Substrate Requirements for Oyster Management

A REPORT TO THE GOVERNOR AND THE MARYLAND GENERAL ASSEMBLY
DECEMBER 31, 2023
As required by the 2022 General Assembly Session Senate Bill 830 and cross-filed House Bill 1228 - MSAR 14098
Maryland Department of Natural Resources Fishing and Boating Services




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Table of Contents

1.0 Purpose

During the Maryland General Assembly's 2022 session, Senate Bill 830, cross filed with House Bill 1228, passed. Within this bill, the Department of Natural Resources was mandated to produce a report on Maryland's substrate needs for oyster sanctuary restoration, oyster public fishery replenishment (sometimes called repletion), and oyster aquaculture for the next 10 years. The statute states:

On or before December 1, 2023, the Department of Natural Resources shall submit a plan to the Governor and, in accordance with § 2–1257 of the State Government Article, the General Assembly describing the substrate needs for oyster repletion, aquaculture, and restoration activities in the State over the next 10 years.

The plan shall include:

1. *an estimate of the quantity of the substrate materials that will be needed and the purposes for which the substrate materials will be used;*
2. *an overview of the full spectrum of substrate materials available;*
3. *an analysis of the availability, sourcing, and relative cost of each substrate material;*
4. *an estimate of the total and annual costs of implementing the plan; and*
5. *opportunities for improving the cost–effectiveness of substrate acquisition and use, including opportunities for increasing coordination with the Commonwealth of Virginia, undertaking larger–scale projects to take advantage of economies of scale, and reducing mobilization and demobilization costs.*

This report will discuss different types of substrates oysters can use for habitat and natural recruitment, substrate sources and availability, and the cost associated with each substrate type. The report describes the estimated need for substrate and the cost associated. In deference to the newly formed Shell and Substrate Task Force under Governor Moore's executive order 01.01.2023.12, this report will not provide a plan to meet substrate needs at this time.

2.0 Substrate Materials

Oysters are broadcast spawners whereas they release their gametes up into the water column. After fertilization, larvae float up and down in the water column until they find a hard substrate to attach to. At this time, the newly-settled oysters are called spat and they stay attached to the substrate permanently unless removed via harvest, natural mortality, or shell dissolution.

On natural oyster reefs, the hard substrate that larvae typically settle on are either loose oyster shells from deceased oysters or live oysters. Some scientific papers have stated that oyster

larvae may prefer oyster shells to attach to as opposed to alternative substrates. However, many scientific studies have shown alternative substrates to be effective for larvae recruitment.

2.1 Shell Materials

2.1.1 Fresh Oyster Shell

Description

Fresh shells are obtained by harvesting oysters from the water and removing the oyster meat. The resulting shells are called fresh shells in Maryland and/or green shells in Virginia. This type of substrate is mostly supplied by shucking houses (oyster processors) but other entities like restaurants and festivals can also be a source of fresh shells. After shucking, the shells have some degree of leftover oyster tissue (meat) on them. Fresh shells are typically stockpiled for later use after the shells have weathered, are free of debris and meat, and become much cleaner. If held over a year the shells have become aged and are also referred to as aged shell. Fresh shell is highly sought after by all three sectors - aquaculture, sanctuary restoration, and public fishery replenishment.

Maryland Department of Natural Resources (DNR) purchases fresh shell to plant back on public fishery oyster bars under the public fishery replenishment program. In the last ten years, 1,836,230 bushels of fresh shells have been replanted on public fishery bars with the majority of the shells coming from one Virginia shucking house that purchases a large portion of Maryland oyster harvest.

Maryland's public fishery replenishment program and sanctuary program also purchase shells that have had spat attached to them through a hatchery and remote setting process. Hatchery reared oyster larvae are released in tanks that are filled with shell in a process called remote setting. Once the larvae settle on the shells, it creates spat-on-shell. The spat-on-shell is then planted on oyster bars either within the public fishery areas or within oyster sanctuaries for restoration. The shell used to create spat-on-shell that is planted for sanctuary restoration comes from regional oyster shell recycling and shucking houses located mostly in the southeastern states. Maryland shell recycling programs collect shells from restaurants, festivals, communities, and individuals mostly within Maryland, Virginia, the District of Columbia, and Pennsylvania. Private vendors producing spat-on-shell that are planted for the public fishery replenishment program obtain shell mostly from shucking houses.

Oyster aquaculturists use fresh shell either to plant directly back on their leases or to produce spat-on-shell that is planted on their leases. These shells are obtained from various shucking houses.

Two large sources of fresh shells from other oyster species have recently been identified. These shells are located in Washington State and in Taiwan. DNR is currently researching these sources of shells to determine if they could be used in replenishment, restoration, and/or

aquaculture, and what safeguards are needed since this will involve importing this material into Maryland.

Spat recruitment potential
High

Availability
Very low availability from Maryland and low availability from Virginia shucking houses. Most states are retaining shells either harvested from their waters or exported in from out-of-state harvest to use in their oyster programs. DNR estimates that 50% to 70% of Maryland harvested oysters are exported out-of-state.

Current Sources
- Maryland shucking houses - 17,000 bushels (annual average sold to DNR over past five years) and an unknown amount sold to out-of-state and to aquaculture
- Virginia shucking houses - 180,000 bushels (annual average sold to DNR over past five years) and an unknown amount sold to aquaculture
- Shell recycling - about 30,000 bushels of shells annually

Potential Sources
- Washington State shell - unknown total amount available but suggested to be over 1 million bushels
- Taiwan shell - unknown total amount available but suggested to be over 1 million bushels

Costs
Fresh shell from Maryland and Virginia shucking houses ranges from $4 to $7 per bushels of shell, or $66 to $116 a cubic yard (excluding the cost to plant the shell). The cost of shell recycling is approximately $5 to $20 a bushel, or $83 to $333 a cubic yard depending on the total amount recycled and the type of group recycling the shells (not including the cost to run the program)[1]. The costs of the shell from Washington State and Taiwan are currently unknown at this time.

2.1.2 Dredged Oyster Shell

Description
Dredged shells are buried shells that have been dredged out of the bay bottom. These shells come from areas where oysters once lived but then died naturally and sediment covered the bar over centuries of time. Historically, DNR retrieved buried shells using a large industrial-scale hydraulic dredge on buried shell deposits in Maryland's upper bay hence the name 'dredged shells'. The dredge made "cuts" that were approximately 30 feet deep and 500 feet wide, yielding approximately a 33% rate of return in shells on sites with large shell deposits. In the past, a 200 foot long dredge distance would yield approximately 33,333 cubic yards of shell per dredge cut. Maryland's historic dredged shell program ran from 1960 through 2006. From 1960

[1] Md. Code Ann., Nat. Rec. § 4-1019.1 Current shell recycling costs

through 1990, about five million bushels of shells were dredged per year. From 1991 through 2006, 1.5 to 2.8 million bushels were dredged per year. Most of these shells were obtained in the upper Chesapeake Bay from areas that were no longer living oyster bars. The dredged shells were transported to and replanted on living, functioning oyster bars for the purpose of enhancing the natural spat set. Spat sets on areas planted with shells were predominantly higher than nearby natural unplanted bars. The program ceased in part due to a reduction in optimal areas to dredge, but primarily due to difficulties in obtaining dredging permits and the current permits expiring.

A new permit to dredge shell from Man O' War Shoals[2] was submitted by DNR in 2008 as required by law[3]. The permit was granted in 2017 by Maryland Department of the Environment (MDE) and USACE, however, it awaits approval/denial from Maryland Board of Public Works.

Another method to retrieve buried shells is to use a hydraulic clam dredge. The shells are excavated from the bottom using high pressure jets of water generated by the clam rig that dig into the bottom. Therefore these shells are called "excavated shells" to differentiate them from dredged shells acquired during the historic dredged shell program. Hydraulic clam dredges have a conveyor that is lowered to the bay bottom. A hose and manifold supply water pressure on the bottom which blows the clams back up onto the conveyor. The conveyor is made of mesh so smaller items like small clams, sediment, and bits of shell are re-deposited on the bottom. The conveyor moves at an incline up to the back of the boat, above the water, where the harvester removes the clams. Recently, DNR has been researching the ability to use hydraulic clam dredges to retrieve buried shells. The efficiency of this gear greatly depends on the amount of shell buried in the bottom which is highly variable. Based on field trials, preliminary data show a range from about 30 bushels per hour to 100 bushels per hour, and potentially higher. A natural spat set occurred on one recent excavated shell planting in summer 2023 that was comparable to nearby natural bottom, showing these shells can enhance oyster populations. Cuts made by the hydraulic dredge are about one foot deep and are mostly refilled during dredging. This is thought to cause fewer changes to the bay bottom than the larger scale dredge used historically to retrieve shells.

Spat recruitment potential
High

Availability
There is no availability of dredge shells currently as neither a permit nor a large dredge are active in Maryland. Many historic shell deposits in the upper bay have already been dredged. Other historic shell deposits still exist but are in locations that have environmental issues such as being within a striped bass spawning reach which prevents access. Total amounts of dredged shell are finite so is not viable as a long term solution. Man-O-War Shoals has an

[2] Man O' War Shoals Permit Application and Information. https://dnr.maryland.gov/fisheries/pages/oysters/permit-applications.aspx
[3] Md. Code Ann., Nat. Rec. §4-1103. 2008 Legislation Session House Bill 1504 / Senate Bill 930. 2009 Legislation Session House Bill 103.

estimated 86-103 million bushels of dredged shells; however the current permit awaiting the Board of Public Works is for a 5 year pilot program to remove 5 million bushels. The amount of excavated shell is unknown. Depending on the area within the bay it could be potentially large due to the extent of buried oyster bars but this is still in the early investigation phase.

Sources
Historic shell deposits are mostly located in the upper bay and upper Potomac. Virginia currently has a dredged shell program but does not sell that shell. Buried shells could be retrieved baywide from buried oyster bars.

Costs
In 2014, DNR estimated the cost of shell dredging at $4 a bushel or $65 per cubic yard. These costs will be higher due to inflation. Virginia is currently paying $3.50 to $4.50 a bushel or $50 to $70 per cubic yard for dredged shells plus additional costs to plant the shell.

The cost to use hydraulic clam dredges to provide excavated shells is unknown at this time since only a small scale field trial has been performed. The recent 2023 trial suggests a potential cost of less than $5 per bushel or less than $83 per cubic yard.

2.1.3 Fossilized Oyster Shell

Description
Fossilized oyster shells are shells obtained by quarrying deposits on land. The shells have been fossilized into limestone. DNR purchased fossilized oyster shells from a quarry in Florida in 2013 and 2014. The shell was shipped to Maryland by train and used in the Harris Creek and Little Choptank River restoration projects. The shell was used as a reef base to make areas more suitable to receive hatchery spat-on-shell and for natural recruitment. Due to perceived environmental concerns by the oyster industry and a grant to pay for the shipping expiring, this material is no longer in use.

Spat recruitment potential
High. While no formal scientific studies have been conducted, DNR and its restoration partners have shown natural recruitment does occur on fossilized shells. Calculation estimates from monitoring data on these reefs have been calculated at over 66 oysters per square meter naturally recruited on the fossil shells. The 2014 DNR Annual Fall Oyster Dredge survey showed naturally recruited spat at a density of 4.3 per meter square on a reef recently restored with fossilized shell in Harris Creek. While the overall average density for spat in 2014 for Harris Creek Sanctuary was 1.6 per meter square.

Availability
Unknown.

Sources
Gulf Coast Aggregates in Carrabelle, Florida

Costs
In 2013, the cost of fossilized shells was $1.23 a bushel or $22.33 per cubic yard. This cost did not include the cost of transportation.

2.1.4 Non-oyster shell

Description
Other mollusk species create shells that have been used as a substrate for oysters. Shell from species such as surf clam, soft clam, hard clam, mussels, and whelk have been purchased from seafood processors after the meat has been removed, either as a single species or as multiple species (mixed shells).

USACE has recently used mixed shells in Harris Creek and Tred Avon River sanctuaries restoration projects from 2012 to 2018 as a reef base to make areas more suitable to receive hatchery spat-on-shell and for natural recruitment. The mixed shells have been found to be more fragile than oyster shells and are prone to being crushed into finer pieces. The settling and compacting of these thinner shells can lead to a lack of interstitial spaces which are important for oyster reefs.

Recently, aquaculturists have been experimenting with using native whelk and other marine mollusk shells as a base for their leases and in the production of spat-on-shell.

Spat recruitment potential
Medium to High. Similar to oyster shell, but shown to not support growth or survival as well as oyster shell (Nestlerode et al. 2007). DNR and its restoration partners have shown natural recruitment does occur on mixed shells. Calculation estimates from monitoring data on these reefs have been calculated at over 35 naturally recruited oysters per square meter on clam shells.

Availability
Availability is dependent on how much is being harvested and processed by seafood processors. The majority of these seafood processors are located in the mid-Atlantic and northeastern states. USACE was not able to procure enough mixed shells to complete the large-scale restoration reefs in the Tred Avon River.

Sources
Seafood processors.

Costs
In 2016, USACE paid about $4 a bushel or $65.00 a cubic yard.

2.2 Stone Materials

2.2.1 Non-Calcium Stone

Description

Stone, such as granite, river rock, or gravel, has been used as substrate for oyster reef bases. Stone can come in many different sizes and shapes thus tailoring it to project needs. Stone can provide good structure and interstitial spaces for a reef. It is also a good choice for use in areas with hard sand or other hard sediment types where it can function as a stable base for a reef.

In recent years, DNR and USACE have been using stone as a reef base in large-scale restoration projects. The stones used for these projects are from a quarry in Havre de Grace, Maryland. On older restoration reefs, the stones fit through a three to six inch sieve. In more recent restoration, the stones used are smaller, fitting through a one to two inch sieve or a two to four inch sieve.

Virginia Marine Resource Commission has used small stones on public fishery ground as a reef base for natural recruitment. Anecdotal information collected from harvesters and seafood processors found the stone to be effective and easy to harvest on gear using hand tongs and dredges.

In late 2021, DNR provided permission for the use of non-calcium stones on one submerged land lease. This permission allowed a lease holder to plant small river stones no larger than 2 inches that have been washed and found free of any other foreign materials to a depth not to exceed 6 inches in a 1 acre area of their lease. The leaseholder is still evaluating growth and survival on these stones and the Department is awaiting results.

Spat recruitment potential

Medium to High. DNR and its restoration partners have shown natural recruitment does occur on stone. Calculation estimates from monitoring data on these reefs in Harris Creek Sanctuary have been calculated at over 16 naturally recruited oysters per square meter on the stone. Additional calculation estimates from monitoring data on stone reefs have been calculated at over 33 naturally recruited oysters per square meter on the stone.

Availability

Highly available in a variety of types and sizes.

Sources

Various queries in Maryland and nearby states.

Costs

In 2021 DNR paid about $0.81 a bushel or $13.57 a cubic yard for stone loaded onto a barge at the quarry. Currently in 2023, DNR is paying about $1.11 a bushel or $18.57 per cubic yard. The price will increase by about $1.43 per cubic yard in January 2024.

In 2021 the cost of stone from a quarry located in Virginia was quoted at $1.07 a bushel or $17.86 a cubic yard. When considering the transportation costs, the loaded barge cost was $1.37 a bushel or $22.86 a cubic yard. This has likely increased with inflation.

In 2021 the cost of river rock from a quarry located in Delaware was quoted at $0.69 a bushel or $11.43 a cubic yard. When considering the transportation costs, the loaded barge cost was $1.32 a bushel or $21.93 a cubic yard. This has likely increased with inflation.

2.2.2 Limestone

Description

Limestone is a calcium based stone thus it has been found to be a suitable substrate as oysters prefer substrates that are calcium based. Like other stones, if the stone size is larger it also can provide a high amount of interstitial spaces for oysters and other reef organisms.

Limestone has been evaluated or used in many of the Gulf states, including Mississippi, Louisiana and Texas. It has been used on reefs in Mississippi since 2003. Reefs built in Louisiana as part of the Deepwater Horizon restoration found that settlement, growth and survival were good on limestone reefs. In St. Charles Bay, TX, it was evaluated as an alternate substrate and was found to have recruitment similar to oyster shells.

Spat recruitment potential

Medium to High. Limestone has been shown across a number of different projects to be as, or more effective than other alternate materials and occasionally oyster shells for recruitment (Louisiana Dept. of Fish and Wildlife [LDFW] 2004).

Availability

Highly available in a variety of types and sizes.

Sources

Limestone quarries can be found in Frederick, MD and Pennsylvania.

Costs

In 2021, the cost to source limestone from a quarry in Pennsylvania was $1.15 a bushel or $19.18 a cubic yard. When considering the transportation costs, the loaded barge cost was $2.08 a bushel or $34.64 a cubic yard. This price likely increased with inflation.

2.3 Man Made Materials

2.3.1 Recycled Materials

Description

Recycled materials have been used as substrate for reef bases mostly for artificial fish reef habitat. However, if the environmental conditions are suitable at these locations where recycled material were placed, natural oyster recruitment can occur. Examples of commonly used materials are cured, concrete recycled from decking from bridges, road culverts, damaged concrete pipe, junction boxes, and manhole covers.

Maryland DNR has an established program, the Maryland Artificial Reef Program (MARI), that acts as a funding mechanism (using private and corporate donations) for reef development in Maryland. The purpose of the MARI is to provide artificial reef habitat on selected Chesapeake Bay, Atlantic Ocean and coastal bay sites to enhance habitat for fish and benthic organisms associated with reefs, increase reef biological carrying capacity, enhance biological diversity, increase fish populations, and provide sustainable fishing opportunities (Loftus and Stone 2007[4]). In general, allowable materials for artificial reefs in Maryland's tidal waters will follow the most recent edition of Guidelines for Marine Artificial Reef Materials. This is a joint publication of the Gulf and Atlantic States Marine Fisheries Commissions (Lukens and Selberg 2004).

Spat recruitment potential

Variable depending on the material

Availability

Variable

Sources

Variable. Often construction companies have access to recycled materials.

Costs

Variable[5]. Some construction companies are willing to donate the recycled materials for free as this can be a less costly option then a landfill.

2.3.2 Concrete

Description

Concrete can be used as substrate base for oyster reefs. The concrete can either be "green" meaning newly produced for the use in oyster projects or recycled. Recycled concrete is produced from demolition of buildings and other sources which is then crushed to the desired

[4] Loftus, A.J. and R.B. Stone. 2007. Artificial Reef Management Plan for Maryland. Pg 260. https://dnr.maryland.gov/fisheries/documents/Maryland_Artificial_Reef_Plan62607.pdf

[5] Maryland Artificial Reef Program. Summary Projects List. https://dnr.maryland.gov/fisheries/documents/MARI_REEF_PROJECTS_SUMMARY.pdf

size and has non-concrete debris like rebar removed. Concrete should be free of contaminants in order to be used in oyster projects. A private company, Grow Oyster Reefs LLC, has developed a concrete mixture specifically formulated to approximately match the chemical composition of oyster shells.

Crushed concrete has been used as a reef base in Maryland waters. Reefs bases have been made in the Severn River and Mill Hill sanctuaries. Recently there is interest from Maryland oyster harvesters and aquaculturists to use recycled concrete on public fishery bars and leases. The low price of this material, high availability, and successful use in Gulf states has prompted this interest.

Spat recruitment potential
Variable. Recruitment potential may vary based on the chemical makeup of the concrete and project location.

Availability
Variable. Availability to procure concrete is dependent on large demolition projects with suitable material and the complex logistics of transporting and processing the material.

Sources
Variable. Large scale demolition projects containing appropriate materials. Often from the demolition of bridges or buildings.

Costs
Costs can vary greatly depending on whether the material is purchased or donated and how much the material needs to be handled for shipping and processing.

In 2021, the cost to source cement (“green”) from a quarry in Pennsylvania was $0.84 a bushel or $13.93 a cubic yard. When considering the transportation costs, the loaded barge cost was $1.76 a bushel or $29.39 a cubic yard. This price likely increased with inflation. A company in Salisbury, Maryland can sell crushed recycled concrete for about $2 per bushel or $33.32 a cubic yard, not including transportation and planting costs.

2.3.3 Slag

Description
Steel slag is a byproduct of iron and steel production. It is a solution of silicates and metal oxides that solidify upon cooling. It can be used as a substrate for the base of an oyster reef.

Steel slag has been used as a reef base by DNR in Mill Hill Sanctuary and by USACE in the Severn River.

Spat recruitment potential
High. Slag evaluated by DNR and USACE resulted in more natural spat when compared to stone, shell, and reef balls when placed in areas conducive to natural spat set.

Availability
Highly available.

Sources
Variable. Past slag used was sourced from Severstal Steel Mill in Sparrows Point, MD.

Costs
In 2014, slag was estimated to be priced at $1.64 a bushel or $27.26 per cubic yard. This price has likely increased due to inflation.

2.3.4 Porcelain

Description
Porcelain or vitreous china, usually from sinks and toilets, has been tested for usage as an oyster reef base in a few areas including Virginia and New York. While one study in the Gulf of Mexico (George at al. (2015)) showed that porcelain performed similarly to other materials, there is little research using the material to draw any conclusions on long term suitability. In New York, the Department of Environmental Protection and the New York City Department of Education had a joint project in which the city retrofitted 500 school buildings toilets and repurpose the old toilets as a reef base for oyster restoration. There can potentially be a negative public perception to this type of material since it can be viewed as dumping trash in the bay.

Spat recruitment potential
Similar to oyster shells and other alternative materials.

Availability
Unknown. No known large sources of this material have been found at this time.

Sources
Unknown. No known large sources of this material have been found at this time.

Costs
Unknown.

2.3.5 Engineered reefs

Description
Engineered reefs are structures formed from molded concrete, such as reef balls, reef castles or fish havens. These structures can be placed on the bottom for a natural spat set or can be placed in remote setting tanks to be set with hatchery reared oyster larvae before being deployed. The composition of the concrete can be tailored for a project to try and increase recruitment by adding calcium or pieces of shell to the mix or the outside of the structure.

The majority of engineered reefs placed in Maryland's bay are in oyster sanctuaries or on MARI sites. The use of engineered reefs is not preferred by the public fishery or aquaculturists as only diver harvest can be used on these reefs.

Spat recruitment potential
High. Structures placed in setting tanks have demonstrated a high suitability to receive spat. Reef balls placed in high natural recruitment areas have also demonstrated a high setting suitability.

Availability
High. Technically unlimited, use of engineered structures is more likely to be limited by the costs and labor associated with their construction on a large scale.

Sources
Groups such as the Coastal Conservation Association and the Chesapeake Bay Foundation construct reef structures with volunteers. There are also companies who produce structures on a more industrial scale.

Costs
$50-$900 per unit depending on size and configuration. Delivery and deployment of many engineered reef structures at one time would add an additional $25,000+ to the cost.

2.3.6 Engineered shells

Description
Biocement, a sandstone like material made from a bacteria that produces calcium carbonate crystals and sand, is being produced and evaluated as an alternative to oyster shell.

Spat recruitment potential
High. Lab tests suggest that it is a better substrate than granite.

Availability
This is in the research and testing stages and not available for purchase.

Sources
Not available.

Costs
Unknown.

2.4 Comparison of Materials

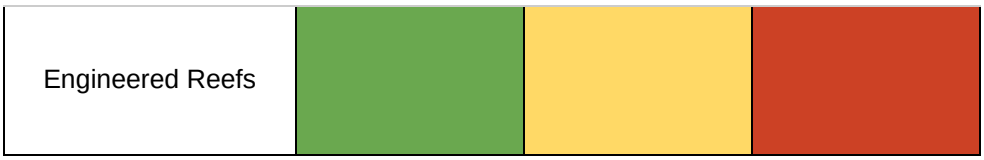
The following table shows a visual comparison of the different material types reviewed for oyster substrate (Goelz et al 2020[5]). Goelez et al 2020 stated all materials other than non-oyster shells

had the potential for high natural spat recruitment, only fresh, dredged, and non-oyster shells had low availability, and costs were low or moderate for all materials except porcelain and engineered reefs.

Table 1. Different types of material that can be used as substrate for oyster reefs. Green denotes high recruitment, high availability and low cost. Yellow denotes moderate recruitment, availability and costs. Red denotes poor recruitment, low availability, and high costs. Comparison was published in Goelz et al 2020[6]

Material	Spat Recruitment	Availability	Cost
Fresh Shell			
Dredged Shell			
Fossilized Oyster Shell			
Non-Oyster Shell			
Non-Calcium Stone			
Limestone			
Concrete			
Porcelain			

[6]Alternative Substrates Used for Oyster Reef Restoration: A Review. Taylor Goelz, Bruce Vogt, and Troy Hartley. Journal of Shellfish Research 39(1), 1-12, (14 April 2020).



3.0 Estimate of Substrate Needs and Costs

3.1 Sanctuary Restoration

As the 2014 Chesapeake Bay Watershed Agreement large-scale sanctuary restoration project is nearing completion in 2025, it is estimated that approximately 337,920 bushels of shell and 54,000 tons of stone are needed to complete the current projects (as of September 2023). The estimated cost for the stone is $1.404 million and the shells are $2.37 million. These costs do not reflect transportation and planting costs. It is unknown at this time if the 2014 Watershed Agreement will be revised, or if a new agreement will be signed. It is also unknown if there will be a new oyster goal beyond 2025. A new restoration goal and projects will require additional substrate in the future.

Other restoration plans over the next 10 years include the Eastern Bay project and small-scale restoration projects. The Eastern Bay project is mandated by Maryland law and requires hatchery-reared spat-on-shell to be placed in Eastern Bay region sanctuaries. This will require about 352,000 bushels of shell over the next ten years with the cost of shell, production of spat-on-shell, and plantings at $10 million. Small-scale restoration projects place hatchery-reared spat-on-shell on approximately 15 acres annually within sanctuaries not receiving large-scale restoration or part of the Eastern Bay regional project. This requires about 144,000 bushels of shells over the next ten years with the cost of shell, production of spat-on-shell, and plantings at $3 million.

The Marylanders Grow Oysters program is a public outreach initiative that allows waterfront homeowners to grow oysters at their piers which go towards restoration activities. Participants are provided with cages and spat-on-shell to tend at their piers for around nine months. After that time the oysters are collected and planted on local sanctuary bars. In 2022, MGO distributed just over four million spat-on-shell to its participants using 853 bushels of fresh shell. If the program remains static over the next ten years, 8,530 bushels of shells will be required at a cost of approximately $50,000. If the program grows, the need for shell will also increase.

Recently, DNR submitted a permit to USACE and MDE to plant hatchery reared spat on substrate other than shell. If approved, this will likely alter the needs and costs of these projects in the future. Also, if additional restoration projects are requested of DNR then the need for substrate will increase.

3.2 Public Fishery Replenishment

The public fishery utilizes shell both directly by planting it on oyster bars and indirectly with the production and planting of spat-on shell. There are two main programs currently ongoing: the Public Fishery Replenishment Program and the Eastern Bay Region Project.

The public fishery replenishment program is funded by a grant from the Maryland Department of Transportation Port Authority, revenue from a surcharge required to be purchased from licensed commercial oyster harvesters, revenue from a tax on each bushel of oysters commercially harvested, and revenue from a tax on each bushel of oyster commercially harvested that was exported out of the state of Maryland. As these funds vary annually, this equates to variability in the annual needs of the program.

Current information indicates a 2 to 1 ratio of shell planted versus oyster harvested is required to maintain productive fishery oyster reefs. This would equate to needing between 500,000 and 1,000,000 bushels of shell, based on current harvest levels, and the recent cost of $3 million to $6 million annually. In 2023, 110,000 bushels of fresh shell was available to procure and plant on public fishery bars and about 72,000 bushels of fresh shell was used to produce spat-on-shell at a cost of $4.6 million for procuring the shell, producing spat-on-shell, and planting the shell and spat-on-shell. The known sources of Man-O-War dredged shell requested in the permit application, Washington State shell, Taiwan shell would be able to cover these needs for an estimated 7 to 15 years. However, a new source of shell or another substrate would need to be used after these sources are depleted. Furthermore, if harvest on alternative substrates is proven effective with traditional harvest gear, the need for alternative substrates will increase.

In lower salinity areas of the bay, harvesters prefer planting spat-on-shell under the public fishery replenishment program. This provides those bars that have lower natural recruitment with shell and living oysters. In 2023, the highest amount of spat-on-shell to date was planted under the public fishery replenishment program. The 450 million spat-on-shell planted in 2023 required about 72,000 bushels of shell at a cost of approximately $1.8 million.

The Eastern Bay project is mandated by Maryland law and requires shell and/or spat-on-shell to be placed on public fishery oyster bars in the Eastern Bay region using a budget of $1 million annually. If the project preferred planting just shells this would equate to about 110,000 bushels of shells each year at the current costs to procure the shell and conduct the planting. If the project preferred planting just spat-on-shell, this would equate to about 40,000 bushels of shell each year at current costs to procure shell, produce spat-on-shell, and conduct the planting.

Recently the public fishery has expressed interest in utilizing alternative substrate on public fishery bars. A permit was obtained from MDE and USACE to plant alternative substrates on a public fishery bar in Pocomoke Sound (Somerset County) and another site in Broad Creek (Talbot County). The project has yet to occur in Pocomoke Sound as planning is still ongoing for the logistics to plant small stone. The Broad Creek site was just approved in late 2023 and will

soon begin planning the planting of crushed, recycled concrete free of debris. At this time the need and costs of these projects and potential future projects are unknown.

3.3 Aquaculture

Aquaculture lease holders in Maryland are required to annually plant at least one–fourth of the leased area at a minimum density of 1,000,000 shellfish seed per acre or comply with any other requirements established by the Department[7]. Due to limitations of shell and seed availability and some years of poor environmental conditions, the Department has reduced the minimum density on several occasions. Currently there are 6,968 acres of submerged land leases (aka bottom leases)[8], all of which require annual shell or oyster plantings. Planting density of shell and spat-on-shell can vary greatly depending on the lease location and current condition of the lease bottom.

As aquaculture continues to grow, the demand for shells will increase. Lease holders have expressed interest in using alternative substrates, like limestone or concrete, either as the base for their lease or for use in remote setting tanks where hatchery-produced larvae are used to produce spat on the substrate. Use of alternative substrates for aquaculture is still in its infancy resulting in the need and cost being indeterminate, but likely to grow with mollusk shell demands.

Shellfish aquaculture lease area has grown, on average, by 10% per year with current leased area totalling 7,536 acres. Continuing this growth trend, in 10 years there may be 18,000 acres leased for shellfish aquaculture. Along with growth in leased acres will necessitate an increase in the demand for shells to meet active use requirements. The current yearly average for reported shell plantings for aquaculture is 229,000 bushels of shell. Following the 10% growth, the 10 year demand will grow to almost 600,000 bushels of shell per year for aquaculture. This estimate is likely conservative, as the Department has lowered the active use requirement in recent years due to limitations in shell supplies and due to reports from aquaculturists indicating that plantings would be greater if more shells were available for purchase.

4.0 Overall Substrate Needs Plan and Costs

The overall future needs of substrate, types, and subsequent costs are difficult to estimate for all three sectors - public fishery, restoration, and aquaculture. It is dependent on the status of the oyster population (in particular natural recruitment which adds shell), the amount of harvest (which removes shell), acreage of aquaculture leases, and acreage of restoration projects.

Recent estimates of fresh shell needed from all three sectors given the current known projects and industry needs ranges from 1.179 to 1.679 million bushels annually for the next two years and then 0.879 to 1.768 million bushels for the following eight years with a maximum need for

[7] Natural Resource Article §4–11A–09(c)
[8] Water column leases usually produce clutchless oysters thus were not included in this analysis.

fresh shells at 17.502 million bushels over the next 10 years assuming the current projects and programs remain constant. Using recent cost estimates, this maximum amount of fresh shell equates to $105,012,000 not including planting costs. Planting costs range based on distance traveled, planting deployment method, and if fresh shell or spat-on-shell is being planted.

Currently, the costs of alternative substrate materials tends to be less than shell, however, planting costs of the substrate may be higher as most alternative substrates are heavier than shell. Cost for planting stone in large-scale restoration areas is about $70,000 per acre for a foot of substrate placed. However, increased oversight, exact placement, placement methodology (barge and crane with a hydropack), multiple bathymetric surveys, and tweaking stone placement afterwards are all factors in deployment costs. The cost to plant an equivalent amount of fresh shell is about $75,000 using a run boat washing the shells of the deck of the vessel using water pressure. Typically this method is used to plant shell or spat-on-shell at a 1 to 2 inch thick layer as opposed to the 12 inch thick placement of stone used to create a reef base in restoration. Methodology for deploying a 1 to 2 inch thick planting of small-sized alternative substrates such as stone or crushed concrete on public fishery oyster bars has yet to be fully determined. After the method is finalized and if the price is less or about the same as shell deployment, the public fishery replenishment program may increase its need for alternative substrate.

In July 2023, Governor Moore issued Executive Order 01.01.2023.12 which created a Shell and Substrate Task Force. The principal functions of the task force are to:

1. Identify strategies and solutions to retain shell, increase abundance and create an overall additive situation for oyster substrate across the Chesapeake Bay;
2. Evaluate strategies based on the ability to meet the demand from the public fishery, aquaculture industry and restoration component in the near term and focusing on meeting needs for the growth of all three components; and
3. Evaluate the economic impacts substrate has on the State and develop recommendations that take into consideration costs and benefits for the fishery.

The Governor appointed 12 member task force will be submitting a report by December 1, 2024 which will provide recommendations towards achieving a positive oyster shell and substrate environment. In deference to this newly formed task force, DNR will hold off on developing a plan until after recommendations are received from the task force so that they may be incorporated.

5.0 Opportunities for Improving Cost-Effectiveness

The loss of shells to out of state oyster sales, as well as the shortage of shells is a long term issue that needs to be addressed. Shells, being a limited resource, are affected by the market value and recently prices have continued to increase. This is a multifaceted issue that will take significant initiatives to help resolve. Furthermore, not just one option will solve the shell

shortage and instead multiple sources of shell and substrate will be required to meet all the needs of Maryland.

One option for improving cost-effectiveness is to retain more shell after harvest within Maryland. There are only a few shucking houses still operational in Maryland and most of them tend to handle lower quantities of oysters as compared to years ago and compared to shucking houses in other states. Thus, the majority of oysters harvested from Maryland waters tend to be exported out of state and only a portion of the shells are purchased back and replanted in Maryland waters. The creation of more Maryland shucking houses and/or expanding the existing ones to increase the volume of oysters they can handle would assist in the retention of more shells. Retention of shells from Maryland harvested oysters may also prove to be a cost savings given the decreased transportation associated with planting these shells back in Maryland waters.

Another option for improving cost-effectiveness is the economy of scale. Purchasing items in bulk normally tends to allow for cost savings. If substrate needs could be consolidated for all three sectors - sanctuary restoration, public fishery replenishment, and aquaculture - there could be a possibility of obtaining the substrate at a lower cost given the higher amount being requested. There is difficulty with implementing this however. The replenishment planting budget is based on bushels harvest, bushel exported out of state, and the amount of harvesters thus it is hard to predict the funding in advance which is used to purchase substrate. Similarly, it is hard to predict if new aquaculture leases need substrate and/or current leaseholders opting to not renewing their leases. Economy of scale could potentially work within just the sanctuary restoration programs as these projects usually have known amounts of substrate required far in advance.