Economic Analysis of the Soft-shell Clam, Mya arenaria, *Industry in Casco Bay*

PROJECT
FINAL REPORT

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Preface

In 1993, with over 44% of the soft-shell clam, *Mya arenaria*, flats in Casco Bay closed to harvesting, the Casco Bay Estuary Project asked: What is the "cost" of these closures to the region's economy? This project is the first Casco Bay-wide study of the economic value of the soft-shell clam fishery in Casco Bay.

The objective of the study was to estimate the total economic value of the clam resource of Casco Bay, including the direct income to diggers and the broader economic benefit to the region; to determine the economic benefit of removing pollution sources from representative closed areas; and to provide a brief overview of the non-market values of the clam fishery in Casco Bay.

In addition to the economic information, the report includes a valuable compilation of currently available resource data, including data from municipal management programs, and new data from resource surveys conducted in closed flats. The researchers have also identified critical data gaps which make a rigorous economic analysis impossible at this time.

Despite the data limitations, the natural variability of the resource, and the funding constraints, the study presents a solid analysis of the economic value of the soft-shell clam fishery in Casco Bay. Most importantly, it provides convincing evidence of the economic benefit of reopening closed flats.

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Executive Summary

The soft-shell clam industry within Casco Bay has a long tradition and has played an important role in the economic vitality of the fisheries of the Bay. It is clear, however, that increased urban development along the Bay's shorelines is beginning to negatively impact the soft-shell clam's intertidal habitat, threatening access to the resource as well as the resource itself.

Scope of Study

Recognizing the potential severity of the problem and the need to better understand the resource distribution, the economic activity associated with it, the threats to it, and the remedies to those threats, the Casco Bay Estuary Project (CBEP) proposed a study in 1993 to answer some of the questions surrounding these issues. Accordingly, the study was divided into four separate tasks: 1) estimation of the size and landed value of the soft-shell clam resource of Casco Bay based on information from selected open and closed areas of the Bay, 2) determination of the broader economic value of the resource beyond the landed value, 3) investigation of the economic cost and benefits associated with pollution source control or removal, and 4) the identification and evaluation of the non-market values associated with the soft-shell clam industry of the Bay.

Task 1. Estimation of current standing crop and total annual landed value

To estimate the soft-shell clam resource of the open areas of the Bay recent historical data was collected from forty-seven (47) currently harvested areas routinely surveyed by Casco Bay's coastal municipalities. These data cover surveys conducted between 1985 and 1993 and include projections for 1994. To develop information on areas currently closed to shellfish harvesting, five (5) surveys were conducted during 1994 in selected areas around the Bay. This information was combined with data collected from ten (10) closed areas studied as part of municipal shellfish management programs or other CBEP funded studies.

Analysis of these data indicates that the *potential* harvest from the open areas of the Bay is between 83,000 and 92,000 bushels per year, with 58,000 to 64,000 bushels *actually* being harvested, assuming ~70% harvesting efficiency. Using the 1994 National Marine Fisheries Service(NMFS)/Maine Depatment of Marine Resources (DMR) mean annual price of $72.95/bushel, this represents a *potential harvestable* resource value of $6,054,850 to $6,711,400 and an *actual harvest*, or *landed*, value of $4,231,100 to $4,668,800. The results of the surveys conducted in closed areas, combined with the existing data for closed areas, reveals a significant variability in population distribution in these areas, making any overall estimate of closed area production potential impossible to calculate. The exact reasons for the high variability in population distribution is not immediately clear, but if one assumes that closed areas, once opened, would produce at levels comparable to currently open areas, then it could be expected that the 1994 potential additional harvest from the Bay's currently closed shellfish areas, (totaling nearly 44.5% of the shellfish areas), could reach 51,160 bushels, representing another $3.73 million.

A review of the most recent projections for the open areas of the Bay further indicates that the resource cannot support the current harvesting effort for much longer. Despite indications of over-harvesting over the past three to four years, municipalities are finding difficulty in controlling harvesting effort, i.e. number of licenses issued, and it may now be necessary to consider alternatives to, or expansion of, current management efforts.

Task 2. Broader economic impact of the Casco Bay soft-shell clam industry

The determination of the broader economic value of the resource involved interviews with municipal officials, statisticians for the National Marine Fisheries Service office in Portland and the Maine Department of Marine Resources, eleven (11) certified shellfish dealers within the Casco Bay region, and fifty-one (51) Casco Bay area restaurants. The results of the statistician and dealer interviews, which focused on landings and landed values, show great variability in the estimated landings and prices paid, due principally to incomplete reporting on landings and different assumptions concerning the fates of certain landed product. This range of possible ex-vessel values, and therefore the broader economic value to the region, is in part due to the fact that there are (at least) three tiers to the Casco Bay clam market: 1) sales by diggers to U.S. Food and Drug Administration-certified shellfish dealers, 2) "direct sales" by diggers to the retail market (restaurants, grocery, and seafood stores) and, 3) "direct sales" by diggers to consumers (roadside sales).

Approximately 70-80% of the clams harvested in Maine are shipped out-of-state by U.S. FDA-certified dealers. Casco Bay area dealers also make significant sales locally to restaurants and some retail outlets. Certified dealers are required to report this activity on a monthly basis to the State of Maine (prices paid, number of bushels purchased, and origin of clams). Diggers are not required to report their sales.

NMFS/DMR collect monthly landings information from registered shellfish dealers (those which choose to comply with the State's reporting requirements). These reported figures are not verified by the State and only reflect the dealer-reported prices. However, dealers interviewed for this study indicated that diggers are paid significantly higher ex-vessel prices for clams than the figures that the towns and NMFS/DMR provide.

The anecdotal information from certified dealers is the basis for the upper end range of estimated value for the resource. Readers should bear in mind that this information was provided voluntarily by the dealers during a standardized survey and cannot be verified by comparing these figures to proprietary records held by the State of Maine. Furthermore, certified shellfish dealers interviewed for this study noted that, unlike other retail outlets, they face compliance costs associated with federal FDA regulations that allow them to ship clams interstate. Thus, prices paid by the retail outlet (as opposed to certified shellfish dealers) to diggers for "direct sales" are reportedly higher than those that certified dealers, with their additional costs, can afford to pay. Usually, these sales are not recorded, and may not appear as income for the diggers. If we were able to track these "direct sale" prices accurately, the documented, landed value of Casco Bay clams would increase as would the value of the resource beyond the landed value.

With respect to employment, the interview results show that there are 383 soft-shell clam resource-supported jobs within the Casco Bay region, 268 as licensed commercial diggers, 35 working as or with shellfish dealers/shippers, and 80 in the restaurant trade. Full-time equivalent jobs are estimated to number 242 positions. Based on these results the total economic activity associated with the soft-shell clam resource could result in an income multiplier (the value beyond the landed value of the clams) of between $11.6 and $15.7 million annually.

Task 3. Economic benefit of pollution source control or removal: two case studies

For the investigation of the economic costs and benefits associated with pollution source control or removal two sites were selected for detailed study: 1) Buttermilk Cove in Brunswick and, 2) Town Landing Cove in Cumberland. These two sites appeared to be impacted by

different pollution problems and therefore to require different abatement strategies.

In the former case, the cost and benefits were readily definable. A twenty-year life was assumed for the waste water disposal system necessary to the remediation of the Cove. For that period, from the municipal perspective, the present value of Brunswick's initial investment of $1,945 plus maintenance of the Buttermilk Cove clam flat would be $69,099. The present value of the total twenty-year income earned by diggers in the cove would be $999,000, or more than fourteen (14) times the cost. The net present value of the remediated resource would therefore be $929,901.

Clearly, the availability of State grant funds makes this project readily affordable for the Town of Brunswick. The State's outlay would be $79,920, or 88% of the total initial outlay of $90,915. How good this investment is for the State is a question. If all of the income likely to be generated is viewed as a benefit of the State investment, it would be a greater than 10-fold return over the twenty-year life of the project, without considering multipliers or non-market values.

The estimated value of the existing harvestable soft-shell clam resource in Town Landing Cove is $39,600. However, because pollution sources can neither be identified nor the cost of their remediation quantified, it is impossible to carry out an economic analysis similar to that done for Buttermilk Cove.

Task 4. Non-market value overview

Assigning a total dollar value to the non-market values of Casco Bay's soft-shell clam resource was beyond the scope of this report. Without this figure it is difficult to compare these values to the total economic value estimated in Task 2. But there are many non-market values associated with the clam resource and clamming industry in the Bay and they are essential to the full valuation of the clam resource, as well as for making decisions on funding of remediation, enhancement, enforcement or other management efforts.

Admittedly, non-market values are difficult to measure. Because they cannot be easily observed in any regular transactions, they must be researched deliberately and are therefore expensive and complex to assess. Assessment was beyond the resources of this study, and would probably cost more than municipal shellfish programs can afford, particularly since their present financial resources are already stretched thin.

However, it is important to devise and apply less expensive measures of approximating non-market values where possible. For example, we may never measure the value of seeing a digger haul in his harvest across the flats, but we can estimate the savings, or avoided costs, from a recreationally harvested meal. This study found that if all the recreationally harvested clams in four towns were equated to 1.5 pound plates of steamers priced at $8.00 each, the estimated 5,262 pecks harvested in 1994 would be worth $449,024 per year, a significant sum. This is a value worth over $110,000 to each town annually.

Even without exact quantification, the concepts of non-market values are gradually becoming a more conscious part of the public's understanding of the clam resource, which will certainly benefit decision making in the future.

This study may represent the best effort to date to quantify the value of the soft-shell clam resource of Casco Bay and the problems associated with preserving the traditional fishery based on that resource. In retrospect, however, the success of this study was compromised by the

unsubstantiated production figures. The economic analysis revealed serious gaps in the reporting of landings and encountered wide variability in the reliability of existing data. In the case of the pollution remediation cost-benefit analysis, in one case there was no clearly defined source(s) of pollution justifying the closure of the area. These, and other related management issues, are discussed in the final section of this report.

Principal Findings

- Based on available information, the estimated *in flat* bushels of soft-shell clams for open areas in 1994 is 91,150. Assuming a 70% harvesting efficiency the 1994 harvest is estimated at 63,805 bushels. Based on the recent historical data the *average* annual *in flat* production is estimated at between 83,680 and 89,660 bushels. Again assuming 70% harvesting efficiency, this results in 58,575 to 62,760 harvested bushels with a landed value of between $4,273,050 and $4,578,340, again using the 1994 National Marine Fisheries Service/Maine Depatment of Marine Resources mean annual price of $72.95/bushel. These values are approximately 20% higher than those reported by the DMR and NMFS.

- Clam production in the *closed* areas in the *eastern Bay* is similar to or *greater* than in open areas. Production in the *closed* areas of the *western part of the Bay* is significantly *less* than in open areas. The causes for this are not immediately clear, but may be natural or indirectly related to the closure.

- The variability in soft-shell clam population densities across the Bay makes extrapolation of the results obtained here to all other closed areas of the Bay impossible. Further, a comparison of the information presented here with that currently available for closed areas suggests that the productive habitat within closed areas may be significantly overestimated. However, if it is assumed that closed areas have the same production capacity as presently open areas, the production from the CBEP estimated 44.5% closed area of Casco Bay in 1994 could have had the potential of increasing *in-flat* production by 73,084 bushels and the *harvest* by 51,160 bushels thus increasing the harvest value by approximately $3.73 million.

- Approximately 383 individuals from towns surrounding Casco Bay work in the Casco Bay soft-shell clam industry, as follows:

    - 268 licensed commercial diggers
    - ~35 individuals employed by Casco Bay-area licensed shellfish dealers
    - 80 restaurant employees: of the 51Casco Bay-area restaurants surveyed for this study, 32 sold Casco Bay-origin clams. These restaurants employ 1370 "full-time equivalent" employees. Of these, it could be asserted that 80 positions are supported by sales of Casco Bay clams, based on the percentage of gross sales that Casco Bay-origin clams (not including clam dinner "frills") represented (approx. 7%).

- Dealers and resource managers interviewed for this study estimated that in-state consumption of local clams is now 20-30%, up from the 10% previously estimated by Briggs, Townsend and Wilson (1982) as part of their analysis. As a result of these changes in in-state consumption of local clams, Dr. James Wilson, (pers. comm., 1/18/95) has encouraged a modification of the "induced effects" category of the income multiplier to reflect the more recent consumption information developed during this study . The increase from 10% to 20-30% in-state consumption yields an increase in the overall income multiplier of approximately 2.5-3.3, up from 1.65. For purposes of this study, we elected to use 3.0 as the income multiplier.

- Analysis of pollution source samples taken after significant (>1.0") precipitation from small streams in forested and undeveloped watersheds in Maine has previously yielded most probable numbers of fecal coliform >1100. Hence, the fecal coliform bacteria concentrations >1100 from a developed watershed, cannot be used to document pollution caused by inappropriate land use and/or failed engineered systems.

- The use of fecal coliform bacteria concentrations in freshwater samples, obtained by multiple tube fermentation methods, in making decisions about the classification, or re-classification, of soft-shell clam harvesting areas is highly suspect.

- Harvesting areas classified as "closed" in part, or entirely, because of test results of this type (eg., Town Landing Cove) cannot be remediated because problems cannot be defined/documented by the analysis of surface water samples using these methods.

- There are many non-market values associated with the soft-shell clam resources and clamming industry of Casco Bay. "Consumptive" values include having a meal that was harvested for personal use rather than purchased, or eating clams fresh out of the mud flats. "Non-consumptive" values include carrying on a family tradition of recreational digging passed on by grandparents and parents, or watching commercial diggers take part in a centuries-old fishery.

- Recreational clamming in Casco Bay is known to be a substantial non-market use of the clam resource. Clams dug "recreationally" for personal use have a value to the digger even though they cannot be sold. According to municipal survey results, recreationally dug clams from four towns in eastern Casco Bay during 1994 were equivalent to over $440,000, based on a comparable number of steamer dinners.

- Such values are essential to a full valuation of the soft-shell clam resource. It is also useful to recognize these values prior to making municipal decisions on remediation, enhancement, enforcement, or other management efforts. Often these efforts are worth more than simply the commercial harvest that would result.

- Based on a brief survey of clam wardens and town clerks, the demand for recreational licenses was found to be rising. In 1994, for the first time, the Towns of Harpswell and Cumberland each sold out their total available recreational licenses. The municipal interest in managing recreational clamming issues is also rising, as evidenced by two town-wide surveys conducted with recreational licenses holders in 1994.

Additional Findings and Conclusions

- The Maine Department of Marine Resources has delegated responsibility for soft-shell clam resource management to individual coastal municipalities, but is currently providing these municipalities only limited guidance in carrying out their management obligations and has failed to consistently enforce management requirements.

- As a consequence of this failure, the soft-shell clam resource information for Casco Bay is incomplete and, where it exists, the collection of the data and the ways in which it is presented and interpreted differs significantly from one Town to another. Some of the data used to develop the estimates presented here are sound and defensible, but others are weak and lack empirical support.

- Clam production in Casco Bay has been high over the past 3-4 years, but the high prices paid for clams in the past two years has dramatically increased digging pressure which has resulted in stock depletion in several areas of the Bay as indicated by recent surveys. Consequently, several municipalities around the Bay are projecting decreased production for the coming year, expanding a trend shown for Freeport over the past four years. This conclusion is supported by anecdotal information from harvesters and dealers. Two options exist: 1) reduce harvesting effort, and/or 2) expand the resource through resource enhancement efforts and recovery of previously productive areas now closed.

- Closures preclude the harvest of mussels as well as clams. Mussels also have significant economic value and the economic loss associated with the prohibition of mussel harvesting in closed areas should not be overlooked. Further, the encroachment of mussel beds onto clam habitat in closed areas may render adjacent areas unfavorable to the settlement and persistence of soft-shell clams.

- Municipalities are appropriating increasing amounts of funds and effort to shellfish management, but continue to find difficulty in achieving effective management. The effort to reopen a substantial portion of the closed areas of the Bay to shellfish harvesting and to properly manage the resource may require measures that the Casco Bay coastal towns can not achieve entirely on their own.

- Availability and quality of landings data were a major impediment to accurate determination of the value of the resource, both the landed value and the economic value beyond the landed value.

- Management and enforcement of harvesting and tracking of sales of Casco Bay soft-shell clams is inadequate, primarily due to inadequate regulations and lack of public funds to support these efforts.

- The most widely identified problem is that of undocumented direct sales by diggers to shellfish dealers and retail outlets. Shellfish dealers who wish to ship interstate must be certified by the U.S. Food and Drug Administration. Under the terms of their license, registered shellfish dealers are required to report all shellfish purchases to the State of Maine Dept. of Marine Resources on a monthly basis. However, due to lack of adequate funds to support effective enforcement, the state resource managers interviewed for this study estimate that perhaps two-thirds of the certified dealers are in compliance with the reporting requirement at any given time.

- Diggers, non-certified dealers, and retailers are not required to document direct sales by diggers to retail outlets such as restaurants and seafood shops, as well as to consumers along the roadside.

- These undocumented sales represent a hole in the State's ability to estimate harvest levels and to ensure product safety for the consumer. Registered dealers and state and federal resource managers interviewed for this study estimate that 20-30% of the Casco Bay soft-shell clam landings are unreported, leaving the resource at risk of continuous over-harvesting.

- The potential human health risk posed by unreported landings that may be harvested out of closed areas may be reduced by improvements to the reporting and enforcement systems.

General Introduction

The folklore surrounding shellfish harvesting in Casco Bay is rich and vivid, from images of bands of indians establishing camps for the summer along the Bay's shores and islands to harvest shellfish to anecdotes of dories so laden with clams that they failed to float on the rising tide. Indeed, since pre-colonial times clams have played an important role in the nutritional and economic health of Casco Bay's coastal communities. The shell mounds and middens found around the bay today are evidence of the extent to which this resource was exploited by the native indians that frequented the shores of Casco Bay as part of their culture and annual migration to the coast.

After the colonists arrived, the clam resources must have continued in importance, for in 1820, when Maine first became a state, laws were established protecting the rights of everyone to the taking of clams. Later, in 1911, laws were established allowing towns to lease areas for the purpose of culturing the clam. However few took advantage of this opportunity, for then, as today, there was a strong public perception that clams are, and should remain, public property (Newell, 1983).

Production peaked in the early 1930's, possibly due in part to the unemployment situation during the depression. This was followed by a slow decline through the first half of the '40's, perhaps as more and more harvesters were sent off to war or were otherwise employed in shipbuilding or other wartime work. Not surprisingly, as men returned from the armed services shortly after the end of World War II, there was a dramatic rise in production, nearly matching the all-time record (see Figure 1) (Dana Wallace, pers. comm.).

The precipitous decline that followed the late '40's boom was not due to any man-made problem, but was instead a result of a steady increase in annual seawater temperature during the 1950's. The mild winter temperatures during the 1950's allowed the green crab, *Carcinus maenas*, the principal predator of soft-shell clams, to survive in unprecedented numbers. The green crabs devoured small clams shortly after settlement and were such effective 'green predators' that by the late 50's and early '60's the soft-shell clam populations up and down the entire Maine coast had been reduced to historically low levels. As a consequence, the number of harvesters also reached a new low. Fortunately, the populations began rebounding in the late '60's as temperatures once again returned to "normal" and over-winter survival of green crabs declined. By the mid '70's the population had once again regained its earlier strength, but in the early to mid 1980's a new decline in the soft-shell clam population was taking place, particularly in the "downeast" region of Maine, the area traditionally responsible for 50-80% of Maine's overall clam production. This decline continues today bringing clam production for the State down near 1960's levels (Figure 2) (Maine Dept. of Marine Resources).

The exact reason for the "downeast" decline is not clear, but over-harvesting and possible toxic contamination by herbicide, pesticides, or other compounds has been suggested. Regardless of the cause, the demise of the clam industry in eastern Maine has increased the pressure to harvest the resource in the western section of the State, particularly in Cumberland County which is now responsible for almost 30% of Maine's clam production, most of which comes from Casco Bay.

Figure 1. Maine Soft-shell clam production 1899-1993

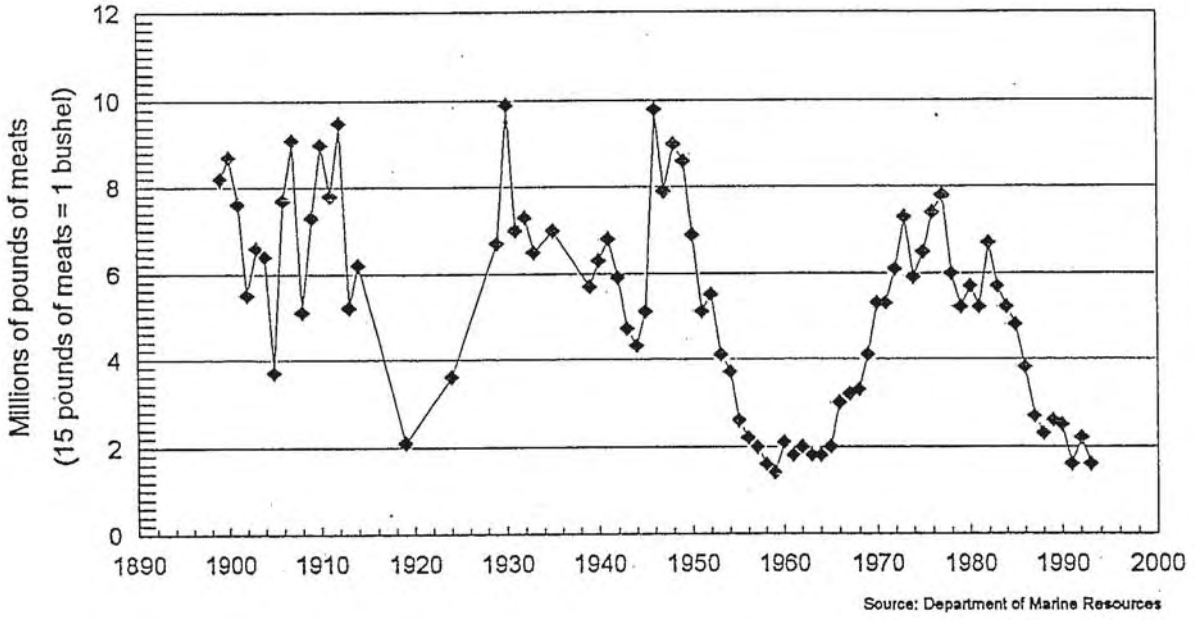
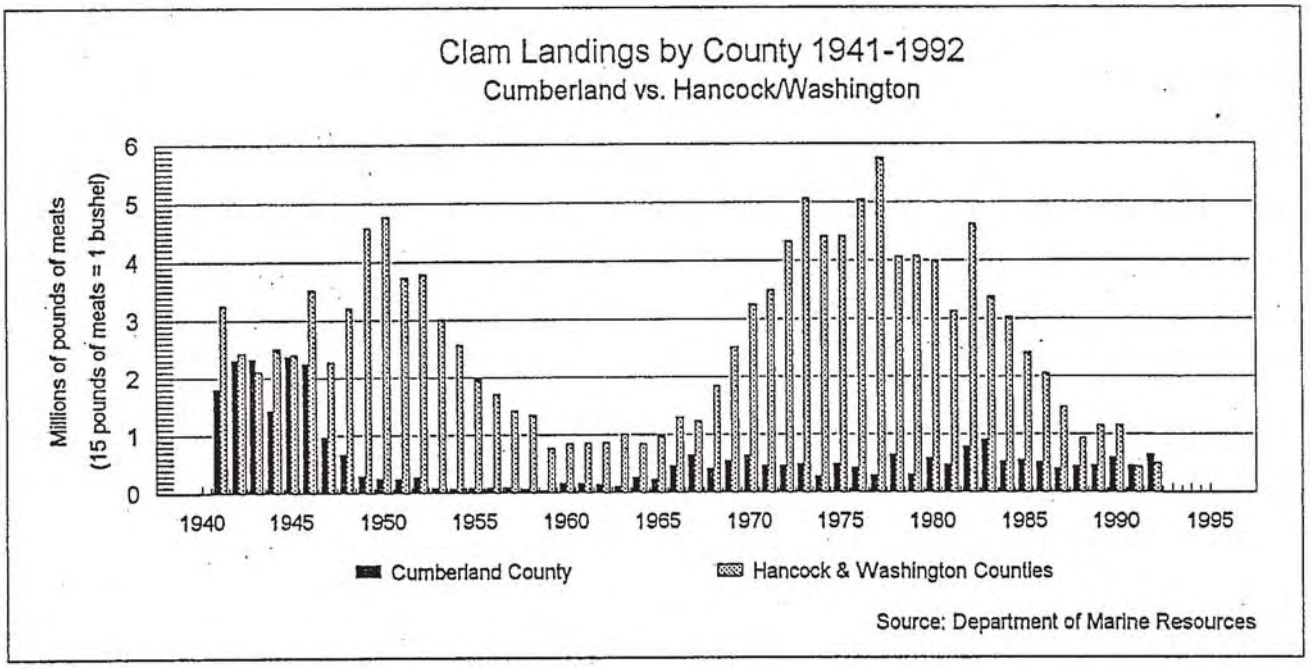


Figure 2. Soft-shell clam production - Washington and Cumberland Counties



Today, even around Portland, the most metropolitan region in Maine, clamming is still viewed as a traditional activity with deep roots into the past. But the tradition is quickly fading as this unique form of capture fishing is increasingly threatened by conflicting uses resulting from an expanding human population and the inevitable development of the shoreline which threatens the water quality of adjacent shellfish harvesting areas. Where the sea was once viewed almost exclusively as a work place for fishing and transport, the emphasis today is shifting towards recreational use, significantly altering the public's perception of marine waters from a place to harvest resources to a place simply to enjoy, perceptions which more and more frequently meet head-on. Questions are being posed regarding the true value of the shellfish resource in view of exorbitant land values. How large is the clam resource? How do the resource and intrinsic values of a clam flat compare to developed shoreline property? What impact does shellfishing have on the community, culturally, economically or otherwise? And finally, should shellfishing even continue to be a priority for coastal communities?

This study, funded by the Casco Bay Estuary Project , is an attempt to answer some of these questions. The study consists of four specific tasks:

Task 1. Estimation of current standing crop, total annual value, and net present value of soft-shell clams, *Mya arenaria*;

Task 2. Evaluation of the broader economic impact of the Casco Bay soft-shell clam industry;

Task 3. Investigation of the economic costs and benefits of pollution source control or removal using two case studies, and

Task 4. An overview of the non-market values of the soft-shell clam industry in Casco Bay and evaluation of their importance in relation to the total economic value of the Bay.

This report is separated into five sections, or chapters, each of the first four corresponding to a specific task, prepared by its respective task manager. Each task, although integrated into a single report, is intended to serve as a "stand alone" document. As such, each section consists of an introduction, method or approach, results, and conclusions. The fifth section contains additional management conclusions and recommendations which are not specific to any of the four tasks.

1.0 Estimate of current standing crop and total annual landed value

by Christopher S. Heinig

1.1 Introduction

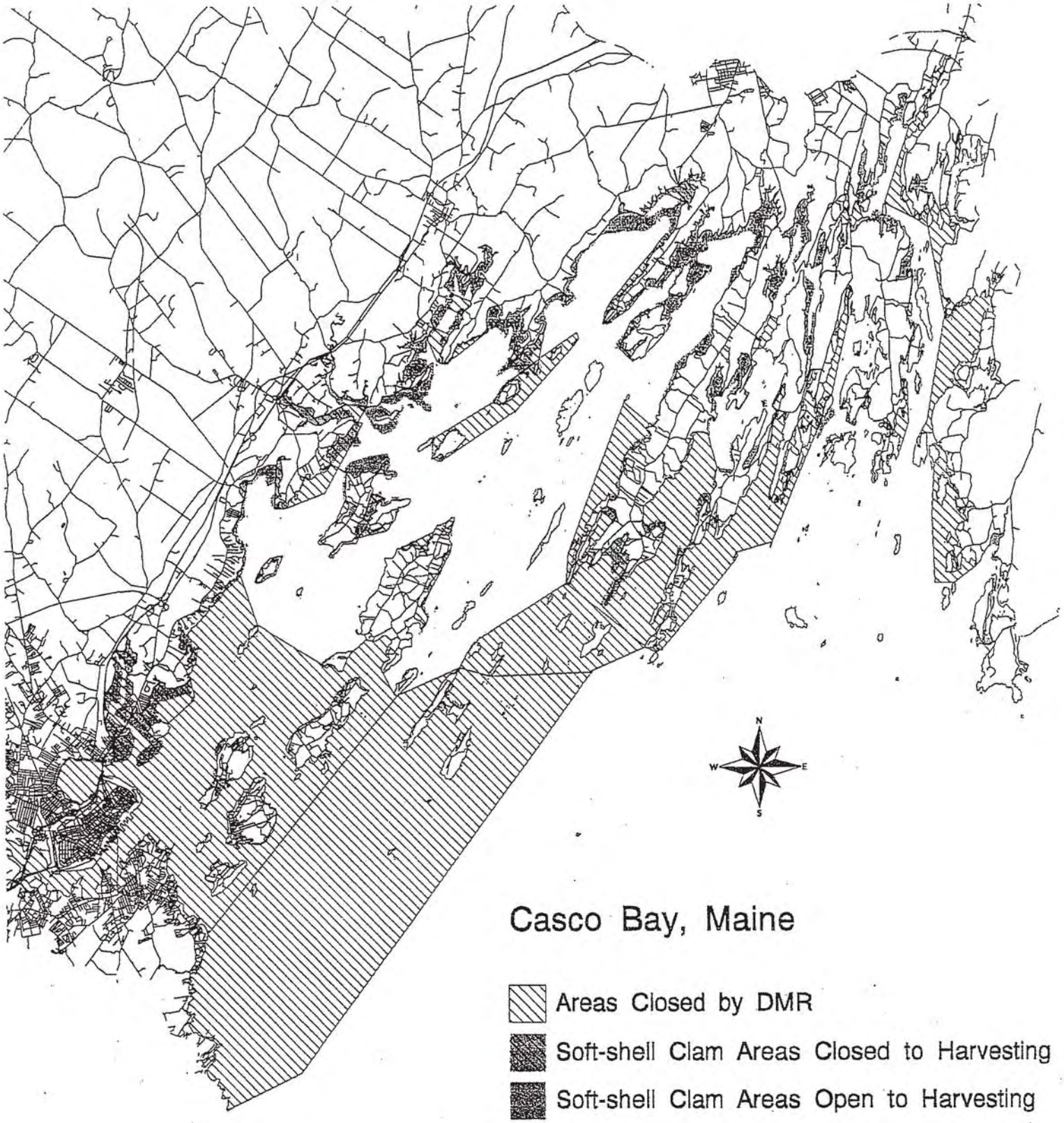
The shellfish resource of the Bay is clearly central to this study and therefore emphasis is placed on its evaluation. It was initially intended that this project would provide a complete evaluation of the soft-shell clam resource of all areas of the Bay, both open and closed. Unfortunately, the level of funding provided for this study, combined with the large potentially productive area of the Bay, would not allow for a complete evaluation of the Bay's soft-shell clam resource. Further, a large portion of Casco Bay, particularly the southwestern area of the Bay in the vicinity of Portland, is currently closed to shellfish harvesting and the prospects of reopening certain sections of this area to harvesting are limited (see Figure 1-1).

The ultimate goal of the Casco Bay Estuary Project is to develop planning/management tools applicable around the entire Bay, as well as other areas along the Maine coast. In view of our inability to cover all potentially productive soft-shell clam areas in the Bay, selection of field study sites was based on the relevance of the presumed reason for closure to other areas around the Bay and the State. Thus, areas presumed closed due to metropolitan development, such as Back Cove surrounded by Baxter Blvd. and Interstate 295, were omitted due to the unusual development-related reasons for closure and the complexity of any remedial procedures, neither of which are representative of conditions elsewhere around the Bay or the State.

Fortunately, considerable information already exists for open areas of the Bay. Several municipalities around the Bay, most notably Brunswick, Harpswell, and Freeport, have developed substantial information on their respective resources as part of their Shellfish Conservation Programs, which in many cases are nothing short of *public sector aquaculture*. Since the information developed through these programs is used principally for the determination of appropriate licensing levels and harvestable resource management, resource assessment efforts are focused on those areas open to commercial and recreational harvesting and relatively little information is available for *closed* areas, that is, areas where shellfishing is prohibited due to observed, presumed, or potential bacterial contamination.

Unfortunately, the information that already exists is not in a consistent format, so the first objective of this portion of the study was to provide a standardized summary of existing soft-shell clam resource information for the open areas of Casco Bay. The second objective was to develop additional, new resource information based on surveys conducted in selected "redeemable" areas of the Bay presently closed due to non-compliance with National Shellfish Sanitation Program (NSSP) standards and/or requirements.

Figure 1-1


N
W
E
S
Casco Bay, Maine
Areas Closed by DMR
Soft-shell Clam Areas Closed to Harvesting
Soft-shell Clam Areas Open to Harvesting
Scale: 1 inch = approx 3 miles

1.2 Geographic description of survey sites

1.21 Municipal surveys of "open" areas

Survey information was compiled for 15 areas in the Town of Brunswick, 11 areas in the Town of Freeport, and 13 areas in the Town of Harpswell. These areas are shown as green-shaded areas in Figure 1-2.

1.22 Surveys of "closed" areas

The following areas were selected for field resource surveys due to their current closed or "restricted" status, as established by the Department of Marine Resources (DMR), or their risk of closure due to their proximity to existing closures. These areas are shown as red-shaded areas in Figure 1-2. The Closed Area numbers used in the location descriptions below refer to the area designations assigned by the DMR.

1. The area between **Mackworth Island and The Brothers, Falmouth, in Closed Area 14,** is currently closed to commercial and recreational harvesting. Depuration harvesting is allowed, suggesting that a commercially valuable resource exists or has existed in the area. The fact that depuration digging (rigorously monitored harvesting followed by a strictly controlled cleansing processes) has been allowed further suggests that the degree of contamination is not severe and remediation is therefore possible.

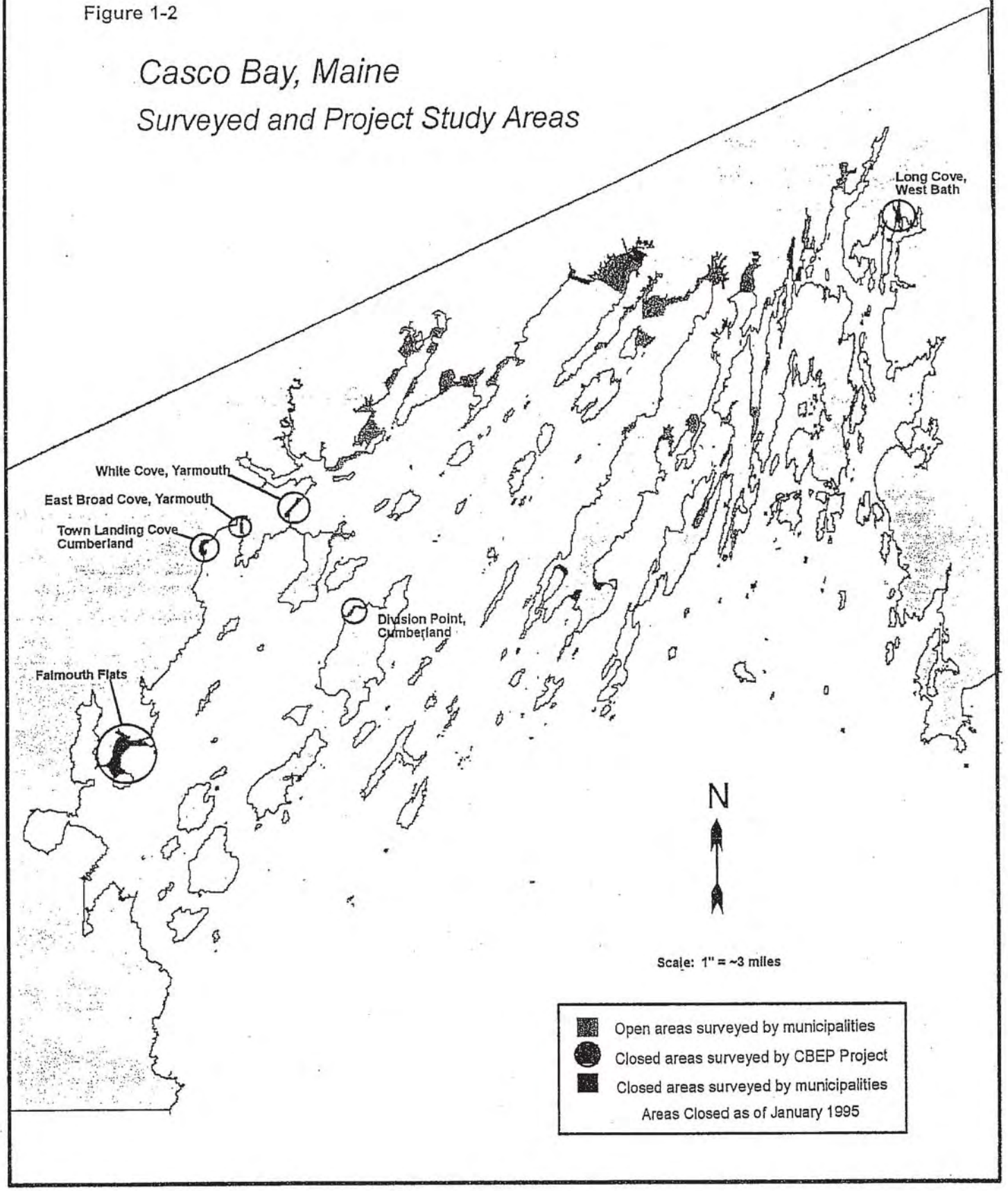
2. **Broad Cove in Cumberland, two sections in Closed Area 15,** is partially closed at either end of the cove where high bacteriological contamination results have been recorded in freshwater entering the cove. Human sources may be implicated, although wildlife and avian sources have also been suggested.

3. The area between **Drinkwater Pt. and Parker Pt. in Yarmouth, in Closed Area 15,** is at the southern mouth of the Royal River. Although presently closed, one likely source of contamination, the Yarmouth sewage treatment plant, was scheduled for replacement in 1994. As one of the outermost areas affected by the existing plant, the prospects for reopening this area may be high if the new sewage treatment plant successfully resolves the current treatment capacity problems and any other proximate sources of contamination, if they exist.

4. **Long Cove in West Bath**, although smaller than the other areas, has been identified, at least preliminarily, as having a resource of commercial significance. Human bacteriological contamination sources are implicated since there are no other identifiable sources other than wildlife.

5. A section of the closed areas on **Chebeague Island, Closed Area 14-D,** along the western shores of the island north of Division Point.

Figure 1-2


Casco Bay, Maine
Surveyed and Project Study Areas
Long Cove, West Bath
White Cove, Yarmouth
East Broad Cove, Yarmouth
Town Landing Cove Cumberland
Division Point, Cumberland
Falmouth Flats
N
Scale: 1" = ~3 miles
Open areas surveyed by municipalities
Closed areas surveyed by CBEP Project
Closed areas surveyed by municipalities
Areas Closed as of January 1995

1.3 Methods

The first phase of the study consisted of collecting soft-shell clam size frequency distribution (number of clams in specific 5mm interval size categories) data from existing information for open, presently harvested area in towns working under municipal shellfish ordinances. These include the Towns of Cumberland, Yarmouth, Freeport, Brunswick, and Harpswell. In the second phase, shellfish surveys were conducted in the selected "closed" areas of the Bay.

1.31 Existing shellfish resource data

Much of the shellfish resource information available from municipalities is relatively current, most having been developed over the past three years. The first effort under Task 1 was to compile existing resource data and, where necessary, to convert the data into a standard format.

Once standardized, all existing resource information was tabulated on a flat by flat basis for each town. These data were then used to develop a Casco Bay-wide table of resources within *open* areas.

1.32 Resource survey methodology for soft-shell clam population evaluations

The methodology used for soft-shell clam population evaluation is the standard methodology developed by the Maine Department of Marine Resources (Dow, 1957). A detailed explanation of this methodology is presented by Newell ed., (1983). A Quality Assurance Project Plan (QAPjP) for the methodology used in this study was submitted to and approved by the EPA. A copy of the QAPjP is included in Appendix Ia.

1.321 Sampling station location

According to this method, the area to be covered by the survey is initially estimated based on a reconnaissance of the selected flat and a prediction of the general configuration of the clam habitat. At the start of the survey, a point of origin is established from which a measured grid is developed across the tidal flat, extending shoreward to the boundary of the shellfish bed, and seaward to the boundary of the shellfish bed or the low water mark, whichever is reached first. Sampling stations are located at 100 foot (or 200 ft., depending on the size of the flat) intervals along imaginary lines which criss-cross, thus forming a grid pattern over the flat. Occasionally, an exception is made in particularly densely populated areas where the grid interval is reduced to 50 feet. Distances between samples along the grid are measured using a 100 ft. line attached to two stakes.

1.322 Sample collection

At each grid intersection, two side-by-side imprints of a 0.1 m^2 (~1 ft^2) frame are made in the bottom to form a 0.2 m^2 (~1 ft. by ~2 ft., or ~2 ft^2), rectangle for sampling. A 0.025 m^2 (~¼ ft^2) subsample of the top ½ to 1 inch of sediment is then removed to estimate clam seed, or "spat", concentrations. This material is placed in a "Zip-Loc" bag bearing the sampling station number. A discrete cut is then made along one of the imprint edges to define the starting boundary. All of the substrate within the imprint boundaries is removed to a depth of at least 25-30 cm (~10-12 inches) and examined for clams. All clams collected from the sample plot are placed in the numbered bag for later measurement and counting.

Sampling in the open and conservation closure areas of Yarmouth was conducted solely by MER Assessment Corp. personnel. Sample collection in the open areas of the Town of Freeport in 1994 was carried out by MER Assessment Corp. with the assistance of commercial diggers from the Town complying with the requirement that each complete twelve (12) hours of Resource Conservation Time in order to be eligible for renewal of their Town issued commercial shellfish harvesting license. Surveys in the Town of Brunswick were conducted by Alan Houston and Shelagh Catlin of Brunswick's Marine Resources Office. Sample collection within the closed areas surveyed as part of this study was conducted solely by MER Assessment Corporation personnel with the permission of the Maine DMR.

1.33 Measurements and calculations

All clams found in each sample, including spat found in the subsample, are measured to the nearest 5 mm interval on a 0 to 95 mm scale. The information for each stations is then tabulated and entered into a spreadsheet used specifically for soft-shell clam population analyses (see Appendix Ib.). The analyses performed in the spreadsheets use equations developed by the Department of Marine Resources for the determination of bushels per acre and harvest yields. These equations are based on size frequency and yield tables developed by Belding (1930) as modified by Stevenson and Sampson (1981).

The upper portion of the spreadsheet is used to input the survey results for each sampling station or "Plot". The data from the individual sampling stations is then summed at the end of this portion of the spreadsheet to develop a size frequency distribution for the entire survey area. The size frequency distribution data are used to calculate *current total* standing crop in bushels and bushels per acre, *current harvestable* standing crop in bushels and bushels per acre, and *current* percentage of crop harvestable.

Using specific assumptions for growth and a sliding scale for mortality (both natural and harvest-related), a first attempt has been made at developing a model to estimate following year production (MER Assessment Corp.). The model requires considerable refinement, but on flats where information for two consecutive years is available, the model has been shown to project following year production with acceptable accuracy. However, it is incapable of projecting beyond the following year. By applying *current* population size distribution data to the model, *following year* projections are made for the flat for both open harvested and closed/ prohibited scenarios.

Unfortunately, since only a portion of a town's clam flats are surveyed in any given year, information with which to project *following year* production is limited and does not adequately respond to a Town's need to know what overall production will be in order to match license issuance to production. Some other method of estimating overall production is therefore needed. To this end, the model referred to above has been reduced to a simpler equation which relates following year production to the volume of sub-legal clams present in the Town's areas open to commercial harvesting (see Notes for Tables 1-1 through 1-3, p. 17).

Finally, the harvestable production estimates for the current year and the model-generated following year projections for open-harvested and/or closed-prohibited scenarios are used to calculate the ex-vessel dollar value of the resource using a matrix of ranges of bushel prices and local economic activity multipliers.

1.4 Results

1. 41 Open areas

Tables 1-1 through 1-3 summarize the results of all shellfish surveys conducted in the areas open to shellfish harvesting in the individual Towns of Brunswick, Freeport, and Harpswell and covers most of the commercially harvested area of the Bay. This information is presented on a flat-by-flat basis for each year in which a flat has been surveyed through 1993. The Town of Brunswick's information already includes the 1994 projections for each flat. The 1994 projections for the Towns of Freeport and Harpswell are based on harvestable and total production data, the calculations for which are carried out for the Town as a whole at the end of its respective Table (see Appendix Ib for supporting information). No population survey information is available for the open or closed areas of the Town of West Bath. No 1993 survey information is available for the open or closed *commercial* harvesting areas of the Towns of Falmouth, Cumberland, or Yarmouth. No survey information is available for the Town of Phippsburg since all shellfish areas of the Town forming part of Casco Bay are either closed to harvesting by the DMR or are in the process of being reseeded and are therefore closed for *conservation* (see note on page 22).

Summing the ***Projected harvestable bushels*** for all three of the Towns of Brunswick, Freeport and Harpswell for 1994 yields the following Open Area estimate:

Brunswick	36,100 bushels
Freeport	23,464 "
Harpswell	31,586 "
Total	**91,150 bushels**

Dow and Wallace (1957) reported a digging efficiency of 84% for diggers observed over several years, the number observed having represented approximately two percent of the commercial diggers of the time. They also pointed out that harvesting methods vary considerably between, and are peculiar to, specific regions of the coast. Other unpublished observations have shown that efficiency can range from as low as 50% to as high as nearly 100%. Given the sediment types found in this region and the digging methods used here, it is generally agreed that in Casco Bay clam diggers are approximately 70% efficient in harvesting market-size clams (Dana Wallace, pers. comm.). Assuming this to be true, it would be expected that 63,805 bushels of the 91,150 harvestable bushels would actually be harvested. At $72.95/bushel (NMFS 1994 mean annual price) the harvest would be worth ~$4,654,575.

Another approach to estimating the total production is to perform the same projections on historical information available on Casco Bay's open areas. Table 1-4 summarizes the information in Tables 1-1 through 1-3 and includes additional information developed for the Towns of Cumberland, Freeport and Yarmouth during 1994 (refer to Appendix Ic). Based on the ten-year historical summary, in the *mean* year there are approximately 68,386 *harvestable bushels in the flats*. However, many of the harvestable bushels numbers for the Town of Brunswick in Table 1-4 include projected harvestable production. Further, there are no corresponding <u>total</u> production estimates for areas where harvestable bushels are simply projected by extrapolation. Given these difficulties, the data for Brunswick must be treated separately from that of Harpswell and Freeport.

The Town of Brunswick estimated projected production for the years 1993 and 1994 at 35,313 and 36,101, respectively. The Town is now projecting production for 1995 at 33,208. Thus, over this three year period the mean total harvestable production for the Town is 34,874 bushels.

Table 1-1
Shellfish Survey Data Summary for 1993 - Town of Brunswick

Cove	Year	Acres	Bu/ac	Total Bu.	Harv. Bu./ac	Harv. Bu.
Barne's Cove	1993	7.0	45.0	315.0	29.7	207.9
	1994 (Est.)	7.0	—	—	15.0	105.0
	Mean	**7.0**	**22.5**	**157.5**	**22.4**	**156.5**
Cole's Cove	1991	7.0	39.9	279.3	8.7	60.9
	1993	7.0	87.0	609.0	59.6	417.2
	1994 (Est.)	7.0	—	—	102.0	714.0
	Mean	**7.0**	**42.3**	**296.1**	**56.8**	**397.4**
Crow Island	1993	10.0	69.8	698.0	29.9	299.1
	1994 (Est.)	10.0	—	—	93.0	930.0
	Mean	**10.0**	**34.9**	**349.0**	**61.5**	**614.6**
Harpswell Cove	1993 (Est.)	57.0	—	—	100.0	5700.0
	1994 (Est.)	57.0	—	—	57.0	3249.0
	Mean	**57.0**	—	—	**78.5**	**4474.5**
Little Bullpen	1993 (Est.)	3.5	—	—	187.2	655.2
	1994 (Est.)	3.5	—	—	148.0	518.0
	Mean	**3.5**	—	—	**167.6**	**586.6**
Maquoit Bay	1992	40.0	116.6	4664.0	39.9	1596.0
	1993	40.0	50.1	2004.0	36.0	1440.0
	1994 (Est.)	44.0	—	—	72.3	3181.2
	Mean	**41.3**	**55.6**	**2222.7**	**49.4**	**2072.4**
Mere Point	1992	11.0	44.7	491.7	11.5	126.5
	1993	11.0	65.9	724.9	27.2	299.2
	1994 (Est.)	10.0	—	—	87.1	871.0
	Mean	**10.7**	**36.9**	**405.5**	**41.9**	**432.2**
Middle Bay	1993 (Est.)	129.0	—	—	87.2	11248.8
	1994 (Est.)	129.0	—	—	93.0	11997.0
	Mean	**129.0**	—	—	**87.2**	**11246.8**
Upper Middle Bay	1993 (Est.)	10.0	—	—	10.0	100.0
	1994 (Est.)	10.0	—	—	10.0	100.0
	Mean	**10.0**	—	—	**10.0**	**100.0**
New Meadows	1993 (Est.)	30.0	—	—	136.0	4080.0
	1994 (Est.)	30.0	—	—	136.0	4080.0
	Mean	**30.0**	—	—	**136.0**	**4080.0**
Prince's Point	1991	15.0	59.4	891.0	18.4	276.0
	1992	15.0	82.1	1231.5	19.2	288.0
	1993	15.0	83.5	1252.5	61.3	919.5
	1994 (Est.)	15.0	—	—	96.1	1441.5
	Mean	**15.0**	**75.0**	**1125.0**	**33.0**	**494.5**
Smith's Cove	1992 04	8.0	36.2	289.6	29.0	232.0
	1992 08	8.0	101.4	811.2	62.7	501.6
	1993	8.0	25.8	206.3	12.4	99.0
	1994 (Est.)	8.0	—	—	32.5	260.0
	Mean	**8.0**	**40.8**	**326.8**	**34.1**	**273.2**
Thomas Point Beach	1992	21.0	267.1	5609.1	110.7	2324.7
	1993	21.0	201.2	4225.8	127.5	2677.5
	1994 (Est.)	21.0	—	—	135.5	2845.5
	Mean	**21.0**	**156.1**	**3278.3**	**124.6**	**2615.9**
Upper Coomb's	1993 (Est.)	24.0	—	—	115.6	2774.4
	1994 (Est.)	24.0	—	—	148.0	3552.0
	Mean	**24.0**	—	—	**131.8**	**3163.2**
Woodward Cove	1991	24.0	192.3	4615.2	85.6	2054.4
	1992	24.0	286.8	6883.2	89.5	2148.0
	1993	24.0	74.1	1778.4	45.3	1087.2
	1994 (Est.)	24.0	—	—	94.0	2256.0
	Mean	**24.0**	**138.3**	**3319.2**	**78.5**	**1886.4**
Sum of the Means		**397.5**	—	—	**1113.3**	**32596.1**
Mean Area over Time		**26.5**	—	—	**74.2**	**2173.1**
Sum of the Means 1993		**396.5**	—	—	**1064.9**	**32006.0**
Mean Area in 1993		**26.4**	—	—	**71.0**	**2133.7**
Sum of the Means 1994		**399.5**	—	—	**1319.5**	**38100.2**
Mean Area in 1994		**26.6**	—	—	**88.0**	**2406.7**

Projected harvest. = 38100
Proj. Lic.s = 68 FOR 1994 @ 70% Efficiency
Licenses = 97 FOR 1994 @ 100% Efficiency

Table 1-2
Shellfish Survey Data Summary for 1993 - Town of Freeport

Cove	Year	Acres	Bu/ac	Total Bu.	Harv. Bu./ac	Harv. Bu.
W. Bartol (WB)	1989	82.9	132.0	10943.0	69.2	5733.0
	1992	82.0	68.3	5601.0	43.2	3546.0
	Mean	82.5	100.2	8272.0	56.2	4639.5
East Bartol (EB)	1989	37.4	72.9	2727.0	50.5	1890.0
	1992	25.0	92.6	2316.0	62.8	1570.0
	Mean	31.2	82.8	2521.5	56.7	1730.0
Collins Cove (CC)	1989	18.0	140.4	2528.0	78.5	1413.0
	1992	26.0	158.2	4112.0	67.5	1754.0
	Mean	22.0	149.3	3320.0	73.0	1583.5
Little River (LR)	1990	42.7	77.9	3327.0	46.6	1990.0
	1992	48.5	46.4	2252.0	33.0	1598.0
	Mean	45.6	62.2	2789.5	39.8	1794.0
Wolf Neck, West (WN)	1989	17.5	169.3	2787.4	86.8	1518.8
Recompense (RC)	1990	32.6	63.6	2072.0	41.6	1356.0
	1991	15.3	45.5	696.0	35.1	537.0
	Mean	24.0	54.6	1384.0	38.4	946.5
Staples/Spar (SS)	1991	88.0	34.3	3045.5	14.9	1314.5
	1993	89.0	47.2	4190.8	38.2	3402.2
	Mean	88.5	40.8	3618.2	26.6	2358.4
Pettingill Cove (PC)	1992	13.0	226.5	2944.0	163.5	2125.0
Winslow Park/Fogg Pt. (WP)	1991	23.4	67.6	1575.0	20.7	485.0
	1993	68.5	42.5	2907.7	37.0	2534.1
	Mean	46.0	55.0	2241.4	28.9	1509.6
Brickyard Cove (BC)	1990	6.2	70.8	438.8	49.3	305.9
Little Flying Point (FP)	1990	4.6	228.6	1049.2	127.8	587.7
Sum of the Means		359.0	1090.5	28045.9	673.8	17515.3
Mean Area		32.6	99.1	2549.6	61.3	1592.3
Sum of the Means 1993		382.0	1084.5	29284.9	693.6	19583.7
Mean Area 1993		34.7	98.6	2662.3	63.1	1780.3

Har. bushels in flat = 19583.7
Projected harvest = 23464.2 harvested bushels in 1994
Proj. Lic. = 50.6 for 1994 @ 1.5 bushels/tide and 70% efficie

Table 1-3
Shellfish Survey Data Summary for 1993 - Town of Harpswell

Cove	Year	Acres	Bu/ac	Total Bu.	Harv. Bu./ac	Harv. Bu.
Doughty Cove	1992	13.3	185.7	2470.0	92.3	1228.0
Strawberry Crk.	1985	7.9	59.2	467.0	38.6	305.0
	1988	7.9	157.9	1248.0	95.7	756.0
	1991	7.8	163.8	1278.0	58.6	457.0
	1993	10.6	151.5	1599.7	83.1	877.1
	Mean	8.5	133.1	1148.2	69.0	598.8
Mill Cove	1985	7.0	85.6	578.0	38.7	271.0
	1987	7.0	307.0	2151.0	98.3	688.0
	1988	7.0	143.0	1001.0	62.5	438.0
	1991	38.3	74.1	2839.0	34.1	1305.0
	1993	32.8	85.3	2791.9	53.6	1756.3
	Mean	18.4	139.0	1872.2	57.4	891.7
Widgeon Cove	1985	3.5	199.0	696.0	125.0	436.0
	1988	5.0	166.0	830.0	94.3	471.0
	1991	7.5	100.0	752.0	30.1	226.0
	Mean	5.3	155.0	759.3	83.1	377.7
Birch Island	1988	7.5	185.5	1392.0	134.0	1005.0
Long Reach	1990	13.8	56.0	778.0	31.8	440.0
	1993	32.8	87.3	2859.1	73.0	2392.1
	Mean	23.3	71.7	1818.6	52.4	1416.1
Long Cove	1992	22.0	95.8	2107.0	54.6	1202.0
Laurel Cove	1989	5.0	43.0	212.0	33.6	168.0
	1993	8.2	261.3	2129.8	178.3	1462.0
	Mean	6.6	152.2	1170.9	106.0	815.0
Rich Cove	1989	3.2	44.0	141.0	31.3	100.0
	1992	5.0	295.6	1478.0	120.4	602.0
	Mean	4.1	169.8	809.5	75.9	351.0
Brickyard Cove	1989	2.3	55.0	126.0	37.8	87.0
	1992	7.0	255.2	1787.0	55.6	389.0
	Mean	4.7	155.1	956.5	46.7	238.0
Indian Pt.	1989	4.3	194.0	822.0	106.7	459.0
Northeast Cove	1993	3.5	267.3	935.6	143.2	501.2
White's/Scrag Islands	1992	50.0	453.0	22646.0	97.7	4885.0
	1993	52.7	250.0	13176.0	159.3	8393.0
	Mean	51.4	351.5	17911.0	128.5	6639.0
Sum of the Means		172.9	2255.6	34172.7	1149.7	15722.3
Mean Area		12.3	161.1	2440.9	82.1	1123.0
Sum of the Means 1993		201.7	2243.6	32808.4	1283.7	20242.3
Mean Area 1993		13.4	149.6	2187.2	85.6	1349.5

Harv. bushels in flats = 25303 adjusted for 80% coverage from 20242.3
Projected harvest = 31586 in 1994 including projected growth
Proj. Lic. = 68 for 1994 @ 1.56 bushels/tide and 70% efficiency

Notes for Tables 1-1 through 1-3

These tables present information, (either actually measured through surveys or simply estimated by extrapolation), on the total productive area (Acres), total bushels per acre (Bu/ac), total production (Total Bu.), market-size, that is, *harvestable*, population density (Harv. Bu/ac), harvestable production (Harv. Bu.), and the percentage of the total population that is harvestable (% Harvestable). Total bushels per acre is missing for those flats in Brunswick where harvestable production was estimated rather than measured. Where more than one survey has been conducted for the flat, averages for all of the survey years' results are presented as **Means**. The **Sum of the Means** are summations of the **Means** for Acres, Bu/ac, Total Bu., etc. for all of the individual flats for all of the years in which the flats have been surveyed. The **Mean Area values** are simply the **Sum of the Means** divided by the total number of flats which are currently surveyed in the Town. These values allow comparison of an individual flat to the mean or average flat in Town, other town, or Casco Bay. The **1993 Sum of the Means** and **1993 Mean Area** are calculated using 1993 data, where available, and mean summary values where 1993 data are not available. The purpose of this is to allow the weighted current year's results, in this case 1993, to be compared with the recent historical average to determine if the resource is increasing, decreasing, or remaining stable.

At the bottom of the Tables, the ***Harvestable bushels in flat*** represents the estimated *aggregate* number of currently harvestable bushels in the Town from all open areas. The ***Projected harvestable bushels*** represents the estimated number of bushels which will be available for harvesting based on the number of harvestable bushels currently available and number of bushels anticipated to be added during the harvesting season as a result of growth of sub-legal-sized clams (see below). Since the Town of Brunswick's Harvestable bushels is based entirely on projections, the **Harvestable bushels in flat** equals the **Projected harvestable bushels.**

A word of caution on relying on averages is necessary. As the data show, clam population densities on individual flats can change dramatically over relatively short periods of time, due in part to the dramatic differences in recruitment which can occur from year to year. In view of this, the use of an *average flat* or *average year* should therefore be understood to be a crude comparison and used only for generalizations.

In view of the limited number of surveys which can be conducted each year and the need for overall production estimates, the model referred to in Section 3.3 above has been simplified. Application of data from several different flats around the Bay to the model, along with field observations over the years, has shown that, during a growing season, the annual volumetric conversion of sub-legal bushels to harvestable bushels in open, harvested areas is in the order of ~0.4 to ~0.7, the rate of conversion varying according to the size frequency distribution of the population (Heinig, in progress). That is, on flats where survey results show a population peak just below the 2-inch (52mm) legal size limit the conversion will be higher; where the population is composed primarily of small juveniles, the conversion will be smaller. Thus a simplified *following year projection* for an individual flat or group of flats can be expressed as:

$$\text{Eq. 1} \qquad Proj_{hb} = H_b + ((T_b - H_b)*C)$$

where $Proj_{hb}$ is projected harvestable bushels, H_b is currently harvestable bushels, T_b is total bushels, and **C** is the conversion factor. It is important to note that this equation does not suggest that a certain proportion of the sub-market bushels moves into the harvestable range, but that the volumetric increase resulting from growth of sub-legal clams reaching legal size is *equivalent* to the approximate volume of a proportion of the current sub-legal bushels. In Tables 1-2 and 1-3 the number of ***Projected harvestable bushels*** for the Towns of Freeport and Harpswell is determined for the aggregated flats using Equation 1 and a rather conservative value of 0.5 for the variable **C**.

The recent historical mean *in-flat total bushels* for Freeport is 28,777 and the mean *in flat harvestable bushels* is 17,747 (refer to Table 1-4). In Harpswell the recent historical *in flat total bushels* is 34,173 and the recent historical mean *in flat harvestable bushels* is 15,723. In Yarmouth the recent historical *in flat total bushels* is 804 and the recent historical mean *in flat harvestable bushels* is 390 (recent historical values for Cumberland are not included here since the results of one survey do not include total bushels, thus preventing projections from being made). Applying each town's values to Equation 1 (see Notes on Tables 1-1 through 1-3, p. 15) and using values of .5 and .7 for **C**, yields a range of 23,262 to 25,468 projected harvestable bushels for Freeport, 24,948 to 28,638 for Harpswell, and 597 to 680 for Yarmouth. Combining these values with the mean for Brunswick yields a range of 83,681 to 89,660 bushels. These combined recent historical, individual town results agree fairly closely with the 91,150 bushels obtained using the 1994 projections for Brunswick, Freeport, and Harpswell. Again assuming harvesting efficiency at 70%, the expected mean annual *actual* harvest for the Bay would be between ~58,575 and 62,760 bushels. The estimated 63,805 for 1994 calculated above therefore suggests that 1994 was a slightly above average year when compared to recent historical data. This situation may be changing, as we shall see later.

Using the mean 1994 annual price of $72.95/bushel, the "in-flat" value of the resource in an average year is $6,104,530 to $6,540,697. The estimated value of the landed harvest in an average year is $4,273,050 to $4,578,340. The NMFS's annual price of $72.95/bushel is used since it is the only *published* number available. However, the actual bushel price may be substantially higher, thus significantly increasing the resource value (see Task 2., Section 2.55).

Finally, the number of commercial shellfish harvesting licenses which can be supported by the resource is determined on the basis of harvesting efficiency, the average number of tides a harvester normally digs, and the average number of bushels harvested per harvester per tide. The values used for these variables have been developed through interviews with harvesters and dealers and differs slightly from town to town. The Town of Brunswick assumes 100% harvesting efficiency when calculating licenses. The number of tides normally harvested per year is estimated at 209 with 1.78 bushels harvested per tide, equivalent to approximately 370 bu./harvester/year. The Towns of Freeport and Harpswell use a harvesting efficiency of 70%, 208 for the number of tides normally harvested per year, and 1.56 for the average number of bushels harvested per tide, equivalent to approximately 320 bushels/harvester/year. Based on these values, the *Projected Licenses* which each town's expected harvest could support in 1994 is presented at the bottom of Tables 1-1 through 1-3.

Table 1-4
Shellfish Survey Data Summary - Open Areas of Casco Bay

Cove	Survey Years	Means for all years surveyed				
		Acres	Bu/ac	Total Bu.	Harv. Bu./ac	Harv. Bu.
BRUNSWICK						
Barne's Cove	1993, 94 (est.)	7.0	—	—	22.4	156.8
Cole's Cove	1991, 93, 94 (est.)	7.0	—	—	56.8	397.6
Crow Island	1993, 94 (est.)	10.0	—	—	61.5	615.0
Harpswell Cove	1993, 94 (est.)	57.0	—	—	78.5	4474.5
Little Bullpen	1993, 94 (est.)	3.5	—	—	167.6	586.6
Maquoit Bay	1992, 93, 94 (est.)	40.0	—	—	49.4	1976.0
Mere Point	1992, 93, 94 (est.)	10.0	—	—	41.9	419.0
Middle Bay	1993, 94 (est.)	129.0	—	—	90.1	11622.9
Upper Middle Bay	1993 (est.), 94 (est.)	10.0	—	—	10.0	100.0
New Meadows	1993 (est.), 94 (est.)	30.0	—	—	136.0	4080.0
Prince's Point	1991, 92, 93, 94 (est.)	15.0	—	—	33.0	495.0
Smith's Cove	1992, 93, 94 (est.)	8.0	—	—	35.9	287.2
Thomas Point Beach	1992, 93, 94 (est.)	21.0	—	—	124.6	2616.6
Upper Coomb's	1993 (est.), 94 (est.)	24.0	—	—	131.8	3163.2
Woodward Cove	1991, 92, 93, 94 (est.)	24.0	—	—	78.6	1886.4
Total/Mean (Italics)		396.5	—	—	*83.1*	32876.8
CUMBERLAND						
Spruce Lane Cove	1994	2.5	17.1	42.8	0.0	0.0
Ole Musket Rd. Cove	1994	3.9	61.9	241.4	13.2	51.3
Chebeague Bar	1994	8.4	—	—	36.0	302.0
Cheb. Is. SW Div. Pt.	1994	12.0	164.1	1969.2	108.0	1296.0
Total/Mean (Italics)		26.8	—	—	*39.3*	1649.3
FALMOUTH	No data available	—	—	—	—	—
FREEPORT						
W. Bartol (WB)	1989, 92, 94	91.4	77.6	6696.0	43.8	3789.7
East Bartol (EB)	1989, 92, 94	31.2	82.8	2521.5	56.7	1730.0
Collins Cove (CC)	1989, 92, 94	22.2	111.6	2486.5	55.5	1210.4
Little River (LR)	1990, 92	45.6	62.2	2789.5	39.8	1794.0
Wolf Neck, West (WN)	1989	17.5	159.3	2787.4	86.8	1519.0
Recompense (RC)	1990, 92	24.0	54.6	1384.0	38.4	946.5
Staples/Spar (SS)	1991, 93	88.5	40.8	3618.2	26.6	2358.4
Pettingill Cove (PC)	1992	13.0	226.5	2944.5	163.5	2125.5
Winslow Prk/Fogg Pt. (WP	1991, 93	46.0	55.0	2241.4	28.9	1509.6
Brickyard Cove (BC)	1990, 94	6.9	72.1	494.6	41.1	276.3
Little Flying Point (FP)	1990, 94	3.9	208.5	813.2	125.0	487.5
Total/Mean (Italics)		390.2	*73.4*	28776.8	*66.0*	17746.9
HARPSWELL						
Doughty Cove	1992	13.3	185.7	2470.0	92.3	1228.0
Strawberry Crk.	1985, 88, 91, 93	8.5	133.1	1148.2	69.0	598.8
Mill Cove	1985, 87, 88, 91, 93	18.4	139.0	1872.2	57.4	891.7
Widgeon Cove	1985, 88, 91	5.3	155.0	759.3	83.1	377.7
Birch Island (North)	1988	7.5	185.5	1392.0	134.0	1005.0
Long Reach	1990, 93	23.3	71.7	1818.6	52.4	1416.1
Long Cove	1992	22.0	95.8	2107.0	54.6	1202.0
Laurel Cove	1989, 93	6.6	152.2	1170.9	106.0	815.0
Rich Cove	1989, 92	4.1	169.8	809.5	75.9	351.0
Brickyard Cove	1989, 92	4.7	155.1	956.5	46.7	238.0
Indian Pt.	1989	4.3	194.0	822.0	106.7	459.0
Northeast Cove	1993	3.5	267.3	935.6	143.2	501.2
White's/Scrag Islands	1992, 93	51.4	351.5	17911.0	128.5	6639.0
Total/Mean (Italics)		172.9	*173.5*	34172.8	*88.4*	15722.5
PHIPPSBURG	No data available	—	—	—	—	—
YARMOUTH						
Cousins I.-Little John	1994	5.6	143.6	804.2	69.7	390.4
WEST BATH	No data available	—	—	—	—	—
Sum of the Totals		964.2	—	—	—	68385.9
Mean Area		24.1	—	—	67.3	1590.4

Harvestable Bushels in flats = 68385.9 from OPEN areas/mean yr.

1. 42 Closed areas

The results of the surveys conducted in the five (5) closed areas are summarized below in Table 1-5. All supporting information for this table is included in Appendix Id.

Table 1-5
Shellfish Survey Data Summary - Selected "Closed" Areas of Casco Bay

Cove	Survey Years	Means for all years surveyed				
		Acres	Bu/ac	Total Bu.	Harv. Bu./ac	Harv. Bu.
MUNICIPAL SURVEYS						
BRUNSWICK						
Bunganuc Creek	1990	26.0	—	—	55.1	1431.6
NE Maquoit Bay	1990	29.0	—	—	26.8	777.2
Mere Point Cove 1	1990	2.3	—	—	155.3	349.4
Mere Point Cove 2	1990	1.0	—	—	86.0	86.0
Gurnet/Buttermilk Cove	1990	8.5	—	—	63.1	536.4
New Meadows	1990	4.5	—	—	126.7	570.2
	Totals	71.3	—	—	—	3750.7
	Means	11.9	—	—	85.5	625.1
HARPSWELL						
Basin Cove	1984, 85, 87, 88, 91, 93	9.0	116.7	1031.3	66.1	581.1
Ash Cove	1988, 91	6.0	68.0	386.5	47.0	286.5
Stovers Cove	1992	3.7	70.2	259.7	67.6	250.0
	Totals	18.7	254.9	1677.5	180.7	1117.6
	Means	6.2	85.0	559.2	60.2	372.5
YARMOUTH						
Lanes I. (Conserv.)	1994	4.3	68.5	291.1	30.5	129.7
CBEP STUDY SURVEYS						
Mackworth Island	1994	114.0	8.3	945.4	2.1	242.8
Broad Cove - Cumb.	1994	11.5	56.9	654.7	47.2	542.8
Broad Cove - Yarm.	1994	3.4	26.7	90.8	12.1	41.1
Long Cove - W. Bath	1994	11.5	294.3	3384.3	248.2	2854.3
White Cove - Yarm.	1994	3.1	79.9	735.0	51.8	476.0
Cheb. Is. N Div. Point	1994	3.9	31.6	123.2	5.2	20.4
	CBEP Totals	147.4	—	5933.4	—	4177.4
	CBEP Means	24.6	83.0	988.9	61.1	696.2
Municipal and CBEP Totals		241.7	—	—	—	9175.4
Municipal and CBEP Means		16.1	—	—	52.8	611.7

Bushels in flats = 9175.4 from OPEN areas/mean yr.
Expected harvest = 6422.8 assuming a 70% harvesting efficiency
Licenses = 30.2 /mean yr.

1.5 Discussion

1.51 *Open area production*

The Maine DMR and National Marine Fisheries Service (NMFS) field office in Portland, Maine compile landings statistics for all of the fisheries in Maine. These statistics are available on a county by county basis for any of the most recent years through 1994. Table 1-6 presents the landings statistics for soft-shell clams in Cumberland County for the years 1992-94. It should be noted that Cumberland County includes the Town of Scarboro which is not considered part of Casco Bay. Conversely, the Town of Phippsburg, at least its western shore, forms part of Casco Bay, but as part of Sagadahoc County, Phippsburg landings are not included in the Cumberland County statistics.

The total landings reported by the NMFS for Cumberland County for the year 1994 is 52,974 bushels. Based on the historical data and projections of the 1993 municipal surveys, 1994 production was estimated at 63,805 bushels, similar to 1993, with Brunswick expecting an increase and Harpswell and Freeport expecting slight decreases. *A comparison of the NMFS/DMR data and the municipal data shows the municipal* ***mean expected harvestable*** *production of 63,805 bushels for 1994 to be approximately 20% higher than the NMFS estimate. The ex-vessel value of $4,654,575 for the* ***mean expected harvestable*** *production, assuming an annual mean price of $72.95 per bushel, is also approximately 20% higher than the NMFS estimated values of $3,864,201.* According to Robert Morrill, chief of the NMFS Portland office, and Bob Lewis, statistician for the DMR, the landings statistics for Cumberland County are believed to account for only 70-75% of the actual landings. The estimated production data presented here appears to suggest a slightly higher level of accounting accuracy.

There are undoubtedly numerous factors which contribute to the discrepancies in the landings estimates. These factors can be related to either the ***accounting of the landings*** *or the* ***estimates of production.*** Perhaps the most important of the ***accounting*** discrepancy results from the incomplete reporting or under-reporting by dealers. There are, however, others which include the sale of Casco Bay-origin clams outside of Cumberland County, i.e. the Lewiston-Auburn area, sales to out-of-state dealers, i.e. Massachusetts, and direct sales to consumers (pick-up truck "tailgate" sales) and/or restaurants. These and other accounting reasons for the difficulties in establishing the actual landings for Casco Bay are discussed in detail in Section 2.51 of Task 2.

Additional reasons for the discrepancies are related to ***the way in which resource information is collected and treated.*** *As mentioned earlier,* ***municipal survey efforts around the Bay focus on the larger, commercially important flats. Smaller, less significant areas undergo little if any evaluation, but despite their individual smaller size, collectively they can represent a substantial area.*** In Harpswell, for example, commercially important flats have been routinely surveyed since the late 1980's. During the surveys, every effort is made to cover 100% of the populated flat and no extrapolation of the data is required for individual flats. These flats, however, represent an estimated 80% of the total productive habitat in the Town (Harpswell Marine Resources Comm.). The more remote harvesting areas around islands and very long, narrow flats, such as along the western shore of Harpswell Neck, are less likely to be surveyed because of logistical difficulties or their perceived insignificance. Thus, in order to more accurately represent and forecast the potential production for the Town, the *harvestable bushels in flat* reported in Table 1-3 have been adjusted to compensate for the failure to cover all of the productive area within the Town (i.e., harvestable bushels in flat/0.8).

Table 1-6
National Marine Fisheries Service, Portland, Maine
Soft-shell Clam Landings Data 1992-94
Cumberland County, Maine

1994

MONTH	POUNDS (MEATS)	BUSHELS	VALUE	$/BU	$ MEATS/LB.
JAN	2,417	161	$11,602	72.00	$4.80
FEB	2,426	162	11,321	70.00	4.67
MARCH	53,889	3593	188,493	52.47	3.50
APRIL	78,045	5203	286,165	55.00	3.67
MAY	109,398	7293	474,058	65.00	4.33
JUNE	119,512	7967	637,403	80.00	5.33
JULY	106,259	7084	637,554	90.00	6.00
AUG	141,638	9443	934,810	99.00	6.60
SEPT	55,922	3728	223,688	60.00	4.00
OCT	52,086	3472	191,156	55.05	3.67
NOV	48,656	3244	178,568	55.05	3.67
DEC	24,355	1624	89,383	55.05	3.67
TOTAL	**794,603**	**52,974**	**$3,864,201**	**$72.95**	**$4.86**

1993

MONTH	POUNDS (MEATS)	BUSHELS	VALUE	$/BU	$ MEATS/LB.
JAN	26,826	1788	$107,304	60.00	$4.00
FEB	4,098	273	12,294	45.00	3.00
MARCH	23,150	1543	69,495	45.03	3.00
APRIL	58,397	3893	175,191	45.00	3.00
MAY	101,186	6746	303,558	45.00	3.00
JUNE	98,142	6543	359,845	55.00	3.67
JULY	98,497	6566	492,485	75.00	5.00
AUG	112,699	7513	601,061	80.00	5.33
SEPT	75,322	5021	326,144	64.95	4.33
OCT	59,423	3962	237,692	60.00	4.00
NOV	46,379	3092	185,516	60.00	4.00
DEC	25,173	1678	120,830	72.00	4.80
TOTAL	**729,292**	**48,619**	**$2,991,415**	**$61.53**	**$4.10**

1992

MONTH	POUNDS (MEATS)	BUSHELS	VALUE	$/BU	$ MEATS/LB.
JAN	21,958	1464	$80,513	$55.00	$3.67
FEB	16,109	1074	59,120	55.05	3.67
MARCH	33,589	2239	100,767	45.00	3.00
APRIL	112,194	7480	336,582	45.00	3.00
MAY	63,854	4257	191,562	45.00	3.00
JUNE	77,216	5148	231,648	45.00	3.00
JULY	89,539	5969	384,003	64.33	4.29
AUG	74,994	5000	374,970	75.00	5.00
SEPT	59,289	3953	256,919	65.00	4.33
OCT	30,629	2042	98,013	48.00	3.20
NOV	32,383	2159	97,149	45.00	3.00
DEC	33,670	2245	101,010	45.00	3.00
TOTAL	**645,424**	**43,028**	**$2,312,256**	**$53.74**	**$3.58**

15 LBS. MEATS = 1 BUSHEL

Brunswick considers its acreage estimate of 395.5 acres for 1994 to represent 100% of the harvestable area. However, for many flats, production projections are based on extrapolated results of surveys conducted on a small portion of the flat. In certain cases where survey information is not available, production estimates are based on extrapolated data from other nearby areas.

Freeport's data covers very close to 100% of the productive areas in the Town and the individual surveys within those areas cover 100% of the productive habitat. Consequently, information is now available for all of Freeport's flats, but in certain cases, information is only available for one year.

The incomplete resource data probably accounts for the majority of the production estimate-related discrepancy, but other, less important factors may also play a role. One is the 10% under-sized clam allowance. According to the DMR laws, up to 10% of a digger's harvest can consist of sub-legal size clams. Most diggers do not "ring", that is, measure each clam, but rely instead on experience to visually gauge size. Consequently, most under-sized clams taken inadvertently by the conscientious digger will be very close to legal size. Therefore, *if all diggers were to take full advantage of the allowance, legitimate under-size clam harvests could account for up to 10% higher production.*

Another complicating factor is the *change which may occur in digging efficiency as demand and/or price increases.* The digging efficiency value used for the calculations presented here is 70%, however, as the price paid per bushel increases, unit value of the clams rises and the incentive to improve efficiency therefore also rises. *Under pressure of exceptionally high prices digging efficiency could approach 100%, potentially stripping the flats of all market-size clams.* Even if individual efficiency does not approach 100%, repeated turning of the mud by successive diggers will eventually result in near complete harvesting of marketable clams. The situation is even further aggravated as the repeated turning of the mud increases breakage and suffocation mortality, particularly of juveniles.

Finally, according to anecdotal reports, despite the 2-inch minimum size law and the associated violation penalties, *the exceptionally high price paid for clams over the past two to three years has increased the temptation to "take" small clams. Similarly, the temptation to stray into closed areas, whether closed for conservation or due to bacteriological contamination, is increasingly high.* Since production estimates are based solely on legal-sized clams in open areas, any harvest resulting from either of these illegal activities would push the actual harvest above the estimated amount. Although there is little doubt that these activities are occurring, the overall impact on production is currently unknown.

1.52 Closed area production

Intuitively it seems reasonable to assume that, if an area of mudflat remains closed and undisturbed for a prolonged period of time, production will eventually approach a maximum. Those who subscribe to this view often consider closed areas sanctuaries for spawning populations. The opposing view, held by most commercial diggers, is that without periodic "turning", the mud "dies" rendering the area useless as productive clam habitat. The results of this study show neither view to be entirely correct, for the results vary considerably from one area to another. The explanations for the variations are neither simple nor clear (refer to Section 5), but one thing is certain...prolonged closure does not guarantee a strong, healthy population. *(It is important to note that there are two types of closures: DMR pollution, or contamination closures, and conservation closures. In the context used here, "closure" refers only to DMR pollution closure and not to conservation closures, the latter being routinely used by municipalities to protect large populations of juvenile clams or areas where transplanting has recently occurred, in order to enhance the resource. These latter closures have specific goals and the period of closure rarely exceeds a year or two).*

The survey results for the Town of Brunswick show that the mean harvestable bushels density on the closed flats is slightly higher than the historical mean in opens areas of the Town (refer to Table 1-2). Two of the areas, Mere Point Cove 1 and New Meadows, show very high densities, three, Bunganuc Creek, Mere Point Cove 2, and Buttermilk Cove have moderate densities, and one, the northeast section of Maquoit Bay, has a low density. All of these areas are located in the northern section of the Bay, and with the exception of Mere Point Coves 1 and 2, all face the southeast or southwest.

In Harpswell, closed area densities of total and harvestable bushels are moderate to low compared to the historical means of open areas (refer to Table 1-3). Basin Cove has been closed for several years, although it was periodically opened during the winter months until about 1990 after which it was permanently closed. The surveys for Ash Cove were conducted prior to its closure in 1992 and therefore represent conditions during heavy harvesting. Historically, however, the cove is reported to be normally highly productive. Both of these coves are at the southern end of Harpswell Neck and are oriented towards the south-southwest. Stovers Cove has been closed for many years due to bacteriological contamination of a spring flowing into the head of the cove. Stovers Cove was one of two coves studied in the Town of Harpswell under a project funded by the Casco Bay Estuary Project (Heinig and Newberg, 1993). Clam densities in the cove are generally very low with the exception of a rather dense population of small clams concentrated in the sandy sediments near the eastern northward projecting spit of land. The results of the 1992 surveys were remarkably similar to the results of a 1952 study (Frank, 1953).

Three of the study sites are located on the western shore of Casco Bay along the Falmouth-Cumberland-Yarmouth shore and are oriented towards the east and south. The fourth area just north of Division Point, Chebeague Island, is located in the south-central Bay area and is oriented toward the north-northwest. The fifth study area, located in West Bath, is longer and narrower than the others, and is oriented towards the southwest. Sediment composition at these sites is similar, but in most cases sediments vary considerably across the individual flat.

The results of the surveys conducted in these study areas showed significant variability from area to area. Two of the study areas, Mackworth Island and the Yarmouth section of Broad Cove, showed exceptionally low clam population densities. Two areas, the Cumberland section of Broad Cove and White Cove in Yarmouth, had moderate population densities. Long Cove in West Bath has an exceptionally high density, most of which is harvestable.

As a result of the high variability between these sites, *the mean values for both total bushels per acre and harvestable bushels per acre presented in Table 1-5 are deceiving.* The means for total bushels per acre and harvestable bushels per acre over all of the study sites are 83.0 and 61.1, respectively. However, if the Long Cove results are omitted, the means drop to 63.1 and 36.7, respectively, more accurately reflecting the conditions in closed areas. This is a clear example of the dangers of using means for highly variable populations and supports resource managers' reluctance to apply mean population density values over broad areas.

Clearly, the shellfish areas around the Bay are highly variable, not only with respect to their physical characteristics, but also with respect to the clam populations they support. The reasons for the high variability in population densities are probably the results of both natural and man-made forces. Given this variability, it is inappropriate, if not impossible, to attempt to apply the results of the surveys reported here to all closed areas of the Bay. Further, *a review of the GIS maps developed by the CBEP to depict the closed areas and shellfish habitat shows that, in most cases, the habitat is significantly overestimated when compared to the actual populated area. Thus, until the actual population boundaries within closed areas are defined, it is impossible to estimate production within these areas with any accuracy.*

One very simplistic approach to estimating the lost production from closed areas is simply to assume that, once reopened, the productivity of closed areas would be similar to that of currently open areas of the Bay. Since it is currently estimated that 44.5% of the shellfish habitat in Casco Bay is closed to harvesting, the lost production from closed areas should approach that of the open areas. If this were true, the 1994 harvest from currently closed areas could be expected to have reached as much as 51,160 bushels with a value of approximately $3.73 million. Using a similar approach which he describes as "relatively simple", Colgan (1991) estimated the production from closed areas at just over $4 million. Colgan qualifies this number as possibly underestimated by as much as 20%, according to the Maine DMR. Nevertheless, the context of his use of "relatively simple" can be interpreted to mean "straight forward" which belies a basic misunderstanding of the complex and highly variable factors influencing productivity. The fact is, *the results of this study indicate that the assumption that the production capacity of the closed areas of the western Bay is similar to that of the open areas of the northern Bay may be incorrect.*

1.6 Conclusions

- Based on available information, the estimated *in flat* bushels of soft-shell clams for open areas in Casco Bay in 1994 is 91,150. Assuming a 70% harvesting efficiency the 1994 harvest is estimated at 63,805 bushels with a value of ~$4.65 million. These values are approximately 20% higher than those reported by the DMR and NMFS for 1994. Based on the recent historical data the *average* annual *in flat* production is estimated at between 83,680 and 89,660 bushels. Again assuming 70% harvesting efficiency, this results in 58,575 to 62,760 harvested bushels with a landed value of between $4,273,050 and $4,578,350.

- Clam production in Casco Bay has been high over the past 3-4 years, but the high prices paid for clams in the past two years has dramatically increased digging pressure which has resulted in stock depletion in several areas of the Bay as indicated by recent surveys. Consequently, several municipalities around the Bay are projecting decreased production for the coming year, expanding a trend shown for Freeport over the past four years. This

conclusion is supported by anecdotal information from harvesters and dealers. Two options exist: 1) fishing effort reduction, and/or 2) expansion of the resource through resource enhancement efforts and recovery of previously productive areas now closed.

- Clam production in closed study areas of the *eastern* Bay is similar to or greater than in open areas. Production in the closed areas of the *western* part of the Bay is significantly less than in open areas. The causes for this are not immediately clear, but may be natural or indirectly related to the closure.

- The variability in soft-shell clam population densities across the Bay makes extrapolation of the results obtained here to all other closed areas of the Bay impossible. Further, a comparison of the information presented here with that currently available for closed areas suggests that the productive habitat within closed areas may be significantly overestimated. However, if it is assumed that closed areas have the same production capacity as presently open areas, the production from the CBEP estimated 44.5% closed area of Casco Bay in 1994 could have had the potential of increasing in-flat production by 73,084 bushels and the harvest by 51,160 bushels thus increasing the harvest value by approximately $3.73 million.

1.7 References:

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2.0 Evaluation of the broader economic impact of the Casco Bay soft-shell clam industry

by Peter J. Moore

2.1 Major findings summary

2.11 Objectives of this task

1) determine the value of the Casco Bay soft-shell clam resource beyond the landed value; and,

2) determine the number of resource supported jobs, including but not limited to shellfish harvesters and processors.

Estimates for these two tasks were developed based in part on incomplete resource surveys and landings data and in part on representative surveys that rely on opinions and "guesstimates" of participants in the local wholesale and retail sectors of the soft-shell clam industry.

Landings and price information used in this report are drawn from two sources:

National Marine Fisheries Service summaries of State of Maine records for 1991-1994; and, anecdotal information derived from interviews with all licensed Casco Bay-area shellfish dealers (some of whom are also commercial diggers), and restaurant owners in the greater Casco Bay communities. The availability and quality of landings data were a major impediment to accurate determination of the value of the resource, both the landed value and the economic value beyond the landed value.

Note: Because of the imperfect nature of the data, and of the limited budget available for a study of this magnitude, we have displayed the data in a range that reflects the coarseness of the available data.

2.12 Major findings of this task

Understanding the limitations of the available data and other qualifications discussed in Section 5.0, estimates of the value of the Casco Bay soft-shell clam resource were derived as follows:

1994 Ex-vessel value: based on the confidential and anecdotal information gathered from dealers and restaurant managers for this investigation, the Casco Bay soft-shell clam resource is a very valuable, local resource. In 1994, estimated ex-vessel values ranged from $3.87 million[1] to $5.25 million[2], depending on source of information used.

[1] NMFS/State of Maine "official" estimate, based on confidential landings data reported by registered shellfish dealers (53,000 bu @ $72.95)
[2] Aggregation of estimates from surveys of 11 CBEP-area registered shellfish dealers of their purchases of Casco Bay clams from diggers (65,600 bu @ $80)

1994 Broader economic value: The value of the Casco Bay soft-shell clam resource beyond the landed value could amount to between $11.6 million and $15.7 million[3].

1994 Clam-supported jobs: It is estimated there are 242 full-time equivalent jobs directly supported by the Casco Bay soft-shell clam resource[4].

2.2 Rationale for study approach, explanation of assumptions, survey methods and application of multipliers

2.21 Rationale for study approach

Due to the limited funds available relative to the scope of work for this project, it was decided to adapt economic models and survey designs already developed for similar economic studies conducted in New England.

In the preparation of its original proposal, some research was done on previous economic analyses and employment surveys of the soft-shell and hard clam resources of Maine and New England in order to determine an appropriate study approach.

Selection of an employment survey protocol and an income multiplier were based on the applicability of each tool to the Casco Bay soft-shell clam resource and associated industry.

Please refer to the discussion in Section 2.5 (Discussion of results) for a more detailed rationale for the study approach selected.

2.22 Assumptions

In the development of our study proposal, it was assumed that:

- the State and federal management agencies maintain a current, relatively accurate landings and ex-vessel price database for soft-shell clam landings statewide, and for Casco Bay in particular;

- the responses to our surveys of certified shellfish dealers and CBEP-area restaurants are accurate and provide the best estimate available of the volume and disposition of US FDA-certified dealer-handled Casco Bay soft-shell clams (note that this information is proprietary and participation in the surveys was voluntary);

[3] Estimates based on application of overall output multiplier of 3.0 [Briggs, Townsend and Wilson, 1982, modified in 1995 for aging of the multiplier (see section 2.5.5, Table 2-7)].
[4] Based on surveys of all CBEP-area restaurants serving Casco Bay soft-shell clams, combined with surveys of all registered shellfish dealers purchasing Casco Bay soft-shell clams, and added to numbers of soft-shell clam harvester's licenses issued by CBEP-area towns (adjusted to full-time equivalents).

- the economic multiplier used in this analysis is applicable, with modifications, to the study area and resource;

- bushels of soft-shell clams represent 52 lbs., while gallons represent approximately 32-26 lbs., or 1.6-2.0 gallons per bushel [this is an average derived through interviews of certified dealers who also process (shuck) their own clams for the fried clam market].

To estimate the number of "full-time equivalent" jobs attributable specifically to the Casco Bay soft-shell clam resource, as opposed to other products or economic activity, we invoked the following assumptions for:

- Harvesters: assumed annual equivalent of six months full-time work. Therefore, 50% of total number of licenses;

- Certified dealers: eleven of thirteen CBEP-area dealers agreed to be interviewed for this study. An average of 80% of the shellfish purchased and sold by each dealer were Casco Bay-origin clams, according to their estimates. Most are primarily clam dealers. Therefore, 80% of the total dealer employee pool was attributed to Casco Bay soft-shell clams;

- Restaurants: of the 51 CBEP-area restaurants surveyed for this study, 32 served Casco Bay clams. Of those serving clams, "full-time equivalent" jobs were derived through analysis of summer (four months) vs. year round employment estimates. This full-time equivalent number was reduced by the proprietor estimated percentage of Casco Bay-origin soft-shell clam sales (cost of clams only, not the clam dinner "frills" such as fries, soda, salad, etc.) to total restaurant sales. A detailed discussion of the results is included in Section 2.5.

2.23 Survey methods

To develop an analysis of the importance of the Casco Bay soft-shell clam resource to the regional economy, we proposed examining the number of jobs (both part-time or seasonal, and full-time equivalent) generated by, and related to, the resource as follows:

- number of licensed harvesters;
- number of employees working for US FDA-certified shellfish dealers doing business in the greater CBEP-area;
- number of employees working for CBEP-area restaurants that serve Casco Bay clams.

Examination of all possible resource-related employment, such as Town-employed shellfish resource managers, State and federal marine resource managers and law enforcement personnel, State and federal sanitary inspection workers, etc., was beyond the scope of this project. However, such a determination of "full-time equivalent" jobs would add to the predicted number of jobs reported in this analysis. A detailed description of the survey methods is included in Section 2.3.

2.24 Application of multipliers

Based on these assumptions and survey methods, we proposed calculating a defensible estimate of both the landed value (annual value and net present value) as well as the value of the Casco Bay soft-shell clam resource that could be generated beyond the landed value (through application of a generally accepted economic income "multiplier" developed by University of Maine economists specifically for valuation of Maine's soft-shell clam resource). Please refer to Section 2.5.5. for a more detailed discussion of the rationale for use of the specific "multiplier" selected for this study.

In actuality, the results from both analysis of available landings data and from the surveys are of necessity presented as a range of values to which the overall economic income multiplier is applied. Even in the case of the clam flats surveyed for this study, where we have a current "best estimate" of the standing stock on which to base an economic assessment of value, we must rely on imperfect data for ex-vessel price levels at certain times of the year. The weighted average values for ex-vessel prices are derived from estimates of U.S. FDA-certified dealer purchases only, and do not reflect the generally higher prices that diggers are rumored to receive from retail purchasers for "direct sales". These "direct sale" prices are rumored to be higher because retail sales outlets are not subject to the same stringent and costly sanitary, handling, and reporting requirements as are certified dealers. These additional requirements drive up the certified dealers' costs and lower the price they can pay for diggers' clams.

This investigation revealed a confidential monthly landings tracking system that operates on the good faith participation of only a small segment of the market--the shellfish dealers desiring to ship product interstate who are required to be inspected by, and registered with, the U.S. Food and Drug Administration (FDA).

Not included in this tracking system are the retail establishments (restaurants, seafood shops, roadside peddlers) which purchase directly from the diggers, and the diggers themselves who frequently make sales directly to consumers. State and federal resource managers interviewed for this study estimate that between 20-30 percent of the harvest of Casco Bay soft-shell clams is unreported.

According to some certified dealers interviewed for this study, this figure is low. Total harvest from Casco Bay is estimated by some at 100,000 bu/yr, or nearly twice the State's estimated harvest.

2.3 Survey methods

An estimate of the number of full- and part-time participants involved in harvesting, processing, distribution, and restaurant/retail sales was developed using a survey format similar to that found in a 1982 analysis of the Cape Ann, Massachusetts, shellfish industry (Ross et al., 1982), and adapted to the CBEP-area soft-shell clam industry. This sub-task was accomplished using the following survey protocol:

2.31 Clammers (full- and part-time)

Numbers of licenses available, and number sold, was obtained from responsible town shellfish authorities and/or Maine Department of Marine Resources.

2.32 Clam wholesalers and retailers

A list of all licensed CBEP-community shellfish wholesalers and retailers was obtained from the Maine Department of Marine Resources.

Each licensed clam dealer was contacted in order to ask the following questions:

1. How many employees of the firm work with clams?
2. How many bushels of Casco Bay-origin clams do you sell per year?
3. How many non-local clams do you sell per year?
4. Of the clams sold per year, what percentage are shucked and what percentage are sold in the shell?
5. What has the ex-vessel price range per bushel been each year since 1990?
6. What do you estimate the 1994 total annual commercial harvest of soft-shell clams in Casco Bay to be?
7. Is the landings data collected by the state accurate? If not, what should they do to improve their data collection?

2.33 Restaurants

It was originally proposed that CBEP-area restaurants be divided into two categories: those specializing in seafood and/or clams; and, all other types of restaurants. All of the restaurants in the first category were then to be asked the following questions:

1. How many employees do you have in the winter? in summer?
2. Are all the clams you sell local? If no, what percentage are Casco Bay clams?
3. If not local, would you prefer to sell local clams? Why?
4. Approximately how many clams do you use per year? (these responses were recorded in bushels of clams in the shell).

5. Approximately how many fried clam plates do you sell per year? steamed clams?
6. How many servings per gallon of shucked meats do you prepare?
7. How many servings of steamed clams per bushel?
8. How much do you charge per plate for fried clams? for steamed?
9. What is your cost per unit for clams? As a percentage of the meal's food cost?
10. What percentage of your annual gross sales do soft-shell clams represent?
11. Where do you get clams during "red tide" closures?
12. What was the price range you paid for clams in 1994?

A statistical sample was proposed of the Casco Bay area non-seafood specialty restaurants (approximately 100). These restaurants were then to be listed alphabetically and every fourth restaurant on the list was to be included in the sample, in order to survey 25% of the total. These restaurants were then to be asked if they serve local clams and, if so, approximately how many bushels do they use per year. These answers were then to be totalled and multiplied by 4 in order to estimate the total number of local clams sold by the "non-seafood" restaurants in the CBEP-region.

Instead, in the course of the survey, it was found that the number of restaurants serving clams did not necessarily fall along seafood specialty vs. non-seafood speciality lines. Therefore, all restaurants surveyed were asked the detailed questionnaire, above. The results were then aggregated for an overall survey response.

2.4 Survey results

2.41 Commercial clammers (full- and part-time)

The appropriate Town authorities were contacted and provided the following data:

total resident commercial clam harvesting licenses:	243
total non-resident commercial clam harvesting licenses:	25
total commercial clam harvesting licenses issued for Casco Bay:	268

Recreational clam licenses, which in 1994 numbered 1,252 for all of Casco Bay, were not considered for this portion of the study. However, there is evidence that "poaching" for commercial clam sales takes place under the "cover" of recreational licenses (see Task 4), which has the effect of increasing the economic value of the clam resource.

The following table illustrates license sales by CBEP-area town. Note that license holders from West Bath may harvest clams in both the Casco Bay area and the Kennebec River drainage, though it is estimated by local certified dealers (Anonymous digger/dealer, pers. comm., 10/31/94) that the majority of the West Bath licensed diggers' harvest takes place in the Casco Bay area.

Table 2-1
CBEP-area
Commercial Clam Harvesting Licenses
1994

TOWN	PHONE NUMBER	# RESIDENT COMMERCIAL LICENSES AVAIL/SOLD	# NON-RESIDENT COMMERCIAL LICENSES AVAIL/SOLD
WEST BATH	443-4342	12 AVAIL/12 SOLD	1 AVAIL/1 SOLD
PHIPPSBURG	389-1088	24 AVAIL/24 SOLD $100 PER LICENSE	3 AVAIL/3 SOLD
HARPSWELL	833-5822	61 AVAIL/61 SOLD $100 PER LICENSE	6 AVAIL/6 SOLD $200 PER LICENSE
BRUNSWICK	725-6658	90 AVAIL/90 SOLD $100 PER LICENSE	9 AVAIL/9 SOLD $200 PER LICENSE
FREEPORT	865-4743	56 AVAIL/56 SOLD $100 PER LICENSE	6 AVAIL/6 SOLD $150 PER LICENSE
YARMOUTH	846-9036	NONE ISSUED	NONE ISSUED
CUMBERLAND AND THE ISLANDS	829-5559	NONE ISSUED FOR AT LEAST 3 YEARS	1-1 MONTH TRIAL
FALMOUTH	781-5253	CLOSED FOR 5-6 YEARS DUE TO POOR WATER QUALITY ISSUES AND SMALL CLAMS	
PORTLAND SOUTH PORTLAND CAPE ELIZABETH	874-8300 767-7601 799-7665	NO ORDINANCE PROVIDING FOR CLAMMING CITY DOES NOT ISSUE LICENSES APPLIES TO PORTLAND, S.PORTLAND, AND CAPE ELIZABETH	
TOTALS (268)		RESIDENT 243	NONRESIDENT 25

Licensed clam diggers are independent, self-employed businessmen. While harvest rates vary from digger to digger, many "dig two tides" in summer months when ex-vessel prices are highest. Daily wages earned from such activity were reported by some dealers to exceed $1,000 per day in August and September of 1994, when diggers were able to dig two tides in one day. Digging bootlegged clams from "closed" areas at night can be even more lucrative, with reports from dealers that some diggers made over $2,000 per night on 2-tides (10-15 bu/tide). This compares with September 1994 average weekly earnings for manufacturing sector workers in the Portland MSA (Manufacturing Statistical Area) of $434/week.

2.42 Clam wholesalers and retailers

The following companies were contacted for this study. Of the total of 19, 13 purchased Casco Bay origin clams. Of these, 11 companies were willing to be interviewed, anonymously, for this study.

Table 2-2
CBEP-area
Certified Shellfish Dealers
Contacted for Task 2

Company	City	Company	City
BAYLEY'S QUALITY SEAFOODS INC	SCARBORO	NORTH ATLANTIC INC	PORTLAND
BRISTOL SEAFOODS INC	PORTLAND	ONE FISH TWO FISH	S. PORTLAND
BROWNE TRADING CO INC	PORTLAND	PERKINS SEAFOOD	HARPSWELL
CLAMHUNTER SEAFOOD	PHIPPSBURG	PINE POINT FISHERMEN'S COOP	SCARBORO
CUSTOM HOUSE SEAFOOD INC	PORTLAND	PLANT'S SEAFOOD	WEST BATH
DENNISON'S SEAFOOD	FREEPORT	S&E SHELLFISH	HARPSWELL
DOUTY BROS. INC	PORTLAND	SEAFOOD EXPRESS INC	BRUNSWICK
J&A SEAFOOD	BRUNSWICK	SEBASCO WHARF INC	SEBASCO ESTATES
P.J. MERRILL SEAFOOD INC	PORTLAND	STILLWATER CLAM CO	FREEPORT
NONESUCH TRUCKING	SCARBORO		

The information gathered for this survey is proprietary to the companies which participated in the study. It is therefore displayed in an anonymous format in Table 2-3, below.

Table 2-3
CBEP-area Certified Shellfish Dealers
Interview Responses

DEALER	TOTAL CB CLAMS (000 bu)	# EMPL.	ESTIMATED PRICE RANGE ($/BUSHEL)				
			1994	1993	1992	1991	1990
A	10-14	2	30-115	30-80	30-80	30-75	25-70
B	8-9	2	35-130				
C	15-18	3	40-125	30-120			
D	0.5	5-8	50-100				
E	4	1					
F	0.1	1					
G	4	2	45-105	45-78			
H	0.1	2	45-110	45-100			
I	2	3	40-100	40-100			
J	8	2	40-125	34-83	30-75	30-70	30-55
K	2	5	39-104	34-83			
TOTAL BU/ RANGE	60.6-65.6 bu	28-31	30-130	30-120	30-80	30-70	25-70

2.43 Restaurants

The following restaurants were interviewed using a standardized survey format as previously described in Section 2.3 (Survey methods).

Table 2-4
Cbep-area Restaurants Serving Clams
Interviewed for Task 2 (59)

Company	City	Company	City
BAKER'S TABLE GRILLE	PORTLAND	KHALIDI'S CREATIVE SEAFOODS	PORTLAND
BAYLEY'S	PINE POINT	LOBSTER COOKER	FREEPORT
BAYVIEW SEAFOODS	PORTLAND	LOBSTER HOUSE	SMALL POINT
BOONE'S RESTAURANT	PORTLAND	LOBSTER SHACK	CAPE ELIZABETH
THE CANNERY	YARMOUTH	LOG CABIN RESTAURANT	BAILEY IS
CAPTAIN DANIEL STONE INN	BRUNSWICK	MARKET ST GRILLE	PORTLAND
CAPTAIN MIKE'S	BRUNSWICK	J R MAXWELLS	BATH
CHANNEL CROSSING RESTAURANT	S. PORTLAND	MOOSE CROSSING	FALMOUTH
CHEBEAGUE ISLAND INN	CHEBEAGUE IS	MUDDY RUDDER	YARMOUTH
CHOWDERHEAD'S	SCARBORO	NEW ENGLAND DELI	PORTLAND
CLAMBAKE RESTAURANT	SCARBORO	NEW MEADOWS INN	WEST BATH
COOK'S LOBSTER	BAILEY IS.	NEWICK'S SEAFOOD RESTAURANT	S. PORTLAND
CORSICAN	FREEPORT	OCEAN FARMS	FREEPORT
CRICKETS	FREEPORT	OCEAN VIEW	PORTLAND
DAVID'S AT THE OYSTER CLUB	PORTLAND	OLD PORT TAVERN	PORTLAND
DI MILLO'S	PORTLAND	PEPPERCLUB	PORTLAND
DOLPHIN MARINA	SOUTH HARPSWELL	PERFETTO	PORTLAND
ESTES LOBSTER HOUSE	SOUTH HARPSWELL	PINE POINT FISHERMEN'S COOP	SCARBORO
F. PARKER REIDY'S	PORTLAND	PINE POINT SEAFOOD DISTR.	SCARBORO
FIDDLEHEAD FARM RESTAURANT	FREEPORT	RED LOBSTER	S. PORTLAND
FREEPORT INN AND CAFE	FREEPORT	SEAMEN'S CLUB RESTAURANT	PORTLAND
GILBERT'S CHOWDER HOUSE	PORTLAND	SNOW SQUALL	S. PORTLAND
HARRASEEKET INN	FREEPORT	STOWE HOUSE	BRUNSWICK
HOLIDAY INN	BATH	SUSAN'S FISH AND CHIPS	PORTLAND
INN BY THE SEA	CAPE ELIZABETH	TASTE OF MAINE	WOOLWICH
JACK BAKER'S OCEAN VIEW RESTAURANT	BAILEY IS	TINY'S TAKE OUT	PORTLAND
JAMESON TAVERN RESTAURANT	FREEPORT	VERRILLO'S	PORTLAND
JORDAN'S SEAFOOD RESTAURANT	S. PORTLAND	WALTER'S	PORTLAND
JOSHUA'S RESTAURANT	BRUNSWICK	WESTCUSTOGO INN	YARMOUTH
J'S OYSTER	PORTLAND		

2.5 Discussion of results

2.51 Availability and quality of landings data

a. Both the federal and state governments [National Marine Fisheries Service (NMFS) and ME Dept of Marine Resources (DMR)] keep records of statewide soft-shell clam landings, as reported by U.S. Food and Drug Administration-certified shellfish dealers only. Certified shellfish dealers are those businesses which have passed a rigorous sanitary inspection of their handling facilities and have received permission from the FDA to buy and sell and ship shellfish interstate. The State does not require submittal of landings reports from any other handler of shellfish, including diggers or retailers.

b. State landings records consist of monthly volumes purchased and shipped (in bushels) and prices paid diggers by dealers (ex-vessel) and are kept confidential to protect the proprietary nature of the reports. Dealers are not required to identify origin of the clams which are transported widely within the state and imported from eastern Canada. State officials estimate that perhaps two-thirds of all certified shellfish dealers file the required monthly landings reports. Thus the monthly landings reports are, at best, an index for statewide landings, by county, based on the location of the dealers.

c. Landings and prices fluctuate on a seasonal basis and are influenced by a variety of factors. Some of these factors include:

• increased tourist demand in summer months	• reduced availability due to "red tide" and other water quality closures
• competition from out-of-state shellfish buyers for Casco Bay soft-shell clams	• competition from out-of-state sellers of soft-shell clams (Maryland and Canada)

Developing a weighted average ex-vessel price, though clearly appropriate based on the seasonal variables listed above, was impossible to undertake due to the proprietary nature of the data in the State's possession. Thus, we relied on data provided by NMFS and anecdotal information from industry participants.

d. Though the State DMR requires dealers to submit landings reports monthly, enforcement actions against dealers for delinquent reporting or noncompliance are not undertaken on a regular basis by the State. Furthermore, processing and analysis of these monthly reports by the State are "two to three years in arrears because of other pressing business and a lack of additional personnel to handle all the legislatively mandated responsibilities", according to State of Maine DMR resource managers responsible for the program.

e. NMFS records are a compilation of the state monthly dealer reports, by county, and are typically unavailable until six months to one year after the landings are made.

f. Both federal and state personnel in charge of annual soft-shell clam landings data estimate that of the total clams landed annually from Casco Bay, approximately 25-30% are unreported [diggers conducting side sales direct to retailers; licensed dealers under-reporting purchases from diggers; sales of undersized clams (< 2 inch)].

2.52 Number of Full and Part-time participants--394 (242 "full-time equivalent" jobs)

The Casco Bay soft-shell clam resource is a highly valued, renewable resource that provides licensed diggers and shellfish dealers a seasonal source of income significantly greater than the local labor wage rates for Cumberland County, Maine.

Approximately 383 individuals from towns surrounding Casco Bay work in the Casco Bay soft-shell clam industry, as follows:

- 268 licensed commercial diggers
- 28-31 individuals employed by the 11 Casco Bay-area licensed shellfish dealers who agreed to be interviewed for this study (of a state-wide total 90 FDA-certified Maine shellfish shippers)
- 80 restaurant employees: of the 51 CBEP-area restaurants surveyed for this study, 32 sold Casco Bay-origin clams. These restaurants employ 1370 "full-time equivalent" employees. Of these, it could be asserted that 80 positions are supported by sales of Casco Bay clams, based on the percentage of gross sales that Casco Bay-origin clams (not including clam dinner "frills") represented (approx. 7%). Fully 95% of the restaurants serving clams claimed they prefer to sell "local" clams from Casco Bay because of their reputation for quality and optimal size.

For the purposes of this analysis, the estimation of full-time equivalent jobs for clammers was based on information provided by area town shellfish wardens. An assumption was made that approximately one half of the licensed clammers worked second jobs and were therefore considered part-time clammers (half-time). For processing and restaurant workers, one of the survey questions asked for full- vs. part-time employment. If the respondents said they had part-time workers, they were then asked to estimate the number of days each part-time employee worked per year. These "days worked" were then aggregated into 5-day/week, 50-week/year equivalents. Full-time equivalents were considered to be 40-hour/week jobs.

This analysis was limited to the employment areas noted above. Other resource-supported "full-time equivalent" jobs can be determined from an analysis of the retail sector (seafood outlets), in addition to resource management and enforcement personnel at the state and municipal level. Such an analysis is beyond the scope of this project, but if undertaken, would increase the number of "full-time equivalent" jobs attributable to the Casco Bay soft-shell clam resource.

2.53 Total ex-vessel value

As has been made abundantly clear in previous sections, reliable landings data for soft-shell clams harvested in the State of Maine is not readily available to the public. Therefore, we have to rely on a couple of sources [NMFS/State DMR data which reportedly underestimates landings and prices by 20-30%; and, the certified shellfish dealer estimates resulting from surveys of eleven dealers (which are probably more reliable figures than those reported by NMFS/DMR)].

Ex-vessel prices for steamed clams have been increasing each year during the 1990s, and reached a record high price in summer 1994. According to certified dealers interviewed for this study, high and low price ranges have been as follows:

Table 2-5
Dealer-quoted prices paid for
Casco Bay soft-shell clams

YEAR	PRICE RANGE/BU ($)
1994	30 - 130
1993	30 - 100
1992	30 - 80
1991	30 - 75
1990	25 - 70

The following calculations are based on the data sources as indicated and result in a range of values which are then carried over to the next section, an estimation of the broader value of the resource beyond the landed value.

Please note that these calculations are for Casco Bay-wide landings and are not specific to the study sites analyzed in Tasks 1 and 3 of this study.

Table 2-6
Total ex-vessel value
Casco Bay soft-shell clams
(as reported by source cited)
1994

SOURCE	TOTAL LANDINGS (BU)	PRICE/BU ($) (mean)	EX-VESSEL VALUE
NMFS/Statistics	52,974	$72.95	$3,864,201
CBEP-area shellfish dealers	60,600 - 65,600	$80.00	$4,848,000 - 5,248,000

Total ex-vessel value
Casco Bay soft-shell clams
(as reported by source cited)
1993

SOURCE	TOTAL LANDINGS (BU)	PRICE/BU ($) (mean)	EX-VESSEL VALUE
NMFS/Statistics	48,619	$61.53	$2,991,527
CBEP-area shellfish dealers	53,600 - 61,600	$70.00	$4,288,000 - 4,928,000

2.54 Net present value

The desire of policy makers to project the economic value of the soft-shell clam resource into the future is laudable.

However, due to the fugitive nature of the resource--its vulnerability to predation, pollution, competition from other filter-feeding organisms such as mussels coupled with the mysteries involved with larval settlement and recruitment--as described in the Task 1 discussion, we believe it is indefensible to project a Bay-wide value for the soft-shell clam resource beyond the following year yield. This is in contrast to some recent studies which project the value of the Casco Bay clam resource out two decades (Colgan and Lake, undated).

Costs and benefits may only be compared as of a common point in time. A net present value calculation uses the technique of discounting in order to calculate *present discounted value*. Present discounted value is a measure of the value to us at the present time of a sum of money which is to be received or paid at some future time.

For purposes of this discussion, present value will be presented because "costs" are not being deducted from benefits to derive a "net" present value. The rationale for not including costs is simply that not all CBEP-licensed clammers could be interviewed in order to develop a defensible estimate of their costs.

Costs may include capital costs and opportunity costs. Clam diggers' capital costs could include boat, trailer and motor, gasoline, maintenance, clam rake and hod. Interviews with CBEP-area shellfish dealers revealed that these costs are expected not to exceed $5,000 and could be amortized over 3-5 years, assuming income taxes are paid... Note: Vehicles used to tow the boat trailers are not included in this figure because they are likely used for personal and/or other income-producing ventures in addition to clam harvesting.

Opportunity costs for clammers are derived by determining what other occupation a clammer could pursue and be paid for, if they chose to live their life differently. What job could a clammer hold if they quit clamming and how would it compare to their clamming income? The difference, assuming their annual income is greater as a non-clammer, would be the "opportunity cost" that "society" bears as a result of the clammer not living up to their full "economic potential". This is a theoretical question for economists, at best.

The fact is that clammers reportedly make relatively high incomes in Maine, relative, that is, to other manufacturing and agricultural workers. According to the Maine Department of Labor's "1994 Year-End Non-farm Employment Review", average weekly earnings for manufacturing workers in the Portland MSA (Manufacturing Statistical Area) amounted to $440/week (approx. $10.50/hour). This is equivalent to $22,880/year for a 52-week year. Full-time professional clammers reportedly can exceed this annual wage in a six-month season (Anonymous digger/dealer, pers. comm., 10/28/94).

As noted above, due to budget limitations, we have derived present value, as follows. The formula for present discounted value is given by:

$$PV = X/(1+R)^t$$

where
- PV = present value
- X = value to be received or paid in the future
- t = number of years until receipt or payment
- R = "discount rate" (in this case we used 5 %, a close approximation of the current Treasury Bill discount rate for one year in the future).

For this calculation of the value in 1995, one year in the future, we used the figures for 1994 from Table 2-6, above.

Table 2-7
1995 Present value: $4.617 - $4.998 million

$$\frac{\$4.848 \text{ million}}{(1 + 0.05)^1} = \$4.848 \text{ mill}/1.05 = \$4.617 \text{ million}$$

$$\frac{\$5.248 \text{ million}}{(1 + 0.05)^1} = \$5.248 \text{ mill}/1.05 = \$4.998 \text{ million}$$

2.55 Value of the soft-shell clam resource beyond the landed value (multiplier applied to both certified shellfish dealer estimated 1994 sales and NMFS 1994 landings data)

The overall significance of the resource value to the CBEP-region economy, and to the State and regional economies can be estimated only through application of "multipliers" which calculate the additional income and economic activity generated by each dollar of "first sale" income.

Deriving a defensible "broader value" for the Casco Bay soft-shell clam resource is dependent on defining a number of variables. Two of the most critical are:

- total annual commercial landings
- associated ex-vessel values.

We have previously fully described the problems involved in deriving these figures for Casco Bay clams. We have made the case for using the data available to provide an estimated range of standing crop, total annual value, and present value.

However, estimates of the current standing crop, total annual value and net present value of the soft-shell clam resource existing in Casco Bay provide a "snapshot" of the existing and potential *in situ*, ex-vessel value, based on current per bushel prices. This simple calculation of the actual first sales, and foregone first sales from redeemable areas, while useful as a "raw resource" valuation, is not an accurate indicator of overall economic welfare derived from the resource (Briggs, Townsend, and Wilson 1982). This "market value" of the resource grossly underestimates the total economic value of the soft-shell clam resource.

Application of an economic "multiplier" can provide policy makers with another range of values that could conceivably be derived from the soft-shell clam resource in the greater CBEP-area and statewide.

Output multipliers calculate the total amount of economic activity (in dollars) generated by each dollar earned by the industry being considered. Income multipliers document that portion of the total economic activity generated by an industry which stays within the local economy and adds to the income of area residents.

While both calculations are significant in determining the economic value of the Casco Bay soft-shell clam resource, the income multiplier yields a less inflated, more defensible characterization of the economic benefits that the CBEP community receives from the soft-shell clam industry.

Development of the detailed information about the region's economy required for an analysis which would yield area-specific multipliers (Wong, 1969) is clearly beyond the scope of this project. Instead use has been made of the in-state income multiplier developed by Briggs, Townsend, and Wilson (1982), for analyzing the harvesting and processing sectors of Maine's statewide soft-shell clam industry. In 1982, this multiplier was 1.65 for soft-shell clam processing sector.

Though there are other shellfish added-value multipliers in use for the pre-retail sales, no others have since been developed specifically for the Maine soft-shell clam industry (Dr. James Wilson, pers. comm., 9/10/93).

For example, King and Storey (1974) developed a multiplier for analyzing the retail sector of the Cape Cod hard clam industry. While this analytical tool has been variously applied to both the Cape Ann (1982) and New Bedford (1988) shellfish resources, it would be misleading to apply such a multiplier to Casco Bay's soft-shell clam resource.

Wilson cautioned, however, that the values derived from the application of the statewide multiplier to Casco Bay landings would likely be overstated because of the "open" nature of the industry relative to landings in other, more "integrated", centers of harvesting activity. That is to say proportionately more Casco Bay clams are shipped out of state, resulting in somewhat less retained value in the local economy. Wilson suggested a simple "rounding down" of the dollar amounts would fairly approximate this differential.

Licensed dealers, and State and federal resource agency personnel interviewed for this study agreed with Wilson's estimates. They guessed that between 70 - 80 percent of all Casco Bay clams are shipped out-of-state in shell, significantly reducing the potential economic benefit to the region and resulting in a relatively low economic multiplier.

The in-state income multiplier in question is based on three categories of income generation (Briggs et al., 1982):

1) the "direct effect" of income generated in the clamming industry;
2) the "indirect effect" of income generated by sales of goods and services to the clamming industry; and
3) the "induced effects" which arise when personal income generated directly and indirectly is spent.

According to Wilson, the aging of the multiplier is in part a function of the industry technology it is applied to, and in part a function of the "induced" effects of the income generation. In the case of soft-shell clam harvesting and processing in Maine, the technology has not changed materially, if at all, since the multiplier was developed in 1982. However, "induced" effects have changed, notably in terms of consumption patterns.

"Induced effects" include changes in consumption patterns of the clams in question. In the case of Casco Bay clams, dealers and resource managers interviewed for this study estimated that in-state consumption of local clams is now 20-30%, up from the 10% that Briggs, Townsend and Wilson (1982) estimated as part of their analysis.

Wilson encouraged the modification of the "induced effects" category of the multiplier to reflect the more recent consumption information developed during this study (Dr. James Wilson, pers. comm., 1/18/95). This increase from 10% to 20-30% in-state consumption yields an increase in the overall income multiplier of approximately 2.5-3.3, up from 1.65. For purposes of this study, we elected to use 3.0 as the income multiplier.

Use of an income multiplier of 3.0 is a best "guesstimate" based on previous studies and known ways in which the current study differs from the situation at the time the multiplier was developed in 1982.

Based on the results of Task 1 (Current Standing Crop) and the calculations in Task 2 of Total Annual Value, and Present Value, the value of the resource beyond the landed value was calculated using this modified protocol as follows:

Table 2-8
Value of the Casco Bay soft-shell clam resource beyond the landed value in 1994*
*** Income multiplier = 3.0 (Briggs, Townsend, and Wilson, 1982, as modified in January 1995)**

NMFS/Maine DMR projections*

Year	Est. Harvestable in flats (bu)	Est. 70% actual harvest (bu) as recorded	Ex-vessel $/bu	Ex-vessel value ($)	Income Multiplier (3)	Total est. annual value ($) (Est harv x $/bu)
1994	75,676	52,974	$72.95	$3,864,201	3	$11,593,000
1993	69,456	48,619	$61.50	$2,990,069	3	$8,970,000
1992	61,469	43,028	$53.74	$2,312,325	3	$6,937,000

* National Marine Fisheries Service/Maine Dept. of Marine Resources data (pers. comm. R. Morrill/R. Lewis)

CBEP-area towns' projections (Harpswell, Brunswick, Freeport)

Year	Est. Harvestable in flats (bu)	Est. 70% actual harvest (bu) as recorded	Ex-vessel $/bu	Ex-vessel value ($)	Income Multiplier (3)	Total est. annual value ($) (Est harv x $/bu)
1994	91,150	63,805	$72.95*	$4,654,600	3	$13,964,000
1993						
1992						

* see note above

Table 2-8
Value of the Casco Bay soft-shell clam resource
beyond the landed value in 1994*
(Continued)

CBEP-area certified shellfish dealers (11) estimated purchases/ex-vessel prices

Year	Est. Harvestable in flats (bu)	Actual purchase (bu) (70% of est. harvest)	Ex-vessel $/bu	Ex-vessel value ($)	Income Multiplier (3)	Total est. annual value ($) (Est harv x $/bu)
1994	86,571-93,714	60,600 - 65,600	$80	$4,848,000-5,248,000	3	$14,544,000-15,744,000
1993	75,714-87,857	53,000-61,500	$70	$3,710,000-4,305,000	3	$11,130,000-12,915,000
1992						

Through application of the income multiplier, we see that in 1994 the economic impact of the Casco Bay soft-shell clam resource beyond the landed value could have ranged from a projected $11.6 million to as much as $15.7 million, depending on the data source used.

2.6 References

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3.0 The economic benefit of pollution source control or removal: two case studies

by Donald W. Newberg

3.1 Introduction

A significant area within Casco Bay is now "closed" and the harvesting of soft-shell clams is "prohibited". Lines drawn on maps which show the extent of the "closed" area are drawn between easily recognizable features of the shoreline. In this way those who harvest shellfish, those who manage the resource, and those who enforce ordinance regulations and marine law will readily recognize the boundaries of these areas. The boundaries of closed areas do not identify either the limits of soft-shell clam habitat, or the limits of commercially viable harvesting areas within them.

Guidelines established by the National Shellfish Sanitation Program (NSSP) of the United States Food and Drug Administration are used by the Maine Department of Marine Resources (DMR) to determine the status of shellfish areas. Where the guidelines are not satisfied, harvesting is prohibited and an area is "closed".

Casco Bay clam flats now closed can be divided into two categories:

- permanently closed .. areas where the value of the soft-shell clam resource is unlikely ever to justify the control or removal of pollution sources..(The Back Cove area of Portland is an example. The political, social, and economic costs of "undoing" development there would be enormous; it would far exceed the value of the resource. Other examples include areas near municipal sewage treatment plants, as well as some anchorages and dock facilities.)

- redeemable areas .. areas where it is assumed that a resource exists, and that its value justifies the identification and control (or removal) of existing or potential sources of pollution

3.2 Purpose

The purpose of this part of the study was to select two soft-shell clam areas in Casco Bay which are currently considered "redeemable" and *to determine the costs and benefits of redeeming each area for commercial harvesting.* Because many of the costs and benefits are difficult to quantify, this was an attempt to develop an analytical "template" and not a rigorous cost/benefit analysis. For example, the cost comparison approach used here does not include an analysis of opportunity costs or an estimation of the economic rent, two elements of a detailed cost/benefit analysis. The template is intended to be useful to coastal towns that face decisions regarding redeemable areas, to others with responsibilities for the soft-shell clam resource, and to people interested in the economy of the Casco Bay region.

The two areas chosen for analysis, Buttermilk Cove in the Town of Brunswick and a part of Broad Cove in the Town of Cumberland, were selected because they appeared to be impacted by different pollution problems, and therefore to require different abatement strategies.

3.3 Background

3.31 Buttermilk Cove

Buttermilk Cove is located in the Town of Brunswick, Maine (see Fig. 3-1). It is in the northeast portion of the Orrs Island 7.5' United States Geological Survey topographic quadrangle. The Cove is oriented north-south, "opens" to the south, and at low tide several acres of soft-shell clam habitat are exposed south of a causeway built to carry the Prince Point Road across the Cove. The Cove extends for approximately one-half mile north of the Prince Point Road as a tidal marsh. A limited area of soft-shell clam habitat exists north of the bedrock sill at the causeway.

Figure 3-2 shows the mosaic of individually owned parcels near Buttermilk Cove. North of the Prince Point Road the west shore (Brunswick Naval Air Station) and the east shore (right of way of State Highway #24) are undeveloped and forested. South of the Prince Point Road there are a number of seasonal and year-round residences, many having been constructed in the early 1900's and renovated, or modified over the years. On the east side houses exist on small lots in a narrow strip of steeply sloping land between Route #24 and the shoreline. Limited soil cover exists, and a considerable amount of bedrock is exposed. Five (5) currently licensed residential waste water disposal systems exist and depend upon overboard discharge of treated effluent (Fig. 3-2).The other residences are served by conventional septic systems which appear to operate satisfactorily, but about which little, if any, design information is available. Most of these residences are year-round dwellings.

On the west side of the Cove the slope of the land, and the amount of soil cover which exists is variable. Areas of gradual slope, and thicker soil cover do exist, notably just south of the Prince Point Road. Two (2) licensed overboard discharge systems exist on the west side of Buttermilk Cove (see Fig. 3-2).

Until recently Buttermilk Cove has been closed (closure orders dated May and December, 1983) and the harvesting of soft-shell clams prohibited. In mid-December, 1994 the area north of the Prince Point Road was opened, but the area south of the bridge remains closed. The reason for closure is the presumed contamination of the shellfish growing area by the overboard discharge systems which exist there. (It is important to note that high levels of indicator fecal coliform bacteria have never been found in seawater samples taken in the Cove. The discharges, then, represent assumed, and not proven, sources of contamination... The NSSP guidelines are such that administering agencies, like the DMR in Maine, may take a very conservative posture when assessing the possible impact of a potential pollution source. Areas may be closed because of suspected or proven sources. Such an approach enhances the protection of the Public Health.)

Following bacteriological monitoring requirements of the NSSP, seawater samples have been taken at three sites located near, or within, Buttermilk Cove. These locations are designated L-21, L-22, and L-23 (see Fig. 3-2).

Although Buttermilk Cove is closed to the harvesting of soft-shell clams, the water quality, as represented by the sampling data, satisfies the requirements for approved areas.

Fig 3-1 Shellfish Area Location Map

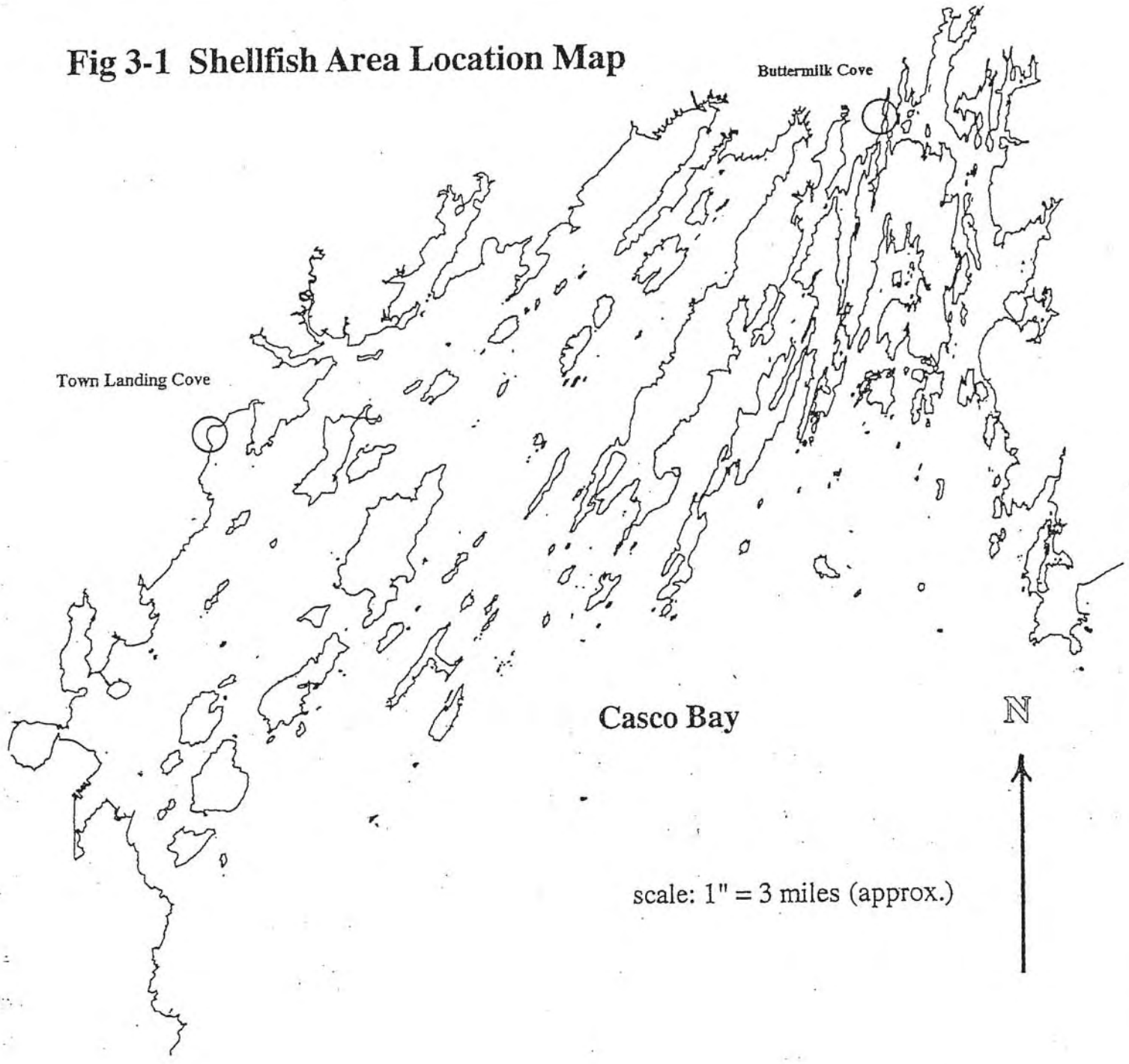
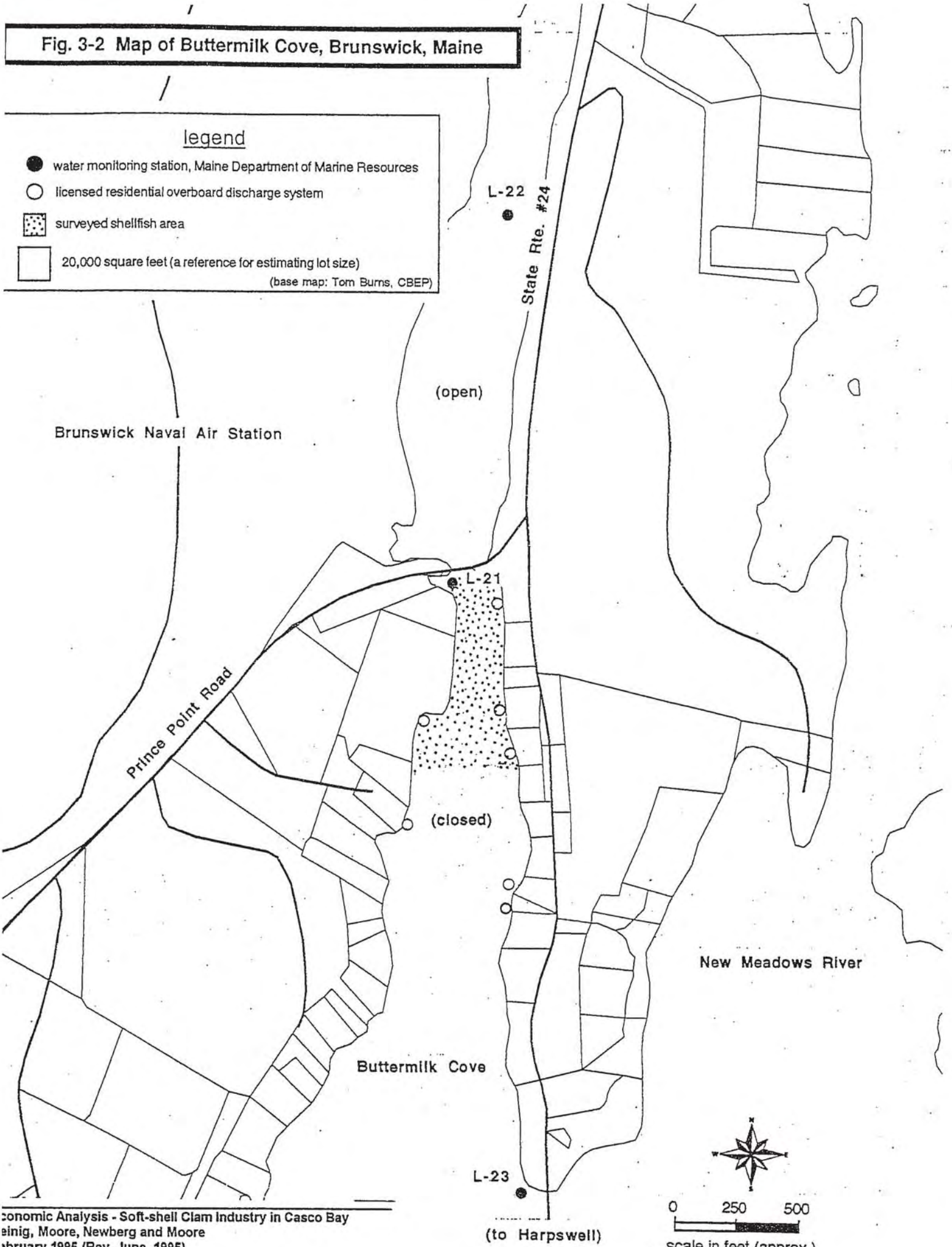


Fig. 3-2 Map of Buttermilk Cove, Brunswick, Maine



Results of analysis of samples from the three stations are as follows:

Table 3-1

Buttermilk Cove Bacteriological Monitoring Results

sta.	sampling int.	no. samples[1]	geom. mean MPN[2]	% >49[3]	90th %[4]
L-21	4/17/91-11/30/93	23	5.1	4.4	17.5
L-22	5/29/92-11/30/93	14	4.8	7.1	16.4
L-23	4/17/91-4/14/93	10	3.2	0	3.7
L-21	4/12/94-11/14/94	7	3.7	0	6.3
L-22	4/12/94-11/14/94	7	4.1	0	11.0
L-23	3/24/94-9/27/94	5	3.0	0	3.4

****

notes:

1... a minimum of 6 samples per year are required to maintain approved status if an area is subjected to "systematic random sampling"; the most recent 30 samples must be considered for re-classification

2... geometric mean of the most probable number (MPN) of fecal coliform bacteria colonies per 100 ml. of sample .. Analysis by Maine Department of Marine Resources, W. Boothbay Harbor, Maine, using a multiple tube fermentation test with A-1 media.

3... percentage of MPN values exceeding 49

4... an MPN value which 90% of the samples will not exceed.. a statistical "prediction" assuming the population being sampled has values which are normally distributed

NSSP requirements for approved shellfish areas are that a minimum of 6 samples be taken from each seawater sampling site established to monitor bacteriological water quality in the area. Those stations (assuming a 9 tube multiple tube fermentation test is used to analyze for the presence of fecal coliform bacteria) must have geometric mean most probable numbers (MPN) which do not exceed 14.7. In addition, the estimated 90th percentile, a statistical measure of the variability of the sample results must not exceed 49.

If Buttermilk Cove is to be re-classified as an area approved for clam harvesting three steps must be taken:

- The seven (7) licensed overboard discharges which exist there must be removed.
- A shoreline survey must be done to document the absence of other sources of pollution, or potential sources of pollution.
- Sampling of stations L-21, L-22, and L-23 must be continued.

3.32 Broad Cove

Broad Cove, as the name implies, is a broad, shallow, south-opening cove (see Fig. 3-1). A medial line drawn along the axis of the cove is the municipal boundary between the Town of Yarmouth to the east and the Town of Cumberland to the west. The boundary separates a small peninsula in Yarmouth, with Sunset Point and Prince Point at its southern tip, from the Cumberland shoreline known as Cumberland Foreside. Broad Cove is located on the southern portion of the Yarmouth 7.5' United States Geological Survey topographic quadrangle.

In the western part of Broad Cove there is a small semi-circular indentation of the shoreline. This smaller cove is the portion of Broad Cove of interest here. (For convenience it will be informally referred to as **"Town Landing Cove"**.) It is readily accessed by Town Landing Road, and there is public access to the water via this road.

Figure 3-3 shows the mosaic of individually owned properties in the area close to the shoreline. All the structures are residential. They are setback at least 75' from normal high water, and, in most instances, a much greater distance. All are occupied year-round; most are served by Town water and sewerage.

A portion of Broad Cove is open to the harvesting of soft-shell clams. However, the eastern shoreline, in the Town of Yarmouth, and part of the western shoreline ie., Town Landing Cove are closed. The latter has been closed since September 8, 1983. Harvesting of soft-shell clams is prohibited because of a suspected source of fecal coliform contamination within the watershed of the small, un-named, stream which discharges to Town Landing Cove (see Fig. 3-4). Reconnaissance of the shoreline and the analysis of freshwater entering the cove by DMR personnel has at several times indicated the presence of fecal coliform bacteria in concentrations greater than 93 colonies per 100 milliliters of sample. The quantitative results were most probable numbers (MPN), that is, statistical statements based upon multiple tube fermentation tests as opposed to observation or measurement. The sampling was done in several instances after significant precipitation in the form of rain, when bacterial concentrations in freshwater are expected to be higher because of "stripping" of the organisms from substrate materials in a watershed and their transport in run-off. While no specific source for these elevated concentrations was ever identified, a pond northwest of the cove which was "crowded" with ducks, geese, and other waterfowl was presumed to be the source of the fecal coliform bacteria. In accordance with NSSP guidelines relative to shoreline survey procedures and the identification of presumed sources of fecal coliform bacterial contamination by "pollution source sampling", Town Landing Cove was closed by DMR.

DMR files and those of the Town of Cumberland contain correspondence between DMR personnel and the Town's Shellfish Committee. Repeatedly the Town challenged the reasons for closure, particularly during the several years after a property owner had moved, thus clearing the pond of its array of waterfowl.

Seawater samples have been taken at two sites in Town Landing Cove. The locations are designated I-30 and I-31 (see Fig. 3-3). Results of analysis of these samples are given in Table 3-2 below.

As is the case for Buttermilk Cove *these water quality results satisfy the requirements for approved areas.*

Fig. 3-3 Map of Town Landing Cove, Cumberland, Maine

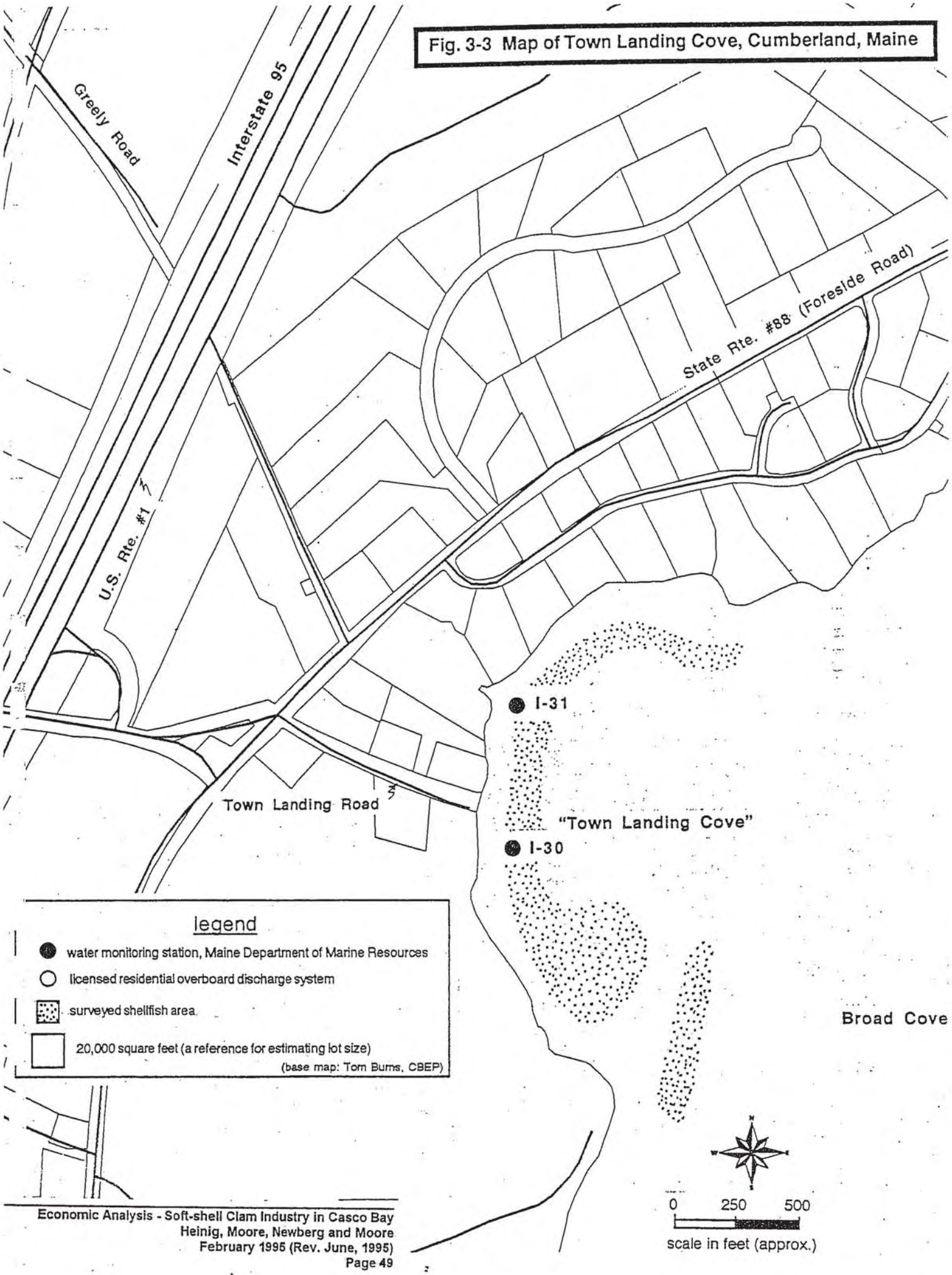


Table 3-2

Town Landing Cove Bacteriological Monitoring Results

sta.	sampling int.	no. samples*	geom. mean MPN	% >49	90th %
I-30	4/10/91-12/13/93	22	3.4	0	5.2
I-31	4/10/91-12/13/93	22	7.2	9.1	37.2
I-30	5/12/94-10/18/94	8	4.6	0	12.1
I-31	5/12/94-10/18/94	8	5.3	0	19.3

****

notes:

1... a minimum of 6 samples per year are required to maintain approved status if an area is subjected to "systematic random sampling"; the most recent 30 samples must be considered for re-classification

2... geometric mean of the most probable number (MPN) of fecal coliform bacteria colonies per 100 ml. of sample .. Analysis by Maine Department of Marine Resources, W. Boothbay Harbor, Maine, using a multiple tube fermentation test with A-1 media.

3... percentage of MPN values exceeding 49

4... an MPN value which 90% of the samples will not exceed.. a statistical "prediction" assuming the population being sampled has values which are normally distributed

3.4 Resource valuation

3.41 Buttermilk Cove

The most recent shellfish population survey was done in Buttermilk Cove in July, 1990 by the Town of Brunswick. Approximately 4 acres were surveyed south of the Prince Point Road bridge. (The methods used were similar to those discussed in Task 1, Section 1.33 of this report.) Assuming an ex vessel price ie., landed value, of $50. per bushel, the value of the harvestable clams ie. those of 52 mm. or greater length, was determined to be $37,900. No analysis of the topology of the population vs. size data was done in order to attempt to predict how the legally harvestable clam population might change in the near future. *It is important to note that the "sustainable yield" of a soft-shell clam area can be established only after repeated surveys during uninterrupted harvesting.* If the harvestable population has remained the same, and assuming a price of $72.95. per bushel, the resource value in Buttermilk Cove is presently $55,500 (see Task 1).

3.42 Town Landing Cove

Town Landing Cove was surveyed on May 5, 1991. A total of 7 acres was studied. It was estimated that there were 76 bushels of clams per acre, of which 74 percent were of legally harvestable size. On May 31, 1994 11.5 acres in the Cove were surveyed. Based upon the results of the 1994 survey, and using the same price per bushel as was used for Buttermilk Cove (see above), the resource value of Town Landing Cove can be calculated to be $39,600.

3.5 Costs to a municipality of resource management and protection

Some of the costs to a municipality of maintaining and managing a shellfish area result from work done within the area per se. Shoreline survey and bacteriological monitoring are examples. One way to estimate other costs is to pro rate costs for an area in accordance with the percent-age of the total productive shellfish area within the municipality which it represents. The development and revision of a Shellfish Ordinance and enforcement of the ordinance are examples.

To accurately pro rate costs, the productive area for a specific growing area must be accurately known. Often it is. Also the total productive acreage of an entire municipality must be known. For some towns in Maine (ie., Brunswick) this figure is reasonably well known; for other towns (ie., Cumberland) it is unknown. There are 431 acres of commercially viable soft-shell clam habitat in the Town of Brunswick, a figure which includes 4.0 acres in Buttermilk Cove. Thus, Buttermilk Cove can be assumed to incur 0.9% of certain total costs of resource management and protection borne by the Town of Brunswick as a whole.

For Town Landing Cove in the Town of Cumberland it is more difficult to pro rate costs since the total size of productive area within the Town is unknown. In the absence of such data the total length of shoreline in proximity to historically productive shellfish areas was determined. Town Landing Cove (3400') represents 8.4% of the 12,170' of mainland + 28,480' of island shoreline. (Most of the latter shoreline is on Great Chebeague Island.)

The costs of resource management and protection result from the following tasks:

site specific:

- shellfish population estimates necessary to establish the numbers of licenses which the municipality will issue in accordance with the procedures established in its Shellfish Ordinance...and the in-place (or "ex vessel") dollar value of the resource in specific growing areas such as Buttermilk Cove and Town Landing Cove

- shoreline surveys, which according to the NSSP, must be done once every 12 years to maintain the "open" status of an area; and must be done each time the re-classification of a "closed" area is considered by the DMR

- bacteriological monitoring of seawater at locations established by DMR. Sampling programs currently used by DMR are referred to as "systematic random sampling". A minimum of six (6) samples are required each year from each station considered to monitor a specific shellfish area (NSSP).

pro-rated:

- administration, including costs of re-writing and/or amending the Shellfish Ordinance, review by Town Attorney; correspondence with DMR concerning the status of areas; preparation of annual reports; coordination with Shellfish Committee

- enforcement of the Shellfish Ordinance and applicable marine law; legal action taken by the Town against alleged offenders

Revenues to a town associated with resource management and protection are as follows:

pro-rated:

- fees from the sale of licenses
- collection of fines for violations and the sale of seized or abandoned shellfish; sales of seized equipment, boats, or vehicles.

Table 3-3 (see p. 72) is an attempt to attach dollar costs or estimates to each of the elements listed above. The notes which accompany some of the entries indicate how the information was obtained. In Table 3-3 the costs are the *maximum predicted annual costs to the Towns* of Brunswick and Cumberland for Buttermilk Cove and Town Landing Cove, respectively.

3.6 Remediation of Buttermilk Cove and Town Landing Cove

As discussed in Section 3.3, both Buttermilk Cove and Town Landing Cove are presently closed and the harvesting of soft-shell clams is prohibited. The remediation of the two shellfish areas to achieve their re-classification as "open" and "approved" poses two different problems. This section addresses the steps which must be taken to remediate the areas and discusses the costs involved.

3.61 Buttermilk Cove

Since the remediation of Buttermilk Cove must begin with the replacement of overboard discharges, a brief review of similar projects recently undertaken by the Town of Brunswick may be useful... In 1987 residential waste water treatment systems which involved, as a final step, the chlorination of the system effluent followed by discharge to the sea below mean low water, were prohibited by law in the State of Maine. Such systems have been re-licensed pending appropriate funding to enable landowners to install alternative systems. Until recently the Town of Brunswick had a total of 37 licensed residential "overboard discharge systems" (OBD'S). Twenty-two (22) of these were located within a 67 acre area at the southwestern, or seaward, end of the Mere Point peninsula. These systems were replaced in 1993 as a result of a comprehensive project involving the investigation of alternative disposal methods, detailed design and engineering studies, and finally, construction. The project, entitled the Mere Point Waste Water Treatment Project, was funded by grants from the United States Environmental Protection Agency and the State of Maine to the Town of Brunswick, as well as by the residents of the area. Overboard discharge was replaced primarily by on-site subsurface disposal, although four (4) residences share a holding tank. The system is owned by the Town of Brunswick, and operated and maintained by the Brunswick Sewer District, with a current annual budget of $14,550. (This does not include capital replacement or power costs. For the latter the Town is billed directly by Central Maine Power Company.) The total cost of the project was $701,300, which included construction costs of $520,500. The waste water flow assumed for design purposes (ie., as required by the Maine State Plumbing Code) was 10,620 gallons per day.

Also in 1993, the Town of Brunswick provided 90% of the funding necessary to replace an additional three (3) residential OBD'S with on-site, conventional, septic systems. These funds were made available by the State of Maine through a grant program administered by the Maine Department of Environmental Protection. Total costs, including design and installation, were $21,416. The total waste water design flow was 860 gallons per day. In 1994 an additional three (3) systems (a total of 810 gallons per day) were replaced at a total cost of $31,077.

Ten (10) licensed OBD'S remain in the Town of Brunswick. Seven (7) of these are located in Buttermilk Cove, two (2) along the west shore and five (5) along the east shore. Work intended to lead to the replacement of these systems has begun, again with the aid of funding from the State of Maine. To date all the residential properties involved have been carefully examined to determine if on-site waste water disposal is possible. In six (6) of the seven (7) cases it is not. Therefore a shared disposal field on a nearby parcel of land is currently being considered. Individual residences would retain septic tanks (and in some cases, underdrained sand filters and pump stations which currently exist) and add pump stations to pump effluent to the common disposal area. Design waste water flow for the Buttermilk Cove Project is 1,890 gallons per day. *Using a weighted average cost of $47. per gallon per day of installed capacity, derived from the above data, the total cost of the Project, including design and construction, is anticipated to be $88,800.*

Once all existing discharges are removed, a shoreline survey would be required to determine whether or not additional sources of bacterial and/or viral contamination existed in, or near, the soft-shell clam harvesting area. The cost of the survey, together with the analysis of any water samples taken to investigate potential pollution sources, would be $630. A more intensive program of "systematic random sampling" of seawater monitoring stations L-20, L-21, and L-22 would also be required. Assuming this involves the analysis of thirty (30) samples from each of the three sites over a period of two years, the cost of bacteriological monitoring ie., for the presence of fecal coliform bacteria, would be $1,485. This information would then be reviewed by DMR and a "Sanitary Survey" written for Buttermilk Cove. It is assumed that at that time Buttermilk Cove would meet requirements of the NSSP allowing its reclassification from "closed" to "open".

The anticipated cost of remediating Buttermilk Cove in the Town of Brunswick is, therefore, $90,915[5].

3.62 Town Landing Cove

Town Landing Cove, a part of Broad Cove in the Town of Cumberland, has been closed to the harvesting of shellfish since May 1983. The closure was the result of high fecal coliform concentrations obtained in analyses of pollution source samples ie., freshwater samples taken along the shoreline of the Cove. "High" concentrations were found, in particular, immediately after heavy rainfall. While the cause of these high concentrations was never established, a pond within the watershed north-northwest of the shore was the suspected source because of a large

[5] The total cost of remediation would be shared as follows: the cost of design and construction of waste water disposal alternatives for Buttermilk Cove residents would be shared, 90% by the State of Maine and 10% by the Town residents directly involved. The shoreline survey and bacteriological monitoring costs would be borne by the Town of Brunswick; the Maine Department of Marine Resources would be responsible for the cost of the Sanitary Survey

Table 3-3 Estimated Maximum Annual Municipal Costs of Shellfish Area Management and Enforcement

task[1]	unit cost[2]	Buttermilk Cove[8] (Brunswick)	Town Landing Cove[8] (Cumberland)
costs:			
shellfish pop. est. (incl. rpt.)	$(?)(V,T) - $60.[3] per ac.(C)	$ 80.[9]	$230.[9]
shoreline survey (incl. rpt.)	$(?)(V,S) - $528.[4] per mi.(T) - $630.[5] per mi.(C)	$ 53.[10]	$ 34.[10]
collection of water samples for bacteriological analysis	$(?)(V,S) - $4.80[6] per sample(T) - $16.50[7] per sample (C)	$300.[11]	$200.[11]
analysis for fecal col. bact.	$(?)(S)	$ (?)	$ (?)
administration..			
Ordinance writing/amending			$ 32.
legal fees for review of Ord.			$ 16.
correspondence with DMR		$ 567.[12]	
annual reports			$224.[13]
Town Shellfish Committee			
enforcement..			
surveillance of shellfish areas		($ 135.)	$413.
fees for legal action		$ 45.	$ (?)
estimated annual costs:		**$1045.**	**$1149.**
revenues:			
license fees		$ 120.	$202.
fines and/or sale of seized shellfish		$ 72.	$192.
estimated annual revenues:		**$ 192.**	**$394.**

notes

1 For a brief description of each task listed see text, section 3.5.

notes for Table 3-3, continued

2 A question mark indicates that the unit cost for the indicated task is unknown. In some cases more than one cost is given because the task may be done by a volunteer (V), a Town employee (T), a State (DMR) employee (S), or a private consultant (C)

3 This represents an average value determined from fees charged to several southwestern Maine municipalities.

4 cost for a 1994 survey, Town of Brunswick

5 average cost for 1994 surveys done by MER Assessment Corp. and D.W. Newberg Associates for the Town of Harpswell

6 cost of 1994 sample collection. This includes labor only, and does not reflect the costs of transportation between sampling sites, or other operating expenses.

7 average total cost for sampling and compilation of analytical data for monitoring work done by MER Assessment Corporation and D.W. Newberg Associates, Town of Harpswell

8 **Values are specific to Buttermilk Cove and Town Landing Cove. They are calculated using maximum unit costs developed in other, similar shellfish areas; or, by using data or estimates provided by municipal employees of Brunswick and Cumberland. Total annual costs for Brunswick were multiplied by 0.9% for Buttermilk Cove; total annual costs for Cumberland were multiplied by 8.4% for Town Landing Cove (see text, Section 3.5).**

9 Recent shellfish population surveys in Buttermilk Cove and Town Landing Cove have involved 4.0 and 11.5 acres respectively. Such surveys must, by law, be done once every three (3) years. Hence, this value represents the number of acres surveyed multiplied by the cost per acre ($60.), divided by 3.

10 The lengths of shoreline which must be surveyed are 1.01 miles for Buttermilk Cove, south of the Prince Point Bridge, and 0.64 miles for Town Landing Cove. The National Shellfish Sanitation Program requires shoreline surveys once every twelve (12) years. (Annual, and 3-year reviews of the survey data are also required. This value represents the length of shoreline in miles multiplied by the cost per mile ($630), divided by 12.

11 Seawater sampling stations L-21, L-22, and L-23 are used to monitor water quality (ie., fecal coliform bacteria concentrations) in Buttermilk Cove. Stations I-30 and I-31 are sampled in Town Landing Cove. If both shellfish areas were open and approved for soft-shelled clam harvesting, six (6) samples would be required each year from each station. The cost of $16.50 per sample was used.

12 The total amount budgeted by the Town of Brunswick for marine resources is multiplied by 0.9% in order to determine costs reasonably attributable to Buttermilk Cove. The annual cost of enforcement ($135.) is included in this figure.

13 This includes the annual costs of correspondence with DMR, preparation of annual reports, and of the participation of municipal employees in the activities of the Cumberland Shellfish Committee, a committee composed of citizen volunteers.

number of waterfowl confined to an area in, and around, the pond by the landowner (see Fig.3-4).

At the time the present study was proposed to the Casco Bay Estuary Project (October 1, 1993) it was assumed that an identifiable source, or sources, of fecal coliform contamination existed with measurable, and unacceptable, impact upon seawater in the shellfish growing area of Town Landing Cove. Such is not the case. Review of bacteriological monitoring data for seawater sampling stations I-30 and I-31(see Section 3.32), of the pertinent DMR files containing shoreline survey and pollution source sampling information, of correspondence between DMR and the Town (see Appendix III), and discussions with Cumberland officials concerning land-use within the watershed support this conclusion.

The remediation of Town Landing Cove does not therefore involve the identification, and removal, of a source, or sources of fecal coliform bacteria. It involves *obtaining action* by DMR based upon the data collected in and near the Cove, including the data presented in this study (see below). That action should include an update of the classification of the area; or, a re-classification, and a clear justification, in terms of the applicable NSSP requirements, for the action taken.

Because of the situation which exists, the cost of "remediating" Town Landing Cove is not predictable.

3.7 Review of water quality data for Town Landing Cove

On April 1, 1994 the 3400' length of shoreline adjacent to Town Landing Cove was examined by Don Newberg and Dick Peterson, Codes Enforcement Officer for the Town of Cumberland. No sources, or potential sources, of pollution were identified other than a seep, or spring, discharging directly to the Cove at the approximate location of the normal high water mark, and the stream which flows beneath State Route #88 and discharges to the Cove. Both of these had been sampled on several previous occasions (DMR pollution source sampling data for Town Landing Cove).

Following examination of the shoreline, roads within the watershed of the stream were travelled by car for the purpose of a general review of land-use within the watershed. Uses observed were not considered apparent or potential sources of fecal coliform bacteria that might effect stream water quality.

Sampling locations were identified for the purposes of comparing the water quality of different tributary brooks, or streams, as well as the water quality at points along the main stream which discharges to Town Landing Cove. The locations were also chosen because they were easily accessed for sampling, could be clearly identified on a topographic map, and had measurable discharge, as well as perennial flow. While only one aspect of water quality, the analysis of samples from these locations would provide some information on the concentrations of fecal coliform bacteria at several sites within the watershed. Six (6) locations were selected for sampling (see Figure 3-4).

On May 11, 1994 these sites were sampled, together with the stream itself just above the point of discharge, and the previously mentioned "seep". Samples were iced as required by sampling protocol and transported to the DMR Laboratory at West Boothbay Harbor. Samples were delivered within 3.5 hours of collection. Sample chain of custody sheets are included in Appendix III. Results are tabulated below.

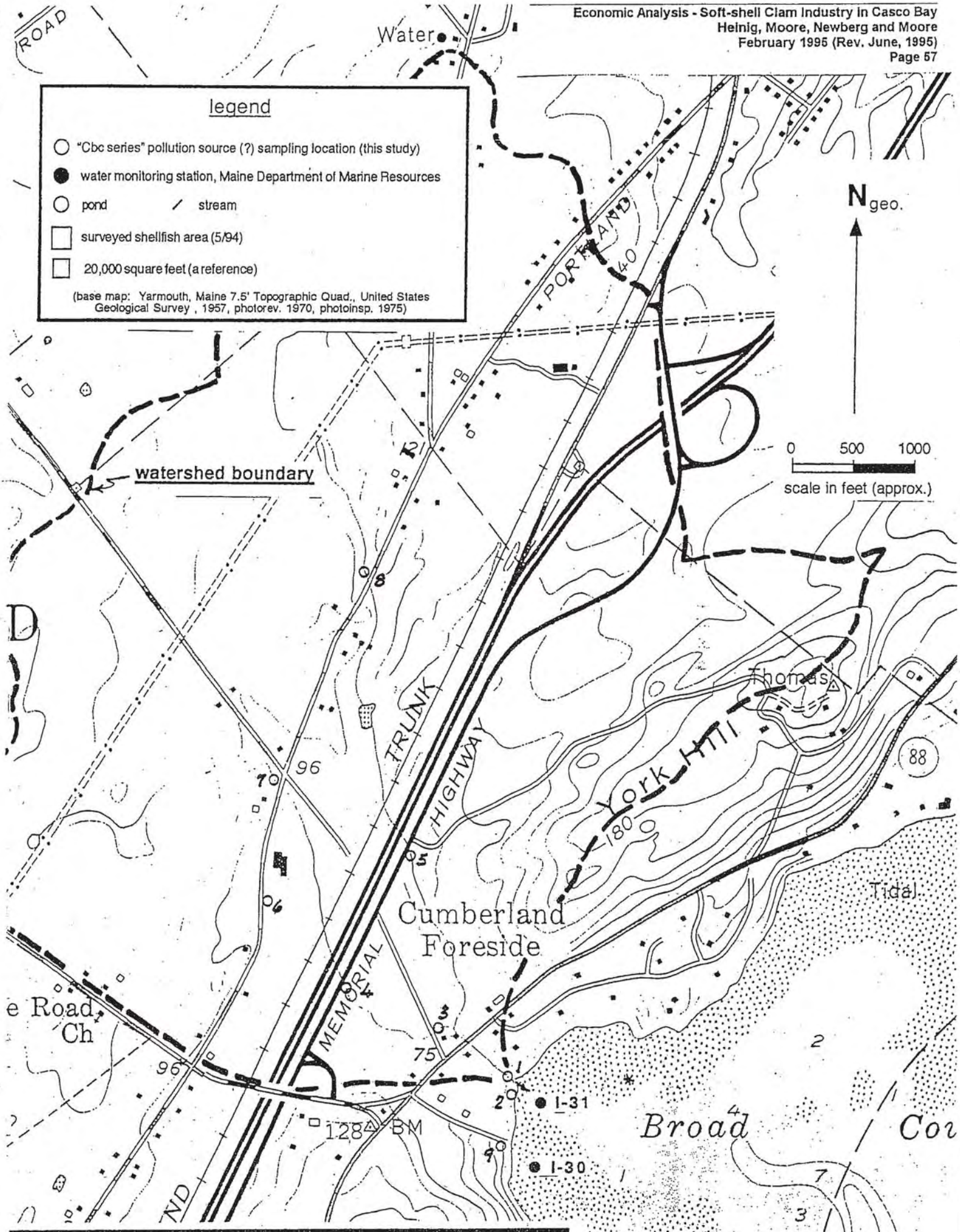


Fig. 3-4 Map of Town Landing Cove Watershed, Cumberland and Yarmouth, Maine

Table 3-4

Pollution Source Sampling , Town Landing Cove, 5/11/94

sample	date	time	temp.[1]	conductance[2]	MPN[3]
Cbc-1	5-11-94	1230	13.5	220	15
Cbc-2	"	1245	9.5	215	15
Cbc-3	"	1255	15	205	<3.0
Cbc-4	"	1305	14.5	170	3.6
Cbc-5	"	1315	14	245	9.1
Cbc-6	"	1327	12.5	225	43
Cbc-7	"	1343	18	90	<3.0
Cbc-8	"	1400	16.5	120	<3.0

notes:

1... temperature is in degrees Centigrade
2... conductance is in microhmos/cm and is **not** corrected to 25 deg. C; values in parentheses represent salinity in parts per thousand
3... most probable number (MPN) of fecal coliform bacteria colonies per 100 ml. of sample .. Analysis by Maine Department of Marine Resources, W. Boothbay Harbor, Maine, using a multiple tube fermentation test with A-1 media.

Samples collected on May 11, 1994 were collected under conditions of higher than normal run-off. 1.48" of rain had been recorded on May 7, 1994 by the U.S. Weather Bureau at Portland, Maine.

Because previous pollution source sampling had been interpreted as showing a relationship between high fecal coliform bacteria concentrations in freshwater and precipitation events, it was considered important to collect a second round of samples. On August 18, 1994, 1.79" of rain fell in the first 16 hours of the day. Samples were collected just after precipitation ended. Results of analysis of the samples are given in Table 3-4a below. Sample locations and a copy of the chain of custody form are included in Appendix III.

Unfortunately seawater samples were not taken from stations I-30 and I-31 at the same time the nine (9) samples were collected. Analysis of seawater samples might have measured the effect of the precipitation event upon the concentrations of fecal coliform bacteria in seawater within the shellfish area.

However, to pursue the question of whether such "events" effect seawater, the data for the two sampling stations were reviewed. Precipitation records were obtained for the thirty (30) sampling dates since April 10, 1991 (see Table 3-2 above). The data were recorded either at Tide Mill Cove in Harpswell, or at the Portland Jetport by the National Weather Service. Rainfall amounts were noted for the day samples were taken, as well as for each of the two days preceeding sampling. Unusually heavy rainfall produced no increase in fecal coliform concentrations in seawater.

Table 3-4a

Pollution Source Sampling , Town Landing Cove, 8/18/94

sample	date	time	temp.[1]	conductance[2]	MPN[3]
Cbc-1	8-18-94	1700	18	250	>1100
Cbc-2	"	1710	15	160	460
Cbc-3	"	1643	18	200	>1100
Cbc-4	"	1630	19	160	>1100
Cbc-5	"	1634	17	90	>1100
Cbc-6	"	1615	18	115	>1100
Cbc-7	"	1605	18	145	>1100
Cbc-8	"	1555	18	110	>1100
Cbc-9	"	1720	18.5	165	1100

notes:

1... temperature is in degrees Centigrade

2... conductance is in microhmos/cm and is **not** corrected to 25 deg. C; values in parentheses represent salinity in parts per thousand

3... most probable number (MPN) of fecal coliform bacteria colonies per 100 ml. of sample .. Analysis by Maine Department of Marine Resources, W. Boothbay Harbor, Maine, using a multiple tube fermentation test with A-1 media.

A detailed discussion of the results of the pollution source sampling of Town Landing Cove is beyond the scope of this study. However, some important preliminary interpretations are as follows:

- Analysis of pollution source samples taken after significant (>1.0") precipitation from small streams in forested and undeveloped watersheds in Maine has previously yielded most probable numbers of ">1100" (Heinig and Newberg, 1994). Hence, the fecal coliform bacteria concentrations given in Table 3-4a, which are for a developed watershed, cannot be used to document pollution caused by inappropriate land use and/or failed engineered systems within theTown Landing Cove watershed.

- The use of fecal coliform bacteria concentrations in freshwater samples, obtained by multiple tube fermentation methods, in making decisions about the classification, or re-classification, of soft-shell clam harvesting areas is highly suspect.

- Harvesting areas classified as "closed" in part, or entirely, because of test results of this type (eg., Town Landing Cove) cannot be remediated because problems cannot be defined/documented by the analysis of surface water samples using these methods.

3.8 Summary of remediation benefits and costs (D.W. Newberg & Louisa Moore)

In any analysis of benefits and costs, it is important to recognize who will benefit and who will bear the cost. With public natural resources such as clam flats, this is particularly true, as there is no singular owner of the resource. Casco Bay towns manage their respective flats for the benefit of "the public". This presents challenging questions to municipal decision makers regarding which public will benefit and which one will pay.

When clam flats are redeemed and reopened for harvest, monetary benefits accrue to certain parties: commercial diggers, recreational diggers, local businesses which are patronized by diggers with "new" income to spend, wholesalers, suppliers, restaurants and employees of all of these entities. Also, assuming income is reported by those earning it, the State treasury would receive increased revenues in the form of taxes from the new income of commercial diggers. Ways in which direct income from clamming "multiplies" through a local economy are discussed in Task 2. Non-market values of the clam resources are reviewed in Task 4.

Costs of redeeming clam flats, however are incurred for other parties: taxpayers statewide foot the bill for state remediation grants; the town (i.e. local property taxpayers) pay for coordination of the project at the municipal level and for the costs of managing the clam resource; and even with a grant program in place, homeowners pay a portion of the cost to replace their septic systems and maintain them in accordance with recent laws against overboard discharges.

Municipal officials may need to decide whether to invest in the opening of the flats in the first place, given scarce municipal funds: would the money be better spent in some other way? Is there a lower cost way for a town to obtain similar economic effects? Would a town rather have a new school building? Interest earned on investing the money instead? Lower taxes? Another social service program? Should the investment be in the clamming industry or in some other local industry or commerce? These are frequently political decisions, not strictly economic ones.

Each of these questions should be answered locally. It is interesting to note, however, that reports from other clam producing areas such as Cape Ann and Buzzards Bay, Massachusetts, have shown very positive returns on investments in remediation. In addition, studies which have compared the clamming industry to other industries have shown that for each dollar earned by a clam digger, more of it stays in the local economy than with each dollar earned in the other industries.[6]

3.81 Buttermilk Cove

The value of the existing, and currently commercially harvestable, soft-shell clams in the affected area of Buttermilk Cove in the Town of Brunswick, Maine is estimated to be $55,500. This estimate is based on an assumed price of $72.95 per bushel and a calculated, legally harvestable, population of clams in a surveyed area of 4 acres. It is certain that this price will fluctuate. It is also certain that the number of harvestable bushels within the 4 acres, as determined by future shellfish surveys, will fluctuate. In addition, the topology of Buttermilk Cove suggests that the commercially viable habitat within it is larger than 4 acres. Considering these

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[6] Resources of Cape Ann, a Project of the Massachusetts Audubon Society, "The Costs of Pollution: The Shellfish Industry and the Effects of Coastal Water Pollution", April, 1982, p. 1.

variables it seems reasonable to assume that the affected area of the Cove, if approved for harvesting, could sustain an annual yield of $55,500. (To calculate the "total estimated economic impact" ie., benefit, this value may be multiplied by an "income multiplier" of 3.0 as discussed in Task 2. Application of such a multiplier changes the way in which the resource is viewed to one in which its impact on the broader Casco Bay region..or even the State becomes the frame of reference.)

Costs and benefits which occur in the future can only be compared in terms of their present values. Table 3-8a below shows the dollar costs of remediating the overboard discharges in Buttermilk Cove, and the present value of those costs ($90,915. and $86,486., respectively). (See Task 2.54 for a description of "present value" calculations. The discount rate, "R", used here is 5%.) The lion's share of this investment is borne by the State administered grant, rather than the homeowners, the Town, or the diggers.

Table 3-8a

Estimated Costs of Remediating Buttermilk Cove for Harvest of Soft-shell Clams

Capital Cost	Dollar Cost Dec. 1994	Present Value (R=.05)
Replace 7 septic systems (design and construction) (1,890 gal./day X $47/gal./day installed capacity)	$88,800.	$84,571.
State grant pays 90% ($79,920.)		
Residents pay 10% ($ 8,880.)		
Reclassification Costs		
Shoreline survey and water sample analysis	630.	600.
Bacteriological monitoring for 2 years	1,485.	1,315.
DMR review and "Sanitary Survey" (costs unknown)	?	?
Total Remediation Costs	**$90,915.**	**$86,486.**

Table 3-8b below shows the benefits and costs of the remediation "project" from the year of construction of the new shared waste water disposal system through the year 2015. The project is envisioned to be the solution to the current closure of the cove. It is considered to have a 20 year life, based on the life of the disposal system. Year one is assumed to be 1995, during which design and construction are completed. (See additional assumptions listed below the Table).

The Town of Brunswick would have to invest approximately $2,115 to reclassify Buttermilk Cove. (Because these costs would not be incurred until 1996 and 1997, the present value to the town is slightly less, $1,945).

Annual operations and maintenance costs were estimated based on existing comparable costs. Operating costs of the new sewer system recently completed on Mere Point (see Section 3.61, above) were $0.00375/gallon/day of installed capacity. Using this rate for the Buttermilk

Cove project results in a conservative (high) estimate, as the Mere Point system includes design features not required here.

The potential direct "net annual benefit" of managed production of soft-shell clams is therefore $55,500 - $853... neglecting use of the multiplier. This benefit is to be compared to the projected capital cost of remediation, $90,915, to which an estimated annual operating cost of $2590. must be added.

From the municipal perspective then, the present value of Brunswick's initial investment of $1,945., plus maintenance of the Buttermilk Cove clam flat would be $69,099. The present value of income earned by diggers over the 20 year period would be $999,000., or more than 14 times the cost. The net present value would therefore be $929,901.

Table 3-8b

Estimated Income to Diggers and Costs to Brunswick over 20 year Project Life for Harvest of Soft-shell Clams in Buttermilk Cove

		Present Value (R=.05)
Income to Diggers through 2015		
$55,500/year (beginning in 1998)		$999,000.
Initial cost to Brunswick for reclassification		1,945.
Annual Operation and Maintenance Costs to Brunswick		
Brunswick Sewer District cost to operate new system (1,890 gal./day X $0.00375/gal/day)	2,590.	
Brunswick resource management and protection [Annual prorated mgmt. costs for B'milk Bay ($1,045.) less annual revenues from fees & fines there ($ 192.)]	853.	
Total Annual Brunswick O &M Costs	$3,443.	
O & M Costs to Brunswick Through 2015		
Maintaining the new sewage system plus annual resource management & protection prorated for Buttermilk Cove		67,154.
Initial costs plus O & M costs to Brunswick Through 2015		69,099.
Present Value of New Income Versus Brunswick Costs ($999,000. - $69,099.)		$929,901.
Deducting the one-time Initial State of Maine Bond Issue Funds Contribution of $79,920		$849,981.

Assumptions Made for Table 3-8b:

1. The 20 year period begins in January 1995 with design and construction of the new shared waste water disposal system.
2. Clam prices will rise 5% per year, as will O&M costs. In each case, this rate offsets the discount rate of 5%, so the present value of future costs is constant ($3,443. / year).
3. The maintenance cost of $853. would not be incurred until the first year the Cove is "open", 1998. Maintenance costs would then be incurred for each year thereafter.
4. Interest rates are assumed to remain constant over the 20 year "life" of the project.
5. The income stream for diggers does not begin until 1998 due to construction, followed by 2 years of monitoring and then a DMR survey.
6. Costs are assumed to be incurred in one lump sum at the end of each year. Likewise, incomes are assumed to accrue at the end of each year. Neither costs nor incomes are compounded during the year.

In addition to these simplified calculations of benefits and costs, the overall economic value to the local and regional economy of remediating Buttermilk Cove can be estimated. In Task 2 of this report, an "income multiplier" was developed. To represent the benefits of new income from the clamming in Buttermilk Cove, the income from direct clam sales ($999,000) would be multiplied by an "income multiplier" of 3. This could result in $2,997,000 of indirect benefits of clamming income as it is spent in supply shops, restaurants, gas stations, etc. of Brunswick and the Casco Bay region.

Also, the "non-market value" of opening Buttermilk Cove may be substantial, though difficult to measure. For example, recreational diggers would have access to new flats, and residents and visitors in the area would be likely to see diggers on the flats instead of seeing signs posting a closure due to pollution. Task 4 discusses the significance of these types of non-market values in more depth.

Clearly the availability of State grant funds makes this project readily affordable for the Town. The State's outlay would be $79,920., or 88% of the total initial outlay of $90,915. How good is the investment from the State's perspective? If all the income likely to be generated is viewed as a benefit of the State investment, it would be a greater than 12-fold return over the 20 year life of the project, without considering multipliers or non-market values. Additional State costs of paying for the bond initiative and administering the grant program are not to be diminished, but are not known or estimated here.

3.82 Town Landing Cove

The value of the existing, and currently commercially harvestable, soft-shell clams in Town Landing Cove in the Town of Cumberland, Maine is $39,600. This value, calculated on the basis of 1994 survey results, is assumed to represent the sustainable annual yield of the Cove (see above discussion of Buttermilk Cove).

The costs of management, and protection, of the resource by the Town of Cumberland, assuming the Cove were open, and commercial harvesting were approved, are summarized in Table 3-3. These costs would be $755. annually.

The potential direct "net annual benefit" of managed production of soft-shell clams is therefore $39,600 - $755... neglecting use of the multiplier. As discussed above (see section 3.62), the cost of "remediating" Town Landing Cove so that it may be re-classified by the Maine

Department of Marine Resources as open, and approved for commercial harvesting, cannot be calculated. However, no capital costs should be required. Therefore the total cost would be only a fraction of the cost for Buttermilk Cove.

It would appear that the costs of remediation of Buttermilk Cove and Town Landing Cove may represent the high and low extremes to be expected for closed shellfish areas in Casco Bay as a whole. If true, it may be cost effective to increase the area approved for harvesting in the Bay. However, it is important to note that it is the sustainable ie., long-term, yield of a healthy soft-shell clam population that will determine appropriate levels of investment in efforts to remediate pollution sources, or potential pollution sources, as well as appropriate levels of investment in the management and protection of the resource. For many growing areas in Casco Bay the sustainable yield is unknown.

Several towns in Casco Bay are faced with opportunities to redeem clam flats. The current bond initiative administered by the Department of Environmental Protection is an economic window of opportunity for Maine's coastal towns. In addition to taking advantage of this program, municipal officials need to assure themselves (and their taxpayers) that the net benefit from *municipal* outlays will be positive. They may also need to pursue means of funding the municipal outlay by capturing some of the new income generated from the reopened flats. These are public policy decisions which belong firmly in the hands of local officials and their constituents.

Given the opportunity for a high local return on investment, the data gathering, assessments of costs and benefits, and decision making can be seen as very affordable. In both the cases reviewed here, the potential benefits are substantial compared with costs.

3.9 References

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4.0 Overview of non-market values of the soft-shell clam industry in Casco Bay, and estimated value of one non-market use: recreational clam digging

by Louisa R. Moore

4.1 Introduction

Casco Bay's residents and visitors place value on many items and activities which are not traded on any markets.[7] A healthy soft-shell clam resource in Casco Bay can provide numerous and substantial benefits beyond those measured in landings or in dinners sold at a restaurant. As such, the soft-shell clam resource supports more than the soft-shell clam "industry".

For example, residents of Casco Bay communities value their opportunity to go recreational clamming for pleasure or for a needed meal. This is a "consumptive use" not resulting in a sale. Tourists might value the opportunity to see diggers working a clam bed at low tide, though the tourists may never dig clams themselves or even eat them. This sightseeing is a "non-consumptive use". A tourist's visit to Maine may be diminished in a significant way by the knowledge that clamming is prohibited due to pollution.

To ignore these consumptive and non-consumptive uses is to underestimate the importance of the clam resource. Recreation and tourism are vital elements of Casco Bay's economy. What are the important non-market values of Casco Bay's soft-shell clam resource, and how can they be measured? How can they be useful to the dozens of officials making decisions affecting environmental quality of Casco Bay's clam beds?

4.2 Purpose

The objectives of this task are to review concepts of non-market value and how it can be measured; to identify non-market values of the soft-shell clam industry in Casco Bay; and, to estimate some values of a non-market use of clams - recreational clamming. From this information, an overview of the importance of non-market values relative to the overall economic value of the Bay's soft-shell clam industry will be suggested, along with potential applications for these findings for the Casco Bay Estuary Project and municipal officials.

4.3 Definition of non-market values and methods for measuring them

4.31 Definition

Economists have long depended upon the market price of goods and services to name their worth. How can we value goods, services or *experiences* which have no price and cannot be bought or sold? These are non-market values, such as a beautiful view from a high point of land, or the experience of catching a fish in a clear stream, for which there is no routine way of

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[7] Colgan, Charles S., "The Economic Value of Casco Bay", by the Edmund Muskie Institute of Public Affairs, University of Southern Maine, prepared for the Maine Coastal Program, Maine State Planning Office, 1989, pp.28.

observing a market price. The difficulties with this question have not stopped economists from trying, however, and non-market valuation is a fast growing field of economics.

Why is this of such interest? During the latter part of this century, there has been a growing recognition that natural resources are the engines of many economic systems but in the past the non-market values of natural resources have been excluded from our economic decisions, for lack of a way to assess them. When public policy decisions must be made affecting natural resources, the thinking goes, the decisions could be much more effective if non-market values could be weighed along with the market values.

For example, the benefits of remediating a certain clam flat might be significantly greater if non-market benefits, such as recreational clamming for family use, were included in a cost benefit analysis. This could make the decision of whether to remediate easier for local officials. Non-market valuation could also show what it is worth to local residents to have the option to dig clams near home, or *option value*. Another type of non-market value is *existence value*. Though a certain resident may not dig clams regularly or even eat them, the fact that productive clam flats exist and some day that resident could take advantage of them, is of value to him or her. So the definition of non-market values includes things people use or consume as well as things they don't use or consume.

4.32 Methods

To assign a value to non-market activities, several types of methods have evolved. Two of these types are: direct methods, in which people are asked about their values in a survey; and indirect methods, in which people are not consulted, but their behavior is observed and interpreted.

Direct survey methods are commonly used by economists for "collectively consumed non-market goods", such as how people value their use of a park, or how much they value a recreational resource.[8] These are known as "contingent valuation" methods. People are surveyed about their *willingness to pay* for the right to use the park (or a clam flat), if they had to pay for it. The various amounts identified by each individual surveyed are summed to show how much the resource is valued collectively.

An alternate approach is to ask people how much they would need to be compensated if their right to use a resource is to be taken away. This approach seeks a sum total for *willingness to accept* the loss of a resource. This approach can result in a higher number than the willingness to pay approach, as personal budget constraints do not affect the respondent's estimates. A study of the economic value of recreational clamming was done in Massachusetts in 1978. Recreational clamming permit holders were asked about the highest amount they would be willing to pay to purchase next year's permit. A mean amount of $17.82 resulted. When asked how much they would have to be paid to surrender a permit they held for the following year, the mean was $278.

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[8] Knapp, Gunnar, Professor of Economics, "Measuring Non-Market Values", (Unpublished Lecture Notes) Institute for Social and Economic Research, School of Public Policy, University of Alaska, 1994.

Indirect methods observe how people spend their money to obtain a non-market outcome. For instance, the time and money they spend to travel to a park (or clam flat) is one way to measure the value they place on spending time there. This is known as the "travel cost method".

Methods must be chosen and implemented very carefully to produce meaningful results. Contingent valuation, as with surveys in general, has numerous pitfalls for biases. For instance, value fluctuates. We may be willing to pay more or less for clean water to swim in, depending upon our most recent experiences with swimming, and the current outdoor temperature outdoors.

Among economists, there is great debate about which methods are best and how they should be conducted. There is also debate about how useful the results are. Some economists question whether we really want to know a dollar figure for resource decisions which should rely upon some measure of gut feeling or political inputs anyway. And the limitations are plenty. Survey data is expensive to collect, so is this the best use of scarce funding available for studies? Also, the methods can't account for how future generations might value these resources, so the data don't reflect the future willingness to pay.[9]

Given the complexity of non-market valuation methods, and the limited funding offered for this project, no new valuation data was generated for the non-market values of clamming in Casco Bay. However, some non-market values were identified, and simplified calculations of one non-market use - recreational clamming - were developed. They are included in Sections 4.4 and 4.5 below. Meanwhile on the larger scale, it is significant that for several years now, the federal government has incorporated certain non-market valuation methods into measurement and decision making regarding damages to natural resources.

4.4 Catalogue of non-market values

4.41 Non-market values of clamming in Casco Bay: "consumptive" and "non-consumptive" values

As mentioned above, some non-market values are obtained by consuming goods or services. Other non-market values involve no consumption, just a passive appreciation of the goods or services, or of an opportunity. Clam wardens in four Casco Bay towns (Harpswell, Brunswick, Freeport and Cumberland) were asked to identify non-market values of clamming that they are familiar with from their time on the flats and talking with the public. Additional values were derived from recent studies of recreational and commercial clamming in Massachusetts.[10]

Consumptive values include the satisfaction of:

- digging clams for one's own use and/ or family use
- having a meal that was harvested for personal use, rather than purchased
- substantial savings from not having to pay for the meal
- eating clams fresh out of the mud
- clamming as part of the knowledge of how to subsist; "the ability to hunt, fish or trap to keep the family bellies full"

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[9] Knapp, Gunnar, personal communication, 2/2/95.

[10] See the studies listed in the References, "An Economic Valuation of Recreational Clamming in Massachusetts, and "The Costs of Pollution"(Cape Ann, Massachusetts).

Non-consumptive values include the satisfaction of:

- spending part of a day on the shore
- carrying on a family tradition of recreational digging passed on by grandparents and parents
- seeing commercial diggers take part in a centuries-old livelihood[11]
- taking part in a centuries old activity recognized by common law which protects the public's right to "fishing, fowling and navigating"
- combining clamming with other coastal recreational activities; picnicking, swimming, fishing, beach-combing, seaweed harvesting, boating
- the opportunity to teach children how to dig clams
- the *option value* or opportunity to dig clams, even if it is not acted upon
- the *existence value* of the clam resource, just knowing that it is there, free from pollution and open for digging.

Due to the individual nature of non-market values, many additional values might be identified if a large sample of people could be contacted.

4.42 Non-market values that should be evaluated in any future study

Without going through an exercise of valuing each of the uses and then comparing them, there is no way to assess which non-market activities are the most highly valued or widely appreciated. The most apparent non-market value, however, is the right to harvest clams with a recreational license in Casco Bay's coastal towns. The demand for these licenses has been rising in recent years and at least two towns have recently surveyed their license holders on questions of local interest, as is discussed in the next section. Further study of the importance Casco Bay residents as a whole place on this right or privilege is recommended.

A second important area of inquiry would be the value placed on maintaining and enhancing water quality in Casco Bay's near shore waters. Public interest in water quality monitoring, marine education and the Gulf of Maine ecosystem has grown enormously over the past ten years. Though many of the interested parties focus on questions broader than the clam harvest, it is likely that many perceive improvements to the clam resource as beneficial outcomes of their efforts. Public interest questionnaires have been circulated, but a more pointed inquiry as to the significance clamming plays in the larger interest would be valuable.

4.5 Estimated value of recreational clamming harvests in four towns

Recreational clamming in Casco Bay is known to be a substantial non-market use of the clam resource. Clams dug "recreationally" for personal use have a value to the digger even though they cannot be sold. This section calculates a hypothetical monetary value for the sum of

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[11] Negative non-market values should also be noted. Certain unpleasant activities are occasionally associated with commercial clam diggers, such as trespassing across private shore property, littering, and the like. Whether the negative image is justified or not is beyond the scope of this report. But the fact that not all aspects of clamming are perceived positively is noteworthy. One shorefront property owner said, "Intrinsic value? what about negative intrinsic value? I'd pay a lot of money to keep those guys from cursing the hours away out in front of my house."

all "avoided meal costs" recreational diggers in four towns would have had to pay if they had purchased their clams in restaurants rather than digging them. This is not a true estimate of non-market value, but an estimate of equivalent market value of the harvested resource.

4.51 Extent of recreational clamming in four Casco Bay towns: Harpswell, Brunswick, Freeport and Cumberland

Clam flats open for commercial digging in Casco Bay towns are open for recreational digging, to recreational license holders. Not all towns have flats open for digging as noted in Section 1 of this report. Four towns in eastern Casco Bay where recreational digging takes place were selected for this exercise: Harpswell, Brunswick, Freeport and Cumberland.

Each town with a shellfish program in place has established a shellfish ordinance which defines who may qualify for a recreational license. Qualifying individuals may purchase a license for a nominal fee. Fees vary by town, so the following fees are approximate: for residents they are approximately $15/year; resident seniors, free; non-residents; $20/year to $5/day. Recreational license holders are permitted to harvest not more than one peck (8 quarts or 1/4 bushel) per tide or per day, depending on the town.

Holders of a recreational license are not permitted to sell their harvest, but the clams harvested have a value to the digger which can be estimated as a dollar figure. One way to calculate this is to find the number of licenses issued (sold) and the average volumes harvested per license per year. Table 4-5a shows that a total of 1,020 recreational licenses were sold by the four towns in 1994.

Table 4-5a

Total Number of Recreational Licenses Sold in 1994 in Four Casco Bay Towns

Town	No. of Rec. Licenses Sold in 1994
Harpswell	450
Brunswick	163
Freeport	207
Cumberland	200
Total	**1,020**

To estimate the volumes which may have been harvested by these permit holders, the average number of pecks harvested per year per permit holder is needed. Original figures were not collected by this study, but the Town of Cumberland completed a survey in the fall of 1994 which provides applicable information. Cumberland results are used here to extrapolate a

volume for the four towns overall.[12] (A copy of the Cumberland survey and results are attached as Appendix IV).

Of the total number of licenses sold, 14% of license holders did not use their licenses in 1994, so 86% did use their licenses, so this needs to be factored in. Then the average number of times a license holder went digging times the average volume harvested each time meant that each license holder harvested six pecks over the course of the year.

Table 4-5b

Estimated Total Pecks Harvested in 1994

Town	Rec. Licenses Sold X(.86)	Total Pecks Harvested
Harpswell	387	2,322
Brunswick	140	840
Freeport	178	1,068
Cumberland	172	1,032
Total Pecks Harvested in 1994		**5,262**

So for the four towns total, approximately 5,262 pecks or **1,316 bushels** were harvested in 1994. These numbers assume the following: the Cumberland results are applicable to recreational harvest in the other three towns; survey respondents were truthful in their responses regarding use or non-use of their licenses, frequency of use and volume of harvest.

None of the four towns have a system for tracking recreational license use or volumes of harvest. The lack of tracking systems has resulted in an absence of information, but clearly the towns are interested in obtaining more information. Brunswick recently completed a survey of recreational license holders' activities, for which results will be tabulated shortly.[13]

4.52 Hypothetical monetary value of recreational clam harvest

One simplified way to estimate a hypothetical monetary value for recreationally harvested clams is to multiply the total volume of harvest by a price that *would have been paid* by the families that harvested the clams, had they bought clam dinners at a restaurant. The price for a 1.5 lb plate of steamed clams is roughly $8.00, (based on results from the survey of restaurants completed for Task 2). If all the recreationally harvested clams were equated to 1.5 lb plates of

[12] Per Chris Heinig, it is reasonable to assume that Cumberland results are close to the numbers that would be found if the other three towns were surveyed with similar questions (pers. comm., 1/26/95).

[13] Alan Houston, Brunswick Shellfish Warden, pers. comm., 2/3/95.

steamers, priced at $8.00 each, the 5,262 pecks would be worth **$449,024. per year.** (5,262 pecks X 16 lbs/ peck = 84,192 lbs ÷ 1.5 lbs = 56,128 plates @ $8.00/plate = $449,024.)

Several assumptions were used here: all clams were dug for personal/ family use and not sold; personal use clams would be most readily equated to steamed clams at a restaurant (as opposed to some other preparation like fried clams, which are priced at approximately $14.00/ plate); recreational diggers would go out to eat clams at a restaurant (in reality some recreational diggers would have no willingness to pay $8.00 for a plate of steamers!); and if 5,262 pecks of clams were delivered to restaurants (in order to be sold as plates of steamers) there would be no losses due to breakage or spoilage, all clams would be turned into $8.00 plates of steamers.

These numbers approximate the "avoided meal cost" of the four towns' recreational harvest in 1994. The numbers do not include the costs associated with recreational digging. They also do not reflect the "non-consumptive" non-market values such as the diggers' appreciation of their right to harvest recreationally. If those values were determined, they could be added to this harvest value for a more complete picture of consumptive and non-consumptive non-market values of recreational clamming.

Note: To estimate the market value of recreationally harvested clams in the four towns in 1994, the total bushels would be multiplied by the market price paid to commercial diggers, resulting in $96,000 (1,316 bu X $72.95/ bu = $96,000.) This is not the subject of this section, however.

4.53 Problems with recreational clamming

One measure of the increased interest in the non-market aspect of clamming might be seen in the total number of recreational licenses sold by the four towns over the past four years. Table 4-5c shows general increases, and in 1994 for the first time, Harpswell and Cumberland each sold out their total available recreational licenses.

The simple increase in demand for licenses does not reveal whether the interest is due more to market or non-market values, however. The town shellfish wardens surveyed indicate that market forces are playing a role. The rise in the market price paid for a bushel of clams, particularly in 1994, has put pressure on the existing limited entry system of commercial licenses. Wardens discovered that some diggers who wanted a commercial license but did not receive one bought recreational licenses in order to dig, but proceeded to dig and sell clams as if they were commercially licensed.

Table 4-5c
Recreational Clamming Licenses Issued / Available
in
Four Casco Bay-area Towns, 1991-1994

TOWN	1991 issued/ avail.	1992 issued/ avail.	1993 issued/ avail.	1994 issued/ avail.
HARPSWELL*	431 / 450	424 / 450	426 / 450	450 / 450
BRUNSWICK	100 / 100	176 / unlim.	146 / unlim.	163 / unlim.
FREEPORT	136 / 136	n/a / 250	184 / 250	207 / 250
CUMBERLAND	n/a / 200	n/a / 200	200 / 200	200 / 200

*NOTE: licenses issued by the Town of Harpswell to Senior Citizens (over 64 years of age) were not counted in the limit of 450 licenses available for sale. These Senior Citizen licenses typically number over 100 per year.

It may also be true that individuals populating Maine's wealthier coastal areas are having increasing amounts of leisure time and therefore the demand for recreational activities in general is rising.

Whatever the reason, the demand for recreational licenses has recently exceeded the supply in two of the four towns considered here. (A third town, Brunswick, offers an unlimited number of recreational licenses each year). The willingness to pay the price of a recreational license is only a partial representation of its value to the holder. This may indicate an opportunity to raise recreational fees. Given the estimated annual volume of clams a Cumberland recreational digger harvested in 1994 (six pecks or 1.5 bushels), the price a commercial digger would charge for that volume of clams is $109.43, (1.5 bu X $72.95/bu = $109.43). An average recreational digger might harvest clams valued at seven to ten times the annual recreational licenses fee he pays for the privilege to harvest them (an annual volume priced at $109.43/ annual fee of $15 = ~7).

Some additional notes on potential non-market values of the recreational harvest privilege follow. In the recreational clamming surveys conducted recently by the Towns of Brunswick and Cumberland, there were two indications of the potential non-market value interests. First, both had very high rates of response, 38% and 52%, respectively. Second, 25% of Cumberland's recreational license holders said they would like to volunteer for shellfish management. This may indicate a high level of sincere interest. However, the question as posed may have also confused some respondents, as is noted on the survey results (see Appendix IV).

A separate story from Brunswick relates to the values perceived by realtors and potential shore property buyers regarding marine resources, notably clamming. A group of 15 realtors invited Brunswick warden Alan Houston to address a meeting with the topic of recreational uses of Brunswick's marine fisheries. The realtors wanted to be able to present current information to their buyers about fishing, clamming, and boating along Brunswick's coast and on the Androscoggin River. It would be very difficult to segregate these values from other items property buyers pay for, however, there is clear interest in these non-market values and some buyers are willing to spend more to obtain them.

4.6 Conclusions

4.61 Importance of non-market values relative to total economic value of soft-shell clam resources in Casco Bay

This study did not attempt to assign a total dollar value to the non-market values of Casco Bay's soft-shell clam resource. Without this figure it is difficult to compare these values to the total economic value estimated in Task 2. But there are many non-market values asociated with the clam resource and clamming industry in the Bay and they are essential to the full valuation of the clam resource, as well as for making decisions on funding of remediation, enhancement, enforcement or other management efforts.

Admittedly, non-market values are difficult to measure. Because they cannot be easily observed in any regular transactions, they must be researched deliberately and are therefore expensive and complex to assess. Assessment was beyond the resources of this study, and would probably cost more than municipal shellfish programs can afford, particularly since their present financial resources are already stretched thin.

However, it is important to devise and apply less expensive measures of approximating non-market value where possible. While we may never measure the value of seeing a digger haul in his harvest on a rising tide, we can estimate the savings or avoided meal costs from a recreationally harvested dinner. This study found that if all of the clams harvested recreationally in the four towns were equated to 1.5 lb plates of steamers, priced at $8.00 each, the 5,262 pecks would be worth **$449,024. per year,** a significant sum for four towns.

4.62 Potential applications of these findings for the Casco Bay Estuary Project and municipal officials

The demand for recreational licenses has recently exceeded the supply in two of the four towns considered here. This may indicate an opportunity to raise recreational license fees. While a large price increase would exclude some users from this recreational privilege and is not recommended, a modest price increase may be perceived as acceptable, to help pay for the increasing management and enforcement tasks with which towns and their wardens are burdened.

Currently, tracking of recreational license use and harvest is not systematic. A simple annual survey or other affordable instrument is recommended so towns can get a better grasp of the importance of recreational digging to their licensees.

There are several potential applications of findings regarding non-market values of soft-shell clamming for the Casco Bay Estuary Project and municipal officials. When there are opportunities to present economic data or to value a resource, it is helpful to mention known non-market values or the fact that they exist.

Education about the indications of non-market values would also help to advance the general concept of non-market values. Evidence of non-market values can crop up in many arenas, such as: realtors' interest in promoting recreational clamming and fishing to potential buyers; or results from surveys on how people value water quality or a renewable source of food and income.

Similarly, an inquiry into the significance of clamming as a discreet part of the larger interest in water quality, marine education, and the health of the Gulf of Maine, would be useful.

4.7 References

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5.0 Resource management and economic assessment observations and recommendations

by Christopher S. Heinig and Peter J. Moore

5.1 Introduction

In the course of carrying out this project, numerous observations were made which are important to the overall subject under investigation. These observations have led to conclusions and recommendations which, although relevant to the overall understanding of the *management* of the soft-shell resources of Casco Bay, are not considered by CBEP to be directly related to any specific task. These observations, conclusions, and recommendations are presented below, separated according to their relevance to resource management and economic assessment.

5.2 Resource Management

5.21 Clam Habitat Observations

The "Falmouth Flats" area between Mackworth Island and The Brothers Islands, on the north side of the causeway leading to Mackworth Island was selected for this study on the basis of historical reports of high productivity and recent depuration digging in the area. During the course of the survey a large expanse of buried relic shell was found across the mouth of the flat, evidence of the flats productive history. Surprisingly, however, today most of the flat is totally unproductive with only a remnant population of large clams in the northwest corner and small, sporadic concentrations of juveniles dispersed across the flat and along the northern shore of Mackworth Island (Figure 5-1 and Appendix Id.). The substrate varies from firm sandy mud along the shore to soft mud towards the center and adjacent to the causeway. Mussels form a large horse-shoe shaped bar across the seaward boundary of the flats, but small clumps of "pioneer" mussels form an intrusion zone approximately 100-150 feet wide on the shoreward side of the bar. Within this intrusion zone and in the areas not populated by clams the predominant fauna are maldanid worms, probably *Clymenella torquata*. A seagrass bed, *Zostera marina*, is found just below the mussel bed from the low water mark to well below the extreme low water mark.

The Town Landing area of Broad Cove in Cumberland is similar to, although considerably smaller than, the Mackworth-Brothers Islands area. This section of Broad Cove faces the east. The sediments within the cove are typically soft mud, but a large expanse of relic shell, sometimes as shallow as only a few inches beneath the mud surface, is found at the mouth of the cove at the seaward boundary. A sandy "spit" projects northward at the southern end of the cove, the eastern shore of which consists of coarse to medium sand. As at the Mackworth flats, a complex series of mussel bars stretches across the mouth of the cove and extends several hundred feet into the center of Broad Cove proper. A large area of pioneer mussel intrusion extends shoreward from the bars. As seen before at Mackworth Island, the sediments are soft within the "intrusion zone" and the fauna is dominated by maldanid worms. Very few clams are found in the immediate vicinity of the mussel bars and intrusion zone, but numerous clams, particularly juveniles, are concentrated in the area just behind the spit and along the upper intertidal area of the sandy spit shore (see Figure 5-2 and Appendix Id.).

In the closed eastern section of Broad Cove in Yarmouth sediments are typically soft silt over clay with occasional areas of marsh material which has broken away from the shore. Here, too, mussel bars cover the area immediately seaward of the flat. The total clam population across the flat is very limited, just under half of which is harvestable. As a result of this low population density and the relatively small area actually populated, this area had the lowest production of all the areas studied (see Figure 5-3 and Appendix Id.).

Figure 5-1 "Falmouth Flats" between Mackworth Island and the Brothers Island, Falmouth

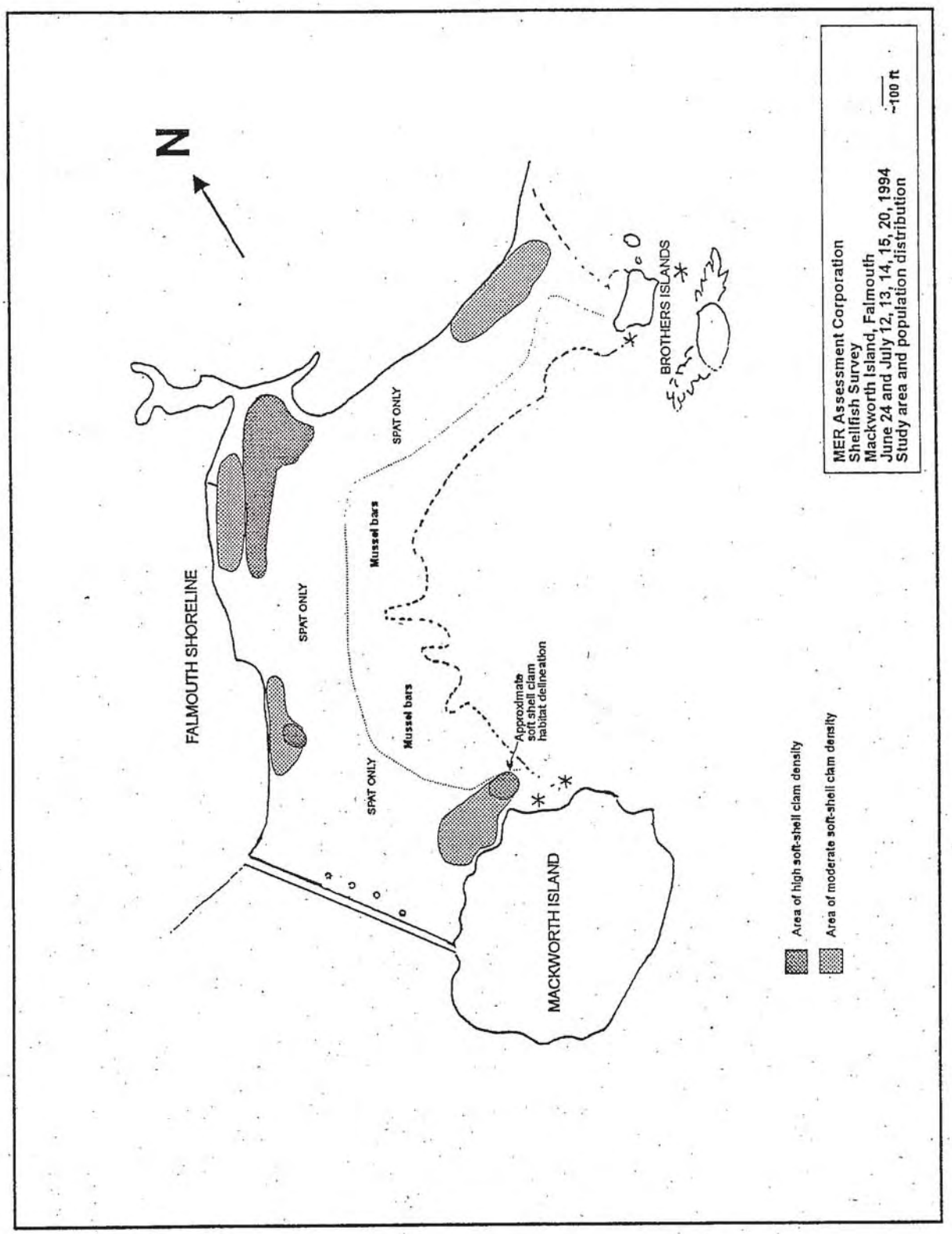


Figure 5-2 Town Landing area, Broad Cove, Cumberland, Maine

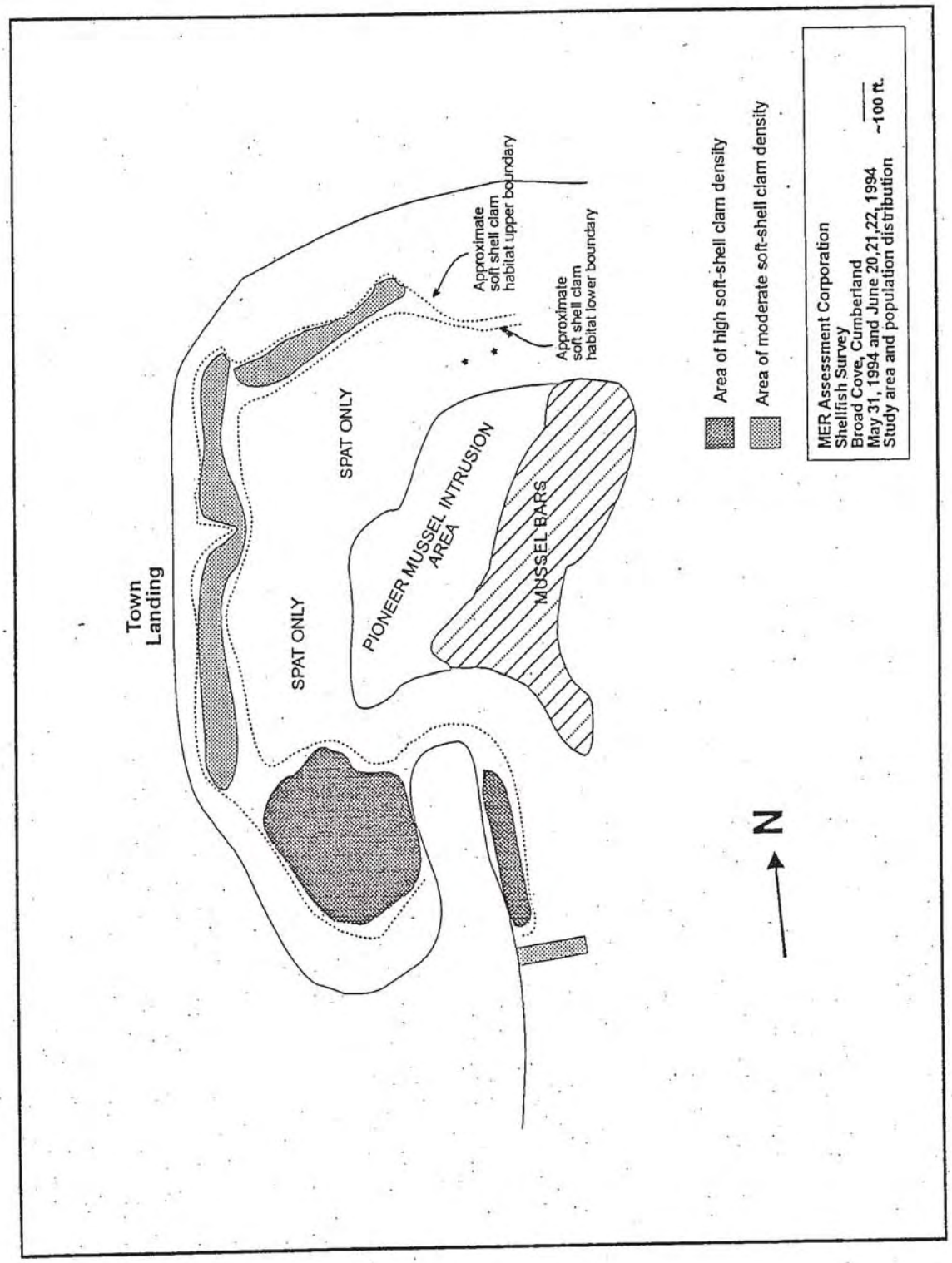


Figure 5-3 Broad Cove - Eastern Shore, Yarmouth, Maine

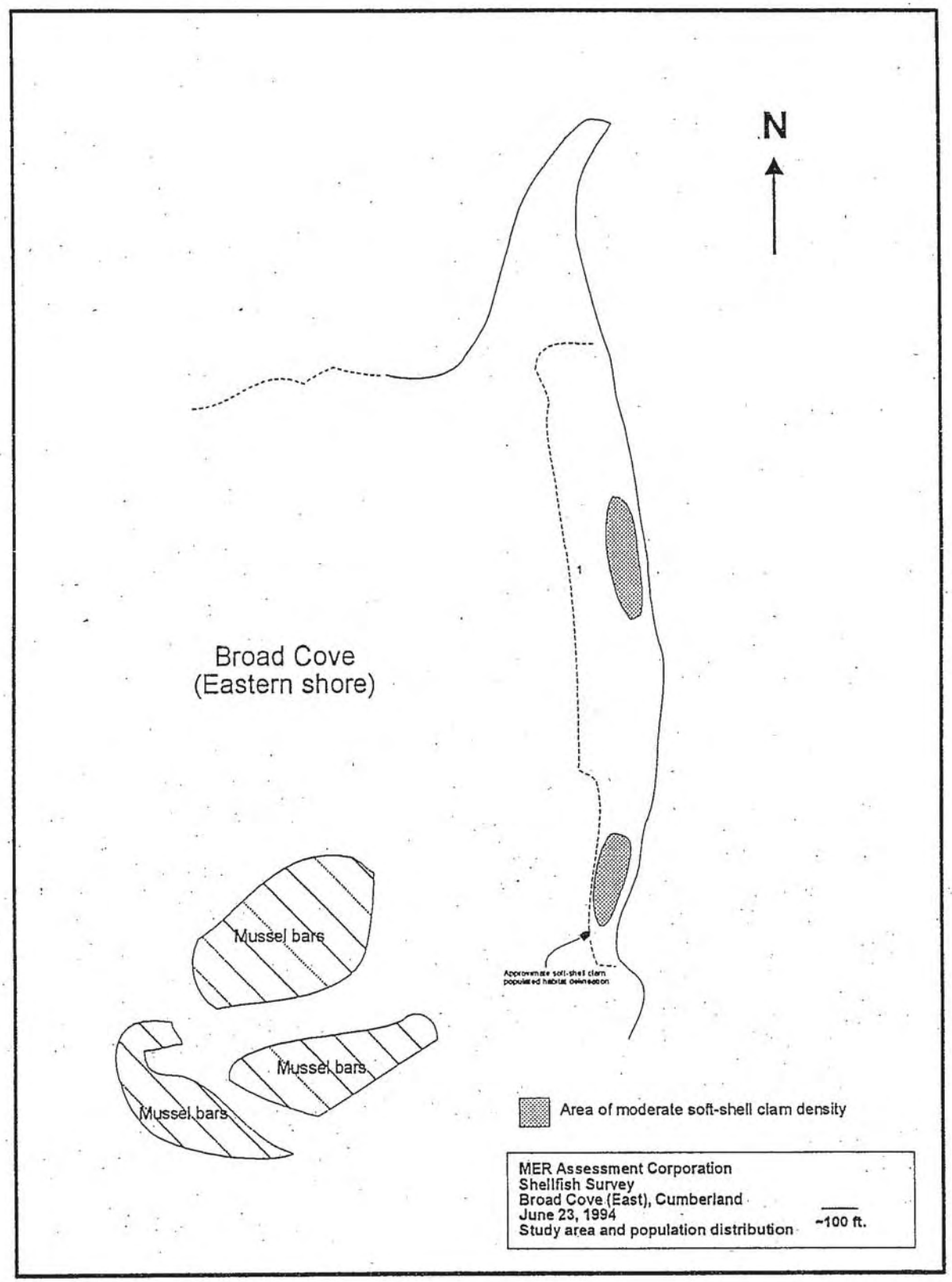


Figure 5-4 White Cove, Yarmouth, Maine

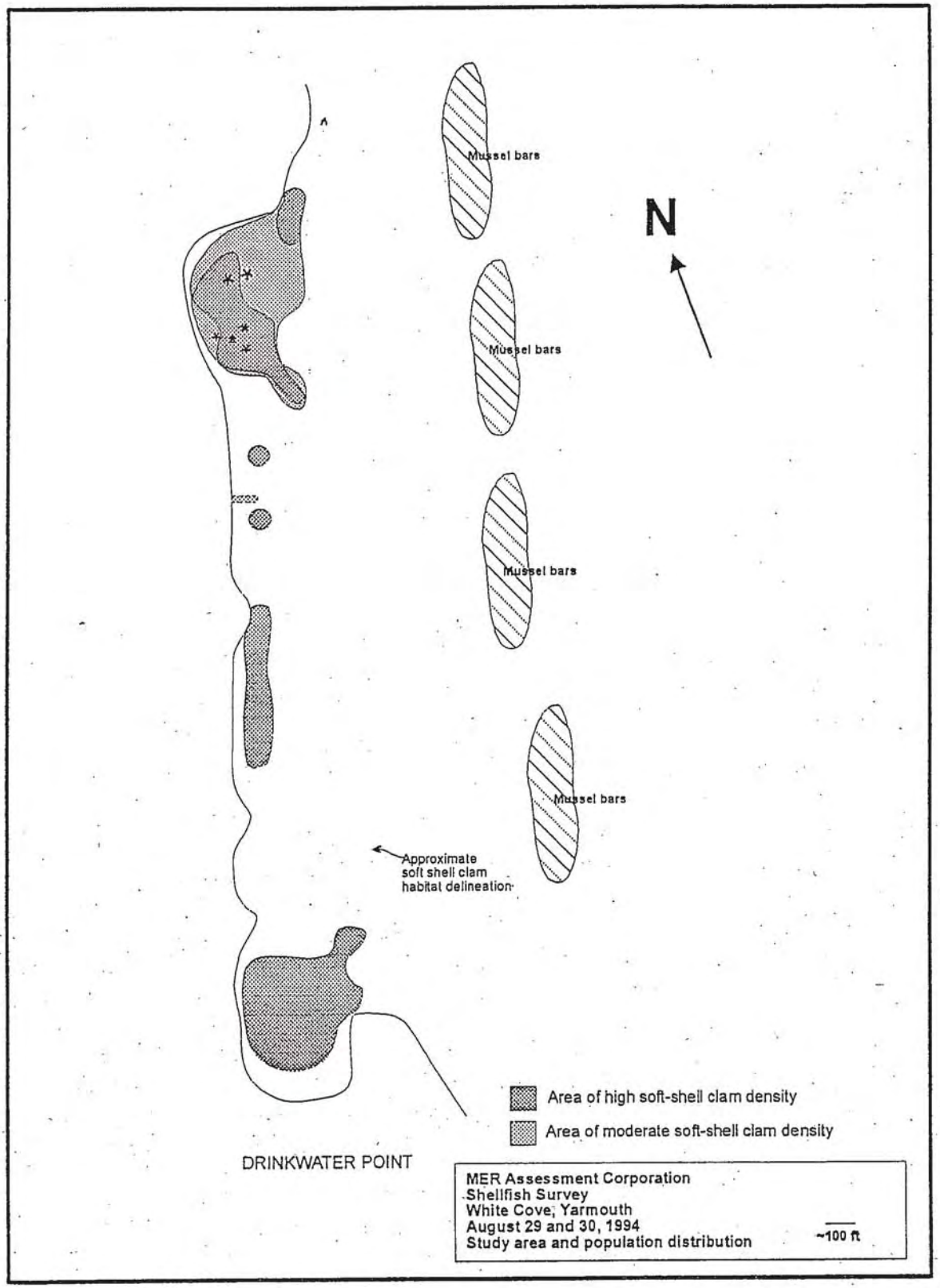


Figure 5-5 Area North of Division Point, Chebeague Island, Cumberland

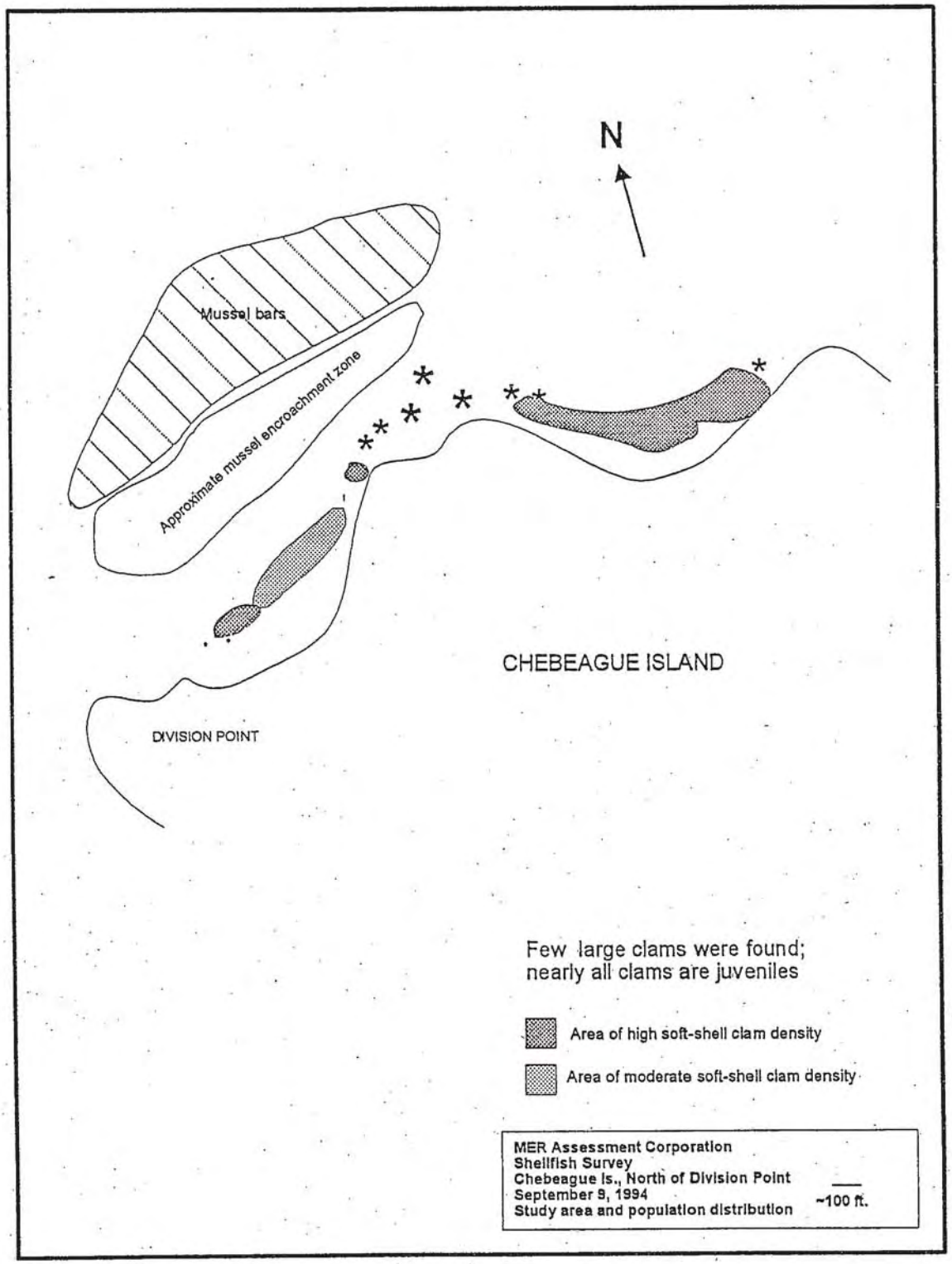
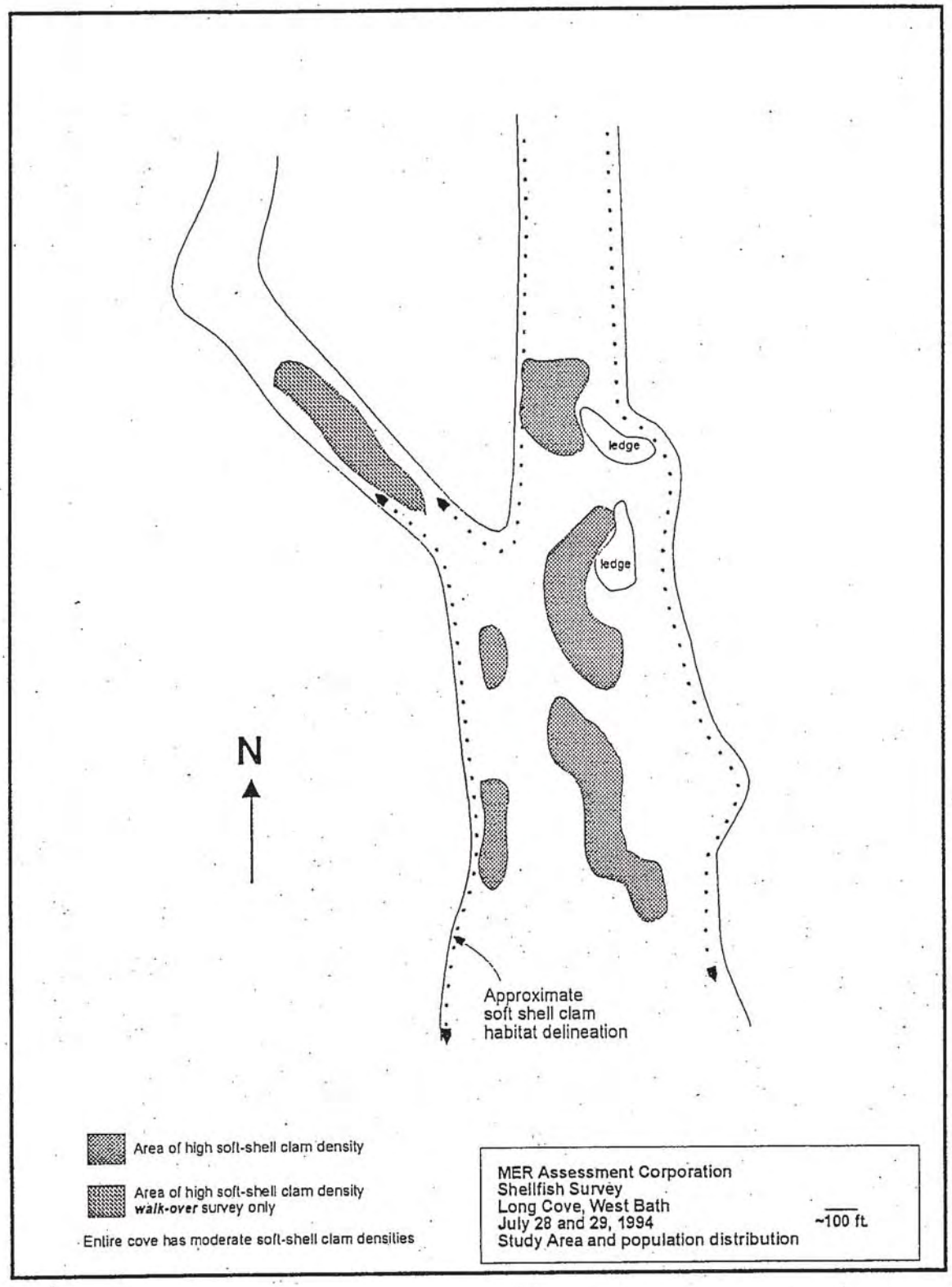


Figure 5-6 Long Cove, West Bath, Maine



White Cove, along the Yarmouth shore and just north of the Cousins Island bridge, also faces east and has a northward projecting point which shelters the southern end of the cove. Similar to the previous three study sites, a complex system of mussel bars is found just east of the flat and extends all the way up along the shore to Parker Point at the mouth of the Royal River (see Figure 5-4). The sediments consist primarily of soft silt and clay, but become sandier in the sheltered southern section. The clam population is concentrated along a narrow band in the upper intertidal area, in the sheltered area at the southern end, and around the rocks at the northern end (see Appendix Id.). As at the other three sites, sediment shoreward of the mussel bars is very fine and no clams were found in the encroachment area. The predominant species is again a maldanid worm, probably *Clymenella torquata*.

The area north of Division Point on Chebeague Island opens broadly to the north-northwest and is divided by a point of land and a rocky sand bar which extends into the intertidal area (see Figure 5-5). West of the point sediments are principally sand while to the east they are a silt and sand mixture. Once again, mussels form large bars on the seaward side of the flat, restricting the clam population to a narrow band near the shoreline. The clam population density is very low with the vast majority of the population composed of juveniles (see Appendix Id.).

In sharp contrast to the previous study areas, Long Cove, as mentioned earlier, has an entirely different configuration and orientation. The cove is long and narrow with an equally narrow mouth (see Figure 5-6). The steep cliff on the western shore and the heavily wooded eastern shore offer considerable wind protection making this an unusually protected area. As a sheltered, "head-of-bay" cove, the sediments are predictably soft throughout with a sandy silt layer over clay. No mussel beds were found at the mouth of the cove, and again in contrast to the other three sites, a very significant clam population covers most of the cove, but is particularly dense in the middle of the lower half of the flat and along the western shore (see Appendix Id.). This has been a historically highly productive area . However, as at the other four sites, the number of maldanid worms increases significantly as the clam density decreases towards the seaward end of the flat.

5.22 Significance of clamflat location and orientation

Little is actually known about the distribution of soft-shell clam larvae in the waters of Casco Bay during spawning season. Further, although it may be presumed by the general public that the larvae which settle in Casco Bay originate within the Bay, the 2-3 week planktonic larval period (Dow and Wallace, 1961) may, in truth, allow larvae from distant origins to settle on Casco Bay flats.

Regardless of their origin, the distribution of larvae around the Bay appears to be far from uniform. *Previous studies* (Gustafson, 1977) *and shellfish surveys conducted in the Bay over the past twenty years seem to indicate that shellfish recruitment, (settlement of late stage pediveligers, or "footed" larvae), of both soft-shell and hard shell clams is most successful in the north-northeastern sections of the "finger" bays of Casco Bay . This is particularly true on "head-of-bay" flats and southerly facing coves* such as Maquoit Bay, Upper Middle Bay at Crow Island, and Thomas Point Beach in Brunswick, and Rich Cove, Brickyard Cove, and Orr's Cove in Harpswell (Harpswell and Brunswick shellfish surveys). To our knowledge, the exact reasons for the tendency towards elevated settlement in these areas has never been specifically investigated, but there are at least two plausible explanations for this phenomenon.

The tidally-driven circulation of Casco Bay is very complex, especially in the upper regions of the Bay around the islands and in the vicinity of straits and narrows (Parker, 1982; Pettigrew, in press). *Tidal circulation probably accounts for most of the water movement in the Bay, but wind-driven circulation may also play a role in the movement of surface water* (Heinig and Campbell, 1992) as suggested by the distribution of floating debris and seaweed, particularly after storms.

The predominant wind direction in Casco Bay during the summer is out of the south-southwest, thus the predominant area for deposition of surface-carried material is in the north-northeast. Indeed, during the summer months seaweed and eelgrass are often found "windrowed" at the heads of southwest facing coves. To the best of our knowledge, no work has been done in Casco Bay concerning the vertical distribution of soft-shell clam larvae in the water column. Nevertheless, as phytoplankton feeders, they are believed to concentrate in the surface layer of the water column and are consequently subject to transport by surface water circulation. In Maine, settlement occurs predominantly from June through September (Dow and Wallace, 1961), the period during which the prevailing wind direction is from the southwest. *Given that larvae are likely to be concentrated in the surface water and the predominant winds would tend to move this water towards the north-northeast, it seems reasonable to suggest that, like other materials carried by surface waters, pre-settlement larvae can also be concentrated in the north-northeast sections of the Bay.*

In addition to being the repositories of surface-carried materials, *the southerly orientation of the upper Bay coves exposes them to prolonged periods of insolation compared to north-facing coves, especially during the summer months. Consequently, south-facing flats often have significantly elevated water temperatures on the flood tide as a result of the water moving over the solarly-warmed mud, particularly on those days when low tide occurs around noon exposing the flats to the sun for a maximum period of time.* Thermal shock to encourage concentrated settlement of bivalve larvae has been effectively used in hatcheries (Castagna and Manzi, 1989). Little information appears to be available on the role thermal shock may play in the wild, however, if the effects observed in the laboratory apply in natural situations, the sudden warming of water flowing over heated flats may serve as an encouragement to setting.

These suggested mechanism are speculative and are clearly not required for successful settlement, for clams are found on almost all flats regardless of their orientation. For example, recent surveys in Long Cove on Orrs Island (Heinig, 1992) and Doughty Cove in Harpswell (Heinig and Newberg, 1993), both of which are oriented toward the northeast, were found to support large, healthy populations of significant economic value (refer to Table 1-3). (It should be noted, however, that due to their locations, both coves could benefit indirectly from a general northeasterly concentration of larvae). Nevertheless, *if these mechanisms do play a role in larval distribution and settlement, they may help explain the consistently high recruitment characteristic of south-facing flats compared to east- and north-facing coves in the southwest section of Casco Bay.*

5.23 Affects of mussel bars

The differences in location and orientation aside, the presence of mussel bars at the seaward boundary is a characteristic shared by four of the areas in the western section of the Bay which was notably missing in Long Cove, West Bath. *The potential effects of mussels on*

clams have been a source of concern for clam resource managers for some time (Dow and Wallace, 1961).

Mussels can affect clam habitat in three ways: 1) depletion of phytoplankton through filtration, 2) entrainment of clam larvae during filter feeding, and 3) competition for space through encroachment into clam habitat with the associated deposition of pseudofeces, (a very fine particulate mixture of organic and inorganic materials), in the prevailing current direction.

Studies on the effects of mussel filtration and feeding on ambient phytoplankton concentrations (Newell, et al., 1989; Muschenheim and Newell, 1992; Newell and Shumway, 1993) have shown that significant lowering of phytoplankton concentrations is restricted to the immediate vicinity of the mussel beds. Little information appears to be available on the entrainment of clam larvae by mussels, but despite the mussels' capacity to filter large amounts of water, the overall significance of entrainment may be relatively small.

Indeed, the presence of a clam population, albeit small, within the western study areas indicates that at least some larvae are not only successfully setting but, under the right conditions, persist to reach market size. However, a comparison of Appendix Id. Figures of Broad Cove shows that all of the clams found in the area adjacent to the mussel encroachment zone were spat (recent recruits). A similar situation exists in the Mackworth Island flats (refer to Appendix Id. Figures for Mackworth Island). This suggests that, even though settlement is occurring in this area, the clams are unable to persist beyond the spat stage. The reasons for the lack of persistence within these mussel encroachment zones is not immediately clear, but the deposition of fine sediments originating from the mussel bars as pseudofeces and the suffocating affect this can have on young clams is probably a major contributing factor.

The suggestion of a negative relationship between mussel bars and clam habitat is not new. In the late 1940s and early 1950s the Maine Department of Sea and Shore Fisheries, the predecessor to the Maine Department of Marine Resources, had identified the encroachment of mussels onto clam flats as a major concern and experimented with a number of measures to eradicate the mussels (Dow and Wallace, 1951). These included hand racking, the application of a mixture of gasoline and crankcase oil, the use of commercial flame guns, and removal using mechanical drags, among others. Of these, the only successful control measure was the removal of the mussels using commercial fishing drags.

Although this study focuses on soft-shell clams, the economic value of mussels, Mytilus edulis, in closed areas should not be overlooked. Given the value of mussels and the fact that commercial harvesting has proven the most effective method of removal, perhaps the most effective way to control mussel encroachment is simply to harvest the mussels for consumption. In closed areas, however, harvesting for human consumption is obviously precluded. Even if permission could be obtained for the removal of the mussels, disposal becomes a problem since the "contaminated" mussels cannot be relocated or dumped in an open area. Further, if the mussels can not be sold, removal becomes costly since no revenue can be generated from their sale. *Thus not only do closures preclude the harvesting of soft-shell clams and mussels, prolonged closures may indirectly degrade or reduce the clam habitat by preventing or complicating removal or control of the mussels.*

5.24 A perspective on the future

As stated in the Introduction, *the soft-shell clam harvest in Casco Bay has been steadily increasing over the past several years.* The NMFS landings statistics shown in Table 1-6 confirm this and show that landings of soft-shell clams from Cumberland County more than doubled between 1991 and 1993. During the same period the maximum price paid per bushel has increased from $62 in December of 1991 to $80 in August of 1993. It is reported that, at times during the summer of 1994 , the price paid per bushed reached as high as $130 (see Task 2). *These historically high prices being paid for clams, along with an abundant resource, has increased the demand for entry into the industry and put tremendous pressure on the resource.*

Based on the estimated harvestable production and the more liberal effort assumption discussed in Section 1.41, the soft-shell clam resource in Casco Bay in 1994 could support approximately 200 harvesters. The 1985-94 data indicates that, on *average* for this period, the resource could support between 183 and 196 commercial shellfish harvesters. Table 5-1 below summarizes the number of commercial clam harvesting licenses sold in each municipality around Casco Bay in 1994.

Table 5-1
1994 Commercial Clam Licenses Sold in Casco Bay

Town	No. Commercial
Cape Elizabeth	0
So. Portland	0
Portland	0
Falmouth	0
Cumberland	0
Yarmouth	0
Freeport	62
Brunswick	99
Harpswell	67
West Bath	13
Phippsburg	27
Total	**268**

Phippsburg and West Bath harvesters work under a reciprocal agreement which allows harvesters from one town to harvest in the other, but they are not allowed to harvest elsewhere in the Bay (unless they purchase a non-resident license). Since nearly all of the Phippsburg shore on Casco Bay is closed, the 27 licensed harvesters in Phippsburg work principally in open areas along the Kennebec River or in open areas of West Bath. West Bath's 13 licensed harvesters work in the open areas of West Bath and/or Phippsburg. The open, harvestable area in West Bath is relatively small compared to the total harvestable area in Casco Bay, therefore, in practice the combined 40 licenses issued by West Bath and Phippsburg have a negligible affect on the Bay's clam resource. *Yet even if these licenses are deducted from the total sold in 1994, the number of licenses being issued by the remaining towns still exceeds the capacity of the resource to support the current effort.*

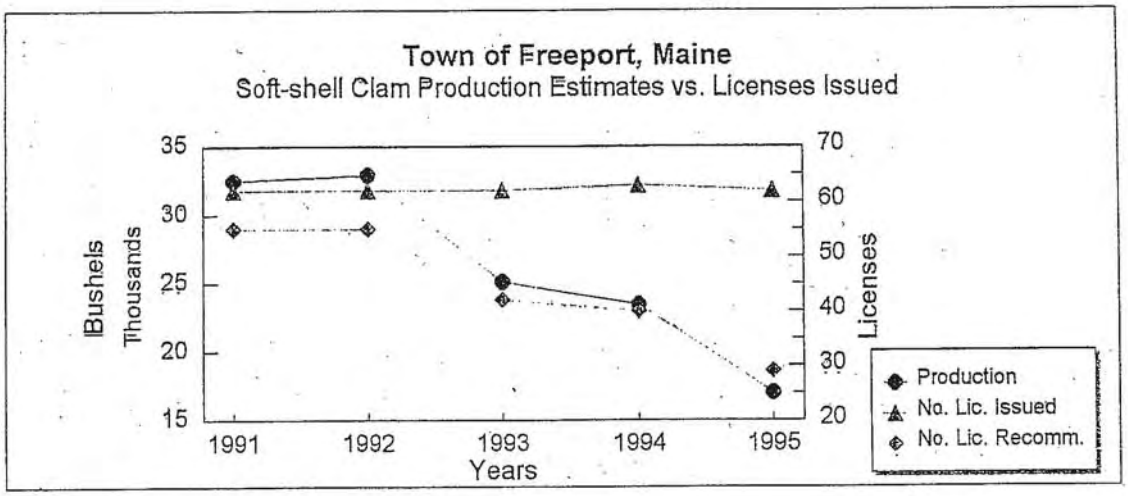
A further complication is the fact that the estimated effort of 1.56 bushels per tide may apply under normal market conditions, but as the price increases, as it has over the past two years, the incentive to work harder may drive the unit catch per tide considerably higher, thus increasing the overall pressure on the resource. Working in a "capture" fishery, harvesters of soft-shell clams are very reluctant to discuss their catch, much less where they harvest. Consequently, *it is very difficult to establish catch per unit effort.*

Similarly, the number of tides harvested assumes a professional harvester works an average of four days per week, year-round. Yet in many cases the holders of commercial harvesting licenses harvest clams only during the peak summer season when the price is high (see Table 1-6). Most "part-timers" have other work for the remainder of the year, often in other fisheries, i.e. lobstering, urchin harvesting, etc.

All of these factors confound the efforts to quantify individual effort and the actual harvest. As a result, municipalities find it increasingly difficult to respond to resource estimates, even if the long term trend is clearly downward.

A case in point is the situation in the Town of Freeport. Since 1990 clam production has been on a consistently downward trend as shown in Figure 5-7.

Figure 5-7 Soft-shell Clam Production vs. Licenses Issued, Freeport, Maine 1991-1995



Each year since 1991 the survey results have indicated the need to reduce effort, but the Town has been under increasing pressure to increase the number of shellfish harvesting licenses it issues. Fortunately, the Town has been able to stabilize the number of licenses issued, but the number may still be too high

Freeport is hardly alone. During 1993 and 1994 the local press was filled with articles concerning the plight of the shellfish harvesters and the difficulties the municipalities were having dealing with the increased demand for licenses. *To further complicate the situation, the DMR*

has been forced to closed several important shellfish areas as a result of contamination or non-compliance with the National Shellfish Sanitation Program (NSSP) requirements. In short then, more and more people wish to harvest an over-harvested resource in a shrinking harvestable area. There are but two solutions: 1) reduction of effort and/or 2) expansion of the resource through resource enhancement efforts and recovery of previously productive areas now closed due to pollution.

Confronted with the need for effort reduction, the municipalities are hardly in an enviable position. On the one hand they are responsible for managing the resources within their jurisdiction while on the other respecting a person's right to make a living. The reluctance on the part of municipalities to reduce the number of licenses issued is therefore understandable. By "cutting" licenses a municipality effectively withdraws a harvester's right to earn a living. Unfortunately, by refusing to reduce licenses it risks serious depletion of the resource, perhaps even to the point where it is no longer feasible to earn a living harvesting clams, thus depriving a person his or her livelihood, which was the reason for the reluctance to cut licenses in the first place.

The situation is further aggravated in municipalities where conservation programs have been adopted which require presently licensed, as well as would-be, harvesters to spend 12 hours of "conservation" time to insure renewal of his or her license. *Once a harvester has a license, that license is guaranteed renewable as long as the required 12 hour conservation time requirement is met, regardless of whether the resource can support the license.* In other words, licenses issued during the "good times" are guaranteed, or "grandfathered", even during the "bad times".

One proposed solution is to base licensing on a "first come, first served" basis. Unfortunately, as was shown in Brunswick in the Spring of 1994, this actually becomes the basis for "licensing of the fittest" as the toughest and the fastest make a dash for the opening door on the day of issuance, leaving the older and slower behind. Another proposed solution is a lottery where chance is allowed to decide who will be licensed. But this, too, is unacceptable to the professional digger who, after years of performing his work, finds himself crossing his fingers, and agonizing over whether he will be able to work the following year.

For the short-term, there are no easy answers and the situation could worsen. As fishermen displaced from other fisheries, i.e. off-shore groundfish boat deckhands, or others become unemployed, i.e. resulting from the down-sizing of Bath Iron Works or the Brunswick Naval Air Station in response to national defense cut-backs, many may look to clamming for alternative employment, increasing the pressure on the resource even further. *Unfortunately, the only ways to achieve effort reduction is by cutting licenses or imposing harvesting limits.* Although the latter would be theoretically effective, in practice, the enforcement requirements to effectively impose the limits do not exist. In the long-term, attrition will eventually reduce the number of available licenses as long as unclaimed or returned licenses are not reissued. *Ironically, the short-term depletion of the resource may serve to accelerate the rate of attrition as more and more harvesters find they can no longer earn their living harvesting clams and voluntarily leave the fishery.*

The second option to improving the situation is to increase the resource. This can be accomplished by increasing the harvestable area and/or increasing the resource within the existing area.

Recently, there have been several successful efforts at opening areas previously closed to commercial clam harvesting. Some of these areas were closed simply due to non-compliance with the requirements of the NSSP and additional water sampling or completion of shoreline surveys were sufficient to reopen the areas. Others had obvious violations to the Maine State Plumbing Code, the identification and correction of which removed the contamination threat and allowed the areas to be reopened. The program to assist with the removal of overboard discharges is beginning to result in the opening of new areas. The citizens' volunteer monitoring programs which have been started in several municipalities under the Shorestewards Program and the Friends of Casco Bay are generating information as well as increasing general awareness of water quality and the impact water quality has on the ecology and economy of the Bay.

As mentioned above, several closed areas suffer from encroachment by mussels. Once these areas are reopened to commercial harvesting, efforts should be directed towards reclaiming the area encroached upon by the mussels. Since closed areas preclude the harvesting of both clams and mussels, the clam and mussel harvesters may wish to investigate the possibilities of joint reclamation efforts which could be mutually rewarding. Once the mussels have been removed, however, reseeding may be required in order to achieve rapid production.

Reseeding, when properly carried out, can have dramatic positive results and has been used as a resource enhancement measure for many years. Several such efforts are currently underway around the Bay, primarily in Phippsburg and in Harpswell. However, due to the disproportionate distribution of "seed" clams around the Bay, transfer "seed" for reseeding must be harvested from areas of concentration for planting, or "broadcasting" in the receiving area. This operation inherently requires an agreement between the providing and receiving municipalities.

Indeed, all of these options require some form of coordination and cooperation to be fully effective. Although individual municipalities have succeeded in reopening certain areas to shellfish harvesting and have engaged in limited reseeding efforts, the task of reclaiming the larger closed areas, particularly in the western part of the Bay, will require cooperation and coordination never before seen in the shellfish harvesting industry of Casco Bay and an effort that transcends municipal boundaries. It may therefore be time to consider management on a larger scale ...a Casco Bay-wide scale where shellfish harvesters may someday be issued a shellfish harvesting license valid throughout Casco Bay instead of only within a single town.

The concept of a regional shellfish management program is not new. From the late 1940s through the 1950s a Casco Bay regional shellfish management council was established to coordinate efforts to enhance and manage the quahog, or hard clam, *Mercenaria mercenaria*, fishery of the period. Among other accomplishments, the council was instrumental in coordinating the transplanting of 38,000 bushels of small juvenile hard clams from heavily concentrated areas to less densely populated areas around the Bay over a period of several years. The council remained in effect until the late 1960s when the quahog population began to decline and the fishery all but disappeared. Interestingly, this period of decline of the quahog fishery coincides with the resurgence of the soft-shell clam fishery.

A more recent attempt at regional management, specifically the Brunswick-Harpswell-West Bath Region Council, was not as successful. Several factors contributed to the failure and eventual dissolution of this Council, including unclear expectations of the participants, lack of communication, and general disorganization. *But perhaps the most important single source of*

contention 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.

The success of any future attempt at regional management will rest on the acceptance of and respect for this sense of ownership. Accordingly, the focus of a regional council should be on issues of broader rather than specific concern. These issues include resource assessment, research and development of new management techniques, including transplanting and assessment techniques, compliance with water quality monitoring requirements, and law enforcement. In addition to their importance in management, these are also the most expensive activities in which municipalities are engaged. *Consideration might therefore be given to ways in which municipalities could share the financial burden of these activities and perhaps seek outside funding through State, Federal, and/or foundation grant programs.* And finally, to ensure participation by all interested parties, the Council should seek representation from all aspects of the shellfish industries, (including harvesters, dealers, processors, and shippers), resource management, the marine scientific community, all municipalities bordering on Casco Bay, and State and local law enforcement personnel.

Regardless of whether a regional management council is established or the municipalities choose to continue independently, it is clear that the current management effort is inadequate to ensure long-term, sustainable exploitation of the soft-shell clam resources of the Bay.

5.25 Conclusions

- The Maine Department of Marine Resources has delegated responsibility for soft-shell clam resource management to individual coastal municipalities, but is currently providing these municipalities only limited guidance in carrying out their management obligations and has failed to consistently enforce management requirements.

- As a consequence of this failure, the soft-shell clam resource information for Casco Bay is incomplete and, where it exists, the collection of the data and the ways in which it is presented and interpreted differs significantly from one Town to another. Some of the data used to develop the estimates presented here are sound and defensible, but others are weak and lack empirical support.

- Closures preclude the harvest of mussels as well as clams. Mussels also have significant economic value and the economic loss associated with the prohibition of mussel harvesting in closed areas should not be overlooked. Further, the encroachment of mussel beds onto clam habitat in closed areas may render adjacent areas unfavorable to the settlement and persistence of soft-shell clams.

- Municipalities are appropriating increasing amounts of funds and effort to shellfish management, but continue to find difficulty in managing effort. The effort to reopen a substantial portion of the closed areas of the Bay to shellfish harvesting and to properly manage the resource will require an effort that transcends municipal boundaries.

5.26 Recommendations

- The Department of Marine Resources (DMR) should revisit, update, and clarify its shellfish resource management policy for the coastal waters of Maine as outlined in its 1981 *Fisheries and Fishery Policy in the State of Maine - An Overview.*

- A standard protocol for conducting shellfish resource assessments should be established by the DMR which all future assessments must follow.

- The resource assessment reporting format used by the DMR should be revised to take advantage of new data management technology and should be standardized to facilitate comparisons of data from all sources.

- A predictive model should continue to be refined with specific emphasis on obtaining better information on individual effort, harvesting efficiency (as a function of demand and price), and changes in harvesting-related mortalities as a function of harvesting pressure.

- The boundaries of the area *actually populated* by clams should be clearly defined for both open and closed areas to ensure accurate stock assessment and allow detection of any future expansion or retreat of the population.

- The boundaries of the *shellfish habitat* should be clearly defined for both open and closed areas to allow detection of any changes which may occur in the habitat over time.

- Additional work should be done to improve our understanding of the effects of physical forces on the distribution of clams within the Bay. Similarly, additional work should be done to improve our understanding of the relationship between competing commercially important shellfish species, specifically between the soft-shell clam, *Mya arenaria*, and the blue mussel, *Mytilus edulis.*

- Joint ventures between the clam industry and the mussel industry, including mussel aquaculture, to recover clam habitat affected by encroachment of mussels, should be investigated.

- In the short-term, municipalities should continue their efforts to protect the shellfish resources and water quality within their jurisdictions as well as their efforts to reopen areas closed to shellfish harvesting due to contamination or non-compliance with the National Shellfish Sanitation Program.

- In the long-term, a Casco Bay-wide Regional Shellfish Management Council should be established to coordinate and oversee resource assessment, research and development of new management techniques, including transplanting and assessment techniques, compliance with water quality monitoring requirements, and law enforcement activities. The Council should include, but not be limited to, representation from all aspects of the shellfish industries (including harvesters, dealers, processors, and shippers), resource management, the marine scientific community, all municipalities bordering on Casco Bay, and State and local law enforcement.

5.3 Economic Assessment

5.31 Conclusions

The results of this economic analysis illustrate in general terms the value of the Casco Bay soft-shell clam resource to the area's economy--annual income generation of $11 million - $16 million and 242 full-time equivalent jobs supported by this resource. This resource is clearly worthy of coherent management, perhaps at the local level on a Bay-wide cooperative basis.

Crucial to successful nurturing of this resource and the jobs it supports is an enforcement and monitoring system and presence that effectively documents harvests, and deters illegal harvesting. The following recommendations and observations are intended to help in improving management and value of the Casco Bay soft-shell clam resource:

- The availability and quality of landings data were a major impediment to accurate determination of the value of the resource, both the landed value and the economic value beyond the landed value.

- Enforcement of harvesting regulations and tracking of sales of Casco Bay soft-shell clams is insufficient to support proper management of the resource, primarily due to inadequate regulations and lack of public funds to support these efforts.

- The most widely identified problem is that of undocumented direct sales by diggers to shellfish dealers and retail outlets. Shellfish dealers who wish to ship interstate must be certified by the U.S. Food and Drug Administration (FDA). Under the terms of their license, registered shellfish dealers are required to report all shellfish purchases to the State of Maine Dept. of Marine Resources (DMR) on a monthly basis. However, due to lack of effective enforcement, the state resource managers interviewed for this study estimate that perhaps no more than two-thirds of the certified dealers are in compliance at any one time with the reporting requirement.

- Diggers, non-certified dealers, and retailers are not required to document direct sales by diggers to retail outlets such as restaurants and seafood shops, as well as to consumers along the roadside.

- These undocumented sales represent a hole in the State's ability to estimate harvest levels and to ensure product safety for the consumer. Registered dealers and State and federal resource managers interviewed for this study estimate that 20-30% of the Casco Bay soft-shell clam landings are unreported, leaving the resource at risk of continuous over-harvesting.

NOTE: beginning in 1995, all diggers of commercially harvested soft-shell clams will be required to tag their harvest before landing the clams. The tag will identify the flat location, weight and date and must be submitted to the purchaser of the clams who in turn must have the tag in their possession when they sell the clams.

5.32 Recommendations

- The State of Maine Legislature and Governor should allocate sufficient funds to the Department of Marine Resources to provide adequate enforcement of existing monthly shellfish landings reporting requirements for certified shellfish dealers.

- The clam resources of Maine are a town-held public asset. The towns therefore have a "right" to know the aggregate value of the clam landings. Thus the towns issuing commercial clamming licenses could require that as a condition of access to the resource, all license holders must report all commercial landings and ex-vessel prices received to the town office. Towns would then provide their reports on a monthly basis to the State DMR. This would be in addition to the tagging requirement currently in force.

  Landings information would be confidential and would be aggregated for purposes of deriving an overall clam resource value. Towns arguably need this information for zoning and land use decision purposes.

- The State of Maine should require that all purchases of shellfish by retail outlets (retail shops, restaurants, roadside sales) directly from diggers (as opposed to through certified shellfish dealers) be documented just as sales by diggers to certified dealers are currently supposed to be tracked.

These latter two improvements would allow the state to be fair to all dealers (in particular to those certified dealers who are currently in compliance with existing regulations). Further, this tightening of the tracking system would also "close the loop" on landings information and would provide town and state resource managers with information that is currently unavailable due to the nature of the system. As a result, the resource is probably being over-harvested by too many license holders.

Finally, the potential human health risk posed by unreported landings that may be harvested out of closed areas may be reduced by such improvements to the reporting and enforcement systems.

"The income generated per dollar of sales is higher for fisheries than for virtually any other industry sector in the state. For instance, the total income multiplier for wood and paper products, the state's most important industry, is 0.98. The higher ratio of income to sales for clams (fisheries) is explained by two factors. First, clamming (and many fisheries) is relatively more labor intensive, generating greater direct value added. Second, clammers (and fishermen in general) seem to purchase more of their inputs in-state as compared with other industries." (Briggs et al., 1982)

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These appendices are available upon request from the Casco Bay Estuary Project, 312 Canco Road, Portland, Maine 04103, telephone: (207) 828-1043.