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LOST HARVEST

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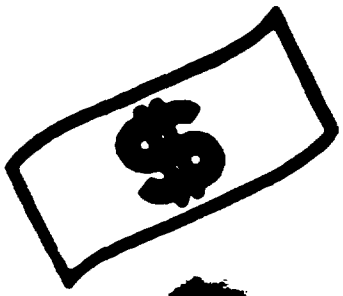

and Economic Losses in the New Bedford Area

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Conservation Law Foundation
of New England

January 1988

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LOST HARVEST:

SEWAGE, SHELLFISH, AND ECONOMIC LOSSES IN THE NEW BEDFORD AREA

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January 1988

EXECUTIVE SUMMARY

- Sewage pollution, not the more widely known PCB problem, is keeping vast areas of New Bedford Outer Harbor and Clarks Cove closed to shellfishing. PCB levels in shellfish of the Outer Harbor and Clarks Cove were found to be below the federal limit in 1981, but the areas had to remain closed to shellfish harvesting because of sewage pollution. Shellfish closures in these areas were first established in 1971, eight years before any fishing closures due to PCBs.

- Sewage discharges into the waters of New Bedford include: the constant discharge from the treatment plant at Fort Rodman of over 23 million gallons each day of sewage that receives only minimal (i.e., less than primary) treatment; the discharge from 38 different outlets along the Inner Harbor, Outer Harbor, and Clarks Cove of over 1.5 billion gallons per year of raw sewage and street runoff during wet weather; and the constant, dry-weather discharge of 4.7 million gallons each day (1.7 billion gallons per year) of raw sewage from many of the same outlets.

- The City of New Bedford is now moving to address all of its sewage problems, guided by a schedule worked out by the City, the U.S. Environmental Protection Agency, the Commonwealth of Massachusetts, and the Conservation Law Foundation of New England.

- The waters of the Outer Harbor and Clarks Cove that are currently closed to shellfishing because of sewage pollution contain a hard-shelled clam (quahog) resource of over 500,000 bushels, with a market value of over $24 million.

- The currently closed areas of the Outer Harbor and Clarks Cove could yield an annual harvest worth nearly $5 million, which could generate a total annual income of nearly $6 million.

- The total economic activity that could be generated by the harvesting, processing, and distribution of shellfish from the currently closed areas of the Outer Harbor and Clarks Cove is nearly $22 millon per year.

TABLE OF CONTENTS

I. INTRODUCTION.....1

II. POLLUTION AND SHELLFISH IN THE NEW BEDFORD AREA.....5

III. RESOURCE ESTIMATES.....10

IV. ECONOMIC LOSSES.....13

APPENDIX.....20

REFERENCES.....26

LIST OF TABLES

Table 1 -- Areas Closed to Shellfishing Due to Sewage Pollution.....9

Table 2 -- Estimated Quahog Populations in the Closed Areas of Clarks Cove and New Bedford Outer Harbor.....11

Table 3 -- Total Potential Economic Benefits of Harvesting the Current Stock of Quahogs from the Closed Areas of Clarks Cove and New Bedford Outer Harbor.....18

Table 4 -- Annual Potential Economic Benefits of Harvesting Quahogs from the Closed Areas of Clarks Cove and New Bedford Outer Harbor.....19

LIST OF FIGURES

Figure 1 -- New Bedford Sewage Discharges.....3

Figure 2 -- Areas Subject to PCB Closures.....7

Figure 3 -- Sewage-Related Shellfish Closures.....8

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We thank the following persons for providing data and/or reviewing an early draft of this report: Ed Williams, New Bedford Shellfishermen's Association; Brad Bourque, New Bedford Shellfish Warden; Joseph Pauline, Fairhaven Shellfish Warden; J. Michael Hickey, Massachusetts Division of Marine Fisheries; Frank Germano, Massachusetts Division of Marine Fisheries; and Dr. Susan Peterson, Ocean Arks International.

I. INTRODUCTION

The City of New Bedford has recently embarked upon the long-overdue process of correcting the serious inadequacies in the systems that collect, treat, and discharge the sewage and industrial wastewater generated by this community of over 90,000. For the first time, the City has a blueprint for action, in the form of a schedule worked out between the City, the U.S. Environmental Protection Agency, the Commonwealth of Massachusetts, and the Conservation Law Foundation of New England and included in a consent decree filed in October 1987 in federal court. The schedule lays out the steps that New Bedford must take over the next several years to bring its aging, overtaxed, and outmoded sewerage system into compliance with federal and state law.

The tasks that lie ahead for the City and its residents are complicated and challenging. The City needs to build a new sewage treatment plant that will provide secondary treatment for its sewage -- over 23 million gallons each day. New Bedford's sewage now receives only minimal treatment before being dumped into the Outer Harbor. The existing treatment plant at Fort Rodman was designed to provide primary treatment, which removes a much lower percentage of pollutants from sewage than secondary treatment. However, because of design flaws and poor operation and maintenance over the years, the Fort Rodman plant has never consistently met even the standards for primary treatment since its construction in 1973.

The City must also find a way to control the flow of pollution from thirty-eight separate discharge points that dot the shores of the Inner Harbor, the Outer Harbor, and Clarks Cove (see Figure 1). During and immediately after storms or snow melts, these outlets act as "relief valves" for the City's sewer pipes, which cannot handle the combined volume of sewage and rainwater that pours into the system. (They also act to protect the treatment plant at Fort Rodman, which cannot always handle all of the flow.) This sort of sewerage system, which collects both sewage and street runoff in the same pipes, is common in older cities and is called a combined sewer system. (Most of New Bedford, except for portions of the northern part of the City, has combined sewers). The discharges of raw sewage and stormwater that flow out of some or all of the thirty-eight relief points each time it rains are called combined sewer overflows, or CSOs. In 1983, the City's consultants estimated that CSOs totalled over 1.5 billion gallons per year (Camp Dresser & McKee Inc. 1983).

Even before these wet-weather overflows are controlled, however, the City must end discharges from CSO outlets during dry weather. While the system was in fact designed to allow wet-weather overflows, dry-weather overflows are the product of design mistakes, poor maintenance, and/or illegal connections of sewage pipes leading directly to CSO outlet. Dry-weather discharges are estimated to account for a flow of 4.7 million

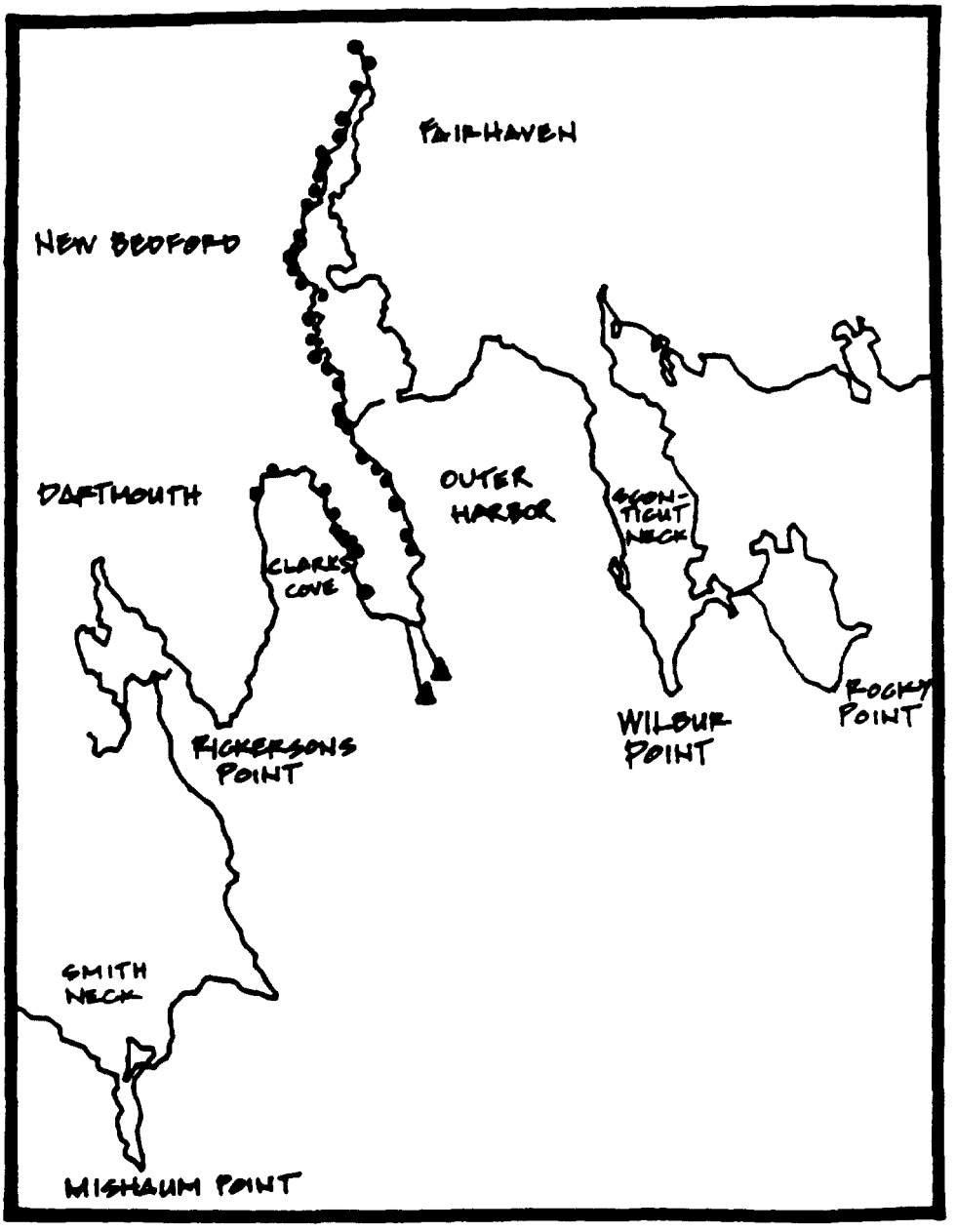

Figure 1. New Bedford Sewage Discharges

▲ Treatment Plant Outfalls (2)

● Combined Sewer Overflow Outlets (38)

discharges are estimated to account for a flow of 4.7 million gallons per day, or another 1.7 billion gallons per year (Camp Dresser & McKee Inc. 1987).

These problems have been with New Bedford for years, and will not be solved overnight. Moreover, since the problems involve the entire sewage treatment and collection system, their solutions will be expensive. But moving ahead toward a solution will also bring undeniable benefits in the form of cleaner water and a healthier environment. **The continuing pollution imposes environmental costs on the entire community.** One of the most serious costs of sewage pollution in New Bedford is the devastating impact that the flow of raw and inadequately treated sewage has had on shellfishing in the productive beds of Clarks Cove and the Outer Harbor.

II. POLLUTION AND SHELLFISH IN THE NEW BEDFORD AREA

Water quality problems have plagued the shellfishing industry in the New Bedford area for much of this century. Massachusetts public health officials closed New Bedford Inner Harbor and the Acushnet River estuary to all shellfishing in 1925 due to "gross pollution." Those water bodies have remained closed since that time (Camp Dresser & McKee Inc. 1987). The discovery in the mid-1970s of extremely high levels of polychlorinated biphenyls (PCBs) in the estuary and Inner Harbor led to a ban on all fishing activities in these areas in 1979. **The closure of the Inner Harbor and estuary to shellfishing, however, predated the PCB-related closure by more than fifty years, and would be in place even without the PCB problem.**

Sewage pollution also led to a ban on shellfishing in the Outer Harbor and Clarks Cove in 1971. Eight years later, concerns about PCB levels led state officials to ban the taking of lobsters, bottom-feeding fish, and shellfish. In 1981, PCB levels in shellfish in the Outer Harbor and Clarks Cove were found to be below the federal standard, but sewage pollution kept most of these areas closed to shellfishing. The only areas that could be re-opened for shellfishing were the western quarter of Clarks Cove and a small area adjacent to Sconticut Neck (Camp Dresser & McKee Inc. 1983). Recurring sewage pollution problems led the Massachusetts Department of Environmental Quality Engineering to re-close all of Clarks Cove to shellfishing in 1983; that closure remains in effect. Thus, sewage pollution --

not the PCB problem -- is keeping vast areas of the Outer Harbor and Clarks Cove closed to shellfishing. Figure 2 depicts the areas closed to various fishing activities due to the PCB problems; Figure 3 shows the areas closed to shellfishing due to sewage pollution. A comparison of the two figures shows that virtually all of PCB closure area 2 and a small part of PCB closure area 3 -- neither of which includes any restrictions on shellfishing due to PCBs -- are closed to shellfishing only because of sewage pollution. Table 1 shows the acreages in Dartmouth, New Bedford, and Fairhaven that are closed to shellfishing solely because of sewage pollution.

The closure to shellfish harvesting of all of Clarks Cove and nearly all of New Bedford Outer Harbor results in a significant economic loss to the area's economy. In addition to its aesthetic and recreation-related impacts, sewage pollution in the New Bedford area carries with it a clear and quantifiable economic impact through its crippling effect on the local shellfishing industry. The balance of this report addresses this economic impact by attempting to estimate the size and economic value of the most important shellfish resource in the area -- the hard-shelled clam or quahog, *Mercenaria mercenaria*. (Other shellfish species, such as soft-shelled clams (*Mya arenaria*) are not considered.)

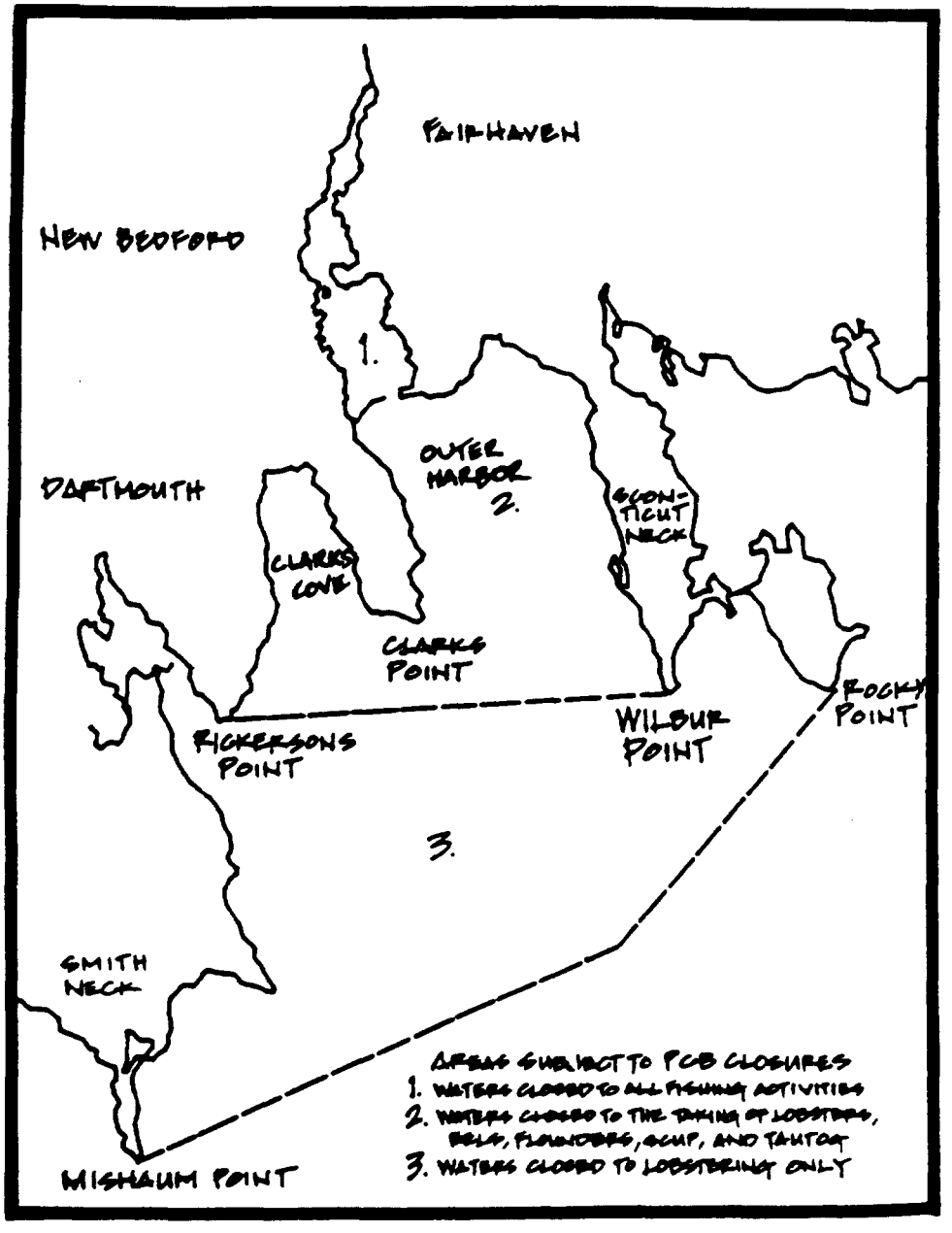

Figure 2. Areas Subject to PCB Closures

Source: Massachusetts Office of Coastal Zone Management

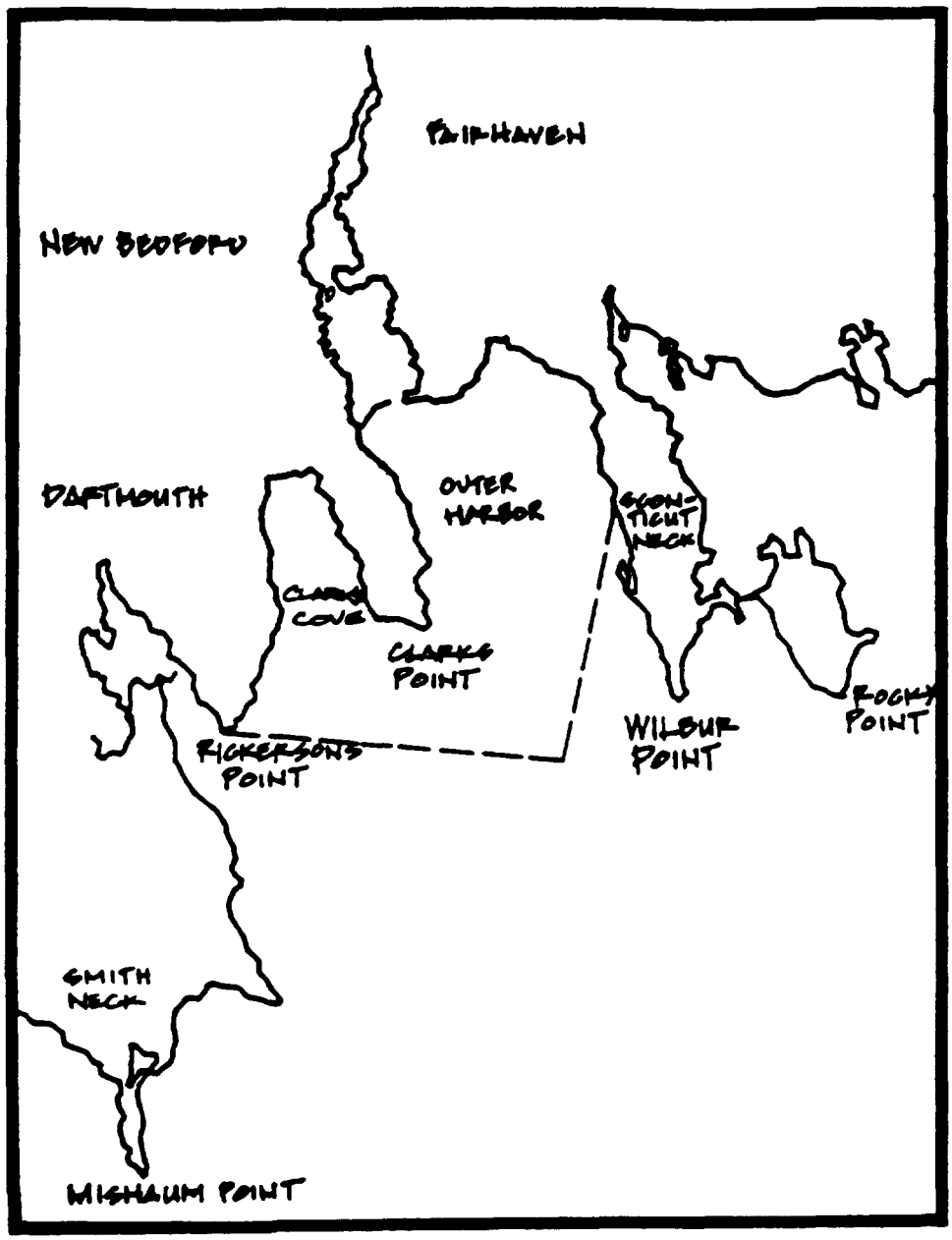

Figure 3. Sewage-Related Shellfish Closures

----- Seaward Boundary of Closed Area

Table 1

Areas Closed to Shellfishing Due to Sewage Pollution
(acres)
(from Germano 1987)

Dartmouth -	Area 2*	792.8
	Area 3*	181.8**
		974.6
New Bedford -	Area 2	2,804.9
	Area 3	673.4
		3,478.3
Fairhaven -	Area 2	2,126.1
	Area 3	130.3
		2,256.4
TOTAL -	Area 2	5,723.8
	Area 3	985.5
		6,709.3

* PCB fishing closure areas established by Massachusetts Department of Public Health; refer to Figure 2. The PCB-related fishing closures in Areas 2 and 3 do not apply to shellfish, but only to bottom-feeding fish and lobsters.

** Does not include 619.2 acres near Mishaum Point.

III. RESOURCE ESTIMATES

A review of existing reports on Buzzards Bay (Tripp 1985) reveals that resource information for the New Bedford area is scarce. The only comprehensive survey of quahog stocks in the New Bedford area is a 1980-81 survey conducted by the Massachusetts Division of Marine Fisheries (Hickey 1983). As Hickey (1983) noted, historical information about the quahog resource is sketchy. Belding (1909, 1912) made qualitative comparisons of quahog-producing areas throughout the Commonwealth. He rated the Inner Harbor (Acushnet River), Clarks Cove, and Priests Cove (the northeastern corner of the Outer Harbor) as "good" and the Outer Harbor as "fair." The western shore of Sconticut Neck was said to yield only small amounts. Hickey also mentions a limited survey by the Division of Marine Fisheries in 1966 (Carr 1966) that yielded some quantitative data, but notes that insufficient information about the sampling techniques used in that study makes it impossible to compare the results with the more recent data. Thus, the 1983 report represents the best available information concerning quahog stocks in the Clarks Cove-Outer Harbor region.

Table 2 shows estimated populations of quahogs within the closed areas in each city or town. **The waters of Clarks Cove and New Bedford Outer Harbor that are currently closed to shellfishing because of sewage pollution contain over 500,000 bushels of quahogs.** The numbers bear out the finding by Hickey

Table 2

Estimated Quahog Populations in the Closed Areas of Clarks Cove and New Bedford Outer Harbor (bushels*)

Dartmouth		25,914
New Bedford -	Clarks Cove	107,242
	Outer Harbor	200,268
		307,510
Fairhaven		186,784
TOTAL		520,208

* Eighty-pound bushels, as used by Hickey (1983).

bushels of quahogs.[1] The numbers bear out the finding by Hickey (1983) that "despite pollution, minimal management and periodic heavy utilization, legal and otherwise, the resource has sustained itself over the years."[2] The estimates in Table 2 incorporate a number of conservative assumptions. For example, they do not include quahogs in the 985.5-acre portion of the closed area (15% of the total) that lies south of the boundary between PCB Areas 2 and 3. See the Appendix for a full explanation of the derivation of the estimates in Table 2.

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[1] The unit of measurement here is the eighty-pound bushel, which was used by Hickey (1983). A "bushel of commerce" is somewhat smaller, weighing sixty-five to seventy pounds.

[2] The estimates are slightly different from those reported by Hickey (1983), who estimated that there were a total of 228,782 bushels of quahogs in Clarks Cove and 249,599 bushels in the Outer Harbor. (He then reduced the Clarks Cove estimate by 62,437 bushels to account for the harvest in the Dartmouth portion of the Cove between 1981 and 1983. Table 2 reflects the same correction.) The primary reason for the difference between Hickey's revised total (415,944 bushels) and the total in Table 2 (520,208 bushels) is that Hickey's survey, which was intended to cover the area north of the "old closure line" running from Rickersons Point to Wilbur Point (equivalent to the boundary between Areas 2 and 3 in Figure 2), did not sample large portions of the Cove and the Outer Harbor. The Hickey survey was a deepwater, dredge survey; it did not sample any of the waters landward of the twelve-foot depth contour. In addition to the unsampled areas of the Outer Harbor discussed in the Hickey report, which totalled 1,682 acres, the Hickey survey did not sample substantial portions of Clarks Cove, which are likely to contain a quahog resource as abundant as that in the rest of the Cove (Bourque 1987). Quahogs from these unsampled areas, with appropriate conservative adjustments, are included in the estimates in Table 2. However, as noted in the text, quahogs in the 985.5 acres of closed waters in PCB Area 3, which were also omitted from the Hickey survey, are not included in Table 2.

IV. ECONOMIC LOSSES

The resource estimates in Table 2 provide a basis for estimating the economic losses to the region due to the sewage contamination-related shellfish closures in Clarks Cove and the Outer Harbor. There are currently no published estimates of these losses for the New Bedford area (Camp Dresser & McKee Inc. 1987).

The simplest measure of the economic value of the lost resource to the community is the price it would bring in the marketplace, i.e., the total number of bushels multiplied by the current per-bushel price for quahogs. The calculations in this study use the 1986 wholesale price for Massachusetts as reported by the National Marine Fisheries Service of $4.25 per pound of meat (Christiansen 1987), based on a conversion factor of 11 pounds of meat per bushel (Alber 1987).[3]

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[3] Although most quahogs in the New Bedford area are sold in the shell, this approach, using a price per pound of meat (shucked clams), was chosen because of a number of uncertainties associated with in-shell prices and the size distribution of quahogs in the area. The ex-vessel price for in-shell quahogs depends on their size, ranging from as low as $0.15 per pound for large quahogs or chowders (>2 3/4 inches) to $0.35 per pound for cherrystones (2 1/4 to 2 3/4 inches) to as much as $1.25 per pound for small quahogs or littlenecks (<2 1/4 inches). At these prices, the value of a eighty-pound bushel (the unit used by Hickey (1983)) can range from $12.00 to $100.00 (versus $46.75 using a price of $4.25 per pound of meat).

The current population of quahogs in Clarks Cove and the Outer Harbor has a high percentage (approximately 60 to 70%) of large quahogs due to the long-standing restrictions on harvesting in these areas. However, the percentage of smaller quahogs is greater in the areas where the density of the resource is highest (Hickey 1983). In addition, in those areas where some harvesting has occurred in recent years for relays to uncontaminated waters,

However, the market value of the resource grossly underestimates the total economic value of the resource. The money earned by shellfish harvesters through the sale of their product is spent by them on the goods and services that they and their families require. The businesses that sell them these goods and services in turn spend this additional income on the things they need to stay in operation. In this way, each dollar earned by the harvesters generates a certain amount of additional income and economic activity. The extra income and economic activity generated by each dollar of income for a particular industry is calculated by means of multipliers.[4]

Economists make use of two types of multipliers to show the effect of a particular industry on a region's economy. The output multiplier is used to calculate the total amount of economic activity (in dollars) generated by each dollar earned by the industry being considered. For example, if the output

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the percentage of smaller quahogs is probably even higher (Hickey 1987). Thus, the existing size distribution would change if harvesting was once again permitted. Transplant cull percentages reported by the New Bedford Shellfish Warden (Bourque 1987) were 60% littlenecks, 30% mix (littlenecks and cherrystones), and 10% large quahogs. At the prices listed above for littlenecks and large quahogs and $0.25 per pound for mix, this distribution would yield a weighted average price of $67.20 per eighty-pound bushel.

[4] Much of the following discussion borrows heavily from the report on economic losses in the shellfish industry from coastal water pollution on the North Shore of Massachusetts by Resources for Cape Ann (1982). See also the discussion in a report on the fisheries of Cape Cod and the Islands by the Cape Cod Planning and Economic Development Commission (1978). For a more theoretical discussion of economic valuation of shellfishing, see Smith et al. (1976).

multiplier for a given industry is 2, then every dollar earned by that industry generates two dollars in total economic activity.

But not all of the dollars generated by a given industry stay within the local economy. When a shellfish harvester spends money for food, the money goes to the store owner, but much of it then goes to pay the producer or distributor of the food and thus leaves the local economy. Only part of the money stays within the local economy as, for example, wages for the store clerk and profits for the store owner. 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 is calculated by means of the income multiplier. The income multiplier gives a clearer picture of the economic benefits that a community receives from a particular industry.

Deriving the output and income multipliers for a given region requires detailed information about the region's economy and the application of a set of analytical techniques known as input-output analysis. Input-output analysis quantifies the relationships among the different sectors of a region's economy and shows how changes in one sector affect all other sectors. However, since it was not possible to collect all of the necessary information about the New Bedford regional economy, this study uses multipliers derived for the shellfish harvesting industry by two other studies. King and Storey (1974) performed an input-output analysis for Cape Cod and calculated an output multiplier of 3.0010 and an income multiplier of 1.1749 for

shellfish harvesting. Rorholm et al. (1967) examined the southern New England region as a whole and calculated an output multiplier of 2.96 and an income multiplier of 1.18 for shellfish and finfish harvesting, which they combined. To be conservative, this study uses the lower of the two numbers in each case (i.e., an output multiplier of 2.96 and an income multiplier of 1.1749).

Finally, the shellfish harvesting industry is only the first of several economic sectors that handle and sell shellfish. After they are sold by the harvesters, the shellfish are sold by wholesalers to retailers and restaurants, which then sell them to the general public. The income earned by the distribution/processing and restaurant sectors itself generates additional economic activity and income in the same way that the income earned by the harvesters does. After subtracting the cost of purchasing the shellfish, these additional dollars should be added to those generated by the shellfish harvesting industry to get a true picture of the economic benefits of the shellfishing industry as a whole.

CLF attempted to gather the kinds of information needed to perform this sort of analysis by surveying area wholesalers, retailers and restaurants. However, the response to the survey was not sufficient to generate the required data. The Massachusetts Division of Marine Fisheries (1985) used an "economic multiplier" (presumably an output multiplier) of 4.5 to estimate the total value of shellfisheries to the Commonwealth. That figure is used here as an overall output multiplier to

obtain a rough estimate of the total economic activity generated by a dollar of income in the shellfish harvesting sector.

The results of the economic calculations are presented in Tables 3 and 4. Table 3 presents the values for the existing resource as a whole (the "standing crop"). Table 4 presents estimates of the annual level of economic activity and income that could be generated if the resource were harvested at a sustained annual yield of twenty percent of the standing crop. Hickey (1983), taking a "conservative approach" to the question of sustained annual yield, found the twenty percent figure reasonable, and based it on estimates for polluted waters of Narragansett Bay with similar quahog densities (Holmsen and Stanislao 1966).

As Tables 3 and 4 show, **the New Bedford area is losing millions of dollars in income every year due to the sewage contamination-related closures of the shellfish beds in Clarks Cove and New Bedford Outer Harbor.** The three affected communities are sitting on a resource that at current prices is worth **over $24 million**, with more than half of that value in New Bedford's waters. (The total value for New Bedford of over $14 million is nearly double the only recent estimate (City of New Bedford 1987).) **Shellfish harvesting alone could generate nearly $6 million <u>per year</u> in income for the area, and over $14 million in annual economic activity. The overall lost economic value of the fishery is nearly $22 million per year.**

Table 3

Total Potential Economic Benefits of Harvesting the Current Stock of Quahogs from the Closed Areas of Clarks Cove and New Bedford Outer Harbor (dollars)

	Market Value*	Indirect Benefits (Harvesting Only)** Output	Income	Total Economic*** Activity Generated
Dartmouth	1,211,480	3,585,981	1,423,368	5,451,660
New Bedford				
Clarks Cove	5,013,564	14,840,149	5,890,436	22,561,038
Outer Harbor	9,362,529	27,713,085	11,000,035	42,131,380
	14,376,093	42,553,234	16,890,471	64,692,418
Fairhaven	8,732,152	25,847,169	10,259,405	39,294,684
TOTAL	24,319,725	71,986,384	28,573,244	109,438,762

* Using National Marine Fisheries Service 1986 Massachusetts wholesale price = $4.25 per pound of meat (Christiansen 1987), at 11 pounds of meat per bushel (Alber 1987).

** Output multiplier = 2.96 (Rorholm *et al*. 1966); income multiplier = 1.1749 (King and Storey 1974).

*** Overall output multiplier = 4.5 (Massachusetts Division of Marine Fisheries 1985).

Table 4

Annual Potential Economic Benefits of Harvesting Quahogs from the Closed Areas of Clarks Cove and New Bedford Outer Harbor (dollars)

	Value*	Indirect Benefits (Harvesting Only)** Output	Income	Total Economic*** Activity Generated
Dartmouth	242,305	717,223	284,684	1,090,373
New Bedford				
Clarks Cove	1,002,694	2,967,974	1,178,065	4,512,123
Outer Harbor	1,872,525	5,542,674	2,200,030	8,426,363
	2,875,219	8,510,648	3,378,095	12,938,486
Fairhaven	1,746,440	5,169,462	2,051,892	7,858,980
TOTAL	4,863,964	14,397,333	5,714,671	21,887,839

* Using National Marine Fisheries Service 1986 Massachusetts wholesale price = $4.25 per pound of meat (Christiansen 1987), at 11 pounds of meat per bushel (Alber 1987).

** Output multiplier = 2.96 (Rorholm *et al*. 1966); income multiplier = 1.1749 (King and Storey 1974).

*** Overall output multiplier = 4.5 (Massachusetts Division of Marine Fisheries 1985).

APPENDIX

Derivation of Quahog Population Estimates Within the Closed Portions of PCB Area 2

A. Dartmouth

Germano (1987) gives a figure of 792.8 acres as the total area closed to shellfishing in the Dartmouth portion of Clarks Cove. Hickey (1983) reports an average density of 184.06 bushels per acre for Clarks Cove. However, he also reports an average density of 155.59 bushels per acre on 316 acres in deep water in the portion of Clarks Cove that was open to shellfishing between 1981 and 1983. Furthermore, he notes that Dartmouth catch statistics for the 453 acres that were open during this period totalled 62,437 bushels (at 80 pounds per bushel), or 137.83 bushels per acre. This leaves a standing crop on those 453 acres of 17.76 bushels per acre.

The reduced density of 17.76 bushels per acre was applied to the 453-acre area that was open between 1981 and 1983, and the original density of 155.59 bushels per acre was applied to the remaining area (792.8 - 453 = 339.8 acres):

453 acres x 17.76 bushels per acre	=	8,045
339.8 acres x 155.59 bushels per acre	=	52,869
		60,914 bushels

Bourque (1987) reports that a total of 70,000 bushels of

quahogs have been removed from Clarks Cove for transplantation to other areas since 1982. It was assumed that half of these "relays" came from Dartmouth waters and half from New Bedford waters. Thus the total resource estimate for the Dartmouth portion of Clarks Cove was

$$60{,}914 - 35{,}000 = 25{,}914 \text{ bushels}$$

It should be noted that both the 60,914-bushel figure and the final 25,914-bushel figure are extremely conservative estimates. Simply subtracting the harvested amounts from the previous totals ignores the fact that quahogs are a <u>renewable</u> resource, and thus underestimates the existing resource. In fact, Hickey (1987) reports good sets of new quahogs in the areas that have been harvested.

B. <u>New Bedford</u>

1. <u>Clarks Cove</u> -- Hickey (1983) estimated a total standing crop of 228,782 bushels of quahogs in Clarks Cove (including both New Bedford and Dartmouth) as of 1981. From this total was subtracted an estimate for the total resource in the Dartmouth portion of Clarks Cove, which was derived using the total area of 792.8 acres and the original (1981) density of 155.59 bushels per acre:

$$228{,}782 - (792.8 \times 155.59) = 228{,}782 - 123{,}352 = 105{,}430 \text{ bushels}$$

To this total was added an estimate for the resource in the shallow waters in the New Bedford portion of Clarks Cove, which was not sampled by Hickey. (This step was unnecessary for the

Dartmouth portion of Clarks Cove because a <u>total</u> acreage for that area was available.) The area of this unsampled portion of Clarks Cove was calculated in the following manner.

Total New Bedford closed area in Area 2 = 2,804.9 acres (Germano 1987)

Total Outer Harbor closed area in Area 2 = 2,380
+1,682 (unsampled)
4,062 acres
(Hickey 1983)

Fairhaven closed area in Outer Harbor portion of Area 2 = 2,126.1 acres (Germano 1987)

Therefore, the New Bedford closed area within the Outer Harbor portion of Area 2 is the total closed area in the Outer Harbor portion of Area 2 minus the Fairhaven closed area within the Outer Harbor portion of Area 2:

4,062 - 2,126.1 = 1,935.9 acres

Furthermore, the total New Bedford area in the Clarks Cove portion of Area 2 is the total New Bedford closed area in Area 2 minus the New Bedford closed area in the Outer Harbor portion of Area 2:

2,804.9 - 1,935.9 = 869 acres

The total closed area within the Clarks Cove portion of Area 2 is thus

792.8 (Dartmouth)
+ 869 (New Bedford)
1,661.8 acres

Hickey (1983) gave a productive towable area of 1,243 acres for Clarks Cove. Assuming that this is the total <u>deepwater</u> area of the Clarks Cove portion of Area 2, then the shallow (i.e.,

unsampled) area within Clarks Cove is

1,661.8 - 1,243 = 418.8 acres

Although more than half of Clarks Cove consists of New Bedford waters, to be conservative it was assumed that less than half of this unsampled area (200 acres) was in New Bedford waters. Bourque (1987) indicated that these shallow waters would likely contain a resource as abundant as that found in the deeper waters of the Cove. Thus, the resource within this unsampled shallow area was estimated by multiplying the area by the density given by Hickey (1983) for Clarks Cove:

200 acres x 184.06 bushels per acres = 36,812 bushels

This total was then added to the estimate for the deep waters of the New Bedford portion of Clarks Cove calculated above to yield a total estimate for the New Bedford portion of Clarks Cove as of 1981:

105,430 + 36,812 = 142,242 bushels

It was then necessary to subtract the amount of quahogs removed from the Cove after 1981 for relays to uncontaminated areas. As explained above, Bourque (1987) reports that 70,000 bushels have been removed from the Cove for relays since 1981; it was assumed that half came from New Bedford waters:

142,242 - 35,000 = 107,242 bushels

It should be noted that this ignores the renewability of the resource. (See section A above.)

2. Outer Harbor -- The total resource for the New Bedford

portion of the Outer Harbor was estimated by first multiplying the area of the New Bedford waters within the Outer Harbor portion of Area 2 (calculated above) by the density for the Outer Harbor given by Hickey (1983):

1,935.9 acres x 104.87 bushels per acre = 203,018 bushels

The total amount of quahogs relayed from the Outer Harbor after 1981 (Alber 1987) was 2,750 bushels (for 1982 and 1984). It was assumed that the entire total was taken from New Bedford waters. The total resource for the New Bedford waters in the Outer Harbor portion of Area 2 is thus:

203,018 - 2,750 = 200,268 bushels

Once again, this estimate is conservative in that it assumes no regeneration of the resource after harvesting. (See section A above.)

C. Fairhaven

Germano (1987) lists the total closed area of Fairhaven waters within Area 2 as 2,126.1 acres. However, Hickey (1983) did not sample this entire area. The unsampled areas entirely within Fairhaven waters were Priests Cove (366 acres) and an area extending from Priests Cove to Silver Shell Beach (162 acres). Hickey notes that parts of Priests Cove are sparsely populated, but that other parts are believed to be heavily populated. The stretch from Priests Cove to Silver Shell Beach, however, is described as sparsely populated. To be conservative, one half of the Priests Cove area (183 acres) and all of the Priests Cove-

Silver Shell Beach area (162 acres) were deleted from the total Fairhaven area for purposes of resource estimation:

2,126.1 - (183 + 162) = 2,126.1 - 345 = 1,781.1 acres

This area was multiplied by the density given by Hickey (1983) for the Outer Harbor to yield the resource estimate for Fairhaven:

1,781.1 acres x 104.87 bushels per acre = 186,784 bushels

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