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Memorandum

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Subject	**Town of Orleans, MA** **Water Quality and Wastewater Planning** **Task Number 3.2 – NT Demonstration Projects** **50% Draft Technical Memorandum on Aqua Culture Preliminary Engineering Design and Work Plan for Preferred Site(s) - Revised**
Project Number	60476644
From	Thomas Parece, P.E., AECOM Project Manager
Date	04/04/16

1. Background

This Technical Memorandum on Preliminary Engineering Design and Work Plan for Preferred Sites presents the specific project designs for four different shellfish demonstration projects. An in-depth critique of the Site Characterization Technical Memorandum was conducted, involving review and comments from several outside experts as well as through 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: increased production of Quahogs in Town Cove through additional seed planting; propagation of oysters in raised beds in a terminal pond of Pleasant Bay; formation of an oyster bed in Quanset Pond; and enhancing oyster aquaculture in Pleasant Bay and Town Cove by either working with existing growers to increase production or through offering additional lease areas.

The following further defines the four projects:

- **Increased Production of Quahogs in Town Cove and Pleasant Bay**
    - Suitable bottom in these estuaries is ideal for enhanced quahog planting;
    - The first step needed is to establish a baseline population count to quantify the success of future propagation efforts; and
    - Baseline populations of quahogs and other shellfish species will be counted in areas historically planted as part of municipal propagation efforts.

- **Propagation of Oysters in Raised Beds in a Terminal Pond of Pleasant Bay**
    - Water quality is most degraded in terminal ponds, need a method of introducing non-traditional technologies in these areas;
    - 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 uptake nitrogen and make a measurable improvement in the water quality of terminal ponds;
    - Terminal ponds have fine-grained, soft sediment that is often anoxic, which precludes bottom-planting, therefore oyster beds will be maintained in trays that are kept off-bottom with footings; and
    - Predation and disease may be minimized by growing remote set (spat-on-shell) in covered trays that are off-bottom and create diverse ecosystem habitats.
- **Formation of 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-planting 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 contribute to the town's water quality goals;
    - Interviewing growers will define the needs of this group relative to the town's numerical goals for shellfish; and
    - Explore the possibility of additional leases.

Design specifications for the quahog population study include an estimate of the bottom area that needs to be surveyed, and the survey parameters. Design specifications for growing oysters in an off-bottom system in one of the terminal ponds in Pleasant Bay, and bottom-planting in Quanset Pond include water surface area and gear requirements, gear layout, and quantities of shellfish to be grown. A work plan is provided for the process of installing, operating and maintaining both of these projects for the first year, and a budget, with capital as well as operation and maintenance costs for subsequent

years. 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 expanded aquaculture. A monitoring program for each demonstration is also described as appropriate, 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 Pond (Oyster reef);
- Pochet (Oyster reef);
- Arey's Pond (Oyster singles in floating bags);
- Town Cove (Quahog propagation);
- Mill Pond (Quahog propagation); and
- Lower River (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
    - 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);
  - Permittability.
- 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.

B. General Description of Demonstration Project Formats

1) Increased Quahog Population and Propagation Planning

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 baseline population has been established. This will provide an estimate of current quahog densities in specific areas where additional quahogs would be planted as part of a demonstration project.

Determining current populations 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.

2) Oyster Bed Installations

The Orleans oyster bed demonstration projects involve growing remote set and planting it 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 methodology proposed for establishing an oyster bed in a terminal pond of Pleasant Bay is modeled after a successful program in Mashpee, MA for growing remote set in trays. Candidate ponds include Meetinghouse Pond, Kescayo-Gansett (Lonnie's) Pond, Arey's Pond, and sections of the River and Namequoit. Paw Wah Pond is also a possibility, but a relay out of this area will be required because this pond is currently closed to shellfishing. These ponds will be evaluated with the town to determine the preferred site. The technique for establishing an oyster bed in the Quanset Pond area is similar to techniques used throughout Cape Cod, and recently implemented successfully in West Falmouth Harbor, MA. Both techniques begin with installing remote set in trays and/or floating bags for an initial growing period. In terminal ponds, oysters will remain in trays that are held off-bottom because the bottom is not suitable for planting. Harvest occurs by bringing the trays to shore, removing the oysters and opening this area to recreational harvest.

In the Quanset area, remote set is 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. Maintaining oyster beds in off-bottom trays is a technique that is replicable to any area in Orleans where the bottom is not a suitable substrate for direct planting. Meetinghouse Pond, Kescayo-Gansett (Lonnie's) Pond, Arey's Pond, Paw Wah and sections of the River and Namequoit are all suitable areas for remote set in off-bottom trays.

3) Shellfish Aquaculture

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 700,000 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 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; implementation techniques need to be tailored to a given site. This project generally includes working with growers to optimize shellfish harvest numbers, identify the needs of this group to increase numbers grown, and design a monitoring plan that can capture the water quality impacts of increased aquaculture. A preliminary monitoring plan has already been developed for this site and is contained in the "Phase I: Orleans Shellfish Operations and Program Expansion Plan" Technical Memorandum dated June, 2015.

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 in this area due to the oyster drill population. The expansion of private grants requires several permitting steps beginning with a recommendation from the Board of Selectmen to the MA Division of Marine Fisheries. 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:

- Discussions with growers to evaluate current growing practices, and opportunities for improving operations; and
- Working with growers to establish a total number of shellfish that can be grown and harvested annually for all leases in aggregate.
- Evaluate areas in Town Cove for expanding shellfish leases

3. Design and Engineering Scope of Work for Demonstration Projects

A. Baseline Quahog Population and Propagation Planning

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. Three, ten meter transects should be defined through the two ends and center of selected quahog planting areas. For each transect, five separate square meter sample areas should be surveyed for all organisms. Quahog numbers 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.

B. Baseline Quahog Population Demonstration Timeline

Timing and activities to accomplish the Oyster Bed in Trays demonstration should proceed as follows:

Spring 2016	• Develop Scope of Work
Spring 2016	• Hire firm to conduct survey
July 2016 – August 2016:	• Conduct population survey
October 2016 – February 2017	• Draft and Final Report • Recommend quantities of quahogs for planting in 2017 • Review with stakeholders • Decision making for 2017 growing season

C. Oyster Bed in a Terminal Pond of Pleasant Bay

1) General

The first year plan is to conduct a viability study by growing 20 bags of oyster remote set in a terminal pond of Pleasant Bay. For remote set bags that weigh 8 pounds (dry), approximately 2 square feet of tray area is required. Remote set will be installed in six trays (approximately 5' wide x 10' long). The trays will occupy approximately 300 square feet, with approximately 300 feet of space around the trays required for access. The first year timeline is detailed in Figure 1, Oyster Bed in Trays Demonstration Gantt Chart. An important aspect of this viability study is to optimize tray size, planting density and installation logistics. After these parameters are defined through this first year viability study, the number of remote set bags grown in the second season will increase to 500, requiring approximately 400 trays to be installed and managed.

Gear includes:

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

INSERT FIGURE 1 FROM TOWN HERE

Remote set can be 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 Division of Marine Fisheries (DMF) also lists approved hatcheries for seed purchase, (Appendix B):

http://www.mass.gov/eea/agencies/dfg/dmf/programs-and-projects/seed-hatcheries.html

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.

2) Oyster Bed in Tray Demonstration Project Engineering Work Plan Timeline

Timing and activities to accomplish the Oyster Bed in Trays demonstration are for illustrative purposes only. Exact timing depends on funding availability:

Winter 2017	• Determine which terminal pond to conduct viability study (Options include Meetinghouse Pond, Kescayo-Gansett (Lonnie's) Pond, Arey's Pond, and sections of the River and Namequoit. Lonnies Pond is a likely choice) • Discuss Request for Determination of Applicability with Conservation Commission • Modify Town Shellfish Propagation permit with DMF Order gear • Order remote set • Town of Orleans to advertise Shellfish Technician position, or otherwise provide for staff to conduct this project
April 2017	• Hire Shellfish Technician (for May 1 start) • Contract for water quality monitoring services
May 2017	• Begin water quality monitoring to establish baseline conditions in selected terminal pond (ongoing throughout spring/summer/fall/winter) • Assemble and install trays
June 2017:	• Install remote set in trays
July 2017 – October 2017	• Shellfish growth, predation, disease monitoring • Operation and Maintenance
November 2017	• Sink trays or install bubbler to prevent freezing over the winter • Repair and storage of equipment

This summary of steps and timing, along with responsible parties, will be detailed in the Oyster Bed in Trays Demonstration Gantt Chart (Figure 1 of Final Preliminary Engineering Technical Memorandum) once stakeholder input is received. As soon as funding is available, all gear and remote set should be purchased. All permitting should be finalized, including the development of a Hurricane Contingency Plan. Shellfish Technician position should be filled .

The preliminary list of permits includes:

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

D. Quanset Demonstration Project

1) Year 1 Engineering Work Plan

The first year plan for Quanset is to grow 500 bags of oyster remote set in the spring, and to bottom plant within the 2 acre demonstration site at the end of the first growing season (Figure 2). Remote set will first be installed in 250 floating bags plus 15 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. The bottom planting for the first year should occupy approximately 4000 square feet because the remote set should be mounded and planted densely. The first year timeline is detailed in Figure 3, Quanset Demonstration Gantt Chart.

Gear includes:

- 9mm mesh bags, closed on one end
- Floats
- 1" PVC pipe, or premade pipe closures
- #7 line, #8 line
- Cinder blocks or other anchoring system with chain
- Gloves, chest waders
- Yellow perimeter marking buoys, with anchoring
- 4" longline clips
- Hog rings and hog ring pliers
- Trays with covers
- Signs
- Materials and equipment to make jig and drill holes, and cut PVC pipe
- Cable (zip) ties

Remote set can be 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 Division of Marine Fisheries (DMF) also lists approved hatcheries for seed purchase, Appendix B:

http://www.mass.gov/eea/agencies/dfg/dmf/programs-and-projects/seed-hatcheries.html

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.

2) Quanset Demonstration Project Engineering Work Plan Timeline

Timing and activities to accomplish the Quanset demonstration should proceed as follows:

May 2017 - October 2017	• Baseline water quality monitoring
February 2018	• 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 • Begin water quality monitoring (winter sample)
April 2018	• Hire Shellfish Technician (for May 1 start)
May 2018	• Ongoing water quality monitoring • Build bags
June 2018:	• Install bags and remote set
July 2018 – October 2018	• Operation and Maintenance
November 2018	• Bottom plant • Repair and storage of equipment

This summary of steps and timing, along with responsible parties, is detailed in the Quanset Demonstration Gantt Chart (Figure 3). As soon as funding is available, all gear required to assemble bags and remote set should be purchased. All permitting should be finalized, including the development of a Hurricane Contingency Plan. Shellfish Technician position should be advertised and position filled by April 1, 2017.

The preliminary list of permits includes:

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

To build 500 bags, a work crew that includes a Shellfish Technician and at least two volunteers should 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 2 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).

A short video documenting the steps in floating bag assembly, available from the Town of Falmouth Little Pond Demonstration Project, should be shown to volunteers as a training tool. The video is included as a CD with this Technical Memorandum, and should be posted on the town website.

In early April, the Shellfish Technician should conduct several site visits to refine the exact layout of rafts and anchoring, given depths and bottom type. One week prior to the deployment of remote set, the empty bags and trays should be installed at the Quanset Pond location. The bags will be installed in two groupings of 100 (called rafts), and one grouping of 50 as follows. Bags will be clipped together in strings of twenty and five strings will be floated in parallel. A shorter raft of five strings containing ten (10) bags will also be assembled. Two to four cinder blocks per side will be used to anchor the raft. Figure 2 shows the two-acre demonstration location and a schematic of the gear layout.

As soon as the remote set is obtained from the hatchery, they should immediately be brought to Quanset 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 remote set at a density of 1.5 bags of remote set per floating bag. The remainder of the remote set should be poured into trays and located next to the rafts.

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, neatness counts. 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 should also be submitted to the Project Manager. End of season activities include bottom planting remote set, then rinsing, repairing and storing bags, trays, anchors and other equipment. The 500 assembled bags will need a storage floor area of approximately 12-foot x 12-foot, with bags stacked 2 high. They will be stored in the Harbormaster Lockdown area located at the Department of Public Works. Section 5 details the baseline monitoring program for this demonstration.

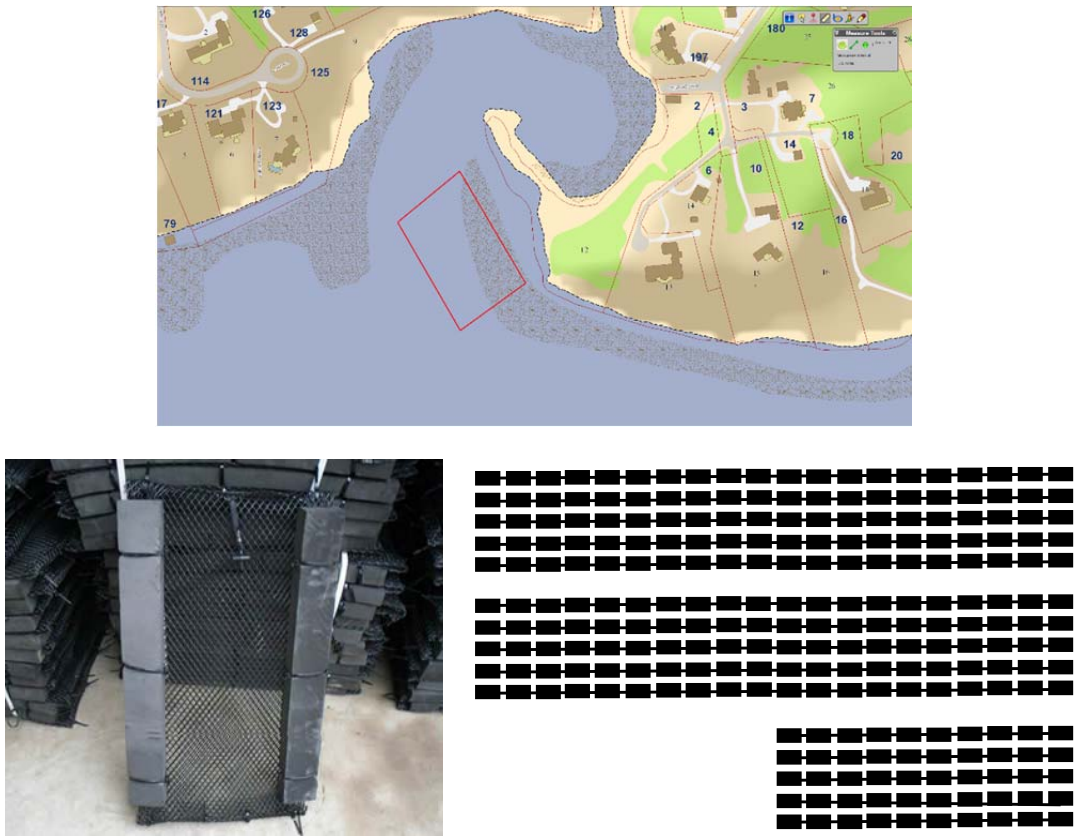

Figure 2 - Two (2) Acre Demonstration Site and Gear Layout

Insert Figure 3. Quanset Demonstration Gantt Chart

E. Shellfish Aquaculture Demonstration Project

1) General

The plan for Little Pleasant Bay is to first work with growers 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 4 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. Section 5 details the baseline monitoring program for this demonstration.

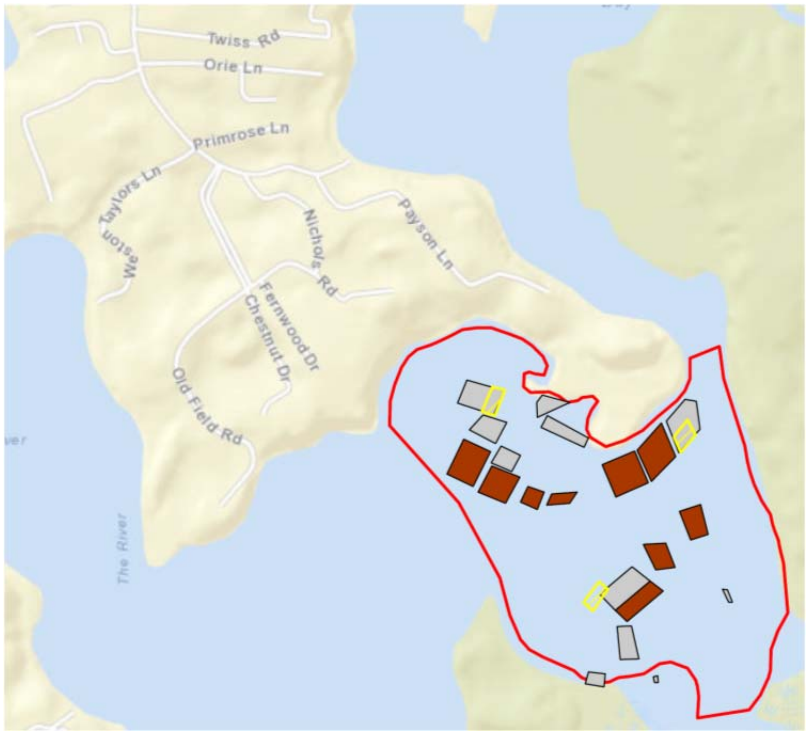

Figure 4 - Current Shellfish Grants

2) Year 1 Pre-Engineering Work Plan

This demonstration includes several components:

1. Work with growers to evaluate current aquaculture growing practices and opportunities to improve these systems;

2. Work with growers to increase production by establishing a total number of shellfish that can be effectively/efficiently managed (grown and harvested annually) for all grants in aggregate;

3. Work with different stakeholders to determine the appropriateness of expanding aquaculture leases in Town Cove; and

4. Discuss lease format options (leaseholders apply for permits individually, or Town applies and sub-leases to growers):

   There are a number of constraints that could limit the productivity of the private aquaculture grants in Little Pleasant Bay. The first step in this demonstration is to meet with growers to identify these issues as well as to offer feasible solutions. Site visits to lease areas with growers will enable collaborative thinking about operations and opportunities. Production constraints may include:

   - Grant size;
   - Bottom conditions;
   - Other location constraints;
   - Available nutrients in the water column;
   - Available financial resources for gear and operation/maintenance expenses (labor);
   - Available labor resources (part-time endeavor); and
   - Infrastructure such as: landing sites, processing/culling facilities, and access to winter storage.

   Once the specific limitations on productivity are identified, they will be documented in a needs assessment report, including alternative solutions. The evaluation of different solutions will be done in close collaboration with growers. The goal of this first phase of the demonstration is to describe recommendations and a budget for optimizing shellfish productivity in existing grants that is well-supported by grant holders.

   A key goal is to work with growers to establish a feasible quantity of shellfish that can be grown and harvested annually, so that results of shellfish aquaculture can be monitored effectively. These harvest goals will be based on the experience of growers in Little Pleasant Bay. Growers should lead the implementation of measures that address any constraints on productivity, which is included in Phase 2 of this demonstration.

   Additional permits are not required for the part of this demonstration in Pleasant Bay. To expand aquaculture in Town Cove, the first step is to develop an inventory of possible locations and sizes with input from the Shellfish Constable, Shellfish and Waterways Committee, Conservation Commission and other stakeholders. Once potential sites are identified, the next step is to conduct a Standing Stock Assessment of these recommended lease areas. This assessment establishes the current shellfish species and densities in these areas. Once the Standing Stock Assessment is completed, additional evaluation and discussions with stakeholders are recommended. After this evaluation stage, the formal permitting process for leases in Town Cove begins with the local Board of Selectmen who review proposed lease sites at a public hearing. The Board of Selectmen may then request approvals from the Division of Marine Fisheries. Additional approvals must also be granted by the Conservation Commission and Army Corps of Engineers.

This summary of steps and timing, along with responsible parties, is detailed in the Aquaculture Demonstration Gantt Chart (Figure 5):

June 2016 – September 2016	• Water quality monitoring to establish baseline conditions in and around the leases in Pleasant Bay and Town Cove • Meet with existing growers, stakeholders, and the Shellfish Constable to assess interest in participation of an expanded production program in Pleasant Bay and Town Cove. Include other technical experts (Cape Cod Cooperative Extension, former Shellfish Constables) in these discussions as available and interested • Site visits to Town Cove to identify specific locations for additional aquaculture leases • Site visits to lease areas to evaluate site constraints and current operations • Develop list of constraints on production (needs assessment) • Identify possible solutions (alternatives analysis) • Identify oyster farming innovations being implemented elsewhere in Massachusetts that may be transferrable to Little Pleasant Bay • List options for enhancing production, based on feedback from growers • Perform an economic study to evaluate market conditions and impacts for the quantities of oysters that will be grown
October 2016	• Review and revise options based on grower preferences (recommended plan) • Develop budget for preferred scenario • Develop a model Memorandum of Understanding between growers and the Town
November 2016 – March 2017	• Additional funding from outside resources
April 2017	• Implement measures that have been identified

Insert Figure 5. Shellfish Aquaculture Demonstration Gantt Chart

4. Budget and Grant Funding for Demonstration Projects

A detailed budget for the Quanset and Little Pleasant Bay demonstrations will be included in Appendix A of the Final Preliminary Engineering Technical Memorandum. The installation of the Quanset bed is expected to be phased over three years. The total budget includes all costs for implementing a demonstration that builds a 1 acre bed with approximately 1 million oysters over the three year period. First year costs include purchasing 500 bags of remote set and the gear required to grow the set, as well as hiring a Shellfish Technician to install, operate, maintain and plant the reef. A project manager (shellfish assistant) to oversee, document and evaluate results is also included. The first year is designed to validate that oyster remote set can be grown successfully at this location, and to allow the town to gain experience with the logistics of operating a demonstration project. The second and third year budgets include the cost of significantly more bags of remote set, summing to a three year total of 5000 bags, as well as the added gear that is needed for growing the remote set. Labor is also included in these budgets. Monitoring costs include sampling and analysis for ten stations as shown in Figure 6.

The Little Pleasant Bay demonstration includes the cost of working with growers, evaluating options and preparing a Technical Memorandum on recommended measures to improve efficiency/density of the current grants. Moreover, an estimate for the cost of producing an additional 1 million oysters in aggregate from these grants is included.

The following list of potential 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. Performance 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 for this water quality improvement planning and decision making. As part of implementing a comprehensive Performance Monitoring Program, a project-specific Quality Assurance Policy Plan (QAPP) is recommended. 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 is appropriate and should be followed. In addition, for other aspects of field and analytical work, an additional QAPP should be developed.

Through the Pleasant Bay Alliance's Monitoring Program, baseline data exists for Pleasant Bay's terminal ponds as well as Quanset Pond. While there are monitoring stations near the existing shellfish grants in Little Pleasant Bay, the first step for this demonstration is to establish pre-installation baseline conditions directly within and adjacent to the shellfish lease areas.

It is recommended that for implementing shellfish projects in Nauset Harbor (Town Cove and Mill Pond) the first step is to reinstate water quality monitoring at stations WMO-25 to WMO-35 that are not currently being monitored and conduct a standing stock assessment for quahog populations in Town Cove and Mill Pond. This is needed to establish pre-installation baseline conditions. Monitoring at these stations, except for the three Sentinel Stations (WMO-25, WMO-24, and WMO-38) has not been reported since 2005.

A. Water Quality Monitoring

To quantify any water quality changes that result from the demonstration projects, bi-weekly sampling from May – September should include the following parameters at both water surface and bottom locations within 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*, Orthophosphate, Salinity, Dissolved oxygen (DO), and Transparency (Secchi depth). Continuous monitoring of Chlorophyll *a*, DO and transparency is recommended. Table 1 shows the frequency and timing of sampling that should occur for water quality monitoring (station names/numbers will be added once draft document is reviewed).

Table 1 - Illustration of Water Quality Sampling Program (Actual program will be defined once details of demonstration project are agreed on by Town)

	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												
Demo-1	2	2	2	2	2	2	2	2	2	2	2	22
Demo-2	2	2	2	2	2	2	2	2	2	2	2	22
Demo-3	2	2	2	2	2	2	2	2	2	2	2	22
QA/QC (10%)												
Total Samples												

B. Measuring denitrification rates associated with oyster aquaculture and oyster beds

Analysis of enhanced sediment denitrification, caused by oyster aquaculture and oyster bed development, is also critical to determining the impact of oysters on the estuary in which they are grown. This analysis includes collecting two sediment core samples; 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, ammonium and ortho-. The rate of oxygen uptake is also necessary in order to: (1) rank sediments relative to organic matter deposition rates and (2) develop a general nitrogen model for oyster impact to the nitrogen cycle in the sediments.

Assays should be performed on cores distributed 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 (N_2) is measured using membrane-inlet mass spectrometry (MIMS). N_2 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.

C. Demonstration Projects

1) Water Quality Monitoring Locations: Terminal Pond Demonstration

A map and monitoring stations (similar to the ones provided below for Quanset and Little Pleasant Bay) will be provided, once the specific terminal pond of the oyster bed in trays is selected.

Year 1 monitoring will establish baseline conditions, while oyster growth viability testing is underway. Final reporting for Year 1 will include:

- Baseline water quality conditions;
- Size classes by length for one year of growth;
- Tray area covered per bag of remote set;
- Review of viability of site for shellfish growth;
- Assessment of operation and maintenance requirements of trays;
- Useful modifications to tray design;
- Recommendations on the type of shellfish grown and whether there should be a mix of species; and
- Assessment of abutter compatibility and use conflicts.

2) Water Quality Monitoring Locations: Quanset Pond Demonstration

To establish whether there is a shellfish impact on water quality, ten sampling stations are proposed. As shown in Figure 6, these stations are located above, within and directly below the proposed oyster reef two-acre growing area (shown as blue rectangle), enabling direct analysis of the water as it flows across the growing areas. In addition, a benthic infaunal survey of the growing area should be conducted to establish baseline benthic environment and species diversity to enable future quantification of the overall impact to habitat through creation of the oyster bed.

3) Water Quality Monitoring Locations: Shellfish Aquaculture (Little Pleasant Bay sites)

To establish whether there is an effect on water quality from the additional oysters, ten sampling stations are proposed. As shown in Figure 7, these stations are located within and directly below the grant areas, enabling direct analysis of the water as it flows through the growing areas.

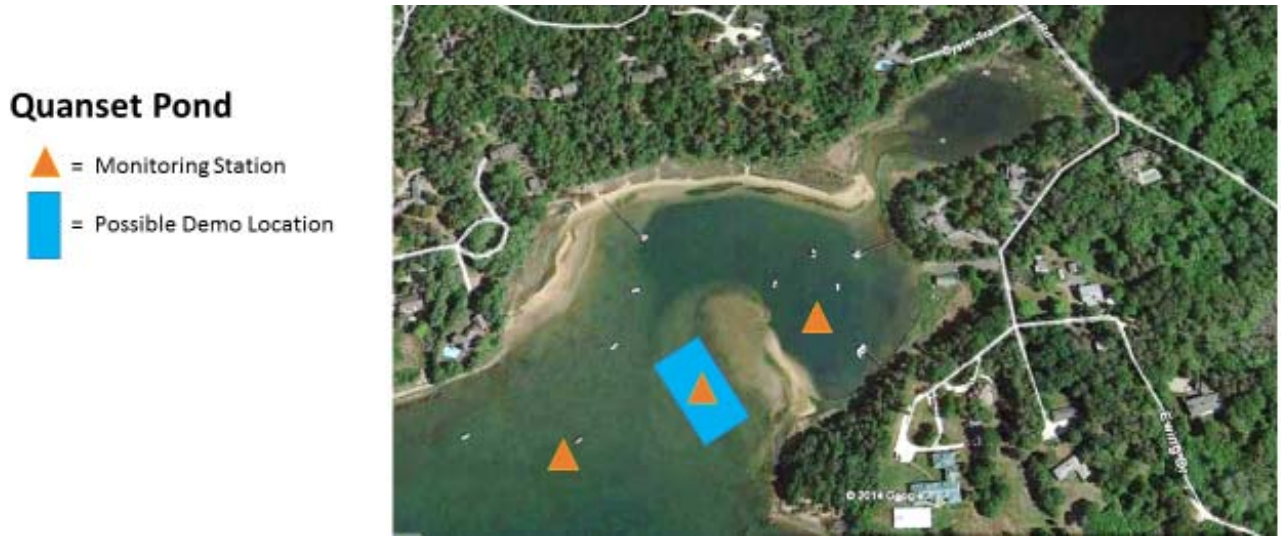

Figure 6 - Quanset Pond Demonstration Monitoring Locations

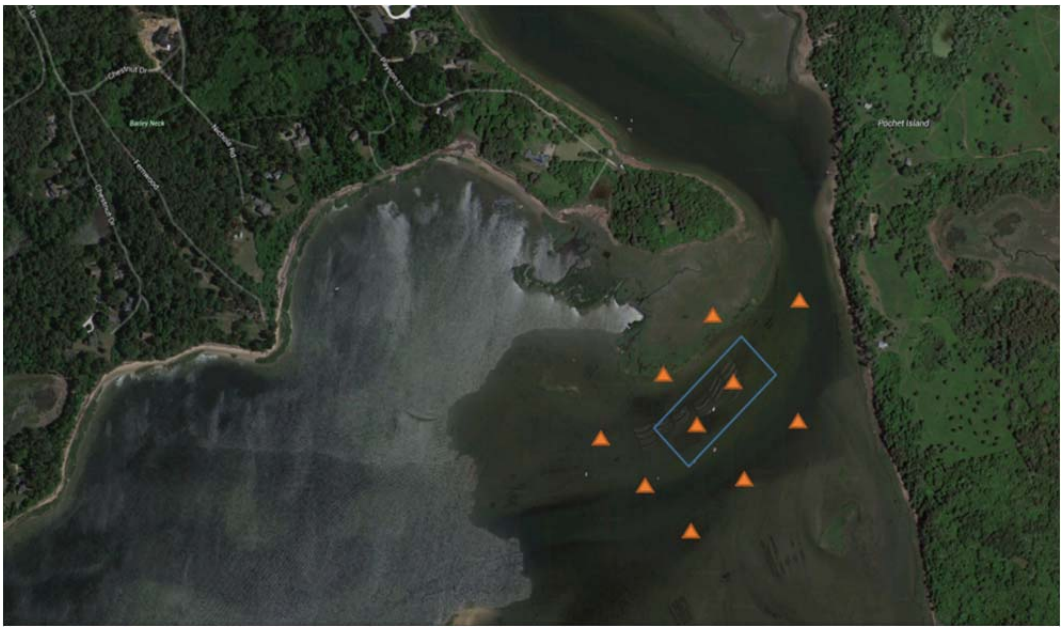

Figure 7 - Map of Recommended Sampling Stations
for the Little Pleasant Bay Demonstration

4) Monitoring Shellfish Growth and Survival at Quanset Pond

In addition to water quality sampling, monitoring the size of the shellfish population, as well as growth and survival rates is also recommended. Remote set oysters should be randomly sampled both from floating bags and from trays, and measured every two weeks to establish a growth rate. Survival should be quantified monthly in both floating bags and trays. Before the oysters are bottom planted in the first growing season, population density should be established, and population counts should be made. Observations regarding predation, and other stressors should be recorded. The population density at the beginning of the second growing season should then be measured.

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

- Population density and overall population counts;
- Number/percent survivors for one year of growth; and
- Evaluation of growth rates and survival in trays versus floating bags.

To determine nitrogen uptake from the oyster bed, 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).

6. Findings/Recommendations

A. General

The goal of full scale implementation of a demonstration of oyster beds in off-bottom trays is to create a permanent system for shellfish growth in the terminal ponds of Pleasant Bay. These trays will provide the filtering and nitrogen-uptake benefits of bottom-planted oyster beds in areas that currently do not have suitable substrate for bottom planting. The tray-based system will enable the town to evaluate the benefits of shellfish in these areas. Once the benefit of oyster beds is validated, projects that create suitable bottom for permanent oyster bed installation can be planned.

- Year 1: 20 remote set bags, grown in trays;
- Year 2: 500 remote set bags, grown in trays, as determined by Year 1 evaluations; and
- Year 3: Scale-up of remote set bags, including creating suitable bottom, as determined by Year 2 evaluations.

The purpose of this phased approach is to ensure that oyster remote set can be grown successfully in trays at this location, and to optimize a system for growing larger quantities. Fouling, predation and survival, as well as aesthetic perceptions and use conflicts will be documented.

The goal of full scale implementation of the Quanset pond demonstration is an oyster bed of approximately 1 acre, growing at least 1 million oysters annually that achieve harvestable size (3-inch). Full scale implementation will be phased as follows:

- Year 1: 500 remote set bags, grown in floating bags and trays;
- Year 2: 1500 remote set bags, grown in either bags or trays or a combination of both, as determined by Year 1 evaluations; and
- Year 3: 3000 remote set bags, grown in either bags or trays or a combination of both, as determined by Year 1 evaluations.

The purpose of this phased approach is to ensure that oyster remote set can be grown successfully at this location, both in gear as well as on the bottom. Trays reduce the visual impact of bed development operations, but sometimes experience fouling, predation and higher mortality. Phasing also allows operations to be scaled-up after determining whether trays are a viable growing technique. Based on information from the West Falmouth reef project and the Mashpee oyster propagation program, it is estimated that an 8 pound remote set bag (regular size) will produce approximately 240 live oysters at the end of one growing season. Therefore, a total of 5000 remote set bags, grown-out over a period of three years, will produce a population of approximately 1.2 million oysters. Quantifying growth rates and survival is needed to enable accurate specification of the number of remote set bags needed to maintain this population level of oysters annually. For planning purposes, it is assumed that 5000 remote set bags will be required to replenish the bed every year, and that there will be an annual harvest of 1 million oysters once the bed is established.

The goal of full scale implementation of the Shellfish Aquaculture demonstration is a total oyster harvest equivalent to 600 kg of nitrogen removal in Little Pleasant Bay. After a determination of the acreage available for leases in Town Cove, based on both environmental as well as public acceptance factors, a plan can be formulated for additional leases needed in order to mitigate nitrogen levels. Full scale implementation will be refined after an assessment of needs and a recommended plan is completed.

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 1 outlines some of the key attributes of each management option.

Table 1 - 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

The Quanset Demonstration can either be run under the Orleans Natural Resources Department, 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 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 Natural Resources Department to grow incrementally. In either case, monitoring would be accomplished under an outsourced consulting contract.