

INTRODUCTION

Oyster beds were historically prolific throughout Rhode Island’s estuarine waters and contributed to the productivity and diversity of marine and estuarine fish and wildlife species. In recent decades, however, declining oyster habitat has led to a reduction in water quality and harvest yields.



Healthy oyster beds provide benefits including a complex living habitat and a biodiverse ecosystem for many species of fish, crabs, mussels, barnacles, and other reef dwellers. Oysters serve as a high protein food source for migratory shorebirds and other marine organisms. The water filtering capacity of oyster beds improves water quality as well as water clarity.

Oyster Life Cycle

The eastern oyster (*Crassostrea virginica*) spawns in Rhode Island waters when water temperatures become greater than 68°F, typically in early summer. The oyster begins its life as a free-floating organism, and within 2 to 3 weeks, develops a foot and eye spots, at which time it is referred to as *eyed larvae*. The eyed larvae settle to the bottom, where they attach to oyster shell or another suitable substrate. Once attached, the tiny oyster larvae are referred to as *spat*. The process of oyster larvae attaching to substrate is known as *spat set*.

Spat grow rapidly and can reach reproductive maturity in 2 to 3 years, with a lifespan of up to 20 years. Oysters feed by filtering plankton and other particulate matter through their gills. Oysters feed at the highest rates when water temperatures are above 50°F. Oyster growth is most successful in areas with firm and stable bottom, and with salinities of 10 to 30 ppt, little sediment accumulation, and oxygen concentrations greater than 5 mg/L.

RESTORATION

Oyster reefs can be rehabilitated or restored in areas where conditions will support their growth and reproduction. A firm or hard bottom, with or without shell, can be used for oyster reef restoration. Soft substrate can also support oyster reef creation if a shell base is placed prior to placement of oysters. Oyster restoration through the EQIP Oyster Restoration Program in RI consists of several phases, including setting of oyster larvae at the hatchery, spat on shell grow-out on a participants lease, deployment of oysters at the restoration site, and several years of monitoring of those constructed oyster reefs.

Restoring and Building the Shell Bed

The appropriate substrate (either naturally occurring or augmented) is critical for oyster reef restoration. A shell base elevates oysters in the water column for feeding, and reduces the potential for smothering by sediment. For best establishment, the shell should be placed at a rate of about 5 cubic yards per 1,100 square feet (prior to deployment of oysters), or 10 cubic yards per 1,100 square feet (if sufficient larval supply is present).

The use of oyster shell as a base material is preferable, but may not always be available. When oyster shell is not available, an alternative shell source may be considered to create the shell base. When using shell other than oyster for the base, the base should be top-dressed with oyster shell to increase the potential for oyster recruitment.

Seeding the Bed

In a limited number of areas within Narragansett Bay and RI coastal ponds, natural spat set occurs at a rate adequate for oyster bed establishment and sustainability. In most areas, however, natural spatfall is insufficient to fully establish or sustain oyster beds and active seeding of the beds is required.

Oyster beds can be actively seeded with spat set on bivalve shell. Rhode Island NRCS has two spat on shell seeding options: Typical and Large. Typical spat on shell size ranges from 1 to 2 inches (on the longest axis), and large spat on shell is 2 inches and greater.

The spat can be set on shell in an oyster hatchery or a remote setting facility. In both cases, eyed-larvae are added to tanks containing clean shell in bags. After 5-14 days in the tanks, depending on the age at introduction into the tank, oyster larvae settle onto the shells, resulting in spat set on shell. The controlled environment enhances the spat setting efficiency, but usually requires 3 to 6 times as many larvae to achieve the desired number of spat on shell (target is 1 million spat on shell across 300 bags). In early summer, once the spat is set, the spat on shell is transported to the oyster farm to be grown out.

For a "Typical" scenario with spat on shell, the oysters are grown for approximately 20 weeks (until they are at least 1 inch in size). For a "Large" scenario spat on shell, the growing period is approximately 40 weeks (until they are at least 2 inches in size). Once oysters reach the appropriate size, the totes of spat on shell are transported to the oyster restoration site and are placed onto the shell base or existing oyster bed. For the "Typical" scenario, 45 totes containing a minimum of 250,000 spat on shell oysters (annual seeding target) will be placed on a 1,100 square foot area. For the large oyster scenario, 60 totes containing a minimum of 200,000 spat on shell oysters (annual seeding target) will be placed on a 1,100 square foot area.

An alternative approach applied in specific situations is the "Single" oyster scenario, in which single-set oysters (oysters set on micro-cultch rather than whole shell), 3.5 inches or greater, are used for seeding. When using this scenario, a minimum of 20,000 oysters (and depending on site conditions up to 100,000 oysters) will be deployed at the restoration site. The equivalency for single-set oysters is 1,200 live oysters is equal to 1 tote payment. Deploying larger oysters is intended to increase survivorship after initial seeding, as they are less susceptible to predation, resulting in a greater proportion of seeded oysters being available for spawning and reproduction.

Oyster Seed Type

Natural oysters are diploid oysters, meaning that each of their cells contains two sets of chromosomes. Diploid oysters are capable of reproducing, and may take as many as 3 years to reach reproductive size. Because diploid oysters are fertile, they have the ability to maintain, reproduce, and expand oyster reefs, and can also help to support natural oyster populations by providing spatfall to area waters.

For NRCS funded restoration projects, only diploid oyster seed will be used. The use of triploids is not permitted. For the Typical scenario, oysters will be deployed in November. For the Large scenario, oysters will be deployed between May and July. For the single oyster scenario, oysters will be deployed anytime between April and December.

Use of Cultch in Restoration

- Sites with suitable recruitment: If the site has sufficient larval supply, but is habitat limited, NRCS will plan to deploy 90 totes of clean cultch. Consideration should be given to the depth of the site, and reduction in the number of totes can be made as appropriate by reducing the planned amount (in consultation with NRCS State Biologist and RI DEM).
- Sites without suitable recruitment: If cultch is used as a substrate (foundation) for a new reef, participants will deploy 45 totes of clean cultch for each 1,100 square foot area. If there are existing, older reefs within the restoration plot, the number of totes of clean cultch can be reduced as needed (in consultation with NRCS State Biologist and RI DEM).

Restoration Options for Oyster Reef Seeding: Typical and Large

1) Seed Type: Spat on Shell

Important: All oysters used for reef creation must be diploids.

- **Typical** Spat on Shell Deployment (1 to 2 inches in size)
 - Each deployment of oysters will occur in ¼ of the 0.1 acre plot (approximately 1,100 square feet) and will include 45 totes containing 250,000 or more spat on shell oysters deployed in a given year (with a minimum threshold of 180,000 oysters deployed to be eligible for full payment).
 - A Typical project will include 4 years of placement with a total project target of 1,000,000 or more oysters, 1 to 2 inches in size deployed at the restoration site. The number and schedule of deployments may be modified by RI DEM and the NRCS State Biologist.
 - Monitoring will be completed as part of the restoration process. Refer to the RI 643 Oyster Monitoring job sheet.
- **Large** Spat on Shell Deployment (2 inches or larger)
 - Planned for sites with high predation/mortality, or other conditions that justify deployment of larger oysters. Each deployment of seed will cover ¼ of the 0.1 acre plot (approximately 1,100 square feet) and will include 60 totes containing 200,000 or more spat on shell oysters deployed in a given year (with a minimum threshold of 144,000 oysters deployed to be eligible for full payment).
 - A typical project will include 4 years of placement with a total project target of 800,000 or more oysters, 2 inches or larger at the restoration site. The number and schedule of deployments may be modified by RI DEM and the NRCS State Biologist.
 - Monitoring will be completed as part of the restoration process. Refer to the RI 643 Oyster Monitoring job sheet.

2) Seed Type: **Single Oysters** of at least 3.5 inches or greater

- A minimum of 20,000 oysters will be deployed at the restoration site
 - For payment purposes: 1,200 single oysters = 1 tote payment

- Monitoring will be completed as part of the restoration process. Refer to the RI 643 Oyster Monitoring job sheet.

ADDITIONAL REQUIREMENTS

Shell Requirements:

- If using shell that is not steam shucked, the shell needs to be cured/weathered according to Rhode Island Biosecurity Board procedures. In short, shell must be cured/weathered for at least 6 months and have no trace of tissue remaining on the shell. If stored in a pile, the pile should be periodically turned over to ensure even weathering.
 - Growers shall contact CRMC for inspection/approval after the 6-month curing period. Prior to deployment, NRCS will require an email from CRMC confirming that this inspection took place.
- It is imperative that shell sent to the hatchery is clean (i.e., bagged shell does not contain sediment, silt, debris, dust, or detritus). This requires that growers power-wash or rinse the shell thoroughly just prior to delivery to the hatchery, even if shell was cleaned prior. Hatcheries have the right to reject bagged shell that is not clean, as it can negatively impact their tanks, setting efficiencies, and conditions for other growers.
- Cultch used to build reef base must be retained on a 2-inch mesh screen. No crushed shell may be used. If necessary, material will need to be sieved prior to being placed in totes for deployment. NRCS shall inspect cultch 2 months prior to deployment.

Seeding, Oyster Handling, and Grow-Out Requirements:

- If using wild lineages for setting, growers need to contact the hatchery by April 1 to initiate discussions so they can plan and prepare appropriately. RI DEM determines the wild lineage that shall be used for a given restoration site/area.
- Participants that are not using wild lineages should contact hatcheries early in the spring to coordinate lineages and setting dates.
- Spat on shell oysters must be transported to the grower's lease following seeding at the hatchery and must be grown out on the grower's lease.
 - The grower must have the space and gear needed on their lease to accommodate the material in 300 hatchery setting bags, which is equivalent to at least 4-5 cubic yards of 'typical' (1 inch) spat on shell at time of deployment, or 5-6 cubic yards of 'large' (2 inch) spat on shell at time of deployment.
- Growers are required to tend/sort oysters on a weekly basis during the growing season, between April and mid-November.
- Growers must transfer spat on shell oysters from setting bags to typical grow out gear (i.e., larger-mesh bags), as needed, to avoid overcrowding and facilitate growth.
- Size of oysters at deployment must be 1 to 2 inches (measured on the longest axis) at time of deployment for the Typical scenario, and 2 inches in size for the Large scenario.
- Hatchery and Grow Out records must be kept in accordance with NRCS form "643 Oyster Restoration Implementation Requirements".
- NRCS will schedule at least one site visit to the grower's lease during the growing season to observe grow-out methods, gear used, document oyster sizes and numbers, and record biofouling observations.

Equipment and Personnel Requirements:

- Growers need to have a minimum of one deck-hand in addition to themselves for deployments.
- Boats used for oyster restoration work must have current registration, USCG safety inspection (decal and/or paperwork), and all required safety gear on board.
- Growers must have equipment on board to stabilize boats during deployment (may include spud bars, anchors, and/or metal poles). For shallow water sites, growers should have at least one crew member on board in waders or a wet suit, who is prepared to be in the water during deployment, holding the boat or spreading cultch or spat on shell. Growers must have multiple anchors on board with at least 4-5 feet of chain and sufficient length of rope to provide stability during deployment. NRCS will reschedule deployment if growers are not prepared.

Monitoring Requirements:

- Monitoring is a required component of the program. Growers are responsible for hiring a qualified monitoring contractor to monitor reefs in the fall of each year following deployment. A list of qualified contractors will be provided by NRCS. Establishing agreements/contracts with a qualified contractor during the late-spring or summer will ensure this component is completed during the appropriate time frame. Growers are responsible for ensuring that monitoring is completed on time.

OPERATION AND MAINTENANCE

In most cases, the reef should be left untouched after seeding. If major siltation is causing mortality (as determined by monitoring) then adaptive management action can be taken.

Shell augmentation and overseeding is another important component of oyster bar maintenance. In some cases, additional oyster shell and oysters may be added to the bar to enhance oyster production.

OTHER CONSIDERATIONS

Oyster bed restoration activities in Rhode Island require permits and compliance with a number of regulatory programs, including CRMC and RI DEM regulations and guidance. Cooperators and participants are responsible for obtaining all necessary licenses and contracts, and ensuring compliance with permits and regulatory program requirements.

REFERENCES

The Rhode Island Shellfish Management Plan, Version II. November 2014. Available at: http://www.rismp.org/wp-content/uploads/2014/04/smp_version_2_11.18.pdf

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