



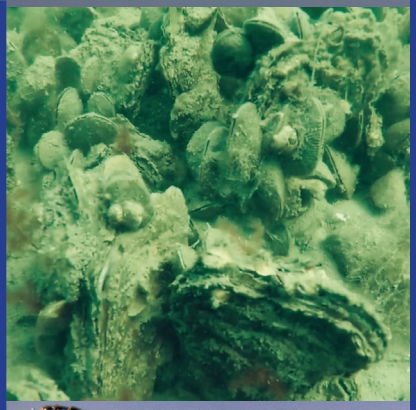

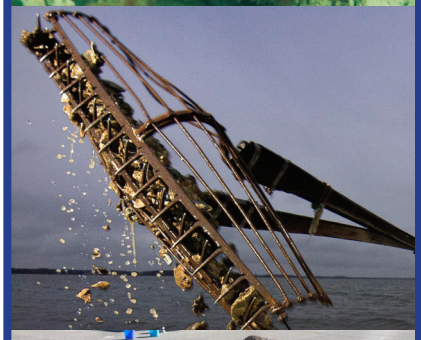






Oyster Futures

Recommendations for Oyster Management and Restoration in the Choptank and Little Choptank Rivers

A Report Submitted to Secretary Belton, Maryland Department of Natural Resources

By the OysterFutures Stakeholder Workgroup

May 14, 2018

Although the location of this oyster shell pile is not known, this image often has been used to symbolize the historic abundance of oysters in Chesapeake Bay and the many people that they supported. The orange triangle indicates a large pile of shell in Maryland today. Image credit: Cooperative Oxford Laboratory Library.

The Back Story

One hundred years ago, oysters in Maryland formed the bedrock of local economies and a healthy and thriving Chesapeake Bay. Today, oysters and the oyster industry are a shell of what they used to be. More oysters are needed to restore the resource and ecosystem, protect and enhance our oyster industry, and preserve Maryland's cultural heritage. Yet, the path to a more productive future is not clear and conflict has slowed forward progress. This research program, OysterFutures, offers a solution by testing a new process for creating policies and regulations that are designed to increase oysters, benefit the ecosystem, and sustain and grow our oyster industry.

ACKNOWLEDGMENTS

The OysterFutures research program would not have been possible without the valuable time and effort of the people on the **Stakeholders** Workgroup. We appreciate their dedication and their weekends, including Super Bowl Sunday. We are grateful to the **National Science Foundation** for funding the OysterFutures program, and to the University of Maryland Center for Environmental Science (UMCES) **Horn Point Laboratory** for logistical support. Special thanks to the professional independent facilitators from Florida State University's FCRC Consensus Center who developed the Consensus Solutions process and facilitated the nine OysterFutures workgroup meetings. Many thanks to the researchers from UMCES and the Virginia Institute of Marine Science for scientific support throughout the process, and to the science communicators from UMCES Integration and Application Network (IAN) who provided design and logistical expertise. We thank the families and organizations of all involved for their support.

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Oyster Futures

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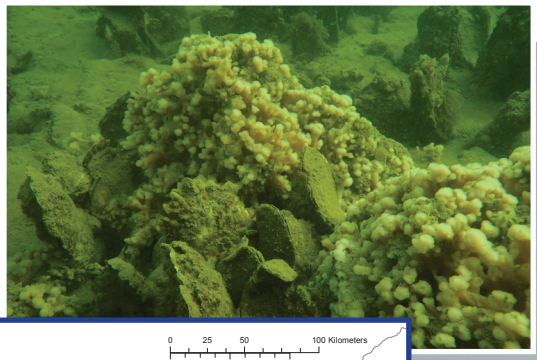
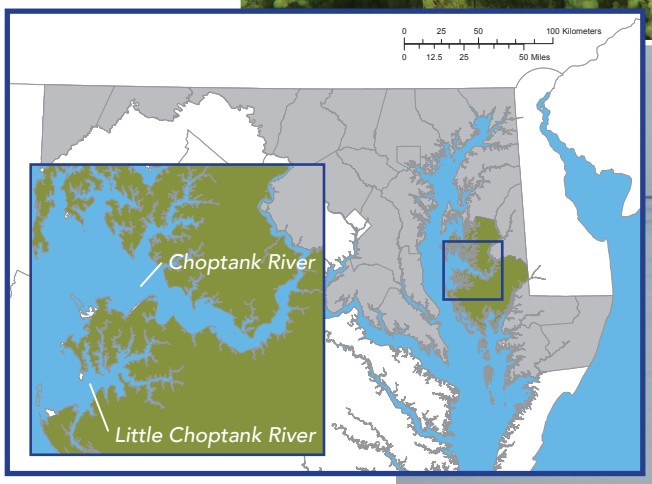
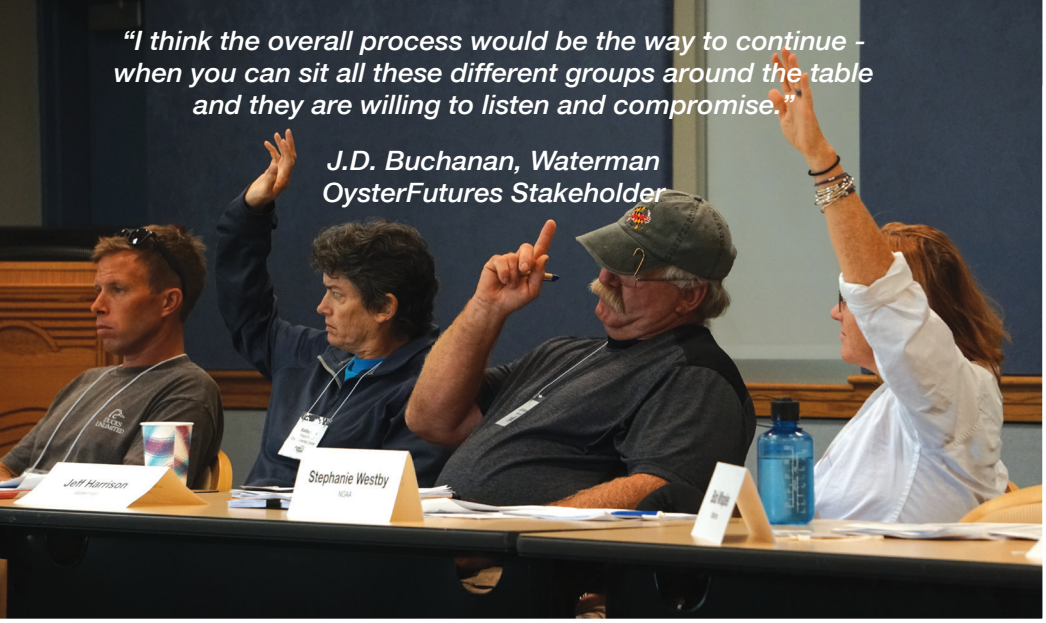




"The issue around oysters is an age-old one. This has been going on for 200 years. I feel that we're finally getting to a place to meet the modern-day needs of the resource, of the industry, of the estuary around it, and that it is a proud day for the state of Maryland."

Johnny Shockley, Hoopers Island Oyster Aquaculture Co.
OysterFutures Stakeholder



"I think the overall process would be the way to continue - when you can sit all these different groups around the table and they are willing to listen and compromise."

J.D. Buchanan, Waterman
OysterFutures Stakeholder

CONSENSUS VISION THEMES

In a visioning exercise at its first meeting, Workgroup members reached consensus on the following **VISION THEMES**. These themes provided structure for the regulation and policy options that stakeholders brainstormed and discussed during the following meetings and provided the foundation for the recommendations in this report.

MANAGEMENT AND REGULATIONS – The management of the oyster resource is conducted by working collaboratively with stakeholders to ensure that protection of the fishery and habitat is implemented in a manner that provides fair and equitable access to the oyster resource.

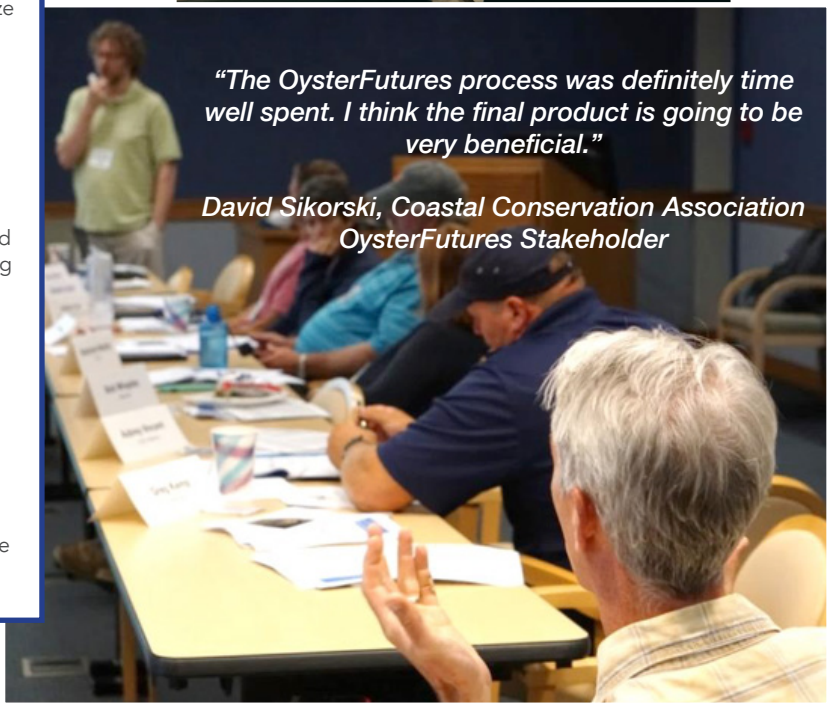
HARVESTING/FISHING PRACTICES – Participants of the oyster fishery are using the most innovative and productive techniques available to maximize efficiency and the protection of the resource, supported by science, data and field experience and observation.

SUSTAINABLE AND ECONOMICALLY VIABLE OYSTER FISHERY – The Choptank River oyster fishery is managed and conducted in a manner that ensures the fishery is sustainable and economically viable for fishery stakeholders.

HEALTHY AND PRODUCTIVE ECOSYSTEM – The ecosystem is managed in a manner that supports ecosystem services by protecting and enhancing the habitat and resource in a sustainable and productive manner.

THRIVING COMMUNITY/REGION – The Choptank River oyster fishery and ecosystem serve as key components of the Region's cultural heritage and economic viability, and serve to sustain an economically viable and thriving fishery, recreation and tourism industry.

EDUCATION INITIATIVES – Stakeholders of the Choptank River region are committed to working together collaboratively to provide education and communication on the importance of maintaining the health and productivity of the oyster resource and the role it plays in ensuring that the community thrives.



"The OysterFutures process was definitely time well spent. I think the final product is going to be very beneficial."

David Sikorski, Coastal Conservation Association
OysterFutures Stakeholder

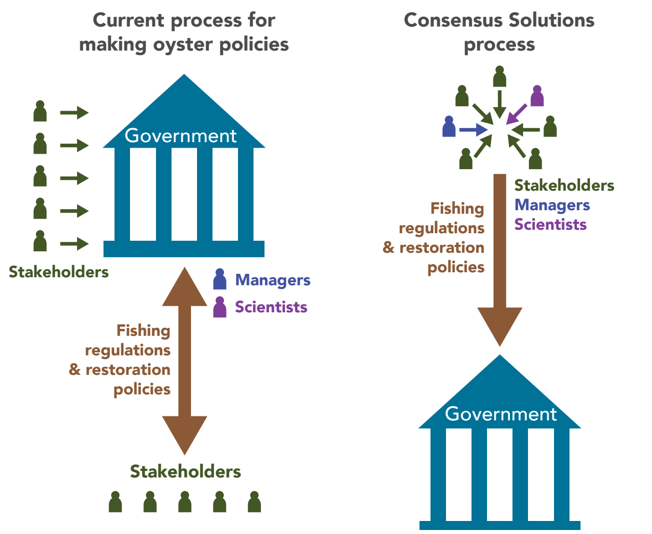
STATEMENT OF PURPOSE

The eastern oyster (*Crassostrea virginica*) has many important roles in the Chesapeake Bay. New regulations and policies are needed to enhance the industry, improve ecosystem health, ensure access for future generations, and maintain Maryland's cultural heritage. The OysterFutures research project addressed this need by testing a new approach for making regulations and policies called the Consensus Solutions process. This process combined stakeholder and scientific knowledge, and provided a structure that allowed the stakeholders to integrate their perspectives, use scientific forecasts, and develop a consensus set of recommendations for new policies and regulations.

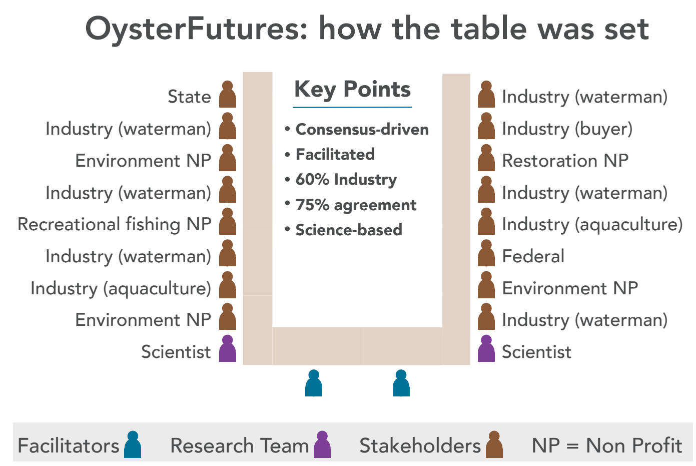
The goal of the OysterFutures Workgroup was to develop a package of consensus recommendations for oyster policies and management that meet the needs of industry, citizen, and government stakeholders in the Choptank and Little Choptank Rivers. With funding from the National Science Foundation, nine workgroup meetings were held with a representative group of stakeholders from the key interest groups that affect and are affected by the oyster fishery. Through these meetings, the stakeholders produced a collective vision for the future of oysters in this region, collaboratively developed a computer model with the OysterFutures research team, and built consensus on policy and regulatory options informed by the model. Scientists on the Research Team served as consultants to the stakeholders. Professional independent facilitators convened the stakeholder meetings and ensured that the Consensus Solutions process was used.

The OysterFutures Stakeholder Workgroup's ultimate goal was to ensure that the regulation and management of the oyster fishery, and oyster restoration polices, are informed by the best available science and shared stakeholder stewardship values, resulting in an economically viable, healthy and sustainable Choptank and Little Choptank Rivers oyster fishery and ecosystem.

This report contains the consensus package of recommendations on oyster management and restoration in the Choptank and Little Choptank Rivers that the OysterFutures Stakeholder Workgroup respectfully submit to Secretary Mark Belton of the Maryland Department of Natural Resources.



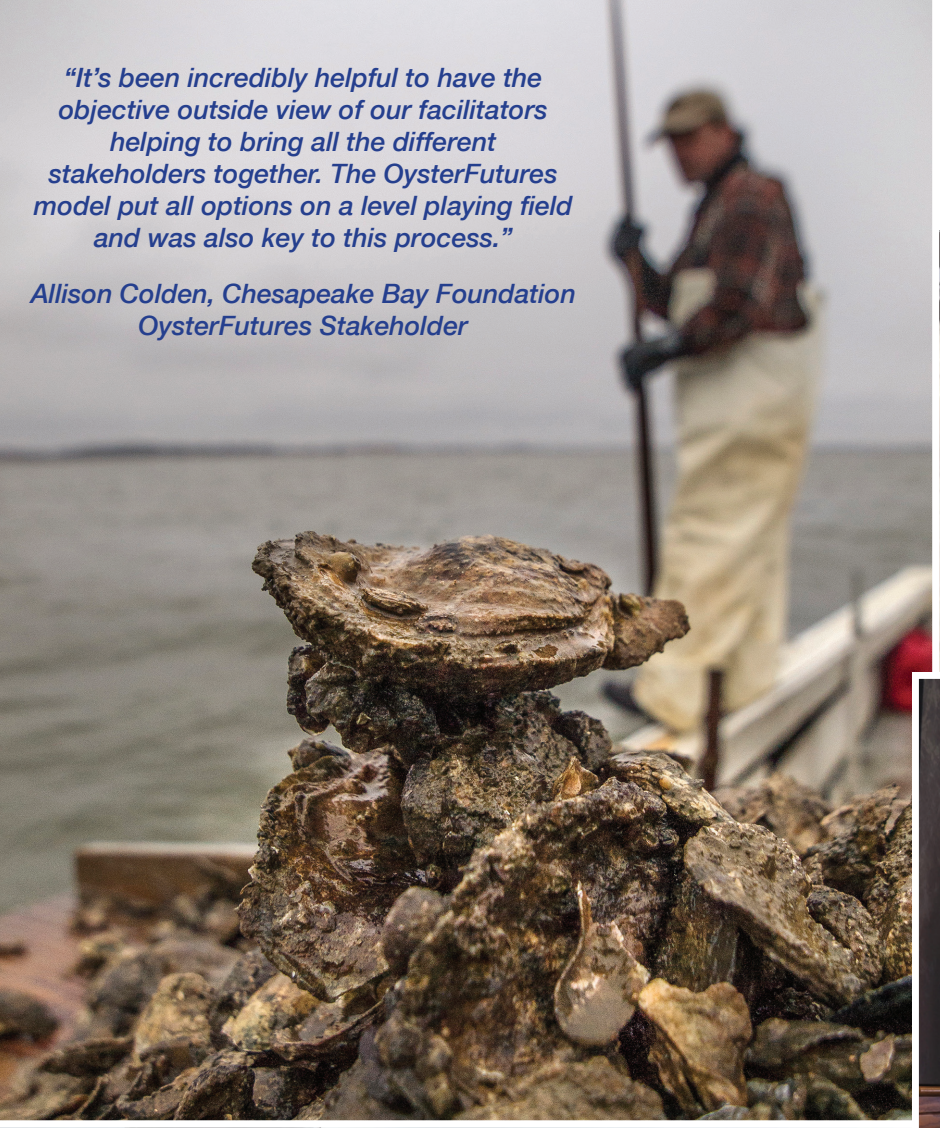
With the consensus solutions process, stakeholders make recommendations for policies to the government. The process can include public comment. Image credit: Elizabeth North.



During the OysterFutures Workgroup meetings, stakeholders sat at a U-shaped table in a different seat at each meeting. Image credit: Dylan Taillie.

"It's been incredibly helpful to have the objective outside view of our facilitators helping to bring all the different stakeholders together. The OysterFutures model put all options on a level playing field and was also key to this process."

Allison Colden, Chesapeake Bay Foundation
OysterFutures Stakeholder



"The Consensus Solutions process is a good way to bring varying viewpoints to the table and ensures all sides are able to meet in the middle and work toward common ground."

Robbie Casho, Waterman
OysterFutures Stakeholder

MANAGEMENT RECOMMENDATIONS

A. THE NEED FOR CHANGE

The OysterFutures Workgroup recommends that DNR take swift and positive action to change existing regulations and policies regarding oyster management in the Choptank and Little Choptank Rivers. Maintaining the Status Quo (current regulations and policies) does not benefit the oyster resource or the ecosystem and human economies that depend on it. Change is needed.

B. ENFORCEMENT RECOMMENDATIONS

The OysterFutures Workgroup reviewed enforcement options that could be modeled to determine their impact on oyster abundance, habitat, and harvest. The Workgroup found that enforcement and compliance play an important role in ensuring the protection of the oyster resource, and has the following recommendations:

1. In consultation with oyster resource stakeholders, DNR should enhance enforcement presence on the water, address noncompliance by providing funding to increase the numbers and training of compliance officers, and support strategies such as checking oysters where they are bought.
2. To enhance compliance, DNR should modify regulations so a single oyster bar is not divided between gear types, or where parts are open and other parts are closed.
3. To help inform and guide oyster resource participants in the Choptank system, DNR should address, correct and update DNR oyster resource mapping issues such as bottom mapping to better define oyster bars, and provide electronic maps that could be used with GPS chart programs.
4. DNR should provide the necessary resources to make its website more user friendly.
5. To protect the oyster resource, oyster populations, and the oyster industry, DNR should strive for full compliance with the current size laws and sanctuary regulations.

C. LIMITED ENTRY RECOMMENDATION

The OysterFutures Workgroup discussed options for maintaining a level of fishing effort which would improve the long-term viability of the oyster fishery and the health of the oyster resource. The workgroup has the following recommendation:

1. Working together with oyster resource stakeholders, DNR should evaluate a limited entry oyster fishery that can provide access to watermen making the majority of their living from commercial fishing, enables generational succession in the fishery, and should have a way for new participants to gain entry that does not solely rely on having a large amount of capital.

D. ROTATIONAL HARVEST RECOMMENDATION

The Workgroup evaluated opening portions of sanctuaries to rotational harvest where no restoration

activities have taken place or are planned, and recommends that DNR implement a 2 year hand tong rotation in Middle Choptank sanctuary paired with planting spat on shell in the closed years.

E. HABITAT MODIFICATION AND RESTORATION RECOMMENDATIONS

The OysterFutures Workgroup reviewed options for improving oyster habitat and restoring oyster populations, and conducted model runs to determine the impact of these options on oyster abundance, habitat, and harvest. The Workgroup found that habitat enhancement and restoration would significantly enhance the oyster resource and industry, and has the following recommendations:

1. Working in consultation with the Talbot County Oyster Shell Committee, DNR should increase the annual budget to support adding shell each year in Broad Creek to significantly enhance the habitat, and increase oyster abundance and harvest.
2. Working in consultation with the Dorchester County Oyster Shell Committee, DNR should open tributaries in the Little Choptank River to hand tonging, and increase the annual budget to support adding spat on shell every three years to significantly enhance the habitat and increase oyster abundance and harvest.
3. DNR should work with federal partners to complete the planned restoration activities in the Little Choptank and Tred Avon Rivers.
4. DNR should help coordinate stakeholder input in the permitting process to enable placement of privately-funded reefballs in the Middle Choptank River in areas that would not be in conflict with fishing activities (e.g., near/around the bridge, channel markers, etc.).

F. PLANTING HATCHERY-REARED SPAT RECOMMENDATION

The OysterFutures Workgroup reviewed options for planting hatchery-reared oysters, and conducted model runs to determine the impact of these options on oyster abundance, habitat, and harvest. The Workgroup found that planting hatchery-reared spat would enhance the oyster resource and industry, and has the following recommendation:

1. Working in consultation with the Dorchester and Talbot County Oyster Shell Committees, DNR should increase the annual budget to support adding spat on shell each year in the Middle Choptank River to enhance habitat and increase oyster abundance and harvest.

G. SHELL RESOURCE RECOMMENDATIONS

The OysterFutures Workgroup recognizes the fundamental need for clean shell and substrate which will support many of their recommendations for enhancement of the oyster resource, including restoration, habitat improvement, and stocking.

1. The Workgroup recommends that DNR should evaluate and develop cost effective strategies, through engagement with stakeholders, for identifying sources of shells and substrate to supplement the oyster bars and increase the viability of the oyster resource.
2. DNR should review the current state regulations and evaluate potential strategies, including providing economic incentives, to retain shell in the state of Maryland.

H. COMBINED OPTIONS RECOMMENDATION

The OysterFutures Workgroup requested that combinations of the options be considered and evaluated for implementation. Model results showed that the oyster resource and fishery would significantly improve when multiple options were combined. The OysterFutures Workgroup recommends that DNR evaluate and consider combining options to take advantage of these improvements. Among the combined options modeled and considered, the Workgroup rated the three below with consensus support:

1. Add spat every year in Middle Choptank; 2-yr rotation in Little Choptank tributaries with spat on shell; Complete Little Choptank and Tred Avon restoration.
2. Add spat every year in the Middle Choptank; Complete Little Choptank and Tred Avon restoration; full compliance with current size laws and sanctuary regulations.
3. Add spat every year in the Middle Choptank; Add shell to each bar every year in Broad Creek; Complete Little Choptank and Tred Avon restoration; Place reefballs in the Middle Choptank region; full compliance with current size laws and sanctuary regulations.

I. CONSENSUS SOLUTIONS PROCESS RECOMMENDATION

Based on its experience with the consensus solutions process, the OysterFutures Workgroup recommends that DNR invest in and support this type of process for including stakeholders in decision making. The Workgroup has found that this type of structured engagement with stakeholders and scientists on oyster resource policies and management issues can meet the needs of industry, citizens, and government stakeholders and will result in better decisions that have the broad support of more groups.

J. BUSINESS PRACTICES & MARKETING RECOMMENDATION

In recognition of the important role that the oyster industry plays in the Choptank region, the OysterFutures Workgroup recommends that DNR should work with other related Maryland, Virginia and Federal agencies to coordinate investments in marketing strategies and development of business plans that celebrate cultural heritage and support the oyster resources in the Chesapeake Bay and Choptank River system. Examples include developing a Chesapeake Oyster Trail, implementing a "True Blue" initiative for oysters, creating strategies to build on the growing consumer interest in local products, and partnering with the Working Waterfronts program.

K. FEES & TAXES RECOMMENDATION

To assist with funding new efforts to enhance the oyster resource and industry, the OysterFutures Workgroup recommends that, in consultation with oyster resource stakeholders, DNR should evaluate and consider changes and increases of oyster fishery related fees and taxes (e.g., increasing the bushel tax and oyster surcharge) to support a thriving and healthy oyster resource for current and future generations.

L. EDUCATION & TRAINING RECOMMENDATIONS

The OysterFutures Workgroup recognizes the important need to educate and train citizens about stewardship of the oyster fishery and resource, with the goal of maintaining thriving and healthy oyster resources for current and future generations. The Workgroup recommends that:

1. DNR should work with stakeholders and other agencies to support environmental education opportunities for the public and children on the important role of oyster resources in the region's economic viability, ecosystem, cultural heritage, and tourism.
2. DNR, in consultation with oyster resource stakeholders, community colleges, and universities, should support educational programs which provide training and apprenticeships for the industry, fisheries science and management, and the Consensus Solutions process.

M. RESEARCH RECOMMENDATIONS

In the process of developing the model, the OysterFutures Workgroup identified several knowledge gaps, which if filled, would enhance management of the oyster resource. The Workgroup supports conducting and funding the following research to:

1. Better understand the efficiency of gear types and their impacts on the oyster resource, habitat quality and shell.
2. Continue to address and find solutions to reduce the effects of oyster diseases.
3. Review data from the restoration efforts to estimate the financial and economic benefits of enhanced water quality, including nutrient credit trading programs.
4. Support research to evaluate the economic benefits and impacts of the oyster fishery and replenishment activities.
5. Review best management practices and outcomes for oyster resources and study and adapt successful techniques and applications from other places and regions.
6. Conduct research on the performance of shell plantings over time.
7. Conduct research on alternative ways to maximize the use of shell resources in plantings and restoration, e.g. cultchless seed setting.

Oyster Futures

STAKEHOLDER WORKGROUP

Top row from left: *Johnny Shockley, Ward Slacum, Cody Paul, Kelley Cox, Allison Colden, David Sikorski, Jeff Harrison, Robert Whaples, J.D. Buchanan, Greg Kemp, Robbie Casho, Bobby Leonard.* **Bottom row from left:** *Dave Blazer, Stephanie Reynolds Westby, Joe Fehrer.* **Not pictured:** *Aubrey Vincent.*

Dave Blazer [Chris Judy designated alternate], *Maryland Department of Natural Resources*

Dave Blazer is the director of Fishing and Boating Service for the Department of Natural Resources (DNR). A graduate of Towson University, Blazer brings over three decades of Maryland-focused environmental and natural resource experience. He has held numerous leadership roles with the DNR, Chesapeake Bay Commission, Maryland Coastal Bays Program, and the Maryland Port Administration.

J.D. Buchanan, *Talbot County Waterman*

J.D. Buchanan is a 3rd generation waterman from Talbot County who has oystered for over 40 years. He is an active member of the Talbot County Waterman's Association.

Robbie Casho, *Dorchester County Waterman*

Robbie Casho is a Dorchester County Waterman. He serves on the Dorchester County Shell Committee for Hand Tongers. He works on the Choptank River year round, trotlining for crabs, power dredging and hand tonging oysters.

Allison Colden, *Chesapeake Bay Foundation*

Dr. Allison Colden, Maryland Fisheries Scientist for the Chesapeake Bay Foundation, is responsible for providing scientific expertise and technical support for the organization's fisheries policy and restoration programs. Allison holds a Ph.D. in Fisheries Science from the Virginia Institute of Marine Science.

Kelley Cox, *Phillips Wharf Environmental Center*

A native of Tilghman Island, Kelley Cox is the founder and executive director of Phillips Wharf Environmental Center. A trained marine biologist with a degree from Salisbury University, Kelley is actively involved with the Maryland Association of Outdoor and Environmental Educators, Mid-Atlantic Marine Educators Association, National Marine Educators Association, and Maryland Oyster Advisory Commission.

Joe Fehrer, *The Nature Conservancy*

Joe Fehrer grew up in Snow Hill MD and works for The Nature Conservancy on the lower shore of Maryland and the eastern shore of Virginia. Joe does substantial public outreach and frequently works with federal, state and local government staff and elected officials on climate change issues. Joe is an active member of the US Coast Guard's Sector VA and MD Area Committees, and the Sector VA Executive Committee.

Jeff Harrison, Talbot County Waterman, *President Talbot Watermen's Association*

Jeff Harrison is a fifth generation commercial fisherman, the President of the Talbot Watermen Association, the chairman of the Talbot County Oystershell Committee, member of the Maryland Oyster Advisory Commission and oystermen for 41 years. Jeff participated in the harvest and shell and seed replenishment program for all of his many years on the Choptank.

Gregory Kemp, *Talbot County Waterman, President Talbot County Seafood Heritage Association*

Greg Kemp is a 4th generation waterman from Talbot County. He is the President of the Talbot County Seafood Heritage Association and is an active member of the Maryland Watermen's Association, the Oyster Advisory Commission, the Talbot Commercial Oyster Committee, and the Maryland Blue Crab Industry Advisory Committee.

Bobby Leonard [Mary-Julia DuBois designated alternate], *Tred Avon Treats, Ruff-N-Ready, LLC.*

Bobby Leonard is the founder and owner of Tred Avon Treats, an aquaculture business, as well as Ruff-N-Ready, LLC., a seafood retail business. He has lived in Talbot County his whole life and takes pride in his oysters which support the health and economy of Broad Creek.

Cody Paul, *Dorchester County Waterman, Dorchester County Oyster Committee Chair*

Cody Paul is a fifth generation waterman from Hoopers Island. He crab pots and harvest oysters for a living and has a degree in Accounting. He is the chairman of the Dorchester County Oyster Committee.

Johnny Shockley, *Hoopers Island Oyster Aquaculture Co.*

Johnny Shockley is a founding partner of Hoopers Island Oyster Company. A third-generation watermen from Hoopers Island, Johnny crabbed and oystered on the Chesapeake for 30 years. Johnny oversees hatchery, nursery and farm operations in Crocheron and Fishing Creek. Johnny works to line up industry partners, policy makers and watermen to lead an oyster farming revolution on the Chesapeake Bay.

David Sikorski, *Coastal Conservation Association*

David Sikorski is the Executive Director of the Maryland chapter of the Coastal Conservation Association (CCA). David is a native Marylander and lifelong sportsman. Davids interest in policy and love for the outdoors led him towards CCA Maryland in 2005 he began volunteering as a part of their Government Relations Committee. David started as the Executive Director of CCA Maryland in early 2017.

Ward Slacum, *Oyster Recovery Partnership*

Ward Slacum is the Director of Programs Operations with the Oyster Recovery Partnership (ORP). Ward is responsible for activities within ORP's programs in Oyster Restoration, Shell Reclamation, Oyster Aquaculture and Fisheries. Ward has a broad background in marine science and has been supporting Bay restoration for the past 20 years through research and cooperative programs with watermen.

Aubrey Vincent, *Lindy's Seafood*

Aubrey Vincent is the Sales Manager at Lindy's Seafood, Inc., a wholesale seafood business which has been in operation in southern Dorchester County for over 40 years. She participates in several organizations including the Chesapeake Bay Seafood Industries Association and the Chesapeake Bay Commercial Fisherman's Association. She currently serves on several committees including the Tidal Fisheries Advisory Committee and the Oyster Advisory Commission.

Stephanie Reynolds Westby, *National Oceanic & Atmospheric Administration*

Stephanie Reynolds Westby is a fisheries biologist for NOAA, where she manages the large-scale Chesapeake Bay oyster restoration program among multiple partners. She holds a master's degree in environmental science and policy from Johns Hopkins University. Stephanie grew up sailing on the Chesapeake. Prior to her work in ecological restoration and fisheries management, Stephanie captained several skipjacks and deadrise workboats for educational foundations, teaching students about Chesapeake Bay ecology.

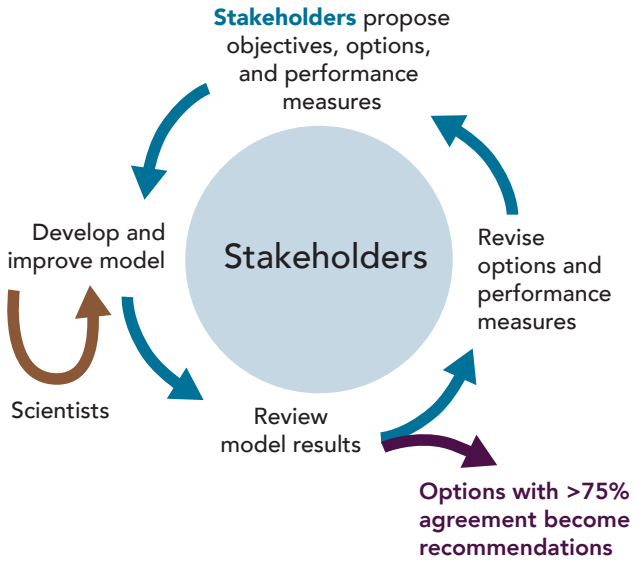
Robert Whaples, *Dorchester County Waterman, President Dorchester Seafood Heritage Association*

Bobby Whaples is the President of the Dorchester Seafood Heritage Association, member of the Dorchester County Commercial Oyster Committee, and member of the Maryland Watermen's Association. He is a third generation waterman who crabs and oysters on the Little Choptank River.

CONSENSUS SOLUTIONS PROCESS

The Consensus Solutions process was pioneered by facilitators at Florida State University and has been in use and refined for over 25 years primarily in the State of Florida. Key elements of the Consensus Solutions process include: transparency, respect, mutual trust building, equitable representation, and multiple iterative facilitated meetings. A super-majority decision making threshold of 75% or greater is required for consensus, and ensures solutions have support across all stakeholder groups at the table. The Consensus Solutions process allows stakeholders and scientists to integrate their knowledge and build trust and agreement on assumptions, data, and outcomes. In addition, the process provides a respectful and constructive framework, which helps stakeholders move from their visions and goals to generation and evaluation of options, and ultimately to consensus recommendations.

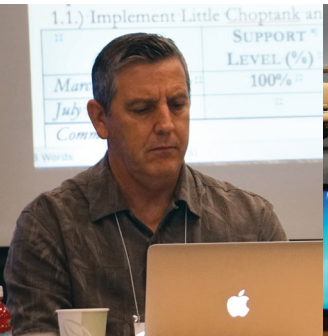
Stakeholders are at the center of the *Consensus Solutions* process



At the start of the Consensus Solutions process, stakeholders were selected by interviewing numerous people within each stakeholder group. Interviewees were asked who would be acceptable and credible representatives for their interests and would also be able to effectively participate in a stakeholder workgroup designed to foster collaboration and build consensus. Stakeholders were asked to participate based on the results of these interviews and the need to ensure diversity in perspectives, ages, and locations on the Workgroup. Once stakeholders agreed to serve on the Workgroup, they were asked to complete a pre-meeting survey. This survey enabled the facilitators to draft vision themes, a goal statement, and a list of oyster resource issues for stakeholder consideration, refinement, and approval at the first stakeholder workgroup meeting. At this meeting, Workgroup members engaged in a shared history exercise and agreed to work together according to the Consensus Solutions operating assumptions, principles, and participation guidelines.

During the subsequent eight meetings, the Workgroup refined their goal statement and vision themes, and discussed and identified regulation and policy issues and options, some of which could be included in a computer model for forecasting expected outcomes (e.g., rotational harvest, complete restoration in sanctuaries, reefball placement), and some of which could not be modeled (e.g., education, business practices and marketing). Each option identified was rated by the members for its acceptability, and members were asked to offer their perspective when they had major concerns or found an option unacceptable. This allowed stakeholders to learn from each other and work toward more acceptable solutions. Stakeholders and scientists collaborated on the development of a computer simulation model which was used by stakeholders to forecast and evaluate the performance of different regulation and policy options. Each option was considered by Workgroup members for its importance, timeliness, feasibility, and practicality. Over the course of the meetings, options were discussed and revised. Those that achieved a 75% or greater level of support moved forward in the process. Of the 100+ options that were considered, 29 were in the final package of consensus recommendations.

At the last meeting on March 23-24, 2018, the Workgroup voted unanimously to accept the comprehensive package of consensus recommendations which appear in this report.



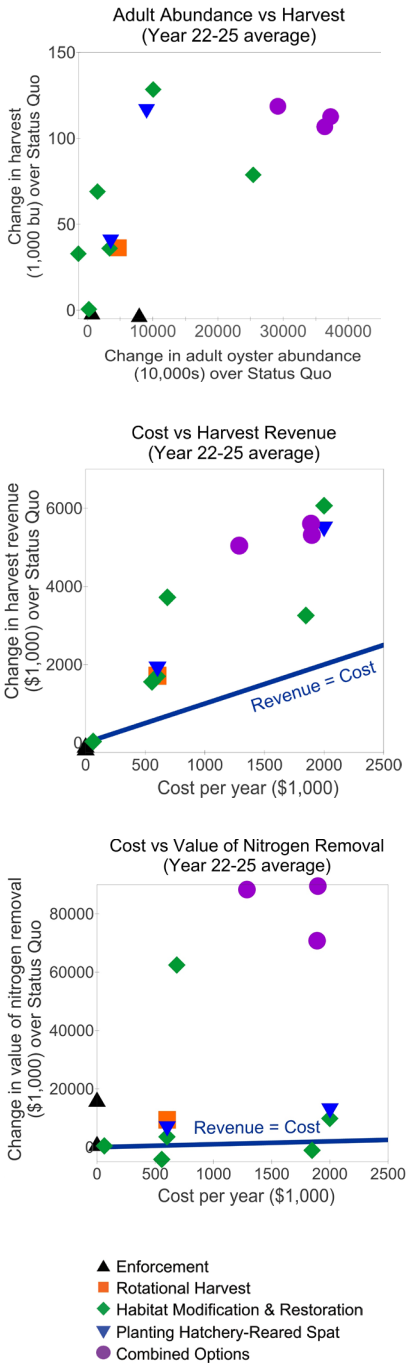
SIMULATION MODEL

Led by Dr. Michael Wilberg, the OysterFutures simulation model was collaboratively developed by stakeholders and scientists to forecast the effects of options for oyster management and restoration 25 years into the future. The model estimated how different management and policy options could affect oysters, the oyster industry, and oyster ecosystem services. During the course of OysterFutures, more than 100 potential options were simulated, including rotational harvest areas, changes in enforcement, changes in sanctuary boundaries, planting shell or spat on shell, and habitat restoration. For each option, the simulation model estimated more than 25 performance measures, which stakeholders used to determine how well each option achieved the workgroup's goals. The performance measures included abundance of oysters, amount of harvest, revenue generated by harvest, and the amount of nitrogen and suspended matter removed. The model was "run" many times for each option to take into account natural variability and to quantify confidence in model results.

The model described important aspects of the oyster life cycle in the Choptank and Little Choptank Rivers. The model included 1,132 separate habitat patches for oysters, which were based on side-scan sonar surveys and stakeholder knowledge. Initial abundances of oysters and the rates of growth and mortality were estimated using a 26-year time series of harvest, the DNR fall survey, and restoration data. On each habitat patch, adult oysters were simulated to spawn during summer, and their larvae were transported to different habitat patches based on water flow and larval swimming. The number of spat (juvenile oysters) that survived on each habitat patch depended on how many larvae arrived and the amount and quality of bottom habitat. Once settled, simulated oysters grew, and their survival depended on the amount of natural and disease mortality, and, for market size oysters, harvest mortality. The amount of harvest on each habitat patch depended on how many oysters were there, the watermen's costs to harvest in that location, the current oyster regulations, and the management options that the stakeholders were evaluating. The majority of oyster harvest in all model scenarios occurred in locations where harvest was legal and profitable.

In the simulation model, and in the figures to the right, the cost of each option was based on costs of shell and spat on shell and, where possible, two levels of investment ($600K and $2M per year) were simulated. The amount of nitrogen reduction was based on removal of nitrogen in the meats of oysters due to harvest and on denitrification, a natural process that occurs on oyster reefs. The revenue from harvest was based on bushels landed and the dockside price of $47 per bushel (the average price in 2016-17). The social value of nitrogen removal was calculated as the average cost of nutrient reduction plans for Talbot and Dorchester Counties. All options were expressed in terms of change from the Status Quo (current regulations and policies); positive values indicate that better conditions are predicted for that option compared to what might happen if there is no change in current regulations and policies. One lesson from OysterFutures is that there is no quick fix for oyster recovery. For most options, strong positive benefits that were seen after 25 years (see graphs to the right) did not start to be realized until around 10 years after implementation.

Simulation Model Predictions



These graphs summarize a small portion of the model results that stakeholders used to inform their recommendations. All accepted options achieved positive results for at least one measure of success, with strong performance across the board for most of them, especially the combined options. Image credit: Elizabeth North.

RESEARCH TEAM

The **OysterFutures Research Team,** led by Elizabeth North, is comprised of researchers, facilitators, graduate students, and science communicators from University of Maryland Center for Environmental Science (UMCES), Florida State University (FSU), and Virginia Institute of Marine Science (VIMS).

Top from left: Rasika Gawde (UMCES), Troy Hartley (VIMS), Johnny Shockley, **Chris Hayes (UMCES), Jeffrey Cornwell (UMCES),** Ward Slacum, Cody Paul, Kelley Cox, Allison Colden, David Sikorski, Jeff Harrison, Robert Whaples, J.D. Buchanan, Greg Kemp, Robbie Casho, Bobby Leonard, Chris Judy (DNR), **Robert Jones (FSU).**
Bottom from left: Lisa Wainger (UMCES), Taylor Goelz (VIMS), Michael Wilberg (UMCES), Dave Blazer, Stephanie Westby, Joe Fehrer, **Elizabeth North (UMCES), Jeff Blair (FSU), Melanie Jackson (UMCES).**

Not pictured: Aubrey Vincent, **Raleigh Hood (UMCES), Matthew Damiano (UMCES).**

Science Communicators: Jane Thomas, Dylan Taillie, Emily Nastase, James Currie.

IMAGE CREDITS

Cover (clockwise from top left): *Oysters being harvested. Image credit: Chesapeake Bay Program. Oysters on the half shell. Image credit: Chesapeake Bay Program. The Kelly Lynn on a foggy morning. Image credit: Integration and Application Network. Underwater oyster reef. Image credit: Paynter Laboratory, University of Maryland, Partner, Oyster Recovery Partnership. Hand tongs. Image credit: David Harp/ChesapeakePhotos.com. Children helping to build reef balls. Image credit: Robert Moron Elementary School. Tiny oysters harvested from the bay. Image credit: Jay P. Fleming for the Hoopers Island Oyster Co. Oyster being measured for size. Image credit: Chesapeake Bay Program. Bucket of oysters after harvesting. Image credit: Chesapeake Bay Program. Reef ball with black seabass at Cook Point Oyster Sanctuary. Image credit: Michael Eversmier, Maryland Artificial Reef Initiative. Boat docked on the bay. Image credit: Chesapeake Bay Program. Farmed oysters being harvested. Impage credit: Jay P. Fleming for the Hoopers Island Oyster Co. Sunset on the bay. Image credit: David Sikorski. Skipjack on the bay. Image credit: Fannie L. Daugherty.*

Page 1: *Map of the Choptank and Little Choptank Rivers in Dorchester and Talbot counties, Maryland. Image credit: Kiri Carini. Watermen on the bay. Image credit: Chesapeake Bay Program. Underwater oyster reef. Image credit: Paynter Laboratory, University of Maryland, Partner, Oyster Recovery Partnership.*

Page 2: *Stakeholders during various workgroup meetings. Image credit: Dylan Taillie.*

Page 4: *A pile of oysters caught on the Choptank River. Image credit: David Harp/ChesapeakePhotos.com. Community planting oysters in the bay. Image credit: Chesapeake Bay Foundation. Oysters in the market. Image credit: Elizabeth North. Oyster lease lines. Image credit: Jay P. Fleming for the Hoopers Island Oyster Co. Oyster Recovery Partnership boat on the Choptank River. Image credit: Ward Slacum.*

Page 8, 11: *Facilitators, scientists, and stakeholders during a workgroup meeting, February 2018. Image credit: Dylan Taillie. Stakeholders at the Center diagram. Image credit: Mike Wilberg.*

Page 13: *OysterFutures Research Team and Stakeholder Workgroup, March 2018. Image credit: Dylan Taillie.*

"All in all, I think it went really well."

J.D. Buchanan, Waterman
OysterFutures Stakeholder

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