coen (8), M. Luckenbach (9), T. M. Caitlyn (10), (1) The Nature Conservancy, 100 Shaffer Road, LML, Santa Cruz, CA, 95060, USA, (2) The Nature Conservancy, PO Box 420237, Summerland Key, FL, 33042, USA, (3) Università di Bologna, Via S. Alberto, 163, Ravenna, Emilia-Romagna, I-48100, Italy, (4) Faculty of Sciences, Igua 4225 Street, Montevideo, Montevideo, 11400 , Uruguay, (5) Faculty of Sciences, Igua 4225 Street, Montevideo, Montevideo, 11400 , Uruguay, (6) The Nature Conservancy, University of Rhode Island Bay Campus, Narragansett, RI, 02882, USA, (7) Donald Bren School of Environmental Science and Management, Bren Hall 3428, Santa Barbara , CA, 93106 , USA, (8) Sanibel-Captiva Conservation Foundation, 900A Tarpon Bay Rd., Sanibel, FL, 33957, USA, (9) Virginia Institute of Marine Science, Eastern Shore Laboratory, Wachapreague, VA, 23480, USA, (10) The Nature Conservancy, 100 Shaffer Road, LML, Santa Cruz, CA, 95060, USA.

We provide the first direct, global estimates for the condition of a subtidal marine ecosystem. Many reefs formed by bivalve shellfish are at high risk of functional extinction globally. For more than 130 bays and most (50+) of the ecoregions in which they occurred in abundance, the condition of oyster reefs is poor or worse. In most bays and ecoregions, oyster reefs are at less than 10% of prior abundance and in some reefs are another order of magnitude lower (< 1%) than that in abundance and functionally extinct. Shellfish have been managed on a bay-by-bay basis with little consideration of the regional much less global pattern in ecosystem decline. These reefs have not been managed as ecosystems or for the services they could provide in coastal bays and estuaries. We identify sensible solutions that could help reverse these losses.

METHODOLOGY OF MONITORING: AN EFFECTIVE TOOL FOR THE MANAGEMENT OF MALACOLOGICAL ISSUES. Benga, A.G.F., University of Ziguinchor, BP 523 Ziguinchor, Senegal.

Monitoring is a continuous observation process, on a given period, which provides basic data used to quantify dynamics, the determining factors of a resource, or possibly to work out a practice. It can call for various observation scales, an interesting element for research in geography. Monitoring presupposes a suitable methodology and specific scientific objectives, especially in the absence, or even the insufficiency, of quantitative and qualitative information supporting a good knowledge and management of malacological resources. It integrates the environmental context and socio-economic practices around which the observed activity that permits to identify indicators takes place. Sometimes the attacks on natural resources induce the recourse to the monitoring methodology and also support the ambition to manage natural resources. The need to get accurate data on the available or exploited stock is among fundamental parameters justifying the sustainability of this exploitation. On the basis of a concrete example, one can note that there is no absolute method, but the monitoring technique, beside other methods, is proving to be particularly efficient and, above all, less expensive. This study, carried out in Senegal, showed that contrary to spread appearances, the risks of arks' "overexploitation" under present conditions were unreal or overestimated. This reflection does not exclude the need to keep on refining indicators in order to guarantee the sustainability of *Anadara senilis L* (1758) collecting activity.

▸ MOLLUSCS TRADITIONAL EXPLOITATION IN SENEGAL: *ANADARA SENILIS L.* (1758). BIOLOGICAL POTENTIALITIES AND RISKS.

Benga, A.G.F., University of Ziguinchor, BP 523 Ziguinchor, Senegal.

The Saloum Delta is a significant part of the Senegalese fisheries because it represents one of the areas where malacological selective collect, mainly *Anadara senilis L.* (1758), holds an important place in the village economy, which benefits the local women. The exploitation of these natural resources requires an examination of the operating mode of this activity. For several years, indices of overexploitation have been evoked. Consequently, an assessment of the available resources and the selecting level are necessary. Are the downswings of the medium productivity per day as well as the reduction of the average size of the selected arks sufficient to justify the overexploitation noticed? The combination of several research methods (follow-up based on socio-economic considerations, finding of indices but also assessment of the available stocks) provided interesting results. From the potentiality-extraction ratio, the reflection leads to a discussion on the situation of overexploitation and the biological rest for this species at the local scale. The conclusions open some prospects for rational exploitation and identification of selecting threshold, for a sustainable exploitation of the resource as no more than 65% of the available stock is exploited. Moreover, the effectiveness of the device of follow-up produces results of a high degree of accuracy which explain the periodic variations of the taking away effort. The existence of strategic factors, such as naturally controlling traditional exploitation, and the manual character of the activity appear as main factors regarding the dynamics of this littoral resource. However, there is still a difficulty: The concern of keeping a balanced approach between a socio-economic motivation on the basis of selective collection and an ecological sensibility in order not to forget the conservation of the biological potential.

▸ LIVING OYSTER REEF SHORELINES USING ALTERNATIVE SUBSTRATE IN THE LYNNHAVEN RIVER, CHESAPEAKE BAY, VIRGINIA.

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Ecological restoration of the eastern oyster with the Chesapeake Bay has been a long-term multi-agency effort. The Lynnhaven River Watershed in Virginia Beach is the location of the once-famed Lynnhaven Fancies - oysters prized for their flavor in the early 20th century. In present day, this watershed suffers from the effects of urbanization and developed shorelines. Use of living shorelines has been a strategy of Lynnhaven River 2007 (LR07), a local community group geared toward rehabilitating the watershed, the Virginia Institute of Marine Science (VIMS) and the Chesapeake Bay Foundation (CBF). With the U.S. Army Corps of Engineers (USACE) - Norfolk District constructing up to 111 acres of oyster reefs (2007 through 2011) in the Lynnhaven River system, this project is of particular interest. In the summer of 2006, just below mean low water, we constructed twelve structures at each of two sites: Three oyster shell reefs, three rip rap reefs, and six stacked sets of two to four concrete modular reefs. They were oriented side-by-side with ~2' spaces between them for a total linear distance not exceeding 54'. In addition, we placed six reef balls at each site; half were seeded with oysters in controlled settings pre-deployment. The primary purpose of this construction was the development of healthy oyster reef habitat - a living shoreline. The secondary purpose is to monitor the comparative success between the reef types with respect to oyster recruitment, growth, survival, and reef structural integrity. This project has offered a unique opportunity to enhance local oyster growth, water quality, and provide the scientific community (USACE, VIMS, CBF, LR07) with important insights regarding oyster reef restoration in the Lynnhaven River system.

▸ **THE DELAWARE ESTUARY LIVING SHORELINE INITIATIVE (DELSI).** Bushek, D. (1), J. Moody (2), D. Kreeger (3), A. Padeletti (4), L. Whalen (5), (1, 2) Rutgers University, Haskin Shellfish Research Laboratory, Port Norris, NJ, 08349, USA, (3, 4, 5) Partnership for the Delaware Estuary, One Riverwalk Plaza, Wilmington, DE, 19801, USA.

Habitat restoration is a fundamental component of the overall strategy to improve ecological conditions within the Delaware Estuary. An emerging priority is the need to develop restoration and enhancement tactics to help offset multiple threats to tidal marsh habitats, which are a hallmark feature of this watershed. The goal of this project is to enhance and protect tidal marshes using intertidal shellfish reefs to "soft armor" shorelines that are suffering heavy erosion from sea level rise and other factors. Fringing oyster reefs are not a prominent feature in the Delaware Estuary, but ribbed mussels (*Geukensia demissa*) often form dense aggregations along marsh edges. Shoreline erosion appears most severe along edges having little or no intertidal mussels. DELSI seeks to arrest shoreline erosion by deploying natural substrates that will enable shellfish communities to become established through natural recruitment and/or directed seeding. During summer 2008, coconut fiber (coir) mats and logs and shell bags were deployed at three sites along a gradient of energy and erosion near the mouth of the Maurice River, NJ. During the upcoming year we will quantify physical and biological responses to the installations relative to controls in order to compare the effectiveness of various combinations of logs, mats and shellbags to their installation costs. We will also test whether seeding mussels onto the treatments enhances recruitment and accelerates establishment of mussel-based communities along the marsh edge. Ultimately, DELSI should provide a new strategy to halt shoreline erosion and protect vital marsh habitats with ribbed mussel populations, which also furnish other important ecosystem services.

▸ **SHELL SHAPE AND MOLECULAR PHYLOGENY OF *NASSARIUS HEPATIEUS* (MOLLUSCA: GASTROPODA: NASSARIDAE).** Cai Li-zhe (1) Wang Wen (2), (1, 2) State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, 361005, China.

Many species of Nassariidae animals have been found in Chinese Coast, but their morphological classification is incomplete. Five different shell shape individuals of *Nassarius hepatieus* were bought in market near Xiamen University. Their 18S rDNA and COI gene sequences and phylogeny were investigated. The results showed there was little difference among individuals of *Nassarius hepatieus* in shell shape. The contents of four bases in the 18S rDNA gene among five individuals were closed, at the range of 23.6%-27.5%, A + T was almost equal to G + C. But in the COI gene fragments, the content of base T was higher than base C. 18S rDNA was 1800 bp in length, of which, 3 sites were variable. COI gene was 500 bp in length, of which, 11 sites were variable, and 10 sites occurred in the third codon position and 1 site in the first codon position. The nucleotide variation of COI gene resulted in no variation of deduced amino acid sequences. It was considered there existed diversity in shell shape and genetic polymorphism of *Nassarius hepatieus*. The shell shape difference may not be a factor of heredity, but of exterior factors.

▶ **GAMETOGENESIS AND SPAWNING IN *CRASSOSTREA VIRGINICA* FROM DISEASE-INTENSE WATERS OF VIRGINIA, USA.** Carnegie, R. B. (1), E. M. Burreson (2), (1, 2) Virginia Institute of Marine Science, Route 1208 Greate Road, Gloucester Point, VA, 23062, USA.

Disease dominates perceptions of challenges facing *Crassostrea virginica* restoration efforts. Chronic susceptibility to *Haplosporidium nelsoni* and *Perkinsus marinus* parasitism (MSX and dermo diseases, respectively) is widely assumed. While abundant emerging data suggest this assumption is not valid, the mechanisms by which oyster populations resist or tolerate MSX and dermo diseases are still unclear. We are studying the effects of parasitism on oyster reproduction, through analysis of oysters at three disease-intense Chesapeake Bay locations (in the Great Wicomico, Rappahannock, and Lynnhaven Rivers) and on the seaside Eastern Shore of Virginia. Oysters in four size classes are being evaluated – < 50 mm, 50-76 mm, 76-100 mm, and > 100 mm – and data collected monthly on parasite prevalences and infection intensities, gametogenic stages, and gonadal area and condition indices. Initial observations favor oysters in their interactions with *H. nelsoni* and *P. marinus*. Large proportions of oysters surviving the previous year's seasonal epizootic produce gametes and spawn, and many do so prior to September and October when *P. marinus* activity peaks. The occurrence of heavy, early season *H. nelsoni* and *P. marinus* infections that arrest gametogenesis is rare. In Chesapeake Bay, disease is greatest in smaller (MSX disease) to intermediate-sized (dermo disease) oysters, a further indication that a proportion of the population passes through multiple windows of disease challenge, grows to large sizes and high fecundities, and thus has the potential to contribute disproportionately to reproduction. While disease continues to kill large numbers of *C. virginica* annually, the potential of sanctuary populations or networks to be locally self-sustaining, particularly where physical conditions favor regular recruitment cannot be discounted.

▶ **DETERMINING HABITAT SUITABILITY USING GROWTH AND SURVIVAL OF BAY SCALLOP (*ARGOPECETEN IRRADIANS*) GENETIC LINES.** Choromanski, J. (1), S. Stiles (2), D. Jeffress (3), (1, 2, 3) DOC/NOAA/NMFS/NEFSC, 212 Rogers Avenue, Milford, CT, 06460, USA.

Laboratory-spawned lines of bay scallops (*Argopecten irradians*) were used to evaluate the habitat suitability of three sites in Connecticut on Long Island Sound for possible stock enhancement. The Niantic River site has a historic precedence as a scallop habitat that has recently had difficulty retaining and recruiting bay scallop populations. The open water site is located off of Bridgeport and has a depth of approximately 10 meters. The final study site is located in the raceway system on the Milford lab property. The raceway tanks are 10m x 1m x 0.5m and typically have a flow rate of 60 L/min. For the off property sites we will continue to test the effectiveness of commercial three-tiered, rigid-meshed cages to overcome scallops' propensity to migrate away from the deposit point. The scallops were spawned in March and held in temperature controlled tanks in the laboratory at 22˚ C until May when ambient sea water temperature reached about 15˚ C. The scallops were then acclimated to the lower temperature and distributed in outdoor raceway tanks. In late July, scallops were deployed at each site with a stocking density of 100 scallops per shelf or 300 scallops/m^2. Cages were checked monthly to the end of the experiment to determine survival and growth, with added attention to shell indentations that might indicate density problems, and to check and remove fouling organisms. Sample observations of water quality and phytoplankton productivity were also taken. Results from this comparative study will help in determining which habitat will support growth in cages and test the selection of genetic lines for faster, more efficient growth.

Oral & Poster

PRESENTATION ABSTRACTS

▸ **RESTORING SHELLFISH IN GREAT SOUTH BAY, LONG ISLAND, NEW YORK, TO ENHANCE ECOSYSTEM, ECONOMIC, AND SOCIAL VIABILITY OF A SUBURBAN ESTUARY.** Clapp, C. S. (1), C. P. LoBue (2), G. T. Greene (3), (1, 2) The Nature Conservancy, 250 Lawrence Hill Rd, Cold Spring Harbor, New York, 11724, USA, (3) Cashin Associates, 1200 Veterans Memorial Highway, Happauge, NY, 11788, USA.

The Great South Bay on Long Island's south shore has been historically important in the formation of many communities. Beginning with the founding of the Hamlet of Sayville by the Dutch community in the late 1600's and continuing to the booming hard clam industry of the 1970's, the harvest of shellfish was once the economic and recreational backbone of many Long Island communities. Increasing population densities and harvest pressure has lead to the demise of native oysters and historic lows of hard clam populations. In 2004, The Nature Conservancy on Long Island completed the acquisition of 13,400+ acres of underwater land in central Great South Bay from the defunct Bluepoint Oyster Company. To date, The Nature Conservancy has stocked over 3 million adult hard clams into a network of over 50 spawner sanctuaries on this property to boost the reproductive potential of hard clams within the bay. A recreational shellfish harvest survey was performed throughout summer 2008 to assess the intensity of recreational harvest pressure on the fishery and to determine the social value of this recreational activity. The results of the survey and other monitoring data will be presented.

▸ **EVALUATING OYSTER SHELL ALTERNATIVES FOR ENHANCING/RESTORING SHELLFISH BEDS AND ASSOCIATED IMPACTS.** Coen, L. D. (1), K. Schulte (2), A. Powers (3), L. Taylor (4), (1) Sanibel-Captiva Conservation Foundation Marine Laboratory, 900A Tarpon Bay Rd., Sanibel, FL, 33957, USA, (2, 3, 4) MRRI-SCDNR, 217 Ft. Johnson Rd., Charleston, SC, 29412, USA.

Oysters are unique in that they form the actual living reef structure and support a host of other associated organisms (over 300 spp. in NC and over 134 spp. in SC) generally not found in surrounding sand or mud habitats. Intertidal and subtidal oysters create complex habitat utilized by fish, crustaceans, bivalves, numerous other mobile and sessile invertebrates, birds, and mammals. Reefs can often match salt marshes in terms of diversity of associated organisms. Reefs closed to harvesting still provide nearly all of the ecosystem services such as supporting large numbers of species, acting as brood stock sanctuaries, supplying larvae to other areas, filtering water, and acting as living bulkheads protecting more fragile intertidal habitats. Given that oyster and whelk shell are getting rare and that they are very costly or impossible to procure throughout their natural range, we evaluated available alternative materials (e.g., concrete, fossil shell, limestone, natural oyster shell) as substrates for the settlement of oysters for restoration efforts. We assessed these materials in replicated footprints side by side within the Cape Romain National Seashore and on an intertidal shoreline near Charleston SC. Along with their progress (oyster accumulation, material retention, ability to reduce fringing marsh erosion), we employed some new approaches for assessing restoration progress, as well as shoreline contours and erosion over time. Results and potential utility of the above are discussed.

▸ **GENETIC EVALUATION OF RECRUITMENT SUCCESS OF DEPLOYED DOMESTICATED OYSTERS ON A MAN-MADE REEF IN THE GREAT WICOMICO RIVER, VIRGINIA.** Cordes, J. F. (1), J. Carlsson (2), M. W. Luckenbach (3), S. J. Furiness (4), K. S. Reece (5), (1) Virginia Institute of Marine Science, P.O. Box 1346, Gloucester Point, VA, 23692, USA, (2) Duke University Marine Laboratory , Nicholas School of the Environment and Earth Sciences, Beaufort, NC, 28516-9721, USA , (3) Virginia Institute of Marine Science, VIMS Eastern Shore Laboratory, Wachapreague, VA, 23480, USA, (4, 5) Virginia Institute of Marine Science, P.O. Box 1346, Gloucester Point, VA, 23692, USA.

An increasingly common strategy in the restoration of degraded oyster populations has been the addition of either wild or hatchery-produced oysters onto sanctuaries to serve as spawning stock. Between 2002 and 2007, the Army Corps of Engineers (ACOE) and the Chesapeake Bay Foundation (CBF) seeded Virginia's Great Wicomico River (GWR) with approximately 15.5 million domesticated, disease-selected aquaculture oysters (DEBYs), with the majority (>90%) going to one man-made reef (Shell Bar Reef). To study the reproductive success of deployed oysters and determine their genetic impact on the standing stock at Shell Bar Reef, we collected naturally-produced spat and used mitochondrial (mtDNA) and nuclear microsatellite markers to determine their wild, domesticated, or hybrid origin. Spat were collected bi-monthly from June to October between 2002 and 2007 at six sites surrounding Shell Bar Reef using wire mesh bags filled with oyster shell and suspended in the water column. Genotyping of these spat using mtDNA markers revealed no appreciable self-recruitment of DEBY-produced spat to Shell Bar Reef. Additional screening of a subset of these spat from 2006 and 2007 using nuclear microsatellite loci were performed to validate the mtDNA analyses and gave similar results. In addition, microsatellite screening of adults at Shell Bar Reef and four other sites up and down river in 2007 indicated that while adult DEBY oysters persisted on Shell Bar Reef, few or no DEBY or DEBY/Wild hybrid adults were found at the remaining sites. Various hypotheses to explain the apparent lack of reproductive success of the deployed DEBY oysters will be presented and the broader implications for this restoration strategy discussed.

▸ **SHIFTING THROUGH TIME: OYSTERS AND SHELL RINGS IN PAST AND PRESENT SOUTHEASTERN ESTUARIES.** Dame, R. F., Coastal Carolina University, 180 Ashley Ave., Charleston, SC, 29403, USA.

Oysters and oyster reefs are important components in the rich and productive southeastern US marsh-estuarine ecosystems. These complex systems are frequently impacted by natural and anthropogenic stresses to which they may respond by reorganizing into another alternate state or regime. Beginning about 4500 B.P., the local Indians built complex structures or oyster shell rings on the landward side of the sea islands. The construction of shell rings is thought to symbolize the conversion of nomadic hunter-gatherers to coastal fisherfolk and is considered a pivotal stage in the evolution of pre-European contact culture in the United States. However, by 3000 B.P., the shell rings were abandoned and the Indians dispersed. With the objective of learning from the past to manage for the future, the Fig Island shell ring system near Charleston, SC is analyzed using ecological comparisons with modern oyster systems, published archaeological and geological data, as well as reverse engineering approaches. In just a few years, the Indians built the Fig Island shell ring using over 1.2 billion oysters. Had these oysters not been removed from the system, they would have cleared or filtered a water mass the size of North Inlet 6-8 times per day. This exercise examines the evidence on how the prehistoric system might have changed or shifted in response to the massive removal of oysters to build shell rings and concurrent changes in the natural environment.

▸ **THE ROLE OF MONITORING IN SHELLFISH RESTORATION: A CASE STUDY OF A HARD CLAM (*MERCENARIA MERCENARIA*) RESTORATION EFFORT IN LONG ISLAND, NEW YORK.** Doall, M. H. (1), D. K. Padilla (2), C. P. Lobue (3), C. Clapp (4), W. Grothe (5), A. R. Webb (6), (1, 2) Stony Brook University, Department of Ecology and Evolution, Stony Brook, NY, 11794-5245, USA, (3, 4) The Nature Conservancy, Uplands Farm Sanctuary, Cold Spring Harbor, NY, 11724, USA, (5) The Nature Conservancy, The Center for Conservation, East Hampton, NY, 11937, USA, (6) Stony Brook University, Department of Ecology and Evolution, Stony Brook, NY, 11794-5245, USA.

Monitoring is an essential component of shellfish restoration. It is needed to measure success and guide the adaptive management of restoration strategies, and can provide important information that is otherwise difficult if not impossible to gain through experimental or laboratory studies. Here, we present a case study of how monitoring has been integrated with a large-scale hard clam restoration effort led by The Nature Conservancy (TNC) in Long Island, New York. To restore hard clams and the ecosystem services they provide, TNC has been transplanting large numbers of adult clams into localized, harvest-free areas, creating a network of spawner sanctuaries throughout Long Island bays. The goal is to boost recruitment in these bays by increasing spawning stocks and fertilization efficiencies, thereby allowing hard clams to naturally repopulate and become self-sustaining once again. The success of this strategy requires that the transplanted clams survive, spawn, recondition, and spawn again in subsequent years. Results from 4+ years of monitoring have shown that while transplanted clams do indeed survive, spawn, and recondition, there is large variability among transplant locations, source populations of clams, clams of different sizes, and high interannual variability. This information has been used to help select the most favorable source populations and sites for transplant to help maximize the longevity and spawning potential of transplant populations and chances of restoration success. This work also indicates that short-term assessments are inadequate for determining the success of restoration for long-lived species such as *Mercenaria*.

▸ **SITE SUITABILITY ANALYSIS FOR OFFSHORE SEA SCALLOP (*PLACTOPECTEN MAGELLANICUS*) AQUACULTURE, MARTHA'S VINEYARD, MASSACHUSETTS.** Edmundson, S. A. (1), A. Frankic (2), (1) University of Massachusetts, Boston, 159 Main Street Box 8, Vineyard Haven, MA, 02568, USA, (2) University of Massachusetts, Boston, 100 Morrissey Blvd., Boston, MA, 02125, USA.

Global catch data reveals that harvests from the world's wild fisheries are approaching exhaustion. Expansion within the field of aquaculture would give promise to an increase in seafood. Aquaculture projects offer a plan that could result in providing an additional source of fish, while stimulating employment opportunities for fishing communities that have been left stagnant from diminishing fisheries. As coastal areas become more populated, suitable near shore sites for aquaculture are scarce. As a result, a focus on offshore sites that might accommodate both spatial and environmental requirements is sensible. This project, aimed at determining the suitability of sites for a sea scallop aquaculture venture offshore the island of Martha's Vineyard, Massachusetts, was undertaken with the hope of giving assistance to the rejuvenation of the island's fishing heritage. Through the use of Geographic Information System (GIS) software, areas offshore the island were mapped according to the environmental requirements for sea scallops and the potential conflicting uses within the area. The overlapping areas resulting from these analyses display many promising sites for a sea scallop aquaculture project. Though a lack of available spatially defined offshore data limits a definitive examination of suitable sites, and the eventual incorporation of more information involving socioeconomic data and current fishing effort is needed before the optimum site for sea scallop aquaculture can finally be selected, reliable advances were made in determining the general suitability of an aquaculture venture off the island's shores.

▸ **A COMMUNITY-BASED OYSTER RESTORATION STRATEGY FOR DELAWARE'S COASTAL (INLAND) BAYS.** Ewart, J. W. (1), E. Chalabala (2), F. Marenghi (3), A. Gibson (4), (1) Delaware Sea Grant Marine Advisory Program, College of Marine and Earth Studies, Lewes, DE, 19958, USA, (2) Delaware Center for the Inland Bays, 39379 Inlet Road, Rehoboth Beach, DE, 19971, USA, (3, 4) Department of Agriculture and Natural Resources, Delaware State University, Dover, DE, 19901, USA.

Delaware's three coastal "inland" bays (Rehoboth, Indian River and Little Assawoman) have been experiencing the impacts of chronic eutrophication, sediment erosion, habitat and water quality degradation resultant from several decades of sustained nutrient input from within the surrounding watershed and increasing suburban development. While current abundance and distribution of wild oysters in the estuary is negligible, environmental conditions in all of the three Inland Bays have been shown to support good to excellent growth of transplanted oysters. Local interest and participation in oyster gardening, modeled after similar programs in the Chesapeake Bay, has rapidly expanded the Delaware Center for the Inland Bay's five-year old community-based program to 125 locations involving the volunteer efforts of 175 individuals with homes in residential lagoon communities within the estuary. Technical potential for commercial market production is also significant. Applied field research and demonstration work to evaluate the efficacy of using aquaculture methods for oyster restoration and commercial production has relied extensively on a private-public sector partnership. Local community involvement has played an integral role by providing policy guidance, materials, in-kind and other services, access to facilities and equipment, volunteers and the support of local municipalities. An oyster restoration strategy and related activities are reviewed including the use of rip rap, commonly found throughout the estuary for shoreline stabilization, as a three dimensional off-bottom substrate for oyster plantings as an alternative to development and maintenance of artificial reefs.

▸ **CAN STONE CRABS PROVIDE BIOLOGICAL CONTROL AGAINST SOUTHERN OYSTER DRILLS AND INCREASE EASTERN OYSTER SURVIVORSHIP?** Fodrie, J. (1), M. D. Kenworthy (2), S. P. Powers (3), (1, 2, 3) Dauphin Island Sea Lab, 101 Bienville Blvd, Dauphin Island, Alabama, 36528, USA.

Previous research has identified southern oyster drills (*Stramonita haemastoma*) as an important predator of eastern oysters (*Crassostrea virginica*) within the northern Gulf of Mexico, where drills can reach densities > 40 drill m^{-2}. In fact, drills are capable of generating > 90% oyster mortality within individual reefs. Because stone crabs (*Menippe adina*) prey on drills, a reasonable prediction would be that stone crabs could aid in biological control of drills and subsequently decrease oyster mortality. However, stone crabs also consume oysters. Therefore, predicting the patterns of oyster mortality when both oyster drills and stone crabs are present has remained difficult. We focused experiments on a three-tiered food web that included eastern oysters as the shared prey of oyster drills and stone crabs. We manipulated predator densities and prey vulnerability to explore how interactions between these two predators affect overall mortality of oysters. Field experiments demonstrated that drills and crabs foraging together generated higher than expected oyster mortality based on each species operating independently, even though crabs also killed some drills. In subsequent laboratory trials, we experimentally mimicked the handling of oysters by foraging crabs, and confirmed that crabs actually facilitated drills by breeching oyster valves, thereby granting easy access for drills to vulnerable oyster soft-body tissue. These interactions significantly enhanced mortality risk for a foundation species within an estuarine ecosystem.

▸ **EVALUATING SUCCESS OF OYSTER RESTORATION: DERIVING SUITABLE BENCHMARKS.** Hadley, N. H. (1), V. Shervette (2), M. Hodges (3), L. D. Coen (4), (1) SC Dept. Natural Resources, Marine Resources Division, 217 Ft Johnson Rd., Charleston, SC, 29412, USA, (2) Baruch Institute for Marine & Coastal Sciences, 607 EWS Building, Columbia, SC, 29208, USA, (3) SC Dept. Natural Resources, Marine Resources Division, 217 Ft Johnson Rd., Charleston, SC, 29412, USA, (4) Sanibel-Captiva Conservation Foundation Marine Laboratory, 900A Tarpon Bay Rd., Sanibel, FL, 33957, USA.

Evaluation of restoration success requires not only assessing the status of the restored area but also determining its progress relative to a target or benchmark. The biggest challenge for many restoration projects may be determining suitable targets. For oyster restoration, no standard exists that defines a "good" natural reef, either in terms of structure or function. In many areas of the country, natural reefs are no longer available for comparison, but in South Carolina we are fortunate to have abundant existing oyster reefs. Whether these are "good" relative to their historic counterparts, we have no way of knowing. We have collected oyster population information, and in some cases some habitat functioning information, from SC oyster reefs for more than a decade. This extensive dataset was used to evaluate different methods of establishing restoration goals. Resulting targets were used to evaluate success of large-scale and small-scale restored sites of varying ages in South Carolina. The strengths and weaknesses of the different evaluation methods and their applicability to intertidal oyster restoration will be discussed.

USING COMMUNITY-BASED RESTORATION AND RECREATIONAL AQUACULTURE AS TOOLS FOR WATER QUALITY IMPROVEMENT.
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There are many examples of successful grassroots efforts to improve water quality, but most of these are from freshwater systems. In conjunction with a community-based oyster restoration program, we have initiated several new efforts to involve coastal residents in water quality improvement efforts. These include adopt-a-creek efforts, water monitoring programs, and recreational aquaculture. Each type of program targets different segments of the coastal population but all have the common themes of promoting water quality awareness and fostering active stewardship. Our underlying premise is to empower citizens to take responsibility for water quality and to encourage them to acquire a "vested interest" in water resources through investment of personal time and energy. Public involvement and ownership of projects is expected to ensure continuation into the future and expansion to address additional environmental issues as these arise.

REEF-ASSOCIATED FAUNA IN CHESAPEAKE BAY: DOES OYSTER SPECIES AFFECT HABITAT FUNCTION?
Harwell, H. D. (1), P. R. Kingsley-Smith (2), M. L. Kellogg (3), K. T. Paynter, Jr. (4), M. W. Luckenbach (5), (1) Virginia Institute of Marine Science, P. O. Box 350, Wachapreague, Virginia, 23480, USA, (2) SC Dept. of Natural Resources, 217 Fort Johnson Road, Charleston, SC, 29412, USA, (3, 4) University of Maryland Center for Environmental Science, 0105 Cole Field House, College Park, Maryland, 20742, USA, (5) Virginia Institute of Marine Science, P.O. Box 350, Wachapreague, VA, 23480, USA.

The Asian oyster, *Crassostrea ariakensis*, is under consideration for introduction to Chesapeake Bay, yet its growth form and reef-building capabilities remain poorly described. Previous studies of the native oyster, *Crassostrea virginica*, indicate that reef morphology affects the development of reef-associated communities. If *C. virginica* and *C. ariakensis* differ in their reef morphology and habitat complexity, the communities that they support may also differ. As part of a larger study comparing the two oyster species, we characterized habitat complexity and investigated associated faunal assemblages at four locations within the Chesapeake Bay region. In the fall of 2005, at each location, caged experimental treatments (*C. virginica* only, *C. ariakensis* only, a 50:50 mix, and a shell only treatment) were established using sterile, triploid oysters. Locations were selected to cover a range of salinities, tidal elevations, relative predator abundances and disease pressures. Sampling was conducted over a 2-year period to evaluate reef-associated fauna in relation to oyster species, habitat complexity, and location. Our findings demonstrate that *C. ariakensis*, like *C. virginica*, is capable of forming complex reefs. Furthermore, subtle differences were found in reef morphology and habitat complexity between the two oyster species, particularly at locations of higher salinity. Differences in faunal assemblages were more pronounced along the salinity gradient (between sites) than along the habitat complexity gradient (within sites). Within-site treatment effects on community composition were observed, however, and were more prevalent at locations exhibiting greater between-treatment differences in habitat complexity. In particular, mobile reef predators, such as the striped blenny, *Chasmodes bosquianus*, and the skillet fish, *Gobiesox strumosus*, exhibited preferential utilization of species-specific oyster treatments, which may produce long-term differences in community structure.

▸ **OYSTER REEF RESTORATION AS ONE ASPECT OF COASTAL ECOSYSTEM SUSTAINABLE DEVELOPMENT.** Hillard, R. (1), N. Chambers (2), K. Walters (3), (1) Coastal Carolina University, Department of Marine Science, Conway, SC, 29528, USA, (2) inForm Studio, 83 Allen Street, NY, NY, 10002, USA, (3) Coastal Carolina University, Department of Marine Science, Conway, SC, 29528, USA.

Bivalves provide a variety of ecosystem services that include improving water quality. Commercial and residential development in coastal ecosystems has led to a decline in water quality. The effects of declining water quality are translated into adjacent coastal oceans and, in some instances, may be responsible for beach closings during peak summer tourist months. We are proposing the creation of oyster reefs within affected inlets and tidal creeks as one possible action to improve water quality and facilitate sustainable development. To test the feasibility and effectiveness of reef creation initial studies are being conducted within a series of swash inlets along the northern South Carolina coastline. Physical characteristics (e.g., salinity, organic matter) and oyster spat settlement are being sampled throughout the summer. Preliminary results suggest that rapidly changing salinity regimes from periodic runoff into the swash inlets may be a critical factor to overcome for the successful establishment of oyster reefs. Data on spat availability and post-settlement survival effects on oyster recruitment are being collected. Additional data also are being gathered on the effects of substrate type and live reef presence on settlement. Results should provide initial information on the feasibility of oyster reef creation as a means for improving water quality and facilitating sustainable development in coastal ecosystems.

▸ **DEVELOPING EDUCATION TOOLS FOR VARIOUS AGE GROUPS THROUGH A COMMUNITY- BASED RESTORATION PROGRAM.** Hodges, M. S. (1), N. Hadley (2), H. P. Nettles (3), V. Shervette (4), (1, 2, 3) SC Department of Natural Resources, Office of Fisheries Management, 217 Fort Johnson Rd., SC, 29412, USA, (4) Belle W. Baruch Institute for Marine & Coastal Sciences, University of South Carolina, Columbia, SC, 29208, USA.

Education and outreach is a critical and integral part of any community-based restoration program. Volunteers of all ages can aid in the success of restoring natural resources on many levels. All volunteers must receive the most basic information about any project to learn why their help is needed to assist with these efforts, and also to learn the importance of hands on restoration. However, more in-depth forms of education volunteers can be developed to give them insight on the complexity of the organisms that they are helping to restore. The education tools can be developed based on the age of the volunteer, grade levels in schools, and the amount of general of specific interest in the restoration program. Over the past 7 years, the South Carolina Oyster Restoration and Enhancement Program has developed numerous education tools to convey the importance of oysters to its volunteers. We have developed a suite of lessons and activities including online tutorials, presentations, laboratory exercises, simple experiments, observational field studies and volunteer-friendly sampling and monitoring techniques to educate and involve individuals and groups of all ages.

▸ **DEVELOPING A COMMUNITY-BASED SHELLFISH INDUSTRY FOR HAWAIʻI.** Howerton, R. D. (1), M. C. Haws (2), (1) University of Hawaiʻi Sea Grant College Program, Maui Community College, Kahului, Hawaiʻi, 96732, USA, (2) Pacific Aquaculture and Coastal Resources Center, University of Hawaiʻi at Hilo, Hilo, Hawaiʻi, 96720, USA.

Hawaiʻi has ideal environmental conditions for bivalve culture including clean, warm water, and the fourth

longest coastline in the United States. Within the shallow coastline are traditional Hawaiian fishponds and as many as sixty ancient fishponds can be found on the southern coast of Molokai. There has been a concerted community-based attempt on Molokai to restore these ponds and put them back into productive use. Part of this effort is the restoration and restocking of bivalve habitat. Hawai'i is a natural locale for a vigorous bivalve culture industry, but the grow-out of edible bivalves is missing from the aquaculture landscape. Ironically, Hawai'i is one of the only coastal states without a shellfish industry. The absence of a major mollusk culture industry for food products is a lost opportunity for the State, and Hawai'i could provide high-value seafood products with strong local and external demand. Considerable opportunities exist to grow both standard bivalve species and similar native Hawaiian species with commercial potential. Significant technical and regulatory constraints need to be addressed before this community-based industry can be developed. It is the goal of this work to address these issues including: the lack of key resources and legal accommodations typical of a producing State, including a certified laboratory to conduct water and tissue analyses, the lack of a State-sponsored program for classification of shellfish growing waters, the need for clarification of regulatory requirements for culturing bivalve species in open systems, specific sites for shellfish grow out have not been identified and adequately tested, and a need to provide training and technology transfer for bivalve culture.

▸ **SHELLFISH RESTORATION PROJECT CASE STUDIES—ONE URBAN, ONE OPEN-WATER, MANY STAKEHOLDERS.** Hundley, Jr., P. L. (1), L. A. Csoboth (2), G. J. Hauske (3), (1) HDR Engineering, Inc., 25 W. Cedar Street, Suite 200, Pensacola, FL, 32502, USA, (2) HDR Engineering, Inc., One Blue Hill Plaza, Pearl River, NY, 10965, USA, (3) HDR Engineering, Inc., 555 N. Carancahua, Suite 1650, Corpus Christi, TX, 78478, USA.

Oyster harvesting has played an important role in the commercial and recreational fishing industries. Oyster reefs also provide critical habitat that support a number of important sport and commercial fish and crabs. Contaminants in bays and estuaries due to urban and industrial developments have resulted in the loss of both commercial and recreational fishing opportunities over the past decades. This paper presents two case studies of successful oyster reef restoration projects. The estuaries of New York City are challenged and challenging in many regards. Various stakeholders have worked together to plan, design, construct, and monitor an apparently successful pilot oyster reef project in the lower Bronx River. The resulting reef structures appear to have provided nursery habitat and refuge to at least 19 fish and macro-crustacean species. Benthic areas surrounding the constructed reefs have high invertebrate densities and species richness. Lavaca Bay on the central Texas coast has a long history of contamination due to nearby manufacturing. Mercury contamination caused ecological injuries and fishing closure in a portion of the bay. Again, various stakeholders have worked together for 15 years to take on a suite of projects in and around the bay, including construction of 11 acres of oyster reef. This "construction project" created a limestone oyster reef, which created immediate habitat for oysters and other species. After a single season, the reef was thriving, producing nearly harvest size oysters in less than one year.

▸ **EVALUATION OF THE IMPACT THAT MODERATE HYPOXIA CAN HAVE ON OYSTER GROWTH AT POTENTIAL REEF RESTORATION SITES IN MOBILE BAY, AL.** Johnson, M. W. (1), S. P. Powers (2), J. Senne (3), K. Park (4), (1) University of South Alabama, Dauphin Island Sea Lab, Dauphin Island, AL, 36528, USA, (2) University of South Alabama, Department of Marine Sciences, Mobile, AL, 36688, USA, (3) Dauphin Island Sea Lab, 101 Bienville Blvd, Dauphin Island, AL, 36528, USA, (4) University of South Alabama, Department of Marine Sciences, Mobile, AL, 36688, USA.

There has been a loss of oyster reefs in Mobile Bay due to an increasing frequency of hypoxic events. To help reestablish oyster populations, it is proposed that a relic reef in central Mobile Bay be restored to 1-m in height. This reef design should lift oysters above stratified, often hypoxic waters. We deployed replicated oyster covered panels at three historically productive sites that experience different patterns of hypoxia. The northernmost site experiences severe hypoxia, the proposed restoration site experiences periods of moderate hypoxia, and the southernmost site experiences minimal hypoxia. Panels were placed at different depths (bottom, 1 m, and surface) and monitored for survival and growth. Instantaneous oyster population growth was different based on location but not depth. Population growth was the least in the north, moderate at the restoration site, and greatest in the south. At the southern site, the oyster population was 3-4 times greater per panel than the other sites. Shell growth was also different among the sites. Greatest growth was at the northern site, followed by the southern site, then the central bay site. These results may be due to reduced oyster growth at the southern site due to crowding rather than exceptional growth at the northernmost site. Our results suggest that extended periods of moderate hypoxia can be as detrimental as short periods of severe hypoxia. At the restoration site, a 1-m reef may not be adequate to ensure re-establishment of oyster populations for Mobile Bay.

COOPERATIVE AQUACULTURE AGREEMENTS BETWEEN THE SUQUAMISH TRIBE AND PRIVATE TIDELAND OWNERS IN PUGET SOUND. Kay, D., Suquamish Tribal Fisheries Department, PO Box 498, Suquamish, WA, 98392, USA.

The rights of waterfront property owners create a unique opportunity for cooperative aquaculture agreements within Puget Sound, Washington. Intertidal and some subtidal lands can be owned by private citizens, however, because of the original treaties that transferred the property from tribal to state ownership, the native tribes within Washington continue to own the harvest rights to fifty percent of all commercially fished species in Washington. This includes the naturally occurring shellfish found on private beaches. The Suquamish Tribe has created cooperative agreements between themselves and the tideland owners to lease these properties for harvest and enhancement purposes. Cooperation between tribes and the public can also help speed the cleanup of polluted areas. The tribes work with the state and county health agencies and other entities to help fund and perform water and current analyses, coliform testing, and PSP sampling. The opportunity for tideland owners to profit from their beaches and the positive word of mouth from those participating in the program can encourage greener practices in homeowners. It becomes financially rewarding to fix a bad septic system or stop using lawn and garden chemicals on beachfront property. The aquaculture performed on these beaches has been used for subsistence purposes, commercial harvest income opportunities for tribal members, and community outreach and education. In exchange, the tideland owner gets a percentage of the profit from any shellfish sale, and the right to harvest clams and oysters for personal use as well.

INVASIVE TUNICATES AT SHELLFISH RESTORATION AND AQUACULTURE SITES ON MARTHA'S VINEYARD, MASSACHUSETTS. Karney, R. M. (1), D. M. Grunden (2), M. M. Carman (3), J. M. Morris (4), P. M. Hoagland (5), (1) Martha's Vineyard Shellfish Group, Inc., P.O. Box 1552, Oak Bluffs, MA, 02557, USA, (2) Town of Oak Bluffs Shellfish Department, P.O. Box 1327, Oak Bluffs, MA, 02557, USA, (3) Woods Hole Oceanographic Institution, Geology and Geophysics Dept., Woods Hole, MA, 02543, USA, (4) NOAA National Ocean Service, National Centers for Coastal Ocean Science, Beaufort, NC, 28516, USA, (5) Woods Hole Oceanographic Institution, Marine Policy Center, Woods Hole, MA, 02543, USA.

Shellfish restoration efforts on the island of Martha's Vineyard, Massachusetts are impacted by invasive tunicate species. Several species of non-endemic tunicates invaded New England marine coastal and offshore habitats in the 1980s and 1990s. While the presence of invasive tunicates is well documented at harbors and marinas in New England, there are few published reports on tunicates at shellfish restoration areas and aquaculture farms. Species such as bay scallops *Argopecten irradians irradians*, Eastern oysters *Crassostrea virginica*, quahogs *Mercenaria mercenaria* and soft shelled clams *Mya arenaria* are being cultured and stocked on Martha's Vineyard in Lagoon Pond, Lake Tashmoo, Menemsha Pond, Sengekontacket Pond, Katama Bay, Cape Pogue Pond, Edgartown Great Pond and Tisbury Great Pond. Our surveys of shellfish restoration areas indicate that the invasive colonial tunicates *Botrylloides violaceus*, *Botryllus schlosseri*, *Didemnum vexillum*, *Diplosoma listerianum*, and solitary tunicates *Ascidiella aspersa*, *Ciona intestinalis Molgula manhattensis*, *Styela clava* were common. The native colonial tunicate *Didemnum albidum* was found to be less common among the fouling organisms on cultured shellfish and shellfish equipment. Untreated aquaculture equipment and cultured shellfish were infested with tunicates in areas with salinities of 28.0 to 33.5ppt. Shellfish in bottom sediments were not fouled with tunicates. Treatment methods such as the spraying of aquaculture gear and shellfish with freshwater, shellfish dipping in salt brine and air-drying were found to be effective biofouling control practices.

- **THE ESE-CBA PLAN: A COMPREHENSIVE, INTEGRATED APPROACH TO ASSESSING THE BENEFITS OF OYSTER REEF RESTORATION.**

Kellogg, M. (1), H. Slacum (2), K. T. Paynter (3), S. Able (4), S. M. Allen (5), L. S. Barker (6), W. Boicourt (7), D. Bruce (8), B. Conkwright (9), J. Cornwell (10), B. Gentner (11), C. Judy (12), L. Karrh (13), J. Lazar (14), D. Lipton (15), D. Meritt (16), T. O'Connell (17), H. Townsend (18), M. Trice (19), (1) Department of Biology, University of Maryland, 3270 Biology-Psychology Building, College Park, MD, 20742, USA, (2) Versar, Inc., 9200 Rumsey Road, Columbia, MD, 21045, USA, (3) Marine Estuarine and Environmental Sciences Graduate Program, UMCES, Department of Biology, 0105 Cole Field House, College Park, MD, 20742, USA, (4, 5) Oyster Recovery Partnership, 1805 Virginia Ave., Annapolis, MD, 21401, USA, (6) Maryland Department of Natural Resources, Annapolis, MD, USA, (7) Horn Point Laboratory, University of Maryland Center for Environmental Science, Cambridge, MD, USA, (8) NOAA, Chesapeake Bay Office, Oxford, MD, USA, (9) Maryland Geological Survey, Baltimore, MD, USA, (10) Horn Point Laboratory, University of Maryland Center for Environmental Science, Cambridge, MD, USA, (11) Gentner Consulting Group, Silver Spring, MD, (12, 13) Maryland Department of Natural Resources, Annapolis, MD, USA, (14) NOAA Chesapeake Bay Office, Annapolis, MD, USA, (15) University of Maryland, College Park, MD, USA, (16) Horn Point Laboratory, University of Maryland Center for Environmental Science, Cambridge, MD, USA, (17) Maryland Department of Natural Resources, Annapolis, MD, USA, (18) NOAA, Chesapeake Bay Office, Annapolis, MD, USA, (19) Maryland Department of Natural Resources, Annapolis, MD, USA.

Increasingly, the goals of oyster reef restoration efforts include restoration of the ecosystem services once provided by healthy oyster populations. When oyster reef restoration is undertaken solely for enhancement of commercial fishing, the benefit-cost analysis entails a straightforward comparison of the discounted stream of restoration costs to the increase in net present value of the resulting harvest. When, in addition to or instead of commercial harvests, restoration is initiated for ecosystem services, net benefit measurement is much more complicated, requiring the incorporation of non-market use values (e.g., recreational finfish angling over reefs) and non-use value (i.e., value of the existence and health of reefs to non- users). Recently, a comprehensive, integrated approach to assessing the benefits of oyster reef restoration has been developed for restoration activities in the upper Choptank River, Maryland, USA. The Ecosystem Services Evaluation and Cost Benefit Analysis (ESE-CBA) plan was developed by a multi-investigator, multi-agency team with the goal of providing: (1) comprehensive assessment of the ecosystem services provided by restored reefs (including seston removal, nutrient dynamics, secondary production, fish and decapods use), (2) assessment of the non-market value of restored oyster reefs to user (e.g. recreational boaters and fishermen) and non-user groups and (3) a detailed cost-benefit analysis that will provide guidance for future management and funding decisions. This six-year plan employs a BACI design for implementation and monitoring of five 2-acre reefs, quantitative assessment of physical and biological parameters at reef and regional scales, and public surveys to assess non-market values. In this presentation we outline the critical planning and design steps in the ESE-CBA process and suggest how similar approaches could be used for other large-scale restoration activities.

▸ **THE ROLE OF ABANDONED CRAB TRAPS IN OYSTER REEF RESTORATION.** Kreutzer, A. (1), N. Hadley (2), D. Wilber (3), V. Shervette (4), (1) College of Charleston, 205 Ft. Johnson Rd., Charleston, SC, 29412, USA, (2) SCDNR Marine Resources, 217 Ft. Johnson Rd., Charleston, SC, 29412, USA, (3) Bowhead Information Technology Services, 664 Old Plantation Rd., Charleston, SC, 29412, USA, (4) Belle W. Baruch Institute for Marine & Coastal Sciences, 607 EWS Building, Columbia, SC, 29208, USA.

Abandoned crab traps are a problem in many coastal areas. Traps are lost due to storms and broken lines or are just abandoned as they get too old to function properly. Moreover, commercial crabbers dispose of hundreds of traps after every season. The goal of this project is to test the validity of using these derelict traps as a base for artificial oyster reefs. Three varieties of traps (a standard wire trap, a vinyl covered trap, and a vinyl -covered trap that has been dipped in cement) have been placed intertidally at three locations around Charleston, South Carolina. At each location there are ten of each trap treatment, all with their funnels closed to prevent bycatch, along with five groupings of bagged oyster shell (already known to successfully recruit oysters). The calcium carbonate in cement mimics the calcium carbonate of oyster shell that attracts larvae to settle on the preexisting shell. If our research demonstrates that crab traps successfully recruit oysters and can be used for oyster reef restoration, not only will it help productively dispose of what would otherwise be trash, but it may also allow oyster reef restoration to move to areas that were previously deemed too muddy. The high vertical profile of the crab trap may allow it to be placed in areas where other more conventional restoration techniques (such as the bagged shell) would sink into the mud or be silted over.

▸ **GIANT CLAM *TRIDACNA GIGAS* RESTORATION PROJECT OF SEAFDEC AQUACULTURE DEPARTMENT: A COMPARISON OF GROWTH AND SURVIVAL FROM THREE OCEAN NURSERIES.** Lebata-Ramos, M. L. (1), E. Doyola-Solis (2), J. Sumbing (3), (1, 2, 3) Southeast Asian Fisheries Development Center Aquaculture Department, Brgy. Buyu-an, Tigbauan, Iloilo, Iloilo, 5021, Philippines.

During the Regional Technical Consultation on Stock Enhancement of Species of International Concern last July 2005, in Iloilo, Philippines, the giant clam *Tridacna gigas* was one of the species identified for the stock enhancement program of SEAFDEC Aquaculture Department to be funded by the Government of Japan. Three sites were identified for this project–the Sagay Marine Reserve (SMR) in Negros Occidental, Malalison Island in Antique, and the Igang Marine Station (IMS) of SEAFDEC AQD in Guimaras. *Tridacna gigas*, obtained from the University of the Philippines, were reared in ocean nurseries from April 2006, August 2006, and February 2007, respectively, and monitored monthly for growth and survival. Temperature, salinity, and total suspended solids (TSS) were also measured every month. Results showed significant differences in growth (ANOVA, $p<0.001$) and survival (ANOVA, $p<0.001$) between sites, with clams reared in IMS having the highest growth rate and survival, and those in Malalison Island the lowest. There were no significant differences in temperature, salinity, and TSS between sites. However, depth significantly varies with IMS being the shallowest and Malalison Island the deepest (ANOVA, $p<0.001$). Correlation analysis also showed that growth was significantly positively correlated with

temperature (Pearson correlation, p<0.01) and salinity (Pearson correlation, p<0.05). These findings revealed that depth, temperature, and salinity are among the factors that need to be considered when selecting a site for giant clam restocking. Moreover, marine protected areas are also recommended as ideal sites for restocking to minimize mortality due to poaching. Thus, this study showed the importance of site selection prior to restocking of giant clams.

CAN EXTENSIVE AND INTENSIVE OYSTER FARMING KEEP THE INDUSTRY ALIVE IN VIRGINIA, USA? Leggett, T. (1), B. M. Goldsborough (2), J. N. Harmon (3), (1) Chesapeake Bay Foundation, PO Box 412, Wicomico, Virginia, 23184, USA, (2) Chesapeake Bay Foundation, 6 Herndon Ave, Annapolis, Maryland, 21403, USA, (3) Chesapeake Bay Foundation, PO Box 412, Wicomico, Virginia, 23184, USA.

Entire towns and cities were built around the oyster fishery in Chesapeake Bay, USA. The oyster fishery was the mainstay for the seafood industry up through the mid 1900s. Eastern oyster (*Crassostrea virginica*) landings numbered in the millions of bushels as recently as 1950. Overharvesting in the late 1800s, the parasites MSX and DERMO, poor water quality, and loss of habitat have reduced the Chesapeake Bay oyster population and fishery to a fraction of historical levels. Interest in both intensive and extensive oyster farming in the Virginia portion of Chesapeake Bay has increased in the last decade as a result of improved strains of the native oyster, the possibility of the introduction of a non-native oyster and the decline of other Bay fisheries, namely the blue crab fishery. The Chesapeake Bay Foundation has supported and actively promoted oyster farming since 2000 as a means to keep watermen working on the water and to relieve pressure on the wild oyster resource. Several projects, in collaboration with our restoration partners, are underway to expand the use of both intensive (cages, racks, and bags) and extensive (spat on shell) oyster farming by processors and watermen. The future is promising but several hurdles exist such as use conflicts for intensive aquaculture, degraded water quality as population growth increase in the watershed, and predation by cow nose rays on planted spat on shell.

BAY SCALLOP POPULATION DYNAMICS WITHIN TWO SOUTHWEST FLORIDA ESTUARIES FOLLOWING RESTORATION PRACTICES UTILIZING COMPETENT LARVAL RELEASES. Leverone, J. R. (1), S. P. Geiger (2), S. Stephenson (3), C. D. Hemmel (4), W. S. Arnold (5), (1) Mote Marine Laboratory, 1600 Ken Thompson Parkway, Sarasota, FL, 34236, USA, (2, 3) Florida Fish and Wildlife Research Institute, 100 Eighth Avenue SE, St. Petersburg, FL, 33701, USA, (4) Bay Shellfish Company, P.O. Box 289, Terra Ceia, FL, 34250, USA, (5) Florida Fish and Wildlife Research Institute, 100 Eighth Avenue SE, St. Petersburg, FL, 33701, USA.

In 2003, a partnership among state biologists, private research scientists and a commercial shellfish hatchery initiated a bay scallop restoration program within two major estuaries along the southwest Florida coast. Both estuaries once supported harvestable scallop stocks, but have since been reduced to relict populations. Through this partnership, a new approach to shellfish restoration was developed and tested. The centerpiece of this strategy involves hatchery spawning and rearing of scallop larvae, and releasing pediveliger larvae into target restoration sites just prior to metamorphosis. This program also involves recruitment monitoring and annual population assessments within each estuary. In Pine Island Sound, larval releases took place at a single site in 2003, four locations in 2005, with another release scheduled for fall, 2008. In Tampa Bay, larval releases began in 2005 at one site and expanded to three additional locations in 2006 and 2007. Three more releases are scheduled at all four locations during the fall, 2008. In Pine Island Sound, increased recruitment, abundance and distribution were all coincident with the timing and location of restoration activities. No appreciable recruitment from outside the estuary has been observed. In Tampa Bay, moderate recruitment occurred independent of adult abundance. However, in 2007 and 2008, dramatic increases in scallop recruitment and abundance were concurrent with restoration activities. Adult abundance in adjacent Sarasota Bay, beyond the restoration footprint but connected hydrodynamically, increased by three orders of magnitude. Future restoration activities, coupled with adaptive management policies, will need to account for estuary specific differences in hydrodynamics and recruitment to effectively rebuild and sustain these disparate populations.

- **COSTS AND BENEFITS OF OYSTER RESTORATION TO THE LOWER HUDSON: PERSPECTIVES ON PHYSIOLOGY, METAPOPULATION STRUCTURE, AND HABITAT VALUE.** Levinton, J. S. (1), M. Doall (2), A. Starke (3), A. Cahill (4), (1, 2) Stony Brook University, Ecology and Evolution Department, Stony Brook, NY, 11794, USA, (3) Stony Brook University, School of Marine and Atmospheric Sciences, Stony Brook, NY, 11794, USA, (4) Stony Brook University, Department of Ecology and Evolution, Stony Brook, NY, 11794, USA.

Oyster restoration in areas that have been long depleted is very difficult, owing to ignorance of physiological performance under current conditions, ability to restore a sustainable structural oyster habitat, and meeting the challenge of creating a sustainable metapopulation of oyster islands that interconnect by recruitment of larvae. We have begun a comprehensive study of the Lower Hudson estuary and coastal New York – NY-NJ Harbor areas, aimed toward the restoration of the eastern oyster, *Crassostrea virginica*. This species lived in great abundance in all of these areas, many of which have been altered significantly since their decline. Physiological and population tradeoffs include: Vigorous growth and earlier time of first reproduction in coastal marine areas relative to oligohaline Haverstraw Bay sites; possibly more favorable metapopulation circumstances in Haverstraw Bay and perhaps Jamaica Bay, relative to other coastal sites; and reduction of disease potential in Haverstraw Bay relative to higher salinity coastal sites. We have established 9 oyster cage sites from eastern Long Island to New Jersey and from New York Harbor to Haverstraw Bay, and are following survival, growth, reproductive state, condition index, and disease. Survival is very high for oysters transplanted to a wide variety of sites. Growth is greater in the coastal sites, but growth has occurred in the lower-salinity Haverstraw Bay after a month's delay. Planned siting of oyster reefs and maps of highest larval retention using standard hydrological models will aid in the next stage of planning a series of experimental reefs that comprise an interactive metapopulation. Some coastal areas, such as Jamaica Bay, have strong potential for localized retentive areas for larvae.

- **ASSESSING THE INITIAL IMPACTS OF FOUR YEARS OF HARD CLAM (*MERCENARIA MERCENARIA*) RESTORATION IN CENTRAL GREAT SOUTH BAY.** LoBue, C. P. (1), C. M. Clapp (2), M. M. Doall (3), T. M. Carrano (4), (1, 2) The Nature Conservancy: Long Island Chapter, 250 Lawrence Hill Rd., Cold Spring Harbor, NY, 11724, USA, (3) Functional Ecology Research and Training Laboratory, Stony Brook University, Stony Brook, NY, 11794-5245, USA, (4) Brookhaven Township, One Independence Hill, Farmingville, NY, 11738, USA.

Since acquiring title to 13,400 acres of submerged lands in central Great South Bay, NY in 2003, The Nature Conservancy has been working with a long list of partners to restore hard clam (*Mercenaria mercenaria*) populations which have been declining for over 3 decades. Our goal is to rebuild the population to an average density of 6 clams per square meter by 2020 for ecosystem health and sustainable harvest, which in the central bay represents a 20 fold population increase. Past population surveys compared to published stock-recruitment relationships suggest that vast portions of the bay are recruitment limited. Restoration work has had an initial focus on rebuilding spawning potential by establishing a network of spawner sanctuaries stocked with adult clams from nearby estuaries. Since 2004 over 3 million adult clams have been stocked on

over 50 sites. The ongoing program includes extensive monitoring of survival, spawning, and recruitment. Over the past four years environmental conditions have varied widely with 2006 representing the most optimal year for spawning based upon our observations of seasonal variation in clam condition and gonad ripeness. During the summer of 2008 a bay-wide shellfish survey was conducted to quantify if there has been an increase in the annual recruitment of clam seed compared to pre-restoration baseline data. Results of the population survey and other monitoring data will be discussed in the context of assessing and adapting the current restoration methodologies being employed.

▸ **FERTILIZATION SUCCESS IN ALTERED BIVALVE POPULATIONS: IMPLICATIONS FOR RESTORATION.** Luckenbach, M. W. (1), E. North (2), L. Kellogg (3), R. M. Mann (4), S. M. Allen (5), K. T. Paynter (6), (1) Virginia Institute of Marine Science, P.O. Box 350, Wachapreague, VA, 23421, USA, (2) University of Maryland Center for Environmental Science, Horn Point Laboratory, Horn Point, MD, 21613, USA, (3) University of Maryland, 0105 Cole Field House, College Park, MD, 20742, USA, (4) Virginia Institute of Marine Science, P.O. Box 1346, Gloucester Point, VA, 23062, USA, (5) Maryland Oyster Recovery Partnership, P.O. Box 6775, Annapolis, MD, 21401, USA, (6) University of Maryland Center for Environmental Studies, 0105 Cole Field House, College Park, MD, 20742, USA.

Molluscan shellfish populations which are the target of conservation and restoration frequently exist at low abundances, especially compared to historical levels. The goal of increasing these populations is aided by high female fecundity, with egg production often 10^6- 10^7 eggs per female. The assumption that most of these eggs become fertilized is implicit in many restoration efforts and often explicit in demographics models. Yet, under conditions which prevail in many shellfish restoration and conservation efforts—low abundance, reduced year classes, skewed sex ratios and altered flow regimes—the validity of this assumption is untested. We examined the roles of gamete characteristics (sperm swimming speed, contact radius, egg sinking speed, longevity), gamete concentrations and turbulent mixing on fertilization success of *Crassostrea virginica* using laboratory experiments and a turbulence-based contact rate model. Male size-specific fecundity was measured using calibrated Coulter Counter techniques and sperm swimming speed was determined with light microscopy. Gamete characteristics were used to parameterize a model of fertilization success that incorporates small-scale turbulent mixing processes based on particle encounter rate theory. Sensitivity analysis indicated that sperm concentration and turbulent mixing levels had the greatest influence on fertilization rate. We then conducted laboratory experiments to investigate the effects of gamete concentrations and sperm: egg ratios under controlled turbulence conditions to validate and refine the model predictions. Results indicate that, even under high gamete concentrations, sperm: egg ratios exert strong influence over fertilization success. At low gamete concentrations and low sperm: egg ratios fertilization success can be very low. We consider the implications for these findings in light of oyster abundance and sex ratio estimates for natural and "restored" oyster populations in Chesapeake Bay.

▸ **SEEDING THE FUTURE—PROJECT PORTS: PROMOTING OYSTER RESTORATION THROUGH SCHOOLS.** M, L. M., Haskin Shellfish Research Laboratory, 6959 Miller Avenue, Port Norris, NJ, 08349, USA.

Project PORTS: Promoting Oyster Restoration Through Schools is a community-based restoration and educational program focusing on the importance of oyster populations in the Delaware Bay ecosystem. The education program utilizes the oyster as a vehicle to acquaint school children, grades K-12, with the Delaware Estuary and basic scientific concepts. The enrichment programming is hands-on and inquiry based. Students are offered cross-curricular lessons that integrate scientific aspects with locally relevant historical and social perspectives relating to the

Delaware Bay oyster resource. The educational value of Project PORTS classroom lessons is greatly enriched by bringing future citizen-scientists into direct contact with the Bay Shore environment via the restoration program. The community-based restoration component engages students in the process of restoring oyster habitat. Students construct shell bags, which are deployed in the Bay to become a settlement surface, and home to millions of young oysters. Participation in the restoration project lends a sense of ownership to the student's academic studies and gives students the opportunity to experience the Delaware Estuary and environmental stewardship first-hand. The restoration project in itself is important as fringe oyster habitat in the Delaware Bay is enhanced for the purpose of conservation. In the last 2 years more than 2000 students have participated in Project PORTS. Their efforts resulted in the deployment of 3000 shell bags. Shell bags (n=1250) deployed in 2007 caught nearly 2.5 million oyster spat at a high recruitment lower Bay site. The spat were transplanted to an upper-bay enhancement area. As a follow-up, students participated in the scientific assessment of the oysters fostering an appreciation and ownership of their stewardship efforts.

- **PHYSIOLOGICAL RESPONSES OF THE EASTERN OYSTER *CRASSOSTREA VIRGINICA* EXPOSED TO MIXTURES OF COPPER, CADMIUM AND ZINC.** Macey, B. M. (1), K. G. Burnett (2), H. R. Williams (3), L. K. Thibodeaux (4), J. L. Ikerd (5), M. Beal (6), J. S. Almeida (7), C. C. Cunningham (8), A. Mancia (9), G. W. Warr (10), E. Burge (11), A. Holland (12), P. S. Gross (13), S. Hikima (14), M. J. Jenny (15), L. E. Burnett (16), R. W. Chapman (17), (1, 2, 3, 4, 5) Grice Marine Laboratory, College of Charleston, 205 Fort Johnson Rd., Charleston, SC, 29412, USA, (6) Marine Resources Research Institute, SCDNR, 217 Fort Johnson Rd., Charleston, SC, 29412, USA, (7, 8, 9, 10) Medical University of South Carolina, 171 Ashley Avenue, Charleston, SC, 29412, USA, (11) Grice Marine Laboratory, College of Charleston, 205 Fort Johnson Rd., Charleston, SC, 29412, USA, (12) Hollings Marine Laboratory, 331 Fort Johnson Rd., Charleston, SC, 29412, USA, (13, 14, 15) Medical University of South Carolina, 171 Ashley Avenue, Charleston, SC, 29425, USA, (16) Grice Marine Laboratory, College of Charleston, 205 Fort Johnson Rd., Charleston, SC, 29412, USA, (17) Marine Resources Research Institute, SCDNR, 217 Fort Johnson Rd., Charleston, SC, 29412, USA.

Increased utilization of coastal watersheds has led to a substantial increase in the amount and variety of pollutants entering estuarine habitats, with heavy metals such as copper (Cu), zinc (Zn) and cadmium (Cd), representing some of the most common and serious forms of environmental contamination. The impacts of exposing oyster populations to low-dose mixtures of heavy metals are poorly understood, but may have even more profound effects than have been documented for individual metals alone. Of particular interest is the ability of heavy metals to influence the oxidative status of the oyster, leading to adverse effects on membrane integrity, acid-base balance, respiration, and immune defense. In the present study we exposed oysters to environmentally relevant levels of Cu, Zn and Cd, either alone or in combination for 1 – 27 days. We measured pH, dissolved gasses and culturable bacteria in hemolymph, and antioxidant levels (glutathione), oxidatively-damaged membranes (lipid peroxidation), and patterns of metal accumulation in the gill and the hepatopancreas. Linear and artificial network analyses revealed that tissue levels of Cu, Zn and Cd were correlated with changes in hemolymph pH and PO_2 and had significant associations with glutathione and lipid peroxidation. ANNs also suggested strong and possibly synergistic effects among the accumulated metals and the other measured variables in this study. Thus, for the first time, oxidative membrane damage from tissue accumulation of environmental metals has been correlated with impaired acid-base balance and respiration in oysters (NOAA's Center of Excellence in OHH at the Hollings Marine Laboratory).

Oral & Poster

PRESENTATION ABSTRACTS

MUNICIPAL SHELLFISH RESTORATION: FORTY YEARS OF EXPERIMENTATION AND PRODUCTION ON CAPE COD, MA. Macfarlane, S. M., Coastal Resource Specialists, PO Box 1164, Orleans, MA, 02653, USA.

When the oil barge "Florida" went aground off West Falmouth Harbor in 1969, shutting down shellfish harvesting in the area for decades, the calamitous event set in motion a concerted effort to restore or augment shellfish populations in all fifteen Cape Cod towns. Not following traditional shellfish sources (transplants from natural production or a contaminated relay system), George Souza, Falmouth Shellfish Constable, began experimenting with seed quahaugs *(Mercenaria mercenaria*) obtained from a commercial hatchery. His success led towns to hire biologists in 1974, and for over thirty years, towns experimented with nursery methods of growing various shellfish species on shoestring budgets, freely sharing results, successful and less so, and produced millions of seed transplanted to the public waters. Their innovative bottom planting techniques led to the MA private shellfish aquaculture industry of today. Upwellers dramatically increased productivity with smaller, cheaper seed, but budgets tightened further and state funds evaporated. Towns deleted biologist positions, increased their duties as harbormasters or conservation agents, or reduced their shellfish propagation efforts. Tracking program effectiveness proved elusive since the seed was broadcast throughout bays, for a public fishery. Town personnel observed increased production of shellfish in the field but quantitative analysis remains a low priority. Today, a public hatchery, upwellers, bottom plantings, cage and bag culture, are all public shellfish propagation efforts, growing seed and transplanting them to the public waters. Quahaugs (*Mercenaria mercenaria*) remain the primary species cultured but towns also grow oysters (*Crassostrea virginica*) and bay scallops (*Argopecten irradians irradians*), working to a lesser degree with clams (*Mya arenaria*) and blue mussels (*Mytilus edulis*). County programs have made a substantial contribution to this effort through funds, bulk seed purchases, experimental plots, and a continuing effort to answer basic questions relative to shellfish enhancement issues.

POPULATION DYNAMICS OF *CERASTODERMA EDULE* AND *RUDITAPES DECUSSATUS* IN RIA DE PONTEVEDRA, GALICIA (SPAIN). Mackinlay, M. J., Universidade de A Coruña, Facultad de Ciencias, A Coruña, A Coruña, E-15071, Spain.

The Ria de Pontevedra in an important site of shellfish culture in Galicia (Spain). *Cerastoderma edule* and *Ruditapes decussatus* are the main species, other, but less important, species are *Ruditapes philippinarum* and *Venerupis senegalensis*. *Cerastoderma edule* and *Ruditapes decussatus* stocks have been monitored during the 2001-2006 period, in order to establish new measures that will ensure a sustainable fishery for local fishermen (mostly women).

SHELLFISH RESTORATION IN THE SOUTHERN GULF OF ST. LAWRENCE: A CASE STUDY IN CARAQUET BAY, NEW BRUNSWICK, CANADA. Mallet, J. (1), M. Ouellette (2), E. Ferguson (3), D. Haché (4), (1) Fisheries and Oceans Canada, 343 University Avenue, Moncton, New Brunswick, E1C 9B6, Canada, (2) Fisheries and Oceans Canada, 343 University Avenue, Moncton, New Brunswick, E1C 9B6, Canada, (3) Fisheries and Oceans Canada, 3267 Main Street, Tracadie-Sheila, New Brunswick, E1X 1G5, Canada, (4) Fisheries and Oceans Canada, 74 Ohio Street, Shediac, New Brunswick, E4P 2J9, Canada.

The southern Gulf of St. Lawrence (sGSL) is a unique and very productive ecosystem that hosts several commercial species of shellfish. The American oyster (*Crassostrea virginica*) is an ecologically important species that also supports both a traditional fishery and an expanding aquaculture industry. There has been a growing interest in the sGSL for oyster population and habitat restoration in order to alleviate the pressures of overexploitation, disease outbreaks, interspecific competition, and habitat alterations. The necessity, and complexity, in conducting restoration work of this valuable species is becoming more pressing with the increasing cumulative effects of human activities on coastal ecosystems. Furthermore, in order to have a certain measure of success, any restoration work that aims at a species that is also commercially sought by humans needs to take into account three basic components (ecological, economical, and social) that will define the outcomes of the activities, thus reasonable expectations. The hierarchal order of these components will certainly be defined by the goal of the activity but they will also remain interlinked. Caraquet Bay hosts the northmost commercially significant population of the American oyster in eastern North America. Caraquet oysters have been harvested since 1757 and are deeply anchored in the culture of the surrounding communities. However, like many regions, the abundance and productivity of this oyster population is in decline. Consequently, a significant drop in the landings has resulted in socio-economic concerns as well as environmental concerns, due to the increasing understanding of the importance of this species in its ecosystem. An ecological restoration pilot project is being undertaken in Caraquet, which will include restoration techniques such as shell spreading, desilting, seeding and relay.

▸ **LIFE HISTORY CHARACTERISTICS AND HABITAT DISTRIBUTION OF *OSTREOLA EQUESTRIS*.** Markwith, A. L. (1), M. H. Posey (2), T. D. Alphin (3), (1, 2, 3) University of North Carolina Wilmington, 601 S. College Rd., Wilmington, NC, 28403, USA.

There has been renewed interest in North Carolina's lesser known native oyster, *Ostreola equestris* (the crested oyster), due to the presence of a previously unknown haplosporidian parasite *Bonamia* sp. Recent work indicates that *Bonamia* sp. may impact several bivalves and it has been suggested that *O. equestris* may harbor this parasite. If this is the case, both restoration of *Crassostrea virginica* (that may be susceptible to *Bonamia* as juveniles) and the introduction of *C. ariakensis* (that has been shown to be highly susceptible to *Bonamia* as early juveniles) for mariculture purposes. Relatively little is known about the general biology and distribution of *O. equestris*. This study addresses some of the uncertainties regarding its ecology by looking at both distribution and life history characteristics. Seven habitat types in various sites are being surveyed along the southeastern North Carolina coast and selected northern areas for presence, size distribution, sub habitat preferences, and patchiness. Recurrent populations at several sites are being used to examine life history characteristics (reproductive period, condition index, and disease presence [i.e. DERMO and *Bonamia* sp.]). *O. equestris* has previously been assumed to be uncommon however to date we have been able to find populations in all locations sampled.

▸ **RESTORING THE EASTERN OYSTER, *CRASSOSTREA VIRGINICA*, IN AN URBAN ESTUARY: A COMMUNITY EFFORT IN THE BRONX RIVER, NY.** Mass, A. (1), V. Ruzicka (2), J. Harris (3), (1) The Graduate Center, City University of New York, College of Staten Island- Biology Department, Staten Island , NY, 10314, USA, (2, 3) New York City Department of Parks and Recreation, Natural Resources Group- Room 240, New York City, NY, 10029, USA.

The Eastern oyster, *Crassostrea virginica*, once thrived in the Hudson River Estuary. Since the 1800s, overharvesting, disease, and pollution have decimated the population. Presently, only a few isolated populations survive. A survey of oysters in the Bronx River found a small population in Soundview Park (at the confluence of the Bronx and East Rivers). New York City Department of Parks & Recreation Natural Resources Group (NRG), along with local community groups, have constructed two pilot oyster reefs (15 m^2) in an effort to understand the linkage between the presence of oysters and surrounding benthic communities. The goal of the project is to provide hard substrate for oyster spat to settle on, which can lead to increases in subtidal diversity and water quality improvement in the Bronx River. Oyster spat abundance, benthic invertebrate, fish, and macroinvertebrate communities, and sediment deposition rates have been monitored since June 2006. Results show that oyster spat have settled on the reefs, and benthic diversity has increased. One of the major successes of the project has been the involvement of multiple Bronx River community groups. Various groups in the Bronx have helped construct the pilot reefs, monitored for spat settlement, maintained oyster "gardens" in the area, and educated the public about the benefit of oyster reefs and their importance to the ecosystem. Under the guidance of NRG, these community groups intensified their focus on oyster restoration in the Bronx River and learned scientific monitoring and species identification skills. The three-year monitoring effort, funded by a WCS-NOAA grant, will be completed in December 2008. Plans to continue the project and incorporate additional community groups and monitoring are underway.

THE NATIONAL FISH HABITAT ACTION PLAN—MORE PEOPLE WORKING FOR MORE FISH AND SHELLFISH. McGraw, K. A., NOAA Restoration Center, SSMC-3 F/HC-3 Rm. 14728, Silver Spring, MD, 20783, USA.

The National Fish Habitat Action Plan (NFHAP) is a national effort to conserve the nation's freshwater and coastal/marine fish and shellfish habitats. Modeled after the North American Waterfowl Management Plan, this is the most comprehensive effort ever attempted to address the causes of fish and shellfish habitat decline, not just the symptoms. It is an investment strategy to leverage federal, state, and privately raised funds directed at fixing the nation's most pressing aquatic habitat problems. NFHAP is being implemented by Regional Fish Habitat Partnerships composed of volunteer organizations and requires a science-based approach to habitat conservation and a national assessment of the condition of fish/shellfish habitats, to be updated every 5 years. Although thousands of restoration projects have been completed in both fresh water and coastal/marine habitats, they have not kept pace with impacts resulting from population growth, land-use changes, pollution, exploitation, and climate change. For example, 72% of native freshwater mussel taxa are endangered threatened, or of special concern, and 51% of crayfish species are at risk. On the west coast, and some places on the east coast (e.g., Chesapeake Bay), native oyster species have been decimated. The need has never been greater for increased action and improved coordination of fisheries conservation agencies and groups. This presentation will explain the structure of NFHAP, how it is being implemented, and the scientific basis for the national habitat assessment.

STUDY OF STRATEGIES TO RESTORE *PAPHIA MALABARICA* STOCKS ALONG THE COAST OF RATNAGIRI, MAHARASHTRA (WEST COAST OF INDIA). Mohite, S. A. (1), A. S. Mohite (2), (1, 2) College of Fisheries, Ratnagiri, Maharashtra, India, 203/A, Shreerang Apartment, Joshi Paland, Ratnagiri, Maharashtra, 415612, India.

Several venerid clams species occur along the west coast of Maharashtra, India (west coast of India). *Paphia malabarica* is one of these important clams, which had formed vast beds in the two major estuaries of Ratnagiri district viz. Kalbadevi estuary and Kajali estuary. They are exploited on a commercial basis throughout the year. Intensive fishing for large size clam was observed from November to May. Due to the continuous exploitation, the clam beds are being destroyed and the stocks of *P. malabarica* are decreasing rapidly. Information about the biology of the clam is essential to understanding the various seasonal changes that may result in the different physiological processes in the animal in relation to its environment, as well as other biological aspects such as reproduction and growth pattern and best season for the fishery. This knowledge was then applied in the culture trials to help in restoring the clam beds. The clams were successfully cultured at the selected centers for a period from February 2005 to January 2006. The local fisherwomen were involved in the culture studies of the clam. The stocking density of 100 nos./m^2 showed 89% survival. Maximum total weight production of 1709.69 ± 5.61g / m^2 was observed during the experimental culture. The clams were found to be re-establishing in the selected locations.

EXPLORING OPTICAL BRIGHTENERS AS A HUMAN SPECIFIC BACTERIAL SOURCE TRACKING TOOL. Muscio, C. M. (1), D. Mess (2), (1, 2) Rutgers Cooperative Extension, 1623 Whitesville Rd., Toms River, NJ, 08755, USA.

Coastal recreation, fisheries, and tourism are multi-million dollar industries at the Jersey Shore. Increased development and continual impact to surface waters threatens the health, quality of life, and economic livelihood of this region. Bacterial pathogen pollution, in particular, often leads to beach closings, condemned shellfish waters, and reduced recreational opportunities, as well as presenting a health concern for both residents and visiting tourists. Although agencies conduct regular monitoring, the isolation of human bacterial pathogens remains a problem for both analysis and remediation of this pollution type. Several new source tracking methods are being investigated, including optical brighteners—an inexpensive method of detecting human sources by the presence of whitening agents in surface waters. Both optical brightener traps and fluorometry were used in known bacterial contamination areas in coastal New Jersey. The methods were tested for ease of use, economic feasibility, and accuracy. The results of this study concluded that the trap design used was prone to vandalism and sedimentation. Other potential issues, such as signal decay in lighted conditions were explored. Continued research is being conducted using fluorometric optical brightener analysis to determine if this technology can be implemented as a low-cost screening tool to identify human effluent bacterial sources by industry folk, non-profits, and volunteer groups.

ALABAMA OYSTER REEF AND FISHERIES HABITAT ENHANCEMENT PROGRAM. Powers, M. J. (1), S. P. Powers (2), K. L. Heck (3), R. L. Shipp (4), (1, 2) University of South Alabama, Department of Marine Sciences, Mobile, Alabama, 36688, USA, (3) Dauphin Island Sea Lab, 101 Bienville Blvd., Dauphin Island, Alabama, 36528, USA, (4) University of South Alabama, Department of Marine Sciences, Mobile, Alabama, 36688, USA.

Recognition that the loss and/or degradation of complex marine habitats may limit recovery of many marine species has led to increased efforts to conserve existing habitats, restore degraded habitats and create new habitats that function to fill critical roles in the life history of marine and estuarine fishes. Unfortunately, our limited knowledge of the dynamic processes that function on the community or ecosystem levels, as well as the role of habitat in mediating many species interactions, represents a significant limitation to the application of ecological theory to fisheries and restoration science. Recognizing that advances in marine restoration science involve both basic ecological and applied studies, the University of South Alabama in collaboration with NOAA Fisheries has designed a habitat enhancement and restoration program that will allow researchers to focus on a broad range of topics of fundamental interest to marine habitat restoration. The program is designed to encompass a variety of fisheries habitats within coastal Alabama including seagrass, oyster reefs, and offshore hard bottom reefs. The program consists of four major components (1) assessment of current marine habitats; (2) large-scale habitat creation/restoration; (3) targeted ecological studies and (4) public outreach, education, and communication. The poster discusses the overall rationale, approach and objective of the program and provides highlights of current research projects.

CORRESPONDENCE BETWEEN OYSTER RECRUITMENT PATTERNS MEASURED FIVE DECADES APART IN MOBILE BAY, AL: IMPLICATIONS FOR OYSTER REEF RESTORATION. Powers, S. P. (1), K. Park (2), C. Kim (3), J. E. Herrmann (4), B. LaCour (5), (1, 2, 3, 4, 5) University of South Alabama, Dauphin Island Sea Lab, Dauphin Island, AL, 36528, USA.

In Mobile Bay oyster reefs represent the primary subtidal biogenic habitat for fish and invertebrates as well as an exploitable fishery. Although some areas of Mobile Bay (e.g., Cedar Point) still support extensive oyster reefs, overall coverage of oyster reefs in Mobile

Bay has likely decreased over the last century. Numerous factors, many of which are of anthropogenic origin (e.g., destructive harvesting practices, poor water quality, and shrimp trawling), have contributed to declines in other Gulf and Atlantic States and are probably factors limiting restoration and expansion of current oyster reefs in Mobile Bay. Here, we compare the results of two recruitment surveys conducted 50 years apart to determine the consistency of recruitment patterns in Mobile Bay. The first recruitment survey, performed by Hoese et al. in the late 1960's, measured recruitment monthly at 14 stations distributed throughout Mobile Bay and adjacent Mississippi Sound. The second survey, conducted from 2006-2008, measured recruitment on a biweekly basis at the same 14 stations plus four additional stations. Because similar methods were used in both studies, the resulting recruitment patterns are comparable. In addition, the 2006-2008 study included measurements of post-settlement mortality and a hydrographic modeling component. Both studies showed a high degree of similarity with a general pattern of low recruitment in the eastern section of the bay and increasing recruitment into Mississippi Sound was obvious. Studies of recently constructed oyster reefs along this gradient have revealed this recruitment pattern in determining restoration success.

- **PROCESSED WASTE WATER: POTENTIAL TOOL FOR PROMOTING OYSTER REEFS IN HIGH-SALINITY WATERS.** Ray, S. M., Texas A&M University at Galveston, PO Box 1675, Galveston, TX, 77553, USA.

A pilot study is underway to determine the feasibility of using the daily production of 10 to 12 million gallons of processed industrial waste water to manage (reduce) the ambient salinity in a small embayment (Swan Lake) in lower Galveston Bay, Texas. The oyster population in Swan Lake is heavily impacted by Dermo disease (*Perkinsus marinus*) and the Southern Oyster Drill (*Stramonita (Thais) haemastoma*). This two year study will include hydrographic measurements, oyster recruitment, oyster meat index, Dermo disease level and assessments of phytoplankton population at several sites in and adjacent to Swan Lake (surface area: 360 acres/259 hectares).

- **GETTING THE MOST BANG FOR YOUR OYSTER (...OR CLAM OR SCALLOP OR MUSSEL...): SUCCESSFULLY INTEGRATING RESTORATION PROJECTS WITH A POLICY AGENDA TO AFFECT ENVIRONMENTAL CHANGE.** Reynolds, S. L. (1), W. J. Goldsborough (2), (1, 2) Chesapeake Bay Foundation, 6 Herndon Ave, Annapolis, MD, 21403, USA.

The oyster reef is built. The press has come and gone. But what happens next? Is this the end of the line for those who dutifully signed in at the registration table? And what about the politician who glad-handed at the event? This should be seen as the beginning—not the end—of citizens' and legislators' role in restoration. This presentation will investigate the nexus between on-the-ground restoration projects and advancing a broader environmental policy agenda-specifically, an agenda aimed at reducing nutrient loading. Described will be the concept that hands-on restoration projects are not only complimentary to, but a critical component of, advancing this agenda. Conversely, a policy agenda with no apparent relationship to physical restoration can be unconvincing and difficult to forward. The presentation will explore the need to help citizens along the continuum from hands-on restoration to advocacy, using tools such as personal communication, targeted messaging, action networks, lobby days and letters to editors. Also addressed will be the need to give politicians and decision makers the opportunity to understand the issues and the level of public interest. This can be initiated by engaging them in restoration projects, but must be followed by asking for their support on, or even the creation of, clear policy vehicles to affect positive, large-scale environmental change.

Oral & Poster

PRESENTATION ABSTRACTS

CHARACTERIZATION OF EASTERN OYSTER GROWTH, REPRODUCTION AND HEALTH IN LAKE WORTH LAGOON, FLORIDA. Scarpa, J. (1), S. Laramore (2), B. Arnold (3), M. Parker (4), A. Volety (5), A. Medri (6), (1) Harbor Branch Oceanographic Institution at Florida Atlantic University, Center for Aquaculture and Stock Enhancement, Fort Pierce, FL, 34946, USA, (2) Harbor Branch Oceanographic Institute at Florida Atlantic University, Aquatic Animal Health Laboratory, Fort Pierce, FL, 34946, USA, (3, 4) Florida Fish and Wildlife Research Institute, 100 Eighth Avenue SE, St. Petersburg, FL, 33701, USA, (5) Department of Marine and Ecological Sciences, Florida Gulf Coast University, Fort Myers, FL, 33965, USA, (6) Palm Beach County - Environmental Resources Management, 2300 N. Jog Rd., 4th Floor, West Palm Beach, FL, 33411, USA.

Oysters and oyster habitat restoration in Florida are taking on new importance as the Comprehensive Everglades Restoration Plan and other local plans are implemented. Oyster populations are being assessed in a number of Florida waterways and goals have been established for restoration efforts. The Lake Worth Lagoon (LWL) in Palm Beach County, Florida is an estuarine habitat 21 miles (~34 km) in length that is significantly influenced by canal drainage and human activities; its watershed is 450 sq mi (1165 sq km). Six sites in the LWL are being monitored for oyster growth, reproduction, recruitment and health (condition index (CI) and Dermo infection) to provide data for ecosystem management. Sites include the northern most area in John D. MacArthur State Recreation Area to the southern edge of Lake Worth. At each site, three spat collectors with two strings each of six shells and a shell array (25 oyster shells tied to wire mesh and supported 10 cm off bottom) are deployed. At monthly site visits basic water quality parameters of salinity, temperature, and dissolved oxygen are measured, spat collectors changed, 30 juvenile oysters measured on the shell array, and 10 oysters are sampled from the oyster beds for CI, Dermo, and reproductive analysis. Data from short and long-term monitoring sites in LWL will be presented and discussed in relation to oyster biology and potential ecosystem management.

GROWTH RATE AND MORTALITY OF DIPLOID *CRASSOSTREA VIRGINICA* AND *CRASSOSTREA ARIAKENSIS* IN MESOCOSMS SIMULATING CHESAPEAKE BAY AND A FLORIDA ESTUARY. Scarpa, J. (1), C. J. Kelly (2), R. I. Newell (3), S. Laramore (4), R. B. Carnegie (5), (1) Harbor Branch Oceanographic Institute at Florida Atlantic University, Center for Aquaculture and Stock Enhancement, Fort Pierce, FL, 34946, USA, (2, 3) Horn Point Laboratory, University of Maryland Center for Environmental Science, Cambridge, MD, 21613, USA, (4) Harbor Branch Oceanographic Institute at Florida Atlantic University, Aquatic Animal Health Laboratory, Fort Pierce, FL, 34946, USA, (5) Virginia Institute of Marine Science, The College of William and Mary, Gloucester Point, VA, 23062, USA.

It has been proposed that the Suminoe oyster, *Crassostrea ariakensis*, be introduced into Chesapeake Bay to supplement declining populations of the eastern oyster, *C. virginica*. However, it is unknown how this species would grow and survive in Atlantic estuaries. Therefore, we compared growth and survival of diploid oysters from both species in quarantine mesocosms in Maryland and Florida. Mesocosms were supplied with flowing water: MD temperature 1 to 28˚C and salinity of 7 to 15; FL temperature 16 to 30˚C and salinity of 27 to 37. Instantaneous relative growth rate (k) was calculated for each species so that an unbiased description of the increasing size of the oysters could be determined. In Maryland, growth of *C. virginica* was significant during the period immediately after settlement (fall 2004) and during the spring-summer period of 2005. Growth of *C. ariakensis* showed seasonal patterns, with the most significant growth occurring during the cooler winter and spring periods. When compared to each other, *C. ariakensis* exhibited significantly faster growth than *C. virginica* during all periods, except during the summer and fall periods of 2006 and 2007. In contrast, in Florida, *C. virginica* grew significantly faster compared to *C. ariakensis* during the first three months of the study (October to December 2006) and generally had a faster, but not significantly different, growth rate during the remaining seven months (Jan-July) of the study. *Crassostrea*

ariakensis suffered total mortality by the end of the experiment. These results suggest that while *C. ariakensis* may be well suited to mesohaline Chesapeake Bay, their distribution elsewhere may be limited. Funding for this project was provided by Maryland DNR and NOAA.

- **UNPRECEDENTED RESTORATION OF A NATIVE OYSTER METAPOPULATION IN CHESAPEAKE BAY.** Schulte, D. M. (1), R. P. Burke (2), R. N. Lipcius (3), (1) Virginia Institute of Marine Science and US Army Corps of Engineers, 803 Front Street, Norfolk, VA, 23510, USA, (2, 3) Virginia Institute of Marine Science, 1208 Greate Road, Gloucester Point, VA, 23062, USA.

In marine and estuarine habitats worldwide, native oyster species were once vital ecosystem engineers whose populations have been sequentially depleted through overfishing and oyster reef habitat destruction. In Chesapeake Bay, the Eastern oyster (*Crassostrea virginica*) has been similarly depleted to approximately 1% of its historical population, leading some to conclude that native oyster restoration is unlikely and that a non-native oyster species should be introduced. We report an unparalleled restoration of a native oyster population in the Great Wicomico River, a sub-estuary of lower Chesapeake Bay, which was selected for experimental restoration in 2004 by the US Army Corps of Engineers. Restoration involved three experimental treatments (medium-relief reefs (~10-24" tall), low-relief reefs (~4" tall), unrestored bottom) and is believed to be the largest permanent restored reef network to date. The network of oyster reefs, comprised of nearly 200 million live oysters of three year classes, represents the largest and densest native oyster metapopulation in restored, permanent sanctuary reefs of Chesapeake Bay and worldwide. Moreover, the oyster reefs have been accreting at a rate that promotes persistence and long-term sustainability, and whose oysters have increased the local population approximately 62-fold, a population roughly analogous to that in all of Maryland's waters. Many of the reefs are exhibiting both vertical and cohesive growth, not following the pattern of decline and loss typically observed in the Bay. Preliminary data indicate an exceedingly strong recruitment of a fourth year class in summer 2008, demonstrating continuing persistence of the metapopulation. Restoration of native oyster populations can be and has been achieved in the Chesapeake Bay, when proper scale and science were applied to a hydrodynamically-distinct segment of the metapopulation.

- **MONITORING SHELLFISH BEDS IN FLORIDA'S INDIAN RIVER AND MOSQUITO LAGOONS FOR *PYRODINIUM BAHAMENSE* AND SAXITOXINS.** Scott, P. (1), J. Wolny (2), C. Brooks (3), E. Faltin (4), J. Abbott (5), H. Beadle (6), B. Browning (7), S. Darlene (8), J. Landsberg (9), J. Tustison (10), (1) Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute, 100 8th Avenue SE, St. Petersburg, FL, 33701, USA, (2) Florida Institute of Oceanography , 830 1st Avenue South, St. Petersburg, FL, 33701, USA, (3) Florida Department of Agriculture and Consumer Services, 1203 Governors Square Boulevard, Tallahassee, FL, 32301, USA, (4) Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute, 100 8th Avenue SE, St. Petersburg, FL, 33701, USA, (5) Florida Institute of Oceanography, 830 1st Avenue South, St. Petersburg, FL, 33701, USA, (6, 7, 8) Florida Department of Agriculture and Consumer Services, 1378 Malabar Road, Palm Bay, FL, 32909, USA, (9) Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute, 100 8th Avenue SE, St. Petersburg, FL, 33701, USA, (10) Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute, 100 8th Avenue SE, St. Petersburg, FL, 33701, USA.

In the United States, Paralytic Shellfish Poisoning (PSP) incidents have occurred along the Pacific and New England coasts, with the saxitoxin (STX)-producing dinoflagellate *Alexandrium* being the main cause. In 2002, saxitoxin was first identified in Florida waters as a result of poisoning incidents involving the consumption of pufferfish harvested from the Indian River Lagoon (IRL). Analyses revealed that southern checkered and bandtail pufferfish (*Sphoeroides* spp.) and water samples

containing *Pyrodinium bahamense* were positive for STX. Because of the public health risks associated with PSP, the Food and Drug Administration (FDA), the FWC, and FDACS, established a biomonitoring plan for saxitoxins in the IRL. The PSP biomonitoring plan for the IRL initially recommended sampling of three fixed sites. The plan involved monthly collection of water and hard clam (*Mercenaria* sp.) samples by FDACS, which were analyzed by FWC for *P. bahamense* and STX concentrations. The plan also provided guidelines (following FDA action limits for saxitoxins) for closing and reopening of shellfish beds using mouse bioassays. In June 2006, an extensive *P. bahamense* bloom necessitated the geographical expansion of the established fixed sites to 61 sites to include the Mosquito Lagoon. Seventeen of the initial *Mercenaria* sp. collections were above the regulatory limit of 80 µg/100g for STX. As a result, 10 shellfish harvesting areas in the IRL were closed for 665 days cumulatively, with the longest single closure of 107 days, until the STX concentrations in shellfish dropped below the action limit. The successful implementation of the biotoxin contingency plan for monitoring *P. bahamense* and STX in the IRL has thus far prevented any PSP public health incidents.

EVALUATING THE BENEFITS OF LANDSCAPE-SCALE OYSTER REEF RESTORATION: A TOOL FOR PROMOTING LIVING-SHORELINES?
Scyphers, S. B. (1), S. P. Powers (2), M. Lott (3), (1) University of South Alabama, Department of Marine Sciences, Fisheries Ecology Lab, Dauphin Island Sea Lab, 101 Bienville Blvd., Dauphin Island, Alabama, 36528, USA, (2) University of South Alabama, Department of Marine Sciences; Fisheries Ecology Lab, Dauphin Island Sea Lab, 102B Bienville Blvd., Dauphin Island, Alabama, 36528, USA, (3) The Nature Conservancy, 257A St. Francis Street, Mobile, Alabama, 36602, USA.

Shorelines at the interface of marine and terrestrial biomes are one of the most degraded and threatened habitats in the coastal zone because of their sensitivity to sea level rise, storms, and increased utilization by man. Previous efforts to restore shorelines have largely involved constructing bulkheads and seawalls. Both of these methods have been shown to cause vertical erosion down the barrier, subsequent loss of intertidal zone, and even increased erosion on adjacent properties. Recently, some restoration efforts have shifted towards biogenic reefs, or “living shorelines.” Beyond shoreline stabilization, living reefs may provide additional ecosystem services such as habitat for resident species of shellfish and finfish, providing feeding resources for transient fishes, and improved water quality via the filter-feeding bivalves. Currently, we are evaluating the effectiveness of multiple configurations and scales of breakwater oyster reefs in coastal Alabama. We hypothesized that over time the presence of Eastern oyster (*Crassostrea virginica*) reefs could stabilize and possibly facilitate the expansion of shoreline marsh grass as well as provide habitat for additional fishes. Our preliminary results support our hypothesis that created oyster reefs will be utilized by transient fishes and provide substrate for oyster reef recruitment. Results from this study and others could provide support for oyster reef and other living shoreline restoration practices.

A GENETIC ASSESSMENT OF BAY SCALLOP RESTORATION IN BOGUE SOUND, NORTH CAROLINA.
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In recent years, bay scallops (*Argopecten irradians*) in North Carolina have been the focus of increasing concern due to declining abundances. The decline is attributable to a combination of natural and anthropogenic factors. While these factors have not completely eradicated bay scallops from North Carolina waters, they have likely upset the natural connections between local aggregations that were, at one time, sufficient to keep bay scallop abundances high throughout the region. As a consequence, the recovery of scallops may initially require hatchery-based restoration to elevate abundances and restore connectivity. In the fall of 2007, we released approximately 2.5 million hatchery-produced competent larvae into Bogue Sound, North Carolina in an effort to evaluate the efficacy of this strategy of restoration. Assessment surveys were conducted in June of 2008. Scallop samples collected during the assessment were subjected to a two-step genetic analysis to estimate the contribution resulting from the restoration effort. Analysis of a variable portion of the mtDNA genome can identify what fraction of the assessment scallops exhibit haplotypes consistent with hatchery origin, and the subsequent analysis of microsatellite loci can distinguish between hatchery and wild origin in cases where the mtDNA haplotypes are not diagnostic. Preliminary data from mtDNA sequencing revealed 24% of the assessment scallops exhibit haplotypes that were observed in the hatchery broodstock, and suggests a marked contribution. Microsatellite analysis is ongoing and will provide a more accurate assessment as to the success of larval releases as a method for bay scallop restoration.

▸ **ECOLOGY, DECLINE AND RESTORATION OF *MODIOLUS MODIOLUS* (L.) BIOGENIC REEFS.** Strong, J. A. (1), A. Mahon (2), D. Smyth (3), J. F. France (4), (1, 2, 3, 4) Queen's University Belfast, Portaferry Marine Station, Portaferry, Newtownards, Co. Down, BT22 1PF, UK.

Modiolus modiolus is a long-lived marine bivalve, which lives semi-infaunally on coarse substrata as continuous reefs or in isolated clumps. In Strangford Lough (Northern Ireland), *Modiolus* forms clumped biogenic reefs which are unusual in the UK as they are on a very soft substratum. Within the Lough, these reefs have very high biodiversity and perform important ecosystem services. Although work in the 1970's showed that *Modiolus* reefs were extensively distributed throughout Strangford Lough, mapping undertaken in the 1990's found that they had been significantly impacted. More recently, it has been reported that over 50% of the *Modiolus* reef habitat had disappeared and the remaining areas were significantly reduced in quality. In February 2008, Queen's University, Belfast was commissioned to examine the current condition of *Modiolus* reefs in Strangford Lough and assess the potential of certain restoration methodologies. Reef mapping has been undertaken by divers using diver propelling vehicles fitted with an Ultra-short Base Line tracking system. The condition and potential natural recovery of the *Modiolus* reefs is being assessed through fixed point quadrats. Initial data on the distribution and condition of *Modiolus* are presented. Restoration techniques for this long-lived, non-commercial species differ from those used elsewhere. Greater emphasis has been placed on the re-structuring of existing reefs and maximising recruitment within the Lough. An explanation of proposed reef restoration techniques are presented with an update of current progress.

▸ **TURNING "DERELICT" CLAM CULTURE EQUIPMENT INTO OYSTER REEF BUILDING BLOCKS THROUGH RECLAMATION OF SHELLFISH AQUACULTURE LEASES IN CEDAR KEY, FLORIDA, USA.** Sturmer, L. N. (1), S. Colson (2), M. E. Berrigan (3), M. J. Charbonneau (4), H. Thomas (5), D. A. Smith (6), (1) University of Florida, P.O. Box 89, Cedar Key, FL, 32625, USA, (2) Cedar Key Aquaculture Association, P.O. Box 315, Cedar Key, FL, 32625, USA, (3) Florida Department of Agriculture and Consumer Services, 1203 Governor's Square Boulevard, Tallahassee, Florida, 32301, USA, (4) Florida Department of Environmental Protection, Big Bend Seagrasses Aquatic Preserve, Crystal River, Florida, 34428, USA, (5) Florida Department of Agriculture and Consumer Services, Suwannee River Partnership, Live Oak, Florida, 32060, USA, (6) Levy Soil and Water Conservation District, P.O. Box 37, Bronson, Florida, 32621, USA.

Producing hard clams, *Mercenaria mercenaria*, on coastal submerged lands is the largest marine aquaculture industry in Florida with an economic impact to the state estimated at $34 million. However, clam farming is a high-risk enterprise and subject to catastrophic production losses. Florida was directly and indirectly impacted by a series of climatic events in 2004-5 that affected clam farming operations. The presence of destroyed and abandoned culture equipment (referred to as "derelict" clam bags) on shellfish leases restricted farmers from replanting. A working partnership with federal, state, and local agencies was developed to assist the industry in their recovery efforts. With state funding, the partnership designed and implemented a pilot project to locate and transport derelict bags. A habitat restoration component was incorporated into the pilot project, which used bags as substrate to construct oyster reef habitat. In 2007, over 1,600 derelict bags were removed from 28 leases in Cedar Key and became structural components of a 0.07-acre oyster reef. It was estimated an average derelict bag contained 0.15 cubic yards of clam shell (a suitable cultch material) and 8,000 live oyster spat. The shoreline of a small offshore island (original settlement of Cedar Key) in which severe erosion was endangering historic landmarks was selected for the oyster reef component. Critical services provided in this pilot program included restoring ecological and commercial value to impaired state-owned lands, accelerating the recovery of clam farming businesses, providing fisheries habitat, reducing shoreline erosion, and protecting natural, archaeological, and cultural resources. Additional funding recently obtained from a NOAA grant program will allow another 2,500 derelict bags to be relocated during 2008-9.

▸ **OLYMPIA OYSTER (*OSTREA CONCHAPHILA*): RESTORATION CHALLENGES DURING A *VIBRIO TUBIASHII* OUTBREAK IN OREGON COASTAL WATERS.** Vander Schaaf, D. (1), P. Archer (2), (1) The Nature Conservancy, 821 SE 14th Avenue, Portland, Oregon, 97214, USA, (2) Oregon State University, College of Ocean & Atmospheric Sciences, Corvallis, Oregon, 97331, USA.

Restoration of the Olympia oyster (*Ostrea conchaphila*) in Netarts Bay, Oregon, has been severely challenged in 2007-2008 due to an unusually strong and long lasting *Vibrio tubiashii* outbreak. Prior to this event, restoration was yielding promising results, was embraced by the local community and, as a result, was being initiated at other sites in Oregon. The outbreak directly impacted the commercial shellfish hatchery in Netarts Bay that spawns and sets Olympia oysters used in the NOAA-funded restoration project in Netarts Bay. The *Vibrio* bacteria release a toxin that impacts and kills bivalve larvae in the free-swimming stage, and has caused a major slowdown in hatchery activities on the Pacific coast. These challenges are cascading across both commercial oyster production and restoration activities. Efforts to combat the bacteria in the hatchery have been partially effective but effects in recovering populations of Olympia oysters are less certain. The causes of the outbreak are unknown but some hypothesize that it is linked with the expanding zone of hypoxia off the Oregon coast. Complicating the matter in 2008 are rapidly falling pH levels in the Bay that appear to have deterred spawning in oysters as well. Adaptive restoration strategies may include seeking resilient genotypes of Olympia oysters, focusing restoration in areas that are less prone to *Vibrio* toxins, or identifying factors that may be positively affecting the bacteria and reducing these threats.

▸ **IF YOU BUILD IT, WILL THEY COME?** Walters, K. (1), L. Coen (2), R. Hilard (3), (1) Coastal Carolina University, Dept. of Marine Science, Conway, SC, 29528, USA, (2) Sanibel-Captiva Conservation Foundation Marine Laboratory, 900A Tarpon Bay Rd., Sanibel, FL, 33957, USA, (3) Coastal Carolina University, Dept. of Marine Science, Conway, SC, 29528, USA.

Oyster reef restoration efforts typically represent projects of opportunity with sites selected based on characteristics not directly connected to reef success. To determine if larval availability and/or reef characteristics could contribute to restoration success, a series of spat settlement experiments were conducted in South Carolina inlets. Oyster settlement was dependent on inlet location, ranging from 17,000 to 58,600 recruits m^{-2}. Collector age affected recruitment suggesting settlement is density-dependent. Spat settlement also was dependent upon location within a reef. Larvae settled in greater numbers within middle and inside-edge reef zones and in significantly lower densities within outside-edge and outside reef zones. Habitat complexity and not conspecific attraction may be more critical to settlement success of *Crassostrea* larvae. Results indicate reef success will be limited if appropriate habitat (>2 wk old) is not available during peak spawning periods. Reef complexity also appears to be an over-riding factor in the successful settlement of oyster larvae, not the presence of adult conspecifics. Based on the results from this study we would recommend that (1) reef construction occur as close to peak spawning periods as possible for greatest settlement success, and (2) construction should maximize reef architectural complexity, similar to that observed on natural reefs.

MEASURING SUCCESS IN OYSTER REEF RESTORATION: APPLICATION OF STANDARDIZED MONITORING METRICS TO CREATED REEFS IN NORTH CAROLINA.

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Oysters along the Atlantic and Gulf coasts of North America have supported a historically important commercial fishery. They are also increasingly recognized as key components of the coastal ecosystem, providing habitat for transient and resident fauna, affecting particulate concentrations in overlying waters, reducing wave energy along sensitive shorelines, and influencing local biogeochemical cycling. As oyster populations have declined along the Atlantic coast, efforts to restore oyster reefs for their ecosystem functions have increased. However, the lack of long-term monitoring using standardized methodologies that target both population and ecosystem functions has been an impediment to assessing the success of many restoration projects, and especially for comparing efforts among regions. In 2004, participants at a Sea Grant sponsored workshop proposed a set of sampling criteria and methodologies to provide standardized population and ecosystem measures for assessing the success of oyster restoration projects. Here we apply a subset of these measures to a series of created reefs of varying ages along the central and southeast North Carolina coast. This approach includes comparing selected habitat and population functions to reference reefs, and examining the influence of reef seeding with remote set spat, varying tidal position (intertidal to shallow subtidal), and landscape attributes such as shell depth and proximity of adjacent habitat types on resulting reef development and function. This project provides a comparison among different restoration designs, as well as information on habitat function in a standardized form that can be compared among similar studies to aid in understanding factors important in reef establishment.

MONITORING THE 2007 FLORIDA EAST COAST *KARENIA BREVIS* RED TIDE AND NSP OUTBREAK.

Wolny, J. (1), P. Scott (2), C. Brooks (3), H. Beadle (4), J. Brame (5), B. Browning (6), E. Faltin (7), D. Snider (8), J. Tustison (9), (1) Florida Institute of Oceanography, 830 1st Avenue South, Saint Petersburg, Florida, 33701, USA, (2) Florida Fish and Wildlife Conservation Commission, 100 8th Avenue SE, Saint Petersburg, FL, 33701, USA, (3) Florida Department of Agriculture and Consumer Services, 1203 Governors Square Boulevard, Tallahassee, FL, 32301, USA, (4) Florida Department of Agriculture and Consumer Services, 1378 Malabar Road, Palm Bay, FL, 32909, USA, (5) Florida Fish and Wildlife Conservation Commission, 100 8th Avenue SE, Saint Petersburg, FL, 33701, USA, (6) Florida Department of Agriculture and Consumer Services, 1378 Malabar Road, Palm Bay, FL, 32909, USA, (7) Florida Fish and Wildlife Conservation Commission, 100 8th Avenue SE, Saint Petersburg, FL, 33701, USA, (8) Florida Department of Agriculture and Consumer Services, 1378 Malabar Road, Palm Bay, FL, 32909, USA, (9)

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Blooms of the toxic dinoflagellate *Karenia brevis* are a common occurrence in the eastern Gulf of Mexico. Less common, however, is the occurrence of *K. brevis* blooms on Florida's east coast. In September 2007, reports of respiratory irritation and fish kills were received from the Jacksonville area. Water samples collected from these areas indicated a bloom of *K. brevis*, the dinoflagellate responsible for causing Neurotoxic Shellfish Poisoning (NSP). For the next 4 months, *K. brevis* was found along approximately 200km of coastal and intercoastal waterways from Jacksonville to Jupiter Inlet. This event represents the longest and most extensive red tide the east coast of Florida has experienced to date and influenced the way commercial shellfish beds were managed. Once *K. brevis* was detected along the east coast, the Florida Department of Agriculture and Consumer Services (FDACS) closed affected shellfish harvesting areas to recreational and commercial harvesting of clams (*Mercenaria* sp.) and oysters (*Crassostrea virginica*). These shellfish harvesting areas were then monitored weekly for *K. brevis* cell concentrations. Once *K. brevis* cell concentrations dropped below 5000 cellsL^{-1} clam and oyster meats were tested using mouse bioassay to determine when the brevetoxins (PbTx) had depurated from the shellfish. Shellfish harvesting areas were closed for an average of 63 days due to this red tide. Interagency cooperation in monitoring commercial and recreational shellfish beds will be discussed. Spatial and temporal data on this *Karenia brevis* bloom, as well as ELISA and mouse bioassay data for PbTx concentrations in the shellfish, will also be presented.