ICSR 2006

INTERNATIONAL CONFERENCE ON SHELLFISH RESTORATION

9th International Conference on Shellfish Restoration

ABSTRACTS and SELECTED PRESENTATIONS

INTERNATIONAL CONFERENCE ON SHELLFISH RESTORATION

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CONFERENCE OVERVIEW

Throughout the world there is a growing commitment to the restoration of degraded coastal ecosystems. Political pressure by shareholders in the future of the world's coastal areas has resulted in renewed interest in preserving and enhancing coastal resources at all levels of government. At the local level many volunteer organizations have developed successful programs to identify problem areas, recommend improvements, and monitor progress.

The 9th International Conference on Shellfish Restoration (ICSR'06) will provide an opportunity for government officials, resource managers, users, community leaders, and residents to discuss approaches to restore coastal shellfish ecosystems through management, enhancement, and restoration efforts, and to learn about and discuss innovative management, ecological, and social approaches to restore degraded shellfish habitat and improve coastal ecosystem health.

The conference, scheduled for November 15-19, 2006 at the DoubleTree Guest Suites in downtown Charleston, S.C., consists of invited keynote and panel presentations and contributed poster presentations. Case studies of successful projects will be presented, with opportunities for roundtable discussions.

More than 200 participants representing ten countries attended the last ICSR conference in the United States in 2004. The conference has been so successful that a European version of ICSR was held in Cork, Ireland in 1999, a Canadian version was held in Nainamo, British Columbia in 2001, and ICSR'05 was held in Brest, France.

ICSR'06 Sponsors

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Thursday, November 16, 2006

Plenary Presentation

King.pps

"Overview of NOAA's Non-native Oyster Research Program"
King, J.L., Habitat Program Manager, Non-native Oyster Specialist, NOAA Chesapeake Bay Office, Annapolis, MD 21403.

Contributed Session A

"Exotic Species, Genetics, and Disease: Challenges for Shellfish Restoration"
Moderated by William Rickards, Virginia Sea Grant College Program, and Geoffrey Scott, NOAA-CCEHBR

Wijsman.pps

"Risk Analysis on the Introduction of Exotic Species with Mussel Transfer" Wijsman, J.W.M. and A.C. Smaal, Institute for Marine Resources and Ecosystem Studies (IMARES) PO box 77 4400 AB Yerseke, Netherlands.

Carlsson.pps

"Tracking Breeding Success Of Deployed Oysters Through Microsatellite Variation" Carlsson J., S.K. Allen Jr, and K.S. Reece, Virginia Institute of Marine Science, P.O. Box 1346, College of William and Mary, Gloucester Point, VA 23062-1346.

Dahl.pps

"Tolerance Of Different Hard Clam Stocks To Various Isolates Of Quahog Parasite Unknown (QPX)" Dahl, S., M. Perrigault and B. Allam, Marine Sciences Research Center, Stony Brook University, Stony Brook, NY 11794-5000.

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Contributed Session A (continued)

Carnegie.pps

"Increasing Tolerance For Perkinsus Marinus Among Natural Crassostrea Virginica Populations From Virginia Waters" Carnegie, R. and E.M. Burreson, Virginia Institute of Marine Science, Route 1208 Greate Road, P.O. Box 1346, Gloucester Point, VA 23062.

Hare.pps

"The Benefits And Consequences Of Restoration Using Selectively-bred Disease-tolerant Oysters" Hare, M., Biology Department, University of Maryland, College Park, MD 20742.

KingsleySmith.pps

"Inter-site And Inter-specific Differences In Rates Of Survival And Growth Of C. Virginica And C. Ariakensis: A Collaborative On-bottom Study In Virginia And Maryland" Kingsley-Smith, P. R.(1), H.D. Harwell, (1), M.L. Kellogg (2), S.K. Allen, Jr.(3), D.W. Meritt (4), K.T. Paynter, Jr.(5), and M.W. Luckenbach, (1), (1) Eastern Shore Laboratory, Virginia Institute of Marine Science, P. O. Box 350, Wachapreague, VA 23480, (2) Department of Biology, University of Maryland, College Park, MD 20742, (3) Virginia Institute of Marine Science, P. O. Box 1346, Gloucester Point, VA 23062, (4) Horn Point Laboratory UMCES 2020 Horn Point Rd, P.O. Box 775, Cambridge, Maryland, 21613, (5) Department of Biology, University of Maryland, College Park, MD 20742.

Goodwin.pps

"Caged Crassostrea Ariakensis Deployment In Chesapeake Bay: Growth, Disease, And Mortality" Goodwin, J., M. Chen, and K.T. Paynter, MEES Program, 0105 Cole Field House, University of Maryland, College Park, MD 20742.

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▸ Contributed Session A (continued)

Cordes.pps

"Genetic Variation Among Native Populations And Hatchery Stocks Of C. Ariakensis: Considerations Regarding Planned Introductions Into The Chesapeake Bay" Cordes, J.F., K.S. Reece, and J. Xiao, Virginia Institute of Marine Science, The College of William and Mary, P.O. Box 1346, Gloucester Point, VA 23062.

▸ Contributed Session B

"Ecological Interactions in Shellfish Restoration" Moderated by Loren Coen, SCDNR, MRRI, and David Bushek, Rutgers University

Burnell.pps

"Managing Mussel Seed in the Irish Sea–the Biological Issues"

Hancock.pps

"North Cape Scallop Restoration In Rhode Island" Hancock, B. (1), N. Lazar (2), J. Turek (1), and J. Catena (3), (1) NOAA Restoration Center, NMFS Northeast Fisheries Science Center, 28 Tarzwell Drive, Narragansett, RI 02882, (2) Rhode Island Department of Environmental Management, Division of Fish and Wildlife, Marine Fisheries, 3 Ft. Wetherill Rd., Jamestown, RI 02835, (3) NOAA Restoration Center, NMFS, 1 Blackburn Dr., Gloucester, MA 01930.

Leverone.pps

" 'Boom Or Bust': Restoring Bay Scallop Populations In Florida Through The Release Of Competent Larvae: Are Containment Booms Necessary?" Leverone, J.R. (1), S.P. Geirger (2), W.S. Arnold (2), and J.M. Greenawalt (3), (1) Mote

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▸ CONTRIBUTED SESSION B (CONTINUED)

Marine Laboratory, 1600 Ken Thompson Parkway, Sarasota, FL 34236, (2) Fish and Wildlife Research Institute, 100 Eighth Avenue SE, St. Petersburg FL 33701, (3) Charlotte Harbor National Estuary Program, 1926 Victoria Ave., Fort Myers, FL 33901.

Posey.pps

"Effects Of Morphology, Age, And Location On Habitat Function Of Oyster Reefs: Implications For Restoration" Posey, M.H. (1), T. Alphin (2), H. Harwell (3), J. Sonnier (2), and S. Artabane (2), (1) Department of Biology and Marine Biology, UNC-Wilmington, Wilmington, NC 28403, 2) UNC Wilmington, 601 S. College Road, Wilmington NC 28403, (3) Virginia Institute of Marine Science, Rt. 1208, Greate Road Gloucester Point, VA 23062.

Walters.pps

"Assessing Resident Faunal Assemblage Similarity Between Restored And Natural Oyster Reefs" Walters, K. (1) and L. Coen (2), (1) Dept. of Marine Science, Coastal Carolina University, P.O. Box 261954, Conway, SC 29528, (2) Marine Resources Research Institute, SCDNR, 217 Ft. Johnson Road, Charleston, SC 29412.

Coen.pps

"Seasonality And Size Of Boonea Impressa Populations On Restored And Natural Oyster Reefs: Does Size Matter?" Coen, L.D. (1), A. Hollis (1), S. Roth (1), and R. Kalisperis (2), (1) Marine Resources Research Institute, SCDNR, Charleston, SC 29412 (2) South Carolina Aquarium, 100 Aquarium Wharf, Charleston, SC 29401.

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▸ **Contributed Session B** (continued)

Lawless.pps

"Secondary Production Of Infaunal Benthic Communties In Chesapeake Bay In Comparison To Restored Oyster Reefs" Lawless, A. and R. Seitz, Virginia Institute of Marine Science, The College of William and Mary, P.O Box 1346, Gloucester Point, VA 23062.

Rodney.pps

"Interaction Of Top Down And Bottom Up Forces And Habitat Complexity In Experimental Oyster Reef Microcosms: Implications For Secondary Production And Trophic Transfer" Rodney, W., M.L. Kellogg, and K.T. Paynter, (1) MEES Program, 0105 Cole Field House, University of Maryland, College Park, MD 20742.

Landry.pps

"Atlantic Zone Aquatic Invasive Species Monitoring Program"

Smaal.pps

"Introduction, impact and management of the Pacific oyster (Crassostrea gigas) in Dutch coastal waters"

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Wijeyaratne.pps

"Conservation Management And Restoration Of Shellfish Habitats In Sri Lanka" Wijeyaratne, M.J.S., Vice-Chancellor, University of Kelaniya, Kelaniya, Sri Lanka.

Ruesink.pps

"West Side Story – The Context, Causes, And Consequences Of The Pacific Oyster Introduction To Washington State" Ruesink, J.L., Associate Professor of Biology, University of Washington, Department of Biology, Box 351800, 24 Kincaid Hall, Seattle, WA 98195-1800.

▸ Panel Session B

"West Coast Native Oyster Panel"

▸ Panel Session C

"Regulatory Aspects of Shellfish Restoration"

▸ Contributed Session C

"Large-scale Approaches to Shellfish Restoration"

Burnell.pps

"Restoring The Boyne Co. (Louth, Ireland) Mussel Population" Burnell, G., Aquaculture and Fisheries Development Centre, Environmental Research Institute, University College Cork, Cork, IRELAND.

Manley.pps

"Assessment Of Cultch Materials For Oyster Habitat Restoration In Georgia" Manley J. (1), A. Power (1), R.L.Walker (1), D. Hurley (2), M. Gilligan (3), and J. Richardson (3), (1) Shellfish Research Laboratory, Marine Extension Service,

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▸ **Contributed Session C** (continued)

University of Georgia, 20 Ocean Science Circle, Savannah, GA 31411-1011, (2) Sapelo Island National Estuarine Research Reserve, P.O. Box 15, Sapelo Island, GA 31327, (3) Savannah State University, College of Science and Technology, Department of Natural Science and Mathematics, 3219 College Street, Savannah, GA 31404.

LoBue.pps

"Re-clam-ation Of The Bluepoints Bottomlands: Results From The First Two Years Of A Large Scale Effort To Restore Sustainable Hard Clam Populations To Great South Bay, NY" LoBue C. (1), C. Clapp (1), and M. Doall (2), (1) The Nature Conservancy on Long Island, 250 Lawrence Hill Rd., Cold Spring Harbor, NY 11724, (2) Department of Ecology and Evolution, Stony Brook University, Stony Brook, NY 11790.

Anderson.pps

"Commercial Techniques In Shellfish Resource Enhancement And Restoration: South Carolina Examples" Anderson, W.D. and J.M. Monck, Marine Resources Division, SCDNR, 217 Ft. Johnson Road, Charleston, SC 29412.

Burke.pps

"Eastern Oyster Recruitment And Survival On Alternative Reef Substrates In Lynnhaven Bay, Virginia" Burke, R.P. (1), Lipcius, R. (1), Luckenbach, M, (3), Ross, P.G. (3), Woodward, J. (1), and Schulte, D. (4), (1) Virginia Institute of Marine Science, The College of William and Mary, 1208 Greate Road, Gloucester Point, VA 23062, (3) Virginia Institute of Marine Science, The College of William and Mary Eastern Shore Laboratory, P.O. Box 350, Wachapreague,

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▸ CONTRIBUTED SESSION C (CONTINUED)

Shore Laboratory, P.O. Box 350, Wachapreague, VA 23480, (4) U.S. Army Corps of Engineers, Norfolk District 803, Front Street, Norfolk, VA 23510.

Allen.pps

"Preliminary Comparison Of Geographic Information System (Gis) Analysis Of Patent Tong Surveys And Bar Cleaning Oyster Population Estimates In The Upper Chesapeake Bay" Allen, S., H. Lane, J. Goodwin, M. Chen, M.L. Kellogg, and K.T. Paynter, MEES Program, 0105 Cole Field House, University of Maryland, College Park, MD 20742.

Kraeuter.pps

"How Long Does Oyster Shell Last On An Oyster Reef?" Kraeuter, J.N., E.N. Powell, and K.A. Ashton-Alcox, Haskin Shellfish Research Laboratory, Rutgers University, 6959 Miller Avenue, Port Norris, NJ 08349.

Babb.pps

"Seeding The Seed Beds: The Delaware Bay Oyster (Crassostrea Virginica) Restoration Program" Babb, R. (1), J. Hearon (1), D. Bushek (2), and E. Powell (2), (1) New Jersey Department of Environmental Protection, Division of Fish and Wildlife, Port Norris, NJ 08349, (2) Haskin Shellfish Research Laboratory, Rutgers University, Port Norris, NJ 08349.

Grizzle.pps

"Oyster Restoration Using "Spat Seeding": Early Reef Performance At Sites In New Hampshire" Grizzle, R., J. Greene, and M. Capone, University of New Hampshire, 85 Adams Point Road, Durham, NH 03824.

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"Factors Influencing Shellfish Restoration Success"

Dang.pps

"Multi-infection Pattern In The Exploited Manila Clam (Ruditapes Philippinarum) Of Arcachon Bay (France)" Dang, C. (1), S. Saez (2), X. de Montaudouin (1), N. Caill-Milly (3), and P. Gonzalez (1), (1) Arcachon Marine Station, UMR EPOC 5805, University Bordeaux 1 - CNRS 2, rue du Pr Jolyet F-33120, Arcachon, France, (2) University Pau Allée du Parc Montaury F-64600 Anglet, France, (3) IFREMER Technopole IZARBEL Côte Basque, Maison du Parc F-64210 Bidart, France.

Parker.pps

"Direct vs. Indirect Impacts Of Salinity On Oyster (Crassostrea Virginica) Health And Abundance" Parker, M.L. and W.S. Arnold, Fish & Wildlife Research Institute, 100 Eighth Ave SE, St. Petersburg, FL 33701.

MacFarlane.pps

"Nosing Around For Wastewater Management Solutions" MacFarlane, S., Coastal Resource Specialist, P.O. Box 1164, Orleans, MA 02653.

Hodges.pps

"Shoreline Stabilization And Changes In Sediment Composition Associated With Small-scale Oyster Reefs In South Carolina" Hodges, M.S. (1), N. Hadley (1), L. Coen (1), S. Roth (1), M. Bolton-Warberg (1), and L. Goodwin (2), (1) S.C. Department of Natural Resources, Shellfish Research Section, 217 Fort Johnson Rd., P.O. Box 12559, Charleston, SC 29412-2559, (2) College of Charleston, MES Program, Charleston, SC 29424.

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▸ Contributed Session D (continued)

Lipcius.pps

"Metapopulation Source-sink Dynamics And Connectivity Of Oyster Reef Networks" Lipcius, R. (1), H. Wang (1), J. Shen (1), M. Sisson (1), and S. Schreiber (2), (1) Virginia Institute of Marine Science, The College of William and Mary, Gloucester Point, VA 23062, (2) Department of Mathematics, The College of William and Mary, Williamsburg, VA 23188.

Kellogg.pps

"Role Of Oyster Age Versus Oyster Size In Determining Sex Ratios On Restored Oyster Reefs In Chesapeake Bay" Kellogg, M.L., M.E. Chen, V.S. Kennedy, C.P. Miller, S.E. Rowland, R.T. Paynter, K. C. Paynter, N.J. Ward, D. Goldsmith, M.W. Sherman, J.D. Goodwin, C.P. McIntyre, S. Allen, and K.T. Paynter, Department of Biology, University of Maryland, 0218E Biology-Psychology Bldg., College Park, MD 20742.

Leggett.pps

"The Effect Of Cow Nose Ray Predation On Oyster Restoration And The Use Of Spat On Shell For Brood Stock Enhancement Of Sanctuary Reefs" Leggett, A.T. Jr. (1), J. Wesson (2), S. Allen (3), R. Mann (3), and M. Bryer (4), (1) Chesapeake Bay Foundation, P.O. Box 412, Wicomico, VA 23184, (2) Virginia Marine Resources Commission, 2600 Washington Ave., 3rd Floor, Newport News, VA 23607, (3) Virginia Institute of Marine Science, P.O. Box 1346, Gloucester Point, VA 23062, (4) The Nature Conservancy, MD/DC Chapter, 5410 Grosvenor Lane, Suite 100, Bethesda, MD 20814.

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Abbott.pps

"Limiting Factors In The Success Of Habitat Restoration Site For O. Conchiphilia In San Francisco Bay" Abbott, R.R. (1), Obernolte, R. (1) and Mulvey, B. (2), (1) MACTEC Engineering and Consulting, Inc., 5341 Old Redwood Highway, Suite 300, Petaluma, CA 94954, (2) NOAA Fisheries, 777 Sonoma Ave., Santa Rosa, CA 95404.

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▸ Keynote Presentation

Smaal.pps

"Shellfish Culture And Nature Conservation"

Reece.pps

"Genetic Considerations In Broodstock Selection For Oyster Restoration, Aquaculture Development, And Non-native Species Introductions"

▸ Contributed Session E

"Small-scale Approaches to Shellfish Restoration"

Craig.pps

"Threats To The Eastern Oyster: Results Of A Survey Of State Resource Managers And Independent Experts" Craig, L.J., NOAA Restoration Center, 263 13th Ave. S., St. Petersburg, FL 33701

Brumbaugh.pps

"The Nature Conservancy's Shellfish Restoration Network: Lessons From A National Perspective" Brumbaugh, R.D. (1) and M.W. Beck (2), (1) The Nature Conservancy, Global Marine Initiative, University of Rhode Island Narragansett Bay Campus, Narragansett, RI 02882, (2) The

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▸ **Contributed Session E (continued)**

Nature Conservancy, Global Marine Initiative, University of California - Santa Cruz, Center for Ocean Health, Santa Cruz, CA 95060.

Karney.pps

" 'The Island Blue Pages"- An Educational Booklet To Minimize The Residential Impacts On The Water Resources Of Martha's Vineyard' " Karney, R.C. and Surier, A.S., Martha's Vineyard Shellfish Group, Inc, P.O. Box 1552, Oak Bluffs, MA 02557.

Schmid.pps

"Peconic Estuary Restoration: A Spat (Southold Project In Aquaculture Training)-assisted Project To Reclaim A Lost Scallop Population" Schmid, O., A. DeLuca, and K. Tetrault, Cornell Cooperative Extension of Suffolk, SPAT (Southold Project in Aquaculture Training) program, Southold, NY 11971.

Bushnell.pps

"The Barnegat Bay Shellfish Restoration Program: Reclam The Bay" Bushnell, R. (1), G. Flimlin (2), and C. Muscio (2), (1) Volunteer President of ReClam the Bay, Inc., 357 North 7th Street, Surf City, NJ 08008, (2) Rutgers Cooperative Extension of Ocean County, 1623 Whitesville Rd., Toms River, NJ 08755.

Muscio.pps

"Making The Water Quality Connection: Successes And Challenges Of The Outreach Component Of The Barnegat Bay Shellfish Restoration Program" Muscio, C., G. Flimlin, and R. Bushnell, Rutgers Cooperative Extension of Ocean County, 1623 Whitesville Rd., Toms River, NJ 08755.

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Hadley.pps

"Establishing Reference Values As Targets For Intertidal Oyster Restoration In The Southeast: Can We Use Natural Reefs As Benchmarks?" Hadley, N.H. (1), L.D. Coen (1), M. Hodges, D.H. Wilber (2), and K. Walters (3), (1) Marine Resources Research Institute, S.C. Department of Natural Resources, Charleston, SC 29412, (2) Grice Marine Biology Program, College of Charleston, SC 29424, (3) Department of Marine Science, Coastal Carolina University, Conway, SC 29528.

Whetstone.pps

"Reinventing Commercial Single Eastern Oyster, Crassostrea Virginica, Culture In South Carolina" Whetstone, J.M. (1), W.D. Anderson (2), and W.A. Cox (3), (1) S.C. Sea Grant Extension Program, Clemson University Baruch Institute, P.O. Box 596, Georgetown, SC 29442, (2) S.C. Department of Natural Resources, P.O. Box 12559, Charleston, SC 29422-2559, (3) Island Fresh Seafood, Inc., 7575 Ethel Post Office Road, Meggett, SC 29449.

Landry.pps

"Exploring The Potential Of Enhancing Oyster Spat Collection Activities Through High Density Productive Sanctuaries In Caraquet Bay, N.b., New-brunswick" Landry, T. and J.F. Mallet, Department of Fisheries and Oceans, 343 Universite Moncton, NB E1A 4Y1, Canada.

POSTER SESSIONS

Exotic and Native Species, Genetics, and Disease: Challenges for Shellfish Restoration

Bejaoui.pdf

▸ MORPHOLOGICAL COMPARISION BETWEEN GEOGRAPHICALLY DISTANT POPULATIONS OF THE PEARL OYSTER *PINCTADA RADIATE* INVADING THE EASTERN MEDITERRANEAN SEA.

Ecological Relationships in Shellfish Restoration

Gooch.pdf

▸ FECAL COLIFORM ENTEROCOCCI AND VIBRIO DENSITIES AT SCECAP AND OYSTER DISEASE MONITORING SITES.

Lederhouse.pdf

ASSESSING OYSTER REEF HABITAT VALUE THROUGH NAKED GOBY (GOBIOSOMA BOSC) LIPID PRODUCTION.

Morlock.pdf

DEVELOPING A RESTORATION GUIDE FOR NATIVE OYSTERS ALONG THE WEST COAST OF THE UNITED STATES.

Richardson.pdf

SCECAP MONITORING OF A CRITICAL ESTUARINE SPECIES ALONG SOUTH CAROLINA'S COAST: ASSESSMENT OF OYSTER DISEASES, CELLULAR RESPONSES AND POPULATION STATUS.

Robinson.pdf

COLIPHAGE AND HUMAN NOROVIRUS PRESENCE AT SCECAP AND OYSTER DISEASE MONITORING SITES.

Factors Influencing Shellfish Restoration Success

KBaird.pdf

▸ EXPERIMENTAL RESPONSES OF CRASSOSTREA VIRGINICA FROM THE ST. LUCIE ESTUARY TO SEQUENTIAL LOW SALINITY PULSES AND INFECTION BY PERKINSUS MARINUS.

POSTER SESSIONS

Factors Influencing Shellfish Restoration Success (continued)

Ross.pdf

▶ RELATIONSHIPS BETWEEN SHELL HEIGHT AND DRY TISSUE BIOMASS FOR THE EASTERN OYSTER (*CRASSOSTREA VIRGINICA*).

Small-scale Approahes to Shellfish Restoration

AllenPower.jpg

▶ BIOREMEDIATION OF BEACH CREEK, JEKYLL ISLAND, THROUGH SHELLFISH RESTORATION.

Congrove.pdf

PRIVATE/ PUBLIC OYSTER RESTORATION IN VIRGINIA.

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Plenary Speaker's

ABSTRACT

Jamie L. King, Ph.D.

King.pps

Abstract

OVERVIEW OF NOAA's NON-NATIVE OYSTER RESEARCH PROGRAM. King, J.L., Habitat Program Manager, Non-native Oyster Specialist, NOAA Chesapeake Bay Office, Annapolis, MD 21403.

Federal and state agencies are preparing an Environmental Impact Statement (EIS) to evaluate the proposed introduction of a non-native oyster, *Crassostrea ariakensis*, in Maryland and Virginia waters. As a Cooperating Agency on the EIS, NOAA is conducting a 3-year, $6M competitive grants program. This Non-native Oyster Research Program is currently in its second year, and is aimed at research priorities previously identified by the National Research Council and the Chesapeake Bay Scientific and Technical Advisory Committee. Major research topics include: understanding *C. ariakensis* taxonomy, pathogens, ecology within its native range, potential for population growth and sustainability of *C. ariakensis* in Chesapeake Bay, susceptibility of *C. ariakensis* to known disease causing parasites and pathogens, interactions between *C. ariakensis* and the native oyster, human consumption risk, potential for *C. ariakensis* to become a fouling nuisance, ecosystem benefits and economic and cultural impacts.

Although the research program's third and final year (FY06) will continue to fund projects through 2007, NOAA's objective is to facilitate the rapid transfer of new findings to the peer-reviewed literature to support EIS evaluations as the research progresses. Toward this end, the NOAA Chesapeake Bay Office is sponsoring Quarterly Reviews to provide a forum for sharing and discussing the most current research findings and to ensure timely incorporation of research results into the EIS evaluations. An overview of the preliminary findings presented at these review sessions will be presented, and also are available on the NOAA Chesapeake Bay Office website at http://noaa.chesapeakebay.net/nonnativeoysterresearch.aspx.

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Keynote Speakers'

ABSTRACTS

Kimberly S. Reece, Ph.D.

Reece.pps

Abstract

GENETIC CONSIDERATIONS IN BROOD-STOCK SELECTION FOR OYSTER RESTORATION, AQUACULTURE DEVELOPMENT, AND NON-NATIVE SPECIES INTRODUCTIONS.

Reece, K.S., Associate Professor of Marine Science, Virginia Institute of Marine Science, The College of William and Mary, Gloucester Point, VA 23062.

Native oyster, *Crassostrea virginica*, populations in the Chesapeake Bay region and other locations along the East and Gulf coasts of the US were drastically depleted through a combination of over-fishing, habitat degradation, and diseases caused by the protozoan parasites *Haplosporidium nelsoni* and *Perkinsus marinus*. There are ongoing intensive native oyster restoration efforts to help rebuild the populations and resuscitate the once lucrative oyster fishery. In addition to the fisheries and aquaculture motivations, the realization that as filter feeders, oysters provide a variety of ecological services ranging from water filtration to reef habitat for other estuarine life, has generated interest in restoring oyster populations from a number of different groups.

It is thought that some early restoration efforts, which involved first construction of artificial oyster reefs to catch natural spat fall of *C. virginica*, and subsequently deployment of hatchery-reared oysters derived from wild brood stock to these reefs, were hampered by mortality due to disease. Selectively bred *C. virginica* lines have demonstrated increased tolerance for the parasites over wild *C. virginica*, and given that it is possible to grow millions of oysters in hatcheries, population supplementation with selectively bred, more disease tolerant, oysters has become a popular strategy in the attempt to rebuild decimated oyster populations. Hatchery stocks, however, and particularly the selectively bred oysters, have significantly reduced genetic variation compared to natural populations. Further, out-crossing *(continued)*

Keynote Speakers'

ABSTRACTS

Kimberly S. Reece, Ph.D.

▸ ABSTRACT *continued*

oysters might compromise disease tolerance due to disruption of gene complexes. The genetic impacts of deploying large numbers of disease-tolerant, though genetically depauperate, oyster strains need to be considered. It is important for us to closely examine the current population genetic structure of *C. virginica*, monitor the breeding success of deployed oysters and the hybridization of deployed with wild oysters, and evaluate the relative performance of the inbred, outbred and hybrid animals. This information will allow us to better predict how hatchery-based restoration might impact, positively or negatively, local natural populations, and determine the probability of success using the current restoration strategies.

The perceived dire state of the native oyster in the Chesapeake Bay region has also prompted proposals to introduce a non-native, more disease tolerant Asian oyster, *Crassostrea ariakensis*. Initially introduction proposals focused on using triploid, essentially reproductively sterile, animals in aquaculture, although recent discussions have included the possibility of on bottom deployment of diploid *C. ariakensis*. Most current plans for introduction of the non-native oyster are focusing on a *C. ariakensis* strain that originated from a small accidental introduction to the U.S. west coast over 40 years ago. This strain shows significantly reduced genetic variation compared to wild populations in Asia. We expect that genetic divergence of isolated hatchery-propagated stocks from their parent groups will accrue over time, although we have observed reduced genetic variability with *C. ariakensis* stocks brought to VIMS from China after just one hatchery generation. Use of a genetically depauperate stock for either fishery restoration and/or aquaculture development may be ill-advised. If introduction and aquaculture development is to be genetically successful, it may be necessary to regularly supplement hatchery stocks with input from wild Asian populations to maintain genetically healthy stocks in U.S. hatcheries, thereby avoiding inbreeding depression and the loss of genetic variability.

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Keynote Speakers'

ABSTRACTS

Jennifer L. Ruesink, Ph.D.

Ruesink.pps

Abstract

WEST SIDE STORY – THE CONTEXT, CAUSES, AND CONSEQUENCES OF THE PACIFIC OYSTER INTRODUCTION TO WASHINGTON STATE.

Ruesink, J.L., Associate Professor of Biology, University of Washington, Department of Biology, Box 351800, 24 Kincaid Hall, Seattle, WA 98195-1800.

Oyster introductions to improve fisheries and restore ecosystem functioning are currently controversial. However, >160 past examples exist, which indicate 1) high rates of establishment (20%), 2) widespread transfer of hitchhiking species, and 3) nearly complete replacement of native oyster harvests. Community- and ecosystem-level impacts of these oyster introductions are just beginning to be studied. In the state of Washington, U.S.A., the west coast native oyster (*Ostrea conchaphila*) suffered from several factors – particularly habitat degradation and overexploitation – and its landings peaked in the late 1800s. Despite an extensive network of marine reserves developed around 1900 and little harvest for many decades, populations remain at depressed abundance. To compensate for the decline of the native oyster, the Pacific oyster (*Crassostrea gigas*) was introduced frequently after 1919 and now makes up nearly all commercial oyster production. This introduction likely contributes to failed recovery of native oysters in at least two ways: first, by providing a commercial alternative that leads to disinterest in restoring the native; and second, in some locations by acting as a recruitment sink. This recruitment sink occurs because native oysters are attracted to settle on Pacific shell, which primarily occurs intertidally where native oysters cannot survive. In addition, oyster introductions vectored a number of exotic species that now compete with native oysters, reducing both survival and growth. This case study cautions against the hope that introducing a new oyster will functionally replace a native species or improve the environment so that native oysters can recover.

ICSR/2006

Keynote Speakers'

ABSTRACTS

Aad C. Smaal, Ph.D.

Smaal.pps

Abstract

SHELLFISH CULTURE AND NATURE CONSERVATION. Smaal, A.C., Chief Scientist, The Institute of Marine Resources and Ecosystem Studies (IMARES), Yerseke, NETHERLANDS.

Aquaculture and nature conservation are often in conflict. Aquaculture activities may have impact on the environment by occupation of space, discharge of material, introduction of exotic species or strains, overexploitation of resources and habitat change. Sustainable aquaculture should avoid adverse impacts and the question is how this can be achieved.

Shellfish culture has been considered as an extensive type of culture with no addition of feed and medicine, hence relatively sustainable. It is normal practice that recruitment comes from natural stocks and no exotic strains are used. Shellfish culture generally results in an increase of shellfish growth and a decrease in mortality, hence a higher biomass in comparison with unexploited systems. As a result of culture activities, the exploited species can be characterized by relatively young and productive populations. These populations play an important role in their ecosystems. They are prey for many bird species, form habitats and play a role in nutrient cycling. Shellfish populations play a key role in the ecosystem, and by shellfish culture, composition, spatial distribution and size of the stocks is influenced. Culture activities also include collection of juveniles, relaying of stocks, removal of predators, harvesting resulting in the removal of biomass from the system and possible habitat disturbance.

As shellfish culture usually occurs in non-polluted, relatively undisturbed coastal waters these systems are also important for nature conservation. An important challenge for stakeholder groups is to identify possible common objectives. As there are still many conflicts this has apparently not always been achieved.

Better knowledge of the role of shellfish in the ecosystem, improvement of culture techniques, innovations in culture practice but also new management strategies are required for a sustainable shellfish culture. This will be illustrated by experiences in shellfish culture in The Netherlands.

ICSR/2006

Keynote Speakers'

ABSTRACTS

M. Jayantha S. Wijeyaratne, Ph.D.

Wijeyaratne.pps

Abstract

CONSERVATION MANAGEMENT AND RESTORATION OF SHELLFISH HABITATS IN SRI LANKA.
Wijeyaratne, M.J.S., Vice- Chancellor, University of Kelaniya, Kelaniya, SRI LANKA.

Sri Lanka is a tropical island (62705 km^2) located a few kilometers off the southeastern coast of India in the Indian Ocean, and has a continental shelf area of around 30,000 km^2 and a brackish water area of around 1580 km^2 used for the exploitation of shellfish resources. The shellfish, including crustaceans and molluscs, contribute about 18% of the total annual fish production of 300,000 mt. The shellfish habitats in the coastal environments in Sri Lanka are degraded both due to natural effects and anthropogenic activities. The major natural effect that destroyed these habitats was the tsunami on 26/12/2004. The anthropogenic activities include denudation of mangrove forests, encroachment of estuarine habitats, land reclamation, use of destructive fishing gear and pollution. Changes in the sedimentation pattern and increased inflow of fresh water due to anthropogenic activities has also caused destruction to these habitats.

The need for protection, preservation, and improvement of the environment for the benefits of the community is identified in the Constitution of Sri Lanka and many Ordinances and Acts regarding the conservation of the environment are enacted. There are many regulations dealing with the conservation and protection of the environment and habitats formulated under these Acts and Ordinances. These include the regulations on banning destructive fishing gear, imposing minimum catchable size for some mollusc and lobster species, discharging effluents into aquatic environments, and conducting environmental impact assessments for development projects. Environmental studies highlighting the conservation of habitats for sustainable utilization of resources are also included in school and undergraduate curricula. The awareness programs are also conducted to the community by professionals and environmentalists. The restoration measures taken include replanting of mangroves, dredging of some habitats, removing sediments, and dredging of the mouths of estuaries to enhance water circulation with the sea.

PANEL SESSION DESCRIPTIONS

Thursday, November 16, 2006

Managing Shellfish in the Wake of Major Hurricanes

Moderator
LaDon Swann
Mississippi-Alabama
Sea Grant Consortium

Panelists
Mark Berrigan
Florida Dept. of Agriculture

Chris Nelson
Bon Secour Fisheries, Inc., Alabama
(invited)

Scott Gordon
Dept. of Marine Resources, Mississippi

Patrick Banks
Louisiana Dept. of Wildlife and Fisheries

Dr. Sean Powers
Dauphin Island Sea Lab, Alabama

Randall.pps

Banks.pps

This panel will review the hurricane seasons of 2004 and 2005, which had a devastating effect on shellfish beds from Florida to Texas. In Florida, Hurricane Frances affected the largest number of shellfish harvesting areas, resulting in 22 harvest area closures with Hurricane Charley a close second, with 18 harvest areas affected. The most powerful hurricane, Ivan, affected 11 harvest areas followed by Hurricane Jeanne's trek across Florida resulting in 14 areas being closed. The tragic event of Hurricane Katrina on August 28, 2005 to coastal and inland areas of Louisiana, Mississippi, Alabama and Florida severely impacted their fishing industries. Soon after Katrina passed Hurricane Rita hit causing severe damage to western Louisiana and eastern Texas. The combined effects of these two hurricanes resulted in the flooding of the entire coast of Louisiana. In Louisiana alone the estimated economic impact could reach $1.6 billion with the losses still mounting. The panel will discuss restoration efforts to restore capacity to the Gulf industry.

PANEL SESSION DESCRIPTIONS

Friday, November 17, 2006

▸ *West Coast Native Oyster Panel*

Moderator
Kay McGraw
NOAA Restoration Center

Panelists
Dick Vander Schaaf
The Nature Conservancy, Oregon

Betsy Peabody
Puget Sound Restoration Fund

Marilyn Latta
Save The Bay Association, San Francisco

Polly Hicks
NOAA Restoration Center

Summer Morlock
NOAA Restoration Center

Jennifer Ruesink
University of Washington

McGraw.pps

VanderSchaaf.pps

Peabody.pps

Latta.pps

Morlock.pps

Efforts to enhance and re-establish the Olympia or West Coast native oyster, *Ostreola conchaphila* are increasing in all west coast states. An overview of the recent West Coast Restoration Workshop is provided by Polly Hicks and Summer Morlock. This panel will provide an opportunity for restoration practitioners to discuss the history of native oysters in their states, progress they have made in recent years, major problems/limitations encountered (biological, ecological, bureaucratic, and socio-economic), and lessons learned in their different venues and restoration projects. A primary focus of the panel will be to discover common successful techniques in site location and oyster growth and survival. It will also offer a chance to compare and contrast basic differences in the biology of the west coast native oyster with the Eastern oyster (*Crassostrea virginica*), and resulting differences in approaches to restoration. Finally, a manual is being developed for the Olympia oyster (see related Morlock poster).

ICSR/2006

PANEL SESSION DESCRIPTIONS

Friday, November 17, 2006

▸ ***Regulatory Aspects of Shellfish Restoration***

Moderator
William D. Anderson
South Carolina Department of Natural Resources

Panelists
Margaret Black
National Fisheries Institute

John Paul Woodley
Assistant Secretary of the Army for Public Works

Robert Rheault
President
East Coast Shellfish Growers Association

Edwin Rhodes
Executive Director
East Coast Shellfish Growers Association

Bill Dewey
Pacific Shellfish Growers Association

Rheault.pps

Dewey.pps

The Army Corps of Engineers (ACOE) implements Section 10 of the Rivers and Harbors Act (RHA) and Section 404 of the Clean Water Act (CWA). RHA Section 10 deals with regulating structures and works that interfere with navigation. CWA Section 404 deals with regulating the discharge of dredged and fill material into waters of the United States, including wetlands. Historically, ACOE authorization has not been required for the vast majority of shellfish seeding, cultivating, and harvesting activities. In recent years the ACOE has begun to assert jurisdiction over a number of shellfish culture activities but has done so inconsistently around the country.

On September 26, 2006, the ACOE released their proposed changes to National General Permits (NWPs) in a Federal Register Notice. Comments are due in 60 days. The notice covers all NWPs, but 4-5 pages deal exclusively with shellfish. NWP would authorize the continued operation of existing commercial shellfish aquaculture activities in the navigable waters of the U.S. but in the case of new construction the NWP would require a pre-construction notification if a project is larger than 25 acres or if submerged aquatic vegetation occupies more than 10 acres of the site. Members of the panel represent the majority of shellfish interests as well as the ACOE.

Oral & Poster PRESENTATION ABSTRACTS

▸ **LIMITING FACTORS IN THE SUCCESS OF *OSTREA CONCHAPHILA* RESTORATON AT TWO SITES IN SAN FRANCISCO BAY.** Abbott, R.R. (1), R. Obernolte (1), B. Mulvey (2), (1) MACTEC Engineering and Consulting Inc., 5341 Old Redwood Highway Suite 300, Petaluma, CA 94954, (2) NOAA Fisheries, 777 Sonoma Ave, Santa Rosa, CA 95404.

Studies at three locations in San Francisco Bay in 2005-2006 suggest a variety of limiting factors that drive native oyster (*Ostrea conchaphila*) abundance. Two studies were focused on the creation of habitat on subtidal mudflats, and a third was a study on a large concentrated population located in an artificial lagoon. After a season of high recruitment rates at the San Rafael site, a decline in salinity and increased turbidity associated with an abnormal rainfall pattern in March 2006 reduced the population by more than 90% on the northwest side of San Francisco Bay, while native oysters on the northeast side of the Bay were apparently unaffected. The Bair Island site in South San Francisco Bay developed a good population of native oysters in spite of the presence of oyster drills, other predators and benthic invasive species. The declines in salinity and water clarity were short-lived and the oysters did not suffer the same mortality rates as the San Rafael population. Shoreline Sailing Lake, in Mountain View, has a narrow band of benthos that is almost exclusively populated with *O. conchaphila*. There is a relative absence of predators and competitors that appear to favor *O. conchaphila* and exclude other bivalves. Seasonal low DO may be the main factor limiting utilization of the available habitat by other species.

▸ **PRELIMINARY COMPARISON OF GEOGRAPHIC INFORMATION SYSTEM (GIS) ANALYSIS OF PATENT TONG SURVEYS AND BAR CLEANING OYSTER POPULATION ESTIMATES IN THE UPPER CHESAPEAKE BAY.** Allen, S. (1), H. Lane (1), J. Goodwin (1), M. Chen (1), M.L. Kellogg (1), K.T. Paynter (1), (1) MEES Program, 0105 Cole Field House, University of Maryland, College Park, MD 20742.

The accuracy and comprehensiveness of oyster (*Crassostrea virginica*) population estimates in the Chesapeake Bay are of vital importance to current and future restoration efforts. In an attempt to lower transmission of the parasite *Perkinsus marinus*, oyster bars are "cleaned" by exhaustive dredging prior to new plantings. The bar cleaning efforts provide an opportunity for ground-truthing GIS spatial analysis applied to patent tong survey estimates of oyster bar populations. Three oyster bars in the Chester River were surveyed using patent tong grabs at 112 to 270 locations within each bar both before and after bar cleaning efforts. From the patent tong data, oyster bar populations were estimated pre- and post-dredge using natural neighbor interpolation via GIS spatial analyst tool (ArcGIS). Number of oysters removed (in bushels) per bar was calculated from these estimates. The GIS estimates were then compared to the actual number of oysters collected during the cleaning effort analyzed by Leslie/DeLury models. Although the two estimates were not expected to be completely concordant, the patent tong survey population estimate on one bar was 10-fold lower than what was actually caught. The other two bars were underestimated as well. Obviously, more study is needed to understand the accuracy of oyster abundance estimates derived from GIS analysis of patent tong surveys.

▸ **MORPHOLOGICAL COMPARISON BETWEEN GEOGRAPHICALLY DISTANT POPULATIONS OF THE PEARL OYSTER *PINCTADA RADIATE* INVADING THE EASTERN MEDITERRANEAN SEA.** Aloui-Bejaoui N. (1), E. Soufi (1), A. Zenetos (2), A. Dosi (2), I. Ammar (3), A. Ibrahim (3), (1) Institut National Agronomique de Tunisie, 43 Avenue Charles Nicolle, 1082 Tunis, TUNISIA, (2) Hellenic Centre for Marine Research, Institute Oceanography, Anavissos 19013, GREECE, (3) High Institute of Marine Research, Tishreen University, Lattakia, SYRIA.

Pinctada radiata is a bivalve mollusc originating from the Indo-Pacific and the Red Sea (Oliver, 1992). Following the opening of the Suez Canal, *P. radiata* has entered the far eastern Mediterranean and intentionally imported for mariculture in other areas as Greece and Italy during the last century. Up to date, it has been recorded as common in the eastern Mediterranean with sporadic occurrences in the western basin (Zenetos et al., 2003). The aim of this study is to reveal morphological differences between five *Pinctada radiata* populations according to a geographical gradient position in Mediterranean Sea: Lattakia (Syria); Saronikos Gulf, Salamina Island and Rodos Island (Greece); Kerkennah Islands (Tunisia). Morphometric analysis of all samples was carried out using five parameters: Height, width, thickness, total weight, dorsal side and comparison of C and R coefficients according to Hynd (1955). The analysis of morphological parameters is based on comparison of the relative growth (regression lines) and on use of a standard animal. The Euclidean clustering method was performed for the measured parameters to visualize better the differences between sites. The Student T-test as well as the Box and Whisker Plot indicates that *P. radiata* from Tunisia present significant differences (P-value <0.001) from all the other sites and have the lowest values. *P. radiata* from Saronikos Gulf (Greece) have the greater values in all parameters measured. The results of this study show that the total weight in Salamina is more important than in the other populations. The dendrogram suggests that the Saronikos population is completely different from all the others which form two subgroups, the Greek sites together and the Syrian and Tunisian in the other subgroup. It is assumed that environmental parameters (salinity, temperature, eutrophication) are responsible for the observed morphometrical differences.

▸ **COMPARISON OF OYSTER CHARACTERISTICS AMONG TIDAL CREEK SYSTEMS IN NEW HANOVER COUNTY, NORTH CAROLINA.** Alphin, T. (1), M. Posey (2), S. Colosimo (2), A. Markwith (2), (1) Center for Marine Science, University of North Carolina at Wilmington, 5600 Marvin K. Moss lane, Wilmington, NC 28409, (2) Department of Biology and Marine Biology, University of North Carolina at Wilmington, 601 South College Road, Wilmington, NC 28403.

The decline of oyster (*Crassostrea virginica*) populations across much of their range has prompted a number of restoration or enhancement efforts focusing on both ecosystem services and fishery support. Measurements of ecosystem health and the relationship among these factors seems critical to understanding potential success of restoration efforts. The tidal creek systems of New Hanover County in southeastern North Carolina have been the subject of a series of studies focusing on changing water quality and impacts to biotic communities since 1992. This study focuses on characterizing the oyster populations and oyster condition in three tidal creek systems of varying background watershed characteristics, Pages, Howe, and Hewletts Creeks. Pages Creek is designated as a Primary Nursery Area (PNA) and considered the least impacted of the creeks while Hewletts Creek is considered the most impacted and Howe represents an intermediate situation. In the last two decades the rate of development within the tidal creek watersheds has increased with an associated decline in water quality. Comparison among creeks was based on oyster reef characteristics (oyster coverage, rugosity, density, and size demography) and oyster condition (dry weight to shell volume, and rate of shell repair). Results indicated few differences among the creeks in terms of reef characteristics or oyster condition, although Pages Creek did have significantly greater shell coverage and showed a trend toward higher condition. Seasonal differences tended to be greater than among creek differences with higher condition and density measures in winter compared to summer for most creeks.

▸ **COMMERCIAL TECHNIQUES IN SHELLFISH RESOURCE ENHANCEMENT AND RESTORATION: SOUTH CAROLINA EXAMPLES.** Anderson, W.D. (1), J.M. Monck (1), (1) SCDNR, 217 Ft. Johnson Road, Charleston, SC 29412.

Coastal population growth has caused commercial shell-fishermen to transform traditional fishery propagation techniques by using more intensive and alternative cultivation processes. A shortage of cultch and declining grow-out areas have created commercial adaptations that respond to these encroaching environmental and economic perturbations of shellfish cultivation. The center of gravity for commercial resource enhancement

initiatives is economic viability. Therefore, unlike other types of shellfish resource enhancement and restoration initiatives, those generated by commercial fishermen generally begin on a small scale with an expected economic return in the immediate future. These resource enhancement processes not only include the species under enhancement/restoration, but incorporate the livelihood of the cultivator as well.
The presentation reviews traditional wild-stock non-propagation, wild-stock enhancement, intensive artificial cultivation and shellfish mariculture in South Carolina's predominantly intertidal shellfish growing waters. Future trends are projected.

▸ **SHELL FISHES AS INTERMEDIATE HOSTS FOR HELMINTH PARASITES.** Awharitoma, A.O. (1), M.S.O. Aisien, (1), F.A.R. Ehigiator (2), (1) Department of Animal and Environmental Biology, P.M.B. 1154, Benin-City, EDO State, NIGERIA, (2) University of Benin, Department of Fisheries, P.M.B. 1154, Benin-City Edo State, NIGERIA.

Five species of shell fishes, including *Tympanotonus fuscatus* (Periwinkle-brackish water snail), *Lanistes varicus*, *Pila ovata* (both freshwater snails), *Penaeus duorarum natialis* and *Callinectus maginata* (both crustaceans) were used for the study. 69 (5.1%) out of 1350 periwinkles examined were infected, 2 (4.0%) out of 50 *Lanistes varicus* were infected, and 10 (3.2%) out of 318 *Pila ovata* were infected, 5 (2.1%) out of 244 shrimps, and 10 (4.9%) out of 202 crabs were infected. The parasites isolated from perinwinkle include *Sporocysts rediae*, cercariae and nematode larvae. From both *Lanistes* and *Pila* were isolated *sporocysts*, *rediae* and cercariae. Nematode larva was also isolated from *Pila*. *Metacercariae* were encountered in both the crabs and shrimps. 85% to 90% of trematode larval stages isolated from the snails were cercariae and the digestive gland harboured the largest number of cercariae. *Metacercariae* were isolated mostly from the body muscles and gill region of shrimps and crabs. Two types of cercariae, gymnocephalus and furcocerous were encountered in perinwinkle. The *gymnocephalus cercariae* encysted at room temperature under bright light and developed in the incubator for about a week into a juvenile with a collar of spine at the anterior end. This implies that the *gymnocephalus cercariae* found in periwinkle is that of echinostome. Two types of *cercariae*, *xiphidiocercariae* and *amphistome cercariae* were isolated from *Pila*. *trematode*, infection in snails has been associated with high mortality rate in the infected snails, as well as reduced egg production of the snails. Furthermore the possibility of these snails and crustaceans acting as a source of infection to humans cannot be overruled since the snails and crustaceans are delicacies to humans in some parts of Nigeria.

▸ **SEEDING THE SEED BEDS: THE DELAWARE BAY OYSTER (*CRASSOSTREA VIRGINICA*) RESTORATION PROGRAM.** Babb, R. (1), J. Hearon (1), D. Bushek (2), E. Powell (2), (1) New Jersey Department of Environmental Protection, Division of Fish and Wildlife, Port Norris, NJ 08349, (2) Haskin Shellfish Research Laboratory, Rutgers University, Port Norris, NJ 08349.

Natural oyster production on Delaware Bay seed beds is close to collapse following six consecutive years of exceptionally low recruitment. While recruitment across the natural seed beds has been below the bay wide average for six consecutive years, consistently high settlement continues to occur in the lower bay when suitable substrate is available, but few oysters survive in this region. In summer 2003, the NJDEP conducted a pilot-scale program where spat was captured from the lower bay on surf clam shell (*Spisula solidissima*), then transferred to a primary seed bed in fall 2003 increasing early recruitment about 75-fold. This small-scale effort increased the oyster industry TAC by nearly 26 percent and had an approximate ex-vessel value of $500,000. Based in large part on the success of this small project, federal funding support was secured by the Oyster Industry Revitalization Working Group (OIRWG) through the Delaware Bay Congressional delegation for activities in 2005 and 2006. This project, involving multi-agency and multi-state partnerships working concomitantly and effectively to restore a valuable natural resource, is noteworthy. Envisioned as a five-year program, Year 1 began in FY '05

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with a total of 280,000 bushels of shell planted in New Jersey and Delaware on about 150 acres. The FY '05 program succeeded in increasing recruitment by about 50 percent in the bay region receiving the shell. Year 2 resulted in greater than 500,000 bushels of shell planted on 12 sites in NJ and DE waters.

▶ **INFLUENCE OF SALINITY AND FRESHWATER INFLOW ON THE RECRUITMENT OF COMMENSAL DECAPOD CRUSTACEANS TO OYSTER REEFS IN ESTERO BAY, FLORIDA.** Bachelor, B.M. (1), S.E. Burghart (2), S.G. Tolley (1), (1) Florida Gulf Coast University, Coastal Watershed Institute, 10501 FGCU Blvd. S, Fort Myers, FL 33965, (2) University of South Florida, College of Marine Science, 140 7th Ave. S, St. Petersburg, FL 33701.

Variability in recruitment of organisms to oyster reefs is dependent, in part, on larval supply. Distribution and abundance of larvae of three dominant decapods found on oyster reefs in Estero Bay, Florida - *Petrolisthes armatus*, *Eurypanopeus depressus* and *Rhithropanopeus harrisii* - were quantified using monthly plankton tows. Larval densities of the marine stenohaline *P. armatus* were greater in bay waters and near passes; the euryhaline *E. depressus* occurred abundantly throughout the bay and near tidal tributaries; and *R. harrisii*, which favors reduced salinities, were most abundant near tidal tributaries with high freshwater inflow. Densities of *P. armatus* and *E. depressus* peaked at the end of the dry season (May) and were depressed with the onset of seasonal rains (June). Larvae of *R. harrisii* were in short supply during dry months but abundant during the wet season. Weighted salinity of capture was higher for *P. armatus* (30.70) and *E. depressus* (30.06) than for *R. harrisii* (9.18), and larval density was positively correlated with salinity for *P. armatus* and *E. depressus* and negatively correlated for *R. harrisii*. The distribution of juveniles and adults, collected using lift nets from oyster reefs at the mouths of the tidal tributaries, largely reflected larval supply: *P. armatus* was absent from reefs experiencing low salinities; *R. harrisii* was found only in association with reefs experiencing low salinities; and *E. depressus* was found on all reefs. These results suggest the importance of considering the effects of salinity on larval supply of commensal organisms when planning and executing oyster-reef restoration projects.

▶ **EXPERIMENTAL RESPONSES OF *CRASSOSTREA VIRGINICA* FROM THE ST. LUCIE ESTUARY TO SEQUENTIAL LOW SALINITY PULSES AND INFECTION BY *PERKINSUS MARINUS*.** Baird, K.D. (1), G. Roesijadi (2), O. Heilmayer (3), J. DiGialleonardo (1), (1) Florida Atlantic University, Department of Biological Sciences, Boca Raton, FL 33431, (2) Pacific Northwest National Laboratory, Marine Science Laboratory, 1529 West Sequim Bay Road, Sequim, WA 98382, (3) Alfred Wegener Institute for Polar and Marine Research, Department of Animal Ecology, P.O. Box 120161 D-27515, Bremerhaven, GERMANY.

The viability of the eastern oyster, *Crassostrea virginica*, was designated as an ecological performance measure for the management of freshwater inflows to the St. Lucie Estuary, Florida. Thus, oysters derived from the St. Lucie Estuary were tested for their physiological response to stress, measured as altered condition index and RNA/DNA ratios, resulting from changes in salinity and infection by the protozoan parasite *Perkinsus marinus*, the agent of Dermo, a common oyster disease. A Rapid Change Experiment was designed to assess the response of non-injected and injected *C. virginica* to low salinity challenges. Two scenarios for salinity stress were tested: one in which oysters were subjected to a single reduction in salinity (5 ppt) and one in which an initial reduction in salinity (5 ppt) was followed by a recovery phase and then subjected to a second challenge of reduced salinity (2 ppt). Condition index was more responsive to changes in salinity regimes than to *P. marinus* infection. Changes in the RNA/DNA ratio were responsive to the infection status, but not changes in salinity; the pattern of change in the RNA/DNA ratio generally followed changes in the measured levels of infection. The lack of mortalities showed that these oysters were able to tolerate short periods of reduced salinity. The work done here proves useful not only for the St. Lucie Estuary but estuaries elsewhere.

Oral & Poster PRESENTATION ABSTRACTS

- **RESTORATION OF INTERTIDAL OYSTER REEFS AFFECTED BY INTENSE BOATING ACTIVITY IN MOSQUITO LAGOON, FLORIDA.**
Barber, A. (1), L. Walters (1), A. Birch (2), (1) University of Central Florida, Department of Biology, 4000 Central Florida Blvd., Orlando, FL 32816, (2) Indian River Lagoon Program, The Nature Conservancy, 1333 Gateway Dr. #1016, Melbourne, FL 32901.

In recent years, intertidal reefs of the oyster *Crassostrea virginica* in central Florida's coastal areas have suffered extensive losses due to wakes from recreational boats. The creation and enforcement of "no wake" zones in the area are unlikely. Thus there is an urgent need for an alternative restoration strategy before oyster reefs decline past the point of no return. The goal of this project is to implement a scientifically-based restoration technique that minimizes wake damage from recreational vessels on intertidal reefs in Canaveral National Seashore (CANA). To accomplish this, we will test a range of restoration measures to determine the optimal design that best increases: 1) the numbers of oysters, 2) 3-D structure of our intertidal reefs, and 3) biodiversity and abundances of sessile and motile species on reefs. These restoration measures will include all combinations of leveling piles of disarticulated shells on reefs, placing seagrass seaward of reefs, and deploying miniature, mobile oyster reefs (restoration mats) to provide substrate for oyster recruitment and survival. Our restoration mat design includes affixing 36 drilled oyster shells to 0.4 x 0.4 m2 pieces of black mesh. After completing this experimental objective, the majority of our effort will be to implement our optimal design to increase reef dimensions to historical levels within the bounds of CANA. Our goal is to restore 15 - 20% of the 400 reefs (60 - 80 reefs) in the project area that have been damaged by wakes from recreational vessels.

- **NEW EVIDENCE OF HERMAPHRODITE CASES OF GREEN-LIPPED MUSSEL *PERNA VIRIDIS* AT SEBTU, COASTAL WATERS OF MALACCA, MALAYSIA.**
Al Barwani, S.M. (1), A. Arshad (1), J.S. Bujang (1), S.S. Siraj (1), C.K. Yap (1), (1) Department of Biology, Faculty of Science, University Putra Malaysia, 43400 UPM Serdang, Selangor, MALAYSIA.

The evidence of hermaphrodite in green-lipped mussel, *Perna viridis* was recorded first time from a mussel culture site at Sebatu, coastal waters of Malacca, Malaysia. Visual identification of the sexes cannot be performed base on the external morphology of the mussels, however the color of reproductive tissue of *P. viridis* varies considerably, male gonadal tissue are usually milky to creamy white, while in females it is orange to red orange and in the case of hermaphrodite patches of orange or red orange occurs on the male mantel. In histological identification of the sexes; the presence of oocytes indicating a female gender while the presence of sperm types (spermatids, spermategonia and spermatozoa) is indicating a male gender and when both appear in the same gonad is indicating a hermaphrodite case. A total of 317 individuals were histological identified. Among them two specimens were identified as hermaphrodites during the months of June and September 2004, respectively. Male and female gametes were on only one side of the mantle in the case of both of the specimens. No trace of hermaphrodism was observed neither in the second side of the mantle nor the mesosoma. The numbers of identified male, female and immature were 156, 157 and 4, respectively. The total sex ratio of male to female was 1.00:1.01.

- **THE NATURE CONSERVANCY'S SHELLFISH RESTORATION NETWORK: LESSONS FROM A NATIONAL PERSPECTIVE.**
Brumbaugh, R.D. (1), M.W. Beck (2), (1) The Nature Conservancy Global Marine Initiative, University of Rhode Island, Narragansett Bay Campus, Narragansett, RI 02882, (2) The Nature Conservancy Global Marine Initiative, University of California Santa Cruz, Center for Ocean Health, Santa Cruz, CA 95060.

Native bivalve shellfish have been identified as a restoration and conservation priority for many coastal bays and estuaries around the U.S. where The Nature Conservancy (TNC) and its partners work. Shellfish are the ecosystem engineers that help to regulate water quality and provide enabling conditions for the biodiversity that is central to TNC's mission. Shellfish restoration is also a priority for many agencies and coastal communities that are or have historically been supported by bivalve fisheries. Restoration efforts in different estuaries have mostly been conducted in relative isolation from each other, and even projects within the same system or basin are sometimes designed without regard to lessons learned relatively nearby. Exacerbating this is the fact that projects have historically had little monitoring from which to derive lessons. TNC's shellfish restoration network is working to address some of these challenges by fostering better communication and coordination among projects, particularly those funded through a National Partnership with NOAA's Community-based Restoration Program. Electronic newsletters and web-based tools are being developed (e.g., http://conserveonline.org/workspaces/shellfish) to support this exchange of information. A Practitioners Guide published jointly with NOAA's Restoration Center in 2006 provides guidance for designing projects that can be monitored effectively and compared across sites. Emerging lessons from the Network include: (1) harvest is still a primary objective of partners, (2) monitoring approaches are still rather coarse, (3) permitting is challenging, particularly in areas with water quality issues, and (4) funding levels are not sufficient in most areas to conduct restoration on ecologically meaningful scales.

▸ **EASTERN OYSTER RECRUITMENT AND SURVIVAL ON ALTERNATIVE REEF SUBSTRATES IN LYNNHAVEN BAY, VIRGINIA.** Burke, R.P. (1), Lipcius, R. (1), M. Luckenbach (3), P.G. Ross (3), J. Woodward (1), D. Schulte (4), (1) Virginia Institute of Marine Science, The College of William and Mary, 1208 Greate Road, Gloucester Point, Virginia 23062, (3) Virginia Institute of Marine Science, The College of William and Mary, Eastern Shore Laboratory, Wachapreague, VA 23480, (4) U.S. Army Corps of Engineers, Norfolk District 803 Front Street, Norfolk, Virginia 23510.

Restoration efforts with native Eastern oyster, *Crassostrea virginica*, in Chesapeake Bay have been extensive, yet impeded by substrate and recruitment limitations along with other environmental factors. In Lynnhaven Bay, a southern sub-estuary of Chesapeake Bay, the Army Corps of Engineers has partnered with the Virginia Institute of Marine Science, National Oceanic and Atmospheric Administration, and Chesapeake Bay Foundation to implement a comprehensive oyster reef restoration strategy. Surveys within the Lynnhaven Bay system indicate that artificial oyster shell reefs created in the past decade are generating marginal oyster densities relative to densities on nearby granite and concrete riprap substrate. In a field experiment, 12 treatments simulating intertidal oyster habitat were placed at three sites within a tidal creek: adjacent to marsh, rip rap, and a manmade oyster shell reef. Treatments consisted of caged and uncaged trays (0.5 m length x 0.5 m width x 0.25 m depth) of large granite, small granite, large limestone marl, small limestone marl, very small concrete/granite, and oyster shells. Granite of both sizes had the highest oyster recruitment and survival across all sites. In addition, there was a distinct recruitment and survival pattern between sites: marsh > rip rap > artificial oyster reef. We therefore propose that granite is a favorable oyster reef construction material, since it appears to enhance oyster recruitment and juvenile survival. Additional biological benefits may accrue from granite reefs as community structure develops on the reefs.

▸ **RESTORING THE BOYNE (CO. LOUTH, IRELAND) MUSSEL POPULATION.** Burnell, G. Aquaculture and Fisheries Development Centre, Environmental Research Institute, University College Cork, Cork, IRELAND.

In 2000 a small (500 tonnes per annum) artisan mussel fishery in the River Boyne Estuary was dredged away in order to create a deeper approach to Drogheda Port. Attempts were made (2000 - 2003) to restore the fishery using seed mussel from offshore stocks. The beds were surveyed (hydroaccoustically) annually (1999 - 2006) to monitor the progress of the mussel beds. The standing stock biomass has not yet reached its pre-dredge levels of 2,000 tonnes but recruitment is occurring. The biological, sociological and economic issues are addressed and the appropriateness of the methodology is discussed.

Oral & Poster PRESENTATION ABSTRACTS

▶ **THE BARNEGAT BAY SHELLFISH RESTORATION PROGRAM: RECLAM THE BAY.** Bushnell, R. (1), G. Flimlin (2), C. Muscio (2), (1) Volunteer President of ReClam the Bay, Inc., 357 North 7th Street, Surf City, NJ 08008, (2) Rutgers Cooperative Extension of Ocean County, 1623 Whitesville Rd., Toms River, NJ 08755.

Ocean County, New Jersey has had a very long association with the coast, the waters of Barnegat Bay, and the natural resources of its estuaries. For the past two years, Rutgers Cooperative Extension in cooperation with the NJDEP Division of Fish and Wildlife Bureau of Shellfisheries has been working on a Barnegat Bay Shellfish Restoration Program. Funding has been provided by the County of Ocean and the Barnegat Bay National Estuary Program. The program has held two years of classes during the winter months related to shellfish biology and culture, trained about 80 volunteers and last year raised 600,000 clam seed. Although there had been some severe mortalities over the winter, the program will be planting seed in the fall of 2006 in conjunction with the Make a Difference Day. Volunteers have formed a non-profit organization to help secure funds for the continuation of the program into the future. The difference is not just the clams in the bay, but the education that is passed by our volunteers to the community at large about water quality and how what happens on land in Ocean County often winds up in the bays. Reclaim the Bay. ReClam the Bay!

▶ **OYSTER SETTLEMENT IN GREAT BAY, NEW HAMPSHIRE.** Capone, M. (1), R.E. Grizzle (1), University of New Hampshire, 85 Adams Point Road, Durham, NH 03824.

The eastern oyster, *Crassostrea virginica*, plays an important role in the ecology of Great Bay Estuary, NH. In recent years, disease and habitat degradation have contributed to dramatic declines in Great Bay oyster populations. In response to this decline, University of New Hampshire researchers have used remotely set oysters to restore degraded habitat. An alternative to the use of remotely set oysters is to locate areas of high natural oyster recruitment and transfer natural spat to degraded areas. This method requires an understanding of the timing and spatial trends of oyster larvae settlement. Oyster settlement is highly variable at almost all scales, but areas of consistently higher recruitment relative to their region have been found in some estuaries. The goal of this study is to determine the time of oyster spawning and to locate areas of high settlement within Great Bay, New Hampshire by monitoring adult oyster gonad development and oyster settlement on 4 of Great Bay's largest oyster reefs. During the summer of 2005, a spawning event occurred between August 8th and August 15th. Three of the four reefs sampled had similar settlement densities as determined by spat samplers deployed prior to oyster spawning. A fourth reef had significantly greater settlement densities with more than four times the spatfall than other tested reefs.

▶ **TRACKING BREEDING SUCCESS OF DEPLOYED OYSTERS THROUGH MICROSATELLITE VARIATION.** Carlsson J. (1), S.K. Allen Jr. (1), K.S. Reece (1), (1) Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, VA 23062.

Oyster restoration efforts in the Virginia portion of Chesapeake Bay have focused on reef construction and seeding of some reefs with broodstock. It is thought that some early restoration efforts were hampered by mortality of oysters derived from wild broodstock caused by the diseases Dermo and MSX. This motivated an increased use of aquaculture lines that have been selected for improved disease tolerance and increased growth for seeding reefs. The DEBYTM line, which demonstrates high disease tolerance and rapid growth, quickly became one of the most popular lines for both aquaculture enterprises and restoration deployments. This strain also has a genetic signal that is relatively rare in Chesapeake Bay oysters at the mitochondrial DNA (mtDNA) locus, which makes it possible to track the breeding success of deployed DEBYTM oysters used for restoration by assessing the ratio of naturally produced spat that are a product of DEBYTM females versus those from local wild oysters. New aquaculture lines with improved disease tolerance and growth are being developed and continued high disease pressure makes these strains attractive for restoration deployment. While the DEBYTM line could be tracked through mtDNA screening, additional molecular markers are needed for tracking the new lines, as not all of them carry the unique mtDNA signal. We present microsatellite data on eight aquaculture lines to test the feasibility of tracking the breeding success of these aquaculture lines after deployment and for determining the extent of interbreeding among deployed lines and wild local oysters already present at deployment sites.

INCREASING TOLERANCE FOR *PERKINSUS MARINUS* AMONG NATURAL *CRASSOSTREA VIRGINICA* POPULATIONS FROM VIRGINIA WATERS. Carnegie,R.(1), E.M. Burreson (1), (1) Virginia Institute of Marine Science, Route 1208 Greate Road, Gloucester Point, VA 23062.

Intensification of dermo, the oyster disease caused by protistan parasite *Perkinsus marinus*, has contributed to the decline of natural *Crassostrea virginica* populations along the U.S. mid-Atlantic coast since the 1980s. *P. marinus* is viewed as a primary impediment to oyster population restoration and the failure of natural oyster populations to respond to *P. marinus* parasitism by evolving dermo resistance underpins arguments favoring restoration using domesticated dermo-resistant oyster strains. Abundance of naturally recruited oysters in dermo-intense waters like the Lynnhaven River, however, suggests that tolerance for *P. marinus* may be manifest at a population level. Mechanisms remain to be determined, but two observations may be important. First, long-term comparison of *P. marinus* levels in natural stocks with levels in naïve imports to dermo-enzootic waters reveals that dermo disease pressure during the first season of exposure has reached high levels. Dermo disease is now acute in the most susceptible oyster stocks, which may limit the reproductive contribution of the most susceptible animals. Second, large oysters in disease-intense waters often display surprisingly light *P. marinus* levels. In 57 samples collected over 2002-2005 from Virginia populations experiencing intense dermo disease (weighted prevalence, 2.00), 216/1412 oysters were 100 mm. Of these oysters, 69.4% had infections below moderate intensity. In Lynnhaven River samples from 2005, 36/49 larger (100 mm) oysters (73.5%) had only lighter infections. One may hypothesize that larger, healthier, more fecund oysters that resist dermo disease over several challenges may contribute disproportionately to reproduction within such populations.

PLOIDY VALIDATION OF TRIPLOID *CRASSOSTREA ARIAKENSIS* BY QUANTITATIVE PCR. Choudhury, A. (1), R. Lundstrom (1), G. Scott (1), (1) NOAA/NOS, Center for Coastal Environmental Health and Biomolecular Research, 219 Fort Johnson Road, Charleston, SC 29412.

Interest in developing a new oyster fishery in the Chesapeake Bay has grown out of concern for the current state of *Crassostrea virginica* populations that have been reduced due to the combined pressures of over harvesting, pollution, and disease over the years. *Crassostrea ariakensis*, a species indigenous to China is considered to be an ideal candidate for introduction due to its wide salinity tolerance, fast growth rate as well as high disease tolerance. Current plans are to introduce only triploid individuals since their sterile state will reduce the chance of reproducing and spreading throughout the Bay. In order for this endeavor to succeed, validation of triploidy must be ascertained throughout the life history of *C. ariakensis*. We created a molecular method to determine ploidy of *C. ariakensis* using quantitative polymerase chain reaction (Q-PCR). Ct values were compared between diploid and triploid individuals across different loci in separate Q-PCR reactions using SYBR green fluorescent dyes for detection. Primers were created for actin, GAPDH, HSP 70, superoxide dismutase, and tubulin from GeneBank sequence data for both *C. ariakensis* and *C. gigas*. The primer pair for ITS-1 was designed from sequence data of amplified PCR product using previously published primers. Q-PCR data was compared to flow cytometry data of the same individuuals to determine accuracy of the assay. Molecular techniques that can easily validate ploidy will assist in the monitoring and expansion of the introduction of *C. ariakensis* into the Chesapeake Bay and may also allow validation of ploidy in the field by growers themselves.

UNDERSTANDING THE ABUNDANCE AND DISTRIBUTION OF PREDATORS ON ADULT HARD CLAMS, *MERCENARIA MERCENARIA*, ON THE BLUEPOINTS BOTTOMLANDS OF GREAT SOUTH BAY, LONG ISLAND, NEW YORK. Clapp, C. (1), C. LoBue (1), (1) The Nature Conservancy, Long Island Chapter, 250 Lawrence Hill Rd Cold, Spring Harbor, NY 11724.

Since 2004, The Nature Conservancy (TNC) has been working to restore *Mercenaria mercenaria*, to increase reproductive potential and improve ecosystem function within the Great South Bay. A network of spawner sanctuaries stocked with various sized clams is being established on 13,000 acres of submerged land owned by TNC. These sites are continually monitored. Early survival assessments of stocked clams found much of the mortality on transplanted clams, ranging from 7-39% (depending upon location), was attributed to whelk (Busycon spp.) predation. Busycon sp. is currently the dominant predator of adult clams in Great South Bay. To maximize survival a number of predator surveys have been conducted to understand where they are most abundant. In the fall of 2004 and again in the spring of 2006 baited pots were set in a grid pattern and spaced approximately 50 m apart and allowed to soak for a minimum of two days. SCUBA surveys were also conducted in the spring of 2005 and again while the baited pots were deployed in the spring of 2006. Channeled whelk, *Busycon conaliculatum*, consists of greater than 95% of the catch in baited pots while knobbed whelk, *B. carica*, accounts for the remainder, however knobbed whelks outnumbered channeled whelks nearly 7:1 in SCUBA surveys. The whelks were mostly captured in pots on slopes of channels where the sediment changes from sand to mud and depths below 2m. Predation rates have tended to be higher at some locations and on smaller sized clams.

SEASONALITY AND SIZE OF *BOONEA IMPRESSA* POPULATIONS ON RESTORED AND NATURAL OYSTER REEFS: DOES SIZE MATTER? Coen, L.D. (1), A. Hollis (1), S. Roth (1), R. Kalisperis (2), (1) Marine Resources Research Institute, SCDNR, SC 29412, (2) S.C. Aquarium, 100 Aquarium Wharf, Charleston, SC 29401.

Long-term studies in S.C. on natural and constructed intertidal oyster reefs have pointed to the ectoparasitic gastropod, *Boonea impressa* (Pyramidelidae) as being an important constituent of reef resident faunas. Previous *B. impressa* work elsewhere has focused on systematics, host energetic costs, host-to-host (bivalves) transmission of *Perkinsus marinus*, effects on host growth and filtration rates, and to a lesser extent snail population ecology. Since the early 1990s, it has been used by archaeologists (e.g., M. Russo, USF&WS) to derive prehistoric seasonal oyster foraging patterns from midden collections in the southeastern U.S. based on their presence and modal size. We typically separate out live and dead Boonea during sorting using rose bengal or by smashing each snail and then examining the resulting squash to determine 'status'. Our previous S.C. work observed a seasonal and/or tidal height abundance signal without the benefit of monthly sampling or individual size measurements. We also wanted to calibrate their assumptions given that they cannot tease apart live vs. dead animals, as we can. Since January 2006, we have been sampling at monthly intervals a natural intertidal oyster reef assessing: (1) % live:dead ratios; (2) measuring all live oysters to correlate with snail densities; (3) measuring individual live and dead snails using digitizing software; and (4) recording other physical data. Overall, % live estimates from natural and constructed reefs ranged from <40% to over 98%. July and August 2006 sampling detected recruiting juveniles >1-2 mm shell length (SL) at densities exceeding 24,000/m2, with few live adults (up to 5 mm SL). We discuss our findings from a broad array of natural and constructed sites, population size trends, and related implications.

Oral & Poster PRESENTATION ABSTRACTS

▶ **GENETIC VARIATION AMONG NATIVE POPULATIONS AND HATCHERY STOCKS OF *C.ARIAKENSIS*: CONSIDERATIONS REGARDING PLANNED INTRODUCTIONS INTO THE CHESAPEAKE BAY.** Cordes, J.F. (1), K.S. Reece (1), J. Xiao (1), (1) Virginia Institute of Marine Science, The College of William and Mary, Gloucester Point, VA 23062.

Heavy fishing pressure, habitat degradation, and disease have severely impacted native oyster *Crassostrea virginica* populations in the Chesapeake Bay. Given the poor prognosis for the native oyster, the states of Maryland and Virginia are considering the introduction of the Asian oyster *Crassostrea ariakensis* for the purpose of establishing naturalized, self-sustaining populations using existing hatchery stocks. If such an introduction occurs, a number of genetic considerations must be taken into account to maximize the chance for success. First, we must be able to insure that only the target species is introduced, whether for use in developing hatchery stocks or for direct introduction. Second, in order to select the best *C. ariakensis* source for introduction and avoid the genetic bottlenecks typically experienced by domesticated stocks, there is an urgent need to assess levels of genetic variation and population structure within and among *C. ariakensis* in its native range, determine the genetic relationship between native populations and existing U.S. hatchery stocks, and quantify levels of genetic variation in the hatchery populations to identify instances of population bottlenecks and inbreeding. Our investigations using mitochondrial, nuclear, and microsatellite markers indicate widespread confusion in the identification of *C. ariakensis* across its native range, significant genetic structure among native *C. ariakensis* populations, and evidence of reduced genetic variation in existing U.S. hatchery stocks.

▶ **THREATS TO THE EASTERN OYSTER. RESULTS OF A SURVEY OF STATE RESOURCE MANAGERS AND INDEPENDENT EXPERTS.** Craig, L.J., NOAA Restoration Center, 263 13th Ave S, St. Petersburg, FL 33701.

The NOAA Fisheries Service received a petition to list eastern oysters (*Crassostrea virginica*) as either threatened or endangered under the Endangered Species Act (ESA). This petition resulted in a review of the status of the species conducted by a team of experts from throughout the species' range (Biological Review Team, "BRT"). As part of a process to review currently available scientific information regarding the biology and status of eastern oysters, the BRT conducted a survey of state resource managers and independent experts. Survey respondents provided information related to a number of issues including the current and historic acreage of oysters, harvest techniques and limits, sustainability of oyster populations, restoration activities, and threats to oyster populations. Twenty resource managers and independent experts responded to the survey with information specific to 72 estuaries in the United States. All survey participants were asked to respond to the following question: What, if any, do you perceive as the primary threats to the oyster population in this estuary/Shellfish Growing Area? Respondents listed a total of 286 occurrences of primary threats. Perceived threats to oyster populations could be broadly categorized as Anthropogenic, Environmental/ Natural, Disease, Harvest-related and Predation. Nearly 70% of all threats were Anthropogenic in nature (excluding Harvest-related threats), with the South Atlantic and Gulf of Mexico regions having a much higher percentage of oyster populations threatened by anthropogenic impacts than the North or Mid-Atlantic regions. With the goal of furthering understanding and communication among stakeholders, this poster provides additional information related to the threats to eastern oyster populations within states, on a regional basis and throughout their range.

▶ **MULTI-INFECTION PATTERN IN THE EXPLOITED MANILA CLAM (*RUDITAPES PHILIPPINARUM*) OF ARCACHON BAY (FRANCE).** Dang, C. (1), S. Saez (2), X. de Montaudouin (3), N. Caill-Milly (4), P. Gonzalez (5), (1) Arcachon Marine Station UMR EPOC 5805, University Bordeaux 1, CNRS 2, rue du Pr Jolyet F-33120, Arcachon, FRANCE, (2) University Pau Allée du Parc Montaury F, 64600 Anglet, FRANCE, (3) IFREMER Technopole IZARBEL Côte Basque, Maison du Parc F-64210 Bidart, FRANCE.

The Manila clam *Ruditapes philippinarum* was first introduced in 1972 in Arcachon Bay (southwestern coast of France) for cultivate purpose and then, this species has spread throughout the whole bay. Arcachon Bay ranks currently at the first French place in term of stock (7300 t) and annual production (450 t declared). Every winter, severe mortalities are observed in clam populations in the inner part of the bay and parasitism is suspected as a potential cause. Manila clam is actually infected by many sorts of parasites. This work examines three kinds of pathogens: a protozoan *Perkinsus olseni*, a bacteria *Vibrio tapetis* responsible of the brown ring disease and a community of digenean trematodes (*Himasthla quissetensis*, *Curtuteria arguinae*). A spatio-temporal analysis of different infection levels was realized. The spatial monitoring concerned fifty stations sampled between May and June 2006 while the temporal survey was monthly conducted on four stations during one year. *P. olseni* appeared as the most abundant parasite in clams and achieved a maximum infection in summer. The brown ring disease was detected on shells and revealed the presence of *Vibrio tapetis* in the bay. On the other hand, infection by digenean was very low, showing that either clams were resistant to infection by digenean, or that these parasites were missing at the study sites. Therefore, an experimental infection was conducted to assess the potential infectibility of clams compared to sensitive species (cockle, *Cerastoderma edule*). This study highlighted the importance of a "pluri-infection" pattern on Manila clam populations, with high seasonal variability and moderate spatial heterogeneity. These data constituted an important argument to incorporate disease in clam dynamics studies.

▸ **TOLERANCE OF DIFFERENT HARD CLAM STOCKS TO VARIOUS ISOLATES OF QUAHOG PARASITE UNKNOWN (QPX).** Dahl, S. (1), M. Perrigault (1), B. Allam (1), (1) Marine Sciences Research Center, University of Stony Brook, Stony Brook, NY 11794.

Quahog Parasite Unknown (QPX) is a protist often recorded in association with severe mortality events of cultured and wild hard clams from Canada to Virginia, but also from very low detection in seemingly healthy clam populations. It was hypothesized that genetic variability in the host and/or in the pathogen was responsible for differences in infection. A laboratory-based inoculation trial used multiple QPX isolates for injection into hard clam seed of various geographic origins. Trends in prevalence and severity of disease were significantly associated with seed type origin and with the isolate of QPX. A field trial was conducted in order to evaluate the infective pressure of QPX in New York State shell-fishing grounds. Aquaculture grow out cages with different clam stocks were deployed in Raritan Bay, where QPX is routinely detected, and in the Peconic estuary; a popular area for transplant of hard clams from Raritan Bay. Results have shown substantial differences in QPX prevalence according to seed type. Awareness of susceptibility differences of hard clam stocks is an important consideration in making decisions concerning applications in the field, especially for restoration of areas that have had significant QPX activity. Differences in pathogenicity reveal the potential threat of QPX disease is greatly dependent on variation in the QPX strain. Overall, our results emphasize a particular consideration of local selection processes as a source of resiliency for a given clam stock.

▸ **RESPONSE SURFACE ANALYSIS OF TEMPERATURE AND SALINITY FOR SUBTROPICAL *CRASSOSTREA VIRGINICA*.** DiGialleonardo, J. (1, 2), O. Heilmayer (3), L. Qian (4), J. Scarpa (5), G. Roesijadi (6), (1) BEM Systems, Inc., 1601 Belvedere Road, Suite 305S, West Palm Beach, FL 33406, (2) Florida Atlantic University, Department of Biological Sciences, 777 Glades Road, Boca Raton, FL 33431, (3) Marine Animal Ecology and Marine Animal Ecophysiology, Alfred Wegner Institute for Polar Marine Research, Bremerhaven, D-27515 GERMANY, (4) Florida Atlantic University, Department of Mathematics, 777 Glades Rd, Boca Raton, FL 33431, (5) Harbor Branch Oceanographic Institution Inc., Aquaculture Division 5600, U.S. 1 North, Fort Pierce, FL 34946, (6) Pacific Northwest National Laboratory, SEQUI, Richland, WA 99352.

Anthropogenic modifications to the St. Lucie river watershed have significantly altered the patterns of freshwater flow, resulting in extreme changes of salinity and the subsequent decline in the health of the estuary.

Since the synergistic combination of salinity and temperature affects virtually all aspects of the biology of oysters, *Crassostrea virginica*, has been designated as a biological indicator for the condition of this ecosystem. While much is already reported for the response of *C. virginica* to temperature and salinity, distinct differences exist along the distribution range warranting site specific assessments for previously unstudied populations. A modified Central Composite Inscribed response surface analysis was designed to describe the response of the local *C. virginica* population to a range of salinity and temperature combinations. The bivalve condition index and RNA:DNA ratio served as response measures. Our results showed that reductions in condition index are greatest at high temperature in combination with low salinity. The analysis of oyster RNA:DNA ratios showed a similar pattern of response, although, in this case, its relationship with temperature and salinity was not as strong. The final models for mean condition index and the RNA:DNA ratios explained 77.3% and 35.8% of the respective variances. Response surface analysis has proven to be a useful tool in describing the physiological response of *C. virginica* to a combination of environmental parameters.

▶ MERISTIC, MORPHOMETRIC AND GROWTH PATTERNS OF *MACROBRACHIUM VOLLENHOVENII* (AFRICAN RIVER PRAWN) FROM OVIA RIVER, BENIN-CITY, EDO STATE, NIGERIA.

Ehigiator F.A.R. (1), A.C. Amos (1), (1) University of Benin, Department of Fisheries, P.M.B. 1154, Benin-City Edo State, NIGERIA.

Macrobrachium vollenhovenii (African River Prawn) were caught with single inlet/single chamber and double chambered traps using a variety of baits along the stretch of Ovia River, in Edo State, Nigeria. Meristic, morphometric and growth patterns in the prawns were studied. *M. vollenhovenii* was observed to have 11-14 and 3-5 spines on the dorsal and ventral side of its rostrum respectively. It was observed that a significant positive correlation exist between total length and all other parameters measured, with the exception of the number of ventral rostral spines which showed a negative correlation. It was observed that the males have bigger chela than the females, and in both sexes, the left chela were bigger than the right chela. It appears that this natural endowment of the males may increase the heighten degrees of injuries inflicted on other prawns especially the female prawns due to their aggressive nature. As a result of this “de–clawing” the chela could be a way of achieving high survival rate with corresponding low mortality rate. This difference in males and female chela makes for easy identification of both sexes. The morphometric parameters pertaining to length or weight considered this study showed allometric growth in which regression coefficient (b) is greater or less than 3. All the parameters studied, total body weight (TBWT), edible portion weight (EPWT), weight of exoskeleton (WTEX), stomach content weight (STWT), gonadal weight (GWT), food weight (FWT) and egg weight (EGWT) were less than 3. They were also positively correlated, indicating that as the prawns grown in size (length) these parameters also increase. The male had higher body weight than the females. Also the males had higher weight of exoskeleton than the females. This factor in conjunction with larger male carapace length and smaller tail portion, suggests that females with larger edible portions weigh more than males of the same size.

▶ DATA ON THE GROWTH OF *PICTADA RADIATE* IN THE COLONIZING FAUNA OF THE PORT YASMINE HAMMAMET (TUNISIA).

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A study of the malacological fauna was carried out in the Yasmine Hammamet Marina, Tunisia. The marina’s artificial environment built in 2001 has been colonized by an important malacological fauna in terms of density and diversity. This fauna is subjected to an ecological study and classified into four classes: Aplacophora, Cephalopoda, Gastropoda and Bivalvia. The seasonal evaluation shows that two species of bivalve populations are particularly abundant. The first species *Pinctada radiata* is a lessepsian migrant (from indo-pacific ocean). The second is *Ostreola stentina* which, so far, has been a subject to a biological study in Tunisia. *Pinctada radiata* is characterised by a better significant growth and a better pearl quality than the other populations already announced in Tunisia. The study of the parameters used to evaluate the significant growth differ according to the month and according to the parameters used; length, width or thickness. The highest growth mean was recorded in January for the length (0.653 ± 0.185), in February for the width (0.869± 0.768) and in April for the thickness (0.576 ± 0.426). Relative variations are observed at the individual level: growth varies from 0.04mm to 2.54mm for the length, from 0.01mm to 2.48mm for the width and from 0.01mm to 2.62mm for the thickness. It is only during the month of January that the weights have registered an average increase of 1.905g. Drops reaching 6.8g have been noted during the months of February, March and April. These weight variations correspond to weight fluctuations due to the population reproductive activity. Indeed, the population goes through a sexual rest during the winter period and gets into gametogenesis staring from February. These morphological characters, different from the other Tunisian populations put in evidence not only the influence of the marine traffic as an enhancing factor of installation for this species but also its ability to adapt to a new biotope during the first period of its installation.

▶ **FECAL COLIFORM ENTEROCOCCI AND VIBRIO DENSITIES AT SCECAP AND OYSTER DISEASE MONITORING SITES.** Gooch, J.A. (1), B.C. Thompson (1), R.F. Van Dolah (2), L.D Coen (2), D. Richardson (2), (1) NOAA, NOS, CCEHBR, 219 Fort Johnson Rd., Charleston, SC 29412, (2) SCDNR, 217 Fort Johnson Rd., Charleston, SC 29412.

A collaborative project between SCDNR and the NOAA Laboratory was conducted to assess human enteric bacterial indicator loads and Vibrios of public health concern in oysters. Twenty-seven composite oyster samples were collected at South Carolina Estuarine and Coastal Assessment Program (SCECAP) stations and DNR oyster long term disease (LTD) monitoring sites (see Richardson *et al.* poster) during July/August 2005 (summer) and January/February 2006 (winter). Fecal coliforms (FC) and enterococci were enumerated using traditional culture based methods; *Vibrio vulnificus* and *Vibrio parahaemolyticus* densities were determined using a DNA non-radioactive probe hybridization technique. The major objective was to obtain a baseline of enteric bacterial indicators and Vibrio pathogens in oysters, as well as elucidate the relationship between these numbers and other environmental variables, oyster population indices, and oyster physiological responses. These factors might also affect shellfish restoration projects. Summer: FC numbers ranged from 8 to 34,000 MPN/100g; 3 stations exceeded the single sample 330 MPN/100g shellfish guideline (FDA). Enterococcus densities ranged from 34 to 18,000 MPN/100g. *Vibrio vulnificus* ranged from the limit of detection (10 CFU/g) to 1,000 CFU/g and *V. parahaemolyticus* numbers ranged from 80 to 2,900 CFU/g. Winter: FC concentrations ranged from 46 to 5,600 MPN/100g; 5 sites exceeded the FDA guideline. Enterococci densities ranged from 4 to 4,800 MPN/100g. *V. vulnificus* counts ranged from 10 to 2,600 CFU/g, and *V. parahaemolyticus* numbers ranged from 10 to 900 CFU/g. Paired T tests showed significant differences between seasonal concentrations of FC ($p = 0.0003$), enterococci ($p = <0.0001$) and *V. parahaemolyticus* ($p = <0.0001$). Significant correlations (Spearman Rank, Log transformed) occurred between *V. vulnificus* and FC summer densities ($R = 0.505$; $p = 0.007$) as well as between *V. parahaemolyticus* and *V. vulnificus* summer concentrations ($R = 0.58$; $p = 0.002$).

▶ **CAGED *CRASSOSTREA ARIAKENSIS* DEPLOYMENT IN CHESAPEAKE BAY: GROWTH, DISEASE, AND MORTALITY.** Goodwin, J. (1), M. Chen (1), K.T. Paynter (1), (1) MEES Program, 0105 Cole Field House, University of Maryland, College Park, MD 20742.

Triploid suminoe oysters, *Crassostrea ariakensis*, and triploid native oysters, *Crassostrea virginica*, were deployed in vexar oyster cages at four shallow subtidal sites in Chesapeake Bay. The sites were located in the York, Patuxent, Choptank and Severn rivers, representing the large salinity gradient present in the Bay. Shell heights of 30 to 50 oysters were measured monthly and dead oysters were counted and removed. As of the writing of this abstract, the mean shell height of the suminoe oysters was larger than the native oyster at all sites except in the Patuxent River. However, the differences in size were relatively small in the Choptank and Severn rivers compared to the differences observed in the York River oysters. At the York River site, the mean shell height of *C. ariakensis* was 160 mm, more than 30% larger than *C. virginica* at 100 mm. Although *Perkinsus marinus* infections were light in most deployed groups (negative in the Severn oysters), reduced growth rates associated with *P. marinus* infections appear to have contributed to the differences in size.

▶ **EVALUATING NATURAL AND HUMAN FACTORS INFLUENCING HABITAT CHANGE, FOR AMELIORATING OBSERVED SHORELINE LOSSES.** Goodwin, L. (1,2), L. Coen (2), L. Walters (3), P. Sacks (4), (1) MES Program, College of Charleston, 66 George St., Charleston, SC 29424, (2) Marine Resources Research Institute, SCDNR 217 Fort Johnson Road, Charleston, SC 29412, (3) Department of Biology, University of Central Florida, 4000 Central Florida Blvd., Orlando, FL 32816, (4) Department of Biology, University of Central Florida, 4000 Central Florida Blvd., Orlando, FL 32816.

In S.C., loss of intertidal habitats (e.g., fringing Spartina and oysters) occurs naturally through wind waves, upland run-off and tidal currents. However, rates may be dramatically increased as land-use changes. Thus, it is important to document and quantify background levels prior to development. We present an overview of a long-term study focusing on shoreline changes, natural rates of erosion and associated physical/biological factors (e.g., currents/flow sediment/soil type, slope) influencing habitat changes prior to a major coastal community/marina development. Our objectives include: (1) quantification of natural erosion rates by zone (n = 5) and stations (n = 51) using direct measurements, shoreline profiles, and imagery from 1965-1999; (2) determining the most cost-effective method(s) for detecting bank edge changes and contributing anthropogenic/physical factors; (3) boat trials (including boat speed and type, distance from shore) with painted oyster shells; and (4) oyster reef construction as a way to minimize fringing marsh losses. We are assessing recruitment potential for the latter objective. To date, directly measured erosion rates range from 1.5-4.2 cm/month; rates from shoreline delineations losses averaged 14 cm/month, accretion rates up to 29 cm/month. Sampling among stations/zones includes sediment and below-ground-biomass, stem counts, fiddler crab burrow counts and vegetational characteristics. Flow rates are being assessed using short-term vertical profiles and longer-term (i.e. days) dental plaster deployments quantifying dissolution. The information gained in this study will help decision makers utilize BMPs to minimize erosion/habitat losses. We will be creating GIS maps, educating boaters to minimize impacts, and helping determine what actions should be taken to alleviate or limit shoreline change.

▶ **DEVELOPING PARTNERSHIPS WITH LOCAL COMMUNITY MEMBERS TO ENCOURAGE PARTICIPATION IN OYSTER RESTORATION PROJECTS.** Greene, J. (1), R. Grizzle (1), J. Odell (2), K. La Valley (3), (1) University of New Hampshire, Zoology Department, 38 College Road, Durham, NH 03824, (2) The Nature Conservancy, NH Chapter, 112 Bay Road, Newmarket, NH 03857, (3) Ken La Valley, N.H. Sea Grant/UNH Cooperative Extension, 131 Main Street, Durham, NH 03824.

The eastern oyster (*Crassostrea virginica*) plays an important economic and ecological role in the Great Bay estuary (NH). There have been dramatic declines in oyster densities and reef acreage since mid-1990s, when the first MSX epizootic occurred. While UNH researchers and federal regulatory agencies are actively involved with the resource, local community members have had little chance for participation. Therefore, in combination with our ongoing reef restoration projects, we have

instituted two new community outreach programs involving oyster reef restoration in New Hampshire: oyster shell recycling and an "oyster conservationist" program. Recreational harvesters are allowed to remove a bushel of oysters per day in New Hampshire. The oyster shell recycling program allows harvesters to return their shell to a central location for use in remote setting of native oyster larvae. This will allow us to use local shell as substrate for future reef restoration projects and minimize the amount of shell going to local landfills. The oyster conservationist program involves providing local dock owners with naturally set oyster spat in cages and allowing them to care for the oysters until they are ready for transplant at one of our restoration sites. Volunteers at 16 sites around Great Bay and its tributaries monitor the growth of the oyster spat and provide helpful observations from areas not usually sampled. Overall, both projects connect the local community with a marine resource that many people utilize and allow them to become an active participant in the restoration process.

▸ **OYSTER RESTORATION USING "SPAT SEEDING": EARLY REEF PERFORMANCE AT SITES IN NEW HAMPSHIRE.** Grizzle, R. (1), J. Greene (2), M. Capone (3), (1) University of New Hampshire, 85 Adams Point Road, Durham, NH 03824, (2) University of New Hampshire, Zoology Department, Durham, NH 03824, (3) University of New Hampshire, 85 Adams Point Road, Durham, NH 03824.

The eastern oyster, *Crassostrea virginica*, has suffered dramatic declines in New Hampshire in the past decade due in part to proliferation of MSX. Remote setting of larvae from disease-resistant and/or fast-growth broodstock and subsequent "spat seeding" has been used in experimental trials aimed at developing cost-effective protocols for full-scale restoration efforts. Early reef performance (2 to 3 yr) at two sites suggests this method has the potential to initiate the restoration process. Experimental reefs constructed in 2003 at Adams Point using larvae from Damariscotta River (Maine) broodstock set on oyster shell and crushed concrete/granite material have shown moderate survival rates but excellent growth, some individuals exceeding 130 mm shell height after 3 years. Experimental reefs constructed in 2004 at Nannie Island using larvae from local broodstock set on oyster shell suffered about 50% mortality after 2 years but had excellent growth, with a mean shell height of 62 mm in 2006. The experimental reefs at both sites have also caught natural spat sets, and reproductive individuals occurred on both reefs in 2006. These experiments indicate that 5 or more years may be needed in New Hampshire for the development of minimal structural characteristics such as multiple generations with coalesced shells and vertical relief typical of oyster reefs.

▸ **ESTABLISHING REFERENCE VALUES AS TARGETS FOR INTERTIDAL OYSTER RESTORATION IN THE SOUTHEAST: CAN WE USE NATURAL REEFS AS BENCHMARKS?** Hadley, N. H. (1), L.D. Coen (1), M. Hodges (1), D.H. Wilber (2), and K. Walters (3), (1) Marine Resources Research Institute, S.C. Department of Natural Resources, Charleston, SC 29412, (2) Grice Marine Biology Program, College of Charleston, Charleston, SC 29424, (3) Department of Marine Science, Coastal Carolina University, Conway, SC 29528.

A goal of many oyster restoration projects is establishment of new or enhanced oyster reefs that approximate healthy natural oyster populations, at existing or historic densities and/or complexities. Comparison of restored reefs to paired, natural "reference" sites is one approach to evaluate the success of restoration efforts. Another approach would be to mine data collected from natural populations over reasonable temporal and spatial scales to establish target or "reference" values for a suite of metrics. In S.C., we have been monitoring natural and constructed oyster populations statewide for more than twelve years, collecting data on both oyster populations and associated resident fauna (e.g. invertebrates). We have data on oyster recruitment (mean= 4,418/ m^2 ± 573), oyster densities on natural reefs (mean= 2,346±192 oysters/m^2), average size (~31 mm), size-abundance patterns (~45% <20mm, <15%>60mm), and associated fauna. Small-scale restored oyster reefs ranging in age from 1 to 3 years old were sampled to evaluate these same parameters. We discuss different approaches to establishing targets using natural data and the resulting evaluations of restored reefs.

▶ **NORTH CAPE SCALLOP RESTORATION PROJECT- PROGRESS AND LESSONS LEARNED.**

Boze Hancock[1], Bryan DeAngelis[1], James Turek[2], John Catena[3] and Najih Lazar[4]
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The 1996 the tanker barge *North Cape* ran aground in Rhode Island waters releasing more than 828,000 gallons of No. 2 fuel oil into Block Island Sound. The spill killed large numbers of American lobster, bivalves, finfish and seabirds. Following case settlement in 2001, the trustees, (National Oceanic and Atmospheric Administration - NOAA, U.S. Fish and Wildlife Service - USFWS, and Rhode Island Department of Environmental Management - RIDEM), developed restoration plans for each of the injured natural resources. To address shellfish injuries, trustees selected multiple target species including the bay scallop (*Argopecten irradians*).

Scallop restoration in the south county salt ponds of Rhode Island progressed in two phases, direct seeding of Broodstock in 2002 and 2003, and a caged spawner sanctuary approach from 2004 to 2006 with concurrent monitoring of scallop spatfall. For direct seeding, scallops were purchased at 25 to 35mm in their first autumn and released in areas of suitable habitat. Stratified random transect dive surveys were conducted the following summer to monitor survival. In 2002, 680,000 scallops were released into Point Judith Pond, with only a few individuals found in the 2003 surveys. In 2003, approximately 286,000 were released into Potter Pond, 189,000 into Green Hill Pond, 581,000 into Ninigret Pond and 1,030,000 into Quonochontaug Pond. The total scallop abundance estimated from the 2004 surveys for each pond was 0, 0, 9,300 (±5,500 SE) and 520 (±370 SE) scallops for the four ponds respectively. A maximum survival of 1.6% in Ninigret Pond. Mortalities were attributed to predation, mainly by crabs.

In 2004 and 2005, 10,000 scallop broodstock were placed in cages in Ninigret Pond from June through November. Cages were 2'x2'x2', made of 1.5 inch mesh, with 4 internal shelves, each supporting a ½" mesh pouch containing up to 100 scallops. Spatfall was monitored from Mid July to mid November using 1mm mesh 'spat bags' containing a loose fill of 'netron' mesh. Bags were deployed on lines with 6 replicates, and 2 lines per site. Each line was deployed for 4 weeks with one line collected every 2 weeks to allow for 2 weeks of overlap in deployment period. Spat bag lines were located at four sites per pond with eight collections per season. In 2006 the spawner sanctuary was moved to Quonochontaug pond and increased to 20,000 scallops. Spatfall was monitored in both ponds in 2006. Because the schedule of spat collections was replicated each season a spat settlement index could be calculated as the sum of the mean spat per bag from the 8 collections from 4 sites per pond.

In 2004 there were approximately 20,000 broodstock in Ninigret Pond, 10,000 free from the direct seeding and 10,000 in the spawner sanctuary. These produced a late spatfall in October and November with a settlement index of 32. Dive surveys estimated that these recruits produced 132,000 (±55,000 SE) broodstock in 2005, and a further 10,000 were added in the spawner sanctuary. These produced a protracted spatfall with an index of 137. This recruitment resulted in 210,000 (±102,000 SE) broodstock scallops in 2006. The2006 spatfall of index was 37. This was possibly due to the low salinities and low oxygen concentrations resulting from relatively stable stratification, resulting from one of the wettest summers on record. In Quonochontaug Pond the 20,000 caged Broodstock produced a spatfall index of 52.

In summary, direct seeding was not a successful restoration technique in Rhode Island's South County salt ponds. A caged spawner sanctuary approach with relatively few Broodstock has produced promising results in two ponds, however water quality remains an issue.

▸ **NORTH CAROLINA'S OYSTER HATCHERY PROGRAM: A MODEL FOR AN INTEGRATED REGIONAL APPROACH TO RESTORATION.** Harcke, J.E. (1), T. Wilgis (2), (3) J. Deblieu, (1) North Carolina Aquarium, Fort Fisher, 900 Loggerhead Road, Kure Beach, NC 28449, (2) North Carolina Coastal Federation, Wilmington Field Office, 131 Racine Drive Suite 101, Wilmington, NC 28403, (3) Albemarle Project, The Nature Conservancy Global Climate Change Initiative, Manteo, NC 27954.

North Carolina is making significant progress to protect and restore the Eastern Oyster (*Crassostrea virginica*) and the waters it inhabits. Many factors contributed to the population's decline since the 1900s. Recognizing the Eastern Oyster's role as a keystone species in the estuarine environment, in 2003 the North Carolina Coastal Federation worked with researchers, harvesters and growers, state and federal regulatory and management agencies, NGOs, and legislators to craft a series of ongoing and new initiatives into the Oyster Restoration and Protection Plan for North Carolina: A Blueprint for Action. In 2005, the North Carolina legislature supported several key initiatives to protect and restore the native oyster. The N.C. Division of Marine Fisheries is creating more oyster sanctuaries and restoration areas, while N.C. Shellfish Sanitation initiated a successful pilot project to identify and mediate pollution sources in priority shellfish waters. The development of oyster hatcheries to support regional restoration efforts and educational programming were identified as critical components. The North Carolina Aquariums are leading an interagency team to design regional hatcheries, including production and research facilities. The Oyster Hatchery Planning Advisory Team includes researchers, educators and restoration experts from state agencies, universities and conservation NGOs. Using innovative strategies implemented by a diverse group of stakeholders, this comprehensive approach to the protection and restoration of shellfish waters and oyster habitat is valuable to the restoration community. Planning and implementation must include a diverse group of partners to be effective, and North Carolina's approach can be a model for other states.

▸ **THE BENEFITS AND CONSEQUENCES OF RESTORATION USING SELECTIVELY-BRED DISEASE-TOLERANT OYSTERS.** Hare, M., Biology Department, University of Maryland, College Park, MD 20742.

Restoration efforts in Chesapeake Bay are now focused on targeted population supplementation using artificially selected, disease tolerant *C. virginica* to combat high mortalities from parasitic diseases. This tactic has potential benefits and considerable risks. I will argue that genetic testing of recruitment is necessary to evaluate and manage the genetic risks of supplementation with inbred oysters, and under some circumstances it also can provide a much needed direct measure of overall restoration efficacy. Results will be presented from a highly collaborative effort to genetically monitor DEBY-strain restoration plantings in two Chesapeake sub-estuaries. The results indicate that the DEBY broodstock currently used to produce restoration oysters is genetically bottlenecked and contributing to severe inbreeding in those tributaries where restoration has had the greatest numerical impact. The consequences of this inbreeding will be discussed and recommendations will be offered for the precautionary use of artificially selected strains in restoration.

COMPARISON OF FREE AMINO ACID POOLS IN *CRASSOSTREA ARIAKENSIS* AND *CRASSOSTREA VIRGINICA*. Harlan, N. (1), D. Meritt (2), K.T. Paynter (1), (1) MEES Program, 0105 Cole Field House, University of Maryland, College Park, MD 20742, (2) Horn Point Laboratory, University of Maryland, Center for Environmental Science, Cambridge, MD 21613.

Early or rapid gaping by the suminoe oyster, *Crassostrea ariakensis* (Fujita), when emersed may indicate a difference in tolerance of low dissolved oxygen between the native oyster, *Crassostrea virginica* (Gmelin), and its Asian counterpart. Since Virginia and Maryland have proposed to use naturalized *C. ariakensis* as an ecological substitute for the native oyster, the ability of the non-native oyster to survive hypoxic and anoxic stress will be critical to the widespread survival of the species. Previous studies showed that the mean time to mortality during anoxic exposure in *C. ariakensis* was three days, while *C. virginica* did not succumb until after 14 days. To determine whether metabolic rates were responsible for the differential mortality, oxygen consumption rates were measured at 10 and 20°C and 5, 15, and 25 psu. Although there was a significant difference in metabolic rates of both species between 10 and 20°C, no difference in metabolic rates between species at any combination of temperature and salinity was found. The metabolic pathways utilized by the two species during anaerobiosis may differ, presenting a possible explanation for the difference in survival time. In order to determine the concentration of metabolic end products, free dicarboxylic acid and amino acid pools were measured and compared in both species under normoxic and hypoxic conditions using a GC-MS. The decreased survival of *C. ariakensis* during periods of hypoxia and/or anoxia compared to *C. virginica* may present an obstacle to its proposed new role to the Chesapeake Bay.

▸ **OYSTER REEF MORPHOLOGY AND HABITAT UTILIZATION: A COMPARISON OF *C. ARIAKENSIS* AND *C. VIRGINICA* IN ON-BOTTOM ENVIRONMENTS IN CHESAPEAKE BAY.**

Harwell, H.D. (1), P.R. Kingsley-Smith, (1), M.L. Kellogg, (2), S.K. Allen, Jr. (3), D.W. Meritt, (4), K.T. Paynter, Jr. (2), M.W. Luckenbach, (1), (1) Eastern Shore Laboratory, Virginia Institute of Marine Science, Wachapreague, VA 23480, (2) Department of Biology, University of Maryland, College Park, MD 20742, (3) Virginia Institute of Marine Science, Gloucester Point, VA 23062, (4) Horn Point Laboratory, 2020 Horns Point Road, Cambridge, MD 21613.

Although the Suminoe oyster, *Crassostrea ariakensis*, is under consideration for introduction into Chesapeake Bay, its growth form and reef-forming capability remain in question. Laboratory trials indicate that *C. ariakensis* exhibits density-dependent growth (Luckenbach, unpublished data), suggesting that this species may not form the dense aggregates seen in the native Eastern oyster, *C. virginica*. Previous studies of *C. virginica* show that certain aspects of reef morphology, such as shape, size, and vertical complexity, may influence the degree to which reefs are utilized as habitat by other species. If *C. virginica* and *C. ariakensis* do indeed differ in their reef-forming capabilities, this could have dramatic effects on the reef-associated fauna of Chesapeake Bay. As part of a larger research project, experimental treatments of sterile, triploid oysters were deployed as spat-on-shell (*C. virginica*, *C. ariakensis*, and a 50:50 mixture of the two), along with a shell only treatment, in four different bottom environments in Chesapeake Bay in late fall 2005. Sites covered a range of salinity, water depth, disease prevalence, and predation pressure. Growth form and habitat complexity are being quantified over a 2-year time-span using measures of vertical height, chain length, fractal dimension, and interstitial space. The abundance and diversity of reef-associated fauna are being evaluated in order to determine whether a relationship exists between habitat complexity and habitat utilization, and whether this relationship differs between oyster species.

▸ **PROGRESS IN RESTORING THE NATIVE OLYMPIA OYSTER TO THE UNITED STATES' WEST COAST: WORKSHOP RESULTS AND DEVELOPMENT OF A PRACTITIONERS' GUIDE.**

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Olympia oyster (*Ostreola conchaphila*, formerly *Ostrea lurida*), the only oyster native to the West Coast of North America, was once an important commercial

commodity and contributor to estuarine health and species diversity. However, over-harvesting, habitat loss, pollution, predators, and disease have caused populations to significantly decline. Today small remnant populations of Olympia oyster are scattered along the West Coast. Over the last ten years interest in restoring Olympia oyster populations and their ecological functions has increased. Local organizations have joined with the shellfish industry, universities, tribes, and state and federal agencies to conduct pilot restorations from Washington to California to test various techniques.
The National Oceanic and Atmospheric Administration's (NOAA) Community-based Restoration Program has provided nearly $1,000,000 to implement these restoration projects. Data gathered from projects have demonstrated that reseeding efforts and substrate enhancement can be successful; however, there is still much to learn about Olympia oyster and its recovery before restoration can move from the small to the large scale. In September, NOAA hosted the first workshop on Olympia oyster restoration. Over 65 individuals from the west and east coast, representing NGOs, academics, state and federal agencies and tribes participated in this workshop to discuss the current state of knowledge on Olympia oyster restoration and biology. This presentation will focus on workshop results including lessons learned, research priorities and next steps. Information will also be presented on the development of a restoration guide by NOAA and their partners that will include synthesis of biology, genetics, habitat requirements, ecosystem services, disease and predators, restoration, monitoring, funding, and permitting.

▸ **SUBLETHAL PREDATION ON THE RIBBED MARSH MUSSEL, *GEUKENSIA DEMISSA*: PREVALENCE, PATTERNS AND EFFECTS.**
Hillard, R. (1), A. Puzo (1), K. Walters (1), (1) Dept. of Marine Science, Coastal Carolina University, Conway, SC 29528.

The general focus of shellfish restoration efforts typically has been on commercially important species including oysters and clams. However, numerous other shellfish may provide equally valuable services (e.g., water quality improvements) and, similar to the more commercial species, be at risk possibly requiring restoration efforts. One such species is the salt marsh mussel, *Geukensia demissa*. Marsh mussels may influence disproportionately the dynamics of intertidal estuarine systems and have been shown to facilitate salt marsh plant growth, improve near-shore water quality, and increase sediment deposition. Primarily reported living within intertidal marsh habitats, mussels also can be found within oyster reefs and mangrove forests in the Southeastern U.S. To assess the effects of oyster reef loss on the survival of marsh mussels, levels of sublethal predation on mussels were determined from a variety of South Carolina intertidal locations and habitats. External and internal shell damage most likely resulting from unsuccessful crab predation attempts were compared between reef and marsh mussels. Results suggest that oyster reefs provide an effective refuge for mussels compared to marsh habitats and the loss of reefs may negatively affect mussel populations within coastal estuaries.

▸ **SHORELINE STABILIZATION AND CHANGES IN SEDIMENT COMPOSITION ASSOCIATED WITH SMALL-SCALE OYSTER REEFS IN SOUTH CAROLINA.**
Hodges, M.S. (1), N. Hadley (1), L. Coen (1), S. Roth (1), M. Bolton-Warberg (1), L. Goodwin (2), (1) S.C. Department of Natural Resources Shellfish Research Section, 217 Fort Johnson Rd., Charleston, SC 29412, (2) College of Charleston, MES Program, Charleston, SC 29424.

Shoreline erosion and sedimentation are major concerns for habitat loss and related restoration. Fringing intertidal oysters often protect fragile shorelines in tidal creeks in S.C. In the absence of oysters, significant marsh may be lost, resulting in diminished nursery habitat. Since 2001 our SCORE Community Restoration Program has constructed over 125 small (~14 m^2) oyster reefs at 29 sites, using over 2,000 community volunteers. These bagged oyster-shell reefs are impacted significantly as sediments either wash down from above salt marshes or settle out with reduced flow rates around new reefs. This can cover newly planted shell with fine sediments, making them unavailable for new recruits or smothering juvenile oysters soon after settlement. We have been measuring marsh edge changes at nine SCORE sites. To date, monthly erosion rates range from 1.28 cm/mo. to 5.54 cm/mo., with total marsh losses (12-58 months) from 40.53 cm to 331.46 cm. At several sites constructed over three years ago, *S. alterniflora* has grown significantly seaward (>8 m) into our developing reefs. This marsh vegetative re-growth appears to be associated with the accumulation of soft sediments and stabilization behind reefs. We are evaluating also sediment compositional changes at 15 sites, ranging in age from one to five years. On average, coarse sediments (% sand, mean +1SE) have been replaced with fine sediments (overall: 74%+ 5.7 to 53%+ 5.3). Two sites had over a 50% decrease in sand composition in 3-4 years. With the ever-increasing cost of marsh restoration, the deployment of shore stabilizing oyster bags using community volunteers can be a cost-effective way to enhance/restore both oyster and marsh habitats.

▸ **EVALUATING LARGE-SCALE INTERTIDAL OYSTER REEF RESTORATION IN S.C. : TRADITIONAL AND NOVEL APPROACHES TO ASSESS SUCCESS OR FAILURE.** Hollis, A. (1), L.D. Coen (1), N. Hadley (1), Marine Resources Research Institute, SCDNR, 217 Fort Johnson Rd., Charleston, SC 29412.

Intertidal oysters are critical for healthy estuaries in the southeastern U.S. Intertidal restoration often requires very different approaches than subtidal efforts. In S.C., we have been expanding our large-scale planting efforts, both to enhance/restore habitat and resources. Our research efforts have mirrored this expanded investment, with a major goal to maximize success. Our approach includes designs to incorporate: (1) mesh for stabilization shell loss from boat wakes; (2) underlayment to reduce sinking; (3) interactions with fringing marsh; (4) site selection criteria (slope, shell); and (5) alternative clutches. Since 2002, over 25,000 m^2 (110,455 U.S. bushels) of whelk, local or Gulf oyster shell were planted at >22 sites. One initial conclusion is that contractors cannot plant complex shell designs as required for rigorous experiments. Monitoring and evaluation of the 2002-06 oyster restoration sites included: (a) monitoring of footprints using GPS surveying quality instruments; (b) evaluation of shell depth change over time; (c) annual sampling for population and resident faunas; (d) local recruitment; and (3) extensive documentation with digital imagery. In general, shell depth changes significantly in the first three months after planting, with siltation and 'subsidence' also significant. Recruitment on reefs is still low relative to adjacent 'substrate collectors' (means=200-600/m^2 vs. >7,000 oysters/m^2). The results of mesh stabilization varied hence experimental trials were initiated to assess why (e.g., greater siltation, mesh stability). We found that investing up front in site selection is key. Surveying of these sites showed significant differences over a period of one year ranging from nearly no change to decreases of more than 75%. With shell becoming scarcer, we will soon be evaluating alternative materials. We discuss our overall observations and recommendations for success.

▸ **APPLICATION OF STATISTICAL-REGRESSION MODELED ESTIMATES OF STREAM NUTRIENT LOADS TO SUPPORT NUTRIENT-MANAGEMENT STRATEGIES FOR ESTUARIES IN THE SOUTHEASTERN UNITED STATES.** Hoos, A.B. (1), G. McMahon (2), (1) U.S. Geological Survey, 640 Grassmere Park, Suite 100, Nashville, TN 37211, (2) U.S. Geological Survey, 3916 Sunset Ridge Road, Raleigh, NC 27607.

The U.S. Geological Survey's National Water-Quality Assessment Program has compiled surface-water quality monitoring data and estimates of nutrient sources (wastewater, agricultural, urban, and atmospheric) from

Federal, State, and local water-resource agencies throughout the southeastern region of the United States. These data provide input to the SPARROW (SPAtially-Referenced Regression on Watershed attributes) water-quality model to predict nutrient loads in individual stream reaches and transport and fate of these nutrients as they move through the stream network to coastal water bodies. Application of modeled findings addresses two questions about stream nitrogen loads entering the 17 nitrogen-impaired estuaries in the southeast, with implications for nutrient-management planning. First, what are the proportional contributions of nitrogen delivered to each estuary from point-source wastewater discharges, agricultural and urban land, and atmospheric deposition, and how will changes in inputs from these sources affect the annual load delivered to the estuary? Second, what are the proportional contributions of nitrogen delivered to the estuary from each individual watershed in its drainage basin, and how does annual delivered load respond to incremental change in the amount of nitrogen exported from individual watersheds?

▸ **INTRODUCTION OF THE SEA SCALLOP *MIZUHOPECTEN YESSOENSIS* TO SUITABLE AREAS OF PUGET SOUND.** Kalashnikov, V. (1), V. Ivin (2), (1) 3804 67th Ave. Ct. NW, Gig Harbor WA, 98335, (2) Institute of Marine Biology, Paltchevskogo 17, Vladivostok, 690041 RUSSIA.

The sea scallop *Mizuhopecten yessoensis* is a Pacific Asian low-boreal species of great commercial value and it is the biggest of all Pectinidae. The species occurs naturally in the Sea of Japan along the northern Korean peninsula, the coastline of Primorsky Territory, near the shores of Sakhalin Island, South Kuriles, around Hokkaido and the northern coastline of Honshu Island. Our extended experiences of research and farming the species in its native waters and commercial diving in NW Pacific area led us to the idea of introducing the scallop to the new habitat. The gigantic species seems to fit even better in the reviewing area of Puget Sound and the neighboring waters than it does in its natural fields, where the scallop struggling for survival from storms in mostly open zones, from plentiful starfish predators and there is also a big deceleration in body growth during severe and long winters. Instead in the considered area usual temperature is close to the species optimal 8-10 centigrade all year around, stable ocean salinity, repetitive refreshing tidal currents assume faster growth for the mollusk in the waters. Dense and developed kelps here show evidential signs of good nutritional and oxygen conditions. Also there are many appropriate beds, banks, bays and coves protected from storm destruction and approachable for sport and commercial diving. There are no signs of mass predators such as starfishes at the first place. The scallop itself is a safe neutral filtrator, it is a non-competitive species. For all of these reasons the scallop *M. yessoences* seems to be a perfect candidate for the faunal enrichment as the subject of cultivation, commercial and recreational fishing in the Puget Sound and neighboring areas.

▸ **"THE ISLAND BLUE PAGES"- AN EDUCATIONAL BOOKLET TO MINIMIZE THE RESIDENTIAL IMPACTS ON THE WATER RESOURCES OF MARTHA'S VINEYARD.** Karney, R.C. (1), A.S. Surier (1), (1) Martha's Vineyard Shellfish Group, Inc, Oak Bluffs, MA 02557.

Over the past 25 years, the population of the island of Martha's Vineyard has grown at a phenomenal rate. In 1976, the year round population was about 6,500. Presently, it is estimated to be over 15,000. Likewise, during the same period, the summer population has increased from about 40,000 to over 105,000. Many of the current water quality problems result from the Vineyard's rapid development and population growth. Every additional septic system and newly fertilized lawn further pollutes the Island's waters. Each new house may seem unimportant by itself, but multiply the impact of a single household by thousands of households and it becomes clear why water resources are deteriorating. Efforts to protect the Island's natural resources in wake of this human flood have mostly taken form of regulations such as zoning to control housing density and septic system design criteria to protect groundwater. There is no doubt that these rules enforced at the time of construction have helped protect the integrity of the island's surface waters but more protection is needed. Residential impacts that occur after construction have been more difficult to control. Once an occupancy permit has been issued, residents are generally free of any environmental regulations, oversight, or enforcement, despite the fact that daily activities around the home can have severe environmental impacts on the community's natural resources. It is doubtful that a homeowner would conduct activities that he knows would be harmful to the water quality of a nearby water body. Most environmentally damaging activities result out of ignorance of their consequences. What is needed is a public education campaign to inform residents of the environmental impacts of their daily activities—encouraging helpful behaviors and discouraging damaging ones. To this end in 2005, "The Island Blue Pages–A Guide to Protecting Martha's Vineyard Waters," an educational booklet directed at the resident homeowners, was created and distributed to every household on Martha's Vineyard. The 54-page booklet includes a water primer covering basics about the water cycle and Island watersheds and much practical advice on water conservation, the proper use of cleaning agents, the effects of polluted road runoff, careful waste disposal, good boating practices, tips on native landscaping and how to recover from lawn obsession. It is an adaptation of the Puget Soundbook, a 1991 publication conceived by the Puget Sound Water Quality Authority to educate individuals regarding their impacts on the Puget Sound ecosystem. The Blue Pages was put together by a group of residents committed to water quality. The project was spearheaded by the Martha's Vineyard Shellfish Group and the bulk of the financial support came from the Wampanoag Tribe of Gay Head (Aquinnah) through a grant from the U.S. Environmental Protection Agency.

▸ **ROLE OF OYSTER AGE VERSUS OYSTER SIZE IN DETERMINING SEX RATIOS ON RESTORED OYSTER REEFS IN CHESAPEAKE BAY.** Kellogg, M.L. (1), M.E. Chen (1), V.S. Kennedy (1), C.P. Miller (1), S.E. Rowland (1), R.T. Paynter (1), K.C. Paynter (1), N.J. Ward (1), D. Goldsmith (1), M.W. Sherman (1), J.D. Goodwin (1), C.P. McIntyre (1), S. Allen (1), K.T. Paynter (1), (1) Department of Biology, University of Maryland, 0218E Biology-Psychology Bldg., College Park, MD 20742.

The eastern oyster, *Crassostrea virginica*, is a sequential hermaphrodite in which small oysters tend to be male while large oysters tend to be female. In most cases, natural recruitment to oyster populations in the field has made it difficult to determine whether changes in sex are more closely correlated with oyster size or oyster age. Our study took advantage of a unique opportunity to sample oysters planted on known dates in areas of Chesapeake Bay where natural recruitment rates have been < 1 spat m^{-2} in recent years. A total of 25 plantings, ranging in age from 1 to 5 years old, were sampled and the length and sex of each oyster collected was determined. Preliminary analyses indicated that both oyster age and size were correlated with sex ratios. As expected, the percentage of females in the population increased with increasing oyster age from 22.5% in 1-year-old oysters to 59.3% in 5-year-old oysters. After initially increasing with increasing size, the percentage of females on plantings decreased from a peak of 53.8% in the 101-120 mm size class to 38.2% in the largest size class (121-140 mm). When the lengths of males and females were compared within year class, females were significantly larger in the 1 year old ($p < 0.001$) and 2 year old ($p = 0.002$) populations, but these differences disappeared in the older populations. Thus, over time, oyster age became more important than oyster size in determining the percentage of females in the population.

Oral & Poster PRESENTATION ABSTRACTS

▸ **INTER-SITE AND INTER-SPECIFIC DIFFERENCES IN RATES OF SURVIVAL AND GROWTH OF *C. VIRGINICA* AND *C. ARIAKENSIS*: A COLLABORATIVE ON-BOTTOM STUDY IN VIRGINIA AND MARYLAND.** Kingsley-Smith, P. R.(1),H.D. Harwell (1), M.L. Kellogg (2), S.K. Allen, Jr.(3), D.W. Meritt (4), K.T. Paynter Jr.(5), M.W. Luckenbach (1), (1) Eastern Shore Laboratory, Virginia Institute of Marine Science, Wachapreague, VA 23480, (2) Department of Biology, University of Maryland, College Park, Maryland 20742, (3) Virginia Institute of Marine Science, Gloucester Point, VA 23062, (4) Horn Point Laboratory, UMCES 2020 Horns Point Rd., Cambridge, Maryland 21613, (5) Department of Biology, University of Maryland, College Park, Maryland 20742.

Predicting rates of survival and growth of the Suminoe oyster, *Crassostrea ariakensis*, in natural bottom habitats within Chesapeake Bay and adjacent coastal waters, is critical to a pending decision on an intentional introduction. Currently our knowledge of such rates is based upon field trials using triploids grown in off-bottom aquaculture trials and ongoing quarantined studies using diploids. Replicated treatments with each oyster species (*C. virginica* and *C. ariakensis*), singly and in combination, were planted in late October-early November 2005 in bottom habitats at four sites in Virginia and Maryland as a first attempt to gather data in a more naturalistic setting. Uncovered trays of oysters were surrounded by large-meshed 10ft x 10ft x 2ft cages both as biosecurity and to preclude disturbances from large, benthic predators and anthropogenic activities. Sites were chosen to encompass a range of salinities (~5-30 psu), water depths (intertidal to ~4m), disease pressure and relative predator abundances. Inter-site and inter-specific differences in rates of survival and growth are presented from quarterly sampling data gathered in April, July and October 2006. Rates of survival and growth of both oyster species were lowest at the high salinity, intertidal site in Virginia. The highest growth rate of *C. ariakensis* was observed at the high salinity, shallow subtidal site in Virginia, where the difference in growth rate between oyster species was greatest. Differences in growth rates between oyster species were less pronounced at the lower salinity, subtidal sites in Maryland.

▸ **HOW LONG DOES OYSTER SHELL LAST ON AN OYSTER REEF?** Kraeuter, J.N. (1), E.N. Powell (1), K.A. Ashton-Alcox (1), (1) Haskin Shellfish Research Laboratory, Rutgers University, 6959 Miller Avenue, Port Norris, NJ 08349.

Programs designed to restore oyster (*Crassostrea virginica*) reefs typically utilize oyster shell. There is an assumption that this shell, unless it is buried, will be available for many years. A reduction in population abundance brought on by 6 years of low recruitment has reduced shell input through natural mortality on Delaware Bay oyster beds. Quantitative stock surveys provide an estimate of surficial shell over the same time period. This permitted the reconstruction of the time history of shell since 1998 and the estimation of addition and loss rates. Shell loss rates were surprisingly high. In most cases, half of the shell added to an oyster bed in Delaware Bay in a given year is lost over the subsequent 2 to 10 years. The expectation that the half-life of shell would be lowest at higher salinities where boring sponges and other epibionts are prevalent was not the case. The shortest half-lives, typically 2 to 3 years, were at intermediate salinities. Half-lives increase to about 10 years both up-bay (lower salinity) and down-bay (higher salinity). Minimal shell doubling times were calculated under the assumption of no shell loss, implying a maximum accretion rate. Doubling time varied from less than 10 to more than 20 years. This indicates that oyster shell has the potential to accumulate rapidly. The lack of shell accumulation in Delaware Bay can be explained if most shell produced yearly does not remain intact for long. Restoration programs need to take into account loss rate of the shell resource.

Oral & Poster PRESENTATION ABSTRACTS

▶ **EXPLORING THE POTENTIAL OF ENHANCING OYSTER SPAT COLLECTION ACTIVITIES THROUGH HIGH DENSITY PRODUCTIVE SANCTUARIES IN CARAQUET BAY, NEW BRUNSWICK.** Landry, T. (1), J.F. Mallet (principal author) (1), (1) Department of Fisheries and Oceans, 343 Universite Moncton, NB E1A 4Y1 CANADA.

Oyster spat collection activities for aquaculture in Caraquet Bay has recently been identified by representatives of the local oyster industry as one of the major contributors to the economy of the Acadian Peninsula. This study consists of an evaluation of restoration scenarios which could be undertaken to enhance larval production and spat collection in this bay. Such evaluation was made by simulating various high density oyster sanctuaries scenarios with established oyster fecundity and fertilization models. Results showed that larvae fertilization efficiency (%) could be enhanced by more than twenty folds through high density (~220 oysters/m^2) reproductive sanctuaries. Findings also suggest that the annual larvae contribution of a high density sanctuary could match or even surpass the actual annual larvae production of the entire inter-tidal zone of this bay, and this in an area about 1000 times smaller. Thus, this study clearly demonstrates the great potential and the feasibility of relaying oysters in high density sanctuaries in order to enhance larvae production and develop a sustainable oyster spat collection industry in Caraquet Bay.

▶ **NATIVE OYSTER RESTORATION IN SAN FRANCISCO BAY USING COMMUNITY VOLUNTEERS- A COLLABORATIVE EFFORT TO RESEARCH POPULATION DYNAMICS AND RESTORATION OPPORTUNITIES FOR *OSTREA CONCHAPHILA* IN THE SAN FRANCISCO ESTUARY.** Latta, M., Save San Francisco Bay Association (Save the Bay), 350 Frank H. Ogawa Plaza, Suite 900, Oakland, CA 94612.

The native Olympia oyster, *Ostrea conchaphila*, was once abundant in many estuaries along the west coast of North America. Loss of habitat, over-harvesting, and degraded water quality have severely depleted the historic native oyster populations in San Francisco Bay, reducing a once dominant local fishery resource to a few scattered populations. Since 2000, the NOAA Restoration Center has been working with many state and local government and non-profit partners in the San Francisco Bay Area to monitor existing native oyster populations and build support for large scale restoration projects in the estuary. In 2002 Save San Francisco Bay Association (Save The Bay) spearheaded a project to monitor oyster populations and water quality at five sites in the Bay, documenting oyster presence at all sites and involving more than 450 community volunteers in the effort. Building upon this and other monitoring projects, Save the Bay is now working with San Jose State University researchers, NOAA Restoration Center, and other organizations in an expanded effort to monitor projects at six sites in San Francisco Bay. The goal is to gain more information about native oyster populations and their settlement preferences in the estuary. This talk will share key elements of these partnerships, the approach and major issues, and next steps for restoration of the native *Ostrea conchaphila* in San Francisco Bay.

▶ **SECONDARY PRODUCTION OF INFAUNAL BENTHIC COMMUNITIES IN CHESAPEAKE BAY IN COMPARISON TO RESTORED OYSTER REEFS.** Lawless, A. (1), R. Seitz (1), (1) Virginia Institute of Marine Science, The College of William and Mary, Gloucester Point, VA 23062.

Restoration projects involving the Eastern oyster, *Crassostrea virginica*, are underway in many locations throughout Chesapeake Bay. The placement of oyster reefs upon certain areas of the bottom requires covering the existing benthic infaunal communities. We designed a replicated experiment to examine the abundance, biomass, diversity, and secondary production of infaunal communities in the footprint of two new oyster reefs in Lynnhaven Bay, Virginia. The sites are shallow subtidal habitats in muddy sand sediments located four meters offshore. The benthic community is comprised of large bivalves such as *Macoma balthica*, *Tagelus plebeius Mercenaria mercenaria*, and *Ensis directus* that dominate the biomass and secondary production of these communities, along with polychaetes and other taxa. The restored oyster reefs were constructed in June 2006 on the Lynnhaven sites, and their productivity will therefore not be quantifiable for some time. Hence, we are using published production values for existing oyster reefs to estimate expected production of the restored Lynnhaven reefs. Production values published for similar Eastern oyster reefs have been estimated at 200-1200 kcal/yr. Preliminary results indicate that the restored reef provides enhanced secondary production over the original infaunal community on a per unit area basis. We propose that it would be beneficial to construct oyster reefs over existing infaunal communities with similarly moderate productivity. These data suggest that further restoration aimed at the native Eastern oyster in the Chesapeake Bay system is warranted and will increase benthic secondary production.

▸ **ASSESSING OYSTER REEF HABITAT VALUE THROUGH NAKED GOBY (*GOBIOSOMA BOSC*) LIPID PRODUCTION.** [Lederhouse, T.M.] (1), C.L. Rowe (2), M.L. Kellogg (3), K.T. Paynter (3), (1) Marine Estuarine Environmental Sciences Program, University of Maryland, College Park, MD 20742, (2) University of Maryland, Center for Environmental Science, Chesapeake Biological Laboratory, Williams St., Solomons, MD 20688, (3) University of Maryland, College Park, MD 20742.

Organismal lipid content has been used as an indicator of habitat quality and has potential for use in the development of oyster reef restoration success criteria. Experimental oyster reefs were created in September 2005 in the Severn River, Maryland, to test habitat quality for naked gobies (*Gobiosoma bosc*). Using plastic trays lined with mesh, twenty 0.34 m^2 reefs were constructed with oyster densities of 0 m^{-2} (control), 30 m^{-2} (low), 120 m^{-2} (intermediate), 240 m^{-2} (high), and loose shell. In November 2005, tray contents were sieved and all visible fish were collected. Each reef tray goby population was pooled and homogenized in a coffee grinder. Lipids were extracted from a sub-sample via the soxhlet method. Mean goby percent lipid contents for loose shell, intermediate, and high density reef trays were 150-200% greater than those from control and low density treatments. No difference was found between control and low density treatments, or among loose shell, intermediate, and high density oysters. These findings indicate that the density of oysters on natural un-restored oyster reefs in the Chesapeake Bay (~1 m^{-2}) provides limited habitat and/or ecological benefits to naked gobies. Significant positive correlations between naked goby lipid content and the abundances and dry weights of other reef organisms indicate that fish percent lipid may be an appropriate metric for determining energy transfer and community health on restored oyster reefs. Ongoing research will determine whether observed differences are due to the presence of live oysters or to the physical structure they provide.

▸ **THE EFFECT OF COW NOSE RAY PREDATION ON OYSTER RESTORATION AND THE USE OF SPAT ON SHELL FOR BROOD STOCK ENHANCEMENT OF SANCTUARY REEFS.** [Leggett, A.T. Jr.] (1), J. Wesson (2), S. Allen (3), R. Mann (3), M. Bryer (4), M.S. Congrove (3), E.C.D. Hudson (1), (1) Chesapeake Bay Foundation, Wicomico, VA 23184, (2) Virginia Marine Resources Commission, 2600 Washington Ave 3rd Floor, Newport News, VA 23607, (3) Virginia Institute of Marine Science, Gloucester Point, VA 23062, (4) The Nature Conservancy, MD/DC Chapter 5410 Grosvenor Lane, Suite 100, Bethesda, MD 20814.

The Virginia oyster restoration strategy has been to recreate habitat in the form of 3 dimensional reefs and stock selected reefs with adult oysters from watermen buy back programs and cultured oysters from oyster gardeners and restoration oyster farms. There is evidence that the strategy has increased oyster biomass in certain rivers such as the Lynnhaven, Elizabeth, Great Wicomico, Tangier and Pocomoke Sounds, and the Piankatank, however, disease pressure and water quality continue to be major impediments to restoration efforts. Cow nose rays have long been known to prey on commercial oyster plots, however, only recently has it been documented that rays are also a major impediment to successful oyster restoration. Rays consumed large quantities of brood stock oysters in the Great Wicomico River in 2004 causing oyster restoration partners to erect a ray exclusion pen around the restoration site for 2005 brood stock deployments. The resulting cost, maintenance, and impracticality of erecting excluder structures around reef restoration sites throughout the Bay led restoration partners to examine a less expensive alternative to protecting brood stock for deployments in the Piankatank River in 2006. Again rays consumed 94% of transplanted brood stock only one day after the final deployment. In 2005 the oyster industry, the Virginia Institute of Marine Science and the Virginia Marine Resources Commission conducted a pilot project to examine the suitability of spat on shell for reef restoration. Results are promising, resulting in increased efforts to produce spat on shell for reef restoration.

▸ **“BOOM OR BUST”: RESTORING BAY SCALLOP POPULATIONS IN FLORIDA THROUGH THE RELEASE OF COMPETENT LARVAE: ARE CONTAINMENT BOOMS NECESSARY?** Leverone, J.R. (1), S.P. Geirger (2), W.S. Arnold (2), J.M. Greenawalt (3), (1) Mote Marine Laboratory, 1600 Ken Thompson Parkway, Sarasota, FL 34236, (2) Fish and Wildlife Research Institute, 100 Eighth Avenue SE, St. Petersburg, FL 33701, (3) Charlotte Harbor National Estuary Program, 1926 Victoria Ave, Fort Myers, Florida 33901.

In 2003, we initiated a new approach to enhancing bay scallop populations in Pine Island Sound, Florida. This technique involved releasing competent, late-stage larvae into containment booms which isolated the water column, thereby preventing the larvae from excessive dispersion. Three booms were used for larval releases and an additional boom served as a control (no larvae added). Scallop spat recruited to artificial substrates within all three treatment booms. Juvenile scallops, surveyed in February 2004, were found in all treatments while being absent from the control. Adult scallops, surveyed in July 2004, were two orders of magnitude greater at the restoration site than the resident scallop population within the sound. In 2005, the entire sound experienced a 100-fold increase in scallop abundance from the previous year. (Pine Island Sound had the highest abundance of bay scallops of any Florida estuary in 2005). In 2005-06, restoration activities expanded to South Pine Island Sound, Sarasota Bay and Boca Ciega Bay along the west coast of Florida. Significant spat recruitment was noted from each of these releases. A second “boomless” larval release was conducted in South Pine Island Sound in May 2006. Recruitment was detected from this release as well. The pros and cons of using containment booms for restoration projects that use the pelagic larvae stage as the restoration unit will be discussed. Impediment to restoration efforts in South Pine Island, which center around alterations in freshwater inflow, will also be addressed.

▸ **FIRST YEAR MONITORING OF NEWLY CONSTRUCTED OYSTER PLATFORMS IN SARASOTA BAY, FLORIDA.** Leverone, J.R. (1), G.E. Raulerson (2), (1) Mote Marine Laboratory, 1600 Ken Thompson Parkway, Sarasota, FL 34236 (2) Sarasota Bay Estuary Program, 111 S. Orange Ave., Sarasota, FL 34234.
Several local partners, led by the Sarasota Bay Estuary Program, created subtidal (White Beach) and intertidal (Turtle Beach) oyster platforms in Little Sarasota Bay, Sarasota, Florida, during August 2005. Each platform was constructed from fossilized shell material placed in mesh bags which allowed for the recruitment of oyster spat. Monthly field trips were made to White Beach (restoration site), Turtle Beach (restoration site), and North Creek (reference site) from August 2005 through August 2006. Monitoring included spat monitoring and fossil shell colonization. For spat monitoring, four settling plates (15 x 15 cm) were deployed within each site and replaced monthly. Total number of oyster spat were enumerated and density calculated. Shell colonization was monitored

by collecting shells from each habitat and counting oyster spat. Spat recruitment was observed in summer and early fall in both 2005 and 2006. Shell colonization occurred throughout the year. Roughly twice the number of spat colonized shell at White Beach (subtidal) than Turtle Beach (intertidal). Recruitment of oyster spat on the settling plates did not adequately mimic spat settlement on the fossilized shell. Recruitment monitoring of bagged shell will continue for another year. Seasonal spat monitoring will use “oyster strings” instead of settlement plates to better assess temporal oyster settlement.

▸ **A VON BERTALANFFY BASED MODEL FOR ESTIMATING *CRASSOSTREA VIRGINICA* OYSTER GROWTH AT RESTORED SITES IN THE CHESAPEAKE BAY.** Liddel, M.(1), M. Christman (2), K.T. Paynter (1), (1) MEES Program, 0105 Cole Field House, University of Maryland, College Park, MD 20742, (2) Department of Statistics, Institute of Food and Agricultural Sciences, 406 McCarty C 110339,University of Florida, Gainesville, FL 32611.

A Von Bertalanffy based model was developed for estimating the mean monthly growth of hatchery-reared oysters (*Crassostrea virginica*) planted as part of an oyster restoration project in the upper Chesapeake Bay. This model uses temperature and salinity time series data to dynamically change the Von Bertalanffy growth constant each monthly time step. This allows the model to capture changes in growth rate due to seasonal effects. The impact of *Perkinsus marinus* disease on growth was also estimated using a series of threshold values estimated from previously published laboratory and field experiments. The model was validated by comparing size at age estimates produced by the model to observed growth from several restoration sites in the upper Chesapeake Bay. If the *P. marinus* impact on growth is not included, the model consistently overestimates mean oyster growth. However, when the *P. marinus* effects are included in the model, the model estimates match the observed mean length closely for at least the first 3 years of growth.

▸ **METAPOPULATION SOURCE-SINK DYNAMICS AND CONNECTIVITY OF OYSTER REEF NETWORKS.** Lipcius, R. (1), H. Wang (1), J. Shen (1), M. Sisson (1), S. Schreiber (2), (1) Virginia Institute of Marine Science, The College of William and Mary, Gloucester Point, VA 23062, (2) Department of Mathematics, The College of William and Mary, Williamsburg, VA 23188.

Various biophysical systems exhibit characteristics of metapopulation and network structure. The specific type of metapopulation or network structure can have substantially different effects on metapopulation dynamics of marine species with open populations displaying varying degrees of connectivity between subpopulations. We investigate the role of connectivity in metapopulation dynamics of the Eastern oyster with a 3D hydrodynamic model simulating advection and diffusion between numerous oyster reefs (i.e., subpopulations) positioned according to historical observations. Model simulations produce estimates of the degree of connectivity between all pairs of oyster reefs, which subsequently permits assessment of the diversity of patterns in network connectivity. From these results we distinguish the major characteristic types of connectivity patterns among oyster reefs, including sources and sinks. Furthermore, we discuss the means by which oyster reef networks, such as those occurring throughout Chesapeake Bay, can be restored successfully.

▸ **RE-CLAM-ATION OF THE BLUEPOINTS BOTTOMLANDS: RESULTS FROM THE FIRST TWO YEARS OF A LARGE SCALE EFFORT TO RESTORE SUSTAINABLE HARD CLAM POPULATIONS TO GREAT SOUTH BAY, NY.** LoBue C.(1), C. Clapp (1), M. Doall (2), (1) The Nature Conservancy, Long Island Chapter, 250 Lawrence Hill Rd., Cold Spring Harbor, NY 11724, (2) Department of Ecology and Evolution, Stony Brook University, Stony Brook, NY 11790.

Since acquiring title to over 20 square miles of underwater lands in Great South Bay, NY in 2003 from the former Bluepoints Company, The Nature Conservancy has been working with a long list of agencies, stakeholders, scientists, and environmental advocates to develop and implement a large scale plan to restore and manage now decimated hard clam (*Mercenaria mercenaria*) populations to the entire estuary. This is one part of a larger effort to restore and protect critical systems and habitats throughout the bay. The long-term plan includes multiple tactics to address recruitment limitation, predation, fishing pressure, and water quality. Baseline population surveys compared to published stock/recruitment relationships suggest that much of the estuary is recruitment limited, thus initial restoration projects have focused on the establishment of a network of spawner sanctuaries. These are no-harvest areas where adult clams from surrounding bays are stocked at high abundance to rebuild reproductive potential. All life stages of clams have been monitored concurrently. In particular, monitoring has included large-scale shellfish surveys, survival assessments of relocated clams, monitoring of reproductive condition in thousands of clams at multiple sites, presence of larvae, abundance and impacts of predators, and general water quality parameters. To date, over 1 million adult clams have been relocated to Nature Conservancy owned bottomlands in Great South Bay and the project is expanding. This presentation will describe the overall project and provide details of progress as measured by the various monitoring programs.

▸ **THE INFLUENCE OF WATER QUALITY ON IMMUNE FUNCTION IN THE EASTERN OYSTER, *CRASSOSTREA VIRGINICA*.** Macey, B. (1), T.E. Miller (1), C.K. Rathburn (1), H. Williams (1), L.E. Burnett (1), K.G. Burnett (1), (1) Grice Marine Laboratory, College of Charleston, and Hollings Marine Laboratory, 331 Fort Johnson Road, Charleston, SC 29412.

Variation in water quality, due to natural and anthropogenic factors, may alter the ability of marine organisms to defend themselves against pathogens. We have developed a bacterial clearance assay to assess overall immune function of the oyster *Crassostrea virginica*. This assay quantifies the ability of oysters to inactivate and degrade the bacterium *Vibrio campbellii* injected into adductor muscle. In laboratory experiments, we have used this assay to show that exposing oysters to hypercapnic hypoxia (2% CO2, 19-20% air-saturation, pH 6.2-6.5) for 4 h significantly reduces their ability to inactivate bacteria. After 60 min 18% (SEM=2, n=10) of injected Vibrio could be cultured from the tissues of oysters exposed to normoxia (98% air-saturation, pH 7.8-8.0) , while 36% could still be cultured from hypoxic oysters (SEM=7.5, n=7). In field experiments, we have used this assay to assess overall immune function of oysters collected from tidal creeks with different contaminant loads. Bacterial clearance and total hemocyte counts were determined in oysters within 3 days after field collection. There was a strong negative correlation (r=0.840, p=0.018) between the total hemocyte counts and the ability of oysters to inactivate bacteria. Preliminary analysis of field data also indicates that oysters from less contaminated sites clear bacteria more rapidly than those from highly contaminated sites. We suggest that poor water quality can increase the risk that oysters will harbor and transmit bacterial pathogens hazardous to human and ecosystem health. (Supported by the OHH Center of Excellence at the Hollings Marine Laboratory.)

▸ **NOSING AROUND FOR WASTEWATER MANAGEMENT SOLUTIONS.** MacFarlane, S. Coastal Resource Specialists, Orleans, MA 02653.

Removing excess nitrogen from Cape Cod estuaries has emerged as a pressing environmental need. While a distinct biogeographic region, the Cape's 15 separate municipalities almost always share estuaries that cross political borders but wastewater management planning as part of the Massachusetts Estuaries Program has been left to the individual municipalities. Because of volunteer water quality sampling programs in existence for a decade or more, some estuaries, including Pleasant Bay in Chatham, Orleans, Harwich and Brewster gained priority on the state's list for determining total maximum daily loads (TMDLs) allowed for each estuary as part of the Estuaries Program. Once the numbers are known, towns will determine methods needed to achieve the goals. To get the public educated about potential solutions, the Friends of Arey's Pond and the Orleans Pond Coalition, both non-profit citizen organizations, sponsored a bus tour of wastewater management options currently functioning on the Cape. A full busload of town officials, committee members, neighboring town officials, and community activists was invited to attend the six-hour tour. The group visited a range of solutions from an existing tri-town municipal septage treatment plant to a single-business, relatively low flow treatment solution, to a residential complex system, to a high school facility. The tour's primary purpose was to introduce the concept that sewering may not be the only solution to the town's wastewater problem. A range of decentralized options is available as the towns plan for wastewater management.

▸ **ASSESSMENT OF CULTCH MATERIALS FOR OYSTER HABITAT RESTORATION IN GEORGIA.** Manley J. (1), A. Power (1), R.L. Walker (1), D. Hurley (2), M. Gilligan (3), J. Richardson (3), (1) Shellfish Research Laboratory, Marine Extension Service, University of Georgia, 20 Ocean Science Circle, Savannah, GA 31411, (2) Sapelo Island National Estuarine Research Reserve, Sapelo Island, GA 31327, (3) Savannah State University, College of Science and Technology, Department of Natural Science and Mathematics, 3219 College Street, Savannah, GA 31404.

High sedimentation rates and high current velocities complicate oyster habitat restoration in the southeastern United States; however intense oyster recruitment (204,700 spat/meter square) in this region provides a unique opportunity to explore several restoration strategies. A two year study was initiated during 2004 within Sapelo Island National Estuarine Research Reserve to evaluate six techniques. Natural cultch (fresh and washed oyster shell and whelk shell) was separately placed into crab traps and plastic mesh bags. Commercial spat collection sticks were also arranged in 1 meter square plots in densities of 81 and 25. Cultch was placed intertidally prior to the spawning season. One hundred oysters per treatment type were measured after a one year period to determine mean oyster growth rate. Oysters from the 81 meter square stick treatment had the highest mean annual growth rate (77.09 mm/yr). After two years this treatment also had the highest mean number of live oysters (4794), greatest mean shell height (85.62 mm) and total mean biomass (119.45 kg), and lowest mean mortality rate (5.33 %) of all treatment types. Plastic bags with fresh shell had the lowest mean growth rate (40.34 mm/yr) and mean number of live oysters (227), mean shell height (47.35 mm), total mean biomass (13.53 kg), and mean species richness (13.5 individual species), and the highest mean mortality rate (34.33%) of all treatment types. Oyster habitat restoration techniques that provide vertical distance from the sediments enhance oyster growth and survival.

▸ **DEVELOPING A RESTORATION GUIDE FOR NATIVE OYSTERS ALONG THE WEST COAST OF THE UNITED STATES.** Morlock, S. (1), N. Cosentino-Manning (2), (1) NOAA Restoration Center, 1315 East-West Highway, Silver Spring, MD 20910, (2) NOAA Restoration Center, 777 Sonoma Ave, Santa Rosa, CA 95404.

Efforts to restore Olympia oyster populations (*Ostreola conchaphila*, formerly *Ostrea lurida*) in Washington, Oregon and California have been gaining popularity with community groups, tribes, academics, and state coastal managers, as well as the press. Data gathered from these projects, while still largely preliminary, indicate that reseeding and the placement of suitable substrate for larval settlement can aid in restoring self-sustaining populations. These positive results have created an overwhelming response to continue expanding restoration efforts, both in scale and number. However, limited science

exists to direct and document successful restoration. This poster presentation outlines the development of a restoration guide by the NOAA Restoration Center and its partners, which will include a synthesis of elements such as biology, genetics, habitat requirements, ecosystem services, disease, predators, restoration and monitoring techniques. In addition, general comparisons are provided on the state of the knowledge and lessons learned from restoration and monitoring efforts among the three west coast states. The Olympia oyster, the only oyster native to the West Coast of North America, was once a profitable commercial commodity and an important contributor to estuarine health and species diversity. Due to over-harvesting, habitat loss, pollution, predation, and disease, populations have significantly declined. Today remnant, reproductive populations of the native oyster still exist in Alaska, Washington, Oregon and California. The National Oceanic and Atmospheric Administration's Community-based Restoration Program, along with its partners, have committed over $1.8 million to implement pilot oyster restoration projects in these states. The restoration guide will aid in future restoration efforts and, hopefully, increase the success of projects in all the west coast states.

▸ **MAKING THE WATER QUALITY CONNECTION: SUCCESSES AND CHALLENGES OF THE OUTREACH COMPONENT OF THE BARNEGAT BAY SHELLFISH RESTORATION PROGRAM.** Muscio, C. (1), G. Flimlin, (1), R. Bushnell (1), (1) Rutgers Cooperative Extension of Ocean County, 1623 Whitesville Rd., Toms River, NJ 08755.

The Barnegat Bay Shellfish Restoration Program, currently in its second year, has won local support, press, and awards for its efforts to "ReClam the Bay." The public education and outreach component of the program has started slowly and faced many challenges, despite overall success. These challenges will be discussed, as well as ideas and attempts at solutions. A summary of planned outreach programs that stress the connection between shellfish restoration, citizen stewardship, and the overall health of the habitat and resources of Barnegat Bay will be presented. In addition, the "What the bay hinges on" curriculum activity guide and the "Box in my backyard" summer camp classes will be highlighted as major components of the greater public outreach effort.

▸ **DIRECT VS. INDIRECT IMPACTS OF SALINITY ON OYSTER (*CRASSOSTREA VIRGINICA*) HEALTH AND ABUNDANCE.** Parker, M.L. (1), W.S. Arnold (1), (1) Fish and Wildlife Research Institute, 100 Eighth Ave. SE, St. Petersburg, FL 33701.

Florida's coastal waters are characterized by a diversity of estuaries and coastal bays that reflect a range of habitats and anthropogenic influences. For example, Mosquito Lagoon is located within a national park and experiences few anthropogenic inputs whereas the St. Lucie Estuary has been substantially altered by development and water management practices. As a result, salinity patterns within those estuaries differ substantially: Mosquito Lagoon is typified by high and stable salinity whereas salinity in the St. Lucie estuary fluctuates seasonally and in response to flood control practices. One prediction that derives from these disparate salinity patterns is that oysters (*Crassostrea virginica*) should experience higher levels of infestation from the parasite *Perkinsus marinus* in Mosquito Lagoon relative to the St. Lucie Estuary. Our data support the validity of that prediction, and yet oysters are far more abundant and temporally stable in Mosquito Lagoon relative to the St. Lucie Estuary. Thus, in contrast to the situation in areas such as Chesapeake Bay where *P. marinus* and other parasites have decimated the population, the detrimental impact of *P. marinus* in Florida waters appears to be secondary to other influences such as direct salinity impact resulting from flood control and coastal development. These results suggest that the impact of anthropogenic activities may exacerbate or exceed the direct impact of *P. marinus* on local oyster populations. Understanding the relative importance of direct (*P. marinus*) versus indirect (salinity) stressors is essential to the long term success of oyster restoration projects.

▶ **NATIVE OYSTER RESTORATION IN PUGET SOUND - 1999-2006.** Peabody, B. (1), and T. Peter-Contesse (1), B. Allen (1), B. Lyons (2), (1) Puget Sound Restoration Fund, 590 Madison Ave., North, Bainbridge Island, WA 98110, (2) The Nature Conservancy, 1917 First Ave., Seattle, WA 98101.

A collaborative approach to restore native oysters has been underway in Puget Sound since 1999 – involving public and private sectors and tribal communities. Spurred initially by the publication of WDFW's Olympia oyster Stock Rebuilding Plan, the restoration effort is increasingly driven by 1) broader community support – from contributors, university scientists, tideland owners, reporters, federal, state and local governments and other nonprofit groups; 2) a growing understanding that restoring native oysters improves the ecosystem; and 3) a recognition that oyster restoration projects are substantive and newsworthy and therefore fit neatly within the broader context of Governor Gregoire's push to restore Puget Sound by 2020. Since the late '90s, our collective knowledge of remnant populations has increased, restoration methods have evolved, the science of monitoring has become more complex, and priorities have shifted as we learn more about current distribution. For instance, restoration efforts have shifted away from seeding and toward habitat enhancement so that remnant populations can recolonize historic ground and the genetic make-up of potential sub-populations can be preserved. In recent years, new partnerships and additional funding have enabled larger-scale efforts to restore native oyster abundance and the ecological benefits associated with that abundance.

▶ **EGG DEVELOPMENT AND POTENTIAL OUTPUT OF WILD VERSUS CAGED BAY SCALLOPS ON THE WEST COAST OF FLORIDA.** Peters, S.C. (1), W.S. Arnold (1), (1) Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute, 100 8th Ave. S.E., St. Petersburg, FL 33701.

Bay scallops (*Argopecten irradians*) can be found over a large geographic range but the general pattern of gamete development is similar from site to site within that range. In Florida, bay scallop reproduction is conventionally thought to occur as water temperatures decline during fall. Over the course of the one-year bay scallop life cycle in Florida waters, we compared the egg development of hatchery-reared caged scallops versus wild scallops collected from our Anclote River restoration site, to assess variability in egg production as characterized by egg size and abundance. During each monthly sampling episode, we collected 20 caged scallops and up to 20 wild scallops, measured the shell height of each scallop, then dissected and preserved the gonad. Gonad samples were histologically processed and then analyzed for reproductive stage, mean follicle diameter, (N=25), the density of eggs within each follicle, and the mean size of eggs (N=50) within each individual. Preliminary results suggest a disparity between the measured parameters in wild versus caged scallops. This implies that, even though scallops planted into cages in an effort to restore wild populations may proceed through the reproductive cycle in a normal manner, they may spawn eggs of lesser quality when compared to the egg quality of their wild conspecifics.

▶ **EFFECTS OF MORPHOLOGY, AGE AND LOCATION ON HABITAT FUNCTION OF OYSTER REEFS: IMPLICATIONS FOR RESTORATION.** Posey, M.H. (1), T. Alphin (2), H. Harwell (3), J. Sonnier (2), S. Artabane (2), (1) Department of Biology and Marine Biology, UNC Wilmington, Wilmington, NC 28403, (2) University of North Carolina at Wilmington, Wilmington, NC, 28403, (3) Virginia Institute of Marine Science, Rt. 1208, Greate Road, Gloucester Point, VA 23062.

Restoration of degraded or lost oyster reefs has become a priority for many states along the Atlantic and Gulf coasts of the United States. While some efforts are still targeted primarily at restoring lost fisheries, increasing emphasis is being placed on restoration of oyster reefs for their ecosystem functions. Oyster reefs may provide critical habitat for many resident and transient species and dense aggregations of oysters have been suggested to significantly remove particulates from the overlying water column. However, morphological characteristics of reefs systems, including fragmentation, reef complexity, proximity to other habitat types, as well as age of reefs and general location may strongly impact their habitat function. Here we report on studies of intertidal reefs in southeastern North Carolina aimed at understanding the impacts of morphology, age and reef location on reef ecosystem function. Reef complexity, shape, patchiness, proximity to channel habitats, and vertical height are all found to affect aspects of faunal use and/or connection with adjacent habitats, though the exact fauna affected and type of impact varies with the specific factor examined.

▶ **BIOREMEDIATION OF BEACH CREEK, JEKYLL ISLAND, THROUGH SHELLFISH RESTORATION.** Power, A. (1), R. Walker (1), K. Gates (2), P. Flournoy (2), J. Day (3), E. Cheney (4), B. Good (4), (1) University of Georgia, Marine Extension Service, 20 Ocean Science Circle, Savannah, GA 31411, (2) University of Georgia, Marine Extension Service, 715 Bay Street, Brunswick, GA 31520, (3) Jekyll Island State Park Authority, 100 James Road, Jekyll Island, Georgia 31527, (4) Georgia Department of Natural Resources, One Conservation Way, Brunswick, GA 31520.

Our objective is to achieve safe "fishable, swimmable" waters at St. Andrews Beach on Jekyll Island, Georgia, an area that has been experiencing chronic bacterial pollution. Source tracking studies indicate that Beach Creek directly to the north is a major source of contamination and that the pathogens are from wildlife sources, thereby limiting management options. We will enhance biofiltration in Beach Creek through the restoration of oyster reefs (*Crassostrea virginica*) and hard clams (*Mercenaria mercenaria*). Once established the shellfish will remove bacterial pollution from the water column through filtration, and alleviate the violations identified for these waters. The project is funded by a Section 319 (h) Georgia Environmental Protection Division (GaEPD) grant and will be conducted over a three-year period. Restoration efforts will dovetail into the GEORGIA (Generating Enhanced Oyster Reefs in Georgia's Inshore Areas) community-based restoration program. Recycled oyster shell and porcelain water tanks from the City of Savannah's retrofit program will be used as cultch and deployed over a total area of 1610 square meters. Ten thousand hatchery produced clams will also be distributed throughout its length. Pre- and post-water quality testing will be performed to determine the impact on water quality. This project will serve as a demonstration of successful mitigation techniques that can be used to reduce the number of non-compliant stream segments. In addition this project should illustrate how government entities (Georgia Department of Natural Resources, GaEPD, Jekyll Island Authority and the University of Georgia) can solve local problems that benefit the coastal economy.

▶ **RESTORATION OF OYSTER REEFS IN COASTAL ALABAMA: ASSESSING THE RELATIVE IMPORTANCE OF LARVAL RECRUITMENT, ENVIRONMENTAL SETTING AND PREDATION IN DESIGNING AN EFFECTIVE RESTORATION PROGRAM.** Powers, S.P. (1), K. Gregalis (1), K.L. Heck (1), (1) University of South Alabama, Dauphin Island Sea Lab, 101 Bienville Blvd., Dauphin Island, AL 36528.

A key expectation of many habitat restoration programs is that creation of additional habitat will lead to enhancement of local fisheries. Success of oyster reef restoration in coastal Alabama appears to be related in large part to spatial variability in spat recruitment, bottom water dissolved oxygen and predation. For the last three years we've investigated how these three factors vary across Mobile Bay and adjacent Mississippi Sound, the implications of this variability on reef success, and how reef design may be used to combat one or more of these problems. Here, we summarize the findings of this research and present the results of a three-year sampling program begun in 2003 that examines recruitment of oysters, mobile invertebrates and fish onto reefs constructed in Mobile Bay as part of the University of South Alabama's Alabama Oyster Reef Restoration Program. The project is designed to quantify the potential fisheries enhancement of created oyster reefs and to evaluate how the design and materials used in the construction of the reef as well as their location within Mobile Bay affect the relative magnitude of fisheries benefits reefs provide. The central hypothesis of the project is that the magnitude of fisheries benefits resulting from oyster reef restoration varies as a function of the design of the reef and the location of the reefs within a basin. Further, we hypothesize that there is an interaction between reef design and location of reefs within the basin.

▸ **SCECAP MONITORING OF A CRITICAL ESTUARINE SPECIES ALONG SOUTH CAROLINA'S COAST: ASSESSMENT OF OYSTER DISEASES, CELLULAR RESPONSES AND POPULATION STATUS.** Richardson, D.L. (1), L.D. Coen (1), M. Yvonne Bobo (1), N. Hadley (1), A. Hollis (1), C. Keppler (1), (1) Marine Resources Research Institute, S.C. Department of Natural Resources, 217 Fort Johnson Rd., Charleston, SC 29412.

The South Carolina Estuarine and Coastal Assessment Program (SCECAP: www.dnr.sc.gov/marine/scecap) is a monitoring program initiated to evaluate the condition of the state's estuaries. It collects physical, chemical and biological data each year at ~50 random stations statewide. During the summer of 2005, we (SCDNR, NOAA) collaborated to sample native oyster populations at a subset of the above stations for diseases, recruitment, population indicators, cellular responses, microbial densities and tissue contaminants (see related posters by Gooch *et al.* and Robinson *et al.*). Here, we report on two oyster diseases, natural population assessments, and cellular bioassays. Disease status was assessed at 21 SCECAP and six long-term SCDNR sampling sites. *Perkinsus marinus* was present at all 27 sites, with prevalence levels from 20%-100% and infection intensity levels (scale of 0-6) from 0.30 (very light) to 3.80 (moderate). Only two of the 27 sites had detectable *Haplosporidium nelsoni* infections. Three bioassays, which may indicate chronic sublethal stress levels, were completed at the same sites. Lysozomal destabilization values ranged from 28%-40%, with 48% of the sites scoring <35%, the normal range for "healthy" oysters. Lipid peroxidation values ranged from 114 -362 nMol/g, with 52% of the sites scoring within the normal healthy range (<160 nMol/g). Glutathione concentrations ranged from 824 -2,725 nMol/g, with 89% of sites within range of healthy oysters (>900 nMol/g). Recruitment potential at 19 sites ranged from 760 to >23,500/m^2, while the total oyster densities at 10 sites ranged from 750-5,320/m^2. The percentage of large oysters (>60 mm) was low at all sites (2% to 9%), with mean sizes ranging from 9-38 mm. These data will help to assess the status of S.C. intertidal oyster populations and identify potential restoration sites and related success criteria.

▸ **COLIPHAGE AND HUMAN NOROVIRUS PRESENCE AT SCECAP AND OYSTER DISEASE MONITORING SITES.** Robinson, B.J. (1), D.L. Richardson (2), J.R. Stewart (1), L.D. Coen (2), G.H.M. Riekerk (2), R.F. Van Dolah (2), J.A. Gooch (1), (1) Center for Coastal Environmental Health and Biomolecular Research, Charleston, SC 29412, (2) S.C. Department of Natural Resources, Charleston, SC 29412.

A collaborative project between the South Carolina Department of Natural Resources and the National Oceanic and Atmospheric Administration's Center for Coastal Environmental Health and Biomolecular Research in Charleston S.C. was conducted to assess coliphage, a viral indicator of fecal contamination, and human Norovirus, an enteric pathogen, loads in oyster tissue at South Carolina Estuarine and Coastal Assessment Program (SCECAP) stations and oyster long term disease monitoring sites (reference Richardson *et al.* poster for more information on this project). Composite oyster samples were collected from 27 coastal South Carolina sites during July/August 2005 (summer) and January/February 2006 (winter). Somatic (F-) and male-specific (F+) coliphage indicators were enumerated using various culture based methodologies and the presence of human noroviruses (NoV), genogroup I and II, was determined by RT-PCR. Summer: Eight sites contained somatic coliphage. Oysters from three sites contained male-specific coliphage. Three of these contained coliphages which could be genotyped. Group I coliphages (indicative of animal contamination) were present at two sites (near the S.C. Aquarium and Callawassie Creek); Group II coliphages (indicative of human source contamination) were detected at Adams Creek. Norovirus was detected in one sample (Ocella Creek, genogroup II). Winter: Twenty-four sites were positive for somatic coliphage. Twenty-one sites contained male-specific coliphage. Group I coliphages were present at 11 sites. No samples were positive for Norovirus. Seasonal male-specific coliphage enrichments were statistically significantly different. Seasonal somatic coliphages concentrations were not statistically significantly different. Viral data were examined in relation to other environmental variables (e.g. water salinity, contaminants including metals, nutrient concentrations, water bacterial loads, etc.) and oyster population indices (e.g. oyster diseases including Dermo and MSX, oyster physiological responses, oyster contaminant loads, proximity to urban areas, etc.). These factors might also affect shellfish restoration projects.

▶ **INTERACTION OF TOP DOWN AND BOTTOM UP FORCES AND HABITAT COMPLEXITY IN EXPERIMENTAL OYSTER REEF MICROCOSMS: IMPLICATIONS FOR SECONDARY PRODUCTION AND TROPHIC TRANSFER.** Rodney, W. (1), M.L. Kellogg (1), K.T. Paynter (1), (1) MEES Program, 0105 Cole Field House, University of Maryland, College Park, MD 20742.

Two ecological functions attributed to oyster (*Crassostrea virginica*) reefs are 1) the provision of nursery and predation refuge habitat to a unique community of macroinvertebrates and small fishes, and 2) the provision of foraging habitat to fish and decapod predators. The ability of oyster reefs to simultaneously fulfill these seemingly contradictory functions is due to the complex interaction of top down and bottom up forces and the mediating effect of habitat structural complexity on these forces. On restored reefs, high concentrations of suspension feeders probably provide a bottom up boost to deposit feeders in the form of feces and psuedofeces (collectively called "biodeposits") while the high densities of predator/omnivores may at the same time exert top down control on deposit feeder numbers. We performed a microcosm experiment that combined predation, energy source, and structural complexity in a factorial design in order to investigate the interaction of these factors on population regulation of a benthic deposit feeder. Amphipods showed strong population responses to both predators and basal energy source. Structural complexity had a mediating influence on the relative importance of the two factors. In low complexity treatments with predators, amphipod density was low due to highly efficient foraging by predators. Amphipod density was high in all treatments lacking predators but highest in those treatments that received an energy subsidy in the form of oyster biodeposits. Structural complexity allowed amphipods to coexist with their fish predators and oyster biodeposits had a positive effect on amphipod density in treatments with high complexity and predators.

▶ **CHARACTERIZATION OF AN OYSTER POPULATION IN AN URBAN LANDSCAPE: COMPARISONS OF MAN-MADE AND NATURAL HABITATS.** Ross P.G. (1), M.W. Luckenbach (1), A.J. Birch (1), (1) Virginia Institute of Marine Science, Eastern Shore Laboratory, Wachapreague, VA 23480.

Traditional oyster habitat in the lower Chesapeake Bay is mainly composed of subtidal (and intertidal to a lesser extent) biogenic reefs. However, with increasing coastal development, manmade habitats used to armor shorelines (e.g. concrete, wood or metal bulkheads and granite or concrete rubble) are becoming prevalent in some areas. These structures are often colonized by oysters and can be considered "non-traditional" oyster habitat. One such area within an urban landscape is the Lynnhaven River basin, a small and relatively closed tidal sub-tributary of the lower Chesapeake Bay. We characterized and compared the oyster population in this system in terms of overall abundance, density and size distribution for different habitat categories. We have previously reported that over 17.5 million oysters inhabit this study area.

We estimate that ~57% (9.9 million) of these oysters are found on intertidal shell patch reefs, which although disturbed to some extent, can be considered "natural"; with ~6% (1.1 million) living on riprap and bulkhead structures. Differences in density, size structure and the relationship between shell height and dry tissue biomass of oysters are evident across habitats. While we do not suggest that shoreline armoring is ecologically advantageous or a prudent restoration technique, we do believe comparisons of these varying habitats may be helpful for elucidating some components of restoration reef design, especially with respect to alternatives to shell as a reef substrate.

- **RELATIONSHIPS BETWEEN SHELL HEIGHT AND DRY TISSUE BIOMASS FOR THE EASTERN OYSTER (*CRASSOSTREA VIRGINICA*).** Ross, P.G. (1), M.W. Luckenbach (1), (1) Virginia Institute of Marine Science, Eastern Shore Laboratory, Wachapreague, VA 23480.

Studies which attempt to evaluate the success of oyster restoration efforts, model oyster population dynamics or evaluate the ecosystem services provided by oysters often rely upon estimates of oyster biomass, both for an individual oyster of a particular size and for the entire population. However, determining dry tissue biomass (DTB) for large numbers of oysters can be time consuming and expensive. Consequently, it is more common to measure shell height and infer DTB from published relationships from other studies. We have been collecting DTB data on *Crassostrea virginica* as part of several different studies in the Chesapeake Bay over several years. These data cover multiple years, seasons, tributaries (with varying salinities) and habitats. We compare the relationship of oyster shell height and DTB between groups with a series of power function equations. Apparent differences are seen, for example, between seasons and between intertidal versus subtidal habitats. We then compare the results of using published relationships between DTB and shell height for *C. virginica* with an overall equation from all of our studies and with an equation specific to an actual dataset and explore how the predicted results from the various equations fit the data.

- **PECONIC ESTUARY RESTORATION: A SPAT (SOUTHOLD PROJECT IN AQUACULTURE TRAINING)-ASSISTED PROJECT TO RECLAIM A LOST SCALLOP POPULATION.** Schmid, O. (1), A. DeLuca (1), K. Tetrault (1), (1) Cornell Cooperative Extension of Suffolk SPAT (Southold Project in Aquaculture Training) Program, Southold, NY 11971.

This presentation described the role of a mature, volunteer community-based, restoration group, Southold Project for Aquaculture Training (SPAT), within a major shellfish restoration project. This project was initiated in 2004 under a grant by the legislature of Suffolk County on Long Island, N.Y. The funding, almost $1.8M, was designated to support a restoration project with the goal of infusing 50 million scallops into the Peconic Bay Estuary over a period of four years. As a result of a disastrous brown tide bloom that began in 1985 and occurred sporadically over the following decade, the once prolific scallop population in the Peconics has been reduced to a fraction of its original size. Restoration efforts to date have had only limited success. The theory exists, however, that a much larger reseeding effort might well encourage and jump-start an even-larger natural set. This, then, provided the impetus for the ambitious restoration project to which Cornell Cooperative Extension of Suffolk County (CCE) and Long Island University, N.Y, committed their efforts. CCE's responsibility to this project is to provide the seed scallops for grow-out both in containment and for controlled bottom planting in designated sanctuaries in Peconic Bay. This effort includes hatchery and nursery operations and the ongoing maintenance of the juvenile scallops while in containment in open waters. Long Island University is responsible for technical monitoring and encoding, including genetics and morphometrics, water quality and survival data. This project has required far more physical resources than previously existed. Cornell Cooperative Extension, with the SPAT volunteers providing much of the labor by logging in 11,437 hours in 2005, has furnished the infrastructure needed to meet the requirements of the project. Over the past year, SPAT volunteers, working with CCE staff, have built a new nursery with raceway tanks, built a new algae room and installed a continuous SEACAPS algae system, constructed a large fully-equipped 36 foot work barge for field maintenance, and a workshop for various support projects. These efforts have saved CCE hundreds of thousands of dollars by eliminating the need for outside contractors. The volunteers also work with CCE staff in maintaining the shellfish in various forms of containment from the larval stage, through post-set and grow-out, participated in a fall deployment of stock to sanctuaries and in preparing approximately 800,000 scallops for over-wintering in lantern nets for a spring deployment in 2007. The goal of the project is to produce upwards of 10-15 million post-set scallops per year. This presentation described how a dedicated volunteer group can work, cost-effectively, within the scientific community to help reach new levels of a restoration effort.

▸ **USING AIRBORNE MULTI-SPECTRAL IMAGERY TO DELINEATE SOUTH CAROLINA'S INTERTIDAL OYSTER REEFS: ASSESSMENT OF ACCURACY FOR MANAGEMENT AND RESTORATION.** Schulte, K.E. (1), W.D. Anderson (1), L.D. Coen (1), R.F. Van Dolah (1), G.M. Yianopoulos (1), M.A. Finkbeiner (2), W.R. Stevenson (2), (1) S.C. Dept of Natural Resources, 217 Fort Johnson Rd., Charleston, SC 29422, (2) NOAA Coastal Services Center, 2234 S. Hobson Ave., Charleston, SC 29405.

The S.C. Department of Natural Resources (SCDNR) is currently undertaking a statewide (over 300 km of shoreline) assessment of its oyster resources as part of a multi-year, collaborative effort with NOAA's Coastal Services Center (CSC) and the U.S. Geological Survey. Previously, NOAA and SCDNR developed an approach for analyzing multispectral ¼ m digital imagery acquired by GeoVantage Inc.'s GeoScanner system, and now Photo Sciences DMC camera. The finalized imagery is sent to PhotoScience as digital orthophoto quarter quads (DOQQs) for processing using Feature Analyst™ to derive oyster reef location (presence-absence), area extent, and 'condition' with respect to the proportion of vertical shell coverage within the oyster bed boundaries. Two SCDNR teams are randomly surveying portions of 60 DOQQs using shallow draft boats and low altitude imagery captured from helicopters at or near MLW for verification of the processed imagery. The post-processed imagery is validated by identifying the number of beds that are correctly and incorrectly identified. This project, when completed, will enable us to be able to: (1) complete future evaluations of oyster resources using high resolution imagery as an integral part of a longer-term monitoring plan to periodically assess changes in the condition of the state's shellfish beds; (2) provide both SCDNR and other interested users with updated maps of oyster resources within South Carolina's coastal zone, and make the detailed imagery available for other possible uses; and (3) focus our oyster bed restoration efforts relative to current state management plans and status and trends analyses.

▸ **DECAPOD UTILIZATION OF OYSTER AND ADJACENT HABITATS IN A GULF OF MEXICO ESTUARY.** Shervette, V. (1), F. Gelwick (2), (1) Shellfish Research Section, Marine Resources Research Institute, SCDNR, 217 Fort Johnson Road, Charleston, SC 29412, (2) Department of Wildlife and Fisheries Sciences, 2258 Texas A&M University, College Station, TX 77843.

In order to better understand the species-specific use of oyster and adjacent habitats in Grand Bay NERR, MS, we examined the temporal abundance patterns and size distributions of seven common invertebrate species among vegetated marsh edge (vme), oyster, and non-vegetated bottom (nvb). The seven species were blue crab *Callinectes sapidus*, brown shrimp *Farfantopenaeus aztecus*, white shrimp *Litopenaeus setiferus*, daggerblade grass shrimp *Palaemonetes pugio*, mud crab *Eurypanopeus depressus*, mud crab *Panopeus simpsoni*, and mud crab *Rhitropanopeus harrisii*. Three main trends emerged concerning habitat use. 1) We observed that the four crab species (juvenile blue crab, *E. depressus*, *P. simpson*i, and *R. harrisii*) occupied oyster and vme habitats at higher abundances relative to nvb with minor to moderate fluctuations in seasonal abundance. Smaller crabs tended to use oyster habitat (although differences were not significant for all four species) and this may be related to the higher abundance of smaller refuges in oyster. 2) We observed for one species (daggerblade grass shrimp) that abundance in vme was significantly higher than the other habitats. This may be related to grass shrimp reliance on vme stems, and associated flora and fauna, for refuge and food. 3) We observed the relatively equal use of vme and oyster by the estuarine-dependent species brown shrimp and white shrimp. Both species selected for structured habitat over nvb and both species were significantly larger in oyster habitat.

▸ **PRELIMINARY INVESTIGATIONS OF CONSTRUCTED OYSTER REEF HABITAT IN LOWER DELAWARE BAY**. Taylor, J. (1), D. Bushek (1), (1) Rutgers University, Haskin Shellfish Research Laboratory, 6959 Miller Ave., Port Norris, NJ 08349.

In June 2006, a preliminary small-scale oyster restoration project began at Rutgers' Cape Shore Hatchery Facility near Green Creek, N.J. The Cape Shore is an extensive high energy intertidal zone with consistently high oyster recruitment, but high predation, disease and other factors apparently limits the formation of oyster reefs. This region of the Bay is an important spawning habitat for Horseshoe Crabs *Limulus polyphemus* and foraging zone for shore birds which is being threatened by shoreline erosion. The establishment of oyster reefs could protect the shoreline and enhance beach habitats. To evaluate different restoration methods, experimental reefs were constructed in the intertidal zone of the lower Delaware Bay where there is the possibility for high oyster (*Crassostrea virginica*) recruitment rates but oyster populations are restricted by high predation rates and sparse hard substrates. About 200 shellbags were constructed and deployed to form three 1.5m x 3m reefs varying height from one to three layers of shellbags. Cement-coated stakes were also placed around the shell plots to test an alternative method. The constructed reefs are being monitored for stability, oyster recruitment and growth, sedimentation rates and colonization by benthic and motile species. Preliminary data will be presented on the sediment stabilization around the three experimental reefs and the associated reef fauna. Even in the project's initial stages, effects on sedimentation and species composition were detected.

▸ **NATIVE OYSTER RESTORATION IN NETARTS BAY, OREGON**. Vander Schaaf, D., The Nature Conservancy, 821 SE 14th Avenue, Portland, Oregon, 97214.

The Olympia oyster (*Ostrea conchaphila*) once inhabited many of the larger bays and estuaries in the Pacific Northwest and was thought to be a keystone species in these estuarine systems. In Oregon the species was known from Netarts Bay on the north coast as well as two other bays to the south. Netarts Bay lies between Cape Lookout to the south and Cape Meares to the north and is characterized by being a saltwater dominated bay that has only minor freshwater inputs. The bay is known for its excellent water quality and has a number of commercial oyster farms operating within it. This project initiated the restoration of the Olympia oyster to Netarts Bay in 2005 under a grant from the NOAA – TNC Community Restoration Program. Broodstock was collected from Netarts Bay and spawned at the Whiskey Creek Shellfish Hatchery. The larvae were settled onto oyster shell in bags that were then moved into the bay in early summer with assistance from local oystermen. In 2006, after several bureaucratic hurtles, the oysters were removed from the shell bags and placed directly onto the substrate. Efforts are being undertaken to reduce stressors to native oyster recovery by removing nonnative predators from the bay.

▸ **CONNECTICUT SHELLFISH RESTORATION PROJECTS LINKED TO ESTUARINE HEALTH.** Visel, T.C., The Sound School Regional Vocational Aquaculture Center, 60 So. Water Street, New Haven, CT 06519.

A series of CT Sea Grant/Extension shellfish restoration programs for hard clam (*Mercenaria mercenerica*); soft clam (*Mya arenaria*); oyster (*Crassostrea virginica*); and bay scallop (*Arogopectin irradians*) were coordinated with local municipal shellfish commissions in the 1980s. Potential candidates for projects were identified by local environmental fisheries history, shellfish maps, natural beds and local shellfish surveys. Several restoration projects were undertaken with federal, state and local agency assistance. Results were highly site-specific, some yielded almost immediate positive results, and some were complete failures. Estuarine health concerns as communicated by small boat inshore fishermen during initial site investigations correlated with project success. Local environmental fisheries reviews were often anecdotal so whenever possible, fishing statistics and U.S. Fish Commission reports were consulted. Methods to restore shellfish populations included spawner areas, reseeding, re-shelling, re-cultivating, shell base restoration and spat collection. This paper reviews shellfish restoration projects in CT from 1979 to 1989 for the following river systems: East; Neck; Hammonassett; Oyster; Pattagansett; Poquonock; and Niantic. These projects are reviewed in terms of "estuarine quality" which included water quality, siltation, sedimentation, tidal obstruction or barriers and upland watershed alterations. Predictions/suggestions by the local residents and resource user groups were often confirmed; therefore their importance and contribution should not be overlooked. Environmental fishery history reviews can be an important tool in understanding the declines in shellfish production from near shore areas. As much information as possible should be obtained before attempting shellfish restoration programs, in this way, scarce shellfish restoration resources can be maximized.

▸ **ASSESSING RESIDENT FAUNAL ASSEMBLAGE SIMILARITY BETWEEN RESTORED AND NATURAL OYSTER REEFS.** Walters, K. (1), L. Coen (2), (1) Dept. of Marine Science, Coastal Carolina University, Conway, SC 29528, (2) Marine Resources Research Institute, SCDNR, 217 Ft. Johnson Road, Charleston, SC 29412.

Assessing differences in resident faunal composition between created and natural oyster reefs is one possible metric for evaluating the ecological success of reef restoration efforts. Yearly changes in resident faunal composition at one South Carolina site were analyzed using multivariate analysis of variance (MANOVA), null model analysis of co-occurrence (ECOSIM), nonparametric analysis of similarity (ANOSIM), and permutation tests for multivariate analysis of similarity (PERMANOVA). The different analytic approaches varied in suitability and effectiveness at discriminating among changes in compositional similarity and indicated convergence in only one instance. MANOVA results were compromised by the inability to transform the data sufficiently to test for multivariate homogeneity violations. Interpretation of ECOSIM results were affected by a lack of design alternatives and the possible inflation of Type I error that weighting by abundance may cause. ANOSIM results also suffered from design constraints and an inability to generate enough permutations to test for significant differences in data sets with relatively small sample sizes. PERMANOVA results generally indicated constructed reef faunal assemblages were not yet similar to natural reefs even after seven years. The negligible limitations of PERMANOVA, flexible design options, and ability to generate significance tests for small sample sizes make the approach powerful. Development of statistical approaches to test for taxonomic differences makes analysis of compositional convergence between natural

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and restored reefs less dependent on the choice of analytic technique. More critical, biological questions including whether convergence of taxa abundance and composition is a valid indicator of similar ecological function remain to be answered.

COST-EFFECTIVE OYSTER REEF RESTORATION PRACTICES: SPRAY, BAG OR STAKE. Walters, K. (1), L. Coen (2), (1) Dept. of Marine Science, Coastal Carolina University, Conway, SC 29528, (2) Marine Resources Research Institute, SCDNR, 217 Ft. Johnson Road, Charleston, SC 29412.

The increasing construction or restoration of oyster reefs is partly in recognition of the loss of suitable substrate for oyster settlement. Some common reef construction techniques include broadcast application of recycled shell, placement of shell-filled bags, or the planting of stakes frequently covered with cement. All construction approaches involve varying costs (e.g., labor, materials) and often anecdotal assessments of success. To evaluate both the costs and benefits of each construction technique we conducted studies within Murrells and Hog Inlet, S.C. The initial study established bag and stake reefs at sites within both inlets. Oyster counts and size was assessed after 2.5 years and compared to adjacent natural reefs. In the second study bag, stake and loose shell reefs were established at 3 sites at the same tidal elevation within Hog Inlet. Labor and material costs associated with the studies were documented. Analyses to date indicate greater live oyster production on bag reefs; however constructing bag reefs involved greater labor costs. Reef success was assessed either in terms of total sediment surface area or taking into account differences in the vertical profile of each reef type. Results should provide the data necessary for managers to predict both construction costs and reef success in order to select the appropriate technique for constructing future oyster reefs.

DIGITAL IMAGE ANALYSIS OF MUD BLISTERS CAUSED BY POLYDORA SP. USED TO ASSESS INFESTATION TRENDS IN *CRASSOSTREA VIRGINICA* AND *CRASSOSTREA ARIAKENSIS* IN THE CHESAPEAKE BAY. Ward, N. (1), M. Sherman (2), M. Chen (2), K. Paynter (1), (1) University of Maryland, Biology Bldg.144 Rm. 1210, College Park, MD 20742, (2) University of Maryland, Biology Bldg. 144 Rm. 0271, College Park, MD 20742.

The prevalence of mud blisters caused by a species of Polydora was compared between triploid *Crassostrea virginica* and *Crassostrea ariakensis* at sites in four rivers of differing salinity in the Chesapeake Bay (Severn, Choptank, Patuxent, and York Rivers). Oysters of both species were sampled at each site seven times between October 2004 and October 2006. ImageJ, a software program developed at NIH, was used to measure both the total area of the inner surface of each valve and the area covered by mud blisters. Initial identification of mud blisters using threshold values in ImageJ was followed by manual editing to produce accurate and consistent results that could be statistically analyzed. The area of shell covered by mud blisters was compared between species, site and month collected. The shell area covered by mud blisters in *C. ariakensis* was significantly greater than those in *C. virginica* at every time point sampled, however, both species show a similar trend in the rise and fall of infestation levels through time and at different salinities. Polydora sp. have been indicated as a cause of lower market value in some oyster markets and may be associated with lower condition index. Our findings suggest *C. ariakensis* may be more susceptible to problems associated with Polydora infestation.

REINVENTING COMMERCIAL SINGLE EASTERN OYSTER, *CRASSOSTREA VIRGINICA*, CULTURE IN SOUTH CAROLINA. Whetstone, J.M. (1), W.D. Anderson (2), W.A. Cox (3), (1) S.C. Sea Grant Extension Program, Clemson University, Baruch Institute, Georgetown, SC 29442, (2) S.C. Department of Natural Resources, Charleston, SC 29422, (3) Island Fresh Seafood, Inc., 7575 Ethel Post Office Road, Meggett, SC 29449.

Saltwater pond oyster culture can be traced back to the Romans in the first century B.C., and even earlier to Chinese aquaculture. In South Carolina, growing large, single eastern oysters in saltwater ponds and abandoned impoundments has been practiced since the 1800s. S.C.'s renowned "mill pond oyster" floated as spat attached to logs into saw-mill ponds, grew near the surface, dislodged, and if it survived in the mud bottom environment, matured into an epicurean delight. Oyster culturists observed pond oysters' adductor muscles to be at least one-third larger than its estuarine sibling, ostensibly to avoid smothering by siltation on the mud bottom. Saltwater ponds generate a favorable environment for controlled autotrophic production and can sustain a higher instantaneous biomass throughout the year compared to adjacent, productive estuarine waters. Through intake filtration, circulation adjustments, fertilization, salinity and water level control, ponds can be intensely managed to inhibit parasites, predators and disease while accelerating growth. Optimum conditions for pond and estuarine aquaculture of eastern oysters have evolved recently in S.C. due to a successful clam mariculture infrastructure seeking diversification, strong market demand for single local oysters, hatchery technology advances and the capacity to cultivate large (>57mm) juvenile oysters in a controlled environment. Island Fresh Seafood has successfully spawned *Crassostrea virginica* seed that has grown 63 mm in six months, considerably faster than wildstock oysters. S.C.'s Cooperative Fisheries Research Initiative funding has spawned the experimentation with various single oyster growout techniques in estuaries by commercial shellfishermen utilizing hatchery-reared oyster seed.

▸ **RISK ANALYSIS ON THE INTRODUCTION OF EXOTIC SPECIES WITH MUSSEL TRANSFER.** Wijsman, J.W.M. (1), A.C. Smaal (1) (1) Institute for Marine Resources and Ecosystem Studies (IMARES), P.O. Box 77 4400 AB, Yerseke, NETHERLANDS.

Due to the variable and unpredictable production of mussels in the Dutch waters, the mussel sector is more and more depending on import of juvenile and consumption mussels from other European countries. With the import of mussels and re-laying in the Oosterschelde, there is a risk of importing exotic plants, animals and micro-organisms that might become invasive and could have a negative impact on the ecosystem. This study presents the results of a semi-quantitative risk assessment using the import of mussels from the Irish and Celtic Sea into the Oosterschelde as a case study. In the Irish and British marine waters, 74 exotic non-indigenous species have been recorded. 22 of these species are unknown for the Oosterschelde and could therefore potentially be introduced with the mussel import. In the risk assessment, the chance of successful introduction and the impact of an introduced exotic species to the ecosystem are quantified based on literature review and expert judgment. The study showed that the chance of introducing exotic species by means of mussel transports is realistic for a number of species. The effect of most of these species to the ecosystem of the Oosterschelde, however, is considered to be limited. The risk analysis shows that a risk management plan including registration, monitoring and frequent evaluation of transfers may provide an effective tool in controlling the risks.

▸ **THE CHESAPEAKE BAY FOUNDATION'S OYSTER RESTORATION CENTER: BRINGING TOGETHER OYSTER SETTING, REEF BUILDING, RESEARCH, AND OYSTER GARDENING AS A MECHANISM FOR PUBLIC ENGAGEMENT.** Willey, K. (1), W.J. Goldsborough (1), S. Reynolds (1), J. Pitz (1), (1) Chesapeake Bay Foundation, 6 Herndon Ave., Annapolis, MD 21403.

As part of the ongoing Baywide effort to restore the native oyster population, the Chesapeake Bay Foundation has established the Oyster Restoration Center (ORC) in Maryland. The mission of ORC is to: Produce oysters for local reef restoration projects; Engage citizens, students and decision makers in hands-on oyster restoration activities; Develop partnerships with community groups, institutions, agencies and organizations; Leverage greater public and private investment in the Baywide oyster restoration effort; Serve as a platform for education and scientific research; Create public awareness of the critical need to restore oysters. The Center serves as a home base for all of our Maryland oyster projects, including oyster gardening, oyster setting, reef building, volunteers events, group tours, meetings, public events, and home port for CBF's 60-foot oyster restoration vessel, the R/V Patricia Campbell. This poster will outline the activities and achievements at ORC, and examine the synergy created by having these activities pulled together in one location.

If you would like information about upcoming ICSR events, please contact the S.C. Sea Grant Consortium, 287 Meeting Street, Charleston, S.C. 29401 U.S.A. 843.953.2078, or visit the ICSR site

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