Recommendations for identifying and implementing alternate materials for use in oyster production industries in the state of Maryland

Submitted to the Aquaculture Coordinating Council

Submitted by the Alternate Materials Workgroup

August 11, 2023

1. Introduction

Demand and Current Practices

Demand and competition for oyster shell have increased over time as Maryland's oyster production industry has expanded alongside similar programs operating in adjacent states. The oyster production industry includes private oyster aquaculture, a managed public oyster fishery, and oyster restoration. Currently, the entire oyster production industry relies on recycled oyster shells to maintain healthy reefs, produce oysters for harvest, and promote natural recruitment.

Oyster shells are used to enhance oyster production through two primary techniques. (1) **Shell Addition**- Shell is added directly to the bottom to enhance or create new aquaculture lease bottom. Shell is also used to replenish materials removed by harvest from bottom aquaculture leases and selected harvest oyster bars under the public fishery. (2) **Spat-On-Shell-** Maryland's oyster population is recruitment-limited, and all three sectors rely on the production of hatchery-produced spat-on-shell to deliver new oysters directly to oyster reefs or aquaculture leases. Spat-on-shell is currently produced by introducing hatchery-reared oyster larvae into setting tanks filled with recycled oyster shell. This process is commonly referred to as "remote setting." The aquaculture industry is currently supporting all three oyster sectors through the creation of spat-on-shell, which are deployed by each sector to meet their specific oyster production needs.

The collective demand for and use of oyster shell across the oyster production industry in Maryland is substantial - totaling approximately 1.8 million bushels from 2015 to 2022, or 224,000 bushels per year (Figure 1). The actual demand for shell is likely significantly higher than this since data is limited on the amount of shell that is deployed by private aquaculture companies each year. Moreover, the shell volume deployed by restoration and aquaculture in 2019 and 2020 was lower than average due to low salinity conditions in 2019 and reduced operations during COVID-19 and, therefore not representative of the growing demand.

The Oyster Advisory Commission (OAC) has repeatedly discussed the issue of limited shell for aquaculture, the public shellfish fishery, and public and private restoration activities, and recommends that resources be used to identify alternates to shell, alternative sources of shell, and/or strategies for increasing shell retention in Maryland (*Final Report: Oyster Advisory Commission Consensus Recommendations on Oyster Management*, 2021). The impacts of a shortage of shell were demonstrated in 2022 when public fishery replenishment activities were restricted by the limited availability of shell (Oyster Recovery Partnership (ORP), personal comm.), and ORP was unable to maintain their required 2-year stockpile of shell to complete restoration activities (MOU 605P1600003; ORP, personal comm.). Adverse impacts to the private aquaculture industry have been repeatedly discussed in OAC and Maryland Aquaculture Coordinating Council (ACC) meetings, leading to the ACC passing a motion to create the Alternate Materials Workgroup to investigate alternate substrates for use in sanctuaries, restoration, leases, and public harvest areas (Maryland Aquaculture Coordinating Council Minutes – July 14, 2022).

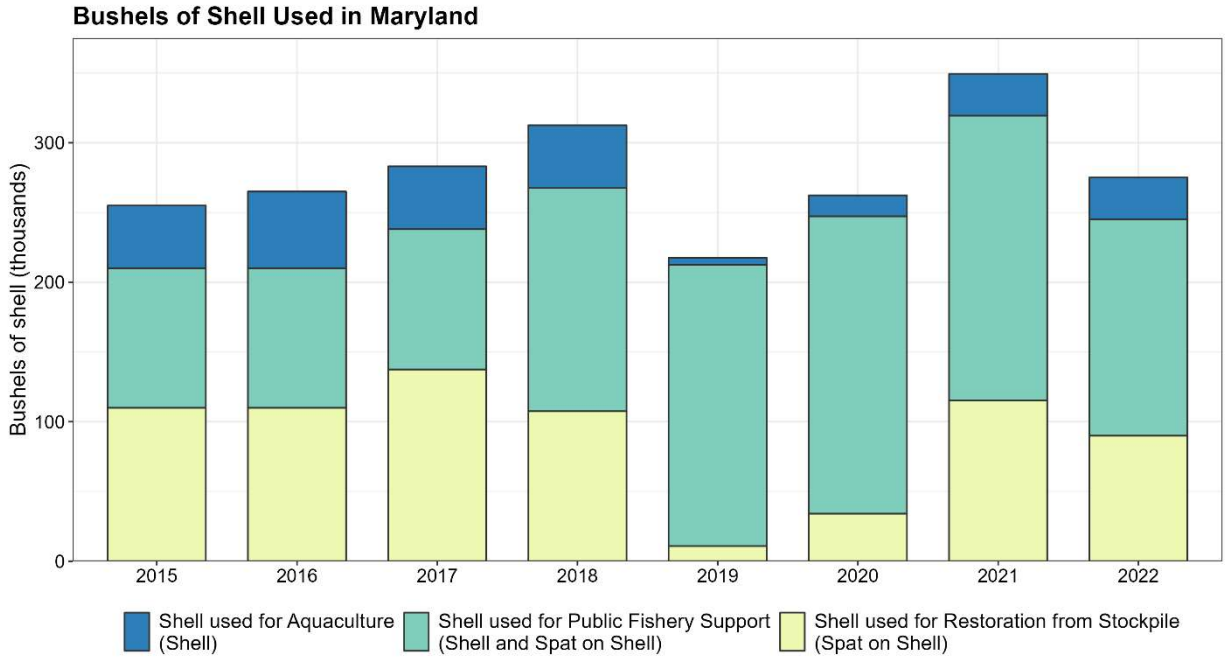

Figure 1. Oyster shell used by Maryland's three oyster production sectors from 2015-2022. Data provided by and tracked by ORP through several Maryland Department of Natural Resources (MDNR) projects. Data include accurate counts and some estimated shell volumes. These estimates are based only on ORP data and are therefore likely conservative.

Alternate Materials Workgroup

The limited availability of shell is jeopardizing the future growth of Maryland's on-bottom aquaculture and other oyster production industries. Considering this, the Aquaculture Coordinating Council convened the Alternate Materials Workgroup (Workgroup) with the goal to (1) identify and evaluate alternatives to oyster shell that could be used in the remote set process and (2) provide recommendations to advance the potential use of alternatives in oyster production industries in Maryland and other coastal states. Workgroup membership included experts in aquaculture, commercial fisheries, restoration, and management, and includes representation from relevant state, federal, and non-governmental agencies, the aquaculture industry, and watermen (Appendix A).

The Workgroup convened a series of meetings to facilitate discussions and gather information to improve the understanding of potential short and long-term alternatives. The workgroup designed the meetings to focus on three broad topics: (1) A review of existing materials/substrates and the history of their use; (2) Current development of new materials and ongoing research evaluations; and (3) Permitting and regulations required to support the use of materials other than shell. A total of six meetings occurred between September 2022 and March 2023 (see Appendix A for details). Meetings were formatted to present information gathered about each subject and to solicit input from managers or researchers with experience implementing programs using or researching materials/substrates. In addition to information provided during Workgroup meetings, this report and its recommendations were informed by additional discussions with experts and managers, a review of other current oyster production programs, and a selection of literature on the topic of testing and implementing alternate materials in oyster production.

2. Alternate Materials

The Workgroup assessed materials based on several characteristics that relate to their suitability for use in the spat set process: efficacy for oyster settlement and growth, the cost and logistics of preparing and transporting the material, and feasibility for use in large-scale efforts. Additionally, the Workgroup reviewed where and how the material has been or is currently being used to assess how well the material works in its current application.

Table 1 describes the four materials that were covered in the greatest detail during the Workgroup meetings: limestone, non-oyster shell, concrete/concrete derivatives, and granite. The table summarizes what the Workgroup learned about each of these materials relative to the following considerations:

- **Where** and **How** the material is being used in aquaculture, restoration, and/or enhancement of harvested oyster bars.
- **Effects on Oysters**: Information that was provided by speakers about how the material affects oyster recruitment, growth, and/or survival (i.e., its suitability for oysters).
- **Cost/availability**: Information on cost or availability of the material, if provided by speakers. Some speakers provided specific cost estimates for the material in their presentations. The cost and availability of materials will vary based on many factors; however, these values can be useful for providing a general relative estimate.
- **Tested for natural recruitment**: Whether any of the speakers presented on testing the material specifically for recruitment purposes, but not necessarily in a controlled remote setting process.
- **Tested in a controlled, remote setting process:** Whether any of the speakers presented on testing the material in a controlled, remote setting process. Since Maryland is recruitment-limited, oyster production activities rely on remote setting. It was therefore essential for the Workgroup to distinguish between suitability for recruitment in the wild and feasibility for use in the remote set process. To replace oyster shell, a material must be able to be easily phased into the remote set process.

The information provided in Table 1 is not intended to be comprehensive or conclusive, but rather summarize what was covered during the Workgroup meetings to provide a broad overview of what we know about these four materials and how they might work as an alternative to shell for use in the spat set process.

Table 1. A description of the information provided by speakers during Workgroup meetings on the four most discussed alternate materials: limestone, non-oyster shell, concrete/concrete derivatives, and granite. Abbreviations for speaker affiliations are listed in Appendix A.

Material	Where material is used	How material is used	Effects on oysters as presented by speakers	Cost/availability as presented by speakers	Tested for natural recruitment?	Tested in a controlled, remote setting process?
Limestone	• Gulf Coast • North Carolina • South Carolina • New Jersey • Maryland	• Sanctuaries • Open harvest areas	• Multiple presenters found variable or inconclusive effects on recruitment & density. • NJDEP: Lower settlement than oyster shell, but about equal for other metrics. • FSU: Smaller limestone pieces had higher recruitment than oyster shell; larger limestone had lower recruitment, but oysters grew to market size faster. • SCDNR: Source of limestone (age and chemical composition) affects oyster settlement.	• Varies by location. • NCDMF: $43-44/ton for material + transportation • SCDNR: Limestone cheaper than oyster shell. ~$17.3K/acre of restoration • FSU: Florida limestone $55 CY vs shell $35 CY.	• Yes	• Yes
Non-oyster shell	• Maryland • New Jersey	• Aquaculture • Sanctuaries • Open harvest areas	• Variable effect on recruitment and density. • NJDEP: Whole surf clam has good settlement but low survival; crushed quahog had good recruitment. • NJ Parsons Seafood: Whole whelk had good survival and growth; surf clam set similar to whelk.	• Variable depending on species and source.	• Yes	• Yes (whelk)
Concrete	• Gulf Coast • Virginia • Maryland • South Carolina • North Carolina	• Sanctuaries • Open harvest areas	Types of concrete for consideration: • Recycled vs. “green” concrete • Crushed concrete vs. engineered structures (reefs tiles, castles, shells) • Good coverage on cement-coated crab pots, oyster castles, and reef balls • Rutgers: Initial tests found concrete was generally not as good as oyster shell. • Coral Defense Project (UMCES) creating “bio-cement”; variable effect on settlement	• Many products currently available • Recycled concrete is cheap but must be processed properly to reduce contamination. • SCDNR: $20k-60k/acre of restoration • FSU: $45 CY	• Yes	• Yes (concrete blocks, oyster castles)
Granite	• Virginia • Maryland	• Sanctuaries	• Limited examples from speakers • UMCES: poor recruitment compared to oyster shell	• *No specific cost information provided by speakers.*	• Yes	• No

Each material presents unique challenges and opportunities. However, a few themes related to (1) material size and (2) cost emerged that apply to all materials. These items should be considered when selecting which material is most appropriate for a practitioner's needs. First, the size of the pieces will impact their suitability for oyster recruitment and the logistics for deploying them. Larger pieces of material may have varying impacts on oyster recruitment and growth rates compared to smaller pieces of the same material (Table 1, limestone). Additionally, larger, heavier pieces can be difficult to handle and transport and can limit the ability to deploy the material. It is essential that the material effectively fit into the current spat set process in Maryland.

The cost of a specific material can depend on its availability, source, and processing requirements. The Workgroup heard repeatedly that it is difficult to make accurate, generalized cost estimates since the price to acquire and transport various materials varies by location. The availability and cost-effectiveness of some materials, such as limestone, may be much greater closer to its natural source. Moreover, some materials may need to be cleaned or constructed/assembled before they can be deployed. For example, recycled concrete can be inexpensive to acquire, but requires multiple processing steps to remove potential contaminants and crush to the desired size. Concrete also has variable physical properties that may influence oyster recruitment success. These factors will affect the amount of time and money required to use the material and should be incorporated into assessments of cost. Engineered structures such as reef tiles and artificial shells may be more suitable for oyster recruitment and survival but require more time and money than using a pre-assembled material such as crushed concrete.

Additional materials

In addition to the materials listed in Table 1, some additional materials were mentioned throughout the Workgroup Meetings, although in less detail. These materials were not explored in depth as they were not commonly used and were unlikely to be suitable for scaling up for larger efforts. These included porcelain, recycled glass, and brick.

The Workgroup also heard from researchers currently developing innovative materials to replace oyster shell. Speakers included Matthew Gray from UMCES, who is part of a team developing a biosynthetic shell using ureolytic bacteria. Initial tests have shown that oyster settlement on the artificial shell was variable, although it did outperform granite. Tests are ongoing and this material is currently being refined. Another UMCES researcher, Scott Hunsicker, presented recent developments by the Coral Defense Project, which is working to create a carbon-neutral concrete mix to create artificial substrates such as bailey balls or tiles. The Coral Defense Project is experimenting with various amounts of precipitated calcium carbonate, types of stone, and types of sand in their materials.

There are also several companies creating various innovative concrete structures, designed to optimize oyster settlement and growth. The Workgroup heard from Evelyn Tickle of GROW Oyster Reefs, one such company that provides a variety of concrete structures including spat catchers and reef tiles, disks, tangles, and rocks. The Sandbar Oyster Company is also incorporating concrete into structures designed for oyster settlement with their Oyster Catcher Substrate, which is currently being used successfully for intertidal oyster reef restoration in North Carolina. While concrete structures have been repeatedly used to enhance oyster settlement and growth in a restoration setting, these structures may pose challenges for harvesting oysters and their applicability in an aquaculture and harvest setting should be evaluated.

Shell Use Reduction Strategies

The Workgroup also identified other strategies that could alleviate the demand for shell rather than, or in addition to, using a replacement. For example, using best practices to increase the survival of hatchery-set spat-on-shell would reduce the amount of shell needed to meet restoration goals. Additionally, the process of direct larval setting is being tested to explore the feasibility of seeding reefs directly without the need for setting spat in tanks. This is already a strategy being employed on a small-scale in aquaculture and restoration in Maryland. The Workgroup also discussed transplanting oysters from an area with high natural recruitment to a location with low recruitment to enhance local populations. This process is currently being used by the New Jersey DEP Marine Resources Administration with "great success." NJ Parson Seafood and Oyster Reef Restoration group described another strategy of planting spat on shell with disease-resistant oysters. Although this strategy still requires shell, it increases survival rates and therefore reduces the demand for shell over the long term. Finally, dredged oyster shell was discussed as an alternate source of oyster shell. Dredged oyster shell was historically used in Maryland but has been restricted in recent years.

The Workgroup also discussed how large quantities of shell are exported and not returned from out-of-state processors, and that policy and regulations could be leveraged to increase the retention of shell within the state of Maryland. The OAC has also recommended this as a promising strategy and recommends a review of current state laws "to evaluate and develop potential strategies, including providing economic incentives, to retain shell within the state of Maryland" (*Final Report: Oyster Advisory Commission Consensus Recommendations on Oyster Management*, 2021).

3. Permitting and Regulation

In Maryland, the primary state agencies involved in wetland and waterway permitting activities, such as oyster restoration and commercial shellfish aquaculture, are the Maryland Department of the Environment (MDE) and the Maryland Department of Natural Resources (MDNR). At the federal level, the U.S. Army Corps of Engineers (USACE) administers a permit program for both activities. Permits for past oyster restoration projects in the state have included authorizations for both shell and/or alternate materials, depending on the specifications of the permit application submitted by MDNR to the USACE for federal approval. However, the list of alternate materials allowed for restoration is still somewhat limiting. State law dictates the types of materials that aquaculture growers can use for shellfish aquaculture, and currently, state law limits planting on shellfish aquaculture leases to shell only, unless granted special written permission by MDNR to use an alternate material. Consequently, statutory changes and the adoption of new regulations will likely be required at the state level to facilitate the broader use of alternate materials on shellfish aquaculture leases.

USACE Regulatory Authorities

USACE primarily operates under two federal regulatory permit authorities: Section 10 River and Harbors Act of 1899 (Section 10) and Section 404 of the Clean Water Act (CWA). Under Section 10, the USACE regulates activities that occur in navigable waters of the United States, such as construction and dredging. The USACE also regulates under Section 404 of the CWA the discharge of dredged or fill material, which includes oyster shell without spat, or other alternate materials such as stone. Section 404 of the CWA also provides guidelines (Section 404(b)(1) Guidelines) that must be met for permit application approval. Therefore, oyster restoration projects involving the construction of structures, the deposition of materials, or other work being performed in navigable waters of the US would be subject to these Corps regulatory authorities.

Permitting

Federal Restoration Permitting

Some restoration projects may qualify to be approved by an existing Nationwide Permit (NWP). Nationwide Permits are General Permits that last five years and include general conditions and permit-specific conditions. NWP 27 can apply to oyster restoration or public fishery enhancement activities as it covers aquatic habitat restoration, enhancement, and establishment, including the construction of oyster habitat and shellfish seeding. This permit requires activities to use "suitable material", which it defines as material free from toxic pollutants in toxic amounts. It does not explicitly restrict projects to the use of oyster shell, but rather permits "appropriate materials" broadly. Note that even if a project does qualify for an NWP, it may still require the acquisition of additional federal, state, or local permits. If a project does not qualify for an NWP, or another form of general permit, an alternate permit review process would be required such as under a Standard Permit (SP)/Individual Permit (IP) where a public notice is issued, and public hearings may be requested. This permit process is more complex and permit decisions are made on a case-by-case basis.

Aquaculture Permitting

A separate Nationwide permit applies to aquaculture activities. NWP 48 regulates the installation of various structures into navigable waters and the discharge of dredged or fill material on aquaculture leases, which could include alternate materials. NWP 48 does not constrain fill materials to only oyster shell.

USACE and MDNR Aquaculture Division have a joint state commercial lease and federal permit application process for shellfish aquaculture activities. Relevant state legislation and regulations for leaseholders seeking to use alternate materials include Maryland Natural Resources Article §4-11A, Code of Maryland Regulations (COMAR), and the Shellfish Lease Agreement. The statutory process for lease acquisition is defined in Natural Resource Article §4-11A and requires applicants to provide detailed production plans for their lease, which would cover the use of alternate materials. Standards for what materials can and cannot be used on shellfish leases are outlined by MDNR in Natural Resources Article §4–11A–10 and COMAR 08.02.23.03.

COMAR 08.02.23.03 states that leaseholders may not add material other than shell without first obtaining MDNR's written consent and therefore requires a leaseholder to obtain additional permission to place any material other than shell on their lease. The Shellfish Lease Agreement requires leaseholders to be in compliance with all applicable laws and restricts leaseholders from adding any materials to their lease other than shell. At the Workgroup meeting, MDNR reported that there have only been a handful of written requests for approval for the use of alternate materials on aquaculture leases, all of which have been for a natural material (e.g., stone), and that those requests are assessed on a case-by-case basis.

The roles of the Maryland Department of the Environment (MDE) related to placement of alternate materials are to (1) review restoration permit applications and write reports and recommendations that go to the Board of Public Works for approval, (2) consider analyses and the potential water quality implications of alternate materials placement on either public or leased areas, (3) participate on the Aquaculture Review Board to provide feedback on proposed aquaculture projects, and (4) provide water quality monitoring for all shellfish growing waters. In addition, while MDNR is the regulating agency for what occurs on leases, they work in tandem with the MDE and Maryland Department of Health (MDH)

to ensure the industry is meeting shellfish health and safety requirements under the National Shellfish Sanitation Program.

Permitting Recommendations

At the Workgroup meeting, both USACE and MDNR conveyed that current authorization mechanisms are not sufficient to broadly allow the use of alternate materials and recommended that, if alternate materials are being considered for more frequent use in the future, consideration should be given to proposing modifications to statute, regulation, and/or related permit approval processes that cover the use of alternate materials.

- For restoration and public fishery plantings, a permit modification request could be submitted for the current MDNR permit from USACE that authorizes dredging and deposition of shell in the Chesapeake Bay to broaden the description of "alternate materials". For example, "*The types of material to be planted will be approved by the State of Maryland and could include but are not limited to the following: clam shell, marl, concrete, stone, brick, and cinderblock; all materials will be free of building debris and protruding rebar*."
- For aquaculture, the current process of leaseholders requesting permission to use material other than shell from MDNR on a case-by-case basis is not efficient and severely limits a transition from shell to alternate materials. MDNR thus recommended that a more general approach would be more efficient for expediting the use of alternate materials in aquaculture if such requests were to become more frequent.

As required by current state law, the review and approval of new materials must come from MDNR; however, USACE is not restricted from considering other "alternate materials" during their permit review. These materials would ultimately be subject to state laws for the USACE permits to be valid, if granted.

4. Conclusions and recommendations

After considering all information discussed during the Workgroup meetings, the Workgroup recognized that the availability and use of alternate materials in the oyster production process can be complex yet is achievable. Several factors related to cost and availability, biological suitability, and permitting needs will ultimately guide the most appropriate selection of materials best suited to a particular oyster production activity and the scale of production. A set of both immediate and longer-term actions should be taken to allow for the use of alternate materials in Maryland and improve the effectiveness of using these materials in oyster production.

Although the following recommendations are specific to oyster production activities in Maryland, broader conclusions can be used to guide the transition from shell to alternate materials in other oyster management programs. When evaluating the use of an alternate material for oyster production in any location, implementers must consider the size of the pieces that will be used, how much to process or prepare the material, and how the weight of the material will impact deployment. The availability of specific materials will vary based on location, and practitioners/industry must consider not only the cost of acquiring a material, but also the cost and feasibility of processing and transporting the material. Additionally, although the Workgroup discussed permitting specifically as it applies to restoration and oyster aquaculture in Maryland, broader lessons learned for regulatory strategies can be applied to areas outside of Maryland, such as reviewing current relevant permits for how they could be most easily updated.

Immediate Recommendations

1. MDNR streamlines the process for reviewing and implementing permit approval for alternate materials on oyster aquaculture leases.
2. MDNR submits permit application to USACE to allow alternate materials used to produce spat in remote setting to be deployed on Maryland Natural Oyster Bars (NOB's).
3. DNR compiles and publishes a list of materials that are not harmful to the Chesapeake Bay and could be deployed on aquaculture lease bottom and NOB's once permits are approved.
4. Test currently available materials in the remote setting process. This includes:
    a. Logistics: Assessing whether current remote set processes can handle different materials (weight and volume requirements, machinery needed to move into and out of setting tanks, etc.).
    b. Biological: Assessing oyster spat densities on these materials in setting tanks, and assessing survival rates in grow-out locations that mimic oyster restoration, public fishery, or aquaculture lease areas.
    c. Use these data to conduct a cost-benefit analysis.
5. Identify sources of alternate materials and transport costs to locations within Maryland relative to current shell stockpiles and aquaculture lease areas.
6. Implement the use of currently available materials in the MDNR public fishery replenishment program. Many coastal states already use materials such as clam shell, limestone, granite, and concrete in their management of public fishing grounds. Integrating an alternate material into Maryland's current repletion program is logistically feasible given the existing protocols and machinery used to transport and plant shell.

Actions already underway

- Immediate Recommendation 1 - The Aquaculture Coordinating Council has approved a motion to add this recommendation to their 2023 annual report.
- Immediate Recommendation 2 - MDNR has submitted a permit application to USACE to allow for deployment of alternate materials on Maryland Natural Oyster Bars (NOB's).

Longer-term Recommendations/ Research Needs

1. Develop industry-wide plan for near-term and long-term use of alternate materials.
2. Additional research on synthesizing oyster shells or substitutes (development, followed by field testing that follows items in Immediate Recommendation 3).

Appendix A. Workgroup Meeting Schedule and Participants

The Workgroup held a total of 6 meetings from September 2022 to March 2023. The Workgroup would like to thank the many speakers who provided their time and expertise on alternate materials.

The meeting topics were as follows:

September 13, 2022 – Workgroup charge, timeline, membership, and introduction.

October 14, 2022 – Alternate materials overview and discussion. The Workgroup reviewed seven potential alternate material options (limestone, granite/non-calcium stone, concrete, non-oyster shell, dredged oyster shell, porcelain, and engineered reefs) guided by a review by Goelz et al. (2020)[1]. For each material, the group discussed what was known and unknown about its biological impacts on oyster settlement, recruitment, growth, and survival; general cost information; and examples of how the material is currently being used.

November 14, 2022 – Current applications of alternate materials. The Workgroup hosted practitioners from other states to share their experiences using alternate materials in the oyster production process.

December 8, 2022 – Permitting and regulation. The Workgroup hosted representatives from the major permitting and regulatory agencies to share insight into the process of acquiring permits to deploy alternate materials.

February 22, 2023 – Recent and ongoing research into alternate materials. The Workgroup hosted researchers developing and/or introducing alternate materials into the oyster production process.

March 14, 2023 – Review of report outline. The Workgroup discussed the information gathered through the Workgroup process and began outlining topics to include in the report to be submitted to the Aquaculture Coordinating Council.

[1] *Goelz, Taylor; Vogt, Bruce; and Hartley, Troy W., Alternative Substrates Used for Oyster Reef Restoration: A Review (2020). Journal of Shellfish Research, 39(1), 1-12.*

Meeting Participants

*Denotes a presenter

Meeting	Participants
Meeting 1 – Introduction September 13, 2022	Ward Slacum (ORP) – Workgroup Chair Olivia Caretti (ORP) – Workgroup Coordinator Jennica Moffat (ORP) – Workgroup Coordinator Jennifer Walters (ORP) Chris Karwacki (Volunteer) Larry Jennings (Coastal Conservation Association) Kathy Brohawn (MDE) Scott Budden (Private Aquaculture) Victoria Brown (Private Industry) Chris Judy (MDNR) Matt Fleming (State of Maryland) Rob Witt (Watermen) Allison Colden (CBF) Reggie Herrell (University of Maryland)

Meeting	Participants
	Stephanie Westby (NOAA) Angela Sowers (USACE) Cody Paul (Watermen)
Meeting 2 – Alternate materials overview and discussion October 14, 2022	Ward Slacum (ORP) – Workgroup Chair Olivia Caretti (ORP) – Workgroup Coordinator Jennica Moffat (ORP) – Workgroup Coordinator Jennifer Walters (ORP) Kathy Brohawn (MDE) Woody Francis (USACE) Jodi Dew-Baxter (MDNR) Stephanie Westby (NOAA) Cody Paul (Watermen) Chris Karwacki (Volunteer) Zack Greenberg (PEW Charitable Trusts) Bill Coney (Legacy Reef Foundation) Allison Colden (CBF) Rob Witt (Watermen)
Meeting 3 – Current applications November 14, 2022	Ward Slacum (ORP) – Workgroup Chair Olivia Caretti (ORP) – Workgroup Coordinator Jennica Moffat (ORP) – Workgroup Coordinator Dale Parsons* (Parsons Seafood and Oyster Reef Restoration) Michael Hodges* (SCDNR) Abby Williams* (NCDMF) Jason Peters* (NCDMF) Craig Tomlin* (NJDFW) Maddie T Kathy Brohawn (MDE) Woody Francis (USACE) Scott Budden (Private Aquaculture) Jodi Dew-Baxter (MDNR) Chris Judy (MDNR) Larry Jennings (Coastal Conservation Association) Rob Witt (Watermen) Reggie Herrell (University of Maryland) Sarah Lane (University of Maryland) Justin Bereznac (MDE) Stephanie Westby (NOAA) Angie Sowers (USACE) Chris Karwacki (Volunteer) Zack Greenberg (PEW Charitable Trusts) Bill Coney (Legacy Reef Foundation) Karen Oertel (Private Industry) Ed Rich Bill Sieling (Private Industry)
Meeting 4 – Permitting and regulation December 8, 2022	Ward Slacum (ORP) – Workgroup Chair Olivia Caretti (ORP) – Workgroup Coordinator

Meeting	Participants
	Jennica Moffat (ORP) – Workgroup Coordinator Jennifer Walters (ORP) Rebecca Thur* (MDNR) Woody Francis* (USACE) Justin Bereznak* (MDE) Michael Hodges* (SCDNR) Kathy Brohawn (MDE) Victoria Brown (Private Industry) Jodi Baxter (MDNR) Chris Judy (MDNR) Larry Jennings (Coastal Conservation Association) Rob Witt (Watermen) Sarah Lane (University of Maryland) Stephanie Westby (NOAA) Angela Sowers (USACE) Cody Paul (Watermen) Chris Karwacki (Volunteer) Zack Greenberg (PEW Charitable Trusts) Eric Campbell (MDNR)
Meeting 5 – Recent and ongoing research February 22, 2023	Ward Slacum (ORP) – Workgroup Chair Olivia Caretti (ORP) – Workgroup Coordinator Jennica Moffat (ORP) – Workgroup Coordinator Jennifer Walters (ORP) Thomas Price (ORP) Matthew Gray* (UMCES) David Bushek* (Rutgers University) Richard Riman* (Rutgers University) Sandra Brooke* (FSU CML) Scott Hunsicker* (UMCES) Evelyn Tickle* (GROW Oyster Reefs) Chris Karwacki (Volunteer) Angela Sowers (USACE) Reggie Harrell (University of Maryland) Jodi Baxter (MDNR) Allison Colden (CBF) Scott Budden (Private Aquaculture) Stephanie Westby (NOAA) Kathy Brohawn (MDE) Abby Stephens (SCCCL) Chris Judy (MDNR) Victoria Brown (Private Industry) Bill Coney (Legacy Reef Foundation) Robb Witt (Watermen) Cody Paul (Watermen) Bill Sieling (Private Industry) Karen Oertel (Private Industry) Zachary Greenberg (PEW Charitable Trusts)

Meeting	Participants
	Justin Bereznak (MDE) Larry Jennings (Coastal Conservation Association)
Meeting 6 – Review of report outline March 14, 2023	Ward Slacum (ORP) – Workgroup Chair Olivia Caretti (ORP) – Workgroup Coordinator Jennica Moffat (ORP) – Workgroup Coordinator Jennifer Walters (ORP) Larry Jennings (Coastal Conservation Association) Evelyn Tickle (GROW Oyster Reefs) Bill Coney (Legacy Reef Foundation) Angie Sowers (USACE) Chris Judy (MDNR) Chris Karwacki (Volunteer) Stephanie Westby (NOAA) David Bushek (Rutgers University) Zack Greenberg (PEW Charitable Trusts) Kathy Brohawn (MDE) Jodi Baxter (MDNR) Richard Riman (Rutgers University) Scott Hunsicker (UMCES) Scott Budden (Private Aquaculture) Sarah Lane (University of Maryland) Reggie Harrell (University of Maryland) Ed Rich Allison Colden (Chesapeake Bay Foundation)

Abbreviations

CBF – Chesapeake Bay Foundation
FSU CML – Florida State University Coastal and Marine Lab
MDE – Maryland Department of the Environment
MDNR – Maryland Department of Natural Resources
NCDMF – North Carolina Division of Marine Fisheries
NJDEP – New Jersey Department of Environmental Protection (Marine Resources Administration)
NOAA – National Oceanic and Atmospheric Administration
ORP – Oyster Recovery Partnership
SCCCL – South Carolina Coastal Conservation League
SCDNR – South Carolina Department of Natural Resources
UMCES – University of Maryland Center for Environmental Science
USACE – United States Army Corp of Engineers