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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 Preliminary Engineering Design and Work Plan for Preferred Site(s)**
Project Number	60476644
From	Thomas Parece, P.E., AECOM Project Manager
Date	02/08/16

1. Background

This Technical Memorandum on Preliminary Engineering Design and Work Plan for Preferred Site(s) presents the specific project design for two distinct shellfish demonstration projects. One demonstration develops an oyster reef in Quanset Pond, and the other demonstration involves working with the current shellfish grant holders in Little Pleasant Bay. In addition, recommendations for two potential demonstration project studies in Town Cove are presented. These analyses are the first step in implementing demonstrations in Town Cove. Although the Scope of Work for this Memorandum requires an engineering design and work plan for only one site, the Shellfish Technical Team felt that presenting both demonstrations, as well as pre-demonstration studies in Town Cove, was warranted for several reasons:

- Including pre-demonstration studies in Town Cove lays the necessary foundation for future demonstrations in the Nauset watershed.
- The two sites in Pleasant Bay received the highest scores using the Site Selection Matrix (both scored 12 out of 14 points), as documented in the Site Characterization and Evaluation Technical Memorandum.
- Each site in Pleasant Bay is fundamentally different, yet offers a potentially advantageous technical approach to growing shellfish.
- Each site in Pleasant Bay utilizes a different management approach.

- Each site in Pleasant Bay has distinct operational advantages:
    - Working with growers leverages existing expertise and experience in shellfish aquaculture.
    - Installing a reef creates a potentially self-sustaining habitat

A benefit of implementing both demonstrations is that the logistics and advantages of these different approaches can be compared as part of the decision making process for larger-scale implementation.

Design specifications for the Quanset Pond demonstration include water surface area and gear requirements, gear layout, and quantity of shellfish to be grown. A work plan describes the process of installing, operating and maintaining the project for the first year. A detailed budget, with capital as well as operation and maintenance costs is also provided. The project description for the Little Pleasant Bay demonstration enumerates the tasks needed to identify appropriate methods of collaboration with growers. A monitoring program for each demonstration 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

2.1 Summary of Site Characterization Technical Memorandum

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
    - 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
    - Overall Likelihood of Monitoring Plan to Yield Quantified Results
- Other/Overriding Considerations

The top two sites derived from both the Site Selection Matrix as well as Team deliberations are Little Pleasant Bay for shellfish aquaculture and Quanset Pond for an oyster reef (Coastal Habitat Restoration [CHR]). These two sites were also recommended by the Orleans Shellfish Constable and Orleans Harbormaster during Team field visits. Working with current shellfish aquaculture grant-holders allows 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 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. The Engineering Work Plan for this option is detailed further in this

TM, but 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 water quality impacts. 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. To demonstrate an oyster reef installation, Quanset Pond has several advantages, including ease of access and patrol, suitable bottom and nutrients, and a reasonable expectation of monitoring to yield quantifiable results.

Pochet is also a favorable location for an oyster reef demonstration, but access and patrol is more difficult; therefore, this site did not rank as high as Little Pleasant Bay or Quanset. Arey's Pond is space-constrained, and the sediment is unsuitable to bottom planting for second year grow-out. Thus, this site does not have good replicability to other areas. Pursuing a shellfish demonstration in Town Cove or Mill Pond is not recommended at this time because (1) oyster propagation is precluded due to excessive oyster drill population (the Massachusetts Shellfish Officers Association advises against oyster propagation where drills are prevalent as a Best Management Practice); and (2) a population study for quahogs is necessary to establish a baseline before any new propagation can be quantified. Finally, given the potential use conflicts and difficulty of monitoring yielding quantifiable results, the Lower River is the least attractive site for an aquaculture demonstration.

In Town Cove, expansion of municipal quahog propagation is recommended to demonstrate and establish maximum practical densities that can be grown and harvested in this area. Based on site reviews, it was found that a quahog propagation demonstration should only be pursued in Town Cove after a population study of current propagation areas is completed. This will establish a baseline for current quahog densities in specific areas where they are currently being planted. Once the baseline population is established, evaluation of a demonstration that increases the number of quahogs that are planted in certain areas in Town Cove can proceed.

The expansion of private grants for oyster aquaculture in certain areas of Town Cove is another possible type of shellfish demonstration. 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 grants is needed to assess the Town's interest in this approach for shellfish propagation in Town Cove.

These two pre-demonstration studies are the first step in moving shellfish demonstrations forward in Town Cove. Section 6 outlines the next steps for these studies.

2-2 Definition of Demonstration Formats

Oyster Reef Demonstration Format

The Orleans oyster reef demonstration project involves growing remote set and planting it in suitable areas, resulting in reef-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 reef 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 a reef in the Quanset Pond area is modeled after a successful reef development program in West Falmouth Harbor, MA. This technique involves a two-stage process:

- Installing remote set in trays and floating bags for an initial grow-out period, typically 8 weeks; and
- Bottom planting this remote set at the end of the first season in the same location as the bags and trays.

The significant benefit of this technique 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 inch (25mm) in size also reduces mortality caused by siltation. Growing out remote set in both trays as well as floating bags will enable an evaluation of the growth and survival rates of each technique.

Shellfish Aquaculture Demonstration Format

The demonstration methodology proposed for Little Pleasant Bay involves working with the growers on the town's existing private shellfish grants. There are currently 12 grants 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 upweller. In total, growers are harvesting approximately 700,000 oysters annually from these grants. Harvesting occurs year-round. To avoid ice damage over the winter, shellfish are submerged to deeper depths or bottom-planted. This demonstration will build on these established growing methods, and includes two phases:

- 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 grants in aggregate.

3. Design and Engineering Scope of Work for Demonstration Projects

3.1 Quanset Demonstration Project

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 1). Remote set will first be installed in 250 floating bags plus 15 trays (4' x 4') (Figure 1). Once the oysters are at least 1 inch 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 2, Quanset Demonstration Gantt Chart.

Gear includes:

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

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 XX: 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.

Demonstration Project Engineering Work Plan Timeline

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

February 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

April 2017	• Hire Shellfish Technician (for May 1 start)
May 2017	• Build bags
June 2017:	• Install bags and remote set
July 2017 – October 2017	• Operation and Maintenance
November 2017	• 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 2). 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:

1. Drill two, ¼ inch holes in mesh bags (a jig should be built beforehand to standardize drilling and to expedite this step);
2. Insert pre-cut line (12" lengths) in each hole, create a loop, secure with 2 hog clips;
3. Attach longline clip to one loop;
4. Attach floats to bag with cable (zip) ties; and
5. 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.

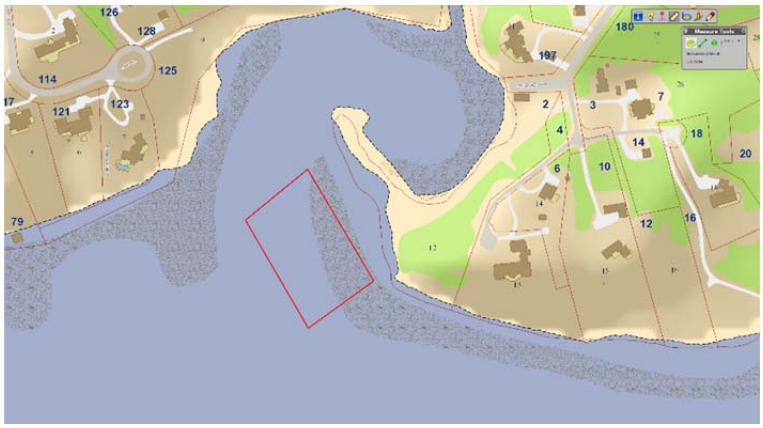
In early April, the Shellfish Technician should conduct several site visits to refine the exact layout of rafts and anchoring, given depths and bottom type. One week prior to the deployment of remote set, the empty bags and trays should be installed at the Quanset Pond location. The bags will be installed in two groupings of 100 (called rafts), and one grouping of 50 as follows.

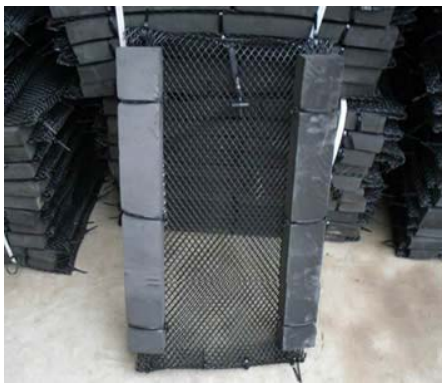
Bags will be clipped together in strings of twenty (20) and five (5) strings will be floated in parallel. A shorter raft of five (5) strings containing ten (10) bags will also be assembled. Two (2) to four (4) cinder blocks per side will be used to anchor the raft. Figure 1 shows the two acre demonstration 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 surrounding should be kept free of unused gear and equipment. Weekly documentation of operational issues should also be submitted. 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' x 12', 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 1 - Two (2) Acre Demonstration Site and Gear Layout





Insert Figure 2. Quanset Demonstration Gantt Chart

3.2 Little Pleasant Bay Demonstration Project

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 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. Section 5 details the baseline monitoring program for this demonstration.

Insert Figure 3. Current Shellfish Grants

Year 1 Pre-Engineering Work Plan

This demonstration includes two phases:

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

2. Work with growers to establish a total number of shellfish that can be grown and harvested annually for all grants in aggregate.

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 feasible solutions. Site visits to grants with growers will enable collaborative thinking about operations and opportunities. 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); 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 of Phase 2 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.

No additional permits are required for this demonstration. This summary of steps and timing, along with responsible parties, is detailed in the Little Pleasant Bay Demonstration Gantt Chart (Figure 4):

June 2016 – September 2016	• Water quality monitoring to establish baseline conditions in and around the grants • Meet with growers and Shellfish Constable to assess interest. Include other technical experts (County Cooperative Extension, former Shellfish Constables as available) • Site visits to grants to evaluate site constraints and 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 • Prepare options for enhancing production, based on feedback from growers • 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 Town
November 2016 – March 2017	• Additional Funding
April 2017	• Implement measures that have been identified

Insert Figure 4. Little Pleasant Bay Demonstration Gantt Chart

4. Budget and Grant Funding for Demonstration Projects

A detailed budget for the Quanset and Little Pleasant Bay demonstrations is included in Appendix A. The installation of the Quanset reef is phased over three years. The total budget includes all costs for implementing a demonstration that builds a 1 acre reef 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 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 (10) stations as shown in Figure 5.

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, preproposals 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
- 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.

Both proposed demonstrations are in the Pleasant Bay watershed. Through the Pleasant Bay Alliance's Monitoring Program, baseline data exists in 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 the shellfish grant 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 the WMO-25 to WMO-35 monitoring stations 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.

5.1 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. The following table shows the frequency and timing of sampling that should occur for water quality monitoring. (add station names/numbers once finalized)

	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												

5.2 Measuring denitrification rates associated with oyster aquaculture and reef building

Enhanced sediment denitrification, caused by oyster aquaculture and oyster reef development, is also recommended to be analyzed. This analysis includes collecting sediment core samples, and incubating them under in situ conditions during the period of maximum denitrification rates in the summer interval (July-September). Time series measurements of total dissolved nitrogen, nitrate+nitrite, ammonium and ortho-phosphate should be made on each incubated core sample. The rate of oxygen uptake should also be measured 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 towards the 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 Quanset Pond and Little Pleasant Bay.

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.

5.3 Demonstration Projects

Water Quality Monitoring Locations: Quanset Pond Demonstration

To establish whether there is a shellfish impact on water quality, ten (10) sampling stations are proposed. As shown in Figure 5, 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 reef.

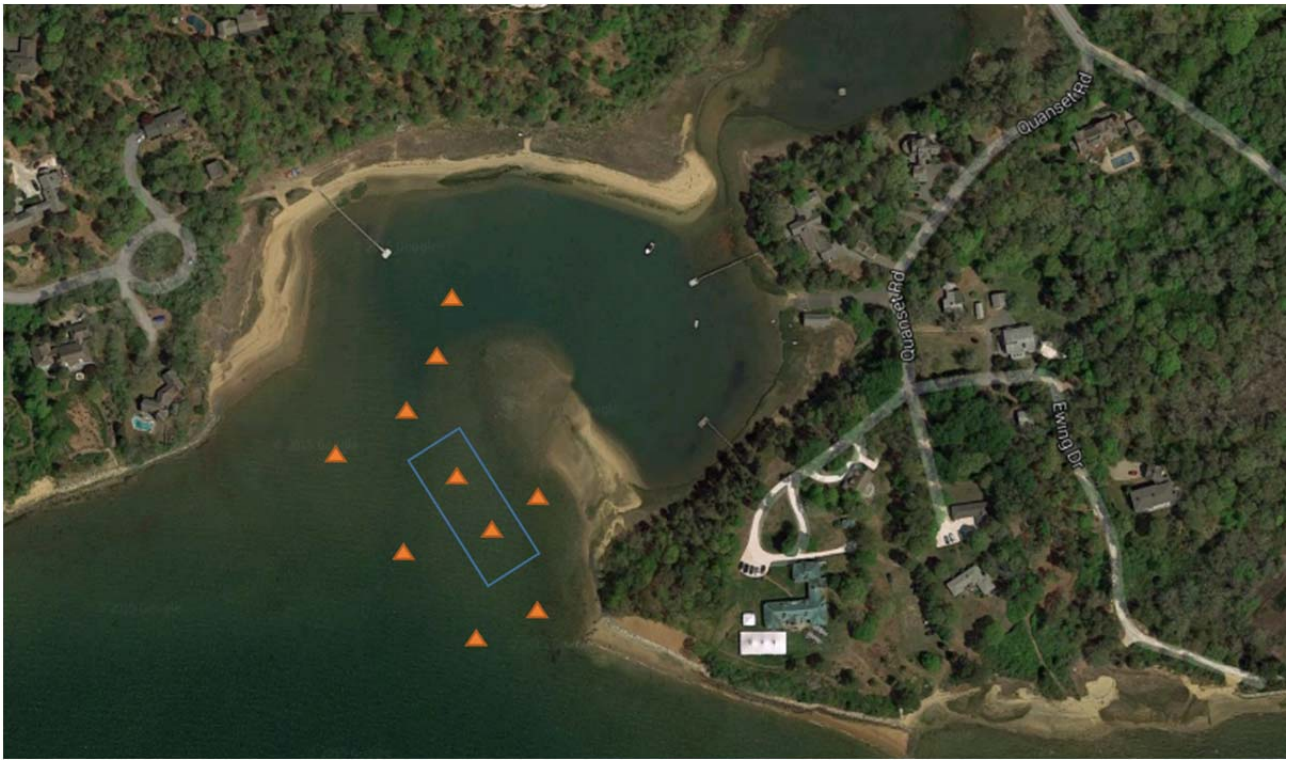


Figure 5 - Map of Recommended Sampling Stations for Quanset Demonstration

Water Quality Monitoring Locations: Little Pleasant Bay Demonstration

To establish whether there is an effect on water quality from the addition of oysters, ten (10) sampling stations are proposed. As shown in Figure 6, these stations are located within and directly below the grant areas, enabling direct analysis of the water as it flows through the growing areas.

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
- Evaluation of growth rates and survival in trays versus floating bags

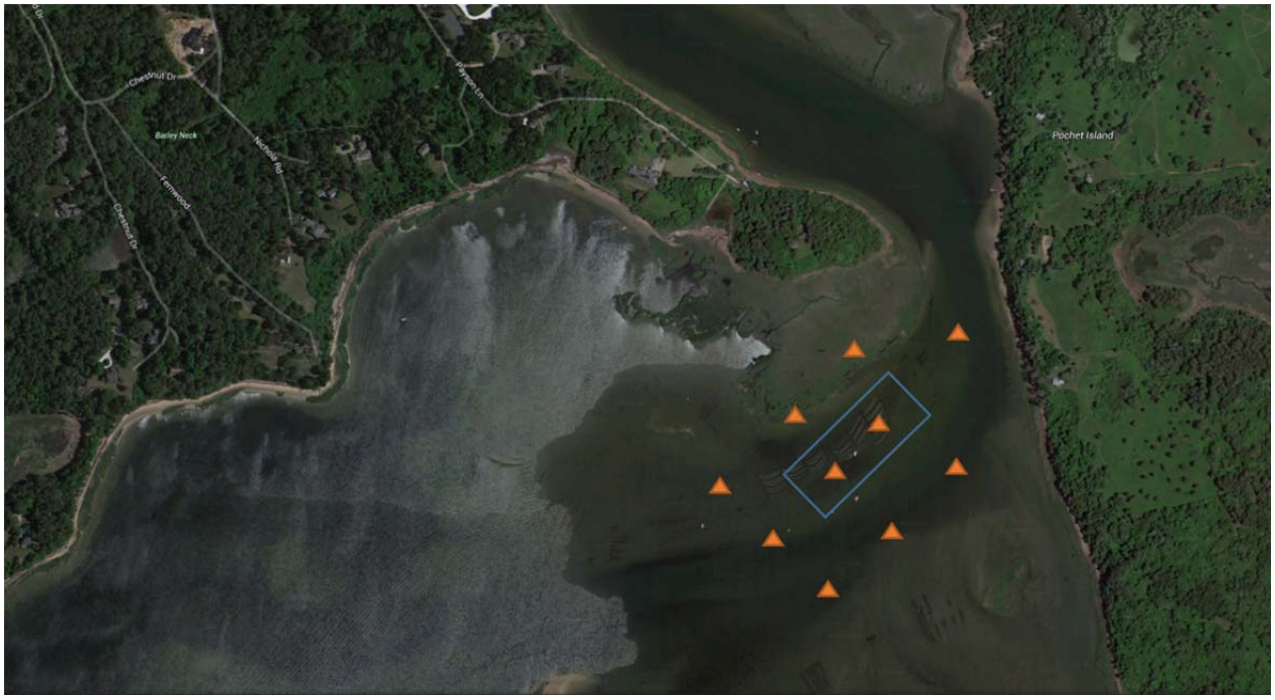


Figure 6 - Map of Recommended Sampling Stations for Little Pleasant Bay Demonstration

- Size Classes by length for one year of growth
- Area of bottom covered by remote set
- Review of viability of site for shellfish growth
- Assessment of operation and maintenance requirements of trays versus floating bags
- Useful modifications to the site selection criteria for shellfish
- Recommendations on the type of shellfish grown and whether there should be a mix of species
- Assessment of abutter compatibility and use conflicts

To determine nitrogen uptake from the oyster reef, 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 10-20 animals
- Measure the percentage of N in tissue and shell separately, using a pooled sample of 10-20 animals
- Tabulate wet weight to dry weight correlations using regression analysis

- 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
    - 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

The goal of full scale implementation of the Quanset pond demonstration is an oyster reef 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 reef 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 reef every year, and that there will be an annual harvest of 1 million oysters once the reef is established.

The goal of full scale implementation of the Little Pleasant Bay demonstration working with growers is a total oyster harvest equivalent to 600 kg of nitrogen removal. Full scale implementation will be refined after an assessment of needs and a recommended plan is completed.

Town Cove Pre-Demonstration Studies

In addition to the Demonstration Projects described above in Pleasant Bay, two pre-demonstration projects are recommended for Town Cove:

The quahog population study in Town Cove should occur in the areas where municipal quahog propagation is currently occurring. Three, ten meter transects should be defined through the two ends and center of these 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.

A study to evaluate whether private aquaculture grants should be expanded in Town Cove would include developing an inventory of possible locations and sizes with input from the Shellfish Constable, Shellfish and Waterways Committee and other stakeholders. Once potential sites are identified, the next step is to conduct a Standing Stock Assessment of these recommended grant areas. This assessment establishes the current shellfish species and densities in these areas. Once the Standing Stock Assessment is completed, additional evaluation and discussion with above stakeholders is recommended. A final set of proposed grant sites is then reviewed by the Board of Selectmen at a public hearing. The Board of Selectmen may then request that the Division of Marine Fisheries approve the location of private grants in Town Cove.

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 full-time seasonal staff person to operate the demonstration as well as technical consulting 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.