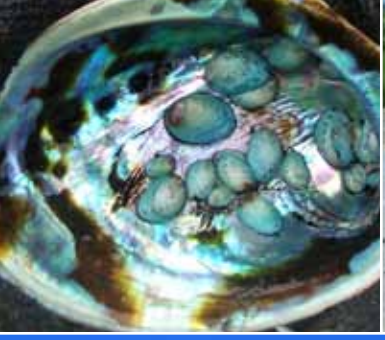


The 18th International Conference on Shellfish Restoration | November 16-19, 2016 Charleston, SC, USA

ICSR2016

Celebrating and Inspiring Healthy Coastal Communities









Table of Contents


Joe Klementovich Photography

ICSR2016 Celebrating and Inspiring Healthy Coastal Communities

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Front cover background: Ma. Junemie Lebata-Ramos, Southeast Asian Fisheries Development Center

Front cover top row, left to right: Tom McCowan, Paua Industry Council Ltd.; Niels Lindquist, University of North Carolina—Chapel Hill; Julie Hills, Ministry for Primary Industries; Claire Everett, Galveston Bay Foundation.

Center, right-hand side: Tristan Hugh-Jones, Atlantic Shellfish Ltd.

Front cover bottom row, left to right: Claire Everett, Galveston Bay Foundation; Niels Lindquist, University of North Carolina—Chapel Hill; Claire Everett, Galveston Bay Foundation.

Conference Overview

The International Conference on Shellfish Restoration (ICSR) provides a forum that draws attention to shellfish restoration, and fosters partnerships, initiatives, and the exchange of information necessary to further the science and practice of shellfish restoration. ICSR'16 highlights the use of shellfish restoration to address challenges and opportunities related to coastal development; resource policy, regulation, and management; shellfish diseases; community engagement in shellfish restoration; shoreline stabilization; and climate change.

The goal of ICSR is to foster partnerships to further the exchange and application of science-based information in support of public and private shellfish restoration and aquaculture.

Twenty years have passed since the first ICSR was held on Hilton Head Island in South Carolina. Since then, a great deal of work has been directed at the restoration and enhancement of shellfish populations worldwide, leading to new challenges and innovative techniques. A growing number of community groups and private enterprises are dedicated to shellfish restoration and these pioneers are benefitting from healthier communities as a result of more abundant shellfish populations. Therefore, the highlighted theme for ICSR'16 is "Celebrating and Inspiring Healthy Coastal Communities." This year, the program features working sessions, case studies, and oral and poster presentations from nearly 20 states and nine countries. We are pleased to have participation from community groups and private enterprises, as well as scientists, educators, and resource managers.

Helen Dickson, The Watershed Project

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Exhibitors, Co-Chairs, and Steering Committee

ICSR'16 **EXHIBITORS**

ICSR'16 is excited to host exhibitors related to shellfish restoration and aquaculture. Make sure you stop by the Sterling Hall Foyer to visit exhibitors during coffee and conversation, lunches, breaks, and the poster session.

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ICSR'16 **STEERING COMMITTEE**

CONFERENCE CO-CHAIRS

Dorothy L. Leonard, Ocean Equities LLC – Maryland, USA
M. Richard DeVoe, S.C. Sea Grant Consortium – South Carolina, USA
Julie Davis, S.C. Sea Grant Consortium – South Carolina, USA

STEERING COMMITTEE

Melanie Bishop, Ph.D., Macquarie University – Sydney, Australia
Tom Bliss, University of Georgia Marine Extension/Georgia Sea Grant – Georgia, USA
Ryan Bradley, S.C. Sea Grant Consortium – South Carolina, USA
Janet Brown, Ph.D., The Shellfish Team/Editor, The Grower – Scotland, UK
Dave Bushek, Ph.D., Rutgers University – New Jersey, USA
Loren Coen, Ph.D., Florida Atlantic University – Florida, USA
Leroy Creswell, University of Florida/Florida Sea Grant – Florida, USA
Jeff Davidson, Ph.D., University of Prince Edward Island – Prince Edward Island, Canada
Annette Dunmeyer, S.C. Sea Grant Consortium – South Carolina, USA
Susan Ferris Hill, S.C. Sea Grant Consortium – South Carolina, USA
Boze Hancock, Ph.D., The Nature Conservancy – Rhode Island, USA
Teri King, Washington Sea Grant – Washington, USA
Peter Kingsley-Smith, Ph.D., S.C. Department of Natural Resources – South Carolina, USA
John Kraeuter, Ph.D., University of New England – Maine, USA
Sandy Macfarlane, Coastal Resource Specialists – Massachusetts, USA
Peter Malinowski, New York Harbor Foundation and Billion Oyster Project – New York, USA
Laura Newcomb, Ph.D., Sea Grant Knauss Fellow – Washington, DC, USA
Niki Pace, J.D., LL.M., Louisiana Sea Grant Law and Policy Program – Louisiana, USA
Andrea Sassard, S.C. Sea Grant Consortium – South Carolina, USA
John Scarpa, Ph.D., Texas A&M University – Texas, USA
Geoff Scott, Ph.D., University of South Carolina – South Carolina, USA
Susannah Sheldon, S.C. Sea Grant Consortium - South Carolina, USA

Important
Conference Information

REGISTRATION INFORMATION
To participate in any aspect of the conference, you must be registered. Badges are required for all technical and social events. The Registration Desk is located in the Sterling Hall Foyer at the Hyatt Place Charleston Historic District.

MESSAGE CENTER
A message board and general information center will be maintained at the ICSR'16 Registration Desk. Anyone who needs to leave a message for you may call the Hyatt Place at 843-414-4900 and ask that a message be given to the ICSR'16 Registration Desk.

NEWS MEDIA
Coordination between ICSR'16 and the news media will be facilitated by Susan Ferris Hill, S.C. Sea Grant Consortium Director of Communications. Please notify Susan if you will be presenting information that is noteworthy for the science or general media. She can be reached through the ICSR'16 Registration Desk.

TECHNICAL PROGRAM
ICSR'16 will feature keynote presentations, panel discussions, and contributed oral and poster presentations on topics related to the six conference themes:

Policies, Regulations, and Permitting: Addressing Barriers to Restoration Success
Documenting Goods and Services Provided by Shellfish Populations and Their Habitats
Creating Long-Term Positive Outcomes for Coastal Communities and Their Citizens through Shellfish Restoration
Ecological, Social, and Economic Impacts of Restored Shellfish Populations
Understanding the Effects of a Changing Climate on Shellfish Restoration
Small-Scale and Large-Scale Restoration: Lessons Learned and Practical Advice

NETWORKING EVENTS
ICSR'16 will provide multiple opportunities for networking with colleagues in the shellfish restoration field. Networking is encouraged during conference breaks, lunches, and at evening events. Evening events include:

Welcome Reception
Wednesday, November 16 from 7:00 p.m. to 9:00 p.m.
Grand Magnolia A/B

Poster Reception
Thursday, November 17 from 6:00 p.m. to 8:00 p.m.
Grand Magnolia C

Bowens Island Networking Event
Friday, November 18 from 7:00 p.m. to 9:30 p.m.
Bowens Island is a Charleston tradition, and this year the event will feature Lowcountry seafood and a live band. The venue is partially outdoors—please dress appropriately.
Meet in the Sterling Hall Foyer for transportation to the venue starting at 6:30 p.m.

Important Conference Information

KEYNOTE PRESENTATIONS
Speakers are:

Tristan Hugh-Jones, *Owner,* Atlantic Shellfish Ltd., County Cork, Ireland

Tom Ysebaert, Ph.D., *Senior Researcher*, Wageningen University and Research, and *Senior Researcher*, Royal Netherlands Institute for Sea Research, The Netherlands

Kim Jones, *Watershed Management Division Manager*, Town of Bluffton, South Carolina, USA

PANEL SESSIONS
The program for each day of the conference will include an interactive panel session that addresses 'hot topics' in today's world of shellfish restoration. The session topics are:

An Historical Perspective of Long-Term and Recent Volunteer Restoration Programs
Chesapeake Bay Oyster Restoration—Progress, Policy, Partners, and Applied Science
Community Engagement in Shellfish Restoration

ORAL AND POSTER PRESENTATIONS
Oral and poster presentations are offered in eight contributed plenary sessions.
All oral presentations will held be in Grand Magnolia A/B.

Posters will be displayed in *Grand Magnolia C*, which will be open for viewing throughout the conference. Poster presenters will give 2-minute Rapid Fire Talks in *Grand Magnolia A/B*, highlighting key take-home points on Thursday, November 17 from 5:15 p.m. to 5:45 p.m. Poster presenters will then be at their posters from 6:00 p.m. to 8:00 p.m.

Keith Walters, Coastal Carolina University

Information for Presenters

ORAL PRESENTATIONS
All presentations will be in *Grand Magnolia A/B.* Twenty minutes will be allotted for a contributed oral talk, including 15 minutes for presentations and five minutes for discussions. Session moderators will adhere strictly to these time limitations. Speakers should check-in with moderators at least 15 minutes prior to session start. Each room will be equipped with a projector, screen, laptop computer, microphone, and laser pointer. Presentation files provided via email will be pre-loaded onto the computer.

POSTER PRESENTATIONS
Posters will be displayed in *Grand Magnolia C* and available for viewing throughout the conference. Each poster presenter will have access to a foam core tackboard measuring 4' high by 4' wide and pushpins will be provided. Board assignment information is in the registration materials as a separate handout. Posters should be set-up, attended, and removed according to the following schedule:

Poster Set-Up
Thursday, November 17, 7:30 a.m. to 12:00 p.m.

Rapid Fire Poster Talks
Thursday, November 17, 5:15 p.m. to 5:45 p.m.
Each poster presenter will give a 2-minute Rapid Fire Talk. The talks will be in *Grand Magnolia A/B* after the conclusion of the formal program. Presenters are asked to check-in with facilitators at least 10 minutes in advance of the talks.

Poster Session
Thursday, November 17, 6:00 p.m. to 8:00 p.m.
Poster presenters are to be present at their poster during this time.

Poster Removal
Saturday, November 19, before 3:00 p.m.

Eric Milbrandt, Sanibel-Captiva Conservation Foundation

Gef Flimlin, Rutgers Cooperative Extension

Schedule of Presentations and Activities

WEDNESDAY, NOVEMBER 16, 2016

4:00 p.m. to 7:30 p.m.
ICSR'16 Registration
Sterling Hall Foyer

7:00 p.m. to 9:00 p.m.
Welcome Reception
Grand Magnolia A/B

THURSDAY, NOVEMBER 17, 2016

** Indicates Presenting Author*

8:00 a.m. to 3:30 p.m.
ICSR'16 Registration
Sterling Hall Foyer

8:00 a.m. to 9:00 a.m.
Coffee and Conversation
Grand Magnolia C


Tristan Hugh-Jones, Atlantic Shellfish Ltd.

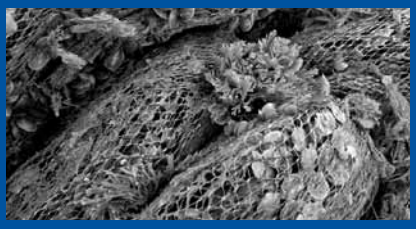
9:00 a.m. to 9:30 a.m.
Welcoming Remarks
Grand Magnolia A/B
"Welcome to Charleston, South Carolina"
Robert Barber, Owner, Bowens Island Restaurant, Charleston, S.C.

"ICSR'16 Welcome"
Dorothy Leonard, Ocean Equities LLC, and M. Richard DeVoe, S.C. Sea Grant Consortium

9:30 a.m. to 10:00 a.m.
Keynote Address:
"Selective breeding of the European flat oyster* Ostrea edulis*, using ponds in Rossmore, Ireland, to increase tolerance to the* Bonamia *parasite."
Tristan Hugh-Jones, Atlantic Shellfish Ltd.
Grand Magnolia A/B

10:00 a.m. to 10:30 a.m.
Break
Grand Magnolia C

Ben Cleveland, University of Melbourne



Julie Hills, Ministry for Primary Industries

Ma. Junemie Lebata-Ramos, Southeast Asian Fisheries Development Center

10:30 a.m. to 12:00 p.m.
Session A – Interactive Panel: An Historical Perspective of Long-Term and Recent Volunteer Restoration Programs: Successes and Challenges
Chair: Sandy Macfarlane, Coastal Resource Specialists
Grand Magnolia A/B

12:00 p.m. to 1:30 p.m.
Lunch (provided)
Grand Magnolia C

1:30 p.m. to 3:10 p.m.
Session B – Contributed Talks: Lessons Learned and Practical Advice I
Moderator: John Kraeuter
Grand Magnolia A/B

1:30

Developing methods for oyster reef restoration in Port Phillip Bay, Victoria, Australia.
Ben Cleveland*, John Ford, Paul Hamer, Steve Swearer

1:50

Current status of European Oyster restoration in Germany.
Bernadette Pogoda*

2:10

Oyster restoration in Maryland: Lessons learned and progress made, the Harris Creek story.
Donald W. Merritt*, Kennedy Paynter, Donald W. Webster, Ward Slacum

2:30

Using Reef Balls for shellfish restoration.
Jim MacFarlane*, Larry Beggs

2:50

The state of oyster restoration in New York/New Jersey Harbor: A review and synthesis.
Michael McCann*, Lauren Alleman, Peter Malinowski, Katie Mosher-Smith

3:10 p.m. to 3:40 p.m.
Break
Grand Magnolia A/B

3:40 p.m. to 5:00 p.m.

Session C – Contributed Talks: Lessons Learned and Practical Advice II
Moderator: Julie Davis
Grand Magnolia A/B

3:40

Effective monitoring to evaluate ecological restoration in the Gulf of Mexico: An overview of the 2016 National Academies report.
Loren D. Coen*, Frank W. Davis, David M. Burdick, Heather Coleman, Peter H. Doering, Frances Gulland, Kenneth L. Heck, Jr., Matthew K. Howard, Stephanie Johnson, Michael S. Kearney, Payton T. Kulina, Claudia Mengelt, Paul A. Montagna, Pamela T. Plotkin, Kenneth A. Rose, Eric P. Smith, Heather M. Tallis, Ron M. Thom, Mark S. Woodrey

4:00

Development of a novel ephemeral substrate for the creation of diverse oyster-based products for aquaculture, habitat restoration, and living shorelines.
Niels Lindquist*, David Cessna

4:20

Pilot deployment of a novel substrate to create oyster habitat in Port Royal Sound and the ACE Basin NERR, South Carolina, USA.
Benjamin W. Stone*, Al Segars, Gary Sundin, Nick Wallover, Peter Kingsley-Smith

4:40

Shellfish restoration: science, education, and art as strange bedfellows.
Gef Flimlin*

5:15 p.m. to 5:45 p.m.

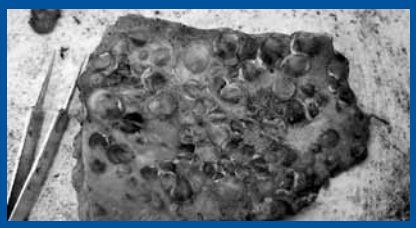
Rapid Fire Poster Talks
Moderators: Janet Brown and Andrea Sassard
Grand Magnolia A/B

6:00 p.m. to 8:00 p.m.

Poster Session and Reception
Grand Magnolia C

8:00 p.m.
Evening on Your Own


Gef Flimlin, Rutgers Cooperative Extension



Eric Milbrandt, Sanibel-Captiva Conservation Foundation

Gef Flimlin, Rutgers Cooperative Extension

Julie Davis, S.C. Sea Grant Consortium

FRIDAY, NOVEMBER 18, 2016

Tom McCowan, Paua Industry Council Ltd.

** Indicates Presenting Author*

7:30 a.m. to 3:30 p.m.
ICSR'16 Registration
Sterling Hall Foyer

7:30 a.m. to 8:30 a.m.
Coffee and Conversation
Grand Magnolia C

8:30 a.m. to 9:00 a.m.
Keynote Address:
"Ecosystem services and biodiversity of shellfish beds: Lessons learned from mussel and oyster restoration in The Netherlands."
Tom Ysebaert, Ph.D., IMARES Wageningen University and Research
Grand Magnolia A/B

9:00 a.m. to 10:00 a.m.
Session D – Interactive Panel: Chesapeake Bay Oyster Restoration—Progress, Policy, Partners, and Applied Science
Chair: Peyton Robertson, NOAA Chesapeake Bay Office
Grand Magnolia A/B

10:00 a.m. to 10:30 a.m.
Break
Grand Magnolia C

10:30 a.m. to 12:10 p.m.
Grand Magnolia A/B
Session E – Contributed Talks: Goods and Services Provided by Shellfish Populations and Their Habitats I
Moderator: Peter Kingsley-Smith

10:30

New Zealand's blackfoot abalone* (Haliotis iris) *fishery: Restoration successes and future prospects.
Tom A. McCowan*

10:50

Effects of scallop* (Pecten novaezelandiae) *spat enhancement on scallop catches in New Zealand.
Julie Hills*, Ian Tuck, James Williams

11:10

Feasibility of shellfish bed restoration (flat oyster* Ostrea edulis L. *and mussel* Mytilus edulis*) in the Dutch part of the North Sea.
Pauline Kamermans*, Tom van der Have, Wouter Lengkeek, Hein Sas, Aad Smaal, Karel van den Wijngaard

11:30

Oyster reef connectivity in lower Chesapeake Bay examined using molecular markers.
Jan R. McDowell*, Brendan D. Turley, Kimberly S. Reece

11:50

Reversing a rapid decline in oyster reefs: Effects of durable substrate on oyster populations, elevations, and aquatic bird community composition in the Big Bend of Florida.
Peter Frederick*, Nicholas Vitale, Bill Pine, Jennifer Seavey, Leslie Sturmer

12:10 p.m. to 1:30 p.m.
Lunch (provided)
Grand Magnolia C

1:30 p.m. to 3:10 p.m.
Session F – Contributed Talks: Goods and Services Provided by Shellfish Populations and Their Habitats II
Moderator: Boze Hancock
Grand Magnolia A/B

1:30

Restoring abalone population through family-based grow-out culture in intertidal reef flats.
Ma. Junemie H. Lebata-Ramos*, Jonas P. Mediavilla, Frances Patrick L. Alicante, Rema C. Sibonga, Ellen Flor D. Solis, Cleresa S. Dionela

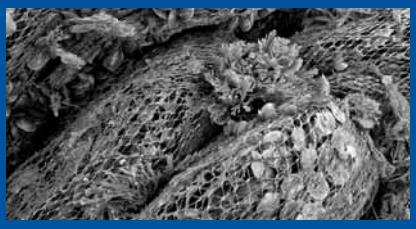
1:50

Ownership of fishing areas by artisanal fishermen targeting marine molluscs along the Petite Côte of Senegal.
Hamet Diaw Diadhiou*, Ismaila Ndour

2:10

Using a suite of innovative science and monitoring practices to quantify the ecological, social, and economic impact a restored oyster reef can have on people and nature: Half Moon Reef, Texas.
Bryan M. DeAngelis*, Mark Dumesnil, Bill Balboa, Stuart Carlton, Jennifer Pollack, Andrew Ropicki, Christine Shepard, R.J. David Wells


Ben Cleveland, University of Melbourne


Julie Hills, Ministry for Primary Industries


Ma. Junemie Lebata-Ramos, Southeast Asian Fisheries Development Center

2:30

Oyster larval settlement in response to experimental seeding of oyster reefs with* Alpheus spp. *snapping shrimp.
Sean Hardison*, Ami Wilbur

2:50

Structural complexity effects on the initial similarity in resident prey survival among natural and created intertidal oyster reefs.
Keith Walters*, Charles W. Martin

3:10 p.m. to 3:40 p.m.
Break
Grand Magnolia C

3:40 pm. to 5:20 p.m.
Session G – Contributed Talks: Climate Change and Shellfish Restoration
Moderator: Geoff Scott
Grand Magnolia A/B

3:40

Estimating the distribution of harvested estuarine bivalves with habitat suitability models and understanding the implications under a changing climate.
Nathaniel S. Lewis*, Theodore H. DeWitt, Eric W. Fox

4:00

Oyster reef (*Crassostrea virginica*) restoration and responses to 2015-2016 El Niño in Southwest Florida.
Eric C. Milbrandt*, Mark Thompson, A.J. Martignette

4:20

Oyster-reef growth tracks annual fluctuations in water level.
Justin T. Ridge*, Antonio B. Rodriguez, F. Joel Fodrie

4:40

Wave exposure structures oyster distribution on natural intertidal reefs but not on hardened shorelines.
Seth J. Theuerkauf*, David B. Eggleston, Brandon J. Puckett, Kathrynlynn W. Theuerkauf

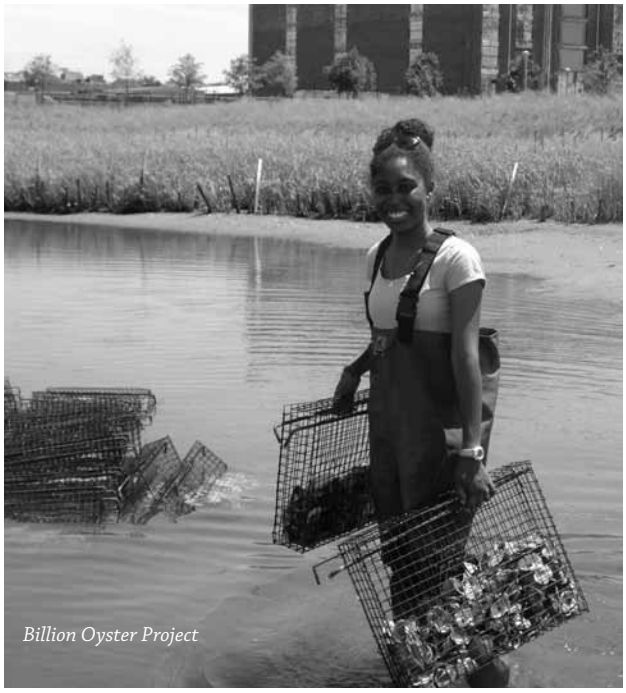
5:00

Constructing oyster castle reefs for increased resilience at Chincoteague National Wildlife Refuge.
Bowdoin W. Lusk*

Schedule of Presentations and Activities

6:30 p.m
Meet for Bus Transportation to Bowens Island
Sterling Hall Foyer

7:00 p.m. to 9:30 p.m.
Networking Event at Bowens Island


Billion Oyster Project

SATURDAY, NOVEMBER 19, 2016

** Indicates Presenting Author*

7:30 a.m. to 12:00 p.m.
ICSR'16 Registration
Sterling Hall Foyer

7:30 a.m. to 8:30 a.m.
Coffee and Conversation
Grand Magnolia C

8:30 a.m. to 9:00 a.m.
Keynote Address:
"Management decision implications resulting from an analysis and assessment of the May River Watershed Action Plan implementation."
Kim Jones, Town of Bluffton, SC
Grand Magnolia A/B

9:00 a.m. to 10:00 a.m.
Session H – Contributed Talks: Positive Outcomes for Coastal Communities
Moderator: Peter Malinowski
Grand Magnolia A/B

9:00

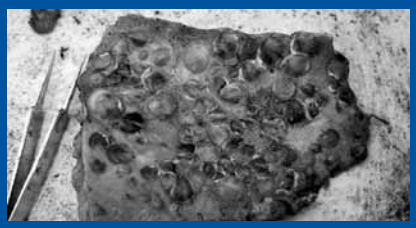
Galveston Bay Foundation's oyster shell recycling program: Methods, management, and moving forward.
Haille N. Carter*

9:20

From Seeds to Shoreline℠: Sharing restoration stories.
Elizabeth V. Bell*, Andrea M. Sassard

9:40

Community reefs in Brooklyn: How reef installations along the Brooklyn shoreline activate communities and build resiliency.
Peter Malinowski*



Eric Milbrandt, Sanibel-Captiva Conservation Foundation

Gef Flimlin, Rutgers Cooperative Extension

Julie Davis, S.C. Sea Grant Consortium

10:00 a.m. to 10:30 a.m.
Break
Grand Magnolia C

10:30 a.m. to 12:00 p.m.
Session I – Contributed Panel: Community Engagement in Shellfish Restoration
Chair: Julie Davis
Grand Magnolia A/B

12:00 p.m. to 1:30 p.m.
Lunch (provided)
Grand Magnolia C

1:30 p.m. to 3:10 p.m.
Session J – Contributed Talks: Perspectives on Shellfish Restoration Planning, Policy, and Regulations
Moderator: John Scarpa
Grand Magnolia A/B

1:30

The Italian problem about 0.3 nm fishery exclusion: Does it make sense? (Maybe or maybe not).
Donatella Del Piero*

1:50

Local government land-use planning and zoning authority: Addressing land-use conflicts and shellfish operations.
Alexandra R. Chase*

2:10

Evaluating living shorelines to inform regulatory decision-making in South Carolina, USA.
Peter R. Kingsley-Smith*, Benjamin W. Stone, Michael Hodges, Andrew Tweel, Sharleen Johnson, Erik Smith, Blaik Keppler, Nancy Hadley, Matt Slagel, Denise Sanger

2:30

What does the future hold for the oyster fishery and oyster restoration in Texas?
Lance Robinson, Joe Fox, John Scarpa*

2:50

From trash can culture to a modern shellfish hatchery: A story of community support on Nantucket Island, Massachusetts.
Leah Cabral*

Schedule of Presentations and Activities

3:15 p.m. to 4:00 p.m.
Closing Plenary Session: "Future Directions"
Dorothy Leonard, Ocean Equities LLC, and M. Richard DeVoe, S.C. Sea Grant Consortium
Grand Magnolia A/B

4:00 p.m.
Conference Adjourns

Seth Theuerkauf, North Carolina State University

Poster Session

** Indicates Presenting Author*

Use of GIS based tools to improve placement of restoration and aquaculture activities and to reduce user conflicts.
Troy Alphin*, Martin Posey, Keith Walls

Engaged communities: Using multiple strategies to keep stakeholders informed and involved in oyster restoration efforts in North Carolina.
Michelle Clower*, Erin Fleckenstein

Fate of contaminants of emerging concern in oyster tissue: Biomagnification or depuration.
Amy S. Costa*, Marc S. Costa

A GIS-based decision support tool for oyster reef habitat restoration.
David B. Eggleston, Seth J. Theuerkauf*, Brandon J. Puckett

Hydrological assessments of tidal creeks.
Kathryn Ellis*, Timothy Callahan, Dianne Greenfield, Denise Sanger, Joshua Robinson

Harvesting the invasive reed,* Phragmites australis*, as a potential nitrogen mitigation strategy: Progress of the first field season.
Emma Green-Beach*, Richard Karney, Jamie Vaudrey, Zachary Gordon

Effects of climate change-related summer heat wave on the condition and physiology of the blue mussel (*Mytilus edulis*).
Carla Hicks*, Luc Comeau, Rejean Temblay, Jean-Bruno Nadalini

Histological investigation of a potential tolerance response to* Perkinsus marinus *in the Eastern Oyster.
Lauren I. Huey*, Ryan B. Carnegie

Celebrating healthy marshes and educating about living shorelines in South Carolina.
Andrea M. Margiotta*, Joy M. Brown

Feasibility of a prototype portable hatchery.
Lisa MacKenzie*, Hauke Kite-Powell

A review of NOAA Aquaculture's work in support of shellfish restoration.
Mark A. Rath*

***Influence of microalgae concentrate diet mixture on growth and survival of larval eastern oysters,* Crassostrea virginica.**
Katelyn Roberts*, Julie Davis, Frank Roberts, Brian Cabral

Celebrating Cedar Key: A model for restoring coastal fishing communities through shellfish aquaculture.
Leslie N. Sturmer*, Suzanne Colson

3-Dimensional Oyster Reef Restoration in Matagorda Bay, Texas.
Julie A. Sullivan*

Research at Half Moon Reef Oyster Restoration in Matagorda Bay, Texas.
Julie A. Sullivan*

Source-tracking and modeling water quality of tidal waters.
Jillian M. Terhune, Timothy J. Callahan*, Vijay M. Vulava, Andrew J. Wunderley, Geoff I. Scott, Jestine Deepe

Keynote Speakers' Biographies

Tristan Hugh-Jones
Owner, Atlantic Shellfish Ltd.
County Cork, Ireland

Tristan Hugh-Jones was born on the family oyster farm in County Cork, Ireland where his parents started to farm oysters in 1969, pioneering the use of ponds for oyster breeding (*Ostrea edulis*). After graduating with honors in geography and geology from Bristol University in 1994, he joined the family business, managing the day-to-day running of the farm, breeding oysters in the summer, and marketing them in the winter. In 1996 Tristan took over the management of the largest Native Oyster (*O. edulis*) beds in Scotland, which are located in Loch Ryan, and has managed the fishery since then, producing 20-40 tonnes/year. In 1999, Tristan started a depuration center near London, which can hold up to 50,000 live oysters, thus enabling oysters from the farms in Ireland and Scotland to be sold directly into the London market, fresh on a daily basis. Tristan is a Council member of the Shellfish Association of Great Britain, and chaired its Mollusc Committee from 2013-2015. He also is on the Management Committee of the Association of Scottish Shellfish Growers. The Loch Ryan Oyster Fishery Company was shortlisted for the Royal Society for the Protection of Birds - Nature of Scotland Award in 2014, and was the winner of the Crown Estate Marine Aquaculture Stewardship Award in 2013.

Tom Ysebaert, Ph.D.
Senior Researcher, Wageningen University and Research, and
Senior Researcher, Royal Netherlands Institute for Sea Research
The Netherlands

Tom Ysebaert is an expert in the ecology of estuarine and marine ecosystems, with special emphasis on benthic ecosystems. He received a Ph.D. degree in 2000 at the University of Antwerp, Belgium. At present Tom is senior researcher at Wageningen University and Research's Marine Research institute and senior researcher at the Royal Netherlands Institute for Sea Research. He also holds a position as professor at the University of Antwerp, teaching a course on ecological engineering. His current research and interests deal with the influence of ecosystem engineers on biodiversity and ecosystem functioning, and the opportunities these offer for the provisioning of ecosystem services. Tom is involved in projects on ecological engineering and building with nature, ecosystem-based adaptation, and shellfish restoration. He also works on predictive modeling of estuarine benthic fauna and the development of benthic indicators.

Kim Jones
Watershed Management Division Manager
Town of Bluffton, South Carolina, USA

Kim Jones' formal education is in biology and ecology, receiving a B.S. degree from Gannon University in Erie, PA and a M.S. degree from Indiana University of Pennsylvania in Indiana, PA. Her biological and ecological research experiences span Lake Erie water quality assessment and small mammal population dynamics of bats and rodents in Pennsylvania; Sub-Saharan granivore guild structure in Zimbabwe, Africa; federally-threatened loggerhead sea turtle reproductive success; and anthropogenic estuarine water quality issues and remediation in South Carolina. Kim is currently a Ph.D. student at University of South Carolina's Arnold School of Public Health Environmental Health Sciences department. Having lived in the Lowcountry of South Carolina since 1995, she has worked for the S.C. Department of Natural Resources' Waddell Mariculture Center, the Coastal Discovery Museum, and Palmetto Bluff Conservancy. In April 2007, she joined the Town of Bluffton and, after holding various positions including interim Director of Engineering, currently serves as the Division Manager for stormwater and watershed management.

Panel Session Descriptions

SESSION A:
An Historical Perspective of Long-Term and Recent Volunteer Restoration Programs: Successes and Challenges
Thursday, November 17—10:30 a.m. to 12:00 p.m.

CHAIR
Sandy Macfarlane
Owner, Coastal Resource Specialists
Massachusetts, USA

PANELISTS
Michael Hodges
Shellfish Management Section, S.C. Department of Natural Resources
South Carolina, USA

Diane Murphy
Cape Cod Cooperative Extension and Woods Hole Sea Grant
Massachusetts, USA

Gef Flimlin
Rutgers Cooperative Extension and ReClam the Bay
New Jersey, USA

Peter Malinowski
New York Harbor Foundation and Billion Oyster Project
New York, USA

DESCRIPTION

Several restoration programs have been on-going for years, such as the Virginia Oyster Garden Program; Suffolk Project in Aquaculture Training (SPAT) Program in Southold, New York; and South Carolina Oyster Restoration and Enhancement (SCORE) Program in South Carolina. Others are newer, such as the Billion Oyster Project, ReClam the Bay, and Barnstable County Municipal Volunteer Programs. Long-standing groups have lessons learned over the years they can share with the other panelists and with the audience. We will be interested in learning what prompted the formation of the organization, its goals, whether the goals changed over the years, successes, and things that did not work out as planned. Issues such as how to maintain enthusiasm among volunteers, work detail organization, member organization, determining skills and abilities, and the best way to capitalize on those skills may have been resolved in innovative ways that can be useful to others. Panel will have sufficient time for audience participation.

Panel Session Descriptions

Session D:
Chesapeake Bay Oyster Restoration—Progress, Policy, People, Partners, and Applied Science
Friday, November 18—10:30 a.m. to 12:00 p.m.

CHAIR
Peyton Robertson
Director, NOAA Chesapeake Bay Office
Maryland, USA

PANELISTS
Eric Weissberger
M.D. Department of Natural Resources
Maryland, USA

Stephanie Westby
NOAA
Maryland, USA

Elizabeth North
University of Maryland Center for Environmental Science
Maryland, USA

Andy Lacatell
The Nature Conservancy
Virginia, USA

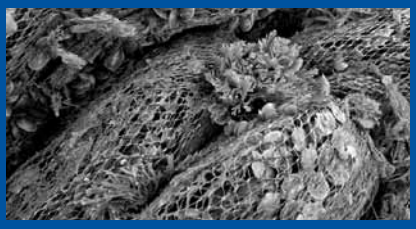
David Bruce
NOAA Chesapeake Bay Office
Maryland, USA

DESCRIPTION

In accordance with the Chesapeake Bay Watershed Agreement commitment to restore and protect oyster reefs in 10 tributaries by 2025, federal, state, academic, and NGO partners are working together to achieve unprecedented, large-scale projects. This work is in state waters, and requires appropriate management policies and reconciliation of different uses, including sanctuaries, public shellfish fishery areas, and aquaculture areas. Sustaining public support requires engagement of stakeholders from the oyster industry, environmental groups, government agencies, and the public to improve the oyster resource while integrating commercial and restoration interests. Ensuring sufficient funding and areas to conduct restoration means leveraging partnerships, including the need for new bottom leases in Virginia, substrate, and oyster restoration dollars. All of this work is conducted by using the best available science, including conducting new field research on oyster reef ecosystem services to document fish utilization, nutrient uptake, and other benefits. This panel will include an integrated discussion of these topics to illuminate how these dots are connected and inter-related.

Key Points:
- The status of efforts to conduct large-scale, tributary-based oyster restoration in accordance with the Chesapeake Bay Watershed agreement, including progress and pitfalls to achieve the vision to restore and protect oyster reefs in 10 tributaries by 2025.
- Policy review and program evaluation – Maryland's Oyster Review Report, reviewing the effectiveness of the locations of sanctuaries, public shellfish fishery areas, and aquaculture areas every five years and to proposing changes where needed.

Ben Cleveland, University of Melbourne



Julie Hills, Ministry for Primary Industries

Ma. Junemie Lebata-Ramos, Southeast Asian Fisheries Development Center

- Better understanding of people and preferences for oyster activities going forward - Oyster Futures, a five-year project funded by the National Science Foundation with a goal of bringing a diverse group of stakeholders together from the oyster industry, environmental groups, and government agencies to make recommendations on ways to improve the oyster resource while integrating commercial and restoration interests.
- Leveraging partnerships to achieve large-scale results - The Nature Conservancy has worked with a number of partners in Virginia's Piankatank River to secure bottom leases, substrate, and oyster restoration dollars to support a comprehensive tributary plan for this river.
- Conducting applied science to better understand the ecosystem services associated with restored oyster reefs – NOAA's Chesapeake Bay Office initiated the Oyster Reef Ecosystem Services (ORES) project to quantify the ecosystem benefits provided by restored oyster reefs, conducting field research to document fish utilization, nutrient uptake, and other benefits.

NOAA Chesapeake Bay Office

Panel Session Descriptions

SESSION I:
Community Engagement in Shellfish Restoration
Saturday, November 19—10:30 a.m. to 12:00 p.m.

CHAIR
Julie Davis
S.C. Sea Grant Consortium
South Carolina, USA

PANELISTS
Haille Carter
Galveston Bay Foundation
Texas, USA

Laurie Sorabella
Lynnhaven River Now
Virginia, USA

Brian Thurber
Proud Pour
Massachusetts, USA

Berlin Kelley
Proud Pour
Massachusetts, USA

Ma. Junemie Hazel Lebata-Ramos
Southeast Asian Fisheries Development Center
Iloilo, The Philippines

Amanda Moeser
The Nature Conservancy, New Hampshire Chapter
New Hampshire, USA

Helen Dickson
The Watershed Project
California, USA


Stewardship Network New England

DESCRIPTION
This session is an opportunity to learn some of the tricks of the trade of running a successful organization that relies on volunteer engagement. Each panelist will give a 10-minute presentation about methods they use to recruit volunteers and maintain their engagement in shellfish restoration projects, as well as creative ways to keep their projects funded. Topics to be covered include: training formats, communications, activities for different audiences, and fundraising. A 30-minute question and answer period will follow.

Use of GIS-based tools to improve placement of restoration and aquaculture activities and to reduce user conflicts.

Troy Alphin (1), Martin Posey (1), Keith Walls (2)
(1) UNCW, 5600 Marvin K Moss Lane, Wilmington, NC 28409, USA; (2) Dial Cordy and Associates, 201 N Front Street, Suite 307, Wilmington, NC 28401, USA

Currently shellfish harvests in NC waters only account for about 1% of the national harvest, but recent efforts within the state have focused on increasing this industry many fold. The focus on aquaculture has raised questions about the feasibility/ compatibility of oyster restoration and ways to reduce potential conflicts. This GIS-based platform is a decision support tool to help reduce user conflicts by providing public data on select water quality parameters, habitat, and conditions relevant to shellfish restoration and aquaculture. Here we present information on uses and challenges of implementing a publicly accessible data visualization tool and the development of a suitability index. The tool is designed to provide information to help potential restoration practitioners and shellfish growers determine site feasibility and help them identify potential risks and long-term suitability for particular areas. This tool organizes and integrates geospatial information specifically related to oyster populations including salinity, bottom type, depth, shellfish growing area classifications, surrounding land cover, and current shellfish growing operations. The suitability index is a weighted, mathematical risk model that utilizes 14 publicly accessible datasets to determine potential conflicts/risk factors within a given watershed and rates suitability on a scale from 0-5. This research demonstrates the advantages of using a GIS-based approach in planning restoration projects and siting aquaculture operations. Although this effort was geographically specific to NC waters, the methodology developed here can be applied to other regions.

From Seeds to Shoreline℠: Sharing restoration stories.

Elizabeth V. Bell (1), Andrea M. Sassard (1)
(1) S.C. Sea Grant Consortium, 287 Meeting Street, Charleston, SC 29401, USA

From Seeds to Shoreline℠ (S2S) is the only student-driven salt marsh restoration program in South Carolina. The program is coordinated by the S.C. Sea Grant Consortium in partnership with the S.C. Department of Natural Resources and the Clemson University Cooperative Extension Service. The S2S program teaches stewardship about the salt marsh ecosystem through seed collection, germination, cultivation, and transplantation of *Spartina alterniflora*, the dominant plant in southeastern salt marshes, with the goal of supplementing shoreline stabilization and creating new habitat. Most importantly, these activities build community awareness of our coastal environment. Through integrating Geographic Information System (GIS) technology, the S2S program is strengthening both restoration and education objectives, while providing technology training to both students and teachers. We are using GIS to visualize restoration activities, creating a spatial context for restoration sites and allowing for better understanding of site attributes, such as oyster beds. A major focus of the presentation is the development of a web-based mapping platform where teachers and students can share their restoration activities.

Galveston Bay Foundation's oyster shell recycling program: Methods, management, and moving forward.

Haille N. Carter (1)
(1) Galveston Bay Foundation, 1100 Hercules Ave. Ste. 200, Houston, TX 77058, USA

The Galveston Bay Foundation's Oyster Shell Recycling Program reclaims spent oyster shells from local seafood restaurants and quarantines the shells in preparation for reuse in local oyster reef restoration projects. The Galveston Bay Foundation has managed this program since 2011, collecting over 530 tons of oyster shells to date. Of this

amount, 130 tons have been incorporated in oyster reef restoration and enhancement projects, with plans for use of the remaining 400 tons in the next two-to-three years. In an effort to reestablish hard substrate in Galveston Bay, the recycled shells are returned to the bay via shoreline protection projects, small-scale and large-scale reef creation projects, as well as reef enhancement initiatives such as volunteer oyster gardening.

As the program has grown from one restaurant partner to eight partners over the last five years, various adaptive management strategies have been employed to overcome obstacles with these partners and determine the most effective methods for collecting, transporting, stockpiling, and utilizing the recycled shells. Standard operating procedures and best management practices for shell collection have been established, including, but not limited to, required equipment, curing site maintenance, and timing of shell collection. As a result of these "lessons learned," GBF has pinpointed components of the program that require additional attention moving forward, particularly streamlining the process of expansion and the selection of new partners. Through the development of an "Expansion Plan" and "Restaurant Selection Criteria," GBF plans to produce a guidance document that will provide a cost-benefit approach to extending the reach of the program in order to capture a larger quantity of the oyster shells discarded by restaurants in the Houston-Galveston region.

From trash can culture to a modern shellfish hatchery: A story of community support on Nantucket Island, Massachuestts

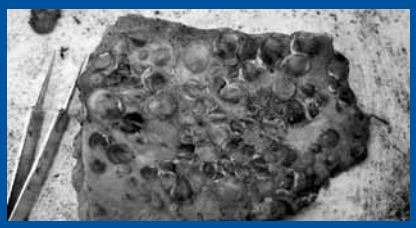
Leah Cabral (1)
(1) Town of Nantucket Natural Resources Department, 2 Bathing Beach Rd, Nantucket, MA 02554, USA

Nantucket has been widely known for its rich history and culture involving a past whaling industry, vibrant commercial bay scallop (*Argopecten irradians*) fishery, and as a resort destination. Increased pressures from population growth and tourism have prompted the Town of Nantucket to implement a Shellfish Management Plan (2012) and other water quality initiatives that provide recommendations and are used as a guide for prioritizing and funding projects. A few examples of the initiatives that are already being implemented involve regulating fertilizer application with licensure and enforcement, increasing wastewater treatment through sewer extensions and mandatory nitrogen reducing technologies for un-sewered Nantucket Harbor watershed septic systems, and repairing the jetties to increase water flow in and out of the harbor. In the last 20 years, the commercial bay scallop fishery has declined dramatically from 100,000 bushels harvested annually to around 10 to 20,000 bushels. Through our town Shellfish Management Plan, we have generated community support to fund a 2 million dollar shellfish hatchery renovation. The hatchery will serve to supplement our commercial bay scallop fishery, create Nantucket's first oyster restoration project, and enhance other species important to our island. All of this work is in tandem with projects aimed at improving water quality, decreasing watershed nutrient loads, and protecting eelgrass resources. It is our hope with added efficiencies to the new hatchery that our shellfish production will dramatically increase as well as provide a space for visiting scientists to research relevant topics concerning our island.

Local government land-use planning and zoning authority: Addressing land-use conflicts and shellfish operations.

Alexandra R. Chase (1)
(1) National Sea Grant Law Center, P.O. Box 1848, University, MS 38677, USA

More than half of the population of the continental United States resides in coastal communities. These popular shorelines are also increasingly home to shellfish operations. Conflicts between residential interests and shellfish aquaculture can result in local land use controversies. Conflicts can arise among long-term coastal residents when



Eric Milbrandt, Sanibel-Captiva Conservation Foundation

Gef Flimlin, Rutgers Cooperative Extension

Julie Davis, S.C. Sea Grant Consortium

shellfish aquaculture and restoration efforts expand or when new residents unfamiliar with working waterfronts move to communities with shellfish operations.

The local land-use conflicts surrounding shellfish aquaculture are similar to those surrounding traditional agriculture. Disputes often center on issues related to noise and hours of operation, obstruction or changes to shoreline views, interference with recreational uses, or tension between shellfish efforts and other marine uses, such as sea grass restoration. Legal attention on shellfish aquaculture and restoration primarily focuses on state leasing and regulatory issues. This presentation will cover the basics of local land-use planning and zoning authority, provide an overview of some recent land-use conflicts with shellfish operations, and highlight mechanisms available to reduce conflicts, such as variances and community outreach and education.

Developing methods for oyster reef restoration in Port Phillip Bay, Victoria, Australia.
Ben Cleveland (1), Steve Swearer (1), Paul Hamer (2), John Ford (1)
(1) University of Melbourne, Parkville, Victoria 3010, Australia; (2) Fisheries Victoria, Australia

Whilst there has been significant work undertaken to restore or repair oyster reefs internationally, in Australia we are only at the beginning of the journey. With losses estimated at 99% nationally, our current understanding of Southern Australia's native oyster reef ecology is limited, particularly as most of the country's oyster reefs were lost over a century ago. Consequently, before oyster reef restoration can be implemented at scale, we must first clearly establish effective good practice methods based on small-scale experimental studies.

A first for both Australian and *Ostrea angasi* restoration efforts, we deployed hatchery reared *O. angasi* to experimental plots across two locations in Port Phillip Bay, Victoria, in early 2015. We aimed to compare survival and growth of oysters on different substrates (limestone vs. natural soft sediment) and at different ages (three- or nine-months post settlement). Results after the first 12 months show clear benefits of extended grow out (i.e., larger size at deployment) and deployment onto limestone substrate. However, strong differences in performance between sites within the Bay show that a multi-faceted approach will be necessary to facilitate restoration in Port Phillip Bay due to the strong gradient of environmental conditions.

Our study is the first step in a broader collaborative project between Fisheries Victoria, The Nature Conservancy Australia, and the Royal Albert Park Fishing and Yacht Club that aims to restore large areas of native shellfish beds. We discuss how our results will be used to guide scale-up options, providing options such as the widespread deployment of limestone rubble or the use of larger modular units.

Engaged communities: Using multiple strategies to keep stakeholders informed and involved in oyster restoration efforts in North Carolina.
Michelle Clower (1), Erin Fleckenstein (1)
(1) North Carolina Coastal Federation, P.O. Box 276, Wanchese, NC 27981, USA

Since 1982 the North Carolina Coastal Federation, a 501(c)3 non-profit organization, has worked with coastal communities to protect and restore a healthy coast. As such, one of the federation's main priorities is to restore and sustainably manage North Carolina oysters by working in an interdisciplinary fashion with researchers, community members, legislators, resource managers, and other stakeholders including commercial fishermen. This effort is led by a coast-wide oyster steering committee and guided by The Oyster Restoration and Protection Plan for North Carolina, A Blueprint for Action. The federation and committee work at a variety of scales and a through a variety of channels

to ensure that the Blueprint, its priorities, actions taken, and results realized are well communicated with a variety of stakeholders.

This poster explores some of the many ways that the federation works to encourage citizens to participate in the protection and restoration of oysters. Working with a multitude of engagement tools the federation involves the public through Oyster Roasts, volunteer restoration events, a bi-annual Oyster Summit, print communications such as their annual progress report (State of the Oyster: Progress Report), through their online award winning newspaper (Coastal Review Online), a website dedicated to oyster efforts in the state (ncoysters.org), social media as well as direct involvement and communication with stakeholders.

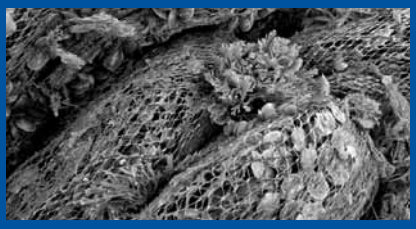
These different communications tools work to engage coastal citizens in the stewardship of oysters, and educate them on the benefits of oyster restoration. The result is enhanced collaboration, a shared vision for the coast, and a community that makes knowledge-based decisions.

Effective monitoring to evaluate ecological restoration in the Gulf of Mexico: An overview of the 2016 National Academies report.

Loren D. Coen (1), Frank W. Davis (2), David M. Burdick (3), Heather Coleman (4), Peter H. Doering (5), Frances Gulland (6), Kenneth L. Heck, Jr. (7), Matthew K. Howard (8), Stephanie Johnson (9), Michael S. Kearney (10), Payton T. Kulina (11), Claudia Mengelt (11), Paul A. Montagna (12), Pamela T. Plotkin (13), Kenneth A. Rose (14), Eric P. Smith (15), Heather M. Tallis (16), Ron M. Thom (17), Mark S. Woodrey (18)
(1) Dept. of Biological Sciences and Harbor Branch Oceanographic Institute, c/o 16007 Waterleaf Lane, Ft. Myers, FL 33908, USA; (2) Bren School of Environmental Science & Management; UC Santa Barbara, 2400 Bren Hall, Santa Barbara, CA 93106, USA; (3) Jackson Estuarine Laboratory, 85 Adams Point Road, Durham, NH 03824, USA; (4) Ocean Studies Board & Board on Atmospheric Sciences and Climate, The National Academies of Sciences, Engineering, and Medicine, 500 5th Street NW, Washington, DC 20001, USA; (5) Applied Sciences Bureau, South Florida Water Management District (SFWMD), 3301 Gun Club Road, West Palm Beach, FL 33406, USA; (6) Marine Mammal Center, 2000 Bunker Road, Fort Cronkhite, Sausalito, CA 94965-2619, USA; (7) Dauphin Island Sea Lab, 101 Bienville Boulevard, Dauphin Island, AL 36528, USA; (8) Dept. of Oceanography, Texas A&M University, College Station, TX 77843, USA; (9) Water Science and Technology Board, National Research Council, 500 5th Street NW, Washington, DC 20001, USA; (10) University of Maryland, College Park, MD 20742, USA; (11) The National Academies, 500 5th Street NW, Washington, DC 20001, USA; (12) Harte Research Institute for Gulf of Mexico Studies, Texas A&M University - Corpus Christi, 6300 Ocean Drive, Unit 5869, Corpus Christi, Texas 78412, USA; (13) Texas A & M University, 730 Lamar Street, 4115 TAMU, College Station, TX 77843, USA; (14) Louisiana State University, Baton Rouge, LA 70803, USA; (15) VA Polytechnic Institute and State University, 416-A Hutcheson Hall, 250 Drillfield Drive, Blacksburg, VA 24061, USA; (16) TNC, 415 Alta Vista Drive, Santa Cruz, CA 95060, USA; (17) Coastal Sciences Division, Pacific Northwest National Laboratory, 1529 W. Sequim Bay Road, Sequim, WA 98382, USA; (18) NOAA/Mississippi Department of Marine Resources Grand Bay National Estuarine Research Reserve, Coastal Research and Extension Center, 6005 Bayou Heron Road, Moss Point, MS 39564, USA

The National Academies recently released a report stressing the importance of monitoring for all restoration projects associated with damages from the 2010 Deepwater Horizon oil spill. Losses were estimated to include a 20% reduction in commercial fishery landings and damage to >1,770 km of coastal wetlands. Funding for restoration and related efforts currently exceeds $16 billion. The report includes discussions on wetlands, seagrasses, oyster reefs, commercial fisheries, marine mammals and birds, coastal beaches, and barrier islands. The report reviews: (a) effective approaches for initial and long-term monitoring; (b) approaches for determining baseline data requirements; (c)


Ben Cleveland, University of Melbourne


Julie Hills, Ministry for Primary Industries


Ma. Junemie Lebata-Ramos, Southeast Asian Fisheries Development Center

essential elements of long-term monitoring; (d) novel approaches to increase effectiveness, reduce costs, and ensure data compatibility for comparisons; (e) approaches for advancing restoration science; and (f) effectiveness of synthesis efforts at large spatial and temporal scales. Historically, restoration monitoring has been underfunded resulting in a loss of accountability and valuable information despite the value of such information to sponsors of restoration projects. The report recommends that monitoring should be viewed as integral parts of all restoration projects and at a minimum should include both construction and performance monitoring. Additionally, when appropriate, monitoring should also support adaptive management. The use of conceptual models is recommended for developing monitoring plans. An initial conceptual model is also recommended in the development of monitoring plans. Section II of the report provides specific restoration monitoring guidelines for six habitats and species groups, including intertidal and subtidal oyster reef habitat. The oyster reef section provides habitat-specific restoration objectives, project-level monitoring and assessment plans, and an extensive table that provides metrics for use in assessing progress toward a suite of restoration objectives. For a copy see http://www.nap.edu/read/23476/chapter/1.

Fate of contaminants of emerging concern in oyster tissue: Biomagnification or depuration.
Amy S. Costa (1), Marc S. Costa (1)
(1) Center for Coastal Studies, 5 Holway Avenue, Provincetown, MA 02657, USA

Several towns on Cape Cod (Massachusetts) are incorporating shellfish propagation into wastewater management plans as a way of removing nitrogen from coastal waters. The oysters are transferred to a grow-out site from which they are then harvested for consumption. Although the ability of oysters to improve water quality is well documented, there have been few studies to investigate the impact on the oysters of being grown in polluted waters. Contaminants of emerging concern (CECs), including pharmaceuticals and personal care products, are typically found in higher concentrations in wastewater-impacted waters. Since 2010, the Center for Coastal Studies has been monitoring Cape Cod's coastal waters for CECs. Several of the CECs found in coastal water samples were also found in oysters grown in these waters.

The Massachusetts Division of Marine Fisheries requires a six-month depuration period for shellfish taken from prohibited areas. This regulation is for depuration of bacteria only. Depuration of other contaminants is not known. If towns on Cape Cod are planning on growing shellfish in coastal areas that are known to be compromised by wastewater, the primary source of CECs to our coastal waters, and then harvesting these shellfish after a depuration period, it is imperative that research is done on the depuration (or lack thereof) of CECs from shellfish tissue. This study measured CEC levels in oysters grown in a wastewater-impacted coastal pond and at set intervals after transfer to the grow-out site to determine depuration rates of detected contaminants.

Using a suite of innovative science and monitoring practices to quantify the ecological, social, and economic impact a restored oyster reef can have on people and nature: Half Moon Reef, Texas.
Bryan M. DeAngelis (1), Mark Dumesnil (2), Bill Balboa (3), Stuart Carlton (4), Jennifer Pollack (5), Andrew Ropicki (6), Christine Shepard (7), R.J. David Wells (8)
(1) The Nature Conservancy, URI Bay Campus, Narragansett, RI 02882, USA; (2) The Nature Conservancy, 205 N. Carrizo Street, Corpus Christi, TX 78401, USA; (3) Texas Sea Grant College Program, 2200 7th Street, Bay City, TX 77414, USA; (4) Texas Sea Grant College Program, P.O. Box 1675, Galveston, TX 77553, USA; (5) Texas A&M University- Corpus Christi, 6300 Ocean Drive, Corpus Christi , TX 78412, USA; (6) Texas Sea Grant College Program, Texas A&M University- Corpus Christi, 6300 Ocean Drive, Corpus Christi , TX 78412, USA; (7) The Nature Conservancy, 311 Berry Street, Punta Gorda, FL 33950, USA; (8) Texas A&M University, 1001 Texas Clipper Road, Galveston, TX 77553, USA

Oyster reef restoration projects provide considerably more services to people, communities, and the ecosystem than just potential increases in the numbers of oysters. Rarely, however, are restoration projects evaluated to comprehensively demonstrate the impact that restored habitats have on the ecosystem and the people of the surrounding community. In 2013-2014 The Nature Conservancy constructed a 54-acre oyster reef restoration project in Matagorda Bay, Texas known as Half Moon Reef. In addition to monitoring the universal metrics to evaluate reef performance post-construction, we implemented several innovative science and monitoring programs to collectively evaluate the ecological, social, and economic impact of the restoration project on the ecosystem, people, and community of Matagorda Bay. Monitoring included evaluating: 1. biodiversity and biomass contributions from increased resident fauna on reef vs. off reef, and increased water filtration provided from increased oyster biomass; 2. spatial and temporal use of the reef by a recreationally important species, *Cynoscion nebulosus*, using passive acoustic telemetry; and 3. social and economic contribution of the fish attraction and fish production from the restored reef using surveys to evaluate angler awareness of the restoration project, angler use and satisfaction of the reef, demographics and motivations of Half Moon Reef anglers, and the consequent economic impact of the Half Moon Reef restoration.

The Italian problem about 0.3 nm fishery exclusion: Does it make sense? (maybe or maybe not).
Donatella Del Piero (1)
(1) University of Trieste, via Giorgieri 10, c/o M Building, Trieste, TS 34127, Italy

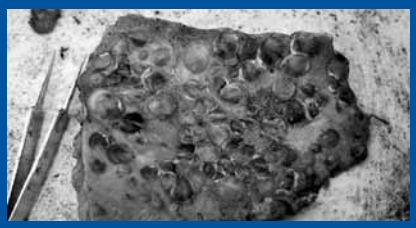
The exclusion of clam dredge fishery from areas inner the 0.3 nm is a source of problems for the mollusc exploitation, due to the fact that both *C. gallina* and *E. minor* are quite abundant in the area. The ban was enforced after June 1, 2010, (Council Regulation (ec) 1967/2006) but, curiously, nobody seemed to care about it. The idea was to preserve the reproduction success possibly granted by unfished clam population, but, if so, why do beach refurbishment that could compromise clam population? The question is still unresolved even if something is going on due to management plans gradual implementation. Nevertheless in the Gulf of Trieste it was possible to exert some exploitation, mainly because it's a really particular area but sounds a bit strange: no fishery ok refurbishment.

Ownership of fishing areas by artisanal fishermen targeting marine molluscs along the Petite Côte of Senegal.
Hamet Diaw Diadhiou (1), Ismaila Ndour (1)
(1) ISRA/CRODT, Route du Front de Terre, Laboratoire de Recherches Vétérinaires de l'ISRA, Dakar BP 2251, Senegal

The occurrence of GPS in Senegalese artisanal fisheries in the 1980s was accompanied by the gradual monopolization of fishing areas containing major deposits of marine molluscs in the coastal area of the Petite Côte of Senegal by artisanal fishermen targeting this resource.

The major deposits are located using GPS and exploited throughout the year continuously with fixed nets background, long of several meters (500 m to 1000 m or more) that are removed for replacement. This behavior, apart from the fact that it participates in the exploitation of fishery resources, has social consequences (conflicts with other fisheries stakeholders), economic (drop in incomes generated by the fishery), and environmental (destruction of marine habitat).

Fishing grounds exploited by the fishery located near the coast are rich in species and contain significant deposits of marine molluscs and other fishery resources consist mainly by individuals which have not reached the size of first sexual maturity and by seagrass. The ecological, social, and economic impacts of the ownership of deposits of marine molluscs from fishing using GPS units are assessed in the oral communication.



Eric Milbrandt, Sanibel-Captiva Conservation Foundation

Gef Flimlin, Rutgers Cooperative Extension

Julie Davis, S.C. Sea Grant Consortium

A GIS-based decision support tool for oyster reef habitat restoration.

David B. Eggleston (1), Seth J. Theuerkauf (1), Brandon J. Puckett (2)
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The global decline of many recreationally- and commercially-important marine species has prompted the use of habitat restoration, such as the construction of oyster reefs, as a management tool to combat population declines. Inadequate scientific information to guide site selection is one of the most common causes of unsuccessful habitat restoration. In this study, we developed a hierarchical, GIS-based optimization approach to selecting the most suitable sites for oyster reef habitat restoration in Pamlico Sound, North Carolina, USA. Our novel approach linked relevant biological, physical, and socioeconomic information within a unifying GIS-based decision support tool framework to guide habitat restoration prioritization using oyster reef habitat restoration in Pamlico Sound, North Carolina, USA as a model system. The underlying framework of this decision support tool is adaptable to inform habitat restoration in other systems. This poster presentation will focus on the GIS-based decision support tool that we have generated for oyster sanctuary site selection in Pamlico Sound, North Carolina, USA, and will focus on our approach, including the: 1) selection of relevant biological, physical, ecosystem services, and socioeconomic spatial layers; 2) convening of an expert panel (including academia, non-profits, and government agencies) to assess underlying model weightings within the tool; 3) development of the tool framework; 4) validation of tool output; and 5) translation of the tool output into meaningful information for decision-makers tasked with oyster reef habitat restoration. The poster presentation will also introduce ongoing updates to the tool to inform intertidal oyster reef habitat restoration and to incorporate ecosystem services (i.e., oyster filtration and finfish habitat enhancement).

Hydrological assessments of tidal creeks.

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The purpose of this study is to provide regulatory agencies, land managers, and scientists with information about the hydrology of tidal creeks by developing mathematical relationships between time, stage, and discharge. Currently, there are no stage-discharge or time-discharge relationships for these creeks, or many other similar creeks in the South Carolina Coastal Plain, so this information will fill an existing knowledge gap. Hydrology data and analysis are useful for evaluating the suitability of coastal wetland and waterway restoration, understanding biological responses (e.g., algal blooms and shellfish vitality), and identifying linkages between flow and water quality conditions in these systems. In other words, can information on tidal flux and nutrient flux predict biological responses or restoration success in coastal wetlands? There are four study sites: two in the Ashepoo-Combahee-Edisto (ACE) Basin and two in the Charleston Harbor system. Opportunistic sampling is occurring over a two-year period (2015-2016) to measure volumetric discharge in each creek with an acoustic Doppler current profiler (ADCP) unit. The goal is to collect data for as large a range of tidal conditions as possible. Additionally, the creek discharge data, combined with information from a related effort to collect nutrient and phytoplankton data, will be used to calculate presumptive Total Maximum Daily Load (TMDL) estimates of nitrogen for these sites. Also, a stormwater runoff model will be used to estimate the potential volume of water from storm events entering the creeks from the adjacent uplands; this quantity will be compared to the total volume of water that enters or exits the creeks (the tidal prism) to better understand how runoff may affect the water quality and algal ecology in these creeks.

Shellfish restoration: Science, education, and art as strange bedfellows.
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Barnegat Bay is a coastal lagoon with barrier islands. Ocean County which surrounds the bay has had intense upland development in the past 60 years. It has a major summer resort population, as well as a year thriving round community, and both groups use the bay for recreation. Faced with declining hard clam (*Mercenaria mercenaria*) stocks, severe shellfishing licenses, and intense growth in the watersheds of the bay, Rutgers Cooperative Extension of Ocean County instituted a community-based shellfish restoration program in 2005. The program partnered with NJDEP Bureau of Shellfisheries. This program started as a result of talks at the International Conference on Shellfish Restoration in Charleston, SC.

The Barnegat Bay Shellfish Restoration Program trained about 250 volunteers as Certified Shellfish Gardeners. About 80 remain very active in the program. Volunteers have grown over 10 million clam and 3 million oyster seed (*Crassostrea virginica*), plus hundreds of thousands of oyster spat on shell for deposition into the bay.

Although on face value, this is supposed to be about shellfish restoration, education about water quality, shellfish, aquaculture, and the Barnegat Bay is key to the program. A myriad of educational opportunities exist to teach the citizens, both young and old. A non-profit corporation "ReClam the Bay, Inc." raises funds to support the program. This includes outside grants, bumper-stickers, tee shirts, and fascinating public art pieces designed to attract people and teach science through a treasure hunt concept.

To learn more about the program, visit http://ocean.njaes.rutgers.edu/marine/bbsrp.html and http://www.reclamthebay.org/.

Reversing a rapid decline in oyster reefs: Effects of durable substrate on oyster populations, elevations, and aquatic bird community composition in the Big Bend of Florida.
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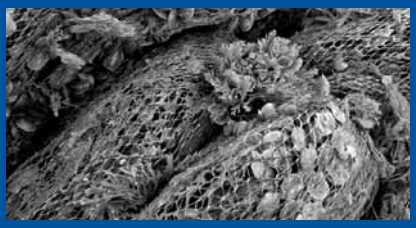
Offshore oyster reefs in the Big Bend Coast of Florida have declined by 88% during the last 30 years, driven by repeated die-offs during high salinity, triggered by episodic and increasing periods of reduced freshwater input to estuaries. Repeated events have led to an apparently nonreversible conversion from shell to sandbar substrate and rapid loss of elevation (8 cm/y). Larval supply is abundant, however, and we hypothesized that the addition of durable substrate would make reefs more resilient to periodic declines in freshwater flow by providing a persistent settlement substrate for larvae. Durable substrate was added in the form of limerock cobbles and recycled clam aquaculture bags filled with cultch to eight paired treatment and control sites spaced along a highly degraded offshore reef chain. Elevation on treatment reefs increased post-construction by an average of 16 cm. Mean oyster density on treatment sites increased by 2.65× on rock, 14.5× on clam bags, and 9.2× overall compared with control sites. Oyster densities on treatment sites were between 89× and 125× those measured at a larger sample of nearby natural reefs, and exceeded the 89th percentile of reported densities at natural and restored reefs in the Gulf of Mexico. Total bird use was higher on treatment sites, but when controlled for elevation, all species but double-crested cormorants and bald


Ben Cleveland, University of Melbourne


Julie Hills, Ministry for Primary Industries


Ma. Junemie Lebata-Ramos, Southeast Asian Fisheries Development Center

eagles preferred control (sand bar) sites. These results indicate that (1) oyster recruitment can be strongly limited by available, durable substrate, especially in high-energy environments; (2) aquaculture byproduct materials can play a significant role in the process of restoration; and (3) restoration of oyster reefs and other living shorelines may have impacts on avian community composition.

Harvesting the invasive reed, *Phragmites australis*, as a potential nitrogen mitigation strategy: Progress of the first field season.

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Degradation of marine habitats by nitrogen eutrophication is a worldwide problem and has become one of the biggest challenges to shellfish restoration. Motivated by the need to improve water quality in order to reach our shellfish restoration goals, this project was designed to employ the competitive nature of this ubiquitous salt marsh plant to remove nitrogen from our estuaries.

Phragmites australis is highly invasive in North America and outcompetes native vegetation, alters nutrient and water cycles, and excludes native animals. However, there is scientific evidence that *Phragmites* provide important ecological services, especially sequestration of nitrogen. This characteristic is exploited for nutrient management in eutrophied estuaries and lakes in other parts of the world, as well as in stormwater ditches and wastewater treatment applications.

Harvesting *Phragmites* offers an especially favorable means for bioextraction for these reasons: 1) *Phragmites* are known for their ability to assimilate nutrients and thrive in high nutrient environments. Their roots penetrate six feet deep and thus intercept both nitrogen rich groundwater and surface runoff. 2) *Phragmites* are abundant in the riparian zone of some ponds. The large amount of biomass could be harvested time and time again without the need to replant, cultivate, or maintain, unlike cultured oysters or macroalgae. 3) *Phragmites* are an invasive species, and as such, harvest of the above-ground biomass should require minimal permits compared to native vegetation. 4) Harvested *Phragmites* could potentially be utilized as a high N component in compost, turned into burnable pellets for biochar production or as a local, sustainable feed source for livestock. We will report on the progress made to address these aspects of *Phragmites* harvest for nitrogen mitigation.

Oyster larval settlement in response to experimental seeding of oyster reefs with *Alpheus spp.* snapping shrimp.

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Exposure to oyster reef soundscapes has been shown to positively affect larval settlement of the eastern oyster *Crassostrea virginica*. The dominant component of these soundscapes is formed by *Alpheus spp*. snapping shrimp, which use oyster reefs as habitat. To better understand the applicability of soundscape manipulation for reef restoration, we manipulated larval recruitment by seeding newly built oyster reefs with snapping shrimp over the course of the *C. virginica* spawning season. We took acoustic samples biweekly at reefs with and without added snapping shrimp, and followed larval recruitment with settlement tiles at each reef site. For the first two weeks of the experiment when most settlement occurred, oysters set significantly more often ($p = 0.04$ and $p = 0.03$ respectively) at reefs without snapping shrimp than at those with shrimp. We used an amplitude filter to identify patterns of shrimp activity near

experimental reefs, and found that added snapping shrimp contributed to the development of reef soundscapes. However, after the first two weeks of the experiment, there was no significant relationship between the presence of snapping shrimp and oyster larval settlement.

Effects of climate change-related summer heat wave on the condition and physiology of the blue mussel (*Mytilus edulis*).

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Observed trends in our coastal regions, as a result of global warming, include not only higher and more frequent peaks in water temperature but also the maintenance of warmer water temperatures for increasing periods of time. To understand the effects of future projected "heat wave" scenarios on the rope cultured blue mussels of Prince Edward Island (PEI), we exposed mussels to a warm (19-25°C) and cold (12-18°C) treatment for 90 days in a flow through system. Their condition and energy reserves (lipids, glycogen, and protein) were evaluated from tissue samples. Mussels from the warm treatment had a significantly lower condition index compared to the cold treatment mussels. In regards to energy reserves, *M. edulis* lipid levels were significantly higher while protein and glycogen levels were significantly lower in the warm treatment compared to their counterparts. The overall energy content, indicative of the structural energy of the organism, was significantly lower in the warm treatment mussels. Furthermore, behavioral differences such as prolonged valve closures were observed by the mussels in the warm treatment. This inferior energy reserve content of the warm treatment mussels is likely the result of higher metabolic costs and decreased filtration rates related to thermal stress.

Effects of scallop (*Pecten novaezelandiae*) spat enhancement on scallop catches in New Zealand.

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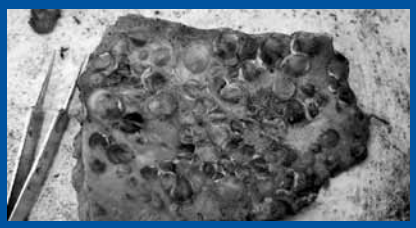
Scallops (*Pecten novaezelandiae*) support regionally important commercial, recreational, and customary fisheries in New Zealand. The Southern scallop fishery (SCA 7) is located at the north end of New Zealand's South Island and over its commercial fishing history has undergone considerable change in terms of both management and productivity. Commercial dredging began in 1959 and reached a peak catch of almost 10,000 t greenweight in 1975, after which landings declined rapidly resulting in the fishery being closed for several years. The fishery was re-opened in 1983 and scallop stock enhancement techniques were trialled through collecting and releasing large numbers of juvenile scallops into the wild. Large-scale enhancement began in the late 1980s along with a three-year rotational harvesting strategy for commercial fishers. Enhancement activities continued at a significant level until the mid 2000s, but very little enhancement has taken place since then. The combination of enhancement and rotational fishing were implemented as a means of stabilising fishery production and reducing periods of low abundance, however, productivity has remained highly variable and fishery biomass is now at its lowest point since catch recording and biomass surveys began. To improve our understanding of the SCA 7 fishery an analysis was undertaken to provide insight into how scallop enhancement and rotational catch activities may have affected the performance of the fishery. It appears that enhancement did have a significant effect on survey catches, although analysis suggested that increased catches of recruited scallops (90 mm shell length or larger) occurred two-to-four years after enhancement.



Eric Milbrandt, Sanibel-Captiva Conservation Foundation

Gef Flimlin, Rutgers Cooperative Extension

Julie Davis, S.C. Sea Grant Consortium

Histological investigation of a potential tolerance response to *Perkinsus marinus* in the Eastern Oyster.

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Oyster restoration strategies in the Chesapeake Bay increasingly include sanctuaries from harvest to promote resistance to diseases caused by *Perkinsus marinus* and *Haplosporidium nelsoni*. On the surface, this strategy seems to be at least partially flawed. The Chesapeake oyster's interaction with *H. nelsoni*, or MSX, has become a success story with convincing evidence of host resistance. On the other hand, wild oysters do not seem to be developing appreciable resistance to *P. marinus*, or *dermo*, as infection prevalence and intensities remain historically high. If wild oysters are not capable of countering *P. marinus*, sanctuaries could become hotspots for disease.

Emerging data shows that oysters may be developing tolerance, not resistance. While resistance limits the parasite's entry, colonization, and/or proliferation, tolerance does not limit the parasite at all. Rather, the oyster minimizes the physiological cost of infection. To address whether the wild oyster response is improving despite continued intense disease pressure, histological analyses of oysters collected from 1988-2014 are being conducted. The focus of the data collection is reproduction; the hypothesis is that oysters developing tolerance would be more capable of normal reproduction relative to the period immediately following the mid-1980s intensification of dermo disease in the region. Quantitative analysis has revealed that contemporary oysters have improved gonadal development compared to oysters at the beginning of the *P. marinus* epizootic, suggesting that wild oysters are developing *P. marinus* tolerance. The average oocyte count per area of gonad in histology from 1988-2002 was just 60.0% of the average for 2003-2014. This supports sanctuaries as a useful restoration tools to increase disease tolerance and improve oyster populations even if *P. marinus* abundance in such sanctuaries may be high.

Feasibility of shellfish bed restoration (flat oyster *Ostrea edulis L.* and mussel *Mytilus edulis*) in the Dutch part of the North Sea.

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Within the Dream Fund project 'Haringvliet – Towards a dynamic delta' (www.haringvliet.nu), partners work actively towards ecosystem restoration within and around the Dutch Haringvliet. One of the elements of this plan is mussel and flat oyster bed restoration in the Haringvliet coastal zone (the so-called Voordelta area), since these shellfish beds are keystones (bio-engineers) in this type of habitat.

Little is known about the conditions under which shellfish beds can develop and sustain themselves in the North Sea area. The current primary objective of the project is therefore to test and analyze these conditions by means of pilot projects. By the end of 2015, two pilots were put into place, at locations with different environmental conditions. Main elements of the pilots are the following:

- The shellfish are placed into cages with different mesh size, in order to investigate the influence of predators of different size classes. These cages are placed into larger racks for stability and protection.
- Empty mussel shells are distributed around the racks, as settling substrate for spat which may originate from the pilot shellfish or elsewhere.
- Reef balls are put around the racks, for physical protection and also as extra settling substrate.

A mixed flat and Pacific oyster reef of about 10 hectares was discovered at one of the locations. The flat oyster larvae probably originate from Lake Grevelingen, which has its outlet near this location. It appears that mussels settle and grow well at the pilot within the reef. This leads to the conclusion that at this location, the environmental circumstances are suitable for mussel as well as flat oyster reef development. For the other location, more information will become available soon.

Evaluating living shorelines to inform regulatory decision-making in South Carolina, USA.
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Living shorelines show great promise in coastal South Carolina as a tool to control erosion and protect coastal areas from hazards in both the short- and long-term. State and federal agencies, as well as conservation groups, have been constructing oyster reef-based living shorelines in South Carolina for the past 15 years. The majority of these living shorelines have used natural oyster shell as substrate, and the emphasis has been on habitat value rather than shoreline protection. Many of these reefs, however, have exhibited significant sediment accretion and subsequent marsh re-colonization. Recently, private property owners have shown increasing interest in using living shorelines as a tool to prevent erosion. The state regulatory agency's permitting process, however, does not specifically address this emerging strategy and therefore serves as a regulatory barrier to private property owners wishing to pursue this approach. The overall goal of the project presented here, funded by NOAA's NERRS Science Collaborative funding opportunity, is to provide coastal regulators with the science-based information necessary to make policy decisions regarding living shorelines. To achieve this goal, we are addressing knowledge gaps by constructing and monitoring new living shorelines, created using a variety of approaches along a gradient of habitat types, and by quantifying the performance of established living shoreline project sites constructed over the last 15 years, to assess long-term trajectories. Ultimately these findings will be developed into a guidance document that can be utilized in the development of a comprehensive regulatory framework and in future implementations of living shorelines in South Carolina. This presentation will give an overview of recent field efforts to create and monitor new living shorelines across a range of study sites.

Restoring abalone population through family-based grow-out culture in intertidal reef flats.
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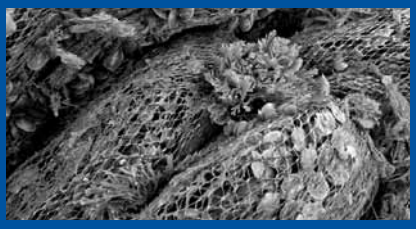
Abalone production in the Philippines peaked in 1995 at 483 mt and has been declining since then. Declining abalone population may have been caused by overexploitation of stocks, habitat destruction, lack or failure in the implementation of fisheries management policies, or a combination of these factors. Aside from releasing hatchery-bred juveniles, wild populations may be restored by promoting family-based grow-out culture in intertidal reef flats. Grow-out culture will minimize, if not totally eliminate, dependence on the wild stocks as source of food and livelihood. Through the National Abalone R&D Program funded by the Department of Science and Technology's Philippine Council for Agriculture, Aquatic, and Natural Resources Research and Development (DOST-PCAANRRD), SEAFDEC/AQD has improved culture techniques for the tropical abalone *Haliotis asinina*. With these recent developments, grow-out culture of abalone may be shortened from 10-12 to 6-8 months. New materials and designs

Ben Cleveland, University of Melbourne



Julie Hills, Ministry for Primary Industries

Ma. Junemie Lebata-Ramos, Southeast Asian Fisheries Development Center

have been tested as culture containers. Of the four containers tested, recycled oil container is recommended for family-based grow-out culture. Experimental runs showed that growth rates for both length and weight after rearing abalone for six months in recycled oil containers were high (0.31 cm mo-1 and 4.04 g mo-1) and comparable with those reared in the more expensive and more stable PVC tubes (0.31 cm mo-1 and 3.64 g mo-1). Although survival after six months was lower in containers (83%) than in tubes (96%), this may be resolved in the future by securing containers well so they won't be easily carried away by big waves. Encouraging coastal communities to engage in grow-out culture will not just boost their income but also help minimize exploitation of wild abalone resources.

Estimating the distribution of harvested estuarine bivalves with habitat suitability models and understanding the implications under a changing climate.

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Habitat suitability models are useful to forecast how environmental change may affect the abundance or distribution of species of interest. In the case of harvested bivalves, those models may be used to estimate the vulnerability of this valued ecosystem good to stressors. Using literature-derived natural history information, rule-based habitat suitability models were constructed in a GIS for several bivalve species (*Clinocardium nuttallii*, *Mya arenaria*, and *Tresus capax*) that are recreationally and commercially harvested in Northeast Pacific estuaries. Spatially-explicit habitat maps were produced for Yaquina and Tillamook estuaries (Oregon) using environmental data (salinity, depth, sediment grain size, and burrowing shrimp density) from multiple studies (1960-2012). Habitat suitability values ranged from 1-4 (lowest to highest) depending on the number of environmental variables that fell within a bivalve's tolerance limits. The models were tested by comparing the observed distribution of bivalves reported in benthic community studies (1996-2012) to the range of each suitability class. Results primarily showed that habitats of highest predicted suitability contained the greatest proportion of bivalve observations and highest population densities. Our model was further supported by logistic regression analyses that showed correspondence between predicted habitat suitability values and logistic model probabilities. We demonstrate how these models can be used to forecast changes in the availability of suitable habitat for these species using projected changes in salinity and depth associated with climate change scenarios. The advantage of this approach is that disparate, independent sets of existing data are sufficient to parameterize the models, and to produce and validate maps of habitat suitability. If the models are robust for multiple estuaries and bivalves, resource managers can transfer the approach to data-poor systems with only modest investment.

Development of a novel ephemeral substrate for the creation of diverse oyster-based products for aquaculture, habitat restoration, and living shorelines.

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Oysters are a tremendously valuable economic, social, and environmental resource. Tragically, populations of this keystone species have experienced substantial, persistent declines worldwide over the past century. In the US and many countries where oysters once dominated coastal ecology and economies, there is growing interest in and resources being devoted to restoring oyster populations and promoting oyster mariculture. In North Carolina, the State's Sea Grant program fostered collaboration between scientists and commercial fisherman through the Fishery Resource Grant Program (FRG). With FRG funds and funds from other agencies, David "Clammerhead" Cessna began working with Prof. Niels Lindquist and other UNC-IMS research groups on various aspects of oyster ecology in North

Carolina waters, and in particular the impacts of carbonate boring sponges and substrate type on oyster health and reef persistence. From this collaboration, Lindquist and Cessna invented an ephemeral substrate on which oysters settle and grow in immense numbers. The novel biodegradable substrate named "Oyster Catcher" is made from plant-fiber cloths infused with cement, and, prior to hardening, the combined materials are formed into different modular shapes that yield seed oysters for aquaculture operations, oyster-coated substrates for fisheries and oyster habitat enhancements, and for the creation of oyster habitat in living shoreline projects. UNC Chapel Hill has filed a PCT patent application for the material and Lindquist and Cessna have founded the Sandbar Oyster Company LLC to exclusively license the patent rights and commercialize the substrate and its multiple uses. This talk will illustrate the utility of the Oyster Catcher substrate and results to date of projects using the novel material.

Constructing oyster castle reefs for increased resilience at Chincoteague National Wildlife Refuge.

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In the wake of Hurricane Sandy, Chincoteague National Wildlife Refuge partnered with The Nature Conservancy's Virginia Coast Reserve to construct oyster reefs from oyster castle substrate to create habitat and increase resilience over two thirds of a mile of the Refuge's shoreline.

The alternative substrate known as oyster castles are being used to create some of the longest complexes of restored oyster reefs ever built on Virginia's Atlantic coast. These reefs are being constructed by The Nature Conservancy along over two thirds of a mile of shoreline at Chincoteague National Wildlife Refuge as part of projects funded by both the US Department of Interior and the National Fish and Wildlife Foundation through funds established by the Disaster Relief Appropriations Act of 2013 designated to support Hurricane Sandy recovery efforts. While oyster castles in Virginia have previously been shown to provide effective oyster substrate and reef habitat structure, their ability to attenuate wave energy has not been measured locally. The University of Virginia will be monitoring wave attenuation at the project sites in the hopes of evaluating the use of oyster castle reefs for increasing shoreline resiliency in future projects. Project logistics including permitting, volunteer coordination, handling adverse tidal conditions, and preliminary monitoring results will be discussed.

Feasibility of a prototype portable hatchery.

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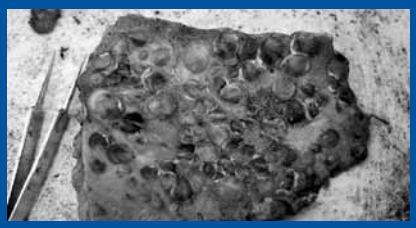
In this project, we address the challenges of establishing shellfish hatcheries in developing countries. Lack of infrastructure and local expertise, difficult logistics, and cost are limitations to shellfish farming in various locations abroad. We explore the feasibility and design of a prototype portable hatchery within a remodeled shipping container that could be assembled in the United States and shipped to a pre-selected site in the tropics. We consider the cases of other modular hatchery projects, hatchery layout and design, water requirements, projected costs, and expenses in comparison to a permanent hatchery. We estimate that the costs of a portable hatchery would be $96,000 compared to the costs of a permanent hatchery at $102,000. We propose the assembly of a portable hatchery within a 20-foot shipping container, with an additional 20-foot shipping container used for transportation and storage of other equipment and supplies. Fashioning a hatchery within a shipping container achieves hatchery mobility. In the case of deteriorating water quality, we would be able to move the hatchery to a new location.



Eric Milbrandt, Sanibel-Captiva Conservation Foundation

Gef Flimlin, Rutgers Cooperative Extension

Julie Davis, S.C. Sea Grant Consortium

This project is inspired by ongoing projects that promote the development of shellfish hatchery operations and aquaculture farming on Zanzibar Island, Tanzania. Building a shellfish farming industry in Zanzibar could have significant implications for socioeconomics and the role of science and technology to expand food sources and markets in the rest of East Africa. The findings from this conceptual design demonstrate the feasibility of a semi-permanent, mobile shellfish hatchery that could be taken to coastal locations worldwide.

Community reefs in Brooklyn: How reef installations along the Brooklyn shoreline activate communities and build resiliency.

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Billion Oyster Project's (BOP) Community Reef Initiative aims to leverage the skills and unique expertise of students in Harbor School's Career and Technical Education Programs to activate a much broader community in the restoration of a keystone species in New York Harbor. The initiative is designed to combat a lack of awareness about and access to New York Harbor and encourage school and community groups to participate directly in the work of restoring oysters to New York Harbor.

A "Community Reef" is an oyster restoration or research installation in a neighborhood. These sites are designed to be physically accessible to school and community groups. Community Reefs provide the next level of engagement for current BOP Schools. These schools have been implementing BOP curricula in their classes and the students and staff have been trained to implement BOP's field science monitoring protocols. The Community Reefs are designed to require similar techniques for monitoring and maintenance. Currently two of these reefs have been installed along the Brooklyn Shoreline.

The physical structure of the Community Reefs was developed through an iterative design process involving all six of Harbor School's Career and Tech Programs. Participants in construction and monitoring events experience the remarkable abundance and diversity of life in New York Harbor. These experiences build affinity for the Harbor and build both resiliency and an environmental ethic in neighborhoods that otherwise would not have a direct connection to the natural world.

Celebrating healthy marshes and educating about living shorelines in South Carolina.

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In South Carolina, The Nature Conservancy (TNC) has been working with communities to highlight and educate on the topic of living shorelines. TNC has been communicating with the land trust organizations in the state and the property owners with easements along the South Carolina coast. TNC believes these groups are a high priority because they will continue to manage and own these conserved lands in perpetuity. Most land trusts do not have coastal zone experts on staff and can not address erosional issues in house. In an effort to spread the awareness of living shorelines, TNC worked with the seven other land trusts in the state to develop a method for staff and property owners to become more familiar with living shorelines. TNC created an educational handout to provide information on resources for nature-based shoreline stabilizing projects, the status of living shoreline permitting (national and state), and a list of tested materials in the state. Working with our coastal land trust partners, TNC hosted an informal education meeting in March 2016 for conservation property owners in South Carolina with erosion issues. This meeting provided the easement property owners the opportunity to ask questions about their specific shoreline

issues. TNC educated about living shorelines and how to combat erosion with nature-based solutions. TNC was able to share information based on our experience with pilot projects installed in South Carolina since 2009.

The state of oyster restoration in New York/New Jersey Harbor: A review and synthesis.
Michael McCann (1), Lauren Alleman (1), Peter Malinowski (2), Katie Mosher-Smith (2)
(1) The Nature Conservancy, 322 8th Avenue, 16th Floor, New York, NY 10001, USA; (2) Billion Oyster Project, New York Harbor Foundation, 10 South Street, New York, NY 10004, USA

New York/New Jersey Harbor was once home to over 200,000 acres of oyster reef. Poor water quality, disease, and overharvest caused these ecosystem engineers to collapse by the early 1900s. As Harbor water quality began to improve towards the end of the 20th century, interest in restoring oysters to these waters grew. After over 15 years of restoration efforts in The Harbor, it is time to take a critical look at the successes and challenges in order to plan strategically for future work. Here, we review and synthesize the past and present oyster restoration efforts in all of NY/NJ Harbor, including Raritan Bay, Jamaica Bay, and the lower Hudson River. Through a review of published literature, reports, and websites, as well as interviews with restoration practitioners, we have compiled a database of restoration projects, which includes details on site characteristics, restoration technology used, and oyster monitoring protocols implemented. We also recorded whether projects attempted to measure the contribution of oysters to ecosystem services, such as water quality, nutrient removal, wave attenuation, or fishery and biodiversity enhancement. Finally, we have generated a map of oyster restoration efforts, which allows us to compare the location of these projects with the expected distribution of suitable habitats from current habitat suitability models.

New Zealand's blackfoot abalone (*Haliotis iris*) fishery: Restoration successes and future prospects.
Tom A. McCowan (1)
(1) Paua Industry Council Ltd., Private Bag 24-901, Wellington, Wellington 6011, New Zealand

New Zealand's blackfoot abalone (*Haliotis iris*, known locally as paua) fishery is a high-value commercial fishery that also has significant recreational and customary value. New Zealand's paua fishery is one of the largest remaining wild abalone fisheries in the world, however sustained fishing pressure combined with changing environmental stressors have lead to the depletion of some stocks in recent decades. This has seen the implementation of a suite of industry-initiated restorative management tools in the last 15 years. Three examples of restorative management tools are increasing minimum harvest sizes, reseeding aquaculture-raised paua into the wild fishery, and translocating paua from slow-growing to fast-growing habitats. These different tools have been implemented at different spatial scales, and targeted towards enhancing different critical life stages of paua to overcome key challenges in managing a sustainable abalone fishery.

Oyster reef connectivity in lower Chesapeake Bay examined using molecular markers.
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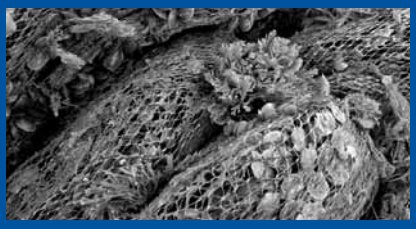
Single nucleotide polymorphism markers (SNPs) were developed for genetic analysis of the Eastern oyster, *Crassostrea virginica*, sampled from the lower Chesapeake Bay. This project was designed in collaboration with the Chesapeake Bay Foundation (CBF) to test a hydrodynamic connectivity model intended to predict where oyster larvae produced in the Lafayette River, Virginia would settle. To test the model, wild oysters from Tangier Island, VA and a hatchery strain were planted in the Lafayette River. Baseline samples from the Lafayette and nearby Elizabeth and James rivers


Ben Cleveland, University of Melbourne


Julie Hills, Ministry for Primary Industries


Ma. Junemie Lebata-Ramos, Southeast Asian Fisheries Development Center

were collected before deployment. Newly recruited oyster spat were sampled from the Lafayette River the summer following deployment and will be sampled again in the fall of 2016. The baseline samples and spat, along with samples from other sites in Virginia, were genotyped and assignment tests were performed to identify source population(s) for the spat. There was a weak pattern of isolation by distance among the lower Chesapeake Bay oysters, suggesting that oyster reef connectivity is high. The hatchery oysters were significantly different from the other oysters in the study; however, the Tangier Island oysters could not be discriminated from the lower Chesapeake Bay oysters. The data support the overall circulation patterns in the region predicted by the model, however, could not provide unequivocal support for the predictions of oyster spat distributions. Several additional hatchery strains were tested to assess the ability of the SNPs to discriminate among hatchery stocks. Results indicate that these markers could be very useful for discriminating hatchery strains from wild populations and for identifying individual hatchery stocks. Additional SNP markers to add discriminatory power are being developed by sequencing a reduced representation genomic library.

Using Reef Balls for shellfish restoration.

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Over the past 250 years we have seen major declines in shellfish populations. Everything from overfishing to water quality to global impacts on the oceans has affected shellfish. The past 20 years a realization of the importance of shellfish to water quality and providing juvenile fish habitat has led to many restoration projects.

Since the 90's Louisiana did a comparative study of materials for oyster restoration showing that Reef Balls outperformed other materials. Many research studies and pilot projects have compared Reef Balls, in shellfish restoration projects, to other artificial and natural structures.

By reviewing the projects using Reef Balls, we can identify best practices for use in shellfish restoration. Site surveys and photo analysis of restoration projects help to identify best practices.

Tampa Bay, Chesapeake Bay, and many organizations have had tremendous success with restoration projects using Reef Balls. The structure provides ideal relief for habitat. The openings and various concave and convex curves in the openings provide eddy current ideal for filter feeders. Reef Balls have survived major storm activity and have a record of staying placed. Creating oyster breakwaters with Reef Balls has been an excellent addition to living shorelines. The concrete mixture is ideal for encouraging spat to settle on the textured surface. Spat can be set in a controlled pool environment then the Reef Ball deployed on site.

Oyster restoration in Maryland: Lessons learned and progress made, the Harris Creek story.

Donald W. Meritt (1), Kennedy Paynter (2), Donald W. Webster (3), Ward Slacum (4)
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Declining oyster populations have been documented worldwide with Chesapeake Bay as a principal example. Efforts to reverse this trend by rebuilding healthy resource populations have occurred in Maryland during the past two decades by significant projects that have had varying successes. The authors illustrate these efforts and provide an assessment of how advances have been incorporated into other restoration activities.

Harris Creek, a tributary of the Choptank River in Maryland's Chesapeake Bay, was the first sanctuary in the state's 2010 Oyster Management Plan to receive concentrated restoration using hatchery-produced spat-on-shell. Participating partners included federal and state agencies, academic institutions and non-governmental organizations (NGOs), allowing aggregation of significant funds for the work. This project coincided with the first significant change in oyster laws and regulations in over a century. Harris Creek resulted in strong successes while allowing participants to identify problems and constraints in the initial project that were subsequently applied to additional locations.

Initial planning classified issues requiring incorporation into successful restoration while identifying known problems typically associated with these projects. Partners identified suitable sites for large-scale restoration as well as types and quantities of substrate to be used as a base. Planting rates and schedules for spat-on-shell hatchery seed were annually determined through group meetings, with evaluation of problems and conflicts requiring modification.

The paper provides a summary of project activities, costs associated with plantings, and the importance of documenting outcomes with ongoing scientific monitoring. A discussion of political and social aspects of large-scale restoration as it affects public harvesters and aquaculture producers is provided with suggestions for addressing these issues as part of project design criteria.

Oyster reef (*Crassostrea virginica*) restoration and responses to 2015-2016 El Niño in Southwest Florida.

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The frequency of extreme events is expected to increase with increased global ocean temperatures. The response of healthy and restored oyster reefs (*Crassostrea virginica*) to extreme climatological events, such as El Niño, is not well understood. The 2015-2016 El Niño affected southwest Florida by having an extended warm and record rainfall during the dry period (November through June). Record rainfall produced high flows and low salinities throughout the region. We examined the response of restored and reference oyster reefs to the 2015-2016 El Niño by measuring and analyzing oyster spat settlement, oyster density and size, the abundance and diversity of oyster reef residents, and salinity. Oyster restoration occurred in November – January 2015 at three sites. Two smaller scale restoration projects (0.25 acres) and one larger scale (0.5 acre) project were compared to nearby reference sites. Salinity was recorded at hourly intervals while settlement was measured monthly. Live oyster density and reef residents were measured before and after construction. A BACI analysis was used to compare mean and variances among restored, control, and reference reefs. Salinity and spat settlement were affected by the El Niño. Long-term viability of restored and reference reefs are threatened by a higher frequency of extreme events and the current flood control policies for Lake Okeechobee and the Caloosahatchee Estuary.

Current status of European Oyster restoration in Germany.

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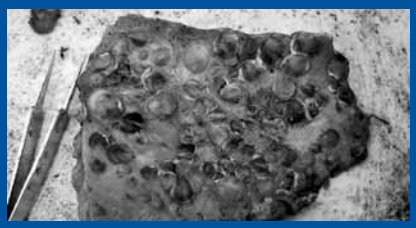
(1) Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research, Am Handelshafen 12, D-27570 Bremerhaven, Germany

In addition to the loss of oyster beds in the North and East Frisian Wadden Sea, also biogenic oyster reef habitats and their associated species-rich fauna and flora in offshore areas of the German Bight vanished within the last century.



Eric Milbrandt, Sanibel-Captiva Conservation Foundation

Gef Flimlin, Rutgers Cooperative Extension

Julie Davis, S.C. Sea Grant Consortium

Because of their high ecological value oyster stocks are now in the focus of European conservation efforts. The Oslo-Paris Commission (OSPAR) identified *Ostrea edulis* as a severely endangered habitat creating species and its protection in their area of distribution was concluded (OSPAR, 2008).

In view of ecosystem-related benefits of oyster reefs, e.g. high biodiversity, the German Federal Agency for Nature Conservation (BfN) is funding a testing and development study for restoration strategies for *Ostrea edulis*. The study is conducted by the Alfred-Wegener-Institute for Polar and Marine Research (AWI) and is considered as a basis for decision making with regard to long-term restoration of the native European oyster in the German North Sea.

The presentation will focus on:
- the historical distribution of *O. edulis* in the German North Sea and reasons for its drastic decline;
- important factors for restoration;
- the special situation in Germany: restoring deep offshore oyster beds;
- current efforts towards regeneration of oyster stocks.

On the one hand, several constraints to restoration have to be considered, e.g. degraded habitats, which are probably less suitable for recruitment. On the other hand, recent developments in water quality improvements as well as the existing knowledge on sustainable management and preservation practices increase the prospects of successful restoration. These aspects will be examined and discussed and aim at the development of strategies for the preservation of this endangered species in European waters.

A review of NOAA Aquaculture's work in support of shellfish restoration.

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NOAA's Office of Aquaculture overseas both regulatory action and scientific research that influence shellfish restoration efforts in every coastal area of the United States. NOAA prioritizes using shellfish farming and restoration to get more oysters, clams, and mussels in water for food, jobs, and ecosystem services. The Office of Aquaculture, in cooperation with its partners, is addressing environmental research, spatial planning, permitting, and restoration and farming techniques through the National Shellfish Initiative.

Marine aquaculture enhances coastal resiliency, creates jobs, improves food security and human nutrition and is a valuable tool to help rebuild some protected species and habitats. Aquaculture techniques can provide valuable tools for managers to help recover threatened and endangered species when recommended in an approved recovery plan or when determined to be necessary to prevent extinction of a species. Aquaculture is also used for habitat restoration and for stock enhancement of commercially and recreationally important species. Shellfish hatcheries are currently being used for oyster restoration efforts in the Chesapeake Bay, Puget Sound, and elsewhere.

From developing and refining tools that can inform aquaculture siting and management decisions, to increasing the understanding of ecosystem services provided by aquaculture, and developing best management practices to reduce potential negative environmental effects of aquaculture operations, NOAA's work spans topics both diverse and critical to shellfish restoration. Touching on ecosystem interactions, genetics, disease, gear/harvest methods, or outreach and social engagement, this talk will review the suite of activities currently in NOAA's aquaculture portfolio that are of interest to the shellfish restoration community.

Oyster-reef growth tracks annual fluctuations in water level.
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Recent advances in measuring oyster-reef growth indicate reefs have a great capacity for growth under the appropriate environmental conditions. Specifically, in lower estuaries, intertidal reefs exhibit a parabolic growth pattern along a tidal-exposure gradient, with distinct no-growth boundaries occurring near mean sea level and mean low water. To assess the growth response of intertidal oyster reefs to interannual fluctuations in mean sea level, we conducted high-resolution topographic surveys along natural and constructed oyster reefs at one- and two-year intervals, a finer temporal scale than previous measurements of reef topography evolution. For each time period, growth rates along different reef elevations were calculated and compared to annual mean sea level, which fluctuated by ± 5 cm. We found that reefs not only exhibited increased vertical growth that scaled with increases in mean sea level, but also experienced erosion in some reef locations during a period of overall lower water-level. Remarkable, reef-scale growth and topography respond to oscillations in water levels that occur over time periods <1 year. These data reinforce the value of intertidal oyster reefs as green infrastructure, being highly resilient to sea-level rise, while also highlighting the need for proper planning in siting intertidal oyster restoration projects.

Influence of microalgae concentrate diet mixture on growth and survival of larval eastern oysters, *Crassostrea virginica*.
Katelyn Roberts (1), Julie Davis (2), Frank Roberts (1), Brian Cabral (3)
(1) Lady's Island Oyster, 16 Marsh Oaks Lane, Seabrook, SC 29940, USA; (2) S.C. Sea Grant Consortium, 102 Industrial Village Road, Beaufort, SC 29906, USA; (3) J & B Island Oysters, Beaufort, SC 29906, USA

Previous studies and success of facilities producing commercial quantities of oyster seed have proven that rearing eastern oyster larvae, *Crassostrea virginica*, using solely microalgae concentrates is effective. Often, these facilities feed solely Shellfish Diet 1800® procured from Reed Mariculture Inc. In an effort to optimize larval survival and growth, varying rations of concentrated Pavlova 1800 was added to the diet for the duration of larval culture. Diet mixtures included: 100% Pavlova, 50% Pavlova/50% Shellfish Diet 1800®, and, as a control, 100% Shellfish Diet 1800®.

Oysters were spawned at the Lady's Island Oyster hatchery in Seabrook, South Carolina, USA. Diet treatments were randomly assigned to eight, 113 L tanks with three replicates per experimental treatment and two control replicates. Larvae were stocked and fed using methods, densities, and volumes recommended by Rikard and Walton (2012). Tanks were drained every other day to assess larval development and survival.

Results indicate that larvae fed a diet consisting of 50% or 100% Shellfish Diet 1800® experienced significantly better survival than oyster larvae fed a diet consisting of 100% Pavlova 1800. While larvae fed a 100% Pavlova 1800 diet performed well initially, they experienced significantly higher mortality by Day 14 than our other treatments. Interestingly, oyster larvae fed a diet consisting of a mixture of 50% Shellfish Diet 1800® and 50% Pavlova 1800 performed the best with regard to survival, achieving 42% greater survival than the control group. Final results of this study will be presented, along with effects of diet on larval growth.

What does the future hold for the oyster fishery and oyster restoration in Texas?
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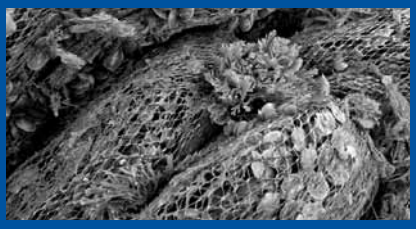
Ben Cleveland, University of Melbourne



Julie Hills, Ministry for Primary Industries

Ma. Junemie Lebata-Ramos, Southeast Asian Fisheries Development Center

The Texas commercial oyster fishery has relied historically on Mother Nature and regulations to maintain the fishery. Production over the past 20 years has averaged five million lbs annually, but with substantial variation (2.7 to 6.8 million lbs) due partly to red tide, extreme weather, and human-induced events. The fishery spans the Texas coast from primarily Copano Bay to Galveston Bay on about 39,000 acres of public reefs in certified waters with harvest from November through April. In addition, about 2,300 acres of private leases in Galveston Bay are harvested year-round by lease-holders. Over the past decade, oyster harvesters on public grounds have not typically reached daily sack limits and independent sampling by Texas Parks and Wildlife Department (TPWD) found catch per unit effort rates diminishing since 2002. Sustainability is understood by commercial oyster industry members, which led to an agreement of a sack tax that has assisted, along with federal support, with placing cultch on approximately 435 acres from 2009-2014. Similarly, non-governmental organizations, such as Galveston Bay Foundation, The Nature Conservancy, and Texas A&M University have been conducting oyster reef restoration projects in Galveston Bay, Matagorda Bay, and Copano Bay, respectively. All private leases are up for renewal this coming year, which is allowing TPWD and Texas General Land Office to examine and suggest changes to assist both fishery and restoration efforts. Potential changes include the expansion of private leases beyond Galveston Bay, the utilization of private industry to assist with reef restoration through lease rollback agreements, and restoration leases being off-limits to harvesting for 15 years, thus acting as a spawning sanctuary. Legislative discussion and action on these changes is pending.

Pilot deployment of a novel substrate to create oyster habitat in Port Royal Sound and the ACE Basin NERR, South Carolina, USA.

Benjamin W. Stone (1), Al Segars (1), Gary Sundin (1), Peter Kingsley-Smith (1), Nick Wallover (1)
(1) S.C. Department of Natural Resources, 217 Fort Johnson Road, Charleston, SC 29412, USA

In South Carolina, naturally-occurring intertidal Eastern oyster (*Crassostrea virginica*) populations are limited by the availability of hard substrate suitable for larval recruitment. The South Carolina Department of Natural Resources (SCDNR) has experimented with alternative reef-building substrates as a means to expand the footprint of oyster reef habitat enhancement and restoration efforts statewide. As an example, the SCDNR has successfully used re-purposed, cement-coated abandoned crab traps to create new oyster reef habitat, while also addressing the ecological threats posed by the ghost fishing mortality caused by this form of marine debris. Current regulations, however, prevent private citizens from removing abandoned traps, creating the need for a similarly effective product that can be easily acquired by the general public. A newly designed modified crab trap structure was purposefully fabricated and field-tested for future adoption by private property owners wishing to create oyster reefs as a living shoreline alternative to traditional armoring structures, such as sea walls or bulkheads, in front of their private property. These modified traps were deployed at two sites along the South Carolina coast in the spring of 2016. The sites were monitored immediately prior to trap deployment and again three months later to evaluate oyster density and growth, as well as changes in surface sediment composition, sediment accretion/erosion, and the position of the marsh edge. These monitoring efforts were aimed at determining the potential of these new reef structures to be utilized by the general public to create "living shorelines" adjacent to their private property. The effectiveness of these new structures, monitoring results, regulatory context to the project, and some lessons learned will be presented here.

Celebrating Cedar Key: A model for restoring coastal fishing communities through shellfish aquaculture.

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Shellfish aquaculture is a relatively new industry in Florida. During the 1990s a transition to clam farming as an alternative employment opportunity for fishermen affected by regulations was facilitated through job retraining programs. Today, over 250 Florida growers produce about 150 million hard clams annually on leases located in inshore coastal waters with sales of $18.7 million reported in 2013. In Cedar Key, where over 80% of the state's clams are harvested, the industry supports an estimated 400 jobs (e.g., seed suppliers, boat builders, truck drivers), generating a gross revenue impact to the area's economy of $31 million. To ensure the sustainability of their new economy, the city, county, state and federal agencies have invested in infrastructure to remove septic tanks, manage storm waters, and preserve coastal lands. These actions have resulted in the restoration of 4,770 acres of shellfish harvesting waters previously classified as prohibited and reclassification of 100,500 acres as approved. In turn, shellfish aquaculture can provide local communities with a variety of ecosystem services. To demonstrate the unique sustainability of clam aquaculture in Florida, three environmentally-beneficial ecosystem services were quantified – 544 million gallons of seawater were filtered by the harvest of 136 million clams in 2012, over 25 thousand pounds of nitrogen and 760 thousand pounds of carbon were removed, and $99,680 in benefits generated. Other benefits of shellfish aquaculture presented include cultural renewal of working waterfronts and creation of aquaculture by-products (clam shell, damaged culture bags containing cultch and spat) for use in oyster restoration projects.

3-Dimensional Oyster Reef Restoration in Matagorda Bay, TX.

Julie A. Sullivan (1)
(1) The Nature Conservancy, Texas Chapter, 205 N. Carrizo Drive, Corpus Christi, TX 78418, USA

Oyster reefs are the most imperiled marine habitat on earth, and are listed as being only in 'fair' condition in the Gulf of Mexico. Half Moon Reef is one such oyster reef that has mysteriously vanished. Nobody knows what happened to the former 500 acre reef that has all but disappeared; possible causes include mud shell dredging, siltation from hurricane Carla, possible overharvest, or altered salinity from man-made diversions. The Nature Conservancy designed an innovative method of reef restoration by placing rows of rock underwater to replicate the 3-Dimensional nature of natural reefs. Design innovations include laying out the reef in rows to increase surface area, using larger rocks that will stay in place, and varying the sizes of the rock material used to increase interstitial spacing. The two-year old project is already a great success, with market sized oysters covering the reef.

Research at Half Moon Reef Oyster Restoration in Matagorda Bay, TX.

Julie A. Sullivan (1)
(1) The Nature Conservancy, Texas Chapter, 205 N. Carrizo Drive, Corpus Christi, TX 78418, USA

Cultch material was placed at Half Moon Reef in winter 2013-2014, with the anticipation that oysters would colonize the size and grow into a restored oyster reef. Two years later, we have seen the success of having a reef covered with an abundance of healthy, market sized oysters. The performance of a restored oyster reef needs to be monitored, and with the innovative 3-dimensional design of this reef, we designed several monitoring points. Half Moon Reef is being monitored for the success of the oysters, habitat function, use of the reef by keystone fishes, morphology of the reef shape, and socioeconomic benefits of the reef. It is our hope that by demonstrating the stacked levels of success on this reef, other project managers will decide to build 3-Dimensional oyster reefs in their bays.

Source-tracking and modeling water quality of tidal waters.

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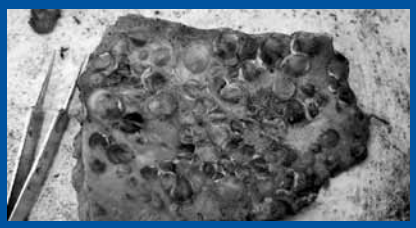
(1) City of Norfolk (VA), 401 Monticello Avenue, Norfolk, VA 23510, USA; (2) College of Charleston Dept. of Geology,



Eric Milbrandt, Sanibel-Captiva Conservation Foundation

Gef Flimlin, Rutgers Cooperative Extension

Julie Davis, S.C. Sea Grant Consortium

66 George Street, Charleston, SC 29424, USA; (3) Charleston Waterkeeper, P.O. Box 29, Charleston, SC 29402, USA; (4) University of South Carolina Arnold School of Public Health, Columbia, SC 29208, USA; (5) Mount Pleasant Waterworks, 1619 Rifle Range Road, Mount Pleasant, SC 29464, USA

Upper Inlet Creek (UIC), located in a tidal basin along the Atlantic Intracoastal Waterway near Charleston, South Carolina is an important estuarine habitat and supports molluscan shellfish operations. UIC has been listed as impaired for shellfishing activities due to high levels of fecal coliform, a type of bacteria indicator (SC 303(d) list). It is unknown whether this impairment is due to human fecal contamination (i.e., sewage or septic waste) or non-point sources (stormwater runoff, pets and/or wildlife). There are no known sewage outfalls in the watershed but possible that residential septic leachate fields (legacy and/or active) exist in the surrounding area. To model causes and sources of fecal coliform contamination in UIC, inexpensive source-tracking methods and site-specific approaches were employed: targeted sampling for fecal indicator bacteria fecal coliform and enterococci; optical brightener measurements (a proxy for human-sourced graywater); and direct water quality sampling in the basin. Optical brighteners served as a screening tool to determine presence or absence of human-sourced waste. Combination of microbiological and optical brightener data and site-specific models showed that human waste was not a likely primary source of fecal coliform pollution in this coastal waterway. Presumptive TMDL (total maximum daily load) model results for fecal coliform showed bacteria loading from non-human sources (dogs, cats and waterfowl) may be as high as 53% of the total bacteria load, with stormwater a potential 46% of total bacteria load, presumed through stormwater runoff into UIC waters. Recommendations for future remediation include best management practices to mitigate stormwater runoff and the use of predictive modeling to understand how land use change could affect fecal coliform loading in this and similar tidal basins.

Wave exposure structures oyster distribution on natural intertidal reefs but not on hardened shorelines.

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Intertidal oyster reefs can protect estuarine shorelines from wave erosion and sea level rise, and recognition of these ecosystem services has fueled global efforts to conserve and restore these reefs. Although intertidal oyster reefs are valued for attenuating wave erosion, little attention has been paid to the effects of wave exposure on their distribution. The present study characterized the role of wave exposure in determining the distribution of natural intertidal oyster (*Crassostrea virginica*) reefs and of oysters on hardened shorelines (e.g., bulkhead and riprap revetments). Wave exposure was determined using the NOAA-developed Wave Exposure Model (WEMo). Field mapping of oyster reefs, defined as ≥ 10 oysters m-2, in Pamlico and Core Sounds, North Carolina, USA was conducted during summer 2014. Hardened shorelines and associated oyster densities were mapped for Pamlico Sound only. A narrow wave exposure threshold (500 J m-1) was identified above which natural intertidal reefs did not occur and below which reef presence was dependent on other structuring variables, such as salinity at the time of sampling and the grain size of surrounding sediments. Wave exposure was not correlated with the presence of oysters on hardened shorelines. We further quantified oyster density and demographic rates (growth and survivorship) on these reef types in Pamlico and Core Sounds, and compared these data with similar data collected for subtidal oyster sanctuaries, natural and cultch reefs. These findings can be useful for selecting locations and materials for intertidal oyster reef restoration.

Structural complexity effects on the initial similarity in resident prey survival among natural and created intertidal oyster reefs.

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Oyster reef structural complexity negatively affects predator success increasing prey survival and positively influencing the density and diversity of reef-resident taxa. In South Carolina, intertidal reefs protected from harvesting typically develop an extensive vertical profile from growth and haphazard aggregation of individual oysters. In contract, created reefs constructed by placing bags of shell out in the environment initially lack the complexity of natural reefs. Effects of reef vertical complexity on prey survival were investigated by comparing predator success within natural reef, created reef, and mudflat habitats. Experiments were conducted within the first year after reef construction before settlement and growth increased structural complexity on created reefs. Prey (e.g., mud crabs, ribbed mussels) were tethered within each habitat and survival monitored over 48h. Crab survival consistently was dependent on structural complexity; natural › constructed › mudflat. Complexity also influenced survival of small (‹40 mm) but not medium (33-55 mm) or large mussels (›70 mm); small mussel mortality was greater within both reefs habitats. Results highlight the importance of considering the role of structural complexity and predator-prey relationships in reef restoration and the need for additional information to determine intertidal oyster reef, both natural and constructed, influences on coastal food webs.

Eric Milbrandt, Sanibel-Captiva Conservation Foundation

Notes

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INTERNATIONAL CONFERENCE ON SHELLFISH RESTORATION

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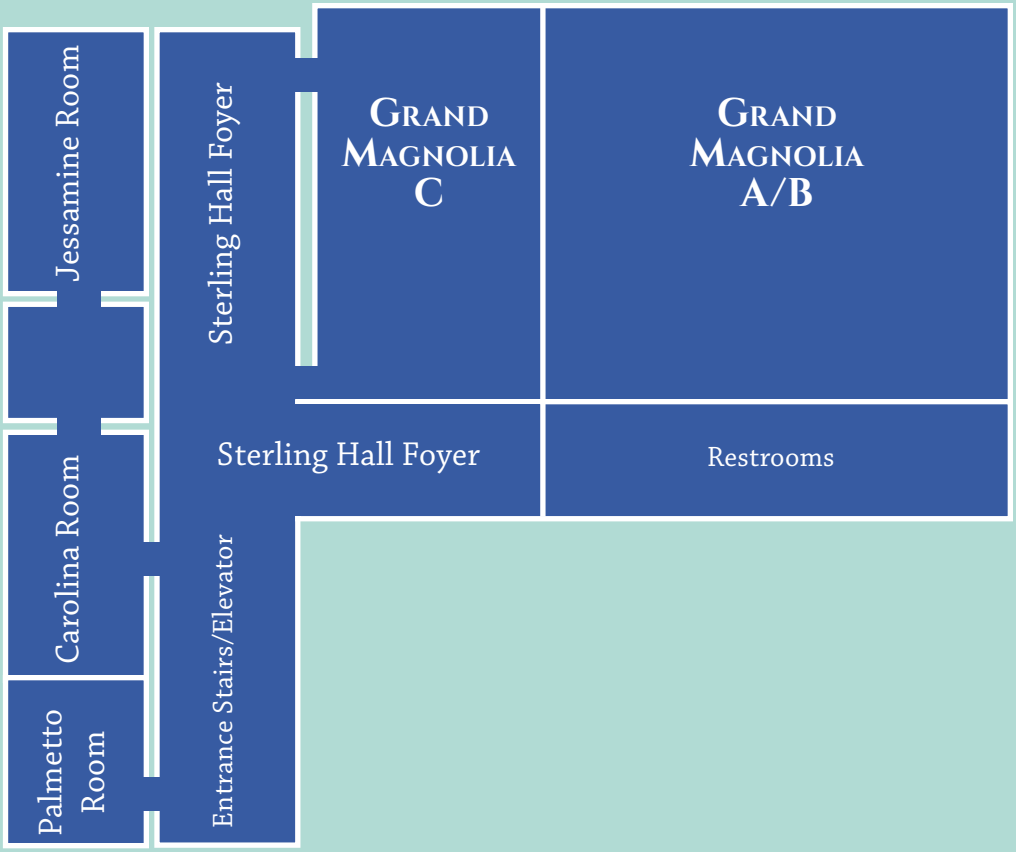

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