AECOM
9 Jonathan Bourne Drive
Pocasset, MA 02559
www.aecom.com

508.833.6950 tel
508.833.6951 fax

Memorandum

To	George Meservey, Director of Planning & Community Development Michael Domenica, PE, Program Manager
CC	Betsy Shreve, AICP, AECOM Project Director Sia Karplus, Science Wares, Inc. Anamarija Frankić, PhD, Biomimicry New England Mark Begley, MT Environmental Restoration Paula Winchell, AECOM
Subject	**Town of Orleans, MA** **Water Quality and Wastewater Planning** **Task Number 3.2 – NT Demonstration Projects** **Final Technical Memorandum on Shellfish Cultivation - Preliminary Engineering Design and Work Plan for Preferred Site(s)**
Project Number	60476644
From	Thomas Parece, P.E., AECOM Project Manager
Date	05/04/16

1. Background

This Technical Memorandum on Shellfish Cultivation - Preliminary Engineering Design and Work Plan for Preferred Sites presents preliminary design for four different shellfish demonstration projects. To identify the sites included in this Technical Memorandum, an in-depth critique of the Site Characterization Technical Memorandum was conducted, involving review and comments from several outside experts as well as several meetings with a Town of Orleans working group that consisted of the Shellfish Constable/Harbormaster and representatives from the Shellfish and Waterways Advisory Committee, Orleans Marine and Freshwater Quality Task Force, Orleans Pond Coalition, Citizens Peer Review Committee, and Orleans Water Alliance. After this detailed review, four demonstration programs were selected for preliminary engineering:; propagation of oysters in Kescayo Gansett (Lonnie's) Pond; increased production of quahogs in Town Cove and Pleasant Bay through additional seed planting; formation of an oyster bed in the outer Quanset Area (Quanset); and enhancing oyster aquaculture in Pleasant Bay and Town Cove by either working with existing growers to increase production and/or through the Town offering additional lease areas.

The following further describes the four projects:

- **Propagation of Oyster Singles in Lonnie's Pond**
    - Water quality is most degraded in terminal ponds, so a method of introducing non-traditional technologies in these areas is needed;
    - A demonstration is needed to determine the extent to which oysters can make a measurable difference in water quality parameters;

- Growing oyster singles starting at a size of at least ½ inch in floating bags allows the impact of larger shellfish to be monitored;
- Terminal ponds have fine-grained, soft sediment that is often low in oxygen, which precludes bottom-planting, therefore floating bags provide a viable growing method and may create diverse ecosystem habitats; and
- Predation and disease should be minimized by growing oysters in floating gear that is off-bottom.

- **Increased Production of Quahogs in Town Cove and Pleasant Bay**
  - Suitable bottom in these estuaries is ideal for enhanced quahog planting;
  - The first necessary step is to establish a baseline population count in areas historically planted by the town to quantify the success of future propagation efforts; and
  - Once baseline populations of quahogs and other shellfish species are quantified, these areas will be planted with additional quahogs under the municipal propagation program, and survival will be evaluated.

- **Formation of the Quanset Oyster Bed with Bottom Planting**
  - Oyster beds are often created by growing remote set (spat-on-shell) in gear for a period of time, then bottom-planted on suitable substrate;
  - Oyster beds have higher densities than gear-based systems per unit area, and create diverse ecosystem habitats;
  - A demonstration is needed to determine whether oyster beds can become a self-sustaining habitat in suitable areas within Pleasant Bay; and
  - Predation and disease prevention must be considered for this growing option.

- **Enhanced Aquaculture in Pleasant Bay and Town Cove**
  - In Orleans, there are twelve aquaculture leases in Pleasant Bay and one in Town Cove. Additionally, Eastham has approximately thirteen leases in Town Cove;
  - Increased production in the aquaculture leases would provide a way to increase the number of shellfish in Pleasant Bay and Town Cove;
  - Meaningful dialogue with growers is needed to build an understanding of the practical extent to which shellfish aquaculture can help contribute to the town's water quality goals;
  - Understanding the opinions and concerns of growers through questionnaires and discussions will help define the needs of this group and ultimately assist in meeting the town's numerical goals for nitrogen removal through growing shellfish; and
  - Explore the possibility of additional leases.

This TM describes the general design specifications for the quahog population study including an estimate of the bottom area that needs to be surveyed and survey parameters. Design specifications for growing oysters in an off-bottom system in Lonnie's Pond, and bottom-planting in Quanset also include an estimation of water surface area, gear requirements, gear layout, and quantities of shellfish to be grown. The project description for working with growers enumerates the tasks needed to identify appropriate methods of collaboration with growers currently operating within Pleasant Bay and Town Cove, and evaluating the potential for expanded aquaculture. A monitoring program for Lonnie's Pond is also described, with maps showing the locations of sampling stations and a description of the water quality and other parameters to be measured. Finally, a pathway to full scale implementation is discussed.

2. Introduction

A. Summary of the Site Characterization Technical Memorandum and Town Review

The Site Characterization and Evaluation Technical Memorandum identified, evaluated, ranked and ultimately recommended specific shellfish demonstration sites and growing methods. Sites and associated species and growing methods that were evaluated included:

- Little Pleasant Bay (Existing aquaculture grants, oysters and quahogs);
- Quanset (Oyster bed);
- Pochet (Oyster reef);
- Arey's Pond (Oyster singles in floating bags);
- Town Cove (Quahog propagation);
- Mill Pond (Quahog propagation);
- Lower River (Oyster singles in floating bags); and
- Lonnie's Pond (Oyster singles in floating bags)

To facilitate a systematic and objective evaluation of each of the potential demonstration sites, a decision support tool, called a Site Selection Matrix was developed. This Site Selection Matrix assesses a number of criteria for Site Suitability, Permitting, and Project Evaluation. Site Suitability criteria assess the environmental, land use and implementation characteristics of each proposed demonstration location. Permitting criteria assess the regulatory issues related to each proposed demonstration location. Project evaluation criteria evaluate the likelihood of obtaining meaningful results from a proposed demonstration site. Other/Overriding Considerations refer to any threshold issue that precludes a demonstration at a given site.

These criteria were first presented as part of the process of developing the Orleans Consensus Plan. The Shellfish Technical Team refined the criteria after reviewing the Site Ecology and Surrounding Environment data as described above. The Site Selection Matrix now includes the following criteria:

- Site Suitability
    - o Available Growing Area/Adequacy of Acreage;

- Water Quality Indicators;
- Disease/Predation;
- Ease of Access;
- Aesthetic Impacts;
- Representativeness of the Site (Transferability);
- Use Conflicts; and
- Ability to Co-Locate with other Non-Traditional Technologies.

- Permitting
  - Abutter Compatibility;
  - Wild Harvest Conflicts (DMF);
  - Grow-Out to Harvest Size Allowed (DMF); and
  - Ability to obtain permits.
- Project Evaluation
  - Expected Survival; and
  - Overall Likelihood of Monitoring Plan to Yield Quantified Results.
- Other/Overriding Considerations

The four projects described in this Technical Memorandum resulted from the Site Selection Matrix and evaluation process, AECOM Shellfish Team deliberations, and input from a range of Orleans stakeholders. The choice of Lonnie's Pond as the preferred location for the town's first shellfish demonstration project was made based on two key factors: the town's strong desire to improve the environmental conditions in the town's terminal ponds, and the expected ability to monitor water quality and other impacts caused by shellfish in this semi-closed sub-embayment.

B. General Description of Demonstration Project Formats

1) Lonnie's Pond Oyster Singles Installation

The first year plan for Lonnie's Pond is to grow between 170,000 – 340,000 oyster singles, starting at a size of at least ½ inch, in floating bags. The foundational work conducted by the Cape Cod Cooperative Extension in Lonnie's Pond (Clark, 2007) provides two valuable insights that form the basis of this demonstration design. First, oyster remote set will grow successfully in Lonnie's Pond. Second, bottom planting remote set leads to very high mortality due to predation and siltation. The current phased approach builds on these lessons and focuses on growing oysters that are functioning at adult size for the purpose of water quality and sediment assessments

This demonstration design also mitigates against the known issues with predation and siltation by maintaining the oysters in floating gear. Monitoring of water quality, sediment impacts, and oyster growth and nitrogen content will provide critical evidence regarding the environmental aspects of shellfish cultivation. This information will help define future shellfish cultivation programs. In addition, operation and maintenance costs and local stakeholder responses will be documented to inform future decision making.

2) **Increased Quahog Population and Propagation in Town Cove and Pleasant Bay**

In Town Cove and parts of Pleasant Bay, expansion of municipal quahog propagation is recommended to establish maximum practical densities that can be grown and harvested in these areas, and to allow water quality changes to be correlated to numbers of new quahogs added to these systems. Quahogs have been grown successfully through the Town's propagation program, and there is suitable bottom in both Town Cove and Pleasant Bay for increased quahog planting. Based on site reviews, it was found that there are existing populations of quahogs throughout Town Cove and Pleasant Bay. Therefore, a quahog demonstration should only be pursued after a determination of baseline quahog density and water quality parameters have been established in specific areas where additional quahogs could be planted as part of a demonstration project.

Determining current densities before additional quahogs are added to these waterbodies is an important first step in evaluating survival, growth, and the impacts of additional quahogs on water and sediment quality. This survey is also critical to determining how many additional quahogs should be planted. Once the baseline population is established, the specific quantities and sizes of additional quahogs will be recommended as part of an expanded quahog propagation program for certain areas in Town Cove and Pleasant Bay.

3) Quanset Oyster Bed Installation

The Orleans oyster bed demonstration projects involve growing remote sets and planting them in suitable areas, resulting in bed-like grow-out under the diverse environmental conditions experienced over the course of a typical Pleasant Bay growing season. Remote set is a firm substrate, or cultch, such as hard clam shells, with oyster spat attached. Eastern oyster larvae (*Crassostrea virginica*) produced in a hatchery can be "set" on cultch after a larval stage spent feeding in the water column. This spat can also be induced to set on microscopic shell fragments to produce seemingly unattached "singles". When attached to a substrate, this spat, invisible to the naked eye, is often called "spat-on-shell" or "remote set". The waters of Pleasant Bay do not have a naturally-occurring oyster population that could spawn. To establish an oyster bed in areas where there is no natural set, remote set can be used to introduce oysters into the growing environment.

The technique for establishing an oyster bed in the Quanset area is similar to techniques used throughout Cape Cod, and recently implemented successfully in West Falmouth Harbor, MA. This technique begins with installing remote set in trays and/or floating bags for an initial growing period. In the Quanset area, remote set will likely be able to be bottom planted after approximately eight weeks. The remote set will likely be planted under the bags and trays in which they were initially grown. The significant benefit of planting remote set after a maturation period is that it allows the oyster spat to mature in a protected environment, thus reducing predation and mortality. Planting remote set when oysters have reached over 1.5 inches (38 mm) in size also reduces mortality caused by siltation. Harvest occurs by opening this area to recreational harvest.

Growing out remote set in both trays as well as floating bags with bottom-planting will enable an evaluation of the growth and survival rates of each technique. Moreover, evaluating the potential for bottom-planting oyster remote set at Quanset will help determine the feasibility of expanding oyster beds in other part of Pleasant Bay where there is suitable substrate, such as areas along the Upper and Lower River, Namequoit, and Pochet.

4) Enhanced Shellfish Aquaculture in Pleasant Bay and Town Cove

The demonstration methodology proposed for Little Pleasant Bay involves working with the growers on the town's existing private shellfish leases. There are currently 12 leases with an average size of 1.75 acres. Typically, single oysters are raised from seed to harvest size in trays, bags and cages. Seed is sometimes purchased at a size large enough to install directly in gear. Smaller seed requires grow-out in an on-shore upweller. In total, growers are harvesting approximately 1,000,000 oysters annually from these leases in Pleasant Bay. Harvesting occurs year-round. To avoid ice damage over the winter, shellfish are submerged to deeper depths or bottom-planted.

Working with growers can create opportunities to demonstrate the water quality benefits as well as implementation logistics and practical densities of oyster aquaculture. Part of the reason for conducting demonstrations is to learn site-specific factors and, where beneficial, adjust farming practices accordingly. Local growers have decades of field experience working in Pleasant Bay and Town Cove, and have learned how to manage and operate within the varying conditions in this location. They have evolved systems based on trial and error for anticipating weather and other events that impact shellfish survival. Successful farming requires local knowledge; and implementation techniques need to be tailored to a given site. Growers also have a unique understanding of any obstacles or challenges that exist which may be limiting production and what steps might help reduce those challenges.

The expansion of private leases for oyster aquaculture in certain areas of Town Cove is also an important option to pursue. Oyster aquaculture in gear, off the bottom would be the only method of growing oysters in this area due to the large population of predatory Atlantic oyster drills (*Urosalpinx cinerea*). The expansion of private grants requires several permitting steps; beginning with a recommendation from the Orleans Board of Selectmen to the MA Division of Marine Fisheries (DMF). A study of the feasibility of expanding private aquaculture leases is needed to assess the Town's interest in this approach for shellfish propagation in Town Cove.

This demonstration will build on these established growing methods, and includes three components:

- Developing and disseminating a questionnaire to determine whether growers are interested in working with the town to expand shellfish propagation for the purpose of water quality improvements;
- Working with growers to establish a total number of shellfish that can be grown and harvested annually for all leases in aggregate; and
- Evaluate areas in Town Cove for expanding shellfish leases.

3. Design and Engineering Action Plan for Demonstration Projects

A. Oyster Propagation in Lonnie's Pond

Project Description: Oyster Propagation in Lonnie's Pond

Figure 1 shows two potential demonstration locations in Lonnie's Pond. The purpose of this demonstration project is to:

- Quantify the water quality changes due to filter feeding by introduced oysters;
- Measure the impacts of oyster depositional processes on sediment and benthic processes; and
- Confirm the nitrogen content in the shell and soft tissue of oysters that reach harvest size.

Figure 1. Potential Locations for Lonnie's Pond Oyster Propagation Demonstration Project

There are two critical planning decisions involved in designing the Lonnie's Pond demonstration project: how many oysters to grow and where in Lonnie's Pond to grow them. Most of an oyster's nitrogen uptake occurs during the second year of growth. Therefore, to maximize the impact of this demonstration project on water quality parameters, oysters should be grown starting with the largest size seed available, with a minimum starting size of ½ inch.

Based on the timing of decision making related to this demonstration, availability of seed is one critical factor that will determine the final number of oysters and initial size that will be grown during this demonstration project. In addition, the number of floating bags and acres required for different quantities of oysters is presented in Table 1. An important caveat to the estimates for the kilogram removal rates provided in Table 1 is that the final amount of nitrogen taken up by the oysters installed in this demonstration will depend on the actual size of the oysters at the end of the 2016 growing season. The time available to procure and build gear is also limited. Given these factors, the first year plan is to grow between 170,000 and 340,000 oyster singles, starting at a size of at least ½ inch, in floating bags. It does not seem feasible to the AECOM Shellfish Team to grow more than the upper limit of 340,000 oysters in 2016.

Table 1. Oyster Demonstration Sizing Factors

Area of Water Surface Utilized (Acres)	Number of Floating Bags at 1700 per Acre	Number of Oysters at 200 per Bag	Kilograms of Nitrogen Removal at .26 grams N per 3 inch (76 mm) oyster
0.5	850	170,000	44
1	1700	340,000	88
2	3400	680,000	177
3	5100	1,020,000	265

Oyster singles are typically ordered through the Barnstable County Cooperative Extension's Municipal Shellfish Propagation Program, which coordinates bulk purchase of seed for the fifteen Cape towns. The Massachusetts DMF also lists approved hatcheries for seed purchase, (Appendix B): Sourcing appropriately-sized seed at this point in the growing season is a critical path item that will be addressed immediately after a notice to proceed is issued by the town for this demonstration.

Gear can be purchased from Ketcham Supply, Atlantic Aquaculture Supply, and Riverdale Mills. The Orleans Natural Resources staff typically purchases ancillary equipment at True Value Hardware and Cape Fisherman's Supply. Once gear arrives, it will be stored at the Harbormaster lockdown located at the Department of Public Works.

Timeline: Oyster Propagation in Lonnie's Pond

Phase I: June 1, 2016 – October 31, 2016

The project period for Phase I of the Lonnie's Pond Oyster demonstration is June 1, 2016 – December 31, 2016. Within this timeframe, the timing and activities to accomplish the various steps of the first phase of this demonstration should proceed as follows:

Timing and activities to accomplish the Lonnie's Pond demonstration are for illustrative purposes only. Exact timing depends on funding availability and the issuance of a notice to proceed by the town:

May 15, 2016 (if possible to start monitoring) - June 30, 2016	• Verify that Town Shellfish Propagation Permit has been appropriately modified • Conduct Standing Stock Assessment if required by DMF • Discuss and File Request for Determination of Applicability with Conservation Commission • Order and build gear • Order seed (at least ½ inch) • Contract for water quality monitoring services • Begin water quality monitoring as soon as possible to establish baseline conditions in Lonnie's Pond (ongoing throughout spring/summer/fall/winter)
July 1, 2016 – July 15, 2016:	• Install oysters in floating bags
July 2017 – November 2017	• Shellfish growth, predation, disease monitoring • Operation and Maintenance
December, 2017	• Overwinter seed by sinking to depth of at least 4 feet in bags and/or pitting • Repair and storage of equipment

Gear includes:

- Floating bags
- Cinder blocks or other anchoring system with chain
- Gloves, chest waders
- #7 line, #8 line
- Yellow perimeter marking buoys, with anchoring
- Signs

To build bags, a work crew that includes a project manager and at least six volunteers will be organized. There are a number of citizens' organizations dedicated to improving estuarine water quality in Orleans that are likely to have members interested in assisting. A work area should be prepared with stations for each of the following steps:

- Drill two, ¼ inch holes in mesh bags (a jig should be built beforehand to standardize drilling and to expedite this step);
- Insert pre-cut line (12-inch lengths) in each hole, create a loop, secure with two hog clips;
- Attach long line clip to one loop;
- Attach floats to bag with cable (zip) ties; and
- Attach pre-prepared PVC pipe closure on open end of bag (PVC pipe should be cut on one side and notched on the other).

In early June, the project manager should conduct several site visits with the monitoring team to refine the exact layout of rafts and anchoring, given depths and bottom type. One week prior to the deployment of oyster singles, the empty bags should be installed in Lonnie's Pond location. The bags will be installed in groupings of 100 (called rafts), as follows. Bags will be clipped together in strings of twenty and five strings will be floated in parallel. Two to four cinder blocks per side will be used to anchor the raft.

As soon as the oyster seed is obtained, it should immediately be brought to Lonnie's Pond and loaded in a skiff located on shore. The skiff can then be driven the short distance to the demonstration site. Working from the water, floating bags should be filled with seed at a density of 1 liter of oyster seed per floating bag.

Weekly maintenance includes flipping the bags to prevent fouling, adjusting strings and rafts so that they remain tight, and checking bags and trays to assess predation and growth. In managing a shellfish project, the layout of the bags on the site should be orderly, and the surrounding should be kept free of unused gear and equipment. Weekly documentation of operational issues, including any bird roosting issues, should also be submitted to the project manager. End of season activities include overwintering seed or bottom-planting, then rinsing, repairing and storing bags, trays, anchors and other equipment. The assembled bags will need a storage floor area of approximately 18 ft. x 18 ft., with bags stacked two high. They will be stored in the Harbormaster Lockdown area located at the Department of Public Works.

The preliminary list of permits includes:

- Town's propagation permit amended by the DMF; and
- Request for Determination of Applicability (RDA) from the Conservation Commission.

B. Baseline Quahog Population and Propagation

Project Description: Baseline Quahog Population and Propagation

This program is implemented by contracting with a qualified firm to conduct a baseline population survey for a number of areas in Town Cove and Pleasant Bay. Appendix A includes a list of the areas that have been historically planted in Orleans. Town Cove in the Nauset Harbor System is the focus of the first phase of the quahog propagation demonstration. Figure 2 shows preferred areas for baseline quahog population assessments in Town Cove that were identified by the Orleans Department of Natural Resources (DNR). In order of preference for conducting a baseline survey for the purpose of enhanced propagation, the areas outlined in red and orange are first priority, with targeted locations within the blue and purple areas to be surveyed as funding becomes available. To conduct the baseline population study, the preferred quahog planting areas will be divided into one-acre plots and three parallel transects will be located within the specific one acre plots that are selected as Phase I quahog planting areas. For each transect, a number of separate square meter sample areas should be surveyed for all organisms. Quahog population counts will then be used as the baseline density. A detailed scope of work will be developed prior to soliciting bids for professional services to conduct this survey.

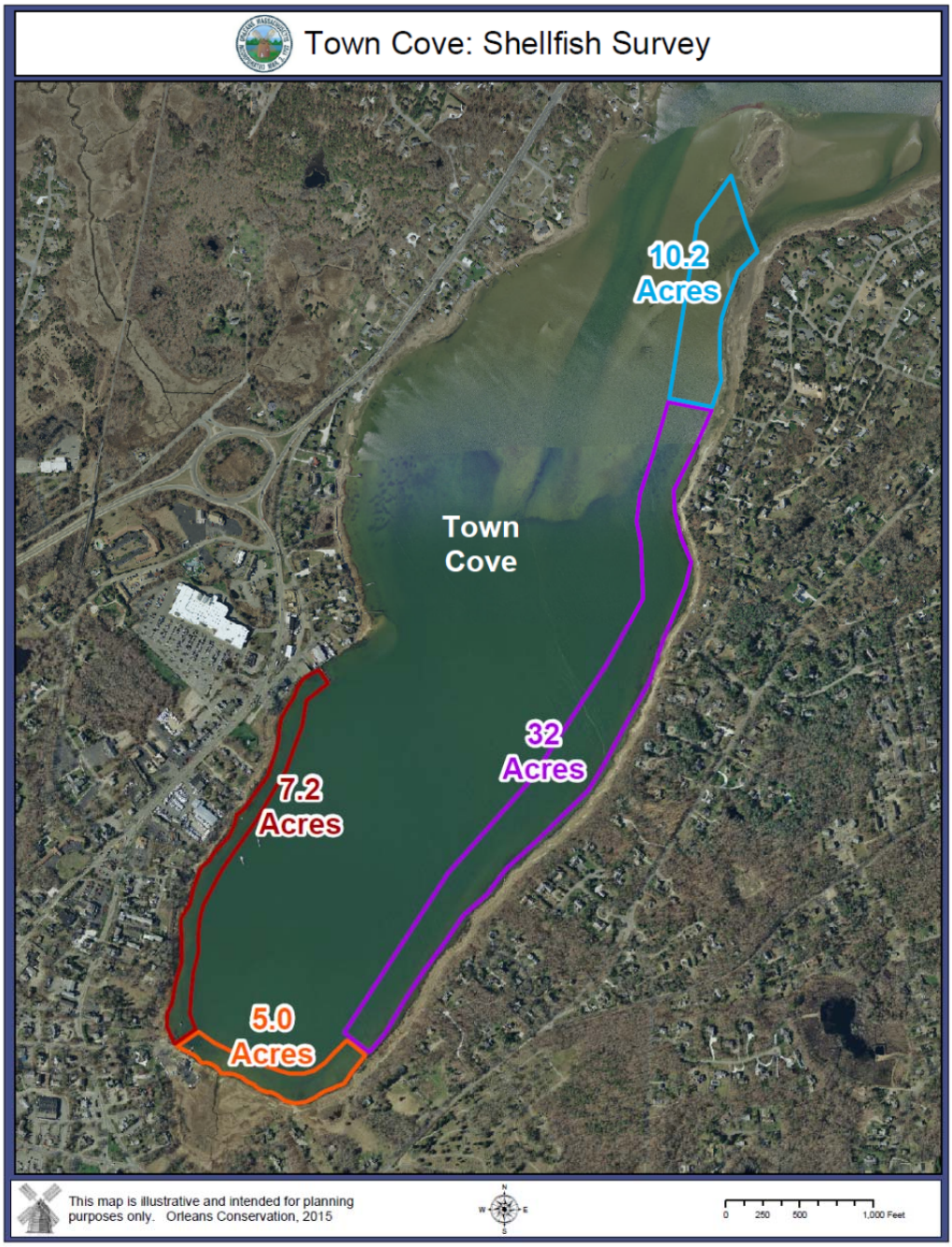

Figure 2. Town of Orleans Preferred Shellfish Survey Areas

Timeline: Baseline Quahog Population and Propagation Demonstration

Phase I: June 1, 2016 – October 31, 2016

The project period for Phase I of this quahog population and propagation demonstration is June 1, 2016 – October 31, 2016. Within this timeframe, the timing and activities to accomplish the various steps of the first phase of this demonstration should proceed as follows:

June – July 2016	• Develop Scope of Work • Purchase quahogs for field-planting in the fall
August 2016	• Hire firm to conduct population survey
September 2016 – October 2016:	• Conduct population survey
October 2016	• Prepare to bottom plant quahogs

The specific areas in Town Cove to be surveyed, quantity of quahogs purchased, as well as the precise location where quahogs will be planted will be determined in close coordination with the Town DNR staff. The acreage that will be surveyed and the number of quahogs that are purchased for bottom-planting will be limited by available funding, final cost per acre for the survey, and the price of quahogs of field-plantable size (approximately 21 – 25mm).

For planning purposes, the goal is to survey at least ten acres, beginning with the area near the Orleans Yacht Club and plant at least 100,000 quahogs in this area.

Phase II: November 1, 2016 – June 30, 2017

The project period for Phase II of this quahog population and propagation demonstration is November 1, 2016 – June 30, 2017. Within this timeframe, the timing and activities to accomplish the various steps of this demonstration should proceed as follows:

November/December 2016	• Bottom plant quahogs purchased in Phase I (temperature-dependent)
November 1, 2016 – January 15, 2017	• Prepare Draft and Final Report of population survey
January 16, 2017 – February 15, 2017	• Recommend additional quantities of quahogs for planting in November 2017
January 16, 2017 – February 30, 2017	• Develop plan and budget for enhanced quahog propagation
March 1, 2017 – March 31, 2017	• Review with stakeholders
March 1, 2017 – March 31, 2017	• Prepare funding request for fall quahog planting program
April 1, 2017 – October 31, 2017	• Conduct additional planning assessments in preparation for fall planting

C. Quanset Oyster Bed Demonstration Project

Project Description: Quanset Oyster Bed Demonstration

The goal of this project is to determine whether it is feasible to establish oyster beds in Little Pleasant Bay. To accomplish this goal, the plan for Quanset is to grow oyster remote set in the spring, and to bottom plant within a 2-acre demonstration site at the end of the first growing season (Figure 2). Remote set will first be installed in floating bags and trays (4' x 4') (Figure 2). Once the oysters are at least 1.5 inches (38 mm) on average, they will be bottom planted in the same area as the floating bag installation.

Timeline: Quanset Oyster Bed Demonstration Project

Phase I - Design: June 1, 2016 – October 31, 2016

The project period for Phase I of the Quanset Oyster Bed demonstration is June 1, 2016 – October 31, 2016. Within this timeframe, the timing and activities to accomplish the various steps of the first phase of this demonstration should proceed as follows:

June 1, 2016 – June 30, 2016	• Develop a Scope of Work for Baseline water quality monitoring within proposed growing area
July 1, 2016	• Begin baseline water quality monitoring
July 1, 2016 – August 1, 2016	• Prepare a draft engineering design for 2017 installation, including quantities of remote set, gear location, monitoring plan and complete implementation budget
August 15, 2016 – September 30, 2016	• Review with Shellfish Working Group
October 1, 2016 – October 31, 2016	• Prepare final engineering design for 2017 installation

Phase II - Installation: November 1, 2016 – June 30, 2017

The project period for Phase II of the Quanset Oyster Bed demonstration is November 1, 2016 – June 30, 2017. Within this timeframe, the timing and activities to accomplish the various steps of the installation phase of this demonstration should proceed as follows:

November 1, 2016 – March 1, 2017	• Order gear • Order remote set • Town of Orleans to advertise Shellfish Technician position • Discuss Request for Determination of Applicability with Conservation Commission • Modify Town Shellfish Propagation permit with DMF • Contract for water quality monitoring services • Order all floating bag components • Build bags with volunteer group
April 2017	• Hire Shellfish Technician (for May 1 start)
May 2017	• Ongoing water quality monitoring • Build additional bags
June 2017:	• Install remote set in bags and trays

It is critical to recognize that the installation of a demonstration at Quanset in 2017 requires funding through November 2017. Therefore, if the implementation of the Quanset oyster bed demonstration is funded, the budget must be planned to cover operation and maintenance and through the end of November 2017.

The following activities are integral to the demonstration and require funding that should be included in budget planning and approval:

July 2017 – October 2017	• Operation and Maintenance
November 2017	• Bottom plant • Repair and storage of equipment

The preliminary list of permits includes:

- Town's propagation permit amended by DMF; and
- Request for RDA from Conservation Commission.

D. Shellfish Aquaculture Enhancement Demonstration Project in Pleasant Bay and Town Cove

Project Description: Enhanced Shellfish Aquaculture

The goal of this demonstration is to enhance private aquaculture in Pleasant Bay and assess the feasibility of enhancing private aquaculture in Town Cove. To accomplish this work two parallel efforts are needed. In Pleasant Bay, the first step is to communicate with growers to assess interest. Depending on the response from growers in Pleasant Bay, the next step is to evaluate current growing practices and opportunities for improving these systems over the short and long term, then to determine a total number of shellfish that can be grown and harvested annually for all grants combined. Figure 3 shows the locations of the current shellfish grants in Little Pleasant Bay. Establishing baseline water quality conditions in this growing area will inform this process, and help quantify impacts from any increases in shellfish density. In Town Cove, the first step in evaluating the potential for expanded aquaculture leases is to inventory potential locations and review with town stakeholders. Once specific areas are identified, the next step is for the Board of Selectmen to request a Standing Stock Assessment from the DMF.

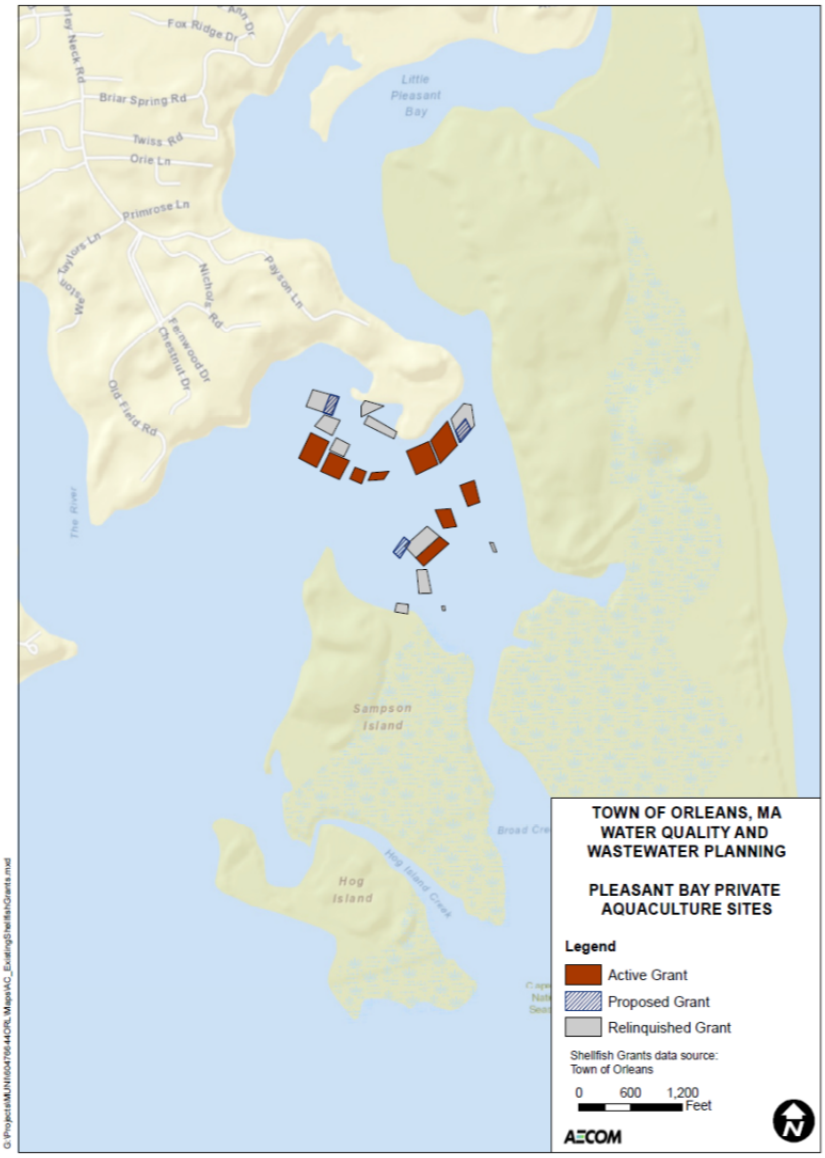

Figure 3: Pleasant Bay Private Aquaculture Sites

Timeline: Shellfish Aquaculture Enhancement Demonstration Project in Pleasant Bay and Town Cove

Phase I: June 1, 2016 – October 31, 2016

The project period for Phase I of this shellfish aquaculture enhancement demonstration is June 1, 2016 – October 31, 2016. Within this timeframe, the timing and activities to accomplish the various steps of the first phase of this demonstration should proceed as follows:

PLEASANT BAY

June 1, 2016 – July 15, 2016	• Develop a survey to gauge interest from Pleasant Bay growers in exploring an expanded production program in Pleasant Bay.
July 15, 2016 – September 1, 2016	• Disseminate survey through Shellfish Constable
September 2, 2016 – September 30, 2016	• Aggregate and understand survey results
October 1, 2016 – October 15, 2016	• Discuss survey findings and grower interest in pursuing an enhanced aquaculture demonstration in Pleasant Bay with Shellfish Working Group

TOWN COVE

June 1, 2016 – September 1, 2016	• Conduct site visits in Town Cove to identify specific locations for additional aquaculture leases, review with Town DNR staff and the Shellfish Working Group
September 2, 2016 – October 15, 2016	• Prepare a preliminary list of possible lease sites in Town Cove • Review with Shellfish Working Group

Phase II: November 1, 2016 – October 31, 2017

The project period for Phase II of this shellfish aquaculture enhancement demonstration is November 1, 2016 – June 30, 2017. Within this timeframe, the timing and activities to accomplish the various steps of the first phase of this demonstration should proceed as follows:

November 1, 2016 – February 30, 2017	• Develop a Scope of Work for Pleasant Bay • Review Scope of Work for Pleasant Bay with Shellfish Working Group • Finalize Scope of Work for Phase II Pleasant Bay • Review with Shellfish Working Group • Develop a Scope of Work for expanded aquaculture in Town Cove • Review with Shellfish Working Group
March 1, 2017 – June 30, 2017	• Action Items as specified in Phase II Scopes of Work

4. Grant Funding for Demonstration Projects

A phased budget for these demonstrations will be provided to the town as part of preparing for both the upcoming annual and special Town Meetings.

The following list of potential external funding sources is based on solicitations that have been published historically:

- Cape Cod Economic Development Council (any organization or individual may apply): Annual, pre-proposals typically solicited in November/December;
- Cape Cod Water Protection Collaborative: Applications from Cape Cod towns are accepted on an ongoing basis;
- USEPA Southeast New England Estuaries Project grants (limited to municipal entities, state government and non-profit organizations): Solicited on an irregular basis, recently pre-proposals due in July and January;
- NOAA Fisheries Saltinstall-Kennedy grant (any organization or individual may apply): Annual, typically early October announcement for full proposal due in November; and
- USDA Community Food Project (CFP) grant (Only food provider organization may apply): Annual, typically early October announcement for full proposal due in November.

5. Detailed Assessment of Lonnie's Pond Monitoring Program

The purpose of implementing shellfish demonstrations in Orleans is to determine the extent to which shellfish can be grown to achieve water quality improvement goals as well as compliance with regulatory standards. Monitoring of both ecological parameters as well as implementation success will provide information that is needed to incorporate shellfish into the town's full-scale water quality improvement program. Both the UMASS Dartmouth's School for Marine Science and Technology (SMAST) and the Center for Coastal Studies have a QAPP for water quality and benthic denitrification and infauna sampling. Either QAPP could be followed. As part of implementing a comprehensive performance monitoring program for this demonstration, a project-specific Quality Assurance Policy Plan (QAPP) may be required. Because we are recommending that the demonstration project in Lonnie's Pond take place first the remainder of this TM focuses on the details to make this project a success.

There are different ways to estimate the number of oysters needed to make an impact on water quality in Lonnie's Pond. Based on Clark (2007), the water volume of Lonnie's Pond is approximately 4,782,000 ft^3 (135,411 m^3), and the daily filtration rate of an adult oyster is 0.075 m^3 (75 liters). Using the filtration approach, 1,805,480 adult oysters would be required to filter the volume of Lonnie's Pond in one day, about 903,000 oysters would be needed to filter the water volume in two days, or 258,000 oysters would be needed to filter the water volume in a week. Based on the target removal load of 297 kg/year of N from MEP, and based on a N content of 0.26 grams for a 3-inchoyster that is cultured off the bottom (Reitsma, 2013), 1,114,135 oysters would remove 100 percent of this nitrogen target or 572,067 oysters would remove 50 percent of the target. For the numbers proposed for this demonstration, 170,000 oysters would remove 15 percent of the target nitrogen removal and 340,000 oysters would remove 30 percent of this target. It seems reasonable to expect that a monitoring program can be designed to measure the impact on water column nitrogen species, especially particulate organic fractions, for this demonstration that is expected to remove at least 15 percent to 30 percent of the target total nitrogen load, and filters the water volume in Lonnie's Pond in about one week (depending on the final number of oysters able to be cultivated). Of note is that the target reduction in the concentration of bioactive nitrogen for Lonnie's Pond is 17 percent. Bioactive nitrogen is comprised of dissolved inorganic nitrogen (DIN) plus particulate organic nitrogen (PON). While the MEP Report does not provide a kilogram equivalent for this bioactive fraction, based on water quality data sets provided by the Pleasant Bay Alliance and summarized in Technical Memorandum 4.a.1 Baseline Monitoring, PON is between 12 percent to 25 percent of the total nitrogen in Lonnie's Pond (Figure 4). Growing shellfish should remove most of this nitrogen fraction. This is based on data from a single monitoring station located in the center of Lonnies Pond (PBA-15).

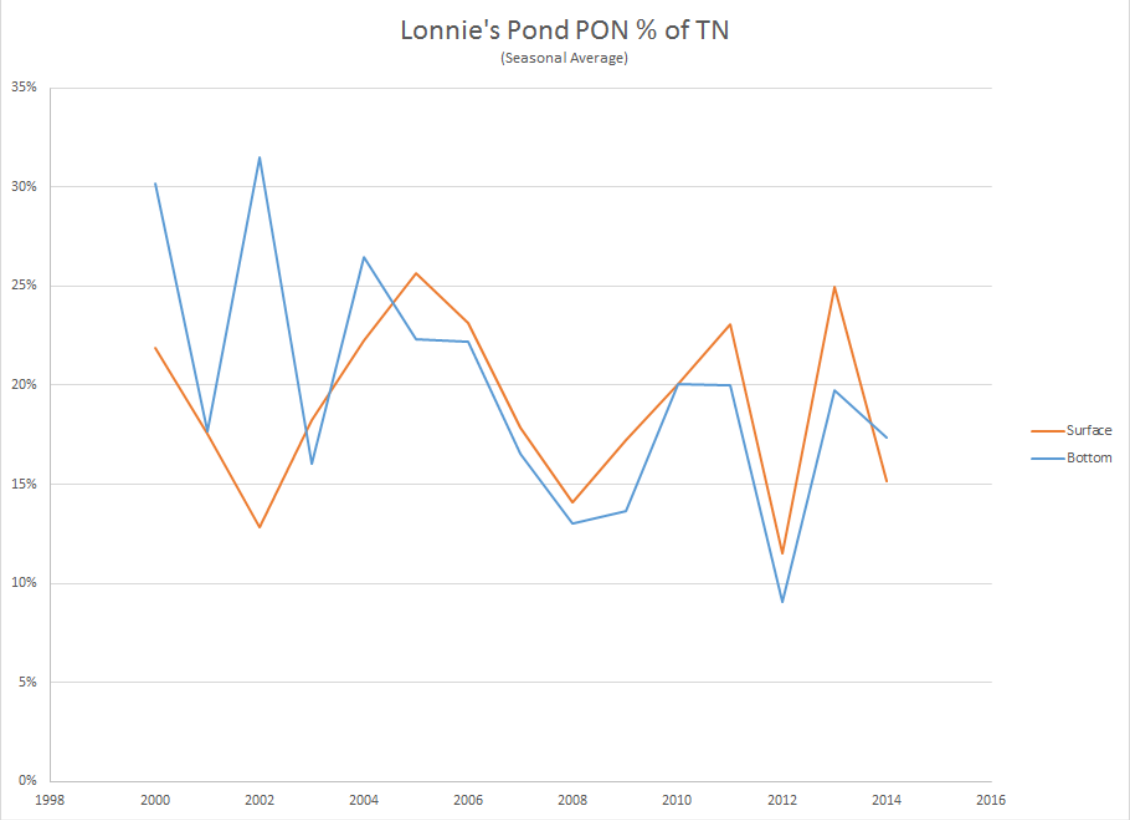

Figure 4. Particulate Organic Nitrogen as a percent of Total Nitrogen in Lonnie's Pond

A. Water Quality Monitoring

To quantify any water quality changes that result from this demonstration projects, twice monthly sampling from May – September should include the following parameters at both water surface and bottom locations (where depth is greater than 5 feet) at the sampling stations: Total Nitrogen (TN), nitrate + nitrite, ammonia, dissolved organic nitrogen (DON), dissolved inorganic nitrogen (DIN), particulate organic nitrogen (PON), Temperature, Chlorophyll *a*, Pheophytin *a*, PO_4 (SRP), Salinity, Dissolved oxygen (DO), and Transparency (Secchi depth). Continuous monitoring of Chlorophyll *a*, DO and turbidity is recommended at one location within the demonstration site and one location outside the growing area. Figure 5 shows the two potential demonstration sites in Lonnie's Pond, with proposed monitoring stations. Table 1 shows the frequency and timing of sampling that should occur for water quality monitoring, and illustrates the framework for monitoring reporting based on the seven recommended locations depicted in Figure 5. Both surface and bottom sampling is assumed. The actual program will be defined in collaboration with the firm responsible for water quality monitoring.

Table 2 - Illustration of Water Quality Sampling Program

	May 1 - 15	May 16 - 31	Jun 1 - 15	Jun 16 - 30	Jul 1 - 15	Jul 16 - 31	Aug 1 - 15	Aug 16 - 31	Sept 1 - 15	Sept 16 - 30	Oct 1 - 15	TOTAL SAMPLES Surface and Bottom
STATION ID												
LDS1	2	2	2	2	2	2	2	2	2	2	2	22
LDS2	2	2	2	2	2	2	2	2	2	2	2	22
LDS3	2	2	2	2	2	2	2	2	2	2	2	22
LDS4	2	2	2	2	2	2	2	2	2	2	2	22
LDS5	2	2	2	2	2	2	2	2	2	2	2	22
LDS6	2	2	2	2	2	2	2	2	2	2	2	22
PBA-15	2	2	2	2	2	2	2	2	2	2	2	22
subtotal:												154
QA/QC (10%)												15
Total Samples												169

Seven water quality sampling locations are recommended as shown in Figure 5, including six Lonnie's Demonstration Stations (LPS) and the Sentinel Station in Lonnie's Pond (PBA-15). Siting and sampling locations will be finalized after consulting with the firm hired to complete the monitoring program for this demonstration. These seven stations are as follow:

- LDS1: Inlet to Lonnies Pond (source);
- LDS2: Storm drain from Cranberry Bog (source);
- LDS3: Herring Run (source);
- LDS3, LDS4 and LDS5: Within oyster growing area; and
- PBA-15: Sentinel Station (middle of pond).

LDS1, LDS2 and LDS3 are included for the first year to measure whether these point sources contribute significant nitrogen inputs over the sampling season that impact overall water quality or measured results within the oyster growing area. The Sentinel Station is included to establish baseline conditions. The three stations within the oyster growing area (LDS4, LDS5 and LDS6) provide triplicate samples for monitoring the impact of oysters on water quality.

B. Measuring changes in sediment and benthic flux associated with oyster aquaculture

Analysis of enhanced sediment denitrification that can be attributed to oyster aquaculture is critical to determining the impact of oysters on the estuary in which they are grown. This analysis

includes collecting sediment core samples and incubating them under in situ conditions during the period of maximum denitrification rates in summer (July-September); and collecting time series measurements of total dissolved nitrogen, nitrate+nitrite and ammonium. The rate of oxygen uptake is also necessary in order to: (1) evaluate sediments relative to organic matter deposition rates; and (2) develop a general nitrogen model for oyster impacts to the nitrogen cycle in the sediments.

Figure 5. Two Potential Demonstration Locations in Lonnie's Pond

Assays should be performed on cores collected throughout the oyster aquaculture area (directly under the oyster aquaculture rafts and along a 100m transect extending south). The results should show any spatial pattern and rate of nutrient exchange between the sediments and water column, and whether these rates are affected by the cultivation of oysters in each demonstration location.

Excess nitrogen gas (N2) is measured using membrane-inlet mass spectrometry (MIMS). N2 produced by denitrification is precisely detected by analysis of its ratio with the inert gas Argon. Water samples should be collected and stored to prevent gas exchange or bubble formation. In the laboratory, sample water is pumped at ml/min rates through a gas permeable membrane in order to extract gas into the mass spectrometer inlet. Based on data from a single monitoring station located in the center of Lonnies Pond (PBA-15), dissolved oxygen levels are below the target threshold for health of 6 mg/L but not anoxic in the center of Lonnie's Pond (Figure 6).

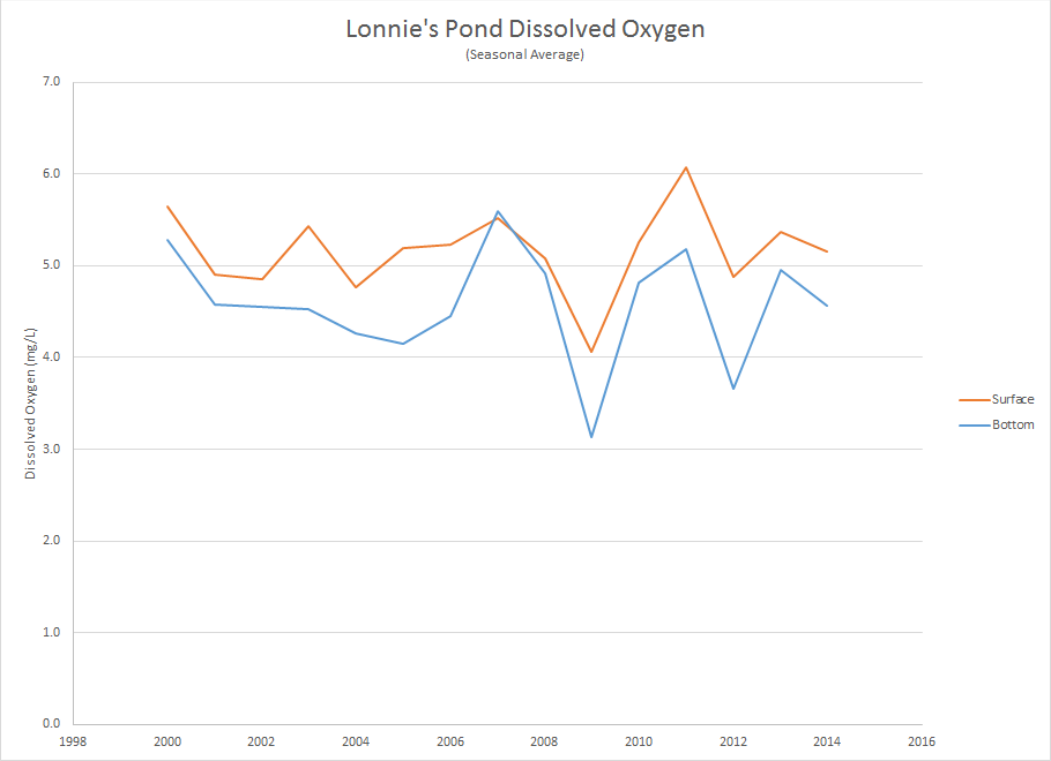

Figure 6. Dissolved Oxygen Concentrations in Lonnie's Pond

C. Monitoring Shellfish Growth and Survival at Lonnie's Pond

In addition to water quality sampling and sediment analysis, tracking the size of the shellfish population, as well as growth and survival rates is also recommended. Single oysters should be randomly sampled from floating bags in different rafts, and measured every two weeks to establish a growth rate. Survival should be quantified monthly in floating bags. Observations regarding predation, and other stressors should be recorded. Survival at the beginning of the second growing season should then be measured.

In addition, observations regarding increased biodiversity should be made and documented. A basic assessment of species (e.g., shrimp, crabs and fish) in the vicinity of the growing area should be made prior to installing the demonstration. This can be accomplished by observing and recording organisms in the water column as well as sorting and identifying benthic infauna in the laboratory. Weekly observations of any species that were not initially present in the water column but have been attracted to the area because of oysters due to the structure created by the floating gear should be recorded.

The first year report documenting the demonstration projects at the end of the first season should include:

- Population density and overall population counts of oysters;
- Number and percent of oyster survivorship for first growing season;
- Predators; and
- Additional species found in and around the growing area.

To determine nitrogen uptake from the oysters growing in floating bags, a measure of the nitrogen content in the shell and soft tissue should be performed for each size class of oyster, as follows:

- Measure dry weights of shellfish tissue and shell separately, using a pooled sample of 10 to 20 animals;
- Measure the percentage of N in tissue and shell separately, using a pooled sample of 10 to 20 animals;
- Tabulate wet weight to dry weight correlations using regression analysis; and
- Determine nitrogen uptake by total weight of shellfish in each size class;
    - Use correlation between the total wet weight of shellfish (shell and tissue) in each size class and dry weight; and
    - Multiply by percent nitrogen for size class.

This plan is consistent with the Cape Cod Commission's draft monitoring plan recommendations (Appendix B).

D. Summary of Project Reporting: Lonnie's Pond Oyster Demonstration

Final reporting for the first year of the Lonnie's Pond Demonstration will include:

- Changes in water quality;
- Changes in sediment conditions and loss of N via denitrification;
- Size classes by length for one year of growth;
- Maximum density of oysters per bag;
- Review of viability of site for shellfish growth;
- Assessment of operation and maintenance requirements;
- Useful modifications to gear design;

- Recommendations on the type of shellfish grown and whether there should be a mix of species;
- Comparison of actual costs to budget; and
- Assessment of abutter compatibility and use conflicts.

6. Findings/Recommendations

A. Lonnie's Pond Oyster Demonstration Project

The goal for full scale implementation of shellfish cultivation in Orleans is to use these biological filters to the maximum extent possible to meet the town's water quality improvement goals, both in the Pleasant Bay and Nauset Harbor estuaries. The impact of shellfish on their surrounding environment is related to both the size and quantity being cultivated, as well as the hydrodynamics and baseline environmental conditions of the waterbody where these shellfish are located.

There are a number of approaches to growing shellfish that could work in Orleans, including cultivating single oysters in gear such as floating bags, growing remote set in gear and then bottom planting, maintaining remote set in trays off-bottom, bottom-planting quahogs and even implementing newer technologies such mussel rafts when possible (see below). There are also several different species that may be part of a full-scale implementation plan. Oysters are a popular choice because they grow to maturity in less than two years, filter rapidly and are tolerant of a range of environmental conditions. Oysters also have a high commercial value relative to other shellfish species.

Quahogs are also being used as part of wastewater planning on Cape Cod because they are less prone to predation in high salinity areas, and can be bottom planted in a wider range of sediment types than oysters. There is considerable interest in blue mussels, but seed is not currently available from hatcheries, and the mechanics of growing mussels in shallow areas is still in the prototype stage. Ultimately, designing systems that use a mix of species may prove to be the optimal approach from an ecosystems services perspective.

Regardless of the final technique used to grow and maintain shellfish in various locations in Orleans, the first step in full-scale implementation is to quantify the impact of a particular species of shellfish on both water quality and sediment processes. In order to design and install a full-scale system for ongoing propagation that is based on an appropriate number and size of shellfish, more precise design parameters are needed. For oyster propagation, there are three factors that will be defined as part of this demonstration project:

- Change in water column nitrogen species due to the filter feeding of oysters;
- Sediment response to oyster depositional processes; and
- Confirmation of nitrogen-content of shell and soft tissue.

To provide the operable information needed for full-scale engineering design, the demonstration project designed for Lonnie's Pond is phased as follows:

- Year 1 (Summer, 2016): Cultivate between 170,000 – 340,000 single oysters in floating bags, starting at the largest size possible, but no smaller than ½ inch;

- Year 2 (Fall, 2016 – Summer, 2017): Design and install a system for cultivating a number of oysters that can remove an appropriate level of nitrogen to achieve water quality goals. This goal may be expressed as bioavailable nitrogen or total nitrogen, depending on the monitoring results from the first year of this demonstration. This design will be for a permanent, ongoing installation.

- Year 3: (Fall 2017 – Summer 2018): Continue program from Year 2.

The moderate number of oysters recommended for a shellfish demonstration during the 2016 growing season is based on the fact that this project will be installed one month after the town makes a decision to pursue this demonstration and funding becomes available. This range of oysters to be grown is the maximum feasible because this is an extremely short timeframe for securing seed that is at least ½ inch, and purchasing and assembling the number of bags required, which takes several hundred person hours. There are several valuable outcomes gained by initiating a moderate-scale demonstration of oyster singles that are likely to grow to adult size this summer. This demonstration allows site-specific environmental conditions such as phytoplankton cycling and sediment response to be better understood and factored into scale-up. In addition, practical logistics and neighborhood responses will be well-understood after this first growing season.

B. Review of Management Options

As noted in the June 2015 Technical Memorandum entitled Phase I: Orleans Shellfish Operations and Program Expansion Plan, shellfish operations can be managed in three distinct ways: by the Town, commercially or as public-private partnerships. There are advantages and disadvantages to each approach. Table 3 outlines some of the key attributes of each management option.

The Lonnie's Pond Demonstration can either be run under the Orleans DNR, or as an outsourced consulting and management contract. If town-run, implementation would include hiring an additional seasonal staff person (shellfish technician) to operate the demonstration as well as technical consulting (shellfish assistant) to assist with the purchase of equipment and supplies as well as project management, oversight and reporting. Another option is for a consulting firm with aquaculture experience to be hired. The advantage of managing the project through the Town is that it builds in-house expertise as the demonstration progresses, and allows the Town DNR to grow incrementally.

Table 3 - Comparison of Shellfish Management Options

Issue	Run by Town	Commercial	Public-Private Partnership
Regulatory (Division of Marine Fisheries)	Flexibility in allowable growing areas (conditionally closed areas may be used for growing)	Growing areas limited to "open" areas/areas where there are not productive wild fisheries	May allow for expanded growing areas for private growers
Regulatory (Division of Marine Fisheries)	Public harvest	Private harvest	May include mix of private and public harvest
Ability to grow shellfish	Must have staff with expertise in growing shellfish dedicated to projects	Growers have experience/skill set required	Expertise of private growers with Town support may enable larger numbers of shellfish to be grown more efficiently
Management Logistics	Many operational issues must be managed and tasks executed	Growers have experience/skill set required and the economic incentive to maximize productivity	Expertise of private growers with Town support may enable larger numbers of shellfish to be grown throughout town
Operational Logistics	Town procurement and other processes less flexible than in private business	flexible decision making	Allows flexible operational decision making, with accountability to Town for end goals
Accountability	All aspects of project are public	Operations privately run	Town tracks outcomes, but is not responsible for daily operations
Cost	Town bears all costs	Minimal cost to town (some staff time for tracking)	Most costs borne by private sector but Town could provide some financial support and staff time for tracking

7. References

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