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Expanding and Sustaining the Shellfisheries of Casco Bay-Phases II & III: Ranking Clam Flats for Potential Remediation

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Casco Bay Estuary Project

Expanding and Sustaining the Shellfisheries of Casco Bay — Phases II and III
Casco Bay Estuary Project

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EXPANDING AND SUSTAINING THE SHELLFISHERIES OF CASCO BAY — PHASES II AND III

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**THIS REPORT IS DEDICATED TO
THE LATE DAVID ACHORN
MAINE DEPARTMENT OF ENVIRONMENTAL PROTECTION
FOR HIS DEDICATION AND HARD WORK.**

OTHER PARTNERS INCLUDE THE TOWNS OF WEST BATH, BRUNSWICK, HARPSWELL, SOUTH PORTLAND, FREEPORT, YARMOUTH, AND PHIPPSBURG; MAINE DEPARTMENTS OF ENVIRONMENTAL PROTECTION AND MARINE RESOURCES, FRIENDS OF CASCO BAY, CASCO BAY CLAM COUNCIL, AND THE MANY HOMEOWNERS WHO INVESTED IN NEW SEPTIC SYSTEMS.

INTRODUCTION

Harvesting shellfish is an important tradition in all of Maine, including Casco Bay. In 2002, nearly 20% of the state licenses were held by commercial harvesters in Casco Bay. Harvesting poses a significant economic benefit to the region, last estimated in 1994 at more than $4 million, with a broader economic value of the fishery (including all of those associated with the industry) between $13 and $14 million (Heinig et al. 1995). As substantial as this value may be, at the beginning of this study (1999), contamination caused nearly half of the harvestable areas within the Bay to be closed to harvesting. Because of the obvious potential socioeconomic benefit from opening clam flats, one of the goals of the Casco Bay Plan (CBEP 1996) is to open and protect shellfish areas adversely impacted by poor water quality. To that end, the Casco Bay Estuary Project (CBEP) secured a Sustainable Development Challenge grant from the U.S. Environmental Protection Agency (US EPA) with two goals: remediate pollution sources keeping clam flats closed to harvest, and investigate options for sustaining that harvest.

In Phase I of this project, with the assistance of many stakeholders, clam resources in 57 closed clam flats in nine municipalities (800 acres) were reviewed and the pollution sources contributing to their closure were identified. Working closely with the municipalities, 21 flats (430 acres) were selected for remediation, based on high clam resource value, ease of remediation, and community support. This process and results for this phase of the project are described in a separate report *(Expanding And Sustaining The Shellfisheries Of Casco Bay — Phase I. Ranking Clam Flats For Potential Remediation.* 1999 Normandeau Associates Inc. and MER Assessment Corporation.)

In Phase II of this project, again with the assistance of other stakeholders, 3 goals were undertaken:

- **Remediation** – Opening clam flats to harvest by partnering with other stakeholders and removing pollution sources,
- **Assessment –** Understanding nonpoint sources of pollution that affect clam flats and
- **Management** –Testing management strategies for increasing and sustaining harvest.

REMEDIATION

Introduction

Maine Department of Marine Resources (DMR) is responsible for classifying waters as safe for shellfish consumption based on criteria provided by the U.S. Food and Drug Administration's National Shellfish Sanitation Program (NSSP). As filter feeders, clams remove particulate matter from the water column. In polluted waters, clams concentrate viral and bacterial materials, increasing the potential for human disease transmission. DMR's water quality monitoring program measures fecal coliform bacteria concentrations because, while are not themselves harmful, coliforms serve as an indicator of fecal contamination, which could carry diseases. Sources of fecal contamination include septic discharge, wildlife, illegal boat discharges, and stormwater runoff.

Phase I results indicated that in 1999, nearly 430 acres of high value clam habitat in Casco Bay with good water quality were closed to harvest. Nearly half were closed simply due to the presence of a septic design called an overboard discharge (OBD); therefore, this project focused a significant amount of effort on removing these systems. An overboard discharge (OBD) system differs from a conventional subsurface wastewater disposal system because a sand filter or commercial mechanical treatment plant is used for secondary treatment rather than a leach field. As a result, OBDs require chlorination of the wastewater required prior to discharge into a body of water. NSSP regulations prohibit shellfish harvesting near OBDs because of the potential for contamination from system malfunction. In Maine, the discharge of untreated wastes was prohibited in 1973 and lots with unsuitable soils for subsurface disposal received overboard discharge licenses or installed a holding tank. The Overboard Discharge Law (38 M.R.S.A § 411-A) phases out existing non-municipal, overboard discharge systems, and, through a grant program, shares the cost of replacement.

Four areas were targeted for OBD removal: Gurnet/Buttermilk Cove in Brunswick/Harpswell and Fosters Point, Birch Point, and Sabino in West Bath. In addition, several sites on the New Meadows River in West Bath were added to the list at the request of the West Bath shellfish committee. These areas contained a total of 31 Overboard Discharge (OBD) systems (8 in Brunswick, 2 in Harpswell, and 21 in West Bath).

Process

Normandeau Associates, in association with Albert Frick Associates, facilitated the OBD removal program, which required the close coordination of several stakeholders:

- The landowner, who was heavily invested in the success of outcome, and in some cases abutters, if easements were required;
- The septic system designer;
- The construction company, who installed the new systems;
- Maine DEP, responsible for licensing (and revoking the license for) OBDs, administering the OBD removal grant program, approving (sometimes with Department of Health and Human Services) replacement systems and variances, when necessary; and
- The municipality, responsible for disbursement of funds, contract for system installation, system approval, variance granting, and negotiation with unhappy landowners.

Results

The OBD removal project resulted in the elimination of 26 of the 31 targeted OBD systems. Out of the ten sites in Sabino, nine were removed; the final OBD will be removed as part of a DEP enforcement action, allowing this area to be opened to harvest. Ten sites were completed in Harpswell and Brunswick. Only one site remains in Harpswell (awaiting signature from an abutter for a well release); its removal will allow the opening of flats in the Gurnet/Buttermilk Cove area. Two of the three systems on Fosters Point in West Bath have been designed, but will not be removed until the design of the third system, which requires either an off-site solution or a holding tank, is complete.

Out of nearly 430 acres of high priority clam flats selected in this project, 311 are open in some capacity. Opening of another 74.5 acres is pending, awaiting removal of the five remaining OBDs, as well as shoreline surveys and resolution of water quality issues. The majority of the openings were facilitated by collaboration with DMR staff who were already working in these areas. Once staff knew where the priorities were, they were able to focus their efforts on the most important areas. The project enhanced collaboration with other stakeholders such as DEP, municipalities, and harvesters, and has continued with groups such as the New Meadows Watershed Committee. While over 243 acres of flat have been opened during the course of this project, only 25 acres are the direct result of OBD removal. However, increased communication and prioritization of flats as a result of this project have played an important role in the opening of the 243 acres. Another 44 acres remain closed due to poor water quality. The issues that remain are the most difficult to resolve and will require the continued efforts of DEP, DMR and the municipalities.

NON-POINT SOURCE POLLUTION ASSESSMENT

Shellfish growing area closures around OBD s are often referred to as “presumptive” closures because it is presumed that even properly operating systems may fail at any time. Clearly, removal of the OBD removes such risk. But before the closure can be lifted, water quality of the surrounding area must be shown to be sufficient to meet NSSP standards. Where no OBDs exist but water quality fails to meet standard, some other, less-obvious contamination source must exist. The non-point source pollution (NPS) assessment portion of this study was designed to evaluate water quality and identify and remove contamination sources, where possible and practical. Eight study sites were initially selected as a result of the Phase I analysis of closed areas: Sebasco/Round Cove in Phippsburg; Sabino and Fosters Point in West Bath; Buttermilk Cove, Middle Bay Cove, upper Maquoit Bay and Bunganuc Stream in Brunswick; and Pettingill Cove in Freeport (Normandeau Associates Inc. and MER Assessment Corporation. 1999. *Expanding And Sustaining The Shellfisheries Of Casco Bay — Phase I. Ranking Clam Flats For Potential Remediation.*) As the study progressed and certain initially-selected areas were opened to harvesting, two additional areas were added, Ash Point Cove in Harpswell and Mussel Cove in Falmouth.

The results of this study indicate that no serious contamination exists in the Sabino and Fosters Point areas and it seems reasonable to conclude that removal of the OBDs in these areas will result in the adjacent shellfish growing areas being opened to harvesting.

Similarly, the study results in the vicinity of Sebasco Harbor indicate that no actual serious contamination exists in the area. Nevertheless, for the area to be opened, the Sebasco Estates overboard discharge must be removed. However, even if the OBD were to be removed, the presence of a large number of vessels in Sebasco Harbor during the summer further complicates efforts to open the area. An analysis of the tidal exchange and estimated dilution would help determine whether Sebasco Harbor flats could ultimately be open to harvest, thereby justifying the substantial expense of OBD removal.

Buttermilk Cove represents a rather unusual situation where the fecal coliform contamination source appears to originate outside of the cove proper. Previous shoreline surveys have not identified any specific source(s) of contamination other than the eight OBDs. Based on the absence of any other specific contamination source, it has been assumed that the levels of fecal coliform bacteria would drop to within acceptable limits following removal of the OBDs. Unfortunately, this has not been the case. The presence of a houseboat with questionable domestic waste disposal facilities in the area just southwest of Buttermilk Cove represents a very plausible source of contamination. The addition of strategically-placed monitoring stations and a new shoreline survey might provide the necessary information to pinpoint contaminant sources.

Fecal coliform contamination affecting upper Maquoit Bay, Bunganuc Stream, Pettingill Cove, and Mussel Cove and their respective freshwater inputs has been difficult to ascertain. In all cases the watersheds draining into these areas are large with complex land-use patterns. Runoff following precipitation events appears to be a major contributor to fecal coliform bacteria loading, although not exclusively. Furthermore, although human sources cannot be ruled out, wildlife and agricultural sources may play an important contributing role.

The NSSP does not discriminate between human and non-human sources. Numerous efforts have been made over the years to identify a human-specific test to allow discrimination between human and non-human sources. More recently, advances in genetic testing has offered the possibility of tracing certain strains of bacteria back to species-specific sources, a process known as Microbial Source Tracking or MST. MST offers the possibility of eventually being able to compare the relative proportion of human and non-human bacteria in a population, thus allowing a determination of the relative risk posed by human sources. The Casco Bay Estuary Project may wish to encourage additional study to advance this very promising technology.

The elevated fecal coliform levels observed in Mussel Cove and Bunganuc Stream could be the result of the location of the DMR water quality stations, which may occasionally sample input waters rather than growing area waters, possibly resulting in overestimation of fecal coliform impacts. To determine whether these stations are representative of conditions affecting shellfish within the growing area proper, it is recommended that at least one additional station be established at each location that might better reflect the bacterial levels over the growing areas during most of the tide cycle.

A review of the recent monitoring results for Pettingill Cove indicates that the area’s bacteriological water quality meets the NSSP requirements for approved status and the area could be opened to harvesting. However, our results suggest that the area may fall under a conditional rainfall management plan similar to those that apply to the other shellfish harvesting areas of the Harraseeket River.

Finally, the results in Maquoit Bay are somewhat puzzling. Given the level of contamination from the input sources and their combined volumes, bacterial levels would be expected to be considerably lower than those found. Furthermore, several of the highest fecal coliform bacteria spikes are associated with high salinities, indicating little influence from freshwater sources. This seems to suggest that sources internal to the bay, such as avian populations reported to frequent the area, may be a transient, intermittent source; as stated previously, however, no large flocks of birds were observed during the study.

The study areas selected for this project are the largest of the last remaining closed areas within Casco Bay. They are the last because they are the most difficult areas in which to identify contamination sources. In addition to the effort expended in all of these areas as part of this project, considerable prior effort has been applied to all by their respective municipalities, environmental organizations, such as Friends of Casco Bay, and the Maine DMR, working either independently or in association with each other. Yet despite all efforts, the sources remain elusive.

MANAGEMENT

The eight coastal communities in Casco Bay where shellfish are harvested use a variety of tools to manage their clam resources including resource enhancement (e.g. clam seeding) and harvest control (e.g. restricting the number of licenses issued). The review of management strategies used in Casco

Bay that was conducted in Phase I of this project indicated that many of these strategies were used universally, but their effectiveness as management tools had not been determined.

Clam Seeding Experiment

The management survey revealed that of the eight municipalities, all except Falmouth and Cumberland, plant spat in clam flats to increase future harvest. However, none routinely survey the seeded areas to determine whether the number of harvestable clams actually increases as a result of their efforts. Furthermore, factors such as season, protection with netting, furrowing to facilitate burrowing, and seed size had never been scientifically evaluated.

Based on this information, the project team developed a seeding study, with a scientifically rigorous sampling design and analysis, to test the overall effectiveness of seeding and the variables that may affect its success. Three municipalities participated in the study: Phippsburg, Freeport, and Yarmouth. Seed was planted in the fall of 2001 and spring 2002 in one flat in each municipality. A follow-up survey to determine the clam survival and seed density was conducted in spring and fall of 2002.

Survival of the seed was very low at all three sites. None of the variables of season (spring vs. fall), seed size, and flat treatment (furrowing) appeared to have a consistent effect on seed survival. These results, therefore, suggest that the success of seeding efforts is highly site-specific. Consequently, conducting follow-up surveys, even simple ones, is important to determine the effectiveness of clam seeding efforts. The data from one site indicate that covering of flats with predator exclusion nets may also increase turbulence of the overlying water, thereby, increasing the opportunities for spat settlement. This phenomenon has also been observed by others (Heinig and LaValley 1999).

Resource Evaluation Method Study

Another universally-employed management tool is license limitation, also termed “limited-entry,” as a measure to control resource exploitation. License limitation is usually tied to the available resource or “standing stock”, that is, the number of licenses issued is based on an estimate of the average harvester’s annual take and the amount of available resource. Annual harvester take is determined based on interviews with harvesters, observations of daily harvests by marine patrol officers, the average number of harvest days, and harvester efficiency. Standing stock is estimated from annual population surveys that usually cover approximately one third of the harvestable area in a given town.

Estimation of clam resource available for harvest is mandatory for all municipalities participating in the DMR clam management program. But population surveys are time-consuming, and thus difficult and expensive to complete. Recognizing these difficulties, the Maine Soft-shell Clam Advisory Council (MSCAC), which serves in an advisory capacity to the Maine Department of Marine Resources, recommended exploring the development of a simpler, alternative method to the standardized systematic-random survey method.

To this end, this project evaluated the effectiveness of several alternative approaches to the mandatory standard resource assessment method. The Casco Bay Regional Shellfish Council study recommended Woodward Cove, Brunswick because of its known productivity, accessibility, annual conservation closure, and ability to be monitored. The Town of Brunswick offered the assistance of its wardens and airboat to assist the project in monitoring harvest amounts.

The entire 33-acre flat was surveyed using the standard DMR resource survey method (systematic random), collecting clams in a 1 by 2 foot square sample every 100 or 200 feet, depending on the size of the flat. One third of the flat was surveyed more intensively, collecting samples every 100 feet. Using these data, the following resource evaluation methods were investigated:

- A systematic random design (surveying the entire area on a 100 foot or 200 foot grid);
- A stratified-random design (looking at only moderate density (>10 clams per 2 ft^2); and
- A stratified-random design looking at high density (>20 clams per 2 ft^2).

Clam density was estimated from the two stratified random designs and compared with the clam density determined using the standard methodology. In addition, the number of samples needed to detect a 200 bushel difference (the estimated annual harvest of one harvester and thus, one license) for the flat was determined.

The results revealed that in Woodward Cove, an estimated 113 samples would be needed to survey the entire flat with enough accuracy to detect a 200-bushel difference in harvestable clams with 90% confidence. The effort would be reduced to 42 samples if the study concentrated only on areas of moderate density. The effort would be reduced to only 19 samples if only high density areas were surveyed.

The traditional approach, surveying an entire flat, normally includes areas not likely to be harvested due to excessively low density from a commercial harvesting perspective and would therefore likely result in an overestimation of the appropriate number of licenses that should be issued. On the other hand, a narrowly focused high-density area survey tends to exclude areas likely to be harvested resulting in an underestimation of the appropriate number of licenses to be issued. Moderate-density area surveys appear to offer a reasonable compromise by requiring considerably fewer sampling stations while covering most, if not all, of the resource likely to be targeted by commercial harvesters.

Regional Management

Another management tool is using a regional approach to resolving common issues. The Georges River Project in mid-coast Maine is a five-town area with reciprocal licenses; shared administrative, equipment and enforcement costs; equal representation on the Shellfish Management Committee and shared responsibility of managing the flats as an ecological unit. The Cobscook Regional Clam Project was formed in 1996 to improve the health of the Bay through water quality improvement; point and non-point source pollution abatement; increased flat productivity; and regional management for Cobscook Bay's resources. The Casco Bay Shellfish Council was established to improve regional collaboration, patterned after the previously-described organizations. The Maine Soft-Shell Clam Advisory Committee (MSCAC) was formed to address state-wide issues. These organizations offer an opportunity for harvesters, wardens, and regulators to discuss common issues and develop solutions. All face challenges in terms of participation and enthusiasm. Harvesting is a solitary profession, so participation in a committee can be unfamiliar and difficult. Furthermore, attendance at municipal shellfish meetings and requirements for conservation time take time away from generating revenue. Participation in yet another organization becomes difficult for many. However, these organizations lay a framework for developing collaborative solutions to regional and state-wide problems that develop in the future.

Future Directions

One of this project's successes is its emphasis on collaboration. Collaboration began with the Clam Team, which directed the project's focus. As the project continued, the Clam Team evolved to include other stakeholders and interested parties. The project joined forces with the New Meadows River Watershed Committee to evaluate clam resources in several New Meadows River flats. Sharing results with the Casco Bay Regional Shellfish Council and Maine Soft-Shell Clam Advisory Committee at the Fishermen's Forum also fostered support for the management initiatives of this project. The project was most successful when all stakeholders jointly made decisions. This model can continue to be used for the OBD removal program as well as for other initiatives.

Results from the NPS survey underscore the difficulty in ascertaining sources of coliform. A further challenge is to better determine the true human health risk as measured by fecal coliform concentrations. Technology offers part of the solution, whether in the form of improved testing methods to determine whether the coliform is of human origin (such as microbial source tracking) or modeling to better project coliform dispersal around sources such as wastewater treatment plants. Continued funding for source and nonpoint source remediation is another part of the solution. Support for DMR's dedicated staff to continue to investigate sources of coliform through its water quality testing and shoreline surveys can link both.

This project focused on northern Casco Bay because of concerns that sediment contamination in southern Casco Bay might be assimilated by the clams, potentially posing human health risks. Further sampling and analysis by a toxicologist is needed to resolve whether clams from southern Casco Bay are safe for human consumption.

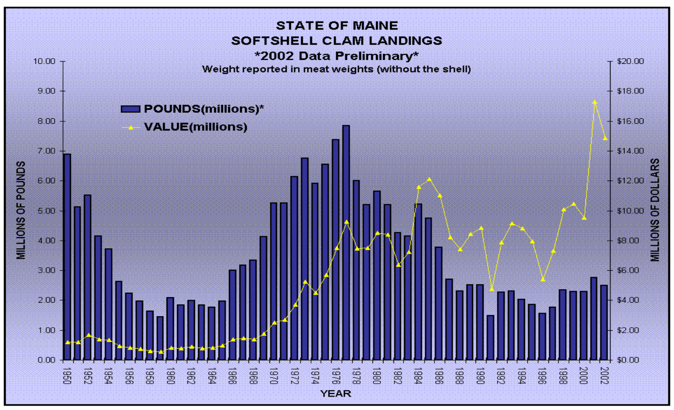
Use of management techniques, particularly resource enhancement techniques is widespread, but their effectiveness is uncertain. Follow-up surveys should be conducted to assess the utility of management tools.

1.0 INTRODUCTION

Harvesting shellfish is an important tradition in all of Maine, including Casco Bay. In 2002, over 2 million pounds were harvested in the State, with a dollar value of nearly $15 million (Figure 1.1-1). Furthermore, as landings in other parts of the state, principally in the DownEast area, have declined, the significance of the Casco Bay area fishery has increased in importance, reaching approximately one-quarter of the statewide harvest in 2002. In 2002, commercial license holders in Casco Bay numbered over 300 (out of a total of 1,600 in the State), with another 1500 recreational license holders.

During the period 1985-1993, Casco Bay clammers harvested approximately 60,000 bushels at a value of more than $4 million (Heinig et. al 1995), almost half of the total landings for the State (Maine Department of Marine Resources, 2003 — www.state.me.us/dmr). The study also estimated local economic activity associated with the fishery at 2.5–3.3 multiplier and suggested the use of an income multiplier of 3.0 as a reasonable value to estimate the broader economic value of the fishery to the local area. Applying this value yields an approximate net local annual fishery value of between $13 and $14.4 million. As substantial as this value may be, at the time of the study an estimated 44.5% of the harvestable areas within the bay were closed to harvesting resulting from actual or potential contamination sources posing serious risks to public health from consumption of shellfish. Assuming that these areas would yield similar harvests as the open area of the bay, the study estimated that, if opened to harvesting, an additional $3.7 million in landed value could be harvested from the closed areas of the bay increasing the overall economic activity associated with the fishery by approximately $11 million. As a result, one of the goals of the Casco Bay Plan (CBEP 1996) is to open and protect shellfish and swimming areas impacted by water quality.

Figure 1.1-1. State Of Maine Annual Soft-shell Clam Landings (source: Maine Department of Marine Resources, 2003 — www.state.me.us/dmr)



To that end, the Casco Bay Estuary Project (CBEP) secured a Sustainable Development Challenge Grant from the U.S. Environmental Protection Agency (US EPA) with two goals: remediate pollution sources keeping clam flats closed to harvest, and investigate options for sustaining harvest. In Phase I of the project (*Expanding and Sustaining the Shellfisheries of Casco Bay: Phase I:Ranking Clam Flats for Potential Remediation.* Normandeau Associates Inc. (NAI) and MER Assessment Corporation, 1999), we reviewed clam resources and pollution sources in 57 clam flats in nine towns that were closed to harvest. Working closely with the municipalities, we selected 21 flats for remediation. We also reviewed management strategies used by each municipality as well as those used in other areas. In Phase II, we undertook 3 goals:

- Opening clam flats to harvest by removing pollution sources and by partnering with other stakeholders (Section 2.0);
- Understanding nonpoint sources of pollution that affect clam flats (Section 3.0);
- Testing management strategies for increasing and sustaining harvest (Section 4.0).

CBEP established a committee of stakeholders concerned about environmental quality as it pertains to shellfish harvest. Members include Maine Department of Marine Resources (DMR), Maine Department of Environmental Protection (MDEP), Friends of Casco Bay, industry associates, and representatives from interested municipalities (Appendix A). The “Clam Team” as it was named varied in membership over the course of the study, as the interest and focus evolved. The most important result of this project was the collaboration of this group throughout the project, diligently working towards common goals.

1.1 SHELLFISH MANAGEMENT

Shellfish harvesting is managed by a collaboration of federal, state, and local governments. Safe consumption is the responsibility of U.S. Food and Drug Administration (USDA), delegated to Maine DMR. Legal and Sustainable harvests are also under the review of DMR in partnership with the municipalities.

The U.S. Food and Drug Administration is responsible for assuring that shellfish is safe for consumption under the National Shellfish Sanitation Program (NSSP). Safe shellfish consumption includes three components: marine biotoxin monitoring, shellfish processing plant inspection, and shellfish growing area classification. Only the latter is germane to the project. As filter feeders, clams concentrate particulate matter in the water column. In polluted waters, clams concentrate viral and bacterial materials, increasing the potential for human disease transmission.

DMR is responsible for classifying waters as safe for shellfish consumption based on criteria provided by NSSP. This program includes two elements: water quality testing and shoreline or sanitary surveys. Fecal coliform bacteria concentrations are measured in the DMR water quality monitoring program. While coliforms are not themselves harmful, they serve as an indicator of fecal contamination, which could carry other diseases. Sources of fecal contamination include wildlife, septic and wastewater discharge, illegal boat discharges, and stormwater runoff. The coliform results from the last 30 samples are used to determine whether a shellfish growing area is open for harvest. DMR will do additional investigations of the effects of rainfall or other parameters determine if there is a relationship with elevated coliforms. If so, a conditional approved status may allow harvesting under certain conditions. The shoreline survey examines potential sources of fecal contamination, mainly septic sources. The presence of likely sources of fecal contamination, such as moored boats, straight pipes, or overboard discharges, can also determine the classification level, regardless of the water quality results. Results of the two elements determine whether a clam flat is classified as “approved” or open for shellfish harvest, conditionally approved, restricted, conditionally restricted, or closed (Table 1.1-1).

Table 1.1-1. Shellfish Growing Area Classification

Classification	Description	Criteria
Approved	Open to harvest at all times	Acceptable water quality; No significant pollution sources Fecal coliform geometric mean (last 30 samples) <14 Most Probable Number (MPN); 90th percentile < 43MPN.
Conditionally approved	Open depending on whether conditions are met	Examples: presence of boats, proper Wastewater Treatment Plant (WWTP) functioning, rainfall.
Restricted	Closed except for depuration	Evidence of marginal pollution.
Conditionally restricted	Depuration harvest allowed under certain conditions	Examples: presence of boats, proper WWTP functioning, rainfall.
Prohibited	No harvest allowed	Evidence of gross pollution; Lack of survey or sufficient water quality data; presence of OBD, outhouse, or straight pipe.

The Maine Department of Environmental Protection (MDEP) is charged with ensuring water quality standards are met, primarily through the regulation of waste discharge. In addition, MDEP regulates the design standards for all subsurface septic disposal systems, which are enforced by the municipal code enforcement officer. MDEP also licenses and inspects septic systems called overboard discharge systems (OBDs).

Soft-shell clam management is shared between the State and municipalities. Public trust doctrine, which originated in Massachusetts during the colonial period, allows the public to access to the intertidal zone for shellfish harvest. Maine DMR regulates harvesting as a trustee for the resource. To that end, DMR reviews municipal shellfish management, including review of the shellfish management ordinances, and provides assistance with management programs and enforcement. Municipalities manage the intertidal shellfish resources within their boundaries through authority conferred by their respective Town Shellfish ordinances. These ordinances must be approved by the DMR before enactment and are administered through local shellfish committees or commissions. Individual town ordinances are developed based on a Model Ordinance developed by the DMR and specifically describe how management will be carried out in the town. The ordinances attempt to strike the balance between ensuring revenue for all licensed diggers (and for the Town from license fees) and sustaining the resource by controlling harvest. This issue is complicated by the difficulty in defining what is sustainable as a harvest. Clam stocks are highly variable. The best predictions are made only after labor-intensive surveys, which are difficult for towns to undertake, given the limited financial resources and limited number of conservation hours supplied by the diggers. These issues will be explored more fully in Section 4.0.

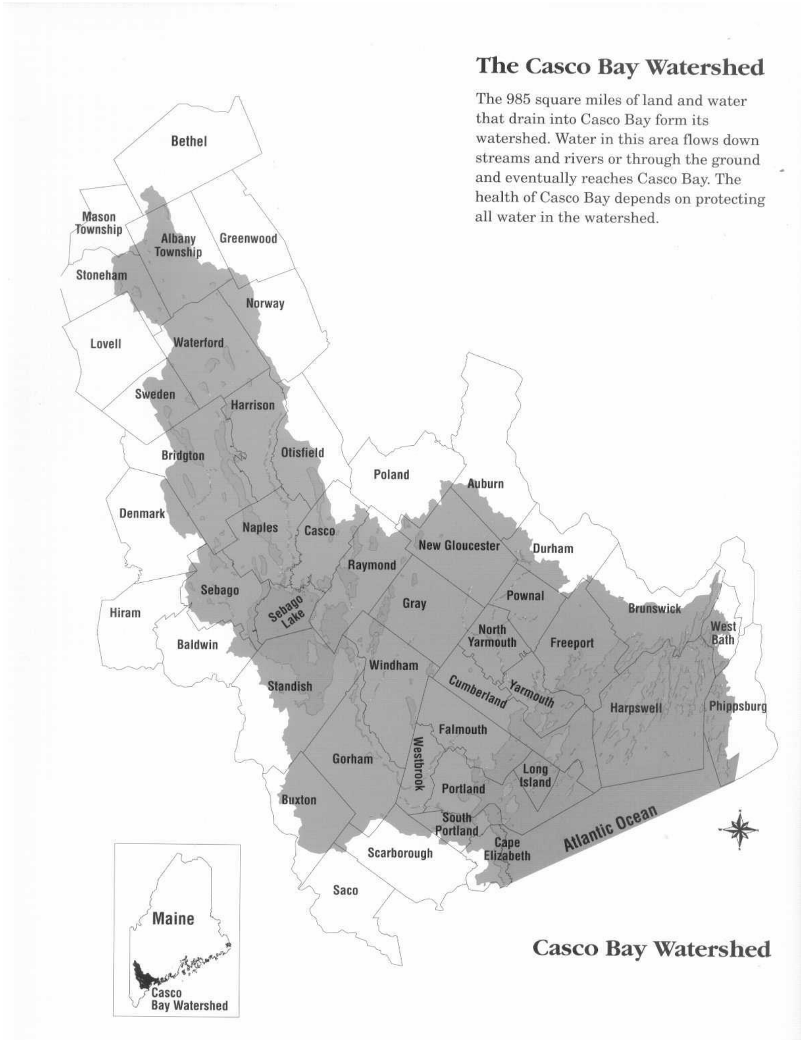
1.2 CLAM HARVESTING IN CASCO BAY

Casco Bay includes 14 coastal municipalities (Figure 1.2-1); of these, eight towns (West Bath, Phippsburg, Brunswick Cumberland, Falmouth, Freeport, Harpswell, North Yarmouth) have shellfish ordinances (Maine/New Hampshire Sea Grant Program/DMR 1995). The City of Portland drafted a Shellfish Ordinance in 1992 in anticipation of DMR reclassification of some of the areas on the City's islands. The Fore River in Portland and South Portland also contains moderate soft-shell clam resources; however, elevated sediment contaminant levels in some area have raised concerns about health risks from consumption. In addition, island residents are concerned about harvesting activities. Therefore, efforts to reclassify any areas in Portland and South Portland have been postponed indefinitely. Cape Elizabeth has little resource and no ordinance. All of Portland, South Portland and Cape Elizabeth remain closed to harvesting. Therefore, this project focused on communities north of Portland.

1.3 REPORT OVERVIEW

This report reviews the remediation efforts undertaken between CBEP, the municipalities, and state agencies (DMR and DEP) to date, and updates the classification status of high-priority clam flats as of 2003 (Section 2.0). A detailed description of the prioritization of clam flats for remediation under this project is provided in the Phase I report (*Expanding and Sustaining the Shellfisheries of Casco Bay: Phase I: Ranking Clam Flats for Potential Remediation.* (NAI and MER 1999, available at www.cascobay.usm.edu or 207-780-4306). Non-point sources of fecal coliform were investigated at several high-priority clam flats to better understand other factors affecting water quality overlying shellfish harvest areas (Section 3.0). Management strategies utilized in Casco Bay and elsewhere are reviewed in Section 4.0; two techniques (Seeding and Assessment Methodologies) were explored through experiments. Lessons learned and recommendations for future projects are discussed in Section 5.0.

Figure 1.2-1. Casco Bay Watershed



2.0 OBD REMOVAL PROGRAM

2.1 INTRODUCTION

In Phase I of the project, the Casco Bay Estuary Project (CBEP) with the Maine Department of Marine Resources (DMR) and towns surrounding Casco Bay completed an inventory of shellfish resources and identified sources of pollution keeping these areas closed to harvesting (Normandeau Associates Inc. and MER Assessment Corp. 1999). From this list, the CBEP worked with the various stakeholders including the "Clam Team," Maine Department of Environmental Protection (DEP) State Overboard Discharge Program Administrator, and the associated municipalities to develop a "priority list" of areas with good potential for remediation and ultimately, to open for shellfish harvest. These areas are shown in Figure 2.1-1 and listed in Table 2.1-1.

Four areas were targeted for Phase II, the implementation phase. These included Gurnet/Buttermilk Cove in Brunswick/Harpswell, and Fosters Point, Birch Point, and Sabino in West Bath. In addition, several sites on the New Meadows River in West Bath were added to the list at the request of the West Bath shellfish committee (Figure 2.1-1). These areas contained a total of 33 lots with 31 Overboard Discharge (OBD) systems (8 in Brunswick, 2 in Harpswell, and 21 in West Bath).

In Maine, the discharge of untreated wastes was prohibited in 1973 and lots with unsuitable soils for subsurface disposal received overboard discharge licenses or installed a holding tank. The Overboard Discharge Law (38 M.R.S.A § 411-A) was established in 1987 and amended in 1989. The objective of the law was to phase out existing non-municipal, overboard discharge systems and replace them with subsurface wastewater disposal systems. The major provisions of the law are:

- Prohibition of any and all new non-municipal overboard discharges after June 1, 1987;
- Inspection of all existing overboard discharge systems by DEP.
- Prohibition of increases in the volume of residential overboard discharges and certain commercial and industrial overboard discharges;
- Establishment of an Overboard Discharge Fund, which helps offset the cost of replacing a system; and
- Establishment of conditional permits, which allow overboard discharge systems to continue to operate until funds for an alternative and/or new technology, become available (MDEP and MDECD 1993).

The Overboard Discharge Grant Program (Chapter 594) offered OBD replacement funds at the following levels:

- 90% for year-round residents;
- 50% for commercial establishments; and
- 25% for seasonal residents.

In September 1999, the OBD law was revised to increase the grant to 50% for a seasonal resident if the Commissioner of DMR certified that the project would result in opening of a shellfish resource.

Figure 2.1-1. High Priority Clam Flats with Good Potential for Remediation

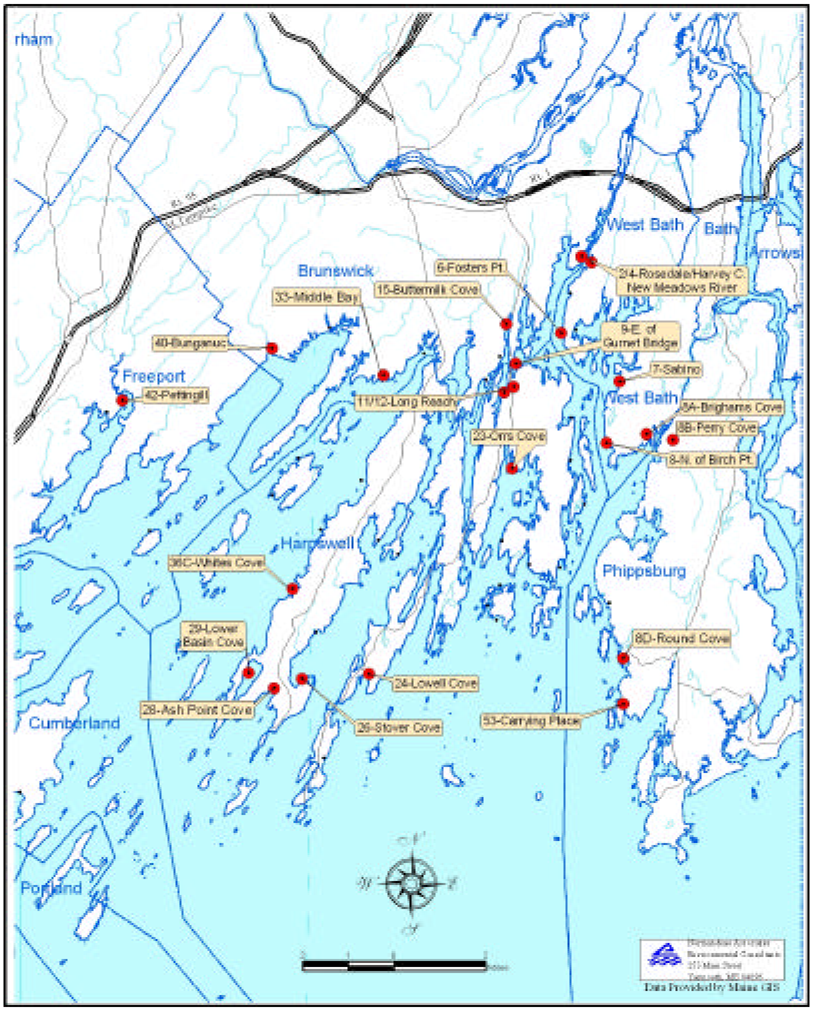


Table 2.1-1. Clam Flats Selected for Remediation in Phase II

Clam Flat	Town	Shellfish Quality*	Habitat Acres	No. of OBDs	OBD Number
Fosters Point to Williams Island	West Bath	L	30	3	2383, 6255, 2289
Sabino	West Bath	L	17.5	10	4017, 1164, 1662, 2185 2336, 3078, 3303, 3335, 8006,4190
N. of Birch Pt	West Bath	L	15	4	1563, 3762, 6440, 5334
New Meadows R	**West Bath**	**L**	**10**	**4**	**4657, 6064, 1678, 2572**
Brighams Cove (now open)	West Bath	M	2.5	1	4875
Perry Cove	West Bath/ Phippsburg	M	15	1	5100
E. of Gurnet Bridge	Harpswell	H	12	4	2391, 6733-H 3173-B, 2196-B
Buttermilk Cove	Brunswick	H	25	6	2803, 2303, 2965, 6721,5248,5249
Orrs Cove	Harpswell	H	10	2	3134, 2476
Lowell Cove	Harpswell	M	5	2	7021
Stover Cove	Harpswell	H	4.5		
Lower Basin Cove	Harpswell	H	5	3	1022, 2340, 2339, 2939
Rosedale/ Harvey C.** .	West Bath/ Brunswick	L	5	6	1133, 1246, 1562, 1631, 1940, 6773

* L= Low, M= Moderate, H= High value; Bold = Part of CBEP program.(See Table 2.6-1 for current (May 2003) status of the flats)

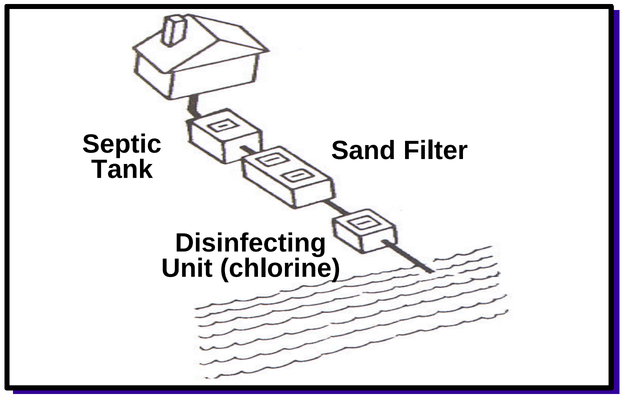
** Area evaluated at request of New Meadows Watershed Committee

In September 2003, the OBD grant program will be changing its funding formula to an income-based system with the following cost-shares:

- 100% for income < $25,000,
- 90% for income between $25,000 and $50,000,
- 50% for income between $50,001 and $75,000,
- 35% for income between $75,001 and $100,000,
- 25% for income greater than $100,000, and
- 50% for a publicly owned system.

An overboard discharge (OBD) system differs from a conventional subsurface wastewater disposal system in that there is no leach field for effluent disposal (Figure 2.1-2). OBD systems instead use a septic tank for primary treatment, as in a conventional system, then a sand filter or commercial mechanical treatment plant for secondary treatment. Prior to discharge into a body of water, the effluent is disinfected in a chlorination unit. OBDs were constructed in areas where soil depth (whether over the seasonal water table, a restrictive soil layer, or bedrock) was insufficient to adequately treat septic waste. Current technologies have made advances in wastewater treatment through pre-treatment and enhanced bed systems, reducing leach field size.

Figure 2.1-2. Typical Overboard Discharge System



Normandeau provided a managerial role, with Albert Frick Associates (AFA) providing design services for the 31 replacement systems according to the Maine Subsurface Waste Water Disposal Rules (144A CMR 241). The project utilized the DEP "Overboard Discharge Grant Program Administrative Handbook" (Handbook; DEP 1998), which provides an overview of the process and forms to be used by a program. The following is an overview of the process taken to implement the program, which is summarized in Figure 2.1-3.

2.2 PROJECT INITIATION

The project was initiated in the spring of 1999 when DEP notified landowners about the Grant Program and their eligibility for grant funds. Normandeau sent a follow-up letter that included an Agreement form for participation in the grant program (Figure 2.2-1) and an information pamphlet. Landowners joined the program by signing the agreement and submitting a $300 deposit. Normandeau organized two informational meetings for participants, one in Brunswick and one in West Bath. A voluntary survey was handed out to landowners, with questions on their system's age, condition, and frequency of service. Landowners were informed that the Casco Bay Estuary Project, through Normandeau, would be assisting the municipalities with the project and conducting a reconnaissance-level survey to assess potential constraints to a subsurface system. By the end of 1999 all but one of the landowners (who chose to work independently of the program) signed up for the grant program.

Normandeau worked closely with West Bath, which had never run an OBD grant program. The Towns of Brunswick and Harpswell had previously been involved with the program and had staff that

Figure 2.1-3. Overview

Maine Department of Environmental Protection (DEP) sends notice letter to property owners, license is expiring. ***Normandeau (NAI) holds informational meeting***

Town signs and returns Grant Offer Forms and updated list of owners to DEP. ***NAI assists with sign-up***

NAI makes landowner contacts; with Al Frick Assoc. (AFA), does preliminary property review.

Property owner (*through NAI*) sends Town executed agreement

AFA develops conceptual designs for replacement systems for landowner approval.

Town Code Enforcement Officer (CEO) sends designs to DEP, and Department of Health and Human Services (DHS) if needed, for review. ***NAI facilitates***

DEP/Department of Health and Humah Services (DHS) issue design approval.

Town develops bid package, advertises for contractor to install

Town forwards Payment Request Form to DEP

Invoice sent to Property owner for his/her share design and construction costs.

DEP reimburses Town for completed design, advertisement, plumbing permit, and construction (awarded, not completed)

Contractor constructs system.

Town Code Enforcement Officer or Licensed Plumbing Inspector inspects construction and completes the septic system inspection checklist.

Completed septic system checklist forwarded to DEP along with final payment request form, with outstanding invoices, change orders, etc. as backup.

NAI and AFA meet with landowners to resolve construction and operational issues.

Figure 2.2-1. Standard Agreement Form for MDEP Overboard Discharge Program

AGREEMENT
TOWN ADMINISTERED PROJECT
OVERBOARD DISCHARGE GRANT PROGRAM

I am aware the State of Maine Department of Environmental Protection has a program for replacement projects to eliminate overboard discharges, and I would like to participate in this program.

I CERTIFY THAT THE PROPERTY I OWN IN THE TOWN OF ____________________ IS A:

☐ YEAR-ROUND HOME (state funded up to 90%). This means that my licensed overboard discharge is from a human habitation which is continuously occupied for more than 6 months by the owner in any calendar year and is the legal residence of the owner for federal and state income tax purposes.

☐ COMMERCIAL BUILDING (state funded up to 50%). This means that my licensed overboard discharge is from a building used primarily for the purpose of trade or commerce, a non-profit organization endeavor, a municipal or quasi-municipal government purpose, or for renting for periods greater than 6 months in any calendar year.

☐ SEASONAL HOME (state funded up to 25%). This means that my licensed overboard discharge is from a human habitation that is not defined under "Year-Round Home" or "Commercial Building".

I understand that the Town will administer this project and I will be responsible for paying the remaining share, not covered by the DEP grant, of the cost of advertising, design, construction, and inspection of the system chosen by the Town's engineer or site evaluator.

Before any design begins, I will pay a $ 300 deposit to the Town. After the project is designed, I will review the plans in order to understand the scope of the project.. After the project is bid, my share will be calculated and I will pay any additional amount to the Town at this time to cover my share of advertising, design, and construction. Credit will be given for the $ 300 previously paid. After construction is complete, my exact share will be determined, and paid to the Contractor and site evaluator by the Town. If my share of advertising, design, construction, and inspection is more than the above amount then I will pay the additional amount, if it is less then my remaining money will be returned to me.

I grant the right to enter my property to construct and install a wastewater treatment project and to do such things on the property as are necessary for any of the above purposes.

I understand that the Contractor will provide a one year warrantee period for defective equipment or workmanship. I also understand that there is no guarantee by the Department of Environmental Protection or the Town concerning the operation and performance of the System. I will be responsible for all maintenance necessary on my system including pumping the septic tank every 3 years.

Considering all the above, I hereby agree to the conditions set forth, and authorize the town to proceed, as soon as possible, with the arrangements for having my property studied and installation of a proper sewerage system completed.

Signed: ________________________________ Date: _____________

Printed Name: _______________________________

were familiar with the process. Each town was responsible for tracking participant's payments, putting the systems out-to-bid, and signing contracts with the selected contractor. The Town's Code Enforcement Officer (CEO) reviewed and signed off on system designs and either sent them to the Division of Health Engineering, if a variance was required, or to the individual in the town responsible for coordinating the bid process.

2.3 SYSTEM DESIGN

Normandeau and AFA conducted two preliminary on-site surveys to assess the likelihood of on-site solutions for the 31 sites. Based on the results of these surveys, Normandeau coordinated site visits in which AFA completed evaluations for each property. Soils were evaluated by excavating test pits to a depth of 48 inches or a restrictive layer to determine if depth and consistency were suitable for a subsurface system. Information on the lot was collected, including building configuration, lot boundaries, distance to abutter's wells, location of the existing OBD and distance to waterbodies. In the majority of cases the landowner was present during the site evaluation, which provided an opportunity for them to ask questions and provide input in the location of the systems. In three cases, off-site solutions were explored: one for a cluster system in Gurnet Strait in Brunswick, one site for the northern section of Sabino in West Bath, and an off-site solution is still being explored for a site on Fosters Point in West Bath. The site evaluations culminated in a draft design for the site (Figure 2.3-1 and 2.3-2), including site constraints, lot layout, soil description and system configuration.

A summary of site constraints based on the Maine Subsurface Waste Water Disposal Rules is provided in Table 2-3-1. A majority of the sites required State variances because of an inability to meet setbacks. Over half the variances were due to proximity to a well, either the owner's or abutter's, or watercourse, generally the ocean. The next- most frequent variances were for distance from basements, property lines and soil condition (depth to water table, restrictive layer, and bedrock). Division of Health Engineering staff and AFA reviewed all the sites requiring variances prior to development of the design.

Table 2.3-1. Summary of Overboard Discharge Site Constraints Based on the Maine Subsurface Waste Disposal Rules

Town	Location	Systems	Well[1]	Watercourse	Slope	Property line	Basement	Soil	Drainage Ditch	Lot Size	Pending
Brunswick	Gurnet	8	5/2	6	2	1	1	4			
Harpswell	Gurnet	2	2	2		1	2	1			1
West Bath											
	Fosters Point	3	2/1	3		1	1			1	3
	Sabino	10	6/6	6	1	4	4	1	1	1	1
	Birch Point and Merry Cove	4	3/3	1		1	2	1			
	New Meadows River	4	1/0	2			1	3			
Total		31	19/14	20	3	8	11	10	1	2	5

[1] Well includes landowners and/or abutters.

Each design went through a thorough review process, first by the homeowner, then by the municipality's Code Enforcement Officer (CEO), and (if a variance was required) by the State. In addition, DEP's project engineer reviewed the design and provided comments to AFA. At least half of the designs required revisions by AFA based on comments from the landowner and another 1/3 required additional site visits due to complex siting issues. On-site solutions were found for all but one of the systems constructed. One site in Sabino required the use of an adjacent parcel, also owned

Figure 2.3-1. Conceptual Plan

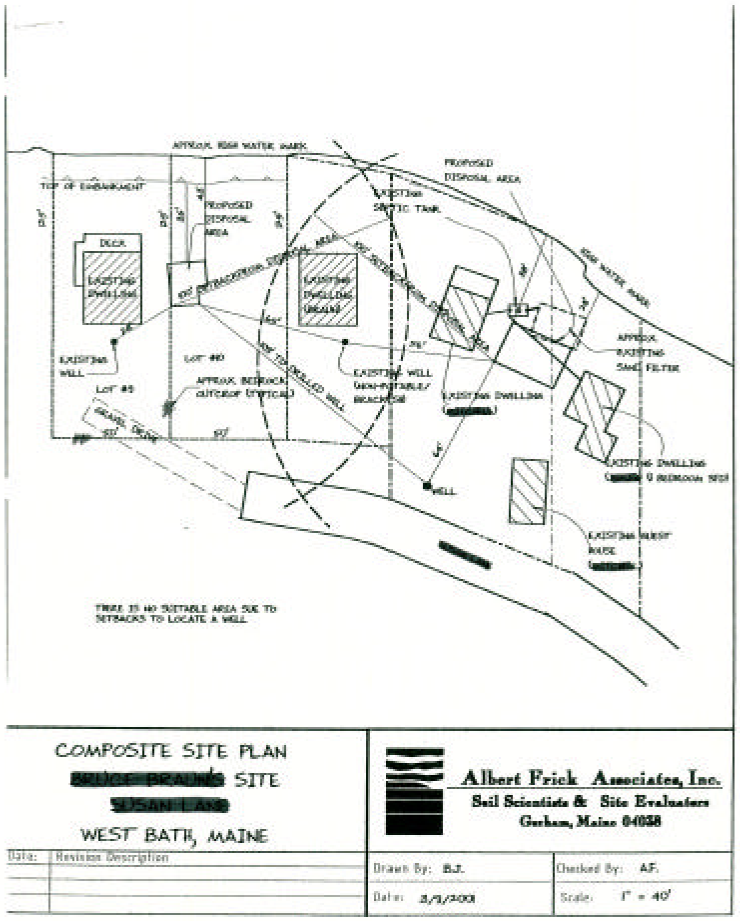
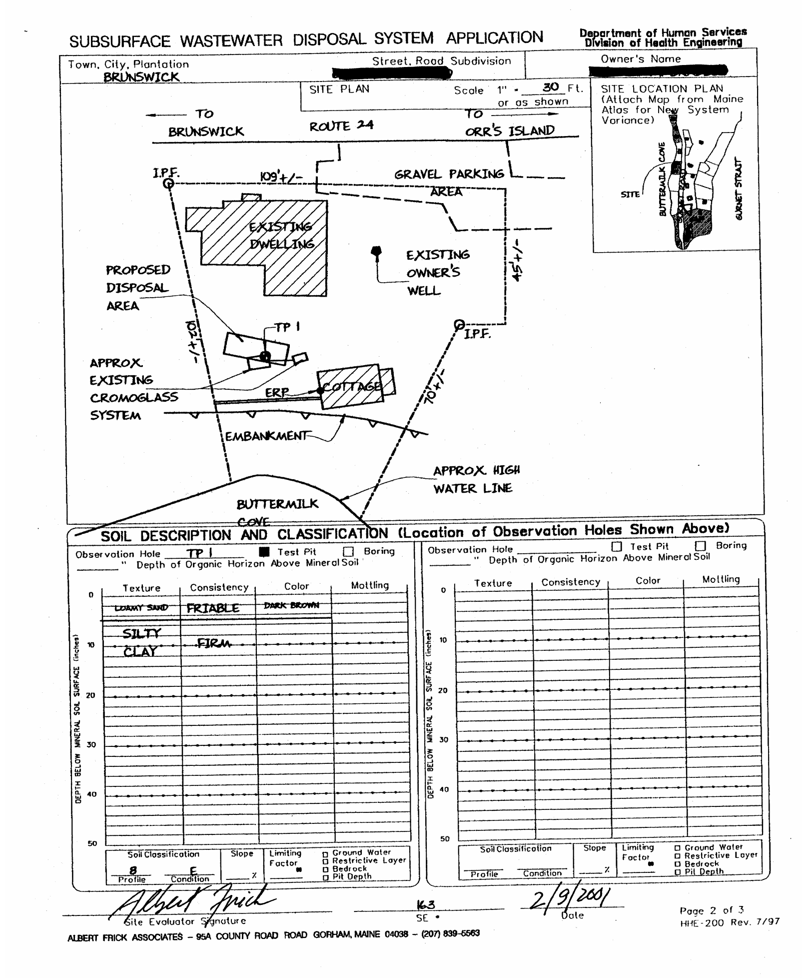


Figure 2.3-2. Typical Subsurface Wastewater Disposal Application



SUBSURFACE WASTEWATER DISPOSAL SYSTEM APPLICATION

Department of Human Services
Division of Health Engineering

Town, City, Plantation: BRUNSWICK
Street, Road Subdivision: [redacted]
Owner's Name: [redacted]

SITE PLAN Scale 1" = 30 Ft. or as shown

SITE LOCATION PLAN (Attach Map from Maine Atlas for New System Variance)

SOIL DESCRIPTION AND CLASSIFICATION (Location of Observation Holes Shown Above)

Observation Hole TP 1 ■ Test Pit ☐ Boring
____" Depth of Organic Horizon Above Mineral Soil

Depth below mineral soil surface (inches)	Texture	Consistency	Color	Mottling
0	LOAMY SAND	FRIABLE	DARK BROWN	
10	SILTY CLAY	FIRM		
20				
30				
40				
50				

Soil Classification		Slope	Limiting Factor	
8 (Profile)	E (Condition)	___ %	___	☐ Ground Water ☐ Restrictive Layer ☐ Bedrock ☐ Pit Depth

Observation Hole ____ ☐ Test Pit ☐ Boring
____" Depth of Organic Horizon Above Mineral Soil

Depth below mineral soil surface (inches)	Texture	Consistency	Color	Mottling
0				
10				
20				
30				
40				
50				

Soil Classification		Slope	Limiting Factor	
___ (Profile)	___ (Condition)	___ %	___	☐ Ground Water ☐ Restrictive Layer ☐ Bedrock ☐ Pit Depth

Albert Frick — Site Evaluator Signature
163 — SE #
2/9/2001 — Date

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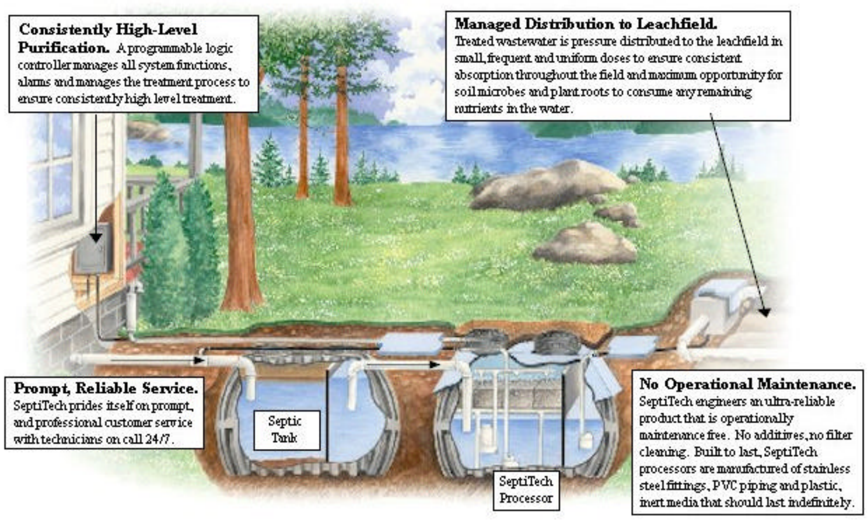
ALBERT FRICK ASSOCIATES – 95A COUNTY ROAD ROAD GORHAM, MAINE 04038 – (207) 839-5563 by the landowner. The West Bath Elementary School required the use of an engineer because of the volume of water generated.

Alternative technologies played an important part in system design. New technologies reduce the size necessary for the disposal field, allowing systems in small lots (Figures 2.3-3 and 2.3-4). As a result, total leach field area was reduced in twenty-six systems of the 31 systems. Only two systems, both in Sabino, required holding tanks, the least preferable option. Six systems were designed with pre-treatment, which generally entailed an aerobic primary treatment. Two systems used concrete chambers, which require additional room for installation, as one site required the septic tank area to also serve as a parking area. The second had adequate area for the tank and leach field.

Figure 2.3-3. Example of a Pre-treatment System



Source: http://www.septitech.com/, August 2003

2.4 BID PROCESS AND CONSTRUCTION

Two municipalities, Harpswell and Brunswick, were already familiar with the bid process and required little assistance while Normandeau assisted the Town of West Bath in establishing the initial system. The bid proposal and contract template from the DEP Handbook DEP Handbook was modified by each town. Bid proposals were advertised in local newspapers and the contractors submitted bids to the municipalities (Figures 2.4-1 and 2.4-2). The towns selected the winning bid (generally the lowest cost qualified bid), which was then reviewed and approved by the DEP. A contract was then executed between the town and contractor based on a form provided in the Handbook (Figure 2.4-3). The town collected payments and submitted reimbursement requests to the

Figure 2.4-1. Legal Notice

INVITATION TO BID

The Town of West Bath is receiving bids from contractors to furnish materials for and install a septic system at the West Bath Elementary School. A portion of the work will be funded by the DEP Overboard Discharge Grant Program and the work will be subject to special requirements of the DEP. Bidding documents may be obtained at the West Bath town office from 8:30- 2 PM Monday through Wednesday and Friday. Inspection of the sites prior to bidding is recommended.

Sealed bids marked "Town of West Bath Septic System Bids" must be received at the town office by 2:00 PM on July 10th. The Board of Selectmen will open bids on July 10th at 7 PM. Bids will be awarded on July 17th at 7 PM. All work on the system must be completed by September 1, 2000.

The Town reserves the right to accept or reject any or all bids. For more information please call 443-4342.

DEP Grant Program (Figure 2.4-4). System costs ranged from $5,500 to $17,600, excluding the engineered system and a system under a parking lot.

Eighteen systems were installed in 2000, five in 2001 and four in 2002, with five systems still pending (including the landowner who did not join the program) (Table 2.4-1). The more complex systems took the longest to arrive at a design that met the landowners needs, site constraints and state regulations.

An additional issue occurred in Brunswick, when no bids were submitted for the construction of 2 systems. The Town, assisted by the Project, contacted firms and encouraged them to bid. After a delay of approximately 6 months, three qualified bidders bid on the projects.

Table 2.4-1. Systems Completed by Year and Town

Town	Total No. of Systems	Year Completed			
		2000	2001	2002	Pending
Brunswick	8	6		3	
Harpswell	2		1		1
West Bath	21	12	4	1	4
Total	31	18	5	4	5

Construction issues caused unexpected repercussions on the Municipalities and the Project. The Town CEO was responsible for reviewing system construction as a part of the state licensing process. AFA provided technical assistance when requested. However, Town staff spend a substantial – and unanticipated – amount of time dealing with construction issues. While the Project and Maine DEP also were involved assisting with these issues, the Town- who had contracted with the contractor and also had to sign off on completion- bore the brunt of resolution of these issues. Construction problems encountered included the following: heavy rains preventing seed establishment, leading to soil

Figure 2.4-2. Bid Proposal Form

BID PROPOSAL FORM
OVERBOARD DISCHARGE PROGRAM

THIS BID IS SUBMITTED TO: ________________________________ (TOWN) OR (OWNER)

________________________________ (ADDRESS)

THE UNDERSIGNED BIDDER PROPOSES AND AGREES AS FOLLOWS:

1. It is the responsibility of the prospective bidder to inspect the construction site and examine the plans & specifications to ensure that he fully understands the construction requirements. The bid prices must be for a complete and finished project as indicated in the bid documents, including any piping, fittings, valves, fill, grading, insulation, site restoration, or other work not directly shown but which can be reasonably inferred by an examination of the site and construction documents to produce a finished product.

2. The Contractor shall maintain in force for the duration of the project Public Liability and Property Damage insurance that shall protect the Contractor from claims and damages arising from operation under this Contract. The minimum amount of coverage shall be as is customary for the work to be performed and shall provide complete indemnification of the Owner for the Contractor's work.

3. It is the responsibility of the Contractor to comply with all laws, regulations, and permit conditions in constructing the project, including safety regulations.

4. The Town will be the sole judge of the acceptability of the bids, and may reject any and all bids if it is judged to be in the Town's best interest. The BASIS OF AWARD for the contracts will be the lowest acceptable bid proposal based on the LUMP SUM PRICE for each individual system. Pump stations indicated on the plans ("REQUIRED" is checked) must be included in the LUMP SUM PRICE. If the need for a pump station is not clear on the plans, ("MAY BE REQUIRED" is checked), the LUMP SUM PRICE shall include a price for the complete system without a pump station. Also for this situation, a price for the pump station must be shown separately in case it is found to be needed.

THE BIDDER WILL COMPLETE THE WORK FOR THE FOLLOWING PRICE(S):

NAME OF SYSTEM	LUMP SUM PRICE (BASIS of AWARD) (includes price for pump station if **"REQUIRED"** is indicated on the plans)	ADDITIONAL PUMP STATION COST (extra cost of pump station if **"M REQUIRED"** is indicated on th
____________________	____________________ $______________DOLLARS	
____________________	____________________ $______________DOLLARS	
____________________	____________________ $ DOLLARS	

Figure 2.4-3. Contract Agreement

CONTRACT AGREEMENT

THIS AGREEMENT made the _________________ day of ________ 19 by and between the Town of____ hereinafter called the Owner and _________ ____ hereinafter called the Contractor.

WITNESS,
That the Owner and the Contractor for the consideration hereinafter named agree as follows:

ARTICLE 1. SCOPE OF WORK
The Contractor shall furnish all of the Materials and perform all the Work shown on the Plans and described in the Specifications entitled:____
Prepared by____, referred to in these Contract Documents as the Engineer, and shall do everything required by this Agreement, the General Conditions, the Specifications, and the Drawings.

ARTICLE 2. TIME OF COMPLETION
The work shall be completed according to the following schedule:

Substantial Completion:____

Final Completion:____

ARTICLE 3. THE CONTRACT SUM
The Owner shall pay the Contractor for the performance of the Contract, subject to additions and deductions provided by approved Change Orders in current funds as follows:

____$_____________________
(In Words) (In Figures)

ARTICLE 4. PAYMENTS
The Owner shall make payment of 90% of the contract amount after the project is substantially completed. That is, all structures installed and operating and all disturbed areas loamed and seeded.

Final payment shall be due after final completion. That is, the Work is completed and operational in accordance with the Contract Documents including a catch of grass.

ARTICLE 5. THE CONTRACT DOCUMENTS
The General Conditions of the Contract, Instructions to Bidders, the Bid Proposal, the Specifications, and the Drawings, together with this Agreement, form the Contract.

The Owner and the Contractor hereby agree to the full performance of the convenants herein.

IN WITNESS WHEREOF the parties hereto have executed this Agreement in the day and year first above written.

BY:____WITNESS:_________________________
Owner

BY:___________WITNESS:_____

Figure 2.4-4. Payment Request Form

MAINE DEPARTMENT OF ENVIRONMENTAL PROTECTION
OVERBOARD DISCHARGE GRANT PROGRAM
PAYMENT REQUEST FORM

PROJECT NUMBER	TOWN	PAYMENT NUMBER	DATE
OBD -			

GRANTEE NAME AND ADDRESS	TYPED OR PRINTED NAME OF CERTIFYING OFFICIAL
	SIGNATURE

NAME OF PROPERTY OWNER	ADMIN. (A)	DESIGN (B)	CONSTRUCT. (C)	INSPECT. (D)	OTHER (E)	SUBTOTAL (SUM A TO E) (F)	% (G)	GRANT AMOUNT (F x G)
	$	$	$	$	$	$		$
			TOTAL PAYMENT REQUESTED:					$

INSTRUCTIONS:

1. Each row includes all the costs associated with each individual system.
2. Columns A-E are the total eligible costs as shown on the invoice.
3. Column A contains eligible administrative costs. These costs may be distributed to each individual system. A calculation sheet should be included showing how the distribution was figured.
4. Column B contains design cost documented by site evaluators or engineers invoice.
5. Column C contains construction costs based on the executed contract.
6. Column D is inspection costs which DEP has previously agreed to pay. Only inspection in excess of the Maine Subsurface Disposal Rules are grant eligible. Inspections paid for must be documented by photos And a completed inspection form.
7. Column E is for approved change orders and other applicable costs
8. Column F is the sum of A to E.
9. Column G is the grant percentage factor: 90%........0.9 50%.........0.5 25%........0.25
10. Grant amount is the product of F x G.
11. Total payment requested is the sum of the grant amount column.

erosion; a septic tank cracked after installation (due probably to equipment traffic), and inadequate fill during construction. One system had major problems the year after construction was completed.

Additional issues that arose during the project included the following examples:

- Road damage cause by construction equipment.
- Inability to secure waivers from abutters

Residents of Birch Point Road complained that equipment traffic during installation at six sites cause road damage. This issue was resolved by the Town, who authorized minor repairs. Abutting landowners were not always sympathetic to the requests for waivers. One landowner abutting two project properties would not sign-off on a well waiver. The DEP agreed to pay the grant portion of the cost to relocate and drill a new well for the abutter. Thus, these issues were ultimately resolved but required additional funding.

With twenty-one systems in town and over half of them being installed in 2000 (Table 2.4-1), the Town of West Bath staff spent a lot of time resolving issues related to the program that reflected the number and complexity of the systems. Issues included landowner complaints, non-payments, lack of bids and management of the books for grant payments. Several property owners initiated or threatened court cases to resolve disputes over OBD installation, opening the Town to unanticipated liability. As stated in a letter from the Town Administrator, “The Selectmen are concerned about the liability of the Town in this process. We currently have two pending court cases against property owners, and two cases against the Town threatened by participants that are not satisfied with the program (D. Williams, West Bath, personal communication, January 30, 2001).” Brunswick staff had fewer systems (9) to manage and more staff and consequently the program ran more smoothly. However, resignation of key staff delayed completing all of the systems until 2002. The project coordinated the completion of one system in Harpswell and initiated a second. The Town decided to assume management of the second system, which was delayed due to the reluctance of an abutter to sign a well release.

2.5 SUMMARY

The OBD removal project resulted in the elimination of 27 OBD systems, which would allow the opening of shellfish harvest areas in Birch Point, Merry Cove and a section of the New Meadows River in West Bath. Out of the ten sites in Sabino, one (the landowner who opted not to participate in the program) has not been completed. Ten sites were completed in Harpswell and Brunswick. Only one site remains in Harpswell (abutter will not sign well release), which contributes to closure of flats in the Gurnet/Buttermilk Cove area closed. In addition, two sites with three systems (two systems have been designed and one system requires either an off-site solution or a holding tank) are pending on Fosters Point in West Bath.

Since the inception of the project, six of the high priority flats have been reclassified, representing nearly 250 acres of shellfish resources now available to harvest (Table 2.6-2). Out of nearly 430 acres of high priority clam flats selected in this project, 311 are open in some capacity and another 74.5 are pending, awaiting removal of OBDs, shoreline surveys, and resolution of water quality issues. Many of these openings were due to collaboration with DMR staff who were already working in these areas. Once staff knew that these areas were a priority, they were able to focus their efforts on the most important areas. The project enhanced collaboration with other stakeholders such as DEP, municipalities, and harvesters, which has continued with groups such as the New Meadows Watershed Committee. While over 243 acres of flat have been opened during the course of this project, only 25 acres is the direct result of OBD removal. Nearly 120 acres remain closed due to remaining OBDs or poor water quality. The issues that remain are the most difficult to resolve and will require the continued efforts of DEP, DMR and the municipalities.

In addition to the direct benefits to clam flats from OBD removal, additional clam flats were opened to harvest as a result of increased communication between agencies and municipalities fostered by this project.

Overall, landowners were receptive to the program once they learned about it and understood the implications of continued discharge of effluent into the ocean. The monies available from the grant program helped provide the incentive for many to have the systems replaced. Working with landowners during the design process required sensitivity and finesse as many individuals resented the State telling them what to do and spend. AFA did an excellent job and should be applauded for the effort they expended in addressing landowner concerns. The majority of effort was spent on a less than a third of the sites where either the landowner was reluctant to proceed for either personal or financial reasons or site constraints required additional site design effort. The State was required to take enforcement action with one program participant and the individual who chose not to participate in the program.

In hindsight, the process probably should have been conducted at a slower pace in West Bath where twelve systems were constructed in one year. The number of systems targeted for removal in the town (21) and the complexity of the designs strained the Town staff, who had to handle landowner complaints, track expenses and follow-up on non-payment in addition to their regular responsibilities. The project greatly appreciated the effort the towns took in managing the grants.

2.6 STATUS UPDATE ON HIGH PRIORITY FLATS

At the end of Phase I of the project, we reviewed the status of the most highly ranked flats (Normandeau et al. 1999). Since that time, the project has undertaken an aggressive OBD removal program, discussed in the previous sections. However, collaborative efforts of the municipalities and DMR, including additional water quality sampling, shoreline surveys, and septic system investigations, have also resulted in changes in status. What follows is a discussion of each area (Table 2.6-1, Figure 2.1-1).

Foster’s Point (Station 6)

The area from Foster’s Point to Williams Island in West Bath contains approximately 30 acres of low value clam habitat. Although clam resources were ranked low, the Town Shellfish Committee indicated that this area was the highest priority for OBD removal because of the potential to collect seed clams for re-seeding in other areas. The Maine Department of Marine Resources (DMR) has reduced the size of the closure to less than five acres (includes both open water and potential clam habitat) as a result of improved water quality and completed shoreline surveys. The closure is restricted to the flats along the shoreline where three OBD’S continue to keep a small portion of the area closed to harvest. Replacement designs for two of the three systems have been completed and construction is on hold pending design of the third. Coupled with the high cost of construction for the first two systems, and the lack of an offsite solution for the third, these projects could be postponed

Table 2.6-1. Status of high priority clam flats

Town	Clam Flat Name	Status	Station No.	Habitat Acres**	Total by Status	Comment
WB*	**Fosters Point**	**Pending**	**6**	**5**		Closure reduced to area around 3 OBDs
WB	**N. of Birch Point**	**Pending**	**8**	**15**		Closed pending shoreline survey results
B	**Buttermilk Cove**	**Pending**	**15**	**25**		Nonpoint sources continue to be an issue
WB	**Sabino**	**Pending**	**7**	**17.5**		1 OBD remains
H	**E. of Gurnet Bridge**	**Pending**	**9**	**12**	**74.5**	Closed pending shoreline survey results; houseboat likely source of coliform.
WB	**Fosters Point**	**Open**	**6**	**25**		
WB	Merritt Island	Open	6A	12		
WB/P	Brighams Cove	Open	8A	2.5		
WB/P	Perry Cove	Open	8B	15		
H	Bethel Point	Open	22	7		
H	Stover Cove	Open	26	4.5		
H	Ash Point Cove	Open	28	40		
B	Middle Bay	Open	33	137.5	**243.5**	Closure area reduced based on improved water quality
H	Orrs Cove	Cond	23	10		Seasonal closure, due to marina and septic issues.
B	Maquoit Bay	Cond	41	57.5	**67.5**	Seasonal, based on rainfall.
P	Round Cove	Closed	8D	7.5		Pending DMR dye study results
WB	Op. Howards Point	Closed	5	5		
WB	E. of Harbor Island	Closed	8C	0		
H/B	E.of Long Reach, N. & S	Closed	11/12	19.5		Poor water quality likely due to houseboat
H	Lowell Cove	Closed	24	5		OBDs
H	Lower Basin Cove	Closed	29	5		OBDs
H	Tank farm, Whites Cove	Closed	36C			Potential contaminants
F	Pettingill	Closed	42	2	**44**	NPS/WWTP
Total				**429.5**		

* Areas in **bold** are part of OBD removal program.
** Acreage refers to habitat area not closure area.

Table 2.6-2. Summary of Status of High-Priority Clam Flats in Casco Bay

Status	Acreage
Pending	74.5
Open	243.5
Conditional	67.5
Closed	44.0
Total	**429.5**

indefinitely. Water quality P90 values for the most recent 30 coliform samples is 24.2 mpn, with occasional high spikes, similar to the 1998 values which ranged from 18.9 to 51.4 mpn.

Sabino (Station 7)

The Sabino area of West Bath contains 17.5 acres of low value clam habitat. The West Bath Shellfish Committee designated this area as their second highest priority for opening, despite the low-ranked shellfish habitat. Ten OBD'S contributed to the closure of this area, nine have been removed. A design for the remaining system has been developed, but has not been accepted by the license holder. This case has been moved to the Maine Department of Environmental Protection Enforcement (MDEP) group. The closure remains in this area pending the removal of the last OBD, and completion of a shoreline survey. Water quality at Stations L53 and L54 for the previous 30 coliform samples remains good at 13.0 and 9.9 mpn, and is slightly improved over the 1998 P90 values of 29–33 mpn.

Brighams Cove and Perry Cove (Stations 8A and 8B)

Brighams Cove and Perry Cove are two adjoining areas in the towns of Phippsburg and West Bath that include approximately 17.5 acres of clam habitat with moderate resource value. The Overboard Discharge Task Force (which pre-dates this project), composed of harvesters and municipal officers from West Bath and Phippsburg as well as other stakeholders including engineers, Bath Iron Works, DMR and MDEP, and, most recently, the New Meadows River Watershed Committee, worked together and successfully eliminated the seven OBDs that had kept the flats in this cove closed. However, the Town has had to fund a significant and unanticipated portion of the project, creating significant funding shortfalls in their budget. A shoreline survey was conducted and the area was opened to harvest in March of 2003. Water quality has remained good, with the P90 for the most recent 30 coliform samples being 16.6 mpn, somewhat higher than the 1998 P90, which was less than 7 mpn.

Round Cove (Station 8D)

Round Cove is an approximately 7.5-acre flat in Phippsburg with moderate resource value. Nonpoint and septic sources were believed to be the causes of poor water quality keeping this area closed. However, improved water quality (P90 of 32 mpn, compared with 68.1 mpn in 1998) and a recent shoreline survey allowed for conditional opening in March 2003. The area was closed again in April, pending results from a DMR dye study from the seasonally operated inn adjacent to the Cove.

Carrying Place (Station 53)

This closure in Phippsburg extends from the north end of Burnt Coat Island southward to Little Wood Island and east to Newbury Point. The closure encompasses approximately 7 acres of soft-shell clam habitat and is due to five OBDs and several old septic systems on West Point. The Town Shellfish Committee was anxious to open this area because of clam resources both on Carrying Place and the islands. A shoreline survey is scheduled for this summer (2003). There are three WQ stations in this closure area, with P90 coliform values ranging from 27.8 mpn to 112.9 mpn, and several peaks up to 1200, indicating a need for improved water quality.

Gurnet Bridge (Station 9)

This moderate-sized (12-acre) flat in Harpswell, has high clam resources. A number of OBDs in both Harpswell and Brunswick have been linked to this closure, all but one have been removed. Construction of the remaining system in Harpswell is pending a well waiver from the abutting property owner. (This system is being monitored by the Town of Harpswell and is no longer in the CBEP program.) The P90 for the previous thirty coliform samples was 20.6 mpn, with occasional spikes over 300, has improved from the 1998 value of 107.2. There is the possibility that two septic systems in this area are not working properly; DMR is scheduling a shoreline survey for 2003 to further investigate the causes of high fecal counts in this cove.

Long Reach (Stations 11/12)

The Long Reach area, nearly 20 acres of high-value clam habitat, bridges Harpswell and Brunswick. A Brunswick “live aboard” float with no septic system, legal under current zoning, currently keeps this area closed. Revision of zoning coupled with an alternative septic arrangement may help open this area. Although, on average, water quality is good (P90 is 5.0 mpn) and the most recent shoreline survey revealed no other direct pollution sources. The area potentially could be opened with the removal of the houseboat.

Buttermilk Cove (Station 15)

Buttermilk Cove is a 25-acre flat with highly ranked clam resources in Brunswick. A 1995 CBEP study (Heinig et al. 1995) determined that at that time the high level of harvestable clam resources and availability of grant money for remediation gave this area a high cost-benefit ratio for opening. Six OBD systems in the Cove were replaced between 2000 and 2002 along with three additional systems on the Gurnet Straight Point that were contributing to the closure in the Cove. Poor water quality, most likely from non-point sources, including wildlife, upstream of the Cove is being investigated. Current water quality P90 coliform value for station L21 (55.2 mpn) is higher compared to 1999 (28.1 mpn), indicating a need for further investigation of nonpoint sources of pollution (see Section 3.0). NPS sampling suggests that stream flow is not a major contributor to coliform levels; wildlife and the houseboat in Long Reach represent potential sources.

Orrs Cove (Station 23)

Orrs Cove is a 10-acre flat in Harpswell with high clam resources. Through the continued efforts of the Town to remove two OBDs from the Cove and improved water quality (P90 of 22.8 mpn, in 2003, compared to ranges from 74.2 to 114.9 mpn in 1998), this area was reclassified in 2003 to a seasonal conditionally approved status. The Cove is now open from December through April, however summer boat usage and summer use ofseptic systems in the area restrict the opening to the winter months. In addition to removing its OBD, Great Island Boat Yard has also installed a pump-out facility, both factors contributing to the improved water quality.

Ash Point Cove (Station 28)

Ash Point Cove is a 40-acre clam flat in Harpswell with highly ranked clam resources. There are no remaining OBDs in Ash Point Cove; however the presence of summer boats, possible nonpoint sources, and faulty septic systems had kept this cove closed to harvesting. Improved water quality and completed shoreline survey allowed a status upgrade to conditionally approved in 2000; NPS and boat usage continue to be issues during the summer months. Water quality has improved since 1998 when P90 ranged from 29.3 to 71.2 mpn to a current range of 12.9 to 25.4 mpn, depending on the station location in the Cove.

Lower Basin Cove (Station 29)

Lower Basin Cove is a five-acre clam flat in Harpswell with moderate clam resources. The Town of Harpswell was successful in removing two of the three OBDs that have kept the entire cove closed;

upper Basin Cove is now conditionally approved. Removal of the third system is in progress. Recent water quality P90 is higher (36.2 mpn) compared with the 1998 P90 (14 mpn), with occasional high spikes indicating other sources of fecal contamination.

Middle Bay. (Station 33)

Middle Bay is a large (137.5-acre) clam flat in Brunswick with moderate to high resources. There are no OBDs in the Bay. Wet and dry weather sampling was conducted to determine the non-point sources of contamination contributing to the high fecal counts. There are several horses, cows, and other livestock in the fields surrounding the Bay and these are likely sources contributing to the NPS pollution. Recent WQ P90 ranges from 13.5 to 51.3 mpn, much improved over the 1999 values of 24.7 mpn to 90 mpn. All but two sections of the Bay have been reclassified. NPS sampling (Section 3.0) suggest livestock and wildlife are likely contributors to fecal coliform levels.

Whites Cove, North of Tank Farm (Station 36C)

Three intertidal areas near the old Navy Tank Farm in Harpswell were investigated. Only one, Whites Cove, had high clam resources. However, this area is small (<5 acres). This area remains closed due to potential sediment contamination from the former Naval Fuel Storage Facility. The fuel storage tanks have been removed and most of the remediation on the land has been completed. Sediment chemistry testing for the intertidal soils would be necessary to determine the levels of contaminants and potential human health risk. Water quality P90 values for this area historically have been very good; recent P90 for Station J57.1 is 5.0 mpn. Completion of a shoreline survey, with no evidence of surface pollutant sources and clean sediment chemistry analyses, could allow this area to be open to harvest.

Pettingill Farm (Station 42)

Pettingill Farm in Freeport is a 2-acre clam flat with moderate resource value in the upper Harraseeket River. A conditionally approved status for the entire river, except for the immediate areas around the WWTP, can be attributed to three factors. These include: improved WQ in part a result of best management practices that have been instituted at the upstream farm, recent changes in the regulations regarding closures around waste-water treatment plants (WWTP) and the completion of a shoreline survey. Current water quality at the two stations in the upper river range from 15.0 mpn to 33.2 mpn with occasional high spikes, perhaps attributable to wildlife use in the area. The recent water quality shows an improvement over the P90 of 95.8 mpn in 1998.

3.0 NON-POINT SOURCE POLLUTION INVESTIGATION

3.1 INTRODUCTION

In view of the potential economic benefits that could be derived from opening closed areas to harvesting, the CBEP has pursued an effort to identify and remove actual and potential contamination sources, where possible and practical. These actual and potential sources vary widely from industrial toxic contamination, as in the Fore River, Portland, to domestic in-ground waste treatment, agricultural, and wildlife fecal coliform contamination, and indication of potential water-borne disease, in the rural areas surrounding the Bay.

Given the complexity of possible contamination sources affecting the closed area in the metropolitan area surrounding Portland in the southern part of Casco Bay and the magnitude of effort that would be required to identify and correct the non-point source problems in this area the CBEP decided to focus initially on the more rural northern portion of the bay where problems might be more manageable and where the majority of the currently landed clams are harvested.

Phase I of the CBEP Sustainable Shellfisheries Project identified potentially productive shellfish growing areas closed either as a result of precautionary closures due to the existence of licensed overboard discharges or unidentified non-point source contamination. Phase II of the project focused on the removal of overboard discharges (OBD), reported in Section 2.0 of this report, and the identification of non-point source contamination, reported here.

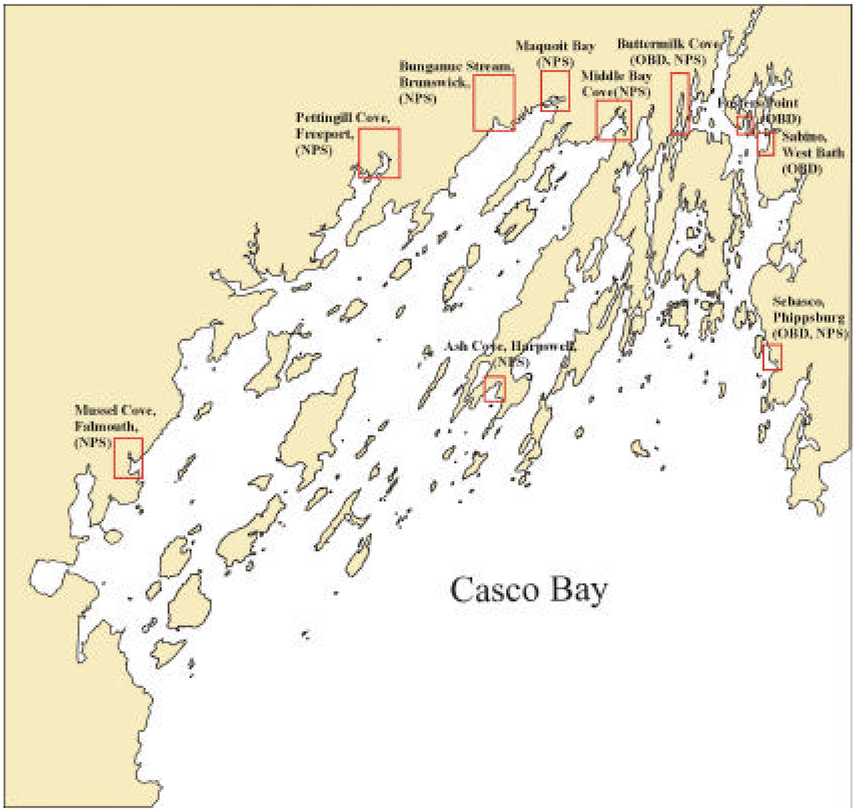
The purpose of the non-point source contamination study was twofold. First, in view of the significant cost associated with OBD removal, the study sought to determine if any non-point source of fecal coliform contamination might prevent lifting of the precautionary closure in each area. Second, the study sought to evaluate the fecal coliform contribution from various potential input sources and identify, where possible, the specific sources and make recommendations for correction.

3.2 STUDY SITES

Eight study sites were initially selected as a result of the Phase I analysis of closed areas: Sebasco/Round Cove in Phippsburg; Sabino and Fosters Point in West Bath; Buttermilk Cove, Middle Bay Cove, upper Maquoit Bay and Bunganuc Stream in Brunswick; and Pettingill Cove in Freeport (Figure 3.2-1). As the study progressed and certain initially selected areas were opened to harvesting, two additional areas were added, Ash Point Cove in Harpswell and Mussel Cove in Falmouth.

The Sabino, Fosters Point, and Buttermilk Cove sites were the focus of the OBD removal effort and non-point source contamination evaluation in these areas was carried out principally to verify that the OBD removal effort would likely result in the opening of these areas; Buttermilk Cove, however, was also considered to be affected by non-point source contamination. The Sebasco area receives discharge from an OBD, but as a commercial OBD associated with a resort, this discharge was not selected for removal under the program. Nevertheless, a non-point source evaluation was carried out to determine if any other sources might result in a closure of the area were the discharge to be removed.

Figure 3.2-1. Study site locations



Round Cove, Middle Bay Cove, upper Maquoit Bay, Bunganuc Stream, Pettingill Cove, Ash Point Cove and Mussel Cove are not affected by licensed OBDs and the studies in these areas focused on the evaluation of the magnitude of non-point source fecal coliform contamination contribution to the respective areas and the identification of specific sources, where possible.

The general locations of the study sites in relation to Casco Bay are shown in Figure 3.2-1, with each site identified with respect to evaluation type as verification for overboard discharge removal (OBD), non-point source (NPS), or both.

3.3 METHODS

3.3.1 Sampling Station Locations

Sampling stations within each study site were located at the point of entry of primary freshwater flows into the marine waters of the shellfish growing areas. Where primary flows were produced by the confluence of secondary tributaries, additional stations were located along the secondary tributaries just upstream from the confluence point with the primary flow. Where no concentrated freshwater flow into the growing area was found, sampling stations were located adjacent to potential contamination sources, such as storm water drainages, paddocks and farm animal enclosures, and areas of concentrated housing along the shoreline. When possible, samples were also collected at the adjacent DMR growing area monitoring stations; since sampling at these DMR stations was conducted under a strategy other than that of the normal DMR routine and often under adverse conditions, data collected at these stations under this project were not included for purposes of growing area classification. For ease of presentation, individual maps showing the location of sampling stations within each study site are included under each study area heading. A complete list of latitude and longitude coordinates for all sampling stations is included under Appendix B.

3.4 SAMPLING

Field data and water sample collection by MER Assessment Corporation (MER) and fecal coliform analyses performed by the Maine Department of Marine Resources (DMR) water quality laboratory in Boothbay Harbor, Maine, were carried out in accordance with a Quality Assurance Project Plan (QAPP) submitted on July 15, 1999, and approved by the Environmental Protection Agency on November 18, 1999. The QAPP provides a detailed description of the procedures and data quality measures associated with each aspect of the sampling and analysis processes and is included here as Appendix C.

Temperature and conductivity/salinity were recorded using a YSI Model 33 S-C-T. Water samples were collected in axenic Nasco WHIRL-PAK plastic bags to a volume of approximately 200 ml, leaving sufficient air space within the bag to allow full agitation prior to extraction of sample water for fecal coliform analysis; bags were sealed by whirling and bending of the sealing tabs. Following collection, samples were placed in a plastic cooler containing frozen refrigerant or ice and maintained at 4° C or less until delivery to the DMR laboratory.

Fecal coliform analyses were performed using the 3 tube/3 dilution Most Probable Number (MPN) method, also known or referred to as the A-1 Multiple Tube Test or simply the MA-1 Method. This method is the standard method used by DMR in its routine monitoring program for the classification of shellfish growing areas in accordance with the Food and Drug Administration’s (FDA) National

Shellfish Sanitation Program (NSSP). This method was selected for this study in order to allow comparison of previous and on-going water quality monitoring efforts.

3.5 DATA QUALITY

3.5.1. In-field Data Collection

Data quality for in-field measurements was assured through a routine calibration check of the YSI Model 33 S-C-T prior to each sampling series in accordance with the QAPP. The calibration log maintained during the project period is shown in Table 3.5-1.

Table 3.5-1. YSI Model 33 S-C-T Calibration Log

					Temperature (°C.)					Conductivity (_mhos/cm)					
Date	**Cond. Std. Date**	**Therm. SN**	**Cable Corr.**	**Time**	**NIST**	**Meter**	**? °C.**	**±% err.**	**A/Q/R***	**Meter**	**Corr'd**	**Calc.**	**?**	**±% err.**	**A/Q/R***
11/5/1999	7/6/1999	A08538	0.30%	1030	22.5	22	0.5	2.2	A	9300	9272	9531	259	2.7	A
5/21/2000	5/21/2000	3F5410	0.30%	1651	23.2	23	0.2	0.9	A						
5/21/2000	5/21/2000	3F5410	0.30%	1704	21.9	21.7	0.2	0.9	A	9100	9073	9419	346	3.7	A
5/22/2000	5/21/2000	3F5410	0.30%	1757	22.5	22.2	0.3	1.3	A	9500	9472	9531	59	0.6	A
6/26/2000	5/21/2000	3F5410	0.30%	2122	25.1	24.8	0.3	1.2	A	9700	9671	10019	348	3.5	A
6/30/2000	5/21/2000	3F5410	0.30%	1211	24.6	24.6	0	0	A	9400	9372	9925	553	5.6	Q
6/30/2000	6/30/2000	3F5410	0.30%	1225	23.5	23.5	0	0	A	9100	9073	9718	645	11.1	Q
7/25/2000	7/25/2000	3F5410	0.30%	1805	24.6	24.2	0.4	1.6	A	9600	9571	9925	354	3.6	A
9/10/2000	7/25/2000	3F5410	0.30%	1600	23.6	23.5	0.1	0.04	A	9300	9272	9737	465	4.8	A
6/1/2001	6/1/2001	471047	0.30%	1438	22.8	22.7	0.1	0.44	A	8950	8977	9587	610	6.36	Q
6/12/2001	6/12/2001	471047	0.30%	1454	22.3	22.4	0.1	0.45	A	9050	9077	9307	230	2.47	A
7/17/2001	7/17/2001	471047	0.30%	747	22.7	22.8	0.1	0.45	A	32.98	33.00%		0.02	0.06	A
7/24/2001	6/12/2001	471047	0.30%	1410	27.1	27.1	0	0	A	9900	9930	10418	488	4.68	A
8/29/2001	6/12/2001	471047	0.30%	1359	25.4	25	0.4	1.57	A	9400	9428	10076	648	6.43	Q
8/29/2001	6/12/2001	471047	0.30%	1413	24.4	24.1	0.3	1.23	A	9700	9729	9887	158	1.59	A

*** A – accept (<5% err.); Q – question (>5% err.<10% err.); R – reject (>10% err.)**

3.5.2 Water Sample Collection and Processing

Duplicate water samples were collected at one to two selected stations on each sample collection data. The purpose of the duplicate samples was to evaluate the overall consistency of sample collection as well as the 3 tube/3 dilution laboratory analysis. Results of the duplicate sampling are shown in Table 3.5-2. The number sequence under the “Number of tubes different” heading represents the difference in number of tubes per 10 ml, 1 ml, and 0.1 ml dilutions, respectively, in the 3 tube/3 dilution analysis matrix.

Table 3.5-2. Duplicate Sample Results

Date	Station	A1COL Results		No. of tubes Different
		Sample	Replicate	
07-07-99	None taken/processed			
07-20-99	L 21	2.9	2.9	0, 0, 0
	L 22	2.9	2.9	0, 0, 0
07-26-99	L 40	2.9	2.9	0, 0, 0
08-09-99	MB 9	43	43	0, 0, 0
	MB 11	43	23	0, 1, 0
05-22-00	None taken/processed			
06-27-00	FP 1	23	9.1	1, 0, 0
	L 21	2.9	2.9	0, 0, 0
06-28-00	MQ 3	23	93	0, 2, 0
	BC 1	93	23	0, 2, 0
06-29/30-00	ML 3	23	43	0, 1, 0
	L 86	2.9	3.6	1, 0, 0
07-25-00	ML 5	43	43	0, 0, 0
07-26-00	L 18	3.6	3.6	0, 0, 0
07-28-00	ML 4	1100	460	0, 0, 1
09-11-00	AC 4	2.9	15	1, 1, 2
	MQ 2	93	93	0, 0, 0
06-02-01	MC 5	1100	1100	0, 0, 0
	BS 3	1101	1101	0, 0, 0
	MQ 2	1100	460	0, 0, 1
	AC 2	93	43	0, 1, 0
	BC 1	240	460	0, 0, 1
	Lab dup. BC 1		1100	0, 0, 1
06-04-01	I 21	93	93	0, 0, 0
	BC 2	43	15	1, 0, 0
06-05/06-01	MC 2	43	93	0, 1, 0
	BS 3	23	93	0, 2, 0
	MQ 4	43	9.1	1, 1, 0
	BC 2	93	9.1	1, 2, 0
06-11-01	L 23	2.9	2.9	0, 0, 0
	L 22	2.9	2.9	0, 0, 0
06-13-01	AC 1	43	43	0, 0, 0
06-18/19-01	MC 1	460	240	0, 0, 1
	BS 4	240	460	0, 0, 1
	MQ 2	93	3.6	**2, 2, 0**
	BC 1	460	1100	0, 0, 1
07-15/16-01	MQ 2	23	15	1, 1, 0
	BC 1	23	9.1	1, 0, 0
07-24/25-1	MQ 2	9.1	3.6	1, 0, 0
	BC 2	93	43	0, 1, 0
	Lab dup. BC 2		43	0, 0, 0

(continued)

Table 3.5-2. Duplicate Sample Results (Continued)

07-25-01	L 53	2.9	2.9	0, 0, 0
	L 22	2.9	2.9	0, 0, 0
08-15-01	MQ 5	7.3	23	**2, 1, 0**
	BC 1	43	43	0, 0, 0
08-16-01	GN 2	2.9	3.0	0, 0, 1
	L 22	3.6	2.9	1, 0, 0
08-29/30-01	MQ 2	9.1	9.1	0, 0, 0
	BC 2	240	43	0, 2, 0
08-30-01	L 18	2.9	2.9	0, 0, 0
			Total count	**49**
			No. > 1 primary tube separation	**2**
			> 1 primary tube separation	**4.08%**

3.5.3 Hold Time

Samples were delivered to the DMR laboratory within 2 to18 hours following collection and on no occasion were samples held longer than 30 hours before delivery to DMR and cooler temperature never exceeded 4°C during the hold time (Table 3.5-3).

Table 3.5-3. Sample Hold Time

First sample date	Time of first sample	Delivery Date	Time of Delivery	Maximum hold time
07/07/99	0608	07/07/99	0900	2:52
07/20/99	0513	07/22/99	1022	5:09
07/26/99	0937	07/26/99	1240	3:03
08/09/99	0849	08/09/99	1305	4:16
05/21/00	1735	05/22/00	0930	16:05
06/27/00	0620	06/27/99	0902	2:42
06/28/00	0611	06/28/00	0900	2:49
06/29/00	1649	06/30/00	0906	16:17
07/25/00	1835	07/26/00	0900	14:25
07/28/00	0528	07/28/00	0825	2:57
09/10/00	1600	09/11/00	0830	16:30
06/02/01	1531	06/03/01	0934	18:03
06/04/01	1605	06/05/01	0900	16:55
06/05/01	1605	06/06/01	0900	16:55
06/11/01	1544	06/12/01	0900	17:16
06/12/01	1817	06/13/01	0900	14:43
06/18/01	1618	06/19/01	0900	16:42
07/15/01	1550	07/16/01	0900	17:10
07/24/01	1459	07/25/01	0900	18:01
07/25/01	1512	07/26/01	0900	17:48
08/15/01	1352	08/16/01	0900	19:08
08/16/01	1705	08/17/01	0900	16:55
08/29/01	1512	08/30/01	0900	17:48
08/30/01	1451	08/31/01	0830	17:39

3.6 DATA AND RESULTS

As water-borne bacteria, fecal coliform counts are often affected by precipitation. Precipitation data from the Brunswick Naval Air Station (BNAS) was initially obtained from the Internet at http://tgsv7.nws.noaa.gov/weather/current/KNHZ.html; however, shortly after the project was started, BNAS ceased reporting precipitation on the site. Thereafter data were obtained from the Maine DMR, which used BNAS data for all Casco Bay monitoring locations. Data from BNAS are fully accurate for the adjacent Middle Bay Cove and Buttermilk Cove areas, but are likely less accurate for the more distant locations at Falmouth, Sebasco, and Phippsburg. Highlighted cells indicate periods of moderate (0.35–1.0") to heavy precipitation (>1.0")(Table 3.6-1).

Table 3.6-1. Precipitation Data (inches) from Brunswick Naval Air Station for 24-Hour Period Prior to Sampling Dates

Date	Rainfall (24-hr period)	Date	Rainfall (24-hr period)
7/5/1999	0.001	5/31/2001	0.000
7/6/1999	**0.490**	6/1/2001	0.000
7/7/1999	0.000	**6/2/2001**	**3.170**
7/18/1999	0.040	**6/3/2001**	**0.360**
7/19/1999	**0.460**	6/4/2001	0.170
7/20/1999	0.000	6/5/2001	0.001
7/24/1999	**0.810**	6/6/2001	0.000
7/25/1999	0.001	6/9/2001	0.000
7/26/1999	0.030	6/10/2001	0.140
8/7/1999	0.000	6/11/2001	0.220
8/8/1999	**0.870**	**6/12/2001**	**0.620**
8/9/1999	0.000	6/13/2001	0.000
		6/16/2001	0.000
5/19/2000	0.000	**6/17/2001**	**1.030**
5/20/2000	0.001	6/18/2001	0.000
5/21/2000	0.050	6/19/2001	0.000
6/25/2000	0.070	7/13/2001	0.000
6/26/2000	0.001	7/14/2001	0.310
6/27/2000	0.001	7/15/2001	0.000
6/28/2000	0.000	7/16/2001	0.330
6/29/2000	0.000	7/22/2001	0.000
6/30/2000	**0.460**	7/23/2001	0.000
7/23/2000	0.000	7/24/2001	0.000
7/24/2000	0.000	7/25/2001	0.000
7/25/2000	0.000	8/13/2001	0.030
7/26/2000	0.000	8/14/2001	0.000
7/27/2000	**0.440**	8/15/2001	0.000
7/28/2000	0.010	8/16/2001	0.000
9/9/2000	0.000	8/27/2001	0.001
9/10/2000	0.000	8/28/2001	0.020
9/11/2000	0.000	8/29/2001	0.000
		8/30/2001	0.000

The results of the A-1 fecal coliform 3 tube/3 dilution analyses for samples collected as part of this study at all sampling stations and all sampling dates, are summarized in Table 3.6-2. The blue-highlighted dates indicate those dates on which precipitation during the preceding 24-hour period was moderate to heavy (>0.35"); light-yellow highlighted dates indicate dry to very dry periods.

According to the NSSP, the geometric mean fecal coliform bacteria MPN (Geo. Mean) for the requisite number of samples taken within a specific shellfish growing area shall not exceed 14 per 100 ml and the estimated 90th percentile MPN shall not exceed 49 per 100 ml in order for the growing area affected by non-point sources of pollution to be classified as approved, or open to harvesting. Exceedances are depicted in red in Table 3.6-2.

The results for each individual study area are presented individually in the following sections. Additionally, a summary of the geometric mean MPN, 90th percentile MPN, % >49 MPN, and number of samples taken as part of the DMR's routine monitoring of the project's study areas during the period covered by this study is also included in Appendix D. These are included because all Maine DMR monitoring stations could not be routinely sampled at several of the study sites due to hold time, processing, and/or tide stage constraints.

Table 3.6-2. Summary of A-1 Fecal Coliform Analysis by Date and Station

	1999				2000								2001															
Station	**07/07**	**07/20**	**07/26**	**08/09**	**05/21**	**06/27**	**06/28**	**06/29-30**	**07/25**	**07/26**	**07/28**	**09/11**	**6/2-03**	**6/04-05**	**06/05-06**	**06/11**	**06/12-13**	**06/18-19**	**07/15-16**	**07/24-25**	**07/25**	**08/15-16**	**08/16**	**08/29-30**	**08/30**	**Geo Mean**	**S.D.**	**90th**
Sebasco/Round Cove, Phippsburg																												
L 86			3.6					3.6																		3.6	0.0	3.6
L 87			9.1					3.6								2.9					7.3		2.9		2.9	4.2	2.5	7.8
SH 1								15								2.9					2.9		3.6		2.9	4.2	4.8	9.6
SH 2								2.9								2.9					3.6		2.9		3.6	3.2	0.3	3.6
SH 3			2.9													2.9					3.6		3.6		2.9	3.2	0.3	3.6
SH 4																2.9					3.6		9.1		2.9	4.1	2.6	7.5
Sabino, West Bath																												
L52			2.9			2.9										3.6					2.9		3.6		2.9	3.1	0.3	3.6
L53			7.3			23										2.9					2.9		2.9		2.9	4.8	7.3	13.0
L54			2.9			2.9										7.3					2.9		2.9		2.9	3.4	1.6	5.3
S 1			3.6			3.6										2.9					2.9		2.9		2.9	3.1	0.3	3.6
S 2			2.9			2.9										3.6					3.6		2.9		2.9	3.1	0.3	3.6
Fosters Point, West Bath																												
FP 1						23																				23.0	0.0	23.0
FP 2			2.9			23																				8.2	10.1	30.7
L 40			2.9																							2.9	0.0	2.9
L 41			3.6			3.6																				3.6	0.0	3.6
Buttermilk Cove/Gurnet, Brunswick																												
BC 1		460			93		93			7.3		1100	240	460	43			460	23	93		43		43		108.1	299.6	628.6
BC 2														43	93			93	43	93		43		240		76.5	64.5	162.3
L 18		9.1			3.6	3.0	23			3.6		2.9				2.9					2.9		2.9		2.9	4.2	6.1	9.7
L19																2.9										2.9	0.0	2.9
L 21		2.9			3.0	2.9	2.9			3.6		460	240	43	3.6	2.9		93	3.6	3.6		3.6		9.1	2.9	8.9	120.3	77.7
L 22		2.9														2.9					2.9		3.6			3.1	0.3	3.5
L 23		15			3.6	7.3	3.6			3.6		2.9				2.9										4.6	4.1	9.4
GN 1						23				3.6		9.1				2.9					3.6		3.6		3.0	5.1	6.8	12.6
GN 2							7.3									93					2.9		2.9			8.7	38.4	53.5

Table 3.6-2. Summary of A-1 Fecal Coliform Analysis by Date and Station (Continued)

	1999				2000								2001															
Station	07/07	07/20	07/26	08/09	05/21	06/27	06/28	06/29-30	07/25	07/26	07/28	09/11	6/2-03	6/04-05	06/05-06	06/11	06/12-13	06/18-19	07/15-16	07/24-25	07/25	08/15-16	08/16	08/29-30	08/30	Geo Mean	S.D.	90th
Ash Point Cove, Harpswell																												
AC 1					2.9				460				23		3.6		43									21.6	177.4	230.5
AC 2					2.9				240				93		15		43									33.4	86.4	235.2
AC 3					3.0				2.9			7.3	43		3.6											6.3	15.6	23.1
AC 4					3.6			2.9				2.9	43		9.1		15									7.5	14.2	26.7
AC 5													93													93.0	0.0	93.0
Middle Bay Cove, Brunswick																												
MB 1	240			43	2.9		15		3.6		240															27.0	106.4	265.8
MB 2	1101			7.3	43		240				9.1	93														64.2	389.2	613.7
MB 3	240			23	3.6		1100				240															87.9	402.4	1167.1
MB 4	3.6	2.9		240																						13.6	111.6	183.2
MB 5	9.1	2.9		43																						10.4	17.6	42.9
MB 6	2.9	2.9		43	3.6		2.9		2.9		23	43														7.6	17.1	35.2
MB 7	23	2.9		43																						14.2	16.4	62.1
MB 9				43																						31.4	10.0	46.9
MB10	2.9	3.6		93																						9.9	42.3	75.4
MB 11	23	2.9		43																						14.2	16.4	62.1
J 49.5	2.9	3.6		9.1																						4.6	2.8	8.6
J 50	2.9	2.9		43																						7.1	18.9	36.3

Table 3.6-2. Summary of A-1 Fecal Coliform Analysis by Date and Station (Continued)

	1999				2000								2001															
Station	**07/07**	**07/20**	**07/26**	**08/09**	**05/21**	**06/27**	**06/28**	**06/29-30**	**07/25**	**07/26**	**07/28**	**09/11**	**6/2-03**	**6/04-05**	**06/05-06**	**06/11**	**06/12-13**	**06/18-19**	**07/15-16**	**07/24-25**	**07/25**	**08/15-16**	**08/16**	**08/29-30**	**08/30**	**Geo Mean**	**S.D.**	**90th**
Bunganuc Stream, Brunswick																												
BS 1		460		240			3.6		43		240	43	1100	43	43		460	93	460	43		15		23		86.0	220.6	596.2
BS 2													1100	240	150		240	93	43							183.4	311.0	656.6
BS 3													1101		23		240	1100	240	43		240		43		170.4	378.8	990.0
BS 4													1100		20		460	240	93	240		43		93		146.9	286.1	692.6
J 29		2.9		3.6																						3.2	3.3	3.7
J 30		7.3		15						2.9							460		1101	93		3.6		3.6		25.8	210.8	426.3
J 31		2.9		9.1						2.9																4.2	5.0	8.5
J 31.5				2.9																						2.9	2.9	2.9
Maquoit Bay, Brunswick																												
MQ 1		240		460			23		43		93	1101	1100	9.1	15			43	23	240		9.1		93		78.5	249.4	600.7
		23					23		460		120	93		93												79.5	135.3	297.5
MQ 4													1100		43			93	23	9.1		2.9		9.1		30.5	182.9	306.2
MQ 5															15			3.6	3.6	2.9		7.3		3.6		5.0	6.0	10.3
J 33		2.9		3.6						2.9																3.1	3.1	3.6
Pettingill Cove, Freeport																												
ML 3		460						23	43		1100	43														116.6	333.8	815.3
ML 4		240						240	23		1100	23														127.4	325.2	873.2
ML 5								23	43		150	1101														113.0	329.3	749.1

Table 3.6-2. Summary of A-1 Fecal Coliform Analysis by Date and Station (Continued)

	1999				2000								2001															
Station	**07/07**	**07/20**	**07/26**	**08/09**	**05/21**	**06/27**	**06/28**	**06/29-30**	**07/25**	**07/26**	**07/28**	**09/11**	**6/2-03**	**6/04-05**	**06/05-06**	**06/11**	**06/12-13**	**06/18-19**	**07/15-16**	**07/24-25**	**07/25**	**08/15-16**	**08/16**	**08/29-30**	**08/30**	**Geo Mean**	**S.D.**	**90th**
Mussel Cove, Falmouth																												
													460	93	43		240	460	43	2.9		43		93		77.5	164.2	510.8
MC-1A																		460								460.0	460.0	460.0
MC-1														43	23		1101	460	93	3.6		43		23		59.9	223.7	519.5
MC-2													1100	93	43		460	1100	150	3.6		460		460		185.0	430.0	1699.4
MC-3													240	23	23		460	460	240			43		240		126.7	216.1	589.6
MC-4													1100		75			460								336.1	545.0	1406.9
MC-5													1100		75			460								336.1	545.0	1406.9
SMH-1														43												43.0	43.0	43.0
Total*	11	24	13	21	12	14	14	10	12	9	11	17	23	14	24	19	13	21	17	15	16	16	16	16	14	392*		

- **Total includes duplicate samples results, which are not included in Table 3.6-2 but are listed separately in Table 3.5-2.**

Blue highlight = Precipitation during preceding 24-hour period – moderate to heavy.
Yellow highlight = Precipitation during preceding 24-hour period – dry to very dry.

3.7 STUDY SITE-SPECIFIC RESULTS AND ANALYSIS

3.7.1 Sebasco Harbor/Round Cove

The Sebasco Estates resort surrounds much of Sebasco Harbor. The resort is a complex of summer cottages and includes a golf course, swimming pool and dining/convention facility. The resort has a licensed OBD that discharges into the cove along the western shoreline. The resort also operates a tour boat and serves as a marina to numerous vessels, commercial and recreational, moored in Sebasco Harbor during the summer. The resort has recently installed a dockside pump-out station to service the waste holding tanks on these vessels.

Sampling stations were located within the Sebasco Estates cove at the most likely points of entry on non-point source pollution, specifically the spillway running under the causeway where flow draining from the golf course pond enters the cove (SH1), in the center of the southern part of the cove in the general vicinity of the OBD discharge (SH2), and along the western shore just south of the dock (SH3) (Figure 3.7-1).

At Round Cove, just south of Sebasco Estates and Sebasco Harbor, numerous small summer cottages are built on the bedrock outcrop forming the western shoreline of the cove, none of which appear to have adequate in-ground sewage treatment systems, thus the potential for fecal contamination from human sources remains relatively high, at least during the summer months. Due to the bedrock and proximity to the sea, none of the cottages appear to be equipped with year-round water supply and none are believed to be occupied year-round. Additionally, a horse is kept in a paddock in the area adjacent to the north end of the cove, runoff from which likely enters the head of the cove. Stations were located along the western shoreline of the bedrock outcrop directly in front of several small cottages (SH4) and at the center of the cove coinciding with DMR station L87. Circulation within the cove appears to be predominantly in and out of the entrance toward the southeast and L87 would therefore be expected to detect contamination entering the cove from any direction.

The geometric mean and 90th percentile MPN for the six sampling runs are well below the NSSP limits at all stations, as are the DMR NSSP routine sampling results (Table 3.7-1). This suggests that no specific non-point source of fecal coliform is excessively affecting the area.

Although the results of both this project and the DMR routine sampling (Table 3.7-2) indicate no serious contamination of the Sebasco Estates cove and Round Cove growing areas, the presence of the OBD in Sebasco Estates cove and the concentration of summer cottages with questionable sewage treatment facilities makes it unlikely that the area can be opened for year-round harvesting. However, the fact that the resort and summer cottages are only operated during the summer, combined with the fecal coliform results presented here, suggest that the area could be opened to harvesting on a seasonal basis during the winter.

The DMR conducted a thorough shoreline survey of this area in 2002 to evaluate the feasibility of seasonal harvesting and determined that winter harvesting, indeed, would not pose a risk to public health and the area was opened to harvesting during the winter of 2002. The DMR is now investigating options for the removal of the Sebasco Estates OBD.

Figure 3.7-1. Sebasco Harbor/Round Cove

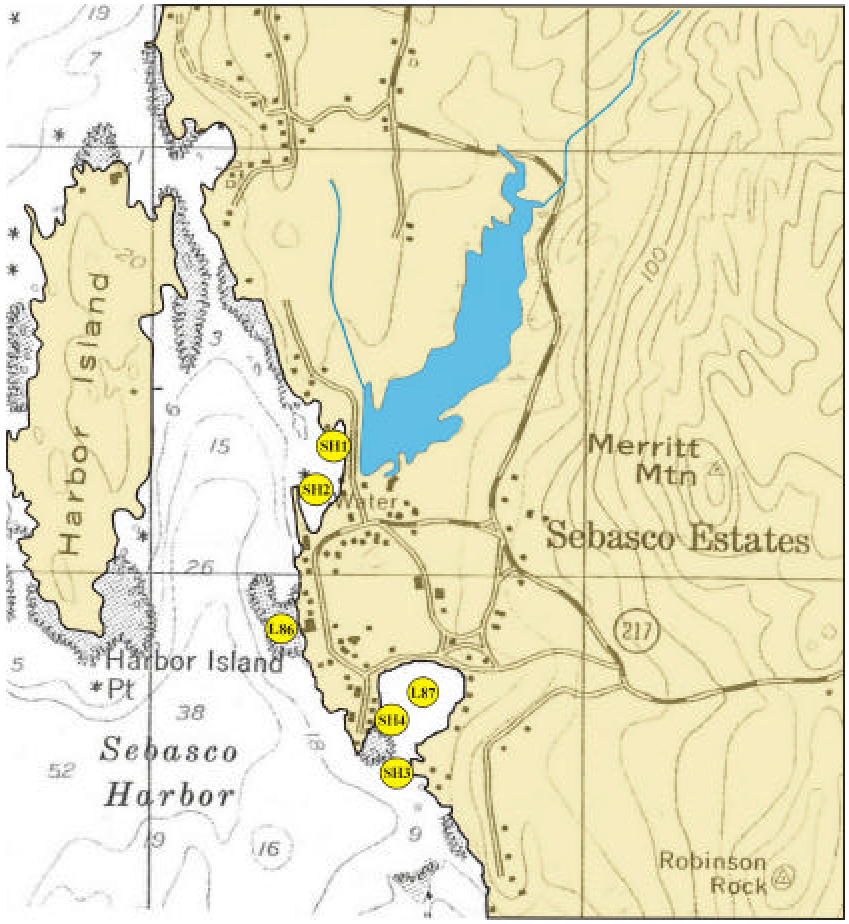


Table 3.7-1. Non-point Source A-1 Fecal Coliform MPN Analysis by Date and Station for Sebasco and Round Cove Areas

Sebasco/Round Cove

	1999	2000	2001								
Station	**07/26**	**06/30**	**06/11**	**07/25**	**08/16**	**08/30**	**Geo Mean**	**Mean**	**Max**	**S.D.**	**90th**
L86	3.6	3.6					3.6	3.6	3.6	0.0	3.6
L87	9.1	3.6	2.9	7.3	2.9	2.9	4.2	4.8	9.1	2.5	7.8
SH1		15	2.9	2.9	3.6	2.9	4.2	5.5	15.0	4.8	9.6
SH2		2.9	2.9	3.6	2.9	3.6	3.2	3.2	3.6	0.3	3.6
SH3	2.9		2.9	3.6	3.6	2.9	3.2	3.2	3.6	0.3	3.6
SH4			2.9	3.6	9.1	2.9	4.1	4.6	9.1	2.6	7.5

Table 3.7-2. Summary of Maine DMR NSSP Sampling Station A-1 Fecal Coliform Analysis for Sebasco and Round Cove Areas, 1999-2002

Station	Geo. Mean	90th Percentile	% >49	Number samples
L86	23.0	23.0	0.0	1
L87	6.0	31.1	7.9	38

3.7.2 Sabino

As in the Sebasco Harbor/Round Cove area, the results of both the current study sampling (Stations S1, S2) and the DMR routine monitoring (Stations L52, 53, 54) in the Sabino area (Figure 3.7-2) have been consistently low and yield geometric mean and 90th percentile MPN values well within the acceptable NSSP limits, indicating little fecal coliform contamination within the growing area (Table 3.7-3).

The shoreline of Sabino is heavily populated and several (9 of 10) OBDs in the area have been removed through the broader Sustainable Shellfisheries project under Phase I; in addition, over the course of the study, at least one in-ground waste treatment system appears to have been installed at one of the large residences along the center portion of shoreline.

The fecal coliform testing results suggest that, once the OBDs are fully removed, no other non-point source of contamination should prevent the area from being opened to harvesting. Nevertheless, the concentration of small cottages along the shore of the northeastern cove, some of which may be occupied year-round, may require intensive review by DMR before the area can be confidently reopened.

Figure 3.7-2. Sabino

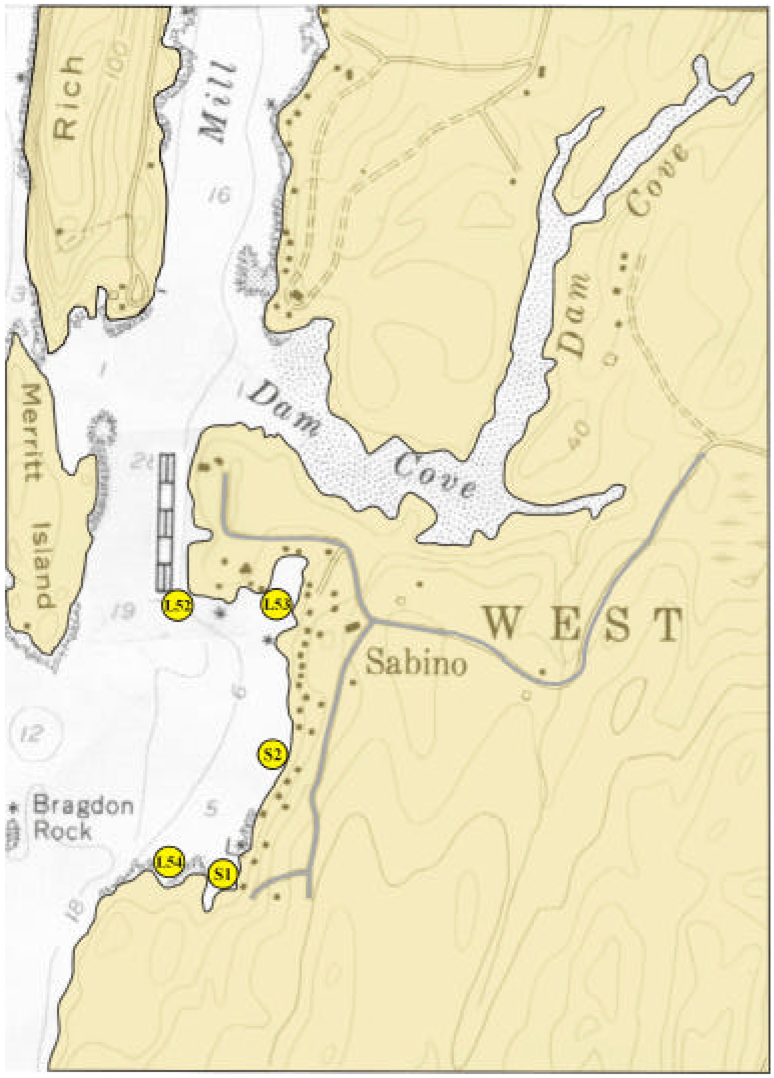


Table 3.7-3. Non-point Source A-1 Fecal Coliform MPN Analysis by Date and Station for the Sabino Area

Sabino

	1999	2000	2001								
Station	07/26	06/27	06/11	07/25	08/16	08/30	Geo Mean	Mean	Max	S.D.	90th
L52	2.9	2.9	3.6	2.9	3.6	2.9	3.1	3.1	3.6	0.3	3.6
L53	7.3	23	2.9	2.9	2.9	2.9	4.8	7.0	23.0	7.3	13.0
L54	2.9	2.9	7.3	2.9	2.9	2.9	3.4	3.6	7.3	1.6	5.3
S 1	3.6	3.6	2.9	2.9	2.9	2.9	3.1	3.1	3.6	0.3	3.6
S 2	2.9	2.9	3.6	3.6	2.9	2.9	3.1	3.1	3.6	0.3	3.6

Table 3.7-4. Summary of Maine DMR NSSP Sampling Station A-1 Fecal Coliform Analysis for the Sabino Area, 1999-2002

Station	Geo. Mean	90^{th} Percentile	% >49	Number samples
L 52	4.9	17.3	0.0	18
L 53	4.7	15.2	4.2	24
L 54	3.7	11.8	4.2	24

3.7.3 Fosters Point

Sampling within this area (Figure 3.7-3) only occurred on two occasions, but on both the results indicated limited fecal coliform contamination and geometric mean and 90th percentile MPN values within acceptable NSSP limits (Tables 3.7-5 and 3.7-6). This area drains nearly completely at low water and is strongly flushed by the immediately adjacent New Meadows River. The New Meadows River is strictly marine waters, relatively deep, and well mixed at this point in its course and it is unlikely that the area would be affected by non-point contamination sources other than the few residences along the immediate shoreline.

The area is currently closed to harvesting because of three licensed OBDs on Fosters Point. These OBDs have been scheduled for removal, but difficulties in locating an acceptable alternative site for one in-ground system has delayed the removal of all three. Given the results of testing in the area, particularly from the long-term, routine DMR monitoring and the difficulties in removing the OBD, the sampling effort in this area was directed elsewhere early in the project.

Figure 3.7-3. Fosters Point

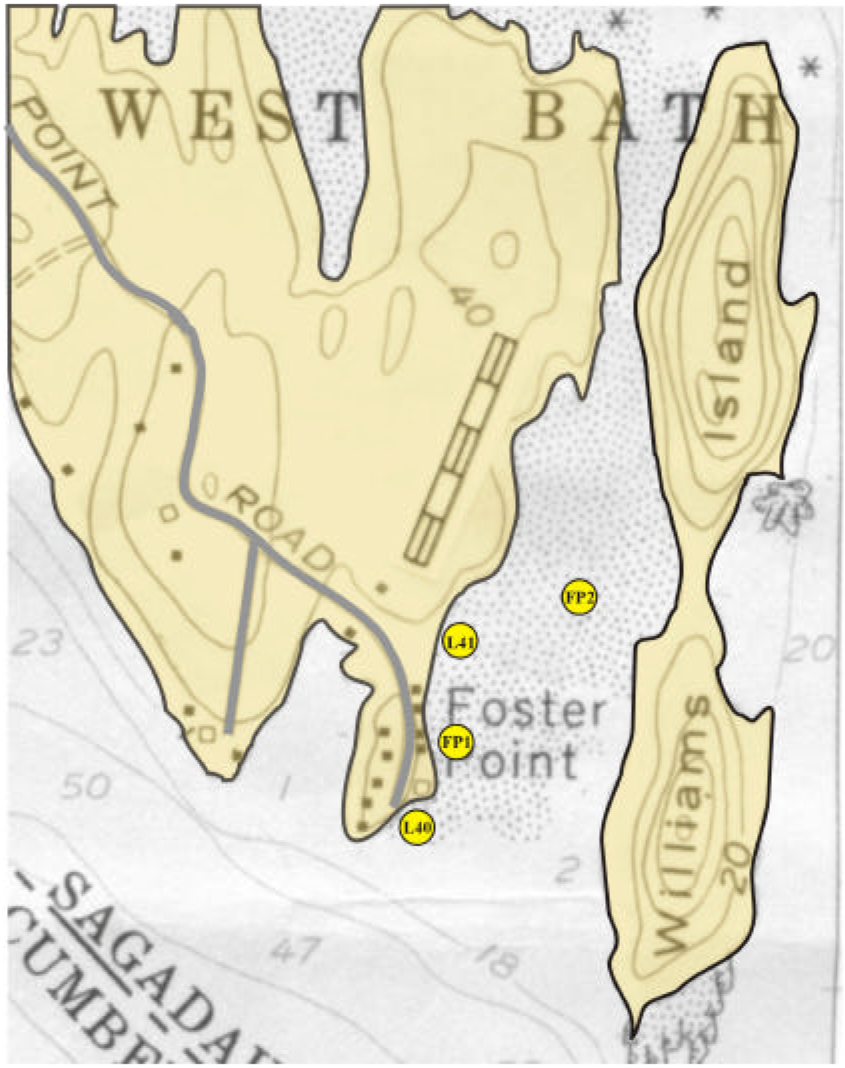


Table 3.7-5. Non-point Source A-1 Fecal Coliform MPN Analysis by Date and Station within the Fosters Point Area

Fosters Point

	1999	2000					
Station	**07/26**	**06/27**	**Geo Mean**	**Mean**	**Max**	**S.D.**	**90th**
FP 1		**23**	**23.0**	**23.0**	**23.0**	**0.0**	**23.0**
FP 2	**2.9**	**23**	**8.2**	**13.0**	**23.0**	**10.1**	**30.7**
L 40	**2.9**		**2.9**	**2.9**	**2.9**	**0.0**	**2.9**
L 41	**3.6**	**3.6**	**3.6**	**3.6**	**3.6**	**0.0**	**3.6**

Table 3.7-6. Summary of Maine DMR NSSP Sampling Station A-1 Fecal Coliform Analysis within the Fosters Point Area, 1999-2002

Station	Geo. Mean	90^{th} Percentile	% >49	Number samples
L 40	4.0	11.8	0.0	24
L 41	3.9	7.0	0.0	24

3.7.4 Ash Point Cove

Ash Point Cove was opened to seasonal winter harvesting from September 16 through May 14 of each year, beginning in 1999. At the suggestion of DMR, the CBEP “Clam Team” requested that sampling be carried out in the cove to provide stream fecal coliform data beginning in 2000.

Fresh water enters Ash Point Cove through three relatively small drainages at the north of the cove (Figure 3.7-4). Sampling stations were located on each of these flows near their entry point into the cove, but above head of tide. Flow through station AC1 runs adjacent to the Ash Point Cove residential development area; flows through stations AC2 and AC3 drain primarily wooded areas, the latter playing fields behind the West Harpswell Elementary School. Station AC4 was located within the cove in proximity to DMR station J68. Station AC5 was used only once to test effluent from a drainage ditch entering the cove along the eastern shore that was subsequently diverted away from the shoreline.

The geometric mean and 90th percentile MPN at stations AC1 and AC2 both exceed the NSSP limits, as did the one-time-only sampling at AC5. Stations AC1 and AC2 exceed the limits as a result of the unusually high fecal coliform MPN found on 07/25/2000 (Tables 3.7-7 and 3.7-8). These anomalously high MPN levels were found during dry weather when stream flow was very low and such high levels were never found during or following rainfall events, suggesting a lack of any chronic source of elevated fecal coliform bacteria contamination. These stream flows appear to have negligible effect on the cove as indicated by the results of study station AC4 and DMR monitoring results at J68, both of which yielded acceptable geometric mean and 90th percentile MPN values. The area remains open for seasonal harvesting to-date.

Figure 3.7-4. Ash Point Cove

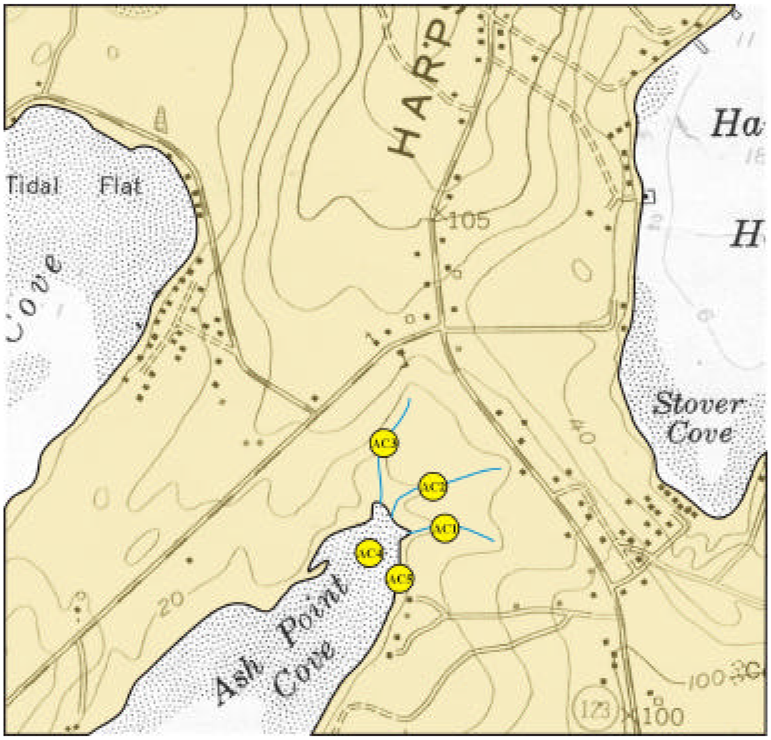


Table 3.7-7. Non-point Source A-1 Fecal Coliform MPN Analysis by Date and Station in the Vicinity of Ash Point Cove, Harpswell

Ash Point Cove

	2000				2001							
Station	**05/21**	**06/29**	**07/25**	**09/11**	**06/03**	**06/06**	**06/13**	**Geo Mean**	**Mean**	**Max**	**S.D.**	**90th**
AC 1	**2.9**		**460**		**23**	**3.6**	**43**	**21.6**	**106.5**	**460.0**	**177.4**	**230.5**
AC 2	**2.9**		**240**		**93**	**15**	**43**	**33.4**	**78.8**	**240.0**	**86.4**	**235.2**
AC 3	**3.0**		**2.9**	**7.3**	**43**	**3.6**		**6.3**	**12.0**	**43.0**	**15.6**	**23.1**
AC 4	**3.6**	**2.9**		**2.9**	**43**	**9.1**	**15**	**7.5**	**12.8**	**43.0**	**14.2**	**26.7**
AC 5					**93**			**93.0**	**93.0**	**93.0**	**0.0**	**93.0**

Table 3.7-8. Summary of Maine DMR NSSP Sampling Station A-1 Fecal Coliform Analysis in the Vicinity of Ash Point Cove, Harpswell, 1999-2002

Station	Geo. Mean	90^{th} Percentile	% >49	Number samples
J 68	4.5	16.4	3.9	51

3.7.5 Buttermilk Cove

The Buttermilk Cove and adjacent Gurnet area were sampled on eighteen and eight occasions, respectively, during the course of the study (Table 3.7-9). Study sampling stations BC1, BC2 and DMR monitoring stations L19, L21, L22, and L23 pertain to Buttermilk Cove; study sampling stations GN1, GN2 and DMR monitoring station L18 pertain to Gurnet and adjacent Indian Rest Cove (Figure 3.7-5).

Most of the stations, with exception of BC1 located at the head of Buttermilk Cove and BC2 located along the principal stream leading into Buttermilk Cove, yielded geometric mean MPN values with acceptable NSSP limits. Study stations BC1, BC2, and GN2 exceeded the 90th percentile limit of 49 MPN, as did DMR monitoring station L21 (Table 3.7-9). Interestingly, the DMR long-term results for station L21 are remarkably similar to the results obtained through the study sampling, yielding a geometric mean MPN of 7.6 compared to 8.9 for the study, and a 90th percentile MPN of 52.9 compared to 77.7 for the study (Table 3.7-10); long-term sampling results for all other DMR stations showed low geometric mean values similar to the study, but the study 90th percentile MPN values were generally lower than those of the long-term data set.

The results of the study sampling and those of the DMR routine monitoring are rather confusing. The level of contamination found by both the study and DMR sampling indicate that L21 is more often contaminated than L22 despite the fact that station L22 is located in the middle of Buttermilk Cove north of the bridge and upstream of L21, with respect to the principal freshwater flow, and hence more likely to be affected by such flow. Although the area north of the bridge has been opened to harvesting since December 1994, the lower portion of Buttermilk Cove south of the Princes Point bridge has remained closed to harvesting for several years, partly as a result of detected contamination but also due to the existence of eight OBDs along the shores of the lower cove. These OBDs have been removed as part of Phase I of this project with the expectation of opening the entire area to harvesting; however, it appears that other external sources are contaminating the area.

It is important to bear in mind that the elevated levels of fecal coliform found at stations BC1 and particularly at BC2, represent contamination in brackish and freshwater, respectively, that would be expected to undergo substantial dilution once these waters reach the head of Buttermilk Cove proper. Some of the results support this conclusion, however, other results indicate that levels remain consistent, or at least trend similarly, between BC1 and L21, particularly following rain events (06/03/2001 and 06/19/2001); however, these two stations also trended similarly during the dry period of 09/11/2000. Despite this, the DMR data seems to indicate a source affecting the lower Buttermilk Cove area along the immediate shoreline or from the south.

A houseboat has been moored in the Reach area just south of Buttermilk Cove for several years. Occupancy of the houseboat and method of waste disposal have been difficult to determine, however the presence of the houseboat clearly represents a potential source of human fecal coliform contamination and it is unlikely that the area can be opened until the vessel is removed or a suitable, secure, and verifiable domestic waste disposal system is installed.

The fluctuations in magnitude of fecal coliform MPN from stations BC1 and BC2 also support the conclusion that stream flow into the northern part of Buttermilk Cove is not a major contributor of fecal contamination from human sources, for contamination from a failed septic system subject to a constant inflow of domestic wastewater would be expected to yield chronically high levels of contamination. Furthermore, a walking survey along the length of a major portion of the stream revealed that most of the residential development along the stream occurs north of station BC2, the section south of BC2 is primarily woodland, providing habitat to abundant wildlife as evidenced by tracks crossing the stream. This latter observation suggests that at least some of the fecal coliform contamination is of wildlife origin. In addition to the wildlife, one drainage area was found to drain a property west of the stream where horses are pastured, posing another potential source of contamination. Although spikes in fecal coliform MPN were observed during dry periods, elevated levels were always found following periods of moderate to heavy rain, suggesting runoff is a major contributor, further implicating wildlife and large domesticated animals.

Based on all of the available data, it appears that stream flow from the north does not represent a substantial source of fecal coliform contamination of human origin. However, a yet to be identified source within or to the south of Buttermilk Cove may prevent the lower Buttermilk Cove area from being opened to harvesting even after all OBDs have been removed, and additional work by the municipality and DMR may be required.

Figure 3.7-5. Buttermilk Cove

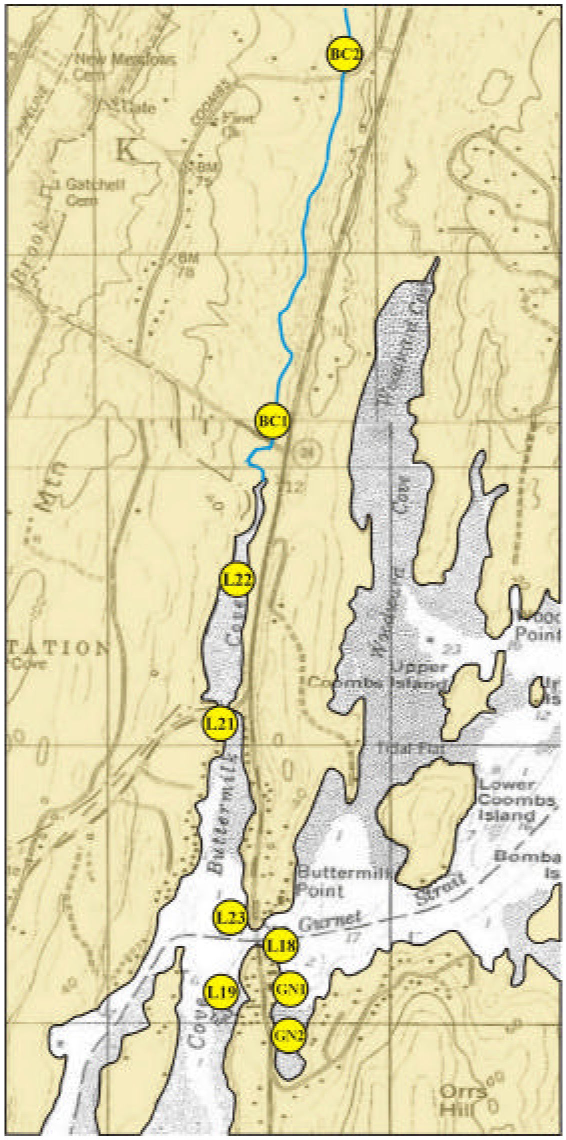


Table 3.7-9. Non-point Source A-1 Fecal Coliform MPN Analysis by Date and Station in Buttermilk Cove, Brunswick

Buttermilk Cove, Brunswick

	1999	2000					2001																
Station	**07/20**	**05/21**	**06/27**	**06/28**	**07/26**	**09/11**	**06/03**	**06/05**	**06/06**	**06/11**	**06/19**	**07/16**	**07/25 AM**	**07/25 PM**	**08/16**	**08/16**	**08/30 AM**	**08/30 PM**	**Geo Mean**	**Mean**	**Max**	**S.D.**	**90th**
BC 1	460	93		93	7.3	1100	240	460	43		460	23	93		43		43		108.1	242.9	1100.0	299.6	628.6
BC 2								43	93		93	43	93		43		240		76.5	92.6	240.0	64.5	162.3
L 18	9.1	3.6	3.0	23	3.6	2.9				2.9				2.9		2.9		2.9	4.2	5.7	23.0	6.1	9.7
L19										2.9									2.9	2.9	2.9	0.0	2.9
L 21	2.9	3.0	2.9	2.9	3.6	460	240	43	3.6	2.9	93	3.6	3.6		3.6		9.1	2.9	8.9	55.0	460.0	120.3	77.7
L 22	2.9									2.9				2.9		3.6			3.1	3.1	3.6	0.3	3.5
L 23	15	3.6	7.3	3.6	3.6	2.9				2.9									4.6	5.6	15.0	4.1	9.4
GN 1			23		3.6	9.1				2.9				3.6		3.6		3.0	5.1	7.0	23.0	6.8	12.6
GN 2				7.3						93				2.9		2.9			8.7	26.5	93.0	38.4	53.5

Table 3.7-10. Summary of Maine DMR NSSP Sampling Station A-1 Fecal Coliform Analysis in Buttermilk Cove, Brunswick, 1999-2002

Station	Geo. Mean	90th Percentile	% >49	Number samples
L 18	5.3	23.9	4.2	24
L19	5.3	23.9	4.2	24
L 21	7.6	**52.9**	8.9	45
L 22	5.5	25.6	2.2	45
L 23	4.3	18.9	7.1	28

3.7.6 Middle Bay Cove

The head of Middle Bay Cove is deeply convoluted with numerous finger-like projections cutting into the surrounding shoreline, each representing a separate drainage, all but one carrying strictly intermittent runoff flow (Figure 3.7-6). The surrounding area is generally open land with limited residential development. Several of the fields surrounding the cove are hayed annually and several pastures within the immediate watershed are used to graze livestock. Additionally, the area at the head of the cove is heavily forested and provides wildlife habitat, particularly for a resident herd of deer routinely seen on the marsh banks during early morning sampling runs.

Three stations, MB1, MB2, and MB3 were located along Route 123 to measure fecal coliform contributions from adjacent drainages, the first two from two paddocks holding a llama, several sheep, a donkey, and horses, and the third from a pond often frequented by ducks. Stations MB4 through MB11 were located in marine waters over the shellfish growing area at the entrance to each of the major drainages where runoff flow enters the cove. Additionally, DMR monitoring stations J49.5 and J50 were also sampled on three rain event dates (Table 3.7-11,12).

Predictably, stations MB1, MB2 and MB3 routinely yielded elevated fecal coliform MPN values, irrespective of rainfall, with geometric mean and 90th percentile values well above NSSP limits. Stations MB9 and MB10 yielded geometric mean or 90th percentile values that exceeded the NSSP limits; both of these stations are affected by livestock, MB9 by cattle grazing a field along the Pennellville Road on the western shore, MB10 by drainage from the paddock along Route 123 on the eastern shore. Station MB11 was located at the opening of the drainage of the pond and hayfields on the eastern shore, just downstream of MB1. Station MB7 was located at the head of the cove adjacent to the marsh where deer were routinely seen standing along the immediate shore.

Both the study and routine DMR monitoring results for DMR stations J49.5 and J50 showed geometric mean and 90th percentile values well below NSSP limits for approved classification.

Although numerous potential sources of livestock and terrestrial and avian wildlife fecal coliform bacteria were routinely observed around the cove, no specific potential human sources were found. According to the DMR, upper Middle Bay was opened to harvesting in 1993. In early 1994, however, the area was closed once again due to elevated fecal coliform levels in the vicinity of J49.5, apparently the result of a failed septic system. The failed system was repaired by 1999 and, based on the results of subsequent sampling and the absence of any other identifiable potential source of contamination, the area was reclassified to approved, open status in late 1999. With the opening of the area to harvesting, sampling in the area as part of this study was reduced in 2000 and the site was dropped from the study early in 2001 to allow efforts to be focused elsewhere.

Figure 3.7-6. Middle Bay Cove

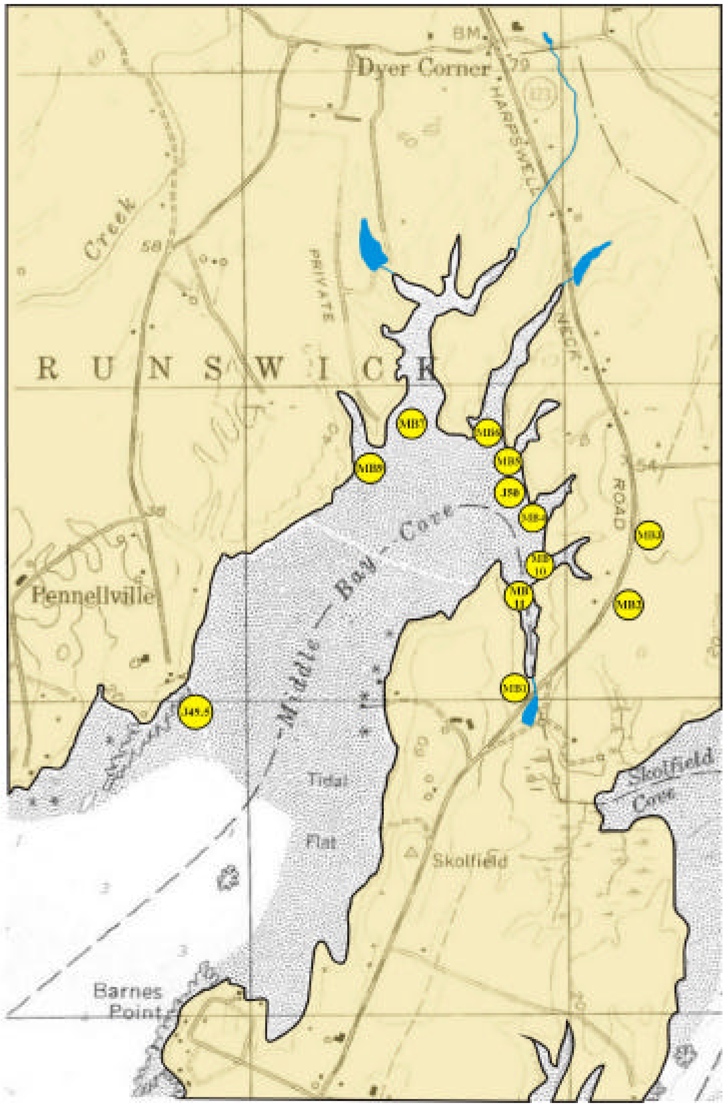


Table 3.7-11. Non-Point Source A-1 Fecal Coliform MPN Analysis by Date and Station in Middle Bay Cove, Brunswick

Middle Bay Cove

	1999				2000									
Station	**07/07**	**07/20**	**08/09**	**08/09 Xtr.**	**05/21**	**06/28**	**07/25**	**07/28**	**09/11**	**Geo Mean**	**Mean**	**Max**	**S.D.**	**90th**
MB 1	240		43		2.9	15	3.6	240		27.0	90.8	240.0	106.4	265.8
MB 2	1101		7.3		43	240		9.1	93	64.2	248.9	1101.0	389.2	613.7
MB 3	240		23		3.6	1100		240		87.9	321.3	1100.0	402.4	1167.1
MB 4	3.6	2.9	240							13.6	82.2	240.0	111.6	183.2
MB 5	9.1	2.9	43							10.4	18.3	43.0	17.6	42.9
MB 6	2.9	2.9	43		3.6	2.9	2.9	23	43	7.6	15.5	43.0	17.1	35.2
MB 7	23	2.9	43							14.2	23.0	43.0	16.4	62.1
MB 9			43	23						31.4	33.0	43.0	10.0	46.9
MB10	2.9	3.6	93							9.9	33.2	93.0	42.3	75.4
MB 11	23	2.9	43							14.2	23.0	43.0	16.4	62.1
J 49.5	2.9	3.6	9.1							4.6	5.2	9.1	2.8	8.6
J 50	2.9	2.9	43							7.1	16.3	43.0	18.9	36.3

Table 3.7-12. Summary of Maine DMR NSSP Sampling Station A-1 Fecal Coliform Analysis in Middle Bay Cove, Brunswick, 1999-2002

Station	**Geo. Mean**	**90th Percentile**	**% >49**	**Number Samples**
J 49.5	5.9	31.0	3.2	31
J 50	6.8	28.7	5.4	37

3.7.7 Maquoit Bay

The upper part of Maquoit Bay has been closed to shellfish harvesting since November 1989 as a result of persistent fecal coliform bacteria contamination in the area. Two major drainages flow into the upper bay area. One enters from the northwest through a culvert under Maquoit Road and drains an area known as the Great Gulch. The second enters at the northeast through a culvert under the Rossmore Road and drains a predominantly wooded area with very limited development; a pond exists approximately midway along the drainage.

Sampling station MQ1 and MQ2 were located at the Maquoit Road and Rossmore Road, respectively (Figure 3.7-7). Stations MQ4 and MQ5 were established further up the Great Gulch, behind the Brunswick High School athletic fields, in 2001, as efforts were reduced in other study areas; station MQ4 was located on the primary flow of the western branch, MQ5 on the smaller flow from the northeast. DMR monitoring station J33 was sampled on three occasions, but the station had to be dropped in 2000 due to hold time constraints and difficulties matching available processing times with tide stages.

NSSP geometric mean and 90th percentile MPN limits were exceeded at MQ1, MQ2 and MQ4. MQ5 yielded consistently low values well below the NSSP limits, as did DMR station J33, based on the limited sampling at the station. The long-term DMR sampling at J33 for the 1999 through 2001 study period yielded a geometric mean MPN value just below the NSSP limit of 14, but the 90th percentile MPN value was substantially higher than the limit of 49 MPN (Table 3.7-13,14).

Similar to the stream entering Buttermilk Cove, fecal coliform bacteria MPN varied widely over sampling dates at stations MQ1, MQ2 and MQ4. MPN values above 93 were only seen on five of the fourteen occasions MQ1 was sampled, only twice of six samplings at MQ2, and only once at MQ4. Again, as in Buttermilk Cove, rainfall events consistently resulted in elevated MPN values at these three stations, although the magnitude of MPN varied widely from one rainfall event to another. Additionally, spikes in MPN were also observed independently at these stations at one time or another during dry periods, as on 07/25/2000, 09/11/2000 and 07/24/2001. This pattern of fluctuating fecal coliform concentrations, irrespective of rainfall, indicates episodic rather than chronically high levels of contamination.

The inconsistent relationship between the upstream MQ4 station and the downstream MQ1 station further confounds the effort to determine the origin of contamination. Following the major rain event of 06/02/2001 when 3.17 inches of precipitation fell, both stations yielded MPN values of 1100 suggesting a close relationship between the two. However, on 06/18/2001 following a smaller, yet nevertheless substantial rain event of 1.03 inches, MPN levels were substantially lower at 93 and 43, respectively. Several weeks later during a dry period the downstream MQ1 station yielded an MPN of 240 while the upstream MQ4 station yielded a comparatively low MPN of 9.1, suggesting little relationship between the two stations and the presence of a source either between the stations or a source “downstream” of MQ1 from which bacteria are carried upstream with the tide. As a further complication, MPN values at both stations dropped to very low levels during the dry period around 08/15/2001, further suggesting intermittent, episodic contamination.

The temperature data taken during sampling generally yielded little out of the ordinary. However, it is noteworthy that the water temperature at MQ4 was considerably and consistently lower than at all surrounding freshwater and marine stations. For example, the water temperature at station BS4 on Bunganuc Stream, which is primarily surface flow over its entire length, varied between 16.0ºC and 24.9ºC between 06/05/2001 and 08/29/2001. Water temperature during the same sample period at MQ4 varied between 10.5ºC and 13.5ºC, indicating that flow at MQ4 is predominantly, or entirely, groundwater discharge. This is not surprising since the adjacent area soils are sand and gravel. Depending on the transit time and distance, this groundwater could potentially carry bacteria from sources beyond the immediate area making a determination of source more difficult.

Based on these results and observations, it appears that no chronic source of elevated bacterial contamination affects the area. The most elevated levels appear to be associated with rainfall events suggesting runoff and groundwater as a primary contributors. It has also been previously speculated that the large flocks of birds often found in the vicinity of Wharton Point may play a role in the fluctuations in bacterial levels at DMR stations J30 and J31.5, further down the bay. However, no evidence of this was observed during the course of the study.

Figure 3.7-7. Maquoit Bay

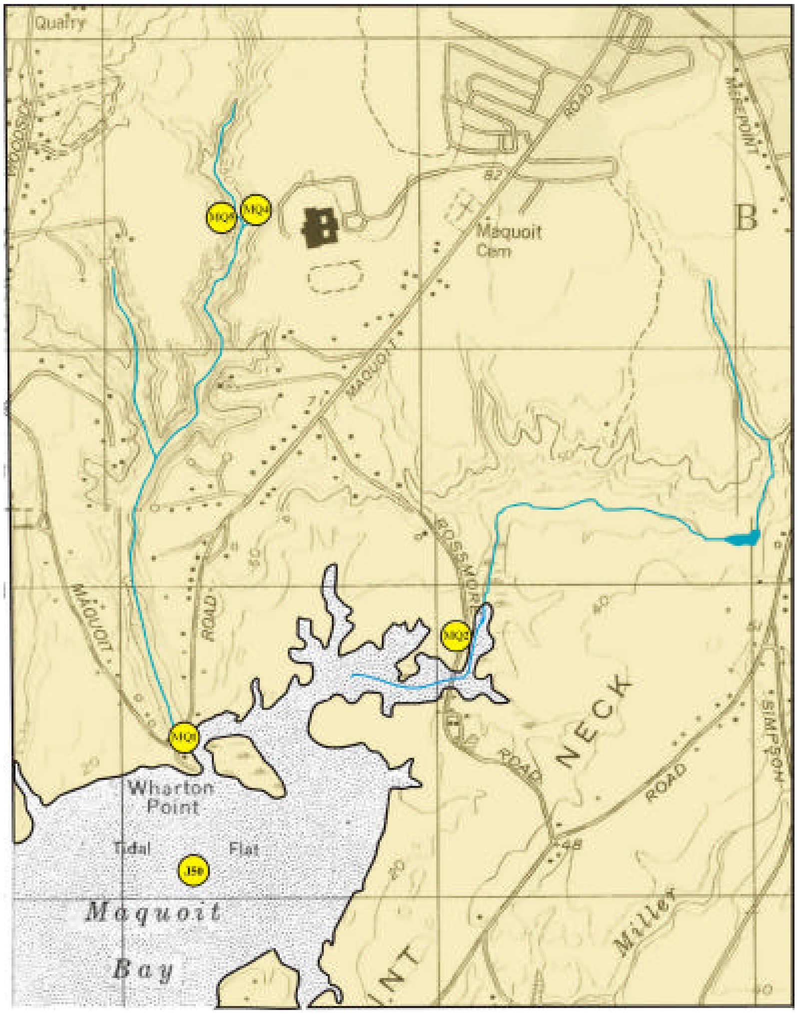


Table 3.7-13. Non-point source A-1 Fecal Coliform MPN Analysis by Date and Station in Maquoit Bay, Brunswick

Maquoit Bay

	1999		2000					2001												
Station	07/20	08/09	06/28	07/25	07/26	07/28	09/11	06/02	06/04	06/05	06/18	07/15	07/24	08/15	08/29	Geo Mean	Mean	Max	S.D.	90th
MQ 1	240	460	23	43		93	1101	1100	9.1	15	43	23	240	9.1	93	78.5	249.4	1101.0	368.4	600.7
MQ 2	23		23	460		120	93		93							79.5	135.3	460.0	149.7	297.5
MQ 4								1100		43	93	23	9.1	2.9	9.1	30.5	182.9	1100.0	375.5	306.2
MQ 5										15	3.6	3.6	2.9	7.3	3.6	5.0	6.0	15.0	4.3	10.3
J 33	2.9	3.6			2.9											3.1	3.1	3.6	0.3	3.6

Table 3.7-14. Summary of Maine DMR NSSP Sampling Station A-1 Fecal Coliform Analysis in Maquoit Bay, Brunswick, 1999-2002

Station	Geo. Mean	90^{th} Percentile	% >49	Number Samples
J 33	13.8	98.1	18.1	83

3.7.8 Bunganuc Stream

Bunganuc Stream drains a large watershed in the western section of Brunswick, west of Church Road. Most of the watershed remains undeveloped with residential development concentrated along Church Road running north-south and Pleasant Hill Road running east-west. The undeveloped area is predominantly forested, but a substantial number of pastures exist, most of which are hayed annually. Several farms exist along the Highland Road that forms the south and southwestern boundary of the watershed.

The aerial photograph (Figure 3.7-8) covers most of the Bunganuc Stream watershed from Bunganuc bluffs at the south and U.S. Route 1 at the north. Watercourses and water bodies are indicated as dark blue overlays.

Sampling stations were established at several strategic points along Bunganuc Stream. Station BS1 was located at the entrance of Bunganuc Stream to marine waters just above head of tide (Figures 3.7-9, 10). Station BS2 was located on the eastern side of Church Road at the end of the culvert crossing beneath Church Road and discharging storm water from the Highland Road. Stations BS3 and BS4 were located close to each other on the north side of Pleasant Hill Road where two tributaries of Bunganuc Stream cross the Pleasant Hill Road before converging into a single flow just south of the road. Station BS3 was located on the eastern, unnamed tributary of that drains the Growstown area; station BS4 was located on the western tributary that drains the northern and western portions of the upper watershed. In addition to the freshwater sampling stations, water samples were also collected at least once during the study at adjacent DMR monitoring stations J29, J30, J31, and J31.5.

As at other study sites where freshwater sources were sampled, fecal coliform bacteria levels consistently increased during or immediately following precipitation events of moderate to heavy rainfall (Tables 3.7-15,16). However, elevated bacteria levels were also found at nearly all study stations on at least one dry period sampling period. Fecal coliform bacteria levels rarely dropped below 23 MPN, even during dry periods, indicating a chronic low level of contamination. As a result, all study stations yielded geometric mean and 90th percentile MPN values that exceed the NSSP limits. DMR monitoring station J30, located immediately below the entrance of Bunganuc Stream to marine waters, also yielded MPN values exceeding the NSSP limits.

It is important to note that, during low water, water passing DMR station J30 is essentially undiluted Bunganuc Stream water, since the area drains complete at low water. Indeed, a review of the conductivity/salinity and fecal coliform bacteria MPN results for each date station J30 was sampled shows that elevated MPN values coincide with low salinities and, with a sole exception on 07/24/01, low MPN values are consistently found in association with high salinities (Table 3.7-17).

Data from DMR monitoring results at J30 show a similar association between elevated MPN levels and low salinity (refer to Appendix D). With the exception of one sample taken in September 2001 at 25 ppt and an exceptionally high temperature of 32ºC that yielded an MPN of 1200, all MPN values >43 recorded between 1999 and 2001 were associated with salinities below 20 ppt, suggesting that the elevated MPN values found at J30 may represent the bacterial condition of Bunganuc Stream rather than the marine waters over the growing area during most of the tide cycle. This may, however, be considered a moot point since it could be argued that Bunganuc Stream waters directly affect the shellfish growing area in the vicinity of station J30 at low water, but the suggestion seems to be supported by the results of DMR monitoring at stations J29 and J31, both of which are beyond the direct and immediate influence of Bunganuc Stream, where test results are well within the NSSP limits of acceptability. The close but slightly more elevated results at J31.5 may be a statistical artifact or an indication of an additional, intermittent source of bacteria affecting the immediate vicinity of the station.

The chronic contamination observed at station BS1 could be taken as an indication of a human source, specifically a failed domestic wastewater treatment system. However, although chronic, the levels of contamination during dry or low-flow periods appear too low to implicate a concentrated bacterial contamination source, such as a failed septic system; as previously stated, a failed septic system would result in a consistent discharge, regardless of precipitation. The study results, particularly the spikes in coliform bacteria levels associated with rain events, suggest runoff as a more likely source of the contamination. As previously mentioned, the watershed contains several farms and pastures, the latter fertilized with manure (pers. comm. Steve Walker, Town of Brunswick). Furthermore, as observed during a walking survey of the upper watershed area, the forested area of Bunganuc Stream provides habitat to a diverse and abundant wildlife population. The size of the watershed combined with the wide spectrum of possible sources of coliform bacteria contamination, of both human and non-human origin, makes it difficult, if not impossible, to definitively identify specific sources. This effort is further complicated by the reluctance of landowners in the watershed to grant access to their properties to determine specific watercourses and possible sources of contamination.

Conclusive determination of the sources of contamination would represent a substantial technical achievement, given the magnitude of the watershed and possible contamination sources. However, from a practical point of view, the effort required for specific source identification would likely prove to be too great relative to the shellfish resource affected in the comparatively small area currently closed to harvesting.

Figure 3.7-8. Aerial Photograph Montage Covering the Bunganuc Stream Watershed

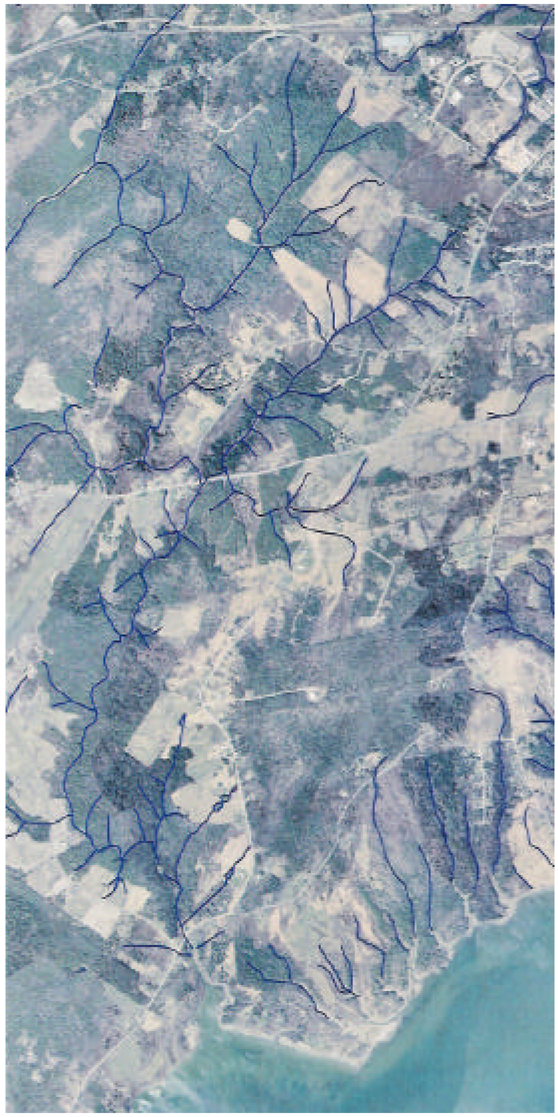


Figure 3.7-9. Bunganuc Stream

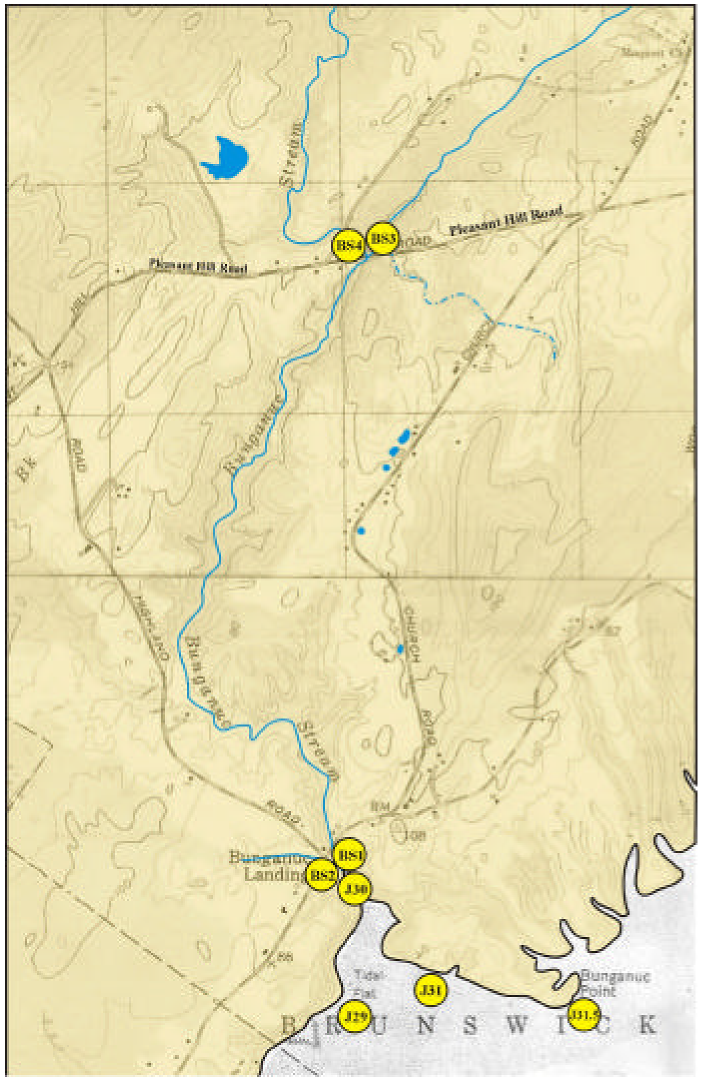


Figure 3.7-10. Bunganuc Stream Detail of Head of Tide

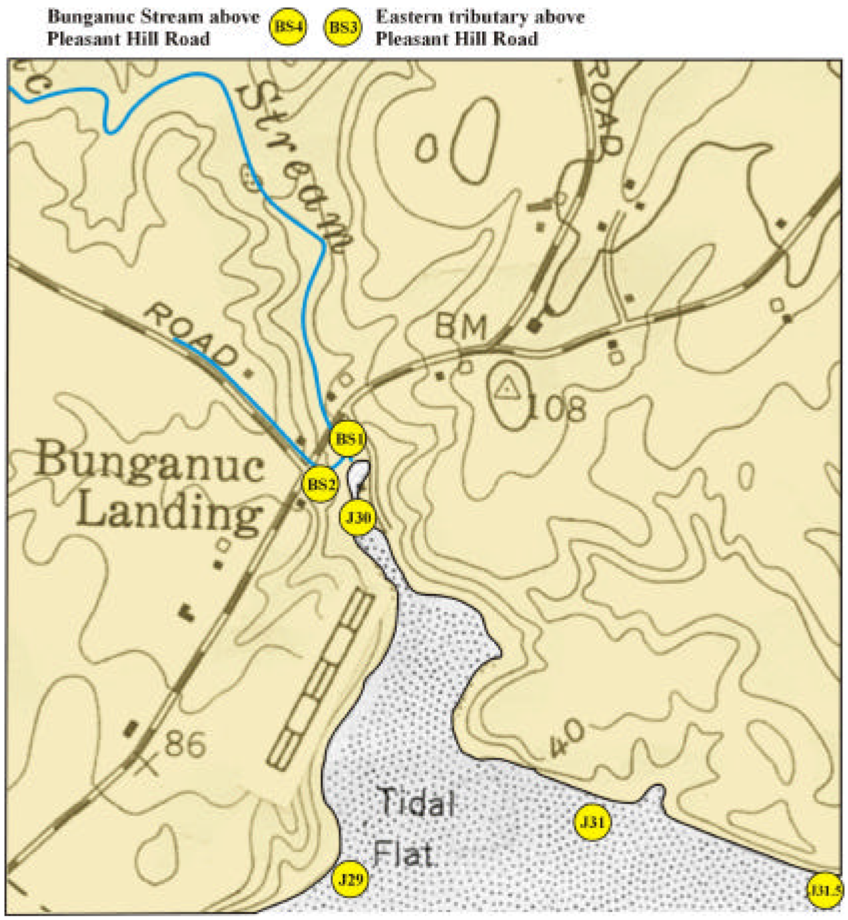


Table 3.7-15. Non-Point Source A-1 Fecal Coliform MPN Analysis by Date and Station in Bunganuc Stream, Brunswick

Bunganuc Stream

	1999		2000					2001													
Station	07/20	08/09	06/28	07/25	07/26	07/28	09/11	06/02	06/04	06/05	06/12	06/18	07/15	07/24	08/15	08/29	Geo Mean	Mean	Max	S.D.	90th
BS 1	460	240	3.6	43		240	43	1100	43	43	460	93	460	43	15	23	86.0	220.6	1100.0	288.5	596.2
BS 2								1100	240	150	240	93	43				183.4	311.0	1100.0	360.1	656.6
BS 3								1101		23	240	1100	240	43	240	43	170.4	378.8	1101.0	426.0	990.0
BS 4								1100		20	460	240	93	240	43	93	146.9	286.1	1100.0	335.7	692.6
J 29	2.9	3.6															3.2	3.3	3.6	0.4	3.7
J 30	7.3	15			2.9						460		1101	93	3.6	3.6	25.8	210.8	1101.0	392.3	426.3
J 31	2.9	9.1			2.9												4.2	5.0	9.1	2.9	8.5
J 31.5		2.9															2.9	2.9	2.9	0.0	2.9

Table 3.7-16. Summary of Maine DMR NSSP Sampling Station A-1 Fecal Coliform Analysis in Bunganuc Stream, Brunswick, 1999-2002

Station	Geo. Mean	90^{th} Percentile	% >49	Number samples
J 29	6.0	32.2	6.9	102
J 30	19.5	197.2	23.4	43
J 31	8.5	48.8	10.0	80
J 31.5	9.5	64.9	14.9	101

Table 3.7-17. Comparison of Conductivity/Salinity and Associated A1 Fecal Coliform Bacteria MPN Levels of Study Samples Taken at DMR Station J30

Date	Cond./[*sal (ppt)*]	A1 MPN
07/20/99	[*22.0*]	7.3
08/09/99	[*20.5*]	15
07/26/00	[*19.5*]	<3.0
06/12/01	2030	460
07/15/01	280	>1100
07/24/01	[*28.0*]	93
08/15/01	[*32.0*]	3.6
08/29/01	[*23.0*]	3.6

3.7.9 Pettingill Cove

Pettingill Cove is located at the northern end of the Harraseeket River and receives freshwater input from two primary sources, Kelsey Brook to the northeast and Mill Brook to the northwest. Mill Brook drains a large area north of Mast Landing between Pleasant Hill Road and I-95. Frost Gully, that drains the northern portion of Freeport's downtown area, runs into Mill Brook in the vicinity of Mast Landing. Kelsey Brook drains a large predominantly rural and agricultural area east of Pleasant Hill Road.

Stations ML3 and ML5 were established on Mill Brook and Frost Gully, respectively, just north of Pleasant Hill Road at Mast Landing; a Freeport sewage pumping station is located adjacent to station ML5. Station ML4 was located on Kelsey Brook just below the culvert crossing beneath Flying Point Road (Figure 3.7-11).

Sampling results for all three stations yielded geometric mean and 90th percentile MPN values well above the NSSP limits, all with very high maxima (Table 3.7-18). As observed elsewhere, elevated levels of fecal coliform were generally associated with rain events, but high levels were also found at ML5 during dry weather. Despite this, the geometric mean and 90th percentile MPN results from DMR station J14.2 are well below the NSSP limits for approved classification (Table 3.7-19), suggesting that the area could be opened to harvesting.

In view of the magnitude of the fecal coliform levels found in the study samples and the size and complexity of the watersheds draining into Pettingill Cove, the CBEP clam team decided to direct efforts elsewhere and the site was dropped from the study at the end of 2000.

Figure 3.7-11. Pettingill Cove

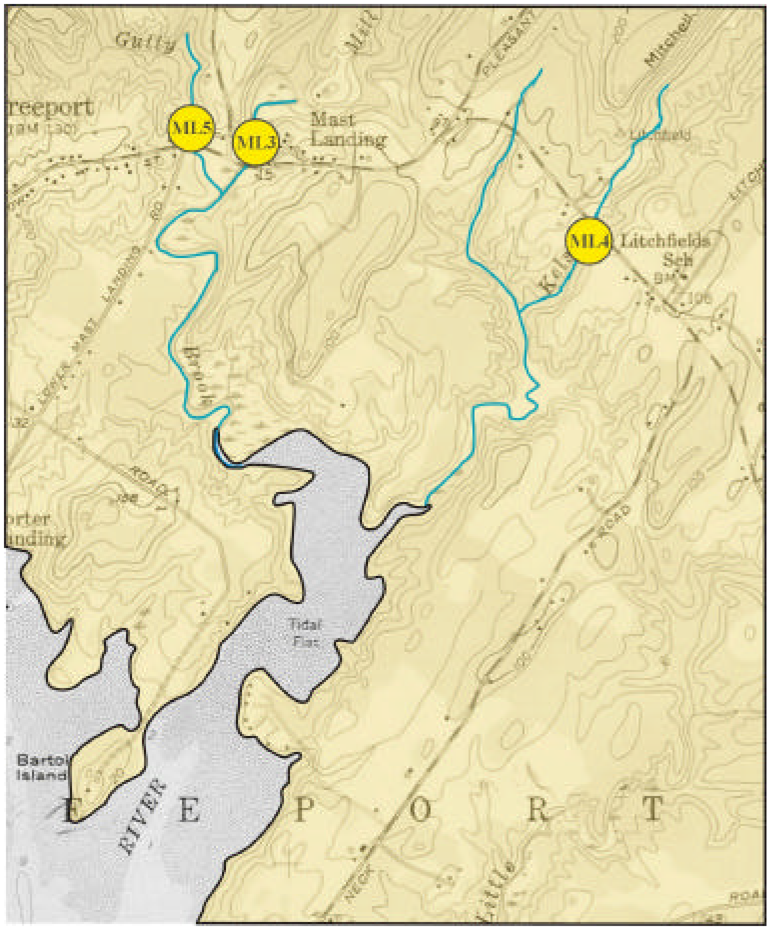


Table 3.7-18. Non-point Source A-1 Fecal Coliform MPN Analysis by Date and Station at Mast Landing/Kelsey Brook, Pettingill Cove, Freeport

Mast Landing/Kelsey Brook

	1999	2000								
Station	07/20	06/29	07/25	07/28	09/11	Geo Mean	Mean	Max	S.D.	90th
ML 3	460	23	43	1100	43	116.6	333.8	1100.0	416.8	815.3
ML 4	240	240	23	1100	23	127.4	325.2	1100.0	399.4	873.2
ML 5		23	43	150	1101	113.0	329.3	1101.0	448.2	749.1

Table 3.7-19. Summary of Maine DMR NSSP Sampling Station A-1 Fecal Coliform Analysis in Mast Landing/Kelsey Brook, Pettingill Cove Freeport, 1999-2002

Station	Geo. Mean	90th Percentile	% >49	Number samples
J14.2	5.2	18.2	5.0	40

3.7.10 Mussel Cove, Falmouth

Freshwater flow into Mussel Cove comes principally from Mill Creek that drains the area north of Mussel Cove, including the large area north and northwest of Interstate 95. Mill Creek, in turn, also receives flow from Chenery and Norton Brooks that drain the north and northeast sections of the watershed, along I-95 and U.S. Route 1, respectively. Additionally, an unnamed stream draining a small area of the watershed west and southwest of the cove joins Mill Creek just above Route 88.

Study station MC1 was located just south of the convergence of the unnamed stream entering from west and Mill Creek; stations MC2 and MC3 were located on Mill Creek and the unnamed stream, respectively. Station MC4 was located at the discharge of a small pond along the Lunt Road, just behind the McDonald's parking area. Station MC5 was located on Mill Creek just south of U.S. Route 1 where the creek runs under the highway; no station was located on Norton Brook because of the inability to access the entrance of Norton Brook into Mill Creek. In addition to the study stations, water samples were also collected at the head of tide DMR monitoring station I21 located immediately south of the Route 88 bridge over Mill Creek (Figure 3.7-12).

Mussel Cove was added as a study site in 2001 and consequently only one year of sampling data was collected. Again, as observed at all other freshwater input sites, elevated fecal coliform bacteria levels were consistently found during or immediately following precipitation events, although elevated levels were occasionally seen during dry periods, i.e. 08/15 and 08/29/01 (Table 3.7-20).

The results over the full study period indicate chronic, low level contamination, leading to geometric mean and 90th percentile fecal coliform MPN values exceeding the NSSP limits at all stations.

Precipitation event results, particularly those of 06/02/01 through 06/05/01, suggest runoff as a major contributor to the bacterial load. The results of the three-day sequential sampling of 06/02/01 through 06/05/01 following the nearly 3.2-inch precipitation event of 06/02, are particularly interesting. During, or immediately following the event, fecal coliform bacteria levels reached very high levels at all sampling stations. Within 48 hours the bacterial levels, although still elevated, had decreased substantially and continued to decline slightly over the next 24 hours. The suggestion of runoff as a major contributor to bacterial loading is made even more likely by the fact that most of the area within the immediate watershed is sewered and serviced by Falmouth’s Richard B. Goodenow Water Pollution Control Facility, sewer lines of which cross through the tidal marsh area just north of Route 88.

Similar to DMR station J30 in the Bunganuc Stream area, DMR station I21 is located the head of tide such that water collected at or near low water may be more representative of the bacterial condition of Mill Creek than the waters covering the shellfish growing area during most of the tide cycle. Sampling conducted at I21 as part of this study was usually done at low water and resulted in consistently elevated MPN levels yielding a geometric mean MPN of 77.5 and a 90th percentile MPN of nearly 511. Sampling by DMR at the station over a wider spectrum of tidal conditions, including numerous samplings at or near high water, yields an improved geometric mean MPN of 14.0 and a 90th percentile of 82.4, still exceeding the NSSP limit of 49 (Table 3.7-21). However, again similar to station J30, only three MPN values >93 were recorded between April 1999 and December 2002, the two highest values of 460 being associated with salinities <10 ppt. If these two anomalously high MPN values at low salinity are eliminated, the geometric mean MPN for the data set drops to 11.0 and the 90th percentile MPN to 44.6, both values within the NSSP acceptable limits. Nevertheless, as observed for station J30, this is probably a moot point since it could be argued that Mill Creek waters, whether fresh or brackish, directly affect the shellfish growing area in the vicinity of station I21 at low water, and given the observed bacteria level, pose an unacceptable risk to public health for the consumption of shellfish from the area.

The watershed drained by Mill Creek and its tributaries is large and this by itself makes identification of sources along its course difficult, at best. However, the immediate watershed surrounding Mussel Cove and its associated marsh is complex and includes large commercial areas with expansive impervious parking areas, residential areas, interstate highways, forested areas, and agriculture.

Figure 3.7-12. Mussel Cove, Falmouth

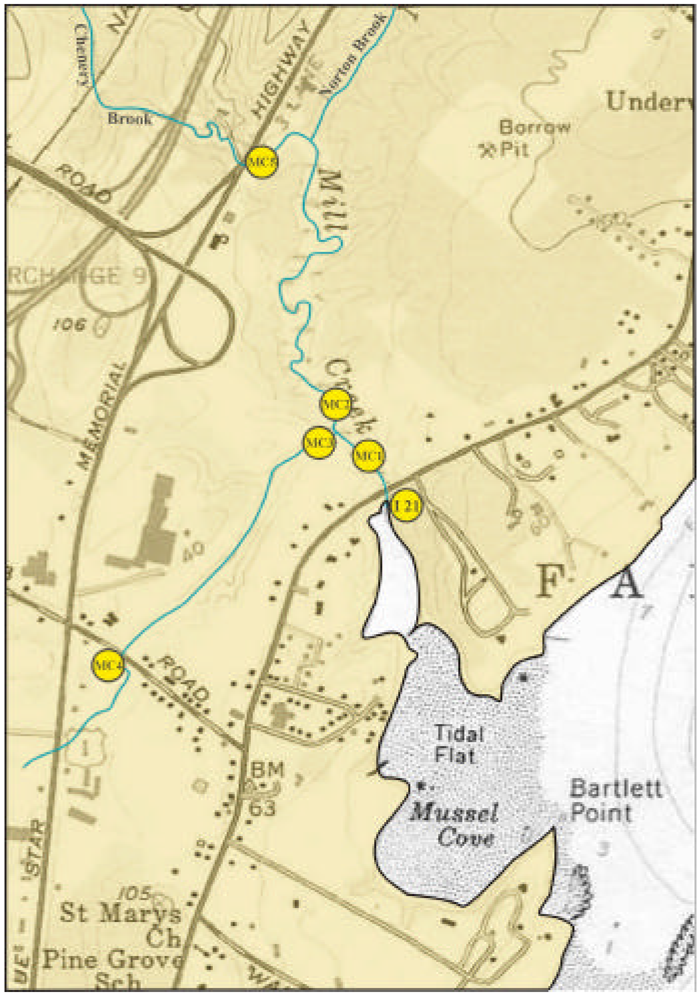


Table 3.7-20. Non-point Source A-1 Fecal Coliform MPN Analysis by Date and Station in Mussel Cove, Falmouth

Mussel Cove

	2001													
Station	**06/02**	**06/04**	**06/05**	**06/12**	**06/18**	**07/15**	**07/24**	**08/15**	**08/29**	**Geo Mean**	**Mean**	**Max**	**S.D.**	**90th**
I-21	**460**	**93**	**43**	**240**	**460**	**43**	**2.9**	**43**	**93**	**77.5**	**164.2**	**460.0**	**170.3**	**510.8**
MC-1		**43**	**23**	**1101**	**460**	**93**	**3.6**	**43**	**23**	**59.9**	**223.7**	**1101.0**	**360.0**	**519.5**
MC-2	**1100**	**93**	**43**	**460**	**1100**	**150**	**3.6**	**460**	**460**	**185.0**	**430.0**	**1100.0**	**397.8**	**1699.4**
MC-3	**240**	**23**	**23**	**460**	**460**	**240**		**43**	**240**	**126.7**	**216.1**	**460.0**	**167.8**	**589.6**
MC-4	**1100**		**75**		**460**					**336.1**	**545.0**	**1100.0**	**422.7**	**1406.9**
MC-5	**1100**		**75**		**460**					**336.1**	**545.0**	**1100.0**	**422.7**	**1406.9**
SMH-1		**43**								**43.0**	**43.0**	**43.0**	**0.0**	**43.0**

Table 3.7-21. Summary of Maine DMR NSSP Sampling Station A-1 Fecal Coliform Analysis in Mussel Cove, Falmouth, 1999-2002

Station	**Geo. Mean**	**90th Percentile**	**% >49**	**Number samples**
I 21	14.0	**82.4**	10.7	28

3.8 DISCUSSION AND CONCLUSIONS

Water quality monitoring, particularly the actual collection of water samples, is undoubtedly the most noticeable activity of the National Shellfish Sanitation Program's (NSSP) shellfish growing area classification process. Consequently, the public is under the general impression that water quality is the most important factor used in determining the safety, or conversely the risk, associated with the consumption of shellfish from a given area.

Water quality, specifically the amount of fecal coliform bacteria in the water, is indeed an important factor. However, according to the NSSP Model Ordinance (MO), the shoreline survey is as important as, and in some cases more important than, water quality in classifying shellfish growing areas.

Where water quality results indicate limited fecal coliform bacteria contamination and the shoreline survey reveals no potential threats of contamination, the adjacent shellfish areas can be opened. Where water quality is acceptable but the shoreline survey reveals the existence of potential contamination sources, the Authority, defined in the NSSP MO as "… the State or local control authority or authorities or its designated agents, which are responsible for the enforcement of [the NSSP] code," must evaluate the degree of risk posed by the source when initially classifying or subsequently re-classifying the area. In Maine the NSSP Authority is the Maine Department of Marine Resources.

During the course of this study, three of the study sites underwent re-evaluation by the DMR. Based on acceptable water quality results and its assessment of the shoreline survey observations, the DMR reclassified these three areas to either approved or seasonally- approved status. Middle Bay Cove in Brunswick was reclassified to approved status, allowing year-round harvesting, in September 1999. Ash Point Cove in Harpswell was also opened in September 1999, but is limited to seasonal fall-winter harvesting. Based on the 2002 shoreline survey, Round Cove in Phippsburg was opened to seasonal winter harvesting in late 2002.

In certain cases, despite acceptable water quality results, the Authority may determine that identified sources along the shoreline pose a sufficient risk of either actual or potential contamination to warrant closure of the shellfish area to harvesting. Such closures are often referred to as presumptive closure since the closure is based on the presumption that contamination from the potential sources may occur *unpredictably* at any time.

DMR considers licensed overboard discharge systems, regardless of whether they are operating properly or not, to constitute sufficient risk to warrant closure of adjacent shellfish areas to harvesting. The Sebasco/Round Cove, Sabino, Fosters Point, and Buttermilk Cove study sites of this project fall into this category of closure. Therefore, in order to open these areas to harvesting, the source(s) of contamination upon which the presumption of possible contamination is based must be removed before the area can be opened, even when water quality data indicate that no actual contamination exists.

The results of this study indicate that no serious contamination exists in the Sabino and Fosters Point areas and it seems reasonable to conclude that removal of the OBDs in these areas will result in the adjacent shellfish growing areas being opened to harvesting.

Similarly, the study results in the vicinity of Sebasco Harbor indicate that no actual serious contamination exists in the area. Nevertheless, for the area to be opened, the Sebasco Estates overboard discharge must be removed. However, even if the OBD were to be removed, the presence of a large number of vessels in Sebasco Harbor during the summer further complicates efforts to open the area.

According to the NSSP MO, a marina is defined as "… any water area with a structure (docks, basin, floating docks, etc.) which is: a) Used for docking or otherwise mooring vessels; and b) Constructed to provide temporary or permanent docking space for more than ten boats." Sebasco Harbor meets this definition based on available facilities and the number of vessels moored in Sebasco Harbor during the summer months.

Section IV 05 of the NSSP MO sets forth specific procedures for the classification of marinas and provides guidance for a dilution analysis to predict fecal coliform loading based on the volume of water in the vicinity of the marina, slip (mooring) occupancy, boat occupancy (minimum of 2 persons/boat), the number of vessels capable of discharging, and a specified discharge rate of 2x109 fecal coliform/person/day.

Counting of moorings, vessels, and a determination of occupancy are relatively simple matters. However, estimation of the volume of water in the vicinity of the marina could be very difficult, particularly given the diurnal tidal exchange and irregular topology of the bottom. To the best of our knowledge, no dilution analysis has been carried out for Sebasco Harbor.

Since the presence of the marina may prevent reclassification of the area as approved following removal of the Sebasco Estates OBD, if a decision is made to pursue the reclassification of Sebasco Harbor, we strongly urge that the impact of the marina be assessed prior to initiation of any removal efforts. We specifically recommend that data be collected on current velocities at Sebasco Harbor and that the volume of the harbor basin be estimated as the first steps towards the development of an accurate water volume/exchange estimate for use in a dilution analysis. Once a dilution analysis has been performed, the results should be evaluated to determine if removal of the Sebasco Estates OBD, which will undoubtedly be very expensive, is worth pursuing at this time.

Buttermilk Cove represents a rather unusual situation where fecal coliform contamination appears to be outside of the cove proper. The fact that the upper portion of the cove has been open to harvesting since December 1994, combined with the results of the sampling conducted as part of this study, indicate that the contamination detected at station L21 just below the Princes Point bridge originates either directly within the cove or outside the cove.

Previous shoreline surveys have not identified any specific source(s) of contamination other than the eight OBDs. Based on the absence of any other specific contamination source, it has been assumed that the levels of fecal coliform bacteria would drop to within acceptable limits following removal of the OBDs. Unfortunately, this has not been the case and it appears that, despite no source of fecal coliform bacteria having been identified in the past, a source other than the OBDs does exist.

Study sampling results, along with those of routine DMR monitoring, at stations L18, L19, and L 23 indicate that flow from the east into Buttermilk Cove is an unlikely source of bacterial contamination. On the other hand, as previously mentioned, the existence of a houseboat with questionable domestic waste disposal facilities in the area just southwest of Buttermilk Cove represents a very plausible source of contamination. We therefore recommend that two additional monitoring stations be established, either by DMR or the Town of Brunswick, south-southwest of Buttermilk Cove, the first midway between Doughty Point, Harpswell and the southwest entrance to Buttermilk Cove and the second in the immediate vicinity of the houseboat, if it still exists. Although the location of the first station can be fixed, the location of the sampling station in the vicinity of the houseboat should be flexible to allow sampling to be conducted immediately downcurrent of the houseboat according to the predominant tidal current direction at the time of sampling. We further recommend that a new shoreline survey be conducted to verify that no new sources of contamination have developed since the last survey was completed in 1994.

Determination of the source(s) of fecal coliform contamination affecting upper Maquoit Bay, Bunganuc Stream, Pettingill Cove, and Mussel Cove and their respective freshwater inputs have proven very difficult. In all cases the watersheds draining into these areas are large with complex land-use patterns. Runoff following precipitation events appears to be a major contributor to fecal coliform bacteria loading, although not exclusively. Furthermore, although human sources cannot be ruled out, wildlife and agricultural sources may play an important contributing role.

The NSSP does not discriminate between human and non-human sources, that is, any and all sources of fecal coliform are considered to pose equal threats to human health. Despite this, numerous efforts have been made over the years to identify a human-specific test to allow discrimination between human and non-human sources. For example, human wastewater discharges usually contain substances not normally found in nature, such as laundry and dishwashing detergents, bleaches, and antibiotic residues. More recently, advances in genetic testing has offered the possibility of tracing certain strains of bacteria back to species-specific sources, a process known as Microbial Source Tracking or MST. MST offers the possibility of eventually being able to compare the relative proportion of human and non-human bacteria in a population, thus allowing a determination of the relative risk posed by human sources.

A proposal was recently made to apply MST technology in two of the areas covered by this study, specifically Bunganuc Stream and Mussel Cove. Unfortunately, this project was not selected for funding and it may be some time before such an opportunity presents itself again. Nevertheless, based on the experience of this study, the Casco Bay Estuary Project may wish to encourage, indeed even advocate for, additional study to advance this very promising technology.

MST and similar technologies are very expensive and the extent to which they can be practically applied is therefore questionable, at least for the foreseeable future. Furthermore, until the NSSP accepts discrimination between fecal coliform sources, efforts in this direction may prove futile to the reclassification process. For the time being, then, magnitude of contamination, rather than specific source, remains the most important factor in reclassification.

As previously pointed out, we believe that the location of DMR stations I21 in Mussel Cove and J30 in Bunganuc Stream, by occasionally sampling input waters rather than growing area waters, may be resulting in an overestimation of the fecal coliform impacts on their respective shellfish growing areas. We recognize the need to monitor these locations and the usefulness of the data they generate. However, to determine whether these stations are representative of conditions affecting shellfish within the growing area proper, we recommend the establishment of at least one additional station at each location that might better reflect the bacterial levels over the growing areas during most of the tide cycle. In Mussel Cove the additional station could be located toward the center of the tidal flat in the area south of the constriction where DMR station L20 is located; such a location would likely require sampling by vessel. In Bunganuc Stream we recommend that an additional sampling station be located over the tidal flat some distance beyond where the narrow Bunganuc Stream inlet enters the broader tidal flat area. It is important to understand that these recommendations are not made for the simplistic purpose of improving the fecal coliform test results of the areas, but more pointedly to determine whether the current station locations are, in fact, resulting in an overestimation of impact to the shellfish growing areas.

With respect to Pettingill Cove, as previously stated, a review of the recent monitoring results for DMR station L14.2 indicates that the area's bacteriological water quality meets the NSSP requirements for approved status and the area could be opened to harvesting. However, if opened the area would probably fall under the conditional rainfall management plan that applies to the other shellfish harvesting areas of the Harraseeket River.

Finally, the results in Maquoit Bay are somewhat puzzling. Given the level of contamination from the input sources and the combined volumes of these sources relative to the volume of the receiving bay water in the middle of the bay where DMR station J33 is located, bacterial levels at J33 would be expected to be considerably lower than those found, if these freshwater sources were the sole sources impacting the station. Furthermore, as the detailed DMR sampling results indicate, several of the highest fecal coliform bacteria spikes are associated with high salinities at or near 30 ppt, indicating little influence from freshwater sources. This seems to suggest that sources internal to the bay, such as avian populations reported to frequent the area, may be a transient, intermittent source; as stated previously, however, no large flocks of birds were observed during the study.

The study areas selected for this project are the largest of the last remaining closed areas within Casco Bay. They are the last because they are the most difficult areas in which to identify contamination sources. In addition to the effort expended in all of these areas as part of this project, considerable prior effort has been applied to all by their respective municipalities, environmental organizations, such as Friends of Casco Bay, and the Maine DMR, working either independently or in association with each other. Yet despite all efforts, the sources remain elusive.

There were several compelling reasons that led to the decision to use the 3 tube/3 dilution Most Probable Number (MPN) method, or A-1 Multiple Tube Test, in this study. First, and most important, this is the method used by DMR under the NSSP for all monitoring. Therefore, use of this method would allow direct comparison of the study results with those of both prior and on-going DMR monitoring at adjacent stations. Second, DMR offered to process all samples taken as part of this study as part of their routine sampling program and therefore at no direct cost to the project. The decision to use this method proved correct on both counts and the participation of the DMR Water Quality Laboratory and its staff proved invaluable to the study.

In the interest of efficiency, sampling for the project was focused on summer sampling that represents the period when most contamination is expected. However, this period coincides with the DMR's most active sampling period. DMR's obligation to annually sample all approved shellfish growing areas to ensure these remain open to harvesting is the DMR water quality facility's highest priority and by itself places a substantial burden on the facility and its staff. Additional sampling to reclassify shellfish growing areas other than approved, such as that associated with this project, by necessity is of secondary priority, and any such sampling must be scheduled around the highest priority needs. The fact that sampling for this project would need to be scheduled around the laboratory's primary function was understood from the beginning, however, the impact of this when combined with other constraints was initially not obvious and consequently not fully appreciated.

Many, if not most, of DMR's routine monitoring stations are located near the shore and must therefore be sampled at high water. Consequently, nearly all high tide periods throughout the summer are blocked out for DMR sample processing leaving only the low tide periods for secondary priority sampling. This had little impact on sampling of the land-side input sources, however, since the shellfish growing areas being studied are all tidal areas, the allowable sampling schedule did not permit simultaneous sampling of input source and adjacent DMR monitoring stations to afford direct comparisons between the two.

An intense rainfall analysis was also originally proposed as part of the study that consisted of sequential sampling at 12-hour intervals over a 72-hour period beginning just before a major rain event and continuing up to 72 hours after the event. The purpose of this analysis was to attempt to discriminate between bacteria contamination originating from runoff and groundwater. Unfortunately, the lack of available sample processing space during most of the summer, the inability to predict rainfall events with any degree of certainty more than 48 hours prior to such events, and the requested 6- to 30-hour sample hold-time, combined to make it impossible to fully carry out this analysis as planned.

As compelling as the reasons were to used the A-1 Multiple Tube Test and the Maine DMR laboratory facilities, in view of the difficulties encountered with scheduling and the exacerbating constraints of time, use of a schedule-independent filtration method may have proven more effective in completing all of the intended sampling. Nevertheless, since the results of the A-1 Multiple Tube Test routinely used by DMR in monitoring are not directly comparable to filtration results, interpretation of these dissimilar method results would still have presented difficulties.

Regardless of the method used, the experience of this study further reinforces the difficulties and frustration associated with identifying bacterial contamination sources, particularly where large and/or complex watersheds are involved. This experience, therefore, lends further support to the argument that research towards the development of a new, more specific test to allow discrimination between human and non-human sources, such as MST, should be pursued, not simply for application in identifying bacterial contamination in waters affecting shellfish growing areas, but also drinking water and both freshwater and marine water bodies used for recreation.

4.0 SUSTAINABILITY

4.1 INTRODUCTION

This project has utilized a three-pronged approach to sustainable clam harvesting: Assessment, Remediation, and Management. Identifying important clam resources and the factors that keep areas closed to harvest has been a relatively straightforward exercise. Remediation has been more complicated, simply because of the array of stakeholders with varied interests and levels of commitment. The result of these two efforts, when successful, is an increase in the area available for harvest. These efforts are futile unless there is an effective management strategy in place to ensure continued harvest at a sustainable level, especially as landings continue to decrease. However, municipalities face conflicting goals in managing clam resources:

- Maximizing the number of licenses provides income to harvesters and revenue to the municipality but results in potential overuse of the resource.
- Detailed assessment data provides the municipality with the best grounds for determining license numbers but is expensive to secure and difficult to interpret, given the lack of definitive scientific information.
- Management techniques such as flat rotation, seeding and predator control should intuitively improve harvest, but site specific data are lacking.

Management techniques vary significantly between municipalities within Casco Bay and between regions within the State, as shown in Table 4.1-1, and when compared with methods used in Massachusetts and Canada.

Most communities in Maine with shellfish resources to protect have ordinances that define the responsibilities and goals of the Shellfish Committee, requirements of license holders, license fees and applicable state regulations. Most towns within Casco Bay do not restrict the amounts of clams that can be harvested per tide by commercial license holders; all towns do have limits on recreational diggers. The state size limit is consistent, 2 inches minimum, for all towns. Conservation time, required of most harvesters to obtain a commercial license, can involve assisting with resource surveys, re-seeding events, collecting water samples or other tasks deemed necessary by the Shellfish Committee. Provisions are set forth in all ordinances to allow for the revocation of licenses for any violation of that ordinance. Most shellfish management plans rely upon resource surveys that vary in extent and complexity depending on budgetary and volunteer resources.

4.1.2 Casco Bay Municipalities

Phippsburg

In northern Casco Bay, the town of Phippsburg has a very active shellfish committee and conservation program. They re-seed flats with hatchery and wild seed (some obtained from Brunswick, West Bath and/or Harpswell), rotate open and closed areas, and require harvesters to participate in these activities to be eligible for a town license. Numbers of licenses are issued based on resource estimates with priority given to harvesters who have held licenses previously and who have completed all conservation requirements. Under the leadership of a few key people, the Shellfish Committee meets monthly to discuss local issues. Phippsburg has successfully worked with property owners and state regulators to eliminate many pollution sources affecting the clamflats. These efforts

Table 4.1-1. Summary of Conservation Measures for Towns Bordering Casco Bay

Town	Paid staff	Equipment	2002 Licenses		License Fees*		Harvest Limit		Harvest Period	Conservation Time (hours)	Habitat Enhancement		
			C	R	Commercial R/NR/S	Recreational R/NR/D	C**	R***			Re-seeding	Flat Rotation	Separated into C and R?
Phippsburg	1 SFW		35	425	$150/ $300/$35	$15/$20	None	1/day	Year-round	12	Yes	Yes	No
West Bath	1 SFW		29		$200/$400/NA	$15/$15	None	1/day	Year-round	12	Yes	Yes	No
Brunswick	4 SFW +1 NRP	Boat	83	159	$100/$200/NA	$15/$30	None	1/tide	Year-round	None	Yes	Yes	No
Harpswell	1 SFW + 1 WQ		85	430	$200/$400/NA	$10/$20/NA	None	2/tide	Year-round	12 hrs	Yes	Yes	No
Freeport	1 SFW/ WQ		55	180	$200/$400/NA	$10/$20	None	1/tide	Year-round	8	Yes	Yes	No
Yarmouth	2 SFW		8	302	$200/$400/NA	$20/30/na	None	1/day	Year-round	8	Yes	Yes	Yes
Cumberland	3 SFW		11	308	$50/$100/NA	$15/$30/$5	1.5 bu /tide	1/tide	2 mo – C 10 mo – R	10 (voluntary)	No	Yes	No
Falmouth	1 SFW		0	165	NA/NA/NA	$15/$30	None	1/day	Year-round	None	No	No	No

***** Cumberland offers monthly ($10, resident; $20, nonresident) and daily ($5, resident and nonresident) licenses; commercial licenses are commercial status for only two months then become recreational licenses for 10 months; Brunswick offers daily licenses ($5) to nonresidents.
****** Bushels per day
******* Pecks per tide unless otherwise noted

SFW = Shellfish Warden
NRP = Natural Resource Planner
WQ = Water Quality Monitor
SPC = Shellfish Program Coordinator
NA = Not available

Licenses: **C** = Commercial **R** = Recreational

Fees: **R** = Resident **NR** = Nonresident **S** = Student **D** = Daily

Data sources: Summary of Town Ordinances DMR, 1998
Town Ordinances
Personal Communications

have resulted in the opening of flats that had been closed for many years, such as at Brighams Cove and Drummore Bay. The Committee continues to work aggressively to open remaining areas within the town, conducting the necessary shoreline surveys, collecting water quality samples and working to remove OBDs. Currently there are eleven active OBDs in Phippsburg (MDEP listing 6/25/03) seven are on the New Meadows River affecting the shoreline north of the Basin, at Sabasco Harbor, and at Carrying Place Head.

West Bath

The West Bath Marine Resources Board is composed of members appointed by the Town Selectmen and oversees the Shellfish Conservation Program. Twelve hours of conservation time is required by the Marine Resource Conservation Ordinance, five of those hours must be applied to re-seeding efforts. Re-seeding constitutes a major part of the conservation portion of the West Bath shellfish program and various techniques have been tried. Generally, they have found that broadcasting seed clams (2 inches or smaller) over tilled flats on incoming tides has proven to be the most successful. Re-seeding events can occur three or four times a year and have taken place for the past eight to ten years. Seed clams are harvested from various flats within the Town and relocated to less productive flats, or heavily dug areas. Newly seeded flats remain closed until the seed reaches harvestable size. The Marine Resources Board surveys one-third of the Town’s flats each year and the number of licenses issued (Table 4.1-1) is based on information gathered during those surveys and first-hand knowledge of the health of the flats. Support of the Selectmen, funding, enforcement of ordinance rules, and obstacles to removing remaining OBDs (15) continue to be challenges for the West Bath Marine Resources Board.

Brunswick

The Brunswick shellfish industry is overseen by a seven-member Marine Resource Committee and is regulated by a municipally funded program that supports a Natural Resource Planner, two Shellfish Wardens and a Marine Patrol boat. Tools used to manage its flats include re-seeding with wild seed, flat rotation, predator control, seasonal closures, intensive resource surveys and enforcement. The number of licenses issued is determined from the data collected from surveys and will vary year to year depending on the abundance of the resource. All of the flats are surveyed each year, types of data collected include growth rates, potential yield, estimate of standing crop, sources of pollution, community level use of the resource, and natural predation effects. Brunswick continues to work on water quality issues and pollution abatement. Remaining problems include OBDs, non-point source pollution (NPS), and a houseboat with a questionable disposal system. Six licensed OBDs were identified in the initial phase of the project as targets for removal. Five were located in the Buttermilk Cove/Gurnet area and all have been removed. A shoreline survey and further investigation into NPS from upstream of Buttermilk Cove is needed before this twenty-five-acre flat could be opened for harvest (see Section 3.0). One OBD remains in Bunganuc Cove. This closure is also associated with NPS originating upstream from the OBD location and further investigation is needed in this area. In Middle Bay, improved WQ and completed shoreline surveys allowed the DMR to reduce the size of the closure, opening over 100 acres for harvest.

Harpswell

The shellfish management program in Harpswell is quite similar in many ways to the program in Brunswick. The Town supports two full time Shellfish Wardens and also partially funds a position for shoreline surveys and water quality monitoring. The Shellfish Ordinance defines as a duty of the seven-member Marine Resources Committee to survey all flats and maintain current information determining size frequency, growth rates, potential yield, pollution sources, green crab predation and mussel competition. One-third of their flats are surveyed each year and the number of licenses issued result from the information collected during those surveys. Conservation time (12 hours or two tides) is required to obtain a commercial town license. Conservation time may include surveys or collecting wild seed from productive, closed or slow-growing areas and subsequent transplanting into more suitable areas for future harvest. Harpswell has removed several OBDs, continues to collect water quality samples, facilitates OBD removal and is working toward completing shoreline surveys to open more areas to harvesting. The number of miles of shoreline within the town remains as the biggest obstacle to completing all of the shoreline surveys and water quality sampling needed to get more acreage open. Assistance from staff of the DMR has allowed for reclassification of several areas including Ash Point Cove, Orrs Cove, and Upper Basin Cove.

Freeport

The Town of Freeport manages its shellfish resources by a seven-member Shellfish Conservation Commission with one full time Shellfish Warden/Water Quality Specialist. Two additional police officers serve as reserve wardens and also help with water quality sampling as needed. The position of Shellfish Program Coordinator was not renewed upon the departure of the first coordinator. Licenses are issued by the town and do not limit the amount of clams a Resident or Non-Resident Commercial harvester can take during one tide; Recreational diggers are restricted to one peck per day. Licenses are not required to dig at the State Park, but the one-peck per day limit applies. Commercial license holders are required to complete eight hours of conservation time, four hours of which are to be applied to clamflat surveys. Resource surveys are coordinated by the Shellfish Committee Chair, and the data is forwarded to the Area Biologist. The Biologist then makes recommendations to the Commission regarding numbers of licenses, conservation closures and other measures to protect the resource. The number of licenses issued is more dependent on the number of returning commercial license applicants, the number is reduced by attrition of diggers, not necessarily based on the survey data. Prior to the beginning of this project the Town’s Shellfish Program Coordinator was successful in removing all OBDs affecting shellfish beds. Through his efforts, and by decree of the Town, monies from the MDEP OBD Removal Program, 99% of the 1,200 acres of clam flats were opened to harvesting. The remaining closure is in the upper Harraseeket River, (See Section 3.0) adjacent to the Wastewater Treatment Plant (WWTP) and to an agricultural operation that is now conducting Best Management Practices. The lower portion of the River has been reclassified to Conditionally Approved status. Because all OBDs have been removed, the biggest challenge facing the continued success of the Freeport Shellfish Conservation Commission are ongoing issues with the Waste Water Treatment Plant. The Town and the Plant are sponsoring an engineering study to explore the possibility of removing the discharge from the River by relocating the entire operation to a site that could support a lagoon type system. As the Plant is privately owned and not staffed on a 24 hour basis, malfunctions continue to cause frequent closures. The Town has been very supportive of the Shellfish Commission, providing funding for the committee, enforcement, and the engineering studies for the WWTP relocation project.

Yarmouth/North Yarmouth

The Shellfish Committee of Yarmouth/North Yarmouth has ten members and supports one full time and one part-time Shellfish Warden. Only eight Commercial Licenses were issued in 2002, while just over 300 Recreational Licenses were sold (Table 4.1-1). Commercial digging is restricted to certain flats while recreational digging is allowed in all open areas. Conservation closures are rotated as needed to conserve the resources, and re-seeding and enhancement projects occur most years. Eight hours of conservation time is required for commercial license renewal, four of those hours must be credited to resource survey time. Enforcement of the Ordinance is the responsibility of the Shellfish Wardens, whose duties also include water quality sampling. Most of the shoreline in Yarmouth is open, at least conditionally, with exception of the areas around the WWTP in the Royal River, a community discharge system on Cousins Island, several OBDs on the southern end of Littlejohn Island, and the upper Cousins River. The Town of Yarmouth has been unsupportive of the Shellfish Committee in efforts to remove OBDs on Littlejohn Island. The Committee Chair will be seeking assistance directly from the MDEP on this issue. Also of concern to the Committee is shoreline erosion and lack of enforcement on shoreline clearing. Enforcement of the Ordinance, town funding and support, and staff shortages continue to be the biggest challenges for the Yarmouth/North Yarmouth Shellfish Committee.

Cumberland

Shellfish resources in the Town of Cumberland, are managed by a five member Shellfish Conservation Committee, using a combination of harvest limits and closure periods. The Shellfish Conservation Ordinance limits a Commercial License holder to 1.5 bushels of clams per tide and a Commercial License is good for two months only. The license holder chooses which two months she/he wishes to dig commercially; the license is valid for recreational digging (one peck per tide limit) for the remaining ten months of the year. One-month Recreational Licenses are offered for the months of June, July, August, September and October. Participation in ten or more hours of Shellfish Conservation Commission activities assure a person of a Commercial or Recreational License for the following year, based on the availability of Commercial Licenses. The number of licenses issued is based on estimates of the resource, determined from the data collected during annual resource surveys. Harvesting is restricted in areas of eel grass (*Zostera marina*) in an effort to protect shoreline stability and valuable nursery habitat. No seeding of the flats occurs in Cumberland; most conservation effort is being placed in enforcement. A full time Shellfish Warden and the Chief of Police are authorized to enforce the restrictions set forth in the Ordinance. Currently, the mainland shoreline of Cumberland is open to digging; closures remain on Great Chebeague Island around an OBD in Chandler Cove, and on the eastern shoreline due to failing septic systems. Involvement and commitment from the Town could help to correct these issues.

Falmouth

The Shellfish Conservation Program in Falmouth is managed by the Shellfish Conservation Commission whose members are appointed by the town council for terms of three years. Falmouth regulates its shellfish resources with a Shellfish Conservation Ordinance, offering Recreational Licenses only, for the months of November through April, and allowing for no more than one peck per day to be taken. A Shellfish Conservation Warden and the Falmouth Police are authorized to enforce the Ordinance that is overseen by the five-member Commission. The number of licenses issued each year is based on estimates of the resource made during annual surveys. As there are no OBDs affecting clam flats within the town, most of the closed area is due to three large anchorages along the shoreline of Falmouth Foreside, resulting in a large seasonal conditionally approved area. This is the primary area for digging. These flats and the flats in the Presumpscot River, which are open only to depuration digging, due, in part, to the presence of the Waste Water Treatment Plant (WWTP), are areas that would require the unlikely removal of the anchorages and the WWTP and significant improvement in water quality to be reclassified as open to harvesting. The Shellfish Commission feels that because the resources are low to moderate, the current status is acceptable.

Long Island

Shoreline surveys and water quality sampling on Long Island were conducted and identified several sources of pollution keeping most of the shoreline closed to shellfish harvesting. Several malfunctioning septic systems and OBDs are the source of consistently poor water quality on the island. Provisions enacted by the Town stipulate that all systems must meet current codes when properties change ownership. This policy has resulted in several improvements, but many more need to be upgraded. Additional stations for water quality sampling were added in recent years to better cover the shellfish habitat, which is primarily on the northwest corner of the island, and is the only portion of the Long Island shoreline not classified as “Prohibited.” The soft-shell clam resources on the island are moderate to low, but would support recreational digging. No town ordinance exists at this time and resources to enforce discharge violations are minimal. Financial and regulatory assistance for OBD removal and system upgrades, as well as local interest and support are needed to correct the remaining failing systems.

Portland

A Shellfish Ordinance for the City of Portland was completed and plans to form a Shellfish Committee were made in 1996 in anticipation of a reclassification of the shoreline on some of the outer islands. Local interest to open flats on the islands triggered a Casco Bay Estuary Project funded study in 1996, which inventoried the soft-shell clam resource, reviewed water quality data and conducted shoreline surveys to identify sources of pollution on Peaks, Cliff and Great and Little Diamond Islands. Although resources were generally low to moderate, the inventory indicated that these areas could support limited recreational digging. There were also concerns of contaminants in the tissues of clams and mussels. As a result, the State Bureau of Health and Environmental Toxicology Program conducted a human health assessment of the mussel contaminant data collected from Casco Bay (Interdepartmental Memorandum October 27, 1999). The results of the assessment indicated high levels of lead were present in some samples, triggering concerns over human health risks from consumption. Efforts to open the flats have been tabled until these issues are resolved. Water quality sampling by the DMR in Portland including the islands has also been suspended. All intertidal habitat remains classified as Prohibited.

4.1.3 Other Communities

South of Casco Bay, soft-shell clam resources and conservation programs vary, as do town support and the amounts of the resource (Normandeau Associates, Inc. et al. 1999). Many of the communities south of Casco Bay have more limited resources and manage their clam flats by allowing only recreational digging. Several towns also limit the time of year that harvests can occur. Wells is the only remaining southern Maine town that raises seed clams for restocking their flats with seed obtained from the Beals Island Regional Hatchery. The Town of Kennebunkport had operated a growing facility with seed and some equipment supplied from Spinney Creek Shellfish, which has since terminated the hatchery portion of their business. The Town of Kennebunk has recently joined the shellfish management program and issues only recreational licenses. Biddeford will issue three commercial licenses in 2004 as a result of one large area being reclassified to conditionally open. The Town of Scarborough continues to successfully manage its very productive flats through several measures such as conservation, limiting licenses, flat rotation, raising seed clams, citizen involvement, and education.

4.1.4 Regional Management Schemes

The Maine Soft-Shell Clam Advisory Committee (MSCAC) was formed in 1997 to serve in an advisory capacity to shellfish committees, harvesters, dealers, and regulators throughout the State to assist in resolving local and statewide issues and to aid in the formulation and passage of new legislation. The council faces several challenges to statewide participation, including geography, and disparity between regions. Perhaps the biggest obstacle facing the Council is the distance from Kittery to Eastport, making getting to the meetings difficult for some who would have to travel several hours to attend. Differences in forms of town government, in population, and in financial resources, as well as in soft-shell clam resources and a strong sense of ownership in local resources, also contribute to low numbers of attendees at the bi-monthly meetings. The initial topic of concern with shellfish harvesters and dealers was depuration digging. The Council did facilitate several discussions, and was successful in passing new legislation to regulate this new industry. Since then, there have been few issues on a statewide level to sustain the initial momentum of the Council. The MSCAC has also developed, introduced and passed a bill to decriminalize violations of shellfish ordinances. Another bill that would work to create markets for green crabs, a heavy predator on soft-shell clams, has also been introduced to the Legislature through the Council.

Plans to form three regional sub-committees have been unsuccessful as interest and energy has waned. In southern Maine, the York County Shellfish Council disbanded after less than one year, after the issues with depuration digging were resolved. Neither a northern, nor a mid-coast Maine council ever organized. Three organizations have continued and have been successful in varying degrees, The Casco Bay Regional Shellfish Committee, The Georges River Clam Project and the Cobscook Bay Clam Project, now part of the Cobscook Bay Resource Center. All three continue to address issues surrounding the soft-shell clam industry on a more “intra-local” level.

The Casco Bay Regional Shellfish Committee

The Casco Bay Regional Shellfish Committee meets monthly to discuss local issues concerning the clam resources in the communities surrounding Casco Bay. Similar to the MSSCAC, the Casco Bay Committee meetings generally have low member turnout. Unless a topic of concern, such as the depuration digging issue, raises enough awareness among the harvesters or dealers, few attend or participate in the meetings. Issues typically discussed include methods of resource assessment, transplanting, water quality monitoring, compliance, and law enforcement. A small core group, comprised of the Committee Chair, the DMR Area Biologist, two Shellfish Wardens, and a few harvesters, generally constituting a quorum, are regular attendees. Suggestions have been presented for the committee to consider meeting less frequently and also to schedule speakers on various topics, in an effort to promote increased interest and participation.

Development of a Management Plan on a regional level, as opposed to individual municipal management, has not progressed as past history has proved this not to be a successful endeavor. A regional committee was formed in the late 1940’s to manage the quahog, or hard shell clam (*Mercenaria mercenaria*) fishery. Credited with several successes, this group remained in effect for nearly twenty years, disbanding when the populations of quahogs declined and the fishery all but disappeared. As the numbers of quahogs declined, the numbers of soft-shell clams increased, and a regional council was formed to address the issues of this species in 1978. The council was comprised of members from the towns of Brunswick, Harpswell, and West Bath. This council was not as successful as the first and dissolved in 1994. Perhaps the biggest reason for this dissolution was the strong sense of ownership each community has towards its clam resources and the unwillingness to relinquish any control over those resources to others, particularly as resources became scarce. This sentiment remains strong today. Three of the Casco Bay communities have agreements for seed clam harvesting/exchange; all other management activities are independently run.

The success of any future attempt at regional management by the CBRSC, will rest on the acceptance of and respect for the strong sense of ownership felt by each of the participating towns. The focus of a regional council should be on issues of broader rather than specific concern, with consideration given to ways in which municipalities could share the financial burdens of the most expensive management activities such as law enforcement and enhancement. A regional Casco Bay Council could perhaps seek outside funding through State, Federal, and/or foundation grant programs to support these activities.

The Georges River Project

The Georges River Project in mid-coast Maine, was the first interlocal collaborative approach to clam management in the State*.* The Georges River Clammers Association worked to formalize the Interlocal Agreement in 1996, in anticipation of a major reclassification of the many acres of flats within the towns bordering the River. The flats were re-opened to harvesting in 1998 after the removal of a wastewater treatment plant and other pollution abatement measures were completed. Since then, the Georges River five-town collaborative has ranked first or second statewide in total number of bushels harvested. The Project supports 128 licenses and brings approximately $2 million dollars into the local economy. The seven year old organization continues to operate under the original agreement, with reciprocal licenses between the towns, shared administrative, equipment and enforcement costs, equal representation on the Shellfish Management Committee and shared responsibility of managing the flats as an ecological unit. “The fox is guarding the henhouse and the hens are doing well” (Sherman Hoyt Fisheries Outreach coordinator, Sea Grant/University of Maine Cooperative Extension, personal communication). This program could serve as a model for other regional or “intra-local” management teams.

The Cobscook Regional Clam Project

The northern region of the State continues to experience declining softshell clam resources, a trend begun in the early 1970s. The Cobscook Regional Clam Project was formed in 1996 to develop interest and methods of restoring clams to the region. The original focus was on improving the health of the Bay through improving water quality; point and non-point source pollution abatement; increasing productivity of the flats; creating regional management for the Bay’s resources and increasing access to resource management education. The group has since grown into the Cobscook Bay Resources Center providing information on clams, as well as other species of shellfish, finfish, phytoplankton, water quality, and currents and circulation within the Bay. Through the Resource Center, the Cobscook Bay Fisherman’s Association was formed to address the needs of all commercial fisheries issues. The marine resources are managed from a ecosystem perspective with equal weight given to all species. This approach to resource management has worked well as most of the commercial fishermen hold multiple gear type licenses and therefore have a stake in conservation, enhancement, and sustainability of more than one species. The soft-shell clam industry has suffered declines in productivity due to several factors. Substantial increase in the areal coverage of two marine algae species, sea lettuce (*Ulva lactuca*) and “green slime” (*Enteromorpha* spp.) on previously productive flats, has prevented spat settlement, reduced or eliminated the ability of the clams to feed, and has caused sediments to become anoxic. In addition, recent mild winters have resulted in explosions of green crab (*Carcinus maenus*) populations, known to be voracious feeders of young soft-shell clams, contributing further to the decline in clam stocks. (The harsh winter of 2002/2003 appears to have had an adverse affect on the green crab population, as draggers reported large numbers of dead crabs in their nets, not previously noted.) As clam resources continue to decrease, so have the numbers of harvesters and the interest to continue with enhancement, or sustainability projects. All reciprocating harvesting agreements between the nine towns surrounding the Bay and the Passamoquoddy Tribe, have dissolved. The focus of most shellfish resource management in the Cobscook Bay region has shifted from soft-shell clams to scallops. (Will Hopkins, Executive Director, Cobscook Bay Resources Center, personal communication)

Other Maine Projects

Just south of Cobscook Bay, in Beals, local harvesters and scientists from the Down East Institute for Applied Marine Research and Education, created the first “clam farm” in the State, with an experimental aquaculture lease from the DMR. Seven “farmers” planted over 75,000 quarter-inch clams in 216 ft^2 plots. The plots were covered with protective netting and will be tended just as one would tend a garden until the crop reaches harvestable size, expected to be in October of 2005. The project was funded through a National Science Foundation grant and is a joint venture between the Institute and the Town (*Bangor Daily News*, 2003). If this initial farm experiment is successful, additional farms could become a means of supplementing the natural stocks of soft-shell clams.

Massachusetts

Management of the soft-shell clam resources in Massachusetts is primarily controlled by the State which conducts all water quality sampling and determines all closure areas. Each town determines the numbers of commercial and recreational permits issued each year and has a shellfish constable and a Department of Natural Resources staff member to oversee their shellfish program. Commercial harvesters must acquire both a State permit and a town permit from the municipality in which they want to dig. There are no prerequisites to obtain a commercial permit and the number of permits issued by a town is somewhat arbitrarily determined. The State will conduct standing crop surveys at the town’s request but these are not routinely conducted. Recreational diggers are also required to obtain a town permit; these permits generally limit the quantity of clams a digger can take. Concerns of the State managers are the lack of conservation and management plans, and enforcement on the local level. The fishery has been in decline for over 20 years, perhaps attributable to a combination of factors including: over fishing, resistance to more regulations and limits on harvesting, increased pollution, and disease (David Whitaker, Aquatic Biologist/Shellfish Program, MA Division of Marine Fisheries, personal communication) Local shellfish committees such as those that exist in Maine could develop similar type town shellfish ordinances to help protect the resources at the local level.

Canada

The soft-shell clam fishing industry has been an important part of the Nova Scotia economy just as in many coastal Maine communities. Concerns regarding unrestricted access to shellfish resources were raised in the early 1900s by people in the clam industry who relied on those resources as the primary source of income. In 1996, the Federal Department of Fisheries and Oceans Canada (DFO) and local harvesters implemented a plan to make new management tools and enhancement efforts work more effectively by restricting access into the fishery. The shellfish resources in the Southwest Nova Scotia/Bay of Fundy region are managed jointly by the DFO and local harvesting associations who work to ensure sustainable harvests. From this group, the Soft-shell Clam Advisory Committee was established to provide advice to the DFO on management issues within Southwest Nova Scotia (SWNS). This area has been divided into three Clam Harvesting Areas (CHA) to better manage harvesting activities. All commercial diggers must obtain an Inshore Clam License, which restricts the holder to the specified CHA. Recreational diggers are not required to purchase a license. Conservation closures, minimum size limits, restricted times of harvesting and limiting access into the soft-shell clam fishery are the most significant measures of managing the resource used in SWNS (Soft-Shell Clam Conservation Harvesting Plan Southwest Nova Scotia 2003, Fisheries and Oceans Canada). The biggest continuing challenges are the illegal harvesting by licensed and un-licensed diggers, issues with depuration harvesters, and funding to support local and regional management committees (Martin Kaye, Manager, Bay of Fundy Marine Resource Center, personal communication).

4.2 RESOURCE ASSESSMENT EVALUATION

4.2.1 Introduction

The management techniques and tools in Section 4.1 are not applied in a standardized manner, each town applying only those that are best suited to their individual situation. Most towns having substantial soft-shell clam resources, however, do use license limitation, also termed “limited-entry,” as a measure to control resource exploitation and often carry out seeding efforts to enhance the resource where depleted through harvesting or as a result of some natural event or cycle. Unfortunately, both measures have proven problematic at one time or another and have consequently been the focus of controversy.

License limitation is usually tied to the available resource, that is, the number of licenses issued is based on an estimate of the average harvester’s annual take and the amount of available resource. Annual harvester take is determined based on interviews with harvesters, observations of daily harvests by marine patrol officers, the average number of harvest days, and harvester efficiency. Standing stock is estimated from annual population surveys that usually cover approximately one third of the harvestable area in a given town. For example, if the average harvester’s annual take is estimated at 200 bushels/year and the estimated standing harvestable stock for the year is 14,000 bushels, the town would set the number of licenses to be issued at 70.

As sensible as resource-based limited entry may appear, many towns have found this measure difficult to apply because of the cost involved in hiring outside consultants to carry out the surveys or the time required to survey the flats if carried out by municipal officials. To avoid these, several towns require their harvesters to carry out surveys as part of a “conservation time” requirement applied to the annual renewal of their town-issued commercial harvesting licenses. In this case, however, the harvesters must give up at least one day of harvesting to conduct a survey at low water, a day that could end up costing them several hundreds of dollars depending on the season.

Recognizing the difficulties associated with mandatory resource surveys, the Maine Soft-shell Clam Advisory Council (MSCAC), which serves in an advisory capacity to the Maine Department of Marine Resources, recommended that resource surveys no longer be required by the DMR for towns to be in compliance with the Department’s Soft-shell Clam Program. In addition, the MSCAC recommended that studies be conducted to determine if a simpler, alternative method to the standardized systematic-random survey method could be developed that would yield results of similar value and usefulness.

The seeding of clam flats with small clams following depletion by harvesting, settlement failure in a given year, or some other natural event has been practiced for years in many of Maine's coastal towns, including those of Casco Bay. Yet despite the substantial efforts and time involved with such projects, little follow-up work has been done to determine their effectiveness or to identify what mix of parameters, i.e., season, clam size, substrate preparation, net covering, yield best results.

MER Assessment Corporation and Normandeau Associates, Inc. approached the Casco Bay Soft-shell Clam Council (CBSCC) in the Summer of 2001 to discuss whether the council concurred with the need to study survey methodology and seeding as a resource enhancement measure. The Council not only agreed, but recommended that such studies be undertaken and several of the participating towns offered to participate in and otherwise facilitate such efforts.

Responding to the recommendations of the MSCAC and CBSCC, the Casco Bay Clam Team in 2002 directed the project team to conduct studies to identify and compare alternative methods for conducting soft-shell clam resources surveys and to investigate the effectiveness of seeding.

4.2.2 Standard Resource Survey Methodology

The Maine Department of Marine Resources began using the standard soft-shell clam resource survey methodology in the 1950s. The method has undergone minor modifications over the years, but has remained essentially the same since first implemented (Stevenson and Sampson 1981). A full, detailed description of the standard methodology can be found in Newell (1983) and Maine/New Hampshire Sea Grant (1998).

Briefly, the standard method involves systematic-random sampling of clam flats. An artificial grid is developed as an overlay on either a navigational chart or topographic map of the area. The grid pattern is normally square and the dimensions of the grid vary according to the size of the flat being surveyed, but under most circumstances a 100 by 100 foot grid is used; on large flats the grid may be expanded to 200 by 200 foot and on small flats, or areas of particularly high concentration on larger flats, reduced to 50 by 50 foot. The grid is applied in the field by establishing a starting point and measuring the distance between sample plots using an appropriately measured line and a predetermined compass bearing.

Sample plots measuring 1 by 2 foot (2 ft^2) are marked on the flat at each intersection point of the grid. If recently settled seed clams, called "spat," are to be assessed, a ½ by ½ foot (¼ ft^2) sample is taken before any other sampling is done. Once the spat sample is collected, the sediment within the marked 2 ft^2 plot is systematically removed using a clam rake, or "fork," and examined for clams of all sizes. Clams are removed, measured, and recorded. The sampling process is repeated at all grid intersection points until the entire grid is covered.

4.2.3 Study Purpose, Approach and Field Methods

The purpose of this study was to evaluate simpler, less time-intensive soft-shell clam population survey methods. To accomplish this, the study compared the results of the standard method survey applied to the entire flat in a systematic random approach as is currently done to: (1) a purely random sampling approach of various sampling intensities over the entire flat, (2) stratified systematic random approach applied to only the areas of moderate-density and high-density populations, (3) stratified systematic random approach applied at various levels of intensity to only the areas of moderate-density and high-density populations.

The standard systematic random method survey was conducted in-field to collect a full complement of actual data and represented the baseline data set against which all other survey approaches were compared. All subsequent survey approaches were carried out as out-of-field “desktop” surveys by using actual data collected through the standard systematic random method for either randomly or specifically selected stations.

The ideal site for this study would have been one that had been closed to harvesting for some period prior to the survey, but one that could be opened to harvesting shortly or immediately following the survey. Additionally, the ideal site would afford relatively easy land-side access for the sampling team and equipment to reach the flat, while also being primarily accessed by boat for harvesting in order to facilitate monitoring of the post-survey harvesting effort. The flat would also have to be exposed for a sufficient amount of time during a normal low tide to allow adequate time for sampling.

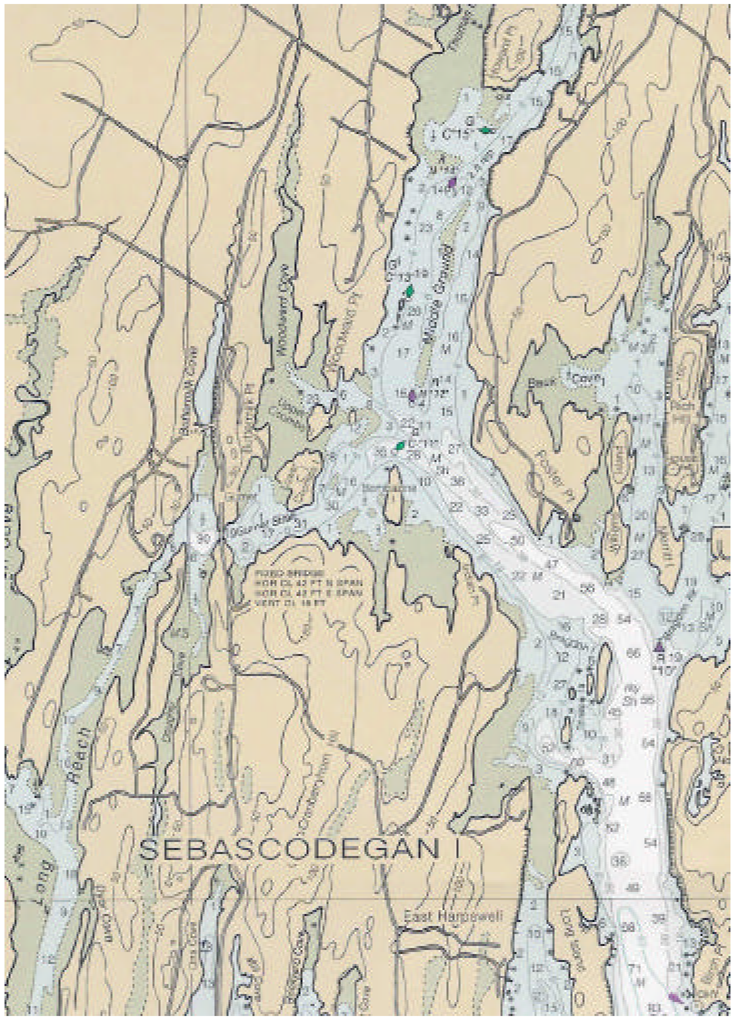
The study team met with the CBSCC in October 2002 to discuss and request suggestions for possible sites for the study. Several possible sites were proposed in Brunswick and Harpswell, however, Woodward Cove, along the New Meadows River on the eastern shore of Brunswick, met nearly all of the ideal site requirements.

Woodward Cove is a commercially important tidal flat that is routinely opened and closed by the Brunswick Marine Resources Committee each year as part of their town-wide management plan. In October 2002 the cove had been closed to harvesting since early Spring 2002 and was scheduled for opening just a few weeks later in early November.

Subsequent to the CBSCC meeting, the Brunswick Marine Resources Committee discussed the issue of having the study conducted at Woodward Cove and the associated steps required of the Committee. In response, the Committee agreed to assist the project team by delaying the opening of the cove to allow sufficient time for the survey to be conducted and offered the assistance of the town’s two shellfish wardens, including use of the town’s airboat. In addition, the town offered to notify the shellfish harvesters of the area about the study and the anticipated need to monitor the harvest, at least for the first few days following the opening of the cove to harvesting, through the recorded message on the town’s toll-free shellfish hotline. Woodward Cove is shown in Figures 4.2-1 and 4.2-2.

As Figure 4.2-2 shows, Woodward Cove is an elongated cove that fully drains at low water. The uppermost portion at the north is a tidal marsh and the lower portion at the south is fine silt and clay, hence the term “mud flat.” The darkened area that the southern extreme near where the flat opens into the broader cove area is a mussel bed and represents the lower extent of the normally exposed flat and therefore the lower extent of the soft-shell clam habitat within the cove study area.

Figure 4.2-1. Woodward Cove



(Source: NOAA/NOS Navigational Chart 13290 34th Ed. Feb. 24/01)

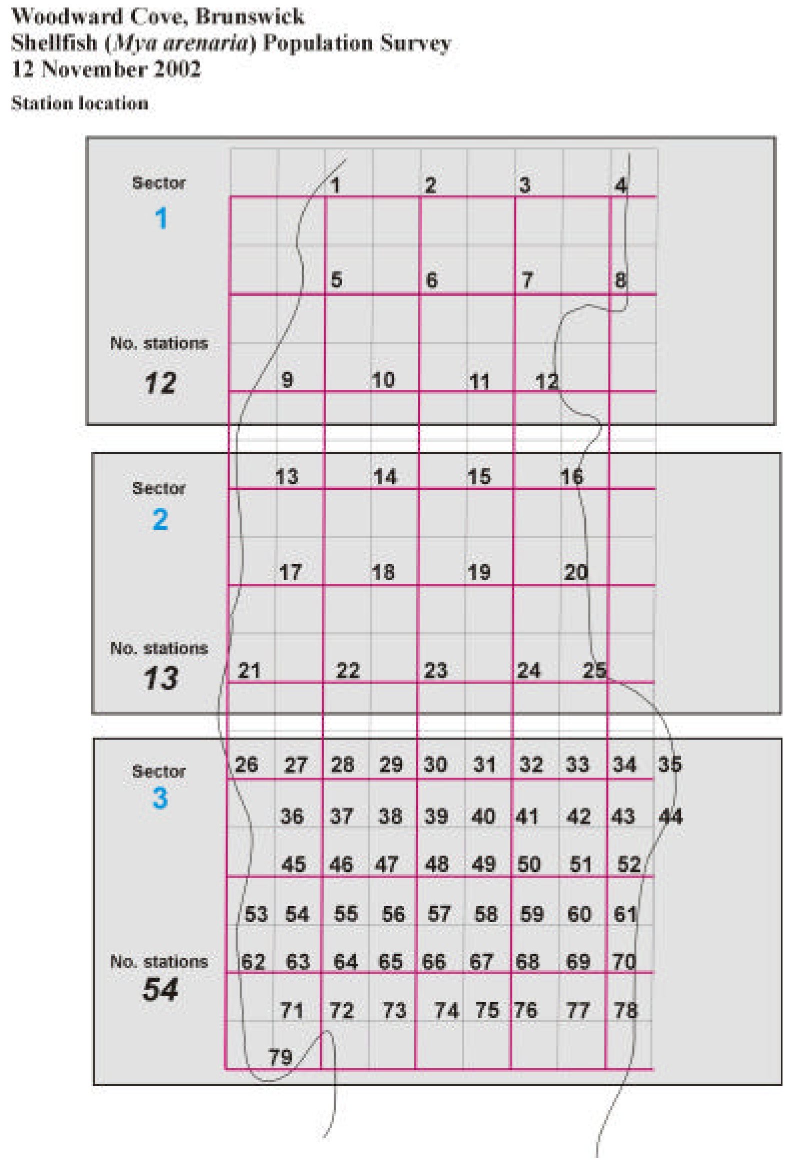
Figure 4.2-2. Aerial View of Woodward Cove

The broader area of tidal flat south of the mussel bed is also suitable clam habitat, but was not included in order to restrict the study area to a workable size that could be covered within a single low tide period.

A scaled schematic of Woodward Cove was developed as an overlay to the aerial photograph shown in Figure 4.2-2. A computer-generated 100 ft. by 100 ft. grid was then applied to that portion of the cove to be sampled using CorelDraw 9® software. A second 200 ft. by 200 ft. grid, based on the initial 100 ft. by 100 ft. grid, was then applied to allow location of sampling stations in the less intensive survey approach areas. The grid overlay and station numbers are shown in Figure 4.2-3.

The flat and sampling stations were segregated into three sectors to facilitate marking of the study area prior to the survey and assignment and allocation of sampling areas to individual survey teams on the day of the survey (Figure 4.2-3). Sectors 1 and 2 at the upper northern end of the flat were

Figure 4.2-3. Sampling Grid for Woodward Cove, Brunswick



populated and intensively harvested area in the cove and was therefore overlaid with the more intensive sampling grid, resulting in 54 sampling stations within the sector.
overlaid with the less intensive sampling grid and contained 12 and 13 sampling points, respectively. Harvesters and the town shellfish wardens had been previously identified Sector 3 as the most densely

The sampling grid was established on the flat the day before sampling. The grid was started at Station 1 at the northwest corner of the sampling area. All subsequent stations were located using 100-foot measures lines, either singly or doubled, depending on the grid intensity, following predetermined compass bearings. A total of 79 sampling stations were marked with pre-numbered tags attached to small wooden stakes.

All sampling was completed in a single tide by four two-person teams on November 12, 2002. One person served as the survey manager to coordinate and direct the effort. One member of the team served as the sampler responsible for marking and digging the 2-ft^2 plot and measuring the clams removed from the sample plot. The second member of the team served as data recorder.

Plots were marked for digging by making two contiguous imprints in the mud using a 1-ft^2 wooden frame sieve. Sediment was removed from along one the outer edge of the marked plot to a depth of approximately 1 foot; any clams found in this sediment were not included in the sample. Once the sediment was removed along one edge of the plot, the sediment within the plot was systematically sectioned down to 1 foot and all clams recovered from the sediment were placed in the sieve.

Once all of the sediment was removed from the plot, all clams recovered from the plot were measured using a metric measuring scale marked in 5 mm increments affixed to the edge of the wooden sieve. Each 5 mm interval is sequentially numbered such that “1” represents 0-4 mm, “2” represents 5-9mm, and so on. All measurements were recorded on a data sheet developed specifically for use with the sequentially numbered measuring scale. All data were processed using spreadsheets developed by MER Assessment Corporation specifically for shellfish survey data analysis.

4.2.4 Analytical Methods

Standard systematic random survey vs. stratified systematic random

Soft-shell clams are usually heterogeneously distributed across a flat with some areas containing high-density populations while others are only sparsely populated. One obvious way to reduce the effort required to survey a flat is simply to reduce the area of flat surveyed by concentrating on those areas most likely to contain the majority of the clams; such an approach is referred to as stratified since it focuses on a certain section(s) of the population or flat.

Comparisons between the full systematic random survey approach and two stratified systematic random approaches, one focused on moderate-density areas of the flat and the other on high-density areas, were carried out as simulations using data collected through the actual, in-field survey. Moderate-density was defined as those areas with <10 clams per sample, or, 10 clams/2ft^2; high-density was defined as >20 clams per sample, or 20 clams/2ft^2.

The moderate-density survey simulation was carried out to simulate a survey team sampling only within the area of the flat known, either through prior surveys or harvesting experience, to contain 10 or more clams per 2ft^2. The simulation calculations were made in the same way as for the standard systematic random survey of the entire flat, but with deletion of all sampling stations where fewer than 10 clams were found. Similarly, the high-density survey simulation was carried out to simulate a survey team sampling only within the area of the flat known to contain 20 or more clams per $2ft^2$. The simulation calculations were made as just described, but with deletion of all sampling stations where fewer than 20 clams were found. Accordingly, 42 of the total 79 sampling stations were used in the moderate-density simulation while only 19 were used in the high-density simulation.

Power analysis

Resource managers issue licenses based on the estimated numbers of bushels harvestable from their municipality. Managers estimate that one digger can harvest 200 bushels annually. Therefore, an increase or decrease of 200 bushels would result in a change in the number of licenses issued by the shellfish council. A power analysis was therefore run on the results of the standard survey and the two stratified survey simulations to determine the numbers of plots necessary to detect a 200 bushel change in total and harvestable bushels with a 90% level of confidence, in other words, "How many samples in a given area would be necessary to detect a change in 200 bushels of clams with 90% accuracy?"

The formula used is:

$$\text{Number of samples} = \frac{2t_{n,\,0.10}^{\,2} * \text{variance}}{\text{Change desired} * \text{mean}^2}$$

In this case, the count and measurement data for each sample was converted to a volumetric estimate (bushels). Data from the full area survey did not meet the assumptions of normality, even when logarithmically transformed, because of the high numbers of samples with no clams. However, data from the moderate- and high-density survey, met the assumptions of normality. Therefore no transformation was used.

Purely random full area survey

Some shellfish harvesters and municipal resource managers have questioned the need for time- and cost-intensive systematic resource surveys, believing that a purely random survey of substantially reduced intensity could yield essentially the same results.

The power analysis described above addresses this question, but strictly on a statistical basis. To respond to the question in a less abstract manner, purely random surveys were simulated by using the "real" data collected in the field on 12 November. Three triplicate simulations were run using 4, 8, and 12 stations for each of the survey approaches.

The random survey simulations were carried out as desktop exercises by developing a set of randomly generated sampling station numbers using a computer random-number-generator routine drawing from a list of all possible stations from the field survey, that is 79 possibilities in the case of the full survey, 42 for the moderate-density area stratified survey, and 19 for the high-density area stratified survey. Data for the randomly selected stations was then input into the standard analytical spreadsheet.

4.2.4 Results

Standard systematic random survey vs. stratified random

The tabulated results of the full survey are included as Appendices E through J. Total standing crop is calculated by multiplying the total number of clams in each size increment by a conversion factor developed by Belding (1930) as modified for Maine by Stevenson and Sampson (1981), dividing this product by the number of samples taken, then multiplying the result by the total number of acres sampled (33.1), and finally summing the total for each size increment; harvestable bushels are calculated as the sum of the incremental totals for clams in the 50-54mm increment or greater. Table 4.2-1 and Figures 4.2-4 and 4.2-5 summarize the standing crop results for the full survey. Complete results are presented in Appendices E through J.

Table 4.2-1. Comparison of Standing Crop of Soft-Shell Clams for Woodward Cove, Brunswick, Based on November 12, 2002 Survey of Entire Flat, Moderate-Density Areas Only, and High-Density Areas Only

Area	Acres	Bushels/Ac.	Bushels	HARVESTABLE BUSHELS	Percent Harvestable
All Areas	33.1	180	5941	4160	70
Moderate-Density Area only	18.2	273	4430	2987	70
High-Density Area only	5.2	356	1852	1134	61

As the most complete survey of the flat, these results represent the benchmark against which all other survey approaches are compared. Table 4.2-2 depicts the number of bushels if the survey relied only upon the 18.2-acre moderate-density portion of the flat and the 5.2-acre high-density area.

Table 4.2-2. Results of Power Analysis to Determine Number of Samples to Detect a 200-bushel Difference with 90% Confidence Using Results from Complete Survey (Moderate-Density Portions and High-Density Areas)

Survey	Size (ac)	No. Samples	Total bushels	Number of Samples to detect 200 bu difference
Complete	33.1	79	5941	130
Moderate	16.2	42	4430	36
High	5.2	19	1852	10

Survey	Size (ac)	No. Samples	Harvestable Bushels	No. of Samples to detect 200 bu difference in harvestable clams
Complete	33.1	79	4160	113
Moderate	16.2	42	2987	42
High	5.2	19	1134	18

Applying the power analysis, these results suggest that in order to detect a 200-bushel difference in clams in Woodward Cove, 130 samples would need to be collected in a complete flat survey (Table 4.2-2). However, only 36 samples would need to be collected in the 16.2-acre moderate-density area, and 10 samples in the 5.2-acre high-density area. In order to detect a 200-bushel difference in harvestable clams, 113 samples would need to be collected in a complete flat survey, 42 samples in the moderate-density stratified survey, and 18 samples in the high-density stratified survey.

Figure 4.2-4. Simulated Stratified Random Systematic Survey Moderate-Density Area

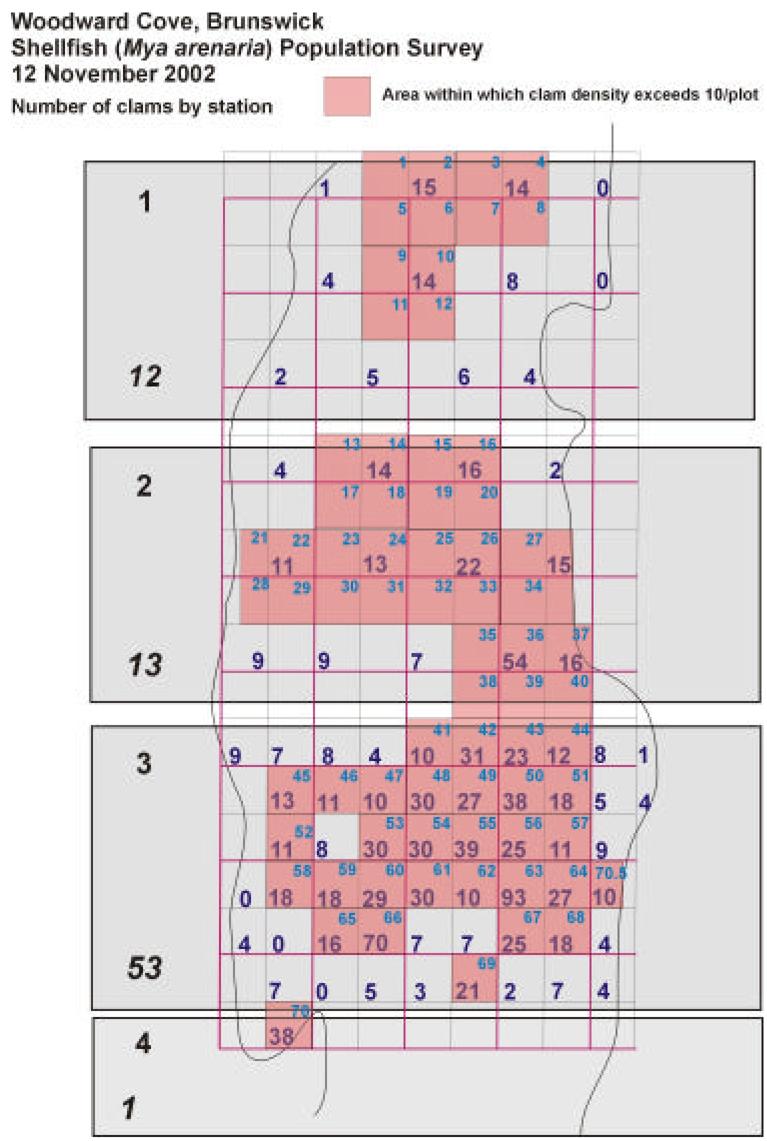
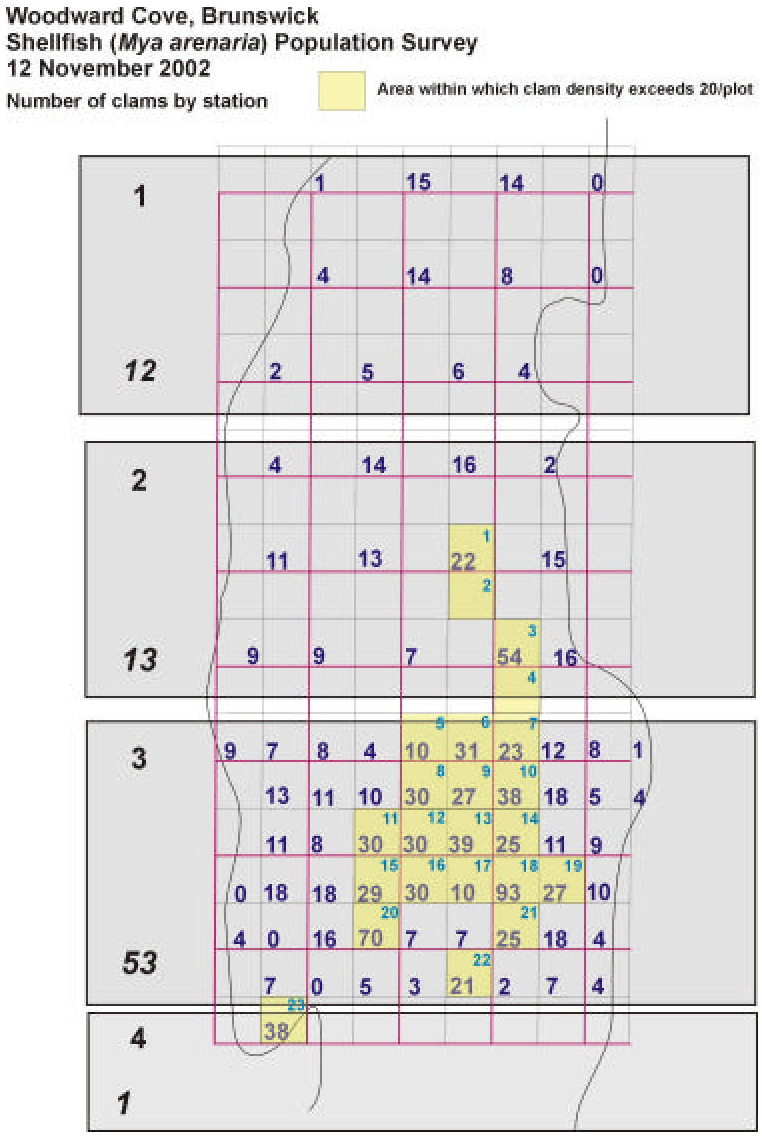


Figure 4.2-5. Simulated Stratified Systematic Random Survey High-Density Area



Purely random full area survey

Table 4.2-3 summarizes the key value results for trials using 4, 8, 12 randomly selected station data for the complete, moderate-density, and high-density area, respectively (complete results are shown in Appendices G, H and I). Comparative values for the entire flat survey and complete values for the respective density survey are also included for comparison. The detailed results of the random trial runs are included in Appendix J.

Table 4.2-3. Comparison of Harvestable Bushels from of Simulated Random Survey (4, 8 And 12 Samples) of the Entire Area, Moderate-Density Only, and High-Density Only

Number of Samples	Acres	4	8	12	Entire Survey
Entire Area	**33.1**	4561	4884	3976	4146
Moderate Density	**18.2**	3589	3071	3006	2987
High Density	**5.2**	1303	1688	1217	1134

4.2.5 Discussion

The degree of difficulty in estimating any population is directly related to the way in which the population is distributed. If a population is relatively evenly distributed, then only a few samples are necessary to estimate the full population with a fairly high level of accuracy. For example, in the extreme case where the population is exactly evenly, or homogeneously, distributed, say exactly 10 individuals per ft^2 over 100 ft^2, the total population would be 1,000 individuals, regardless of the number of samples to be analyzed. But as populations become more and more unevenly, or *heterogeneously*, distributed, the more difficult it becomes to accurately estimate the population and the higher the number of samples needed to accurately estimate the population.

Clams are well adapted to occupy a wide variety of sediment habitats, from coarse sand and gravel to very soft silt. However, the extent to which a particular habitat may be suitable or unsuitable for colonization is determined by numerous other factors such as topology of the substrate, depth within the intertidal zone, current direction and velocity, amount of freshwater flow, orientation of the habitat with respect to prevailing wind and the sun, just to name a few. Given all of these factors and the nearly infinite number of ways in which they can combine, it is unusual, indeed rare, to find homogeneously distributed clam populations.

In the vast majority of cases, clams are very heterogeneously distributed across a mudflat, the population tending to be concentrated within specific areas of the flat, leaving other areas only sparsely populated. Since clam harvesters work within a rather narrow window of time between half ebb tide and half flood tide, they must maximize their limited time on the flats and consequently gravitate to the most concentrated area to get the greatest number of clams per "flip," a reference to the action of flipping the mud over with a clam rake to expose the clams beneath.

The resource manager responsible for estimating the standing crop population for an area to establish the proper number of licenses to insure sustainable exploitation is similarly limited with respect to available time and resources to conduct surveys. The question then becomes: "Knowing that only the most heavily populated areas of a flat are going to be harvested, is the time and cost required to survey an entire flat worthwhile?" As the results of this study show, the answer is: "Probably not."

Woodward Cove is a classic example of the heterogeneous way in which clams are usually distributed across a flat. As the results shown in Figure 4.2-4 demonstrate, the upper portion of the cove is rather sparsely populated although localized areas of elevated density do occur. Most of the population is concentrated in the lower third of the flat, and then more toward the eastern shore than the west; it is no coincidence that the main channel that drains most of the cove, as well as the highest density of clams, is along the eastern shore.

A comparison of the reduced effort moderate-density and high-density areas surveys to the complete standard survey must assume that the latter is an accurate reflection of the actual standing stock. As the power analysis shows, however, due to the heterogeneous distribution of the population, particularly in the upper portion of the flat as just mentioned above, to insure that the total and harvestable bushels results were within ±200 bushels at a 90% confidence level, an additional 51 and 34 samples would need to be taken, respectively (Table 4.2-4). Consequently, the 5,941 total bushel and 4,160 harvestable bushel standing crop estimates may not be completely accurate, but are certainly sufficiently accurate to demonstrate the value of focused, or stratified, surveys. In contrast, the more intense survey within the moderate-density area actually exceeded the requisite number of samples to achieve the same level of confidence for total bushels and was exactly the right number for the harvestable stock. By concentrating on the less heterogeneous moderate-density area, only half the area would need to covered, approximately 30% of the number of samples would need to be taken, and almost 75% of the total standing crop and 72% of the harvestable stock would be covered by the survey. However, considering that the 25%-28% of the standing crop omitted by the moderate-density area survey is distributed over the remaining half of the flat, it is reasonable to assume that commercial harvesters would not spend much time on this portion of the resource since it would require digging through twice the amount of mud for a quarter of the return. Consequently, the 72%-75% of the standing crop covered in the moderate-density area survey may, in practice, represent close to 100% of the actual harvested resource. If true, the tripled effort to survey the entire flat could well result in a 25%-28% overestimation of the actual exploited resource, something that could be problematic to those responsible for setting a licensing level that matches a sustainable rate of resource exploitation.

Table 4.2-4. Power Analysis Results by Survey Type, Including Percent Estimated Total and Harvestable Standing Crop Compared to Full Survey

Survey area	Size (ac)	No. of samples in survey	Total bushels	% of full survey	Number of Samples to detect 200 bu difference
Complete	33.1	79	5941	—	130
Moderate	16.2	42	4430	*74.6*	*36*
High	5.2	19	1852	31.2	10

Survey area	Size (ac)	No. of samples in survey	Harvestable bushels	% of full survey	Number of Samples to detect 200 bu difference
Complete	33.1	79	4160	—	113
Moderate	16.2	42	2987	*71.8*	*42*
High	5.2	19	1134	27.8	18

The simulated high-density area survey also exceeded the requisite number of samples, although by just one. In this case less than 16% of the total area was covered and only a fraction of the number of samples required for the complete survey would need to be taken. However, by focusing on only the highest-density area, only 31% of the total crop and 28% of the harvestable crop are captured by the survey. While it is almost certain that this area would be the prime focus of harvesters, it is nearly equally certain that the effort would not be restricted just to this area. Consequently, while requiring a minimal effort, such a narrowly focused survey would likely result in serious underestimations of the total and harvestable resource.

Finally, the results of the purely random survey approaches show rather definitively that this approach does not provide the level of accuracy and confidence necessary to properly assess standing crops. In fact, of the nine triplicate purely random trials run, only the high-density area 12 random station trials yielded results within the acceptable limits. This is not surprising since the power analysis predicted the need for 10 samples to achieve the desired level of accuracy and confidence for total bushels and 18 samples for the same level of confidence for harvestable bushels, thus the purely random survey would not result in any true savings of either time or effort.

4.2.6 Conclusions and Recommendations

A total area survey normally includes areas not likely to be harvested due to excessively low density from a commercial harvesting perspective and will therefore likely result in an overestimation of the appropriate number of licenses that should be issued. On the other hand, narrowly focused high-density area survey tends to exclude areas likely to be harvested resulting in an underestimation of the appropriate number of licenses to be issued.

Moderate-density area surveys appear to offer a reasonable compromise by requiring considerably fewer sampling stations while covering most, if not all, of the resource likely to be targeted by commercial harvesters.

The densities of >10 and >20 clams/sample (>5 and >10 clams/ft^2) used in this study to define moderate- and high-density are strictly arbitrary. These values could change substantially from digger to digger depending on their individual perceptions of what constitutes moderate or high, that is, what one may consider high density may be considered only moderate by a more aggressive harvester. Consequently, we believe that additional effort needs to be made to better define moderate and high densities.

Of course, the use of moderate-density area surveys presumes that sufficient hard data or anecdotal information exist to properly delineate the boundaries of the moderate-density area within the area to be surveyed. These data can be obtained from previous surveys or, if these are not available, from harvesters experienced with the area. Regardless of the extent or quality of the information used to support the decision and delineate the area, the municipality must feel comfortable that it can adequately defend its decision to apply a stratified survey approach. Furthermore, since clam population distribution changes with time, periodic full area surveys may be advisable to insure that established boundaries accurately insure the population is properly assessed.

4.3 SEEDING STUDY

4.3.1 Purpose

The clam seeding project was conducted to determine the overall effectiveness of seeding. Additionally, several seeding options were studied as a treatment matrix that included planting season, clam size, substrate preparation, and net covering. The project was started in October 2001 and continued into December 2002.

4.3.2 Study Sites

Three areas were selected for the study: (1) Cousins Island, Yarmouth, (2) Lower Raspberry Cove, Freeport, and (3) Lobster House Cove, Phippsburg. The Yarmouth and Freeport areas are located on the western side of Casco Bay while the Phippsburg area is located in eastern Casco Bay Figure 4.3-1.

All three areas are tidal flats, but differ to some degree with respect to their elevation in the intertidal zone and consequently their exposure time at low water. The Yarmouth experimental site was the highest in the intertidal zone, followed by the Phippsburg site, and finally by Freeport where the site was low in the intertidal zone and surrounded by eelgrass. The Yarmouth area is located between Cousins and Little John Islands, is relatively sheltered and faces eastward; it is at the end of a cove bounded by a causeway with a small bridge through which water passes from approximately mid-tide to high water. The Freeport area is highly exposed to a long fetch from the west and subject to buffeting from strong winds from the west, particularly in late-fall and winter. Phippsburg also faces westward, but is exposed to a much shorter fetch than the Freeport area.

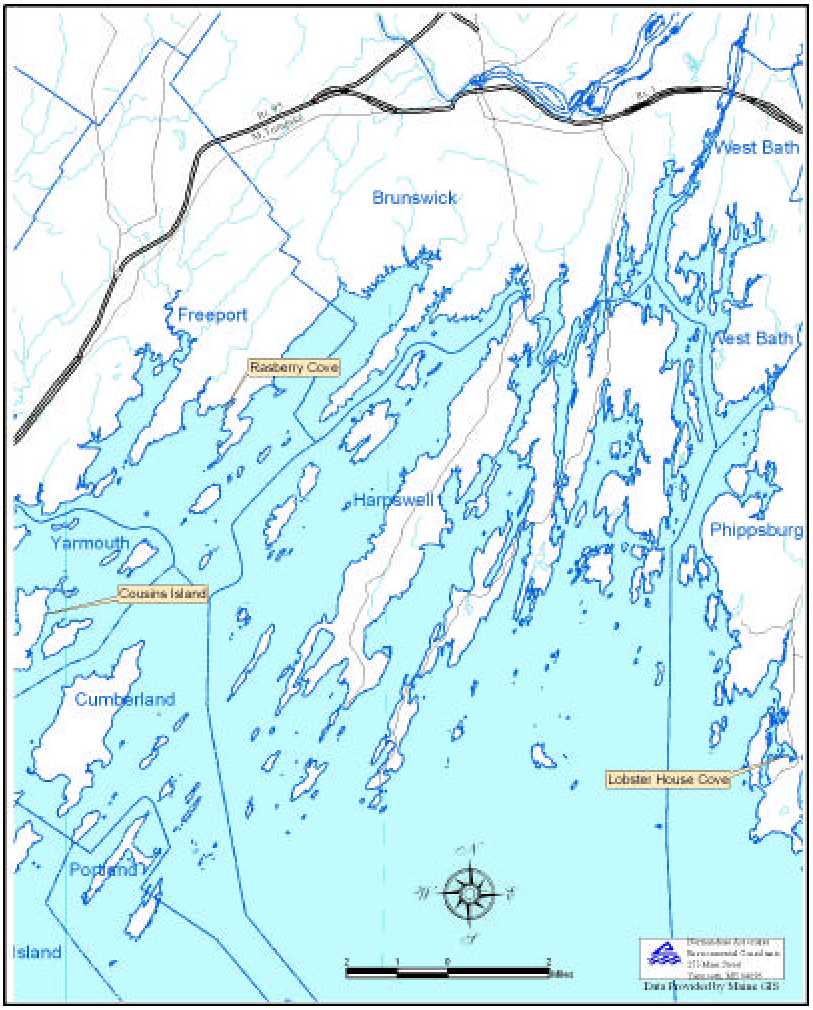
4.3.3 Experimental Design

The basic experimental plot consisted of an approximate square measuring 25 ft. by 28 ft. covering a 700 ft^2 area; this slightly rectangular shape was used to maintain a standard 700 ft^2 area while accommodating the 14 ft. width of the mesh used to cover certain portions of the plot. One half of the plot was left untouched while the other half was furrowed using a clam rake prior to seeding. U.V.-stabilized black ½” by ½” plastic mesh was placed over one half of the plot such that half of the area covered by the mesh was furrowed and the other have left untouched. This experimental plot layout resulted in four sections per plot, each measuring approximately 12½ by 14 feet , each representing a separate mix of parameters: (1) furrowed-uncovered (F-UC), 2) unfurrowed-uncovered (UF-UC), (3) furrowed-covered (F-C), and (4) unfurrowed-covered (UF-C). Three experimental plots were set contiguously, parallel to the advancing tide line at all three study areas at the start of the study; one additional plot was added in Yarmouth and Phippsburg in Spring 2002. An example of an experimental ploy layout is shown in Figure 4.3-2.

4.3.4 Seeding

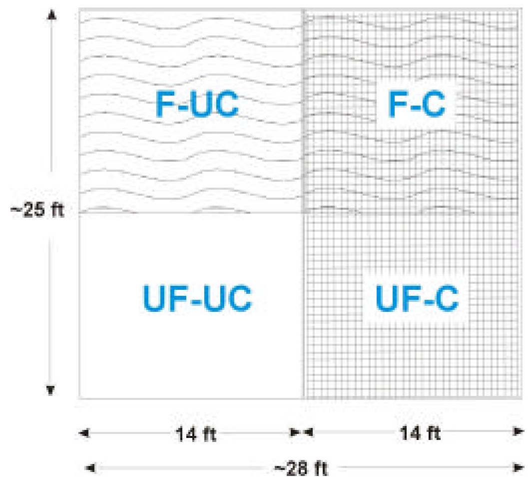
At each study area, one of the plots was seeded with small seed, measuring 8-10 mm and a second seeded with large seed, measuring 18-20 mm, all obtained from Spinney Creek Shellfish, Eliot, Maine; this represents the Fall 2001 seeding. Seed was broadcast across the plot as evenly as possible by broadcasting from all sides; rate of distribution was estimated at approximately 30 seed/ft^2. The third experimental plot was used as the control and was therefore not seeded. The plastic mesh was applied to the appropriate sections of the plots once seeding was completed; the sides of the mesh covers were buried approximately 6-8 inches into the mud and metal reinforcing bar staples were

Figure 4.3-1. Study Sites



pushed through the mesh and into the mud at each corner. Mesh was also applied to the control plot even though no seed was distributed. The individual site layouts are shown in Figures 4.3-3 through 4.3-7.

Figure 4.3-2. Standard Experimental Plot Layout



Each study area was visited in December, just before ice was expected to begin forming on the flats, to remove the ½" by ½" mesh netting. The plots remained undisturbed by the project through the winter until the April 2002 sampling.

A new, fourth plot was established at the Yarmouth and Phippsburg sites in April 2002. The plot layouts were exactly as described above. A portion of the larger seed retained from the Fall 2001 and over-wintered in suspended trays in South Portland was used to seed these plots at an approximate density of 30 seed/ft^2. The Freeport study site was disturbed during the winter when worm diggers inadvertently worked through the entire plot as a result of a misunderstanding on study site location. Thus, no samples were collected. The Freeport site, shown in photo in Figure 4.3-8, was reestablished, as described for Fall 2001, in April 2002 just north of the previous location using only the larger, over-wintered seed and a density of 30 seed/ft^2. The plastic mesh was replaced over the appropriate plots at all locations in April 2002.

Figure 4.3-3. Experimental and Spring 2002 sampling layouts at Cousins Island, Yarmouth

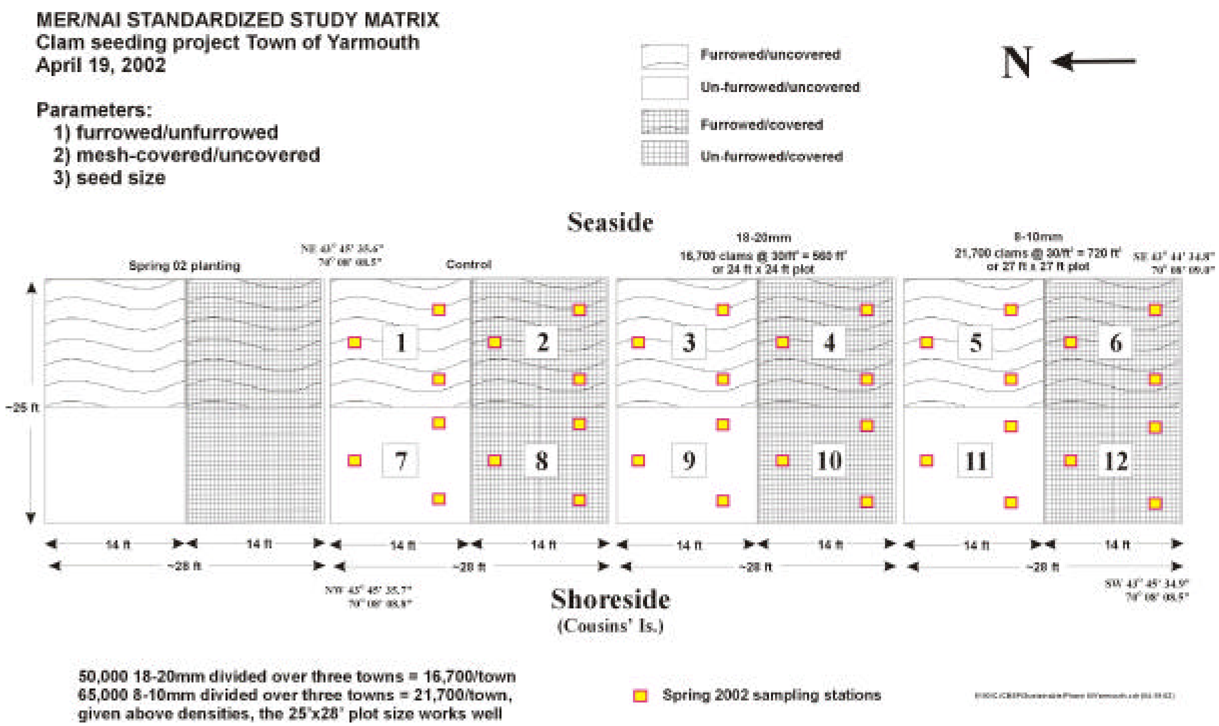


Figure 4.3-4. Experimental and Spring 2002 sampling layouts at Lobster House Cove, Phippsburg

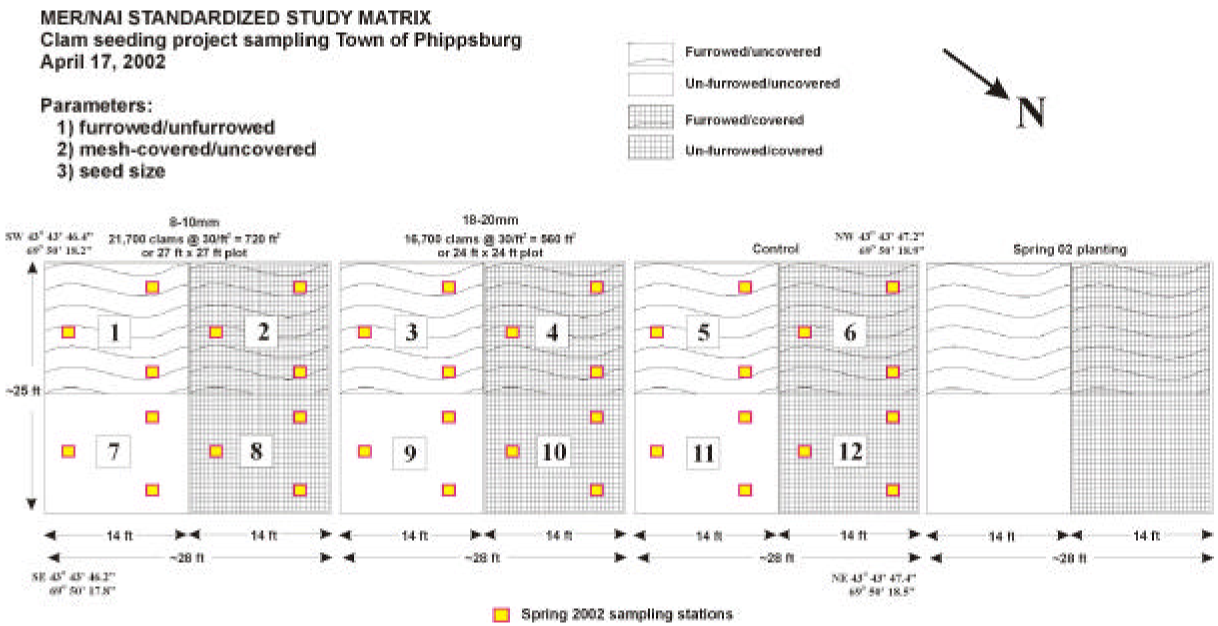


Figure 4.3-5. Fall 2002 sampling layout at Cousins Island, Yarmouth

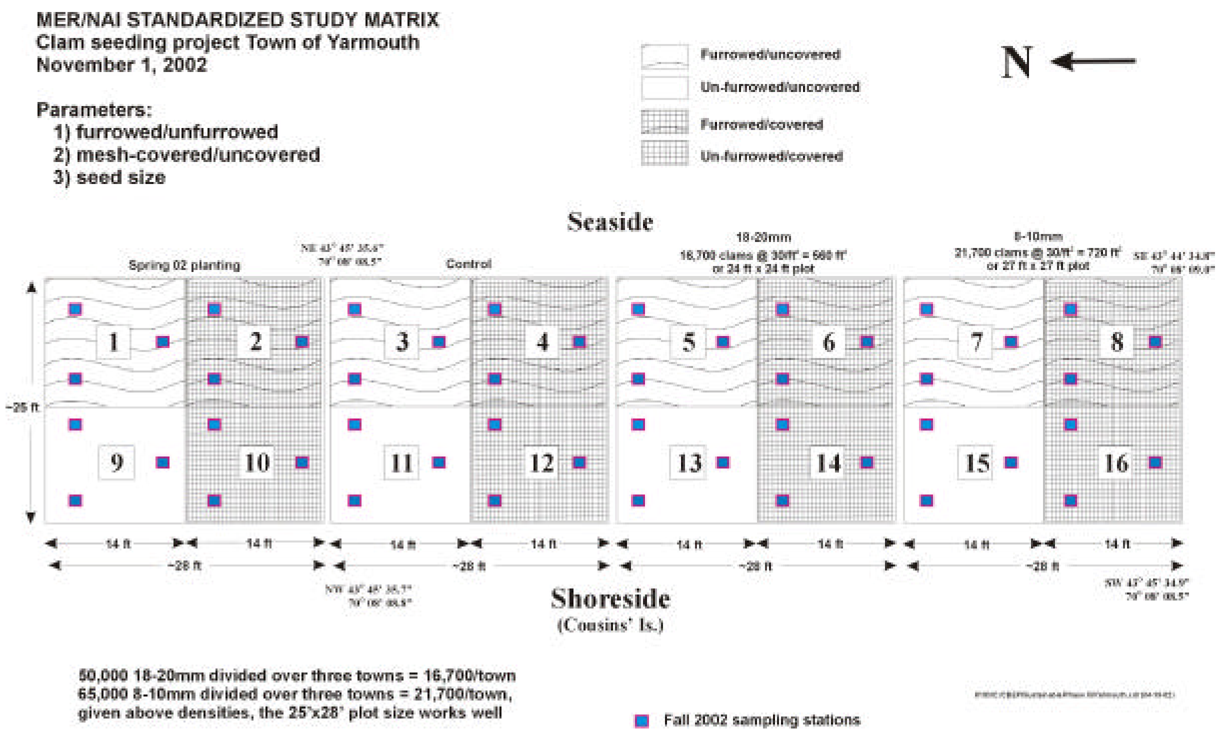


Figure 4.3-6. Fall 2002 sampling layout at Lobster House Cove, Phippsburg

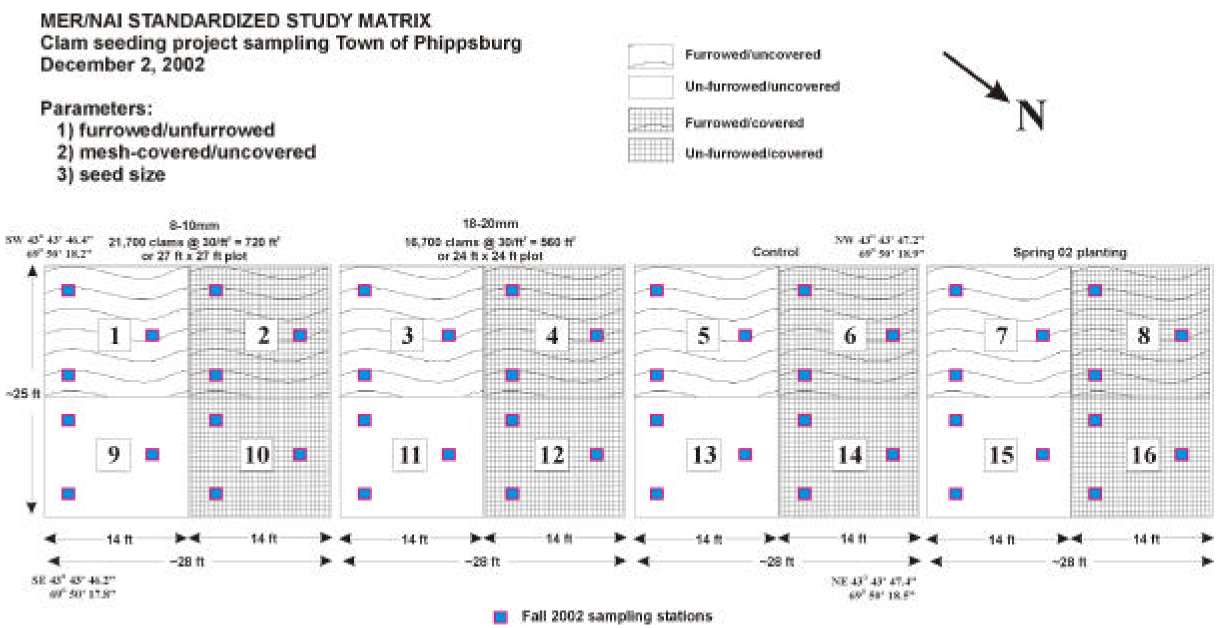


Figure 4.3-7. Experimental layout at Lower Raspberry Cove, Freeport

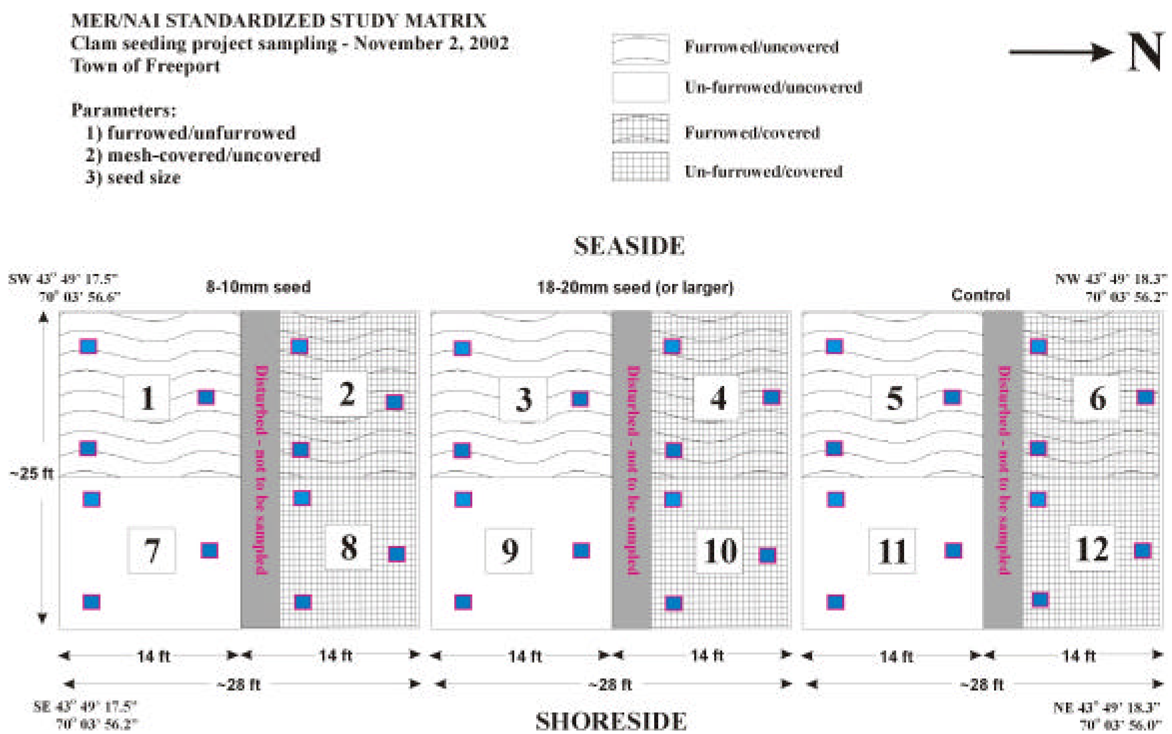


Figure 4.3-8. Photograph Showing Experimental Layout at Lower Raspberry Cove, Freeport Immediately after Reestablishment on 23 April 2002

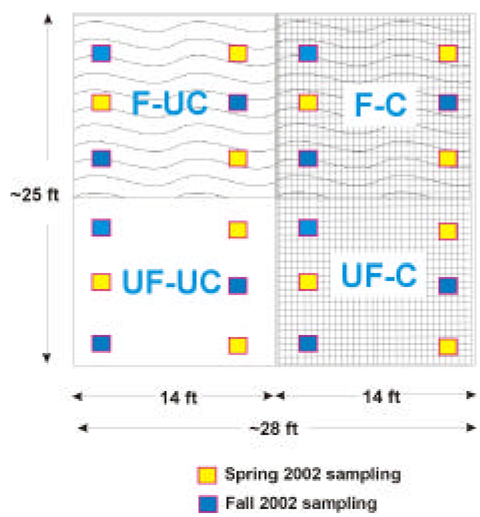
4.3.5 Sampling

According to the original study plan, all three study sites were to be sampled twice, once in the Spring of 2002 following the initial planting of Fall 2001 and again in the Fall 2002 following the Spring 2002 planting. The Yarmouth and Phippsburg sites were sampled in Spring 2002, but due to the disturbance of the Freeport site, no sampling could be done there in Spring 2002. All three sites were sampled in the Fall 2002.

Upon arrival at the site the corners of the site were found by GPS and the use of a metal detector to find the metal staples left in the bottom following removal of the mesh the previous fall. Once the outer corners of the site were established, lines used for the initial layout were relayed to re-establish the entire plot layout.

Three 1ft^2 samples were taken from each of the four treatments within each plot on each sampling occasion. To avoid the possibility of sampling a given spot twice, two sampling stations were located on one side of the treatment and one on the other for the Spring 2002 sampling and the location of sampling stations per side was reversed in the Fall 2002 sampling. This sampling arrangement is shown in Figure 4.3-9 and in Figures 4.3-5 through 7.

Figure 4.3-9. Spring 2002 and Fall 2002 Sampling Station Arrangement



To ensure proper identification of samples, each treatment plot was assigned a number, (in Spring 2002 from 1 through 12 and in Fall 2002 from 1 through16), and each sampling station within the treatment was assigned a letter, A through C, tied to the treatment number, e.g., 2A, 2B, 2C, and so on. A station identification tag bearing the station number was stapled to a small stake placed at each sampling station location.

Individual samples were taken at each sampling station by marking the sampling area with the imprint of a 1-ft^2 wooden frame, removing all sediment within the imprint area to a depth of approximately 8-10 inches, and placing the entire sediment sample and station identification tag into a double lined plastic bag. All of the bagged samples were transported to a sieving site where the samples were sieved through approximately 1mm mesh window screen. All soft-shell clams retained by the mesh, including those outside of the study size range, were measured and recorded.

4.3.6 Results

The results of the two sampling periods are presented in tabulated summary in Tables 4.3-1 and 4.3-2 and Figure 4.3-13; additional details and graphic representations of the results are included as Figures 4.3-10,11 and 12. In the tables, the mesh-filled cells represent the sections covered with mesh and the light-green-filled cells the control, or reference, plots. The boldfaced, first number in a cell is the combined plots, again suggesting that the clams recovered at this site were also of natural origin and not the seeded stock.

Regardless of the origin of the seed, the density of clams is rather low in all cases. Since the number of clams reported is a composite of all three replicate samples for the treatment, these numbers represent the number of clams per 3 ft^2, and when converted to number/ft^2, range from 0-4.7 mm in Yarmouth to 0-11.3 mm in Phippsburg, both well below the estimated seeding density of 30 clams/ft^2.

Table 4.3-1. Number (per 3 ft^2) and Mean Size (mm) of Clams Collected in Spring 2002 Sampling

Yarmouth

	UC-SmS	C-SmS	UC-LS	C-LS	UC-REF	C-REF
Furrowed	**4** / 8.8	**1** / 5.0	**2** / 11.5	**13** / 12.8	**3** / 7.0	**2** / 10.5
Unfurrowed	**0** / ---	**5** / 14.2	**9** / 16.0	**8** / 14.5	**5** / 7.6	**14** / 8.8

Phippsburg

	UC-SmS	C-SmS	UC-LS	C-LS	UC-REF	C-REF
Furrowed	**3** / 15.0	**1** / 7.0	**8** / 12.3	**31** / 15.0	**4** / 7.5	**14** / 14.1
Unfurrowed	**3** / 6.7	**0** / ---	**4** / 12.0	**34** / 7.1	**7** / 18.1	**11** / 13.8

Table 4.3-2. Number (per 3 ft^2) and Mean Size (mm) of Clams Collected in Fall 2002 Sampling

Yarmouth

	UC-SmS	C-SmS	UC-LS	C-LS	UC-REF	C-REF	UC-SP	C-SP
Furrowed	**2** / 2.5	**148** / 3.0	**1** / 2.0	**32** / 4.2	**0** / ---	**0** / ---	**0** / ---	**0** / ---
Unfurrowed	**0** / ---	**106** / 1.0	**73** / 2.8	**0** / ---	**1** / 2.0	**4** / 1.8	**0** / ---	**7** / 2.0

Phippsburg

	UC-SmS	C-SmS	UC-LS	C-LS	UC-REF	C-REF	UC-SP	C-SP
Furrowed	**1** / 21.0	**15** / 24.7	**0** / ---	**21** / 29.5	**0** / ---	**30** / 27.1	**0** / ---	**46** / 33.2
Unfurrowed	**2** / 29.0	**19** / 13.6	**2** / 39.0	**26** / 32.0	**2** / 35.5	**49** / 31.6	**1** / 43.0	**61** / 29.5

Freeport

	UC-SmS	C-SmS	UC-LS	C-LS	UC-REF	C-REF
Furrowed	**0** / ---	**7** / 1.6	**0** / ---	**3** / 2.7	**0** / ---	**0** / ---
Unfurrowed	**1** / 2.0	**1** / 3.0	**0** / ---	**8** / 1.9	**2** / 3.5	**21** / 1.9

Figure 4.3-10. Count and Mean Size in Yarmouth Spring and Fall 2002 Sampling.

Yarmouth Spring 2002 sampling
Summary

Treatment Number	Type		Count	Mean sz.	No/ft^2
1	F-U-SmS		4	8.8	1.3
2	F-C-SmS		1	5.0	0.3
3	F-U-LS		2	11.5	0.7
4	F-C-LS		13	12.8	4.3
5	F-U-REF		3	7.0	1.0
6	F-C-REF		2	10.5	0.7
7	UF-U-SmS		0		0.0
8	UF-C-SmS		5	14.2	1.7
9	UF-UC-LS		9	16.0	3.0
10	UF-C-LS		8	14.5	2.7
11	UF-UC-REF		5	7.6	1.7
12	UF-C-REF		14	8.8	4.7
			66	**10.6**	

Yarmouth Fall 2002 sampling
Summary

Treatment Number	Type		Count	Mean sz.	No/ft^2
1	F-U-SpS		0		0.0
2	F-C-SpS		0		0.0
3	F-U-REF		0		0.0
4	F-C-REF		0		0.0
5	F-U-LS		1	2.0	0.3
6	F-C-LS		32	4.2	10.7
7	F-U-Sm		2	2.5	0.7
8	F-C-Sm		148	3.0	49.3
9	UF-U-SpS		0		0.0
10	UF-C-SpS		7	2.0	2.3
11	UF-U-REF		1	2.0	0.3
12	UF-C-REF		4	1.8	1.3
13	UF-U-LS		73	2.8	24.3
14	UF-C-LS		0		0.0
15	UF-U-Sm		0		0.0
16	UF-C-Sm		106	1.0	35.3
			374	**2.4**	Spat

Figure 4.3-11. Count and Mean Size in Phippsburg Spring and Fall 2002 Sampling.

Phippsburg Spring 2002 Sampling Summary

Treatment Number	Treatment Type		Count	Mean sz.	No/ft^2
1	F-U-SmS		3	15.0	1.0
2	F-C-SmS		1	7.0	0.3
3	F-U-LS		8	12.3	2.7
4	F-C-LS		31	15.0	10.3
5	F-U-REF		4	7.5	1.3
6	F-C-REF		14	14.1	4.7
7	F-U-Sm		3	6.7	1.0
8	F-C-Sm		0		0.0
9	UF-U-LS		4	12.0	1.3
10	UF-C-LS		34	7.1	11.3
11	UF-U-REF		7	18.1	2.3
12	UF-C-REF		11	13.8	3.7
			120	**11.7**	Spat

Phippsburg Fall 2002 Sampling Summary

Treatment Number	Treatment Type		Count	Mean sz.	No/ft^2
1	F-U-SmS		1	21.0	0.3
2	F-C-SmS		15	24.7	5.0
3	F-U-LS		0		0.0
4	F-C-LS		21	29.5	7.0
5	F-U-REF		0		0.0
6	F-C-REF		30	27.1	10.0
7	F-U-SP		0		0.0
8	F-C-SP		46	33.2	15.3
9	UF-U-SmS		2	29.0	0.7
10	UF-C-SmS		19	**13.6**	6.3
11	UF-U-LS		2	39.0	0.7
12	UF-C-LS		26	32.0	8.7
13	UF-U-REF		2	35.5	0.7
14	UF-C-REF		49	31.6	16.3
15	UF-U-SP		1	43.0	0.3
16	UF-C-SP		61	29.5	20.3
			275	**29.9**	

Figure 4.3-12. Count and Mean Size in Freeport Fall 2002 Sampling.

Freeport Fall 2002 sampling Summary

Number	Treatment Type	Treatment	Count	Mean sz.	No/ft^2
1	F-U-SmSP		0		0.0
2	F-C-SmSP		7	1.6	2.3
3	F-U-LSP		0		0.0
4	F-C-LSP		3	2.7	1.0
5	F-U-REF		0		0.0
6	F-C-REF		0		0.0
7	UF-U-SmSP		1	2.0	0.3
8	UF-C-SmS		1	3.0	0.3
9	UF-U-LSP		0		0.0
10	UF-C-LSP		8	1.9	2.7
11	UF-U-REF		2	3.5	0.7
12	UF-C-REF		21	1.9	7.0
			43	**2.4**	

number of clams recovered from the three samples taken in the treatment and the second the mean size of the clams recovered. The abbreviations are: UC – uncovered, C – covered, SmS – small seed, LS – large seed, SP – spring seed.

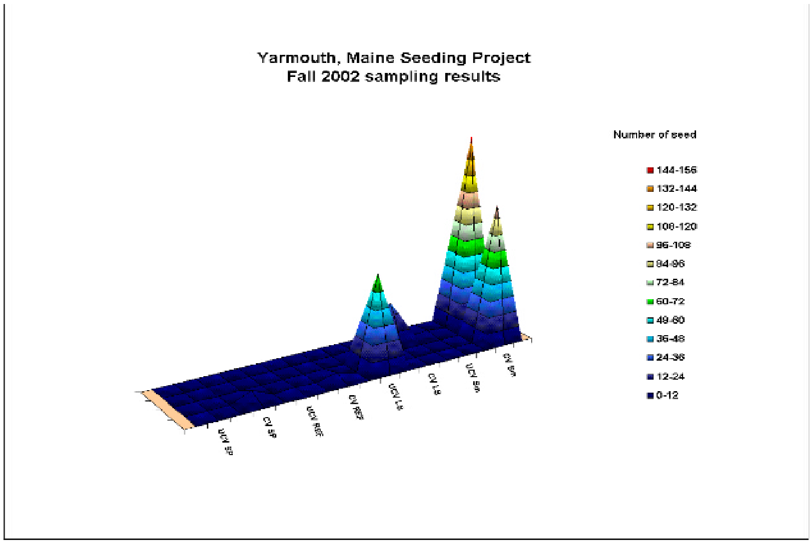
4.3.7 Discussion

The most dramatic result of the study is the near complete failure of seeded clam survival for both Fall 2001 and Spring 2002 plantings (Tables 4.3-1 and 4.3-2).

The Spring 2002 data from Yarmouth appears to show some survival amongst the covered large seed (C-LS) with a mean size of 12.8 mm on the furrowed portion and 14.5 mm on the unfurrowed portion. However, these mean sizes are out of the original LS range of 18-20 mm, suggesting the recovered clams might be naturally settled rather than seeded. The covered reference plot also yielded a comparatively large number of clams, but the magnitude found in the furrowed and unfurrowed areas here are the reverse of the C-LS plot. In addition, clams with a mean size of 14.2 mm were found in the covered, small seed plot (C-SmS), again a mean size outside the SmS range of 8-10 mm, further suggesting a pre-existing population. Finding a similar number of clams of a size not significantly different from those found in the C-LS plot in the reference and small seed plots suggests that all of the clams could be of natural settlement origin. The recovery of clams of similar to slightly larger size from the uncovered large seed plot (UC-LS) lend some support to greater survival of larger seed over smaller seed, but the numbers of survivors is too small to draw any definitive conclusions.

The situation at the Phippsburg site is similar to that of the Yarmouth site, although survival appears to be just slightly better. Here, too, however, the mean size of the clams recovered from the LS plots

Figure 4.3-13. Number of Seed Recovered (per 3 ft^2) from Seeding Experiments in Yarmouth, Phippsburg and Freeport



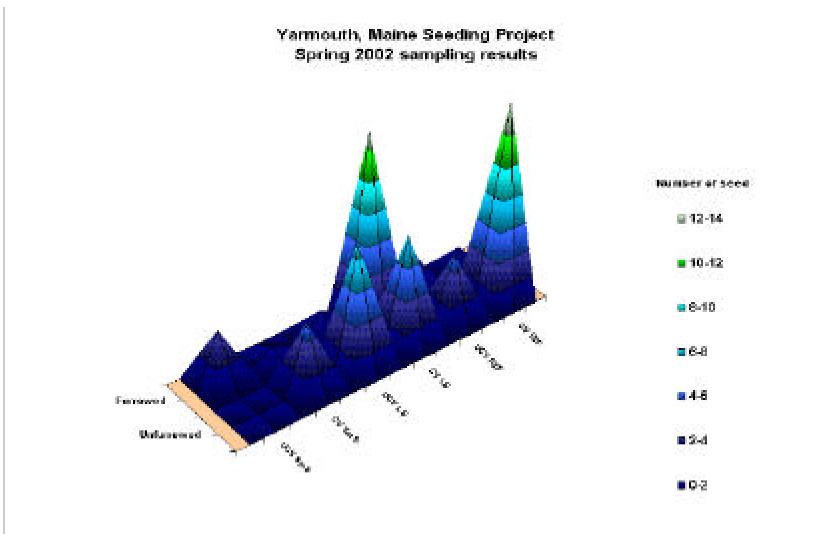
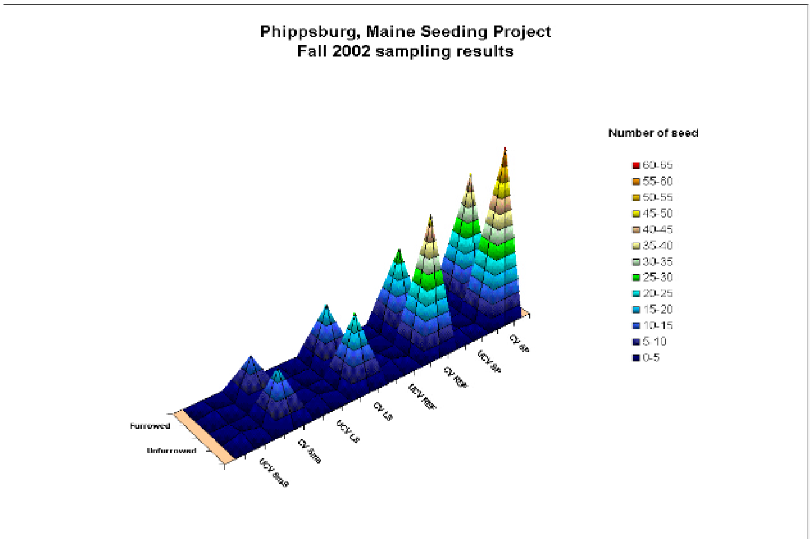


Figure 4.3-13. Number of Seed Recovered (per 3 ft^2) from Seeding Experiments in Yarmouth, Phippsburg and Freeport (cont'd)



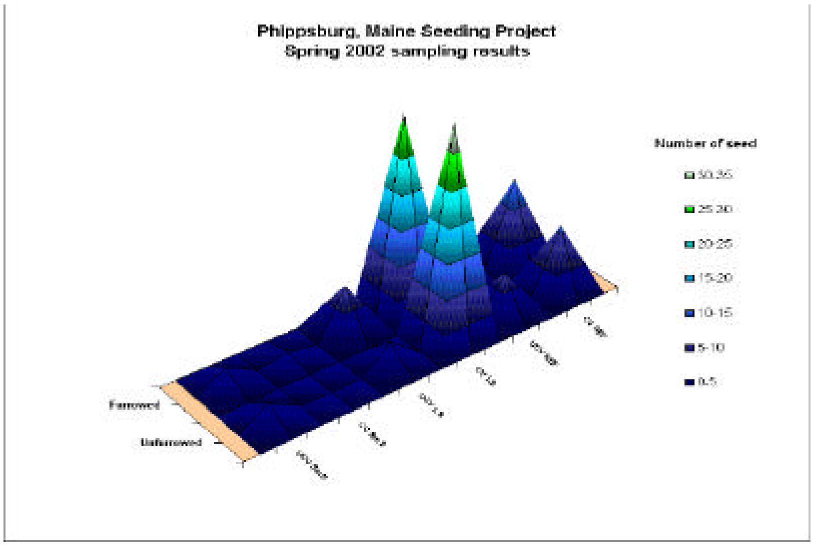
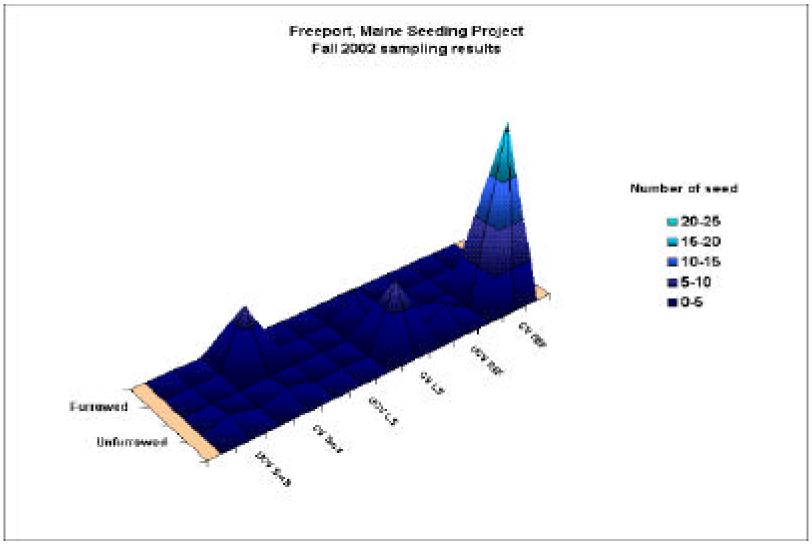


Figure 4.3-13. Number of Seed Recovered (per 3 ft2) from Seeding Experiments in Yarmouth, Phippsburg and Freeport (cont'd)



(12.3, 12.0, 15.0, and 7.1) do not match the size range of the LS clams seeded (18-20 mm). Furthermore, as in Yarmouth, similar size, albeit fewer, clams were recovered from the reference

The Fall 2002 results are similarly discouraging with regard to seeded clam survival. In both Freeport and Yarmouth, by Fall 2002 none of the Fall 2001 or Spring 2002 were found, all of the recovered seed being extremely small with mean sizes in the range of 1mm to 4.2 mm and therefore strictly of recent natural settlement. In Phippsburg the rate of survival across all treatments was markedly better than in Freeport and Yarmouth; however, both the number and mean size of clams recovered from the various treatments were either smaller or very similar to the number and mean size of clams recovered from the reference plot, corroborating the early findings of the Spring 2002 sampling.

These results, particularly those of Fall 2002, indicate rather conclusively that seed survival was very low and the seeding effort was a failure. The exact reasons for this failure are not immediately obvious; however, several possibilities exist.

The project was intended to simulate a seeding project carried out as a municipal effort. It is highly unlikely that such an effort would include the search for and removal of any crabs, specifically green crabs, *Carcinus maenas*, since the mere scale of a municipal project would almost certainly preclude it. Consequently, no effort was made in this project to either look for or remove any green crabs from the site. Clearly, those areas left uncovered would be subject to predation by transient crabs and any effort to remove crabs from those areas would be useless. On the other hand, any crabs trapped under the plastic mesh as it was applied would be captive until the mesh was removed or they were able to burrow out beneath the mesh; this latter possibility is remote given the depth to which the edge of the mesh was buried. Trapped crabs would clearly pose a serious threat of heavy predation within their confined space since their prey would be limited to the seeded clams. Although no crabs were observed under the mesh covers on the two occasions when these were removed, *C. maenas* is known to burrow and conceal itself in the mud, and it is unlikely that crabs would have been observed.The loss of 100% of clams with a mean size of >4.2 mm at Yarmouth and Freeport over the course of the Summer of 2002 suggests that predation was extremely high over the period. This observation is consistent with other observations and reports by harvesters, resource managers, and researchers that the *C. maenas* population in Casco Bay and along most of the Maine coast was much above normal in 2002, likely the result of higher than normal winter survival following several years of mild winters.

A second, far less likely, possibility is that the seed used in the study may not have been well suited for transplantation at these particular sites. It has been often speculated that the best seed to use for transplantation is seed originating from similar sediments; to the best of our knowledge, such claims have never been scientifically tested in Maine. Clearly, there is no way of assuring that seed of hatchery origin developed in sediments similar to those at the study sites. Furthermore, the suggestion that the poor survival was related to the seed stock is not supported by the fact that nearly all of the clams in the reference plot at Yarmouth and the vast majority of clams in the uncovered plots in Phippsburg, all apparently the products of natural settlement, similarly disappeared, strongly suggesting predation as the primary cause of mortality.

Despite the poor survival, the results from the Phippsburg site show rather convincingly that protection of established seed with a mesh covering during the high predation period of summer can be very effective. In Spring 2002 the mean number of seed in covered plots was 15 compared to 5 in the uncovered plots, yielding a ratio of 3:1. By Fall 2002 the mean number of seed in covered plots was 33 compared to just 1 in the uncovered yielding a ratio of 33:1. The reason for the increase in clams in the covered plots in the fall is not exactly clear, however, whatever caused the decrease in the uncovered plots obviously did not affect the covered, plots, again strongly suggesting predation.

Finally, considering the near complete loss of all seed from the Yarmouth site, the very large amount of small, recently settled clams, or spat, found in the covered plot with small seed (C-SmS) in the Fall 2002 sampling is rather interesting. This spat was certainly not present in Spring 2002 and, given the mean size of 3.0 and 1.0 mm, can only be the result of late-Summer or early-Fall 2002 recruitment.

The reason for this large settlement of spat in just this one area of the study site is not clear, however, it demonstrates nonetheless that covering a portion of the flats with mesh may have an enhancing effect on spat settlement. The notion that structures projecting above the sediment surface, such as buoyed nests, might enhance recruitment of spat is not new. Measures to increase surface area on flats and promote turbulent rather than laminar flow on the incoming tide (thereby increasing the potential for larval contact with the sediments) have been used for many years. Perhaps the oldest technique is the “brushing” of flats where pine bows from discarded Christmas trees are placed upright in the mud around the time of settlement. Covering the flats with nets is another, more recent techniques that is reportedly used in Massachusetts and parts of southern Maine. A study conducted by MER Assessment Corporation, with funding from the National Marine Fisheries Service Saltonstall-Kennedy Program (Heinig and LaVallee 1999), evaluated several types of structures for their spat enhancing capabilities.

4.3.8 Conclusions and Recommendations

Based on the results of this study, the success of seeding efforts is highly variable and such efforts appear more likely to fail than succeed. In the past there seems to have been little in the way of follow-up studies or even general verification of the level of success of seeding projects. The results presented here indicate rather strongly that the assumption of success may very well be wrong and that project follow-up is very important. We therefore recommend that all seeding efforts be followed up with some means to assess or verify success. Such an assessment can be as simple as taking a few standardized random samples within the area known to have been seeded and one or two samples from an area known to be outside of the seeded area. If the comparison results show a substantially greater number of seed in the seeded area, then the effort can be considered successful; if the results show little difference, then the effort should be questioned with regard to selected area and methods used for seeding.

Testing the covering of flats with mesh as a measure to enhance spat settlement was not within the purpose of this study; however, the results indicate that this may occur, but the results are not sufficiently clear to allow any definitive conclusion to be drawn. Nevertheless, in the one instance where enhancement appears to heave occurred, the results are impressive enough to warrant further investigation into the potential use of a *properly developed* “meshing” technique. The terms “properly developed” are emphasized because there are some potential hazards associated with meshing, such as trapping predators under the mesh and providing substrate for the settlement of undesirable competitors, such as blue mussels; these should be considered in any investigation.

5.0 LESSONS LEARNED/NEXT STEPS

5.1 REMEDIATION

Results of the OBD Removal Program

The mission of this project has revolved around assessment, remediation, and management. One of DEP's objectives is to reduce the fecal non-attainment area in coastal waters by 10% by 2005 (EPA and DEP 2002). This will be accomplished through both point and nonpoint source reduction. DEP's OBD removal grant program, along with the Small Community Grant program, focuses on point source reduction and represent an opportunity for homeowners and municipalities to improve their septic systems at a significantly reduced cost. To date, nearly $5 million has been spent in the grant program, more than 30% in communities surrounding Casco Bay (Table 5.1-1). If the State's Environmental Bond is approved in November, 2003, an additional $500,000 would be earmarked for OBD removal. To date, nearly $1.6 million has been paid to the towns and individuals in Casco Bay since the program's inception in the late 1990s (Table 5.1-1; source: R. Green, Maine Department of Environmental Protection, personal communication), with the majority expended in West Bath, Harpswell, Portland and Brunswick. This includes dollars disbursed directly to this project ($28,050)

Table 5.1-1. Maine DEP OBD grant disbursements in Casco Bay since program inception.

City	Grant Amount	Payments to Date	Balance
Brunswick	$ 290,000	$ 275,973	$ 14,027
Casco Bay Estuary Project	$28,050	$28,050	$ -
Cape Elizabeth	$ 44,699	$ 44,699	$ -
Cumberland	$ 11,782	$ 11,782	$ -
Freeport	$ 76,514	$ 76,514	$ -
Harpswell	$ 365,000	$ 334,487	$ 30,513
Phippsburg	$ 30,000	$ 23,942	$ 6,058
Portland	$ 265,495	$ 265,496	$ -
West Bath	$ 380,000	$ 331,173	$ 48,827
Yarmouth	$ 100,143	$ 100,143	$ -
Total Casco Bay	$ 1,591,683	$ 1,492,259	$ 99,425

with the balance disbursed to the communities of West Bath, Harpswell, and Brunswick (included as a portion of the grant amount in Table 5.1-1.) . The Town of Freeport removed all of its OBDs, using slightly over $76,000, opening all of its clam flats (closure area of 87 acres) except those around its

WWTP. OBD removal is more challenging in towns with significant coastline and ledge soils, such as Harpswell, Brunswick and West Bath.

Out of nearly 430 acres of high priority clam flats selected in this project, 311 are open in some capacity and another 74.5 are pending, awaiting removal of OBDs, shoreline surveys, and resolution of water quality issues. Many of these openings were due to collaboration with DMR staff who were already working in these areas. Once staff knew that these areas were a priority, they were able to focus their efforts on the most important areas. Table 5.1-3 summarizes the status of the individual areas. While over 243 acres of flat have been opened during the course of this project, only 25 acres are the direct result of OBD removal. However, increased communication and prioritization of flats as a result of this project have played a role in the opening of the 243 acres. Nearly 75 acres remains closed due to remaining OBDs or poor water quality. The issues that remain are the most difficult to resolve and will require the continued efforts of DEP, DMR and the municipalities.

Table 5.1-2. Summary of status of high priority clam flats in Casco Bay.

Status	Acreage
Pending	74.5
Open	243.5
Conditional	67.5
Closed	44.0
Total	**429.5**

Challenges and Recommendations for OBD Removal

The OBD removal program is not universally embraced by all participants. For example, the homeowners in this program were essentially forced to remove their OBDs, which represented unanticipated expenses, especially for some who had already invested in their existing system. Added to this is the small lot size and difficult soils in most of these properties, so that design was neither straightforward nor inexpensive. Other issues arose for towns that did not have the staff to assist with the program. While this project was designed so that project staff assisted with the program, there are some tasks that only the Town can do, such as transfer funds, contract with the construction firm, etc. West Bath in particular was challenged by the installation of 12 systems. This situation was further exacerbated when a faulty contractor was hired. The standard procedure for selecting contractors by hiring the lowest bidder can result in also using the least competent or experienced. When contractors do not meet expectations, the town bears the brunt of the controversy, just because of mere proximity. Finally, when town management changes, there is a loss of expertise, commitment, and momentum.

Table 5.1-3. Status of high priority clam flats.

Town	Clam Flat Name	Status	Sta. No.	Ac.**	Total	
WB	**Fosters Point**	**Pending**	**6**	**5**		Closure reduced to area around 3 OBDs
WB	**N. of Birch Point**	**Pending**	**8**	**15**		1 OBD remains
B	**Buttermilk Cove**	**Pending**	**15**	**25**		Nonpoint sources continue to be an issue
WB	**Sabino**	**Pending**	**7**	**17.5**		1 OBD remains
H	**E.of Gurnet Bridge**	**Pending**	**9**	**12**	**74.5**	Closed pending shoreline survey results
WB	**Fosters Point**	**Open**	**6**	**25**		
WB	Merritt Island	Open	6A	12		
WB/P	Brighams Cove	Open	8A	2.5		
WB/P	Perry Cove	Open	8B	15		
H	Bethel Point	Open	22	7		
H	Stover Cove	Open	26	4.5		
H	Ash Point Cove	Open	28	40		
B	Middle Bay	Open	33	137.5	**243.5**	Closure area reduced based on improved water quality
H	Orrs Cove	Cond	23	10		
B	Maquoit Bay	Cond	41	57.5	**67.5**	
P	Round Cove	Closed	8D	7.5		Pending DMR dye study results
WB	Op. Howards Point	Closed	5	5		
WB	E. of Harbor Island	Closed	8C	0		
H/B	E.of Long Reach, N & S	Closed	11/12	19.5		Poor water quality likely due to houseboat
H	Lowell Cove	Closed	24	5		
H	Lower Basin Cove	Closed	29	5		
H	Tank farm, Whites Cove	Closed	36C			
F	Pettingill	Closed	42	2	**44**	
Total				**429.5**		

Areas in bold are part of OBD removal program. Acreage refers to habitat area not closure area.

Our recommendations for improving the OBD removal process include the following:

- Ensure that all parties that will be involved in the OBD program (harvesters, selectmen, code enforcement officers) are willing to invest the time to complete the projects. The decision should not be made solely by harvesters.
- Consider a stipend for the Town to implement the program rather than an outside consultant for at least some of the role.
- Anticipate problems- there are reasons why these septic systems have not been replaced.
- Consider developing specifications for contractors so that Towns can hire qualified bidders
- Encourage the Town to hire the lowest qualified bidder.

5.2 ASSESSMENT

5.2.1 Shellfish safety

One of DMR's goals is a zero-tolerance policy towards seafood-related illness (DMR 2002). Ensuring the safety of shellfish for human consumption involves the intersection of several areas. Human health risks are minimized by ensuring that there are acceptable levels of fecal contamination, minimizing the risk of disease. Water quality testing and shoreline survey are the two tools used by DMR to assure shellfish harvesting occurs in clean growing areas.

Fecal coliform concentration in water overlying shellfish beds is the commonly accepted tool for assessing the safety of shellfish for consumption, as it is relatively inexpensive. However, it is admittedly a "blunt tool" for this assessment. Results from this study uncovered several factors that can affect shellfish bed classification:

- Non-human sources
- Presumptive sources (OBDs, WWTPs, marinas and moorings)
- Non-representative locations of water quality sampling station

The currently used method for detecting fecal coliform bacteria includes non-human and human coliforms, but the latter poses the greatest risk to human health. Our work demonstrates that some shellfish closure areas likely occur from wildlife and livestock, which pose less risk for humans. Some growing areas might be opened if the technology showed that sources were non-human. Much work has been done recently to try to separate human and non-human fecal coliform during testing. New technology (microbial source tracking, antibody testing) is key to refining this tool and should continue to be investigated.

The shoreline survey is an equally important tool for the growing area classification. Indeed, the sharp eyes of DMR staff often locate problems not indicated by the weekly sampling program. DMR may close areas that are presumed to pose sufficient risk. However, this policy also results in overly conservative closures- for example, overboard discharges, marinas, and wastewater treatment plants. With unlimited resources, DMR could determine *actual* risks posed by these potential sources. However, given the current budgetary situation, DMR must prioritize its efforts. Our study suggests that OBDs in the high priority flats are not significant contributors to the fecal coliform levels. Presumptive closures due to the presence of OBDs in areas we studied appear to be purely protective. In Casco Bay, some of the most valuable clam flats are adjacent to wastewater treatment plants (Yarmouth, Freeport, and Falmouth). For example, a dye study is being conducted around the Freeport WWTP that will allow DMR to establish realistic closures and conditions. Similarly, marinas and moorings, some located near valuable clam flats, can pose a risk of contamination. Studies to better determine the coliform risk as it relates to tidal volume, flow, and number of boats, would allow DMR to make closures based on data rather than presumption. These initiatives will assist in meeting the dual goals of both safe shellfish consumption and maximum acreage available for harvest.

One issue that is particularly discouraging is the houseboat in Long Reach, which has no apparent septic facilities. Our study indicates it is a possible contributor to high coliform in Buttermilk Cove, which is a high valued shellfish area currently closed to harvest. According to Steve Walker, Town of Brunswick, septic disposal from the houseboat is a DEP enforcement issue, as the Town has no legal grounds for compliance. Additional sampling around the houseboat could determine whether it indeed is a source of coliform. A shoreline survey could determine whether there are other sources. A collaborative approach including the Town, DMR and DEP could resolve this issue.

The NPS study helped elucidate sources of coliform; this information indicated some of the DMR sampling stations are placed in areas of source water rather than in areas indicative of water quality in the growing areas. This new information may allow DMR to relocate sampling stations so that they best reflect water quality over the clam flats.

If the Environmental Bond is passed in 2003, there will be additional funds in the OBD removal program. However, OBDs in Casco Bay are not keeping high priority flats closed. Waste water treatment plants, boat moorings and marinas, and unlicensed or poorly functioning septic systems are the major contributors to high valued resources at this time. Therefore, the focus of future work can be on improving/removing unlicensed and faulty septic systems and understanding the potential bacterial contributions from WWTP and boat moorings. Some of this work is already in progress.

5.3 SUSTAINABILITY

Our review of management strategies revealed that all communities employed a variety of tools. These included assessment (clam surveys, water quality monitoring), augmentation (seeding, settlement enhancement), predator protection (netting, crab removal) and harvest management (license control, flat closure, enforcement). However, there was very little follow-up in terms of the success of these measures, understandable given the scarcity of town resources.

Assessment is one of the key tools in sustainability. One of the best predictors of current density is the density by length class in the previous year (Heinig et al. 1995). Since resource assessment is time-consuming, any method that can expedite the standard assessment without compromising results would be a valuable. Surveys that are concentrated in areas most likely to be harvested (i.e. areas of moderate density) are likely to better estimate harvestable densities while using resources more efficiently.

Seeding has demonstrated success in other areas, including both southern and Downeast Maine; the poor survival of seed in this study underscores the need for follow-up to determine success. Seed marking of a representative sample, with small scale assessment in successive years after the survey will provide further information on whether seeding is valuable as an augmentation tool; if so, what parameters help assure success? One clear result was that at at least one site, the additions of a mesh cover enhanced native settlement, consistent with other studies.

5.3.1 Collaboration

One of the most positive lessons learned from this project is the importance of collaboration. Much is accomplished when all decision-makers are at the table and share a common goal. The model of the “Clam Team” can serve as a template for other processes. One of the “lessons learned” from this project is the difficulties that ensue when all stakeholders are not participating in the decision making. For example, the impetus to open clam flats in West Bath was largely the result of the Shellfish Commission; however, other Town staff (CEO, Town Administrator, Selectmen) were not involved in this decision but only out of necessity participated in the implementation. This created an “unfunded mandate” situation. The New Meadows River Watershed Committee is successfully implementing a process that involves all stakeholders.

At the outset of this project, opening clam flats to harvest seemed like a reasonable mission, as shellfish harvest provides an important livelihood consistent with traditional Maine values. OBD removal to increase the areas open for harvest seemed like a straightforward process. One of the difficult lessons learned was that not all citizens support the goal of increasing areas open to harvest. Many –but not all- clammers are respectful of private property and considerate of others who use coastal areas. However, a minority has created a negative image for some landowners, who refuse to grant access across their properties to the harvesting areas. Other landowners consider the presence of harvesters as negatively affecting their water view. This is symptomatic of a larger issue throughout the state where traditional ways of making a living conflict with a new set of values and priorities imposed by others. Thus there was not unanimous support for our overall goal, but despite this fact, there are many agency staff at both DEP and DMR and the municipalities as well as individual harvesters that work diligently to continue to improve water quality and open clam flats. Organizations such as the existing Casco Bay Regional Shellfish Committee are an example of an effective venue to achieve these goals.

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