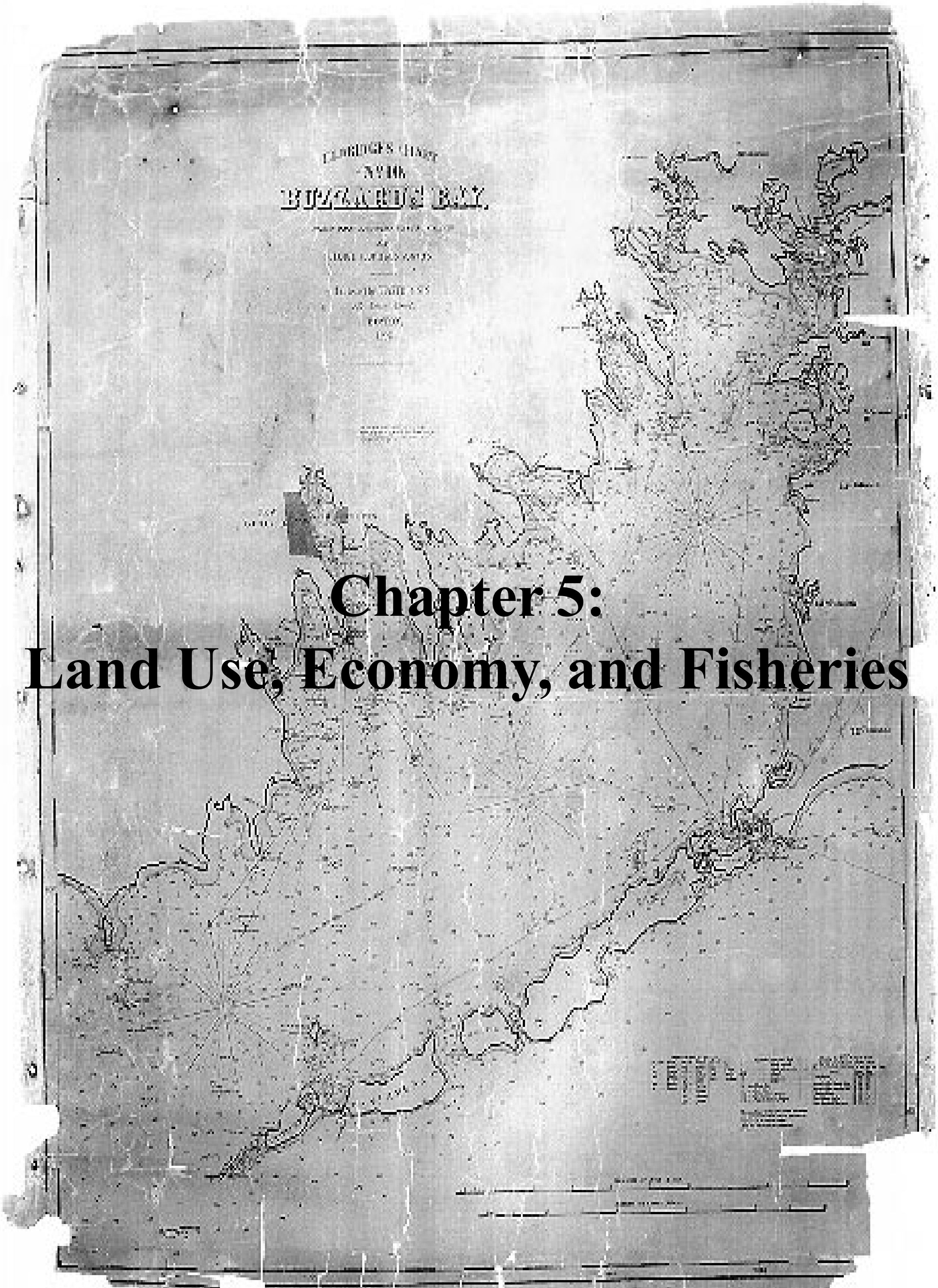

Chapter 5:
Land Use, Economy, and Fisheries

To evaluate water quality in coastal embayments, it is important to identify not only point sources of pollution discharging directly into the bay itself but also those inputs entering from the entire watershed. Nonpoint source inputs from the watershed are frequently less discrete and more difficult to quantify than point sources yet frequently last longer and potentially have more impact. This impact is especially true for nutrient inputs to coastal systems. To understand the variations in water quality throughout Buzzards Bay it is beneficial to look at the various land uses of the communities that make up the watershed as well as the economic factors influencing activities within and surrounding the bay.

5.1. Land Use

Many different land uses are found within the Buzzards Bay watershed; however, the relative dominance of land use patterns has been shifting in recent decades. Forested land represents the largest acreage in the watershed, followed by residential development. Agricultural (including cropland and pastureland), commercial, and industrial development make up the bulk of the remaining land uses. Over the past four decades, forestland area has decreased the most, closely followed by agricultural land, primarily due to the large increase in residential development. Commercial and industrial development has also been on the rise, primarily in response to the increase in year-round populations from new residential development and conversion of summer homes to year-round occupancy.

The changing patterns of land use within the Buzzards Bay watershed have had many consequences for the region, both environmentally and economically. Increased populations require additional services such as new or improved roads, adequate waste disposal, and increased utilities. The numbers of commercial enterprises such as stores, restaurants, and recreational facilities also increase. Increased development of watershed areas, especially in areas with on-site septic disposal of wastes (as is the primary method within the Buzzards Bay watershed), can create long-term problems with groundwater protection and can threaten the health of nearshore coastal waters through increased nutrient loading. The gradual loss of vegetated land surface to buildings, roads, or other paved surfaces affects many ecological processes, from the role of plants in the cycling of nutrients and water to the permeability of soils to precipitation. One of the greatest challenges facing land use planners and managers for the towns within the Buzzards Bay watershed is balancing these changing land use patterns with environmental protection. Maintaining this balance is important to ensure both a healthy environment and a healthy economy, with the health of the economy depending to a great degree on that of the environment, especially in this predominantly tourism-based region.

5.2. Economy

5.2.1. Towns Within the Watershed

The Buzzards Bay drainage basin includes 10 towns located directly on the bay, and 8 noncoastal towns located completely or partially within the watershed boundary. A brief description of these towns (Fig. 1.3), as they relate to Buzzards Bay waters, follows (information summarized from Buzzards Bay Project 1986, 1987, 1989, 1990; Camp, Dresser, and McKee, Inc. 1990; Terkla et al. 1990; personal communication with town representatives).

Coastal:

Westport. Westport is primarily a rural and agricultural community supporting much of the dairy industry within the Buzzards Bay watershed. In recent years, however, the town has experienced rapid residential growth. The Westport River, which actually comprises two rivers, the East and West branches, with independent subwatersheds, flows through parts of Westport and Dartmouth, with tributaries as far north as Freetown (East Branch) and Tiverton (West Branch). Both the East and West branches of the Westport River have relatively high water quality; however, increased numbers of closures to swimming and shellfishing because of high levels of coliform bacteria and evidence of increasing nutrient inputs from residential development and upstream agricultural activities are of growing concern to the community.

Dartmouth. A relatively large town, Dartmouth includes the historic seaport village of Padanaram in its southeast corner. The town maintains a secondary treatment plant built in 1970 (to be expanded sometime in the 1990's) that discharges effluent into Buzzards Bay south of Salters Point. A portion of the watershed for the East Branch of the Westport River lies within the town's boundaries. Increased nutrient loading from development is a concern in this area; Lake Noquochoke, lying along one of the source rivers for the East Branch, currently suffers from eutrophication, with overproduction of aquatic plants due to excessive nutrient loading. Apponagansett Bay is also subject to high nutrient loads and resulting low oxygen conditions.

New Bedford. This city has the largest population in the region, with most of its land area (approximately 5,261 ha) developed. The Achushnet River (along the city's southeast border) has been heavily polluted by industrial and organic wastes. High levels of coliform bacteria, heavy metals, and polychlorinated biphenyls (PCB's) are found in the river waters and sediments. The sources of this pollution range from runoff and residential inputs in the upper portions of the river to direct industrial discharges and combined sewer overflows in the inner harbor (lower Acushnet River). From 1920 to 1973, wastewater was discharged directly into New Bedford Outer Harbor; since 1974 New Bedford has maintained a municipal wastewater treatment facility that continues to discharge primary effluent into the harbor, including storm-related wastewater. Also, there is a growing concern over the potential contamination of groundwater from the existing municipal landfill, which contains more than 225,000 kg of capacitors and barrels containing PCB's.

Fairhaven. As with many of the towns along Buzzards Bay, Fairhaven historically maintained a seaport. Bordering Buzzards Bay and the Acushnet River across from New Bedford, Fairhaven has experienced rapid residential and commercial growth in recent years. Fairhaven drains by the Acushnet River basin in the west, the Mattapoisett River basin in the northeast, and the Nasketucket River basin in the central portion of the town. Runoff of pollution from municipal and industrial sources into the Acushnet River has resulted in periodic low oxygen levels and high bacteria counts, exacerbated by inputs from treatment plant effluent and runoff from both New Bedford and Fairhaven.

Mattapoisett. Mattapoisett is a small coastal residential community. The town historically supported agriculture and shipbuilding but now is primarily residential with a seasonal influx of tourists during the summer months. The southern portion of the town drains directly into the bay through several small streams. Most of the town drains into the Mattapoisett River basin except for a small part in the northeast corner, which is part of the Sippican River basin. Mattapoisett River discharges into Mattapoisett Harbor; both have relatively high water quality without significant municipal or industrial discharges, although the harbor is occasionally closed for shellfishing because of high numbers of coliform bacteria. The source of this bacteria is primarily from discharge at the town pier of a small stormwater and sanitary collection system. High levels of nutrients and coliform have been measured in the stream that drains the center of the town, presumably from septic system leachate and domestic waste discharge. Runoff from nearby dairy farms is also identified as a source of pollution. Natural sources, however, cannot yet be ruled out.

Marion. Marion is a small rural community on the upper bay with a large seasonal influx of summer tourists. Most of the town's watershed drains directly to the bay through a series of streams and Sippican Harbor. Water quality has historically been high in all but a small portion of the Sippican River found to contain high mercury concentrations originating from the former use of mercury-based antifouling paints. Marion's wastewater treatment facility discharges into a small stream that enters Aucoot Cove. Studies conducted in Aucoot Cove, the recipient of the town's municipal wastewater treatment plant, indicate this area maintains relatively high water quality (Howes 1993). The former town landfill was graded and planted to reduce leachate production and now serves as a waste transfer station.

Wareham. Located near the southern end of the Cape Cod Canal, Wareham contains significant areas of tidal wetlands through which three rivers, the Weweantic, Agawam, and Wareham, enter the bay. Wareham supports a large tourist industry with substantial commercial and retail activity. Intensive cranberry agriculture along the Weweantic River has historically resulted in problems with pesticide pollution. The river is often stagnant and occasionally experiences problems with low oxygen conditions; however, overall water quality conditions appear to be relatively good. Occasional fuel oil spills have occurred from business in Wareham Center. Buttermilk Bay, although receiving no known major point source discharges, is affected by nonpoint source discharge of nutrients from several nearby residential developments and historically has suffered from periodic eutrophication. Buttermilk Bay also experiences some oil pollution from the large number of boats that frequent this area. Onset Bay, immediately southwest of Buttermilk Bay, experiences much the same inputs from the substantial surrounding development. Cranberry growing is also prevalent in these areas, but studies of bog and bay exchanges indicate pollutant inputs from this source are small (Gill 1988; Howes and Teal 1992).

Bourne. Three-quarters of the population of Bourne resides within the Buzzards Bay watershed. The majority of developed land is residential with historic summer cottages now year-round homes. The town borders on Buttermilk Bay, an important source of soft-shelled clams that has been repeatedly closed to shellfishing since 1984 due to high levels of coliform bacteria. These waters also have provided an important area for scallop harvesting. Some areas, such as Barlow's Landing in the village of Pocassett and areas around Toby's Island, are also frequently closed to shellfishing because of high coliform bacteria numbers.

Falmouth. Primarily a residential community, the population of Falmouth increases from 27,000 in the winter to 63,000 in the summer. Tourism is a major economic resource, with tax revenues from tourist accommodations more than twice that of all the other towns within the Buzzards Bay watershed combined. Although some of this activity is located along the southern shore of the town, which is outside the bay's watershed, about one-third of this seasonal population increase is located within the watershed. West Falmouth Harbor has long been known for its high water quality and scallop fisheries; however, it is an area of future concern because it lies in the path of the groundwater nutrient plume generated by the Falmouth Wastewater Treatment Facility. The village of Woods Hole also lies within the Falmouth portion of the Buzzards Bay watershed.

Gosnold. The town of Gosnold actually represents the Elizabeth Islands made up of Nonamessett, Naushon, Pasque, Nashawena, Cuttyhunk, and Penikese islands. The 1990 census identified a population for Gosnold of 98 people, but even with the limited accessibility of the islands, the population does increase in summer with a small influx of tourists. Gosnold maintains no real manufacturing or industry, with the exception of a handful of small businesses serving the few residents.

Noncoastal:

Fall River. Fall River represents a major industrial city in the region, with a significant manufacturing center. Although locally important, only a small portion of the city resides within the Buzzards Bay watershed. The northeast corner of Fall River lies in the Westport River basin, and drains into the bay, with most of the city's discharge entering the Taunton River basin.

Freetown. Primarily a residential community, Freetown is situated between Fall River and New Bedford. Within the town's boundaries lies a 1,214-ha state forest, which has substantially contributed to the relatively undeveloped nature of this community. Its resultant nutrient input to Buzzards Bay waters is likely to be correspondingly small.

Lakeville. Lakeville is a small but growing town that has seen recent increases in residential development. The town includes several large ponds that provide fresh water for New Bedford and surrounding towns. Interest in maintaining high levels of water quality in these ponds has focused attention toward protecting the quality of the surrounding groundwater to prevent contamination of these source ponds.

Middleborough. A large rural town, Middleborough lies partially within the Buzzards Bay drainage basin. The southeast corner of the town is in the Weweantic and Sippican drainage basins, which empty into Buzzards Bay. A substantial amount of Middleborough is preserved for watershed protection and conservation and does not provide significant pollutant inputs to the bay.

Rochester. Rochester is a rural agricultural community with limited highway access and subsequently little commercial or industrial development. The town is drained by the Sippican River on the east and the Mattapoisett River on the west. Although there are numerous cranberry bogs in the town, water quality remains high in the waters flowing towards Buzzards Bay. A regional trash incineration facility is located here that accepts trash from many coastal communities in southeastern Massachusetts.

Carver. Carver is a rural community with large areas of forest and about 40% of the cranberry bog area within the entire bay watershed (University of Massachusetts Cranberry Experiment Station, personal communication). Most of Carver is drained by the Weweantic River basin; southeastern Carver is part of the Winnetuxet River basin. To the north, the Winnetuxet River basin flows to the Taunton River basin, and the remainder of the town drains south to Buzzards Bay. Because it receives no municipal waste input, water quality is good in this river, with the exception of some areas identified to have pesticide residues from cranberry agriculture. The Wankinco River makes up part of the Carver-Plymouth boundary and maintains many impoundments as well as cranberry bogs. Except for some evidence of pesticide residues, this river is considered relatively clean as well.

Plymouth. This town maintains the largest land area in the commonwealth, sharing with Carver and Wareham the largest groundwater aquifer in Massachusetts. Plymouth has experienced substantial pressure for development of year-round and seasonal housing. Rivers from the watershed discharge primarily into Buzzards Bay, Plymouth Bay, and the Cape Cod Canal; the rivers flowing into Buzzards Bay have their sources in the Plymouth-Carver aquifer. These rivers include the Weweantic River, Wankinco River, Agawam River, and Red Brook, with Herring River discharging into the canal. The municipal sewage treatment plant for Plymouth discharges into Plymouth Harbor and Cape Cod Bay and therefore is generally not considered to influence Buzzards Bay.

Acushnet. The town of Acushnet supports a mixture of industry, residential development, and rural area and is located on the Acushnet River northeast of New Bedford. Runoff from the dairy industry has been identified as the cause of periodic low oxygen conditions and high coliform counts; although some reaeration of river waters is provided by a dam, this has no effect on the increased coliform populations identified downstream. Evidence of residual mercury inputs has been found, possibly from the historic use of mercury-based pesticides on nearby orchards (Terkla et al. 1990). Potential inputs from the municipal landfill to a tributary of the Acushnet River have been of growing concern in this area.

5.2.2. Economic Resources and Water Quality

For a coastal community, high water quality has both direct and indirect economic benefits. The health of valuable natural resources such as recreational and commercial fish and shellfish species depends on the environmental health of the ecosystem as a whole. For many coastal communities, tourism is also an important economic resource. Poor water quality seriously affects the desirability of a coastal area for tourism; it can also affect the value of real estate, which subsequently affects the revenue base for many of these towns. To evaluate the potential long-term impacts of declines in water quality on the local economy, it is important to differentiate between those changes caused by natural processes as opposed to human activities. In some cases, activities aimed toward stimulating economic growth in coastal areas (such as increased development) can, if not planned with consideration for the potential long-term ecological impacts, ultimately result in decreased desirability and overall economic loss to the region. Environmental boundaries are more easily delineated than economic ones because the success of local economies is generally closely related to that of the surrounding region. In addition to local aesthetics, employment and business opportunities are important influences on the desirability of an area for development. Nearby metropolitan areas serve both to attract tourists and allow towns to serve as bedroom communities. In that much of the attractiveness of an area depends on its aesthetic appeal, it is somewhat ironic that the inherent beauty of the natural system may so often lead to its environmental decline. One of the primary challenges facing managers and land planners today is to maintain economic growth while ensuring environmental protection; this is difficult to achieve in that both objectives are affected by local as well as regional factors. This is certainly the case for Buzzards Bay, for within its watershed boundaries lies a wide variety of economic industries and natural resources, each affected to some degree by the other.

Identifying the sources of pollution and evaluating their potential impacts on the Buzzards Bay region are difficult because, although many point sources exist, the primary inputs are via nonpoint sources widely dispersed throughout the watershed. Another challenge lies in estimating the economic losses caused by pollution and the benefits of remediative measures, which often involve overlapping or widely separated political jurisdictions. Because rivers, streams, and groundwater are the transport mechanisms for many types of estuarine contamination, a pollutant's source may originate far from the resulting impact. Responsibility for monitoring, evaluating, and protecting water quality often lies simultaneously within different levels of government: federal, state, and local. The combination of these overlapping political, economic, and environmental boundaries often interferes with the efficient development and implementation of integrated environmental management and economic development plans. With pressures from development- and conservation-oriented interests, along with indications of potentially declining water quality in some areas of Buzzards Bay, increased attention is being given to the interrelationship between environmental and economic factors within the bay and its watershed.

A study of economic growth and environmental change in Buzzards Bay (Terkla et al. 1990) has identified population growth as the dominant factor currently affecting the environmental health of Buzzards Bay. The continued increase in residential development and tourism within the bay's watershed, as for most coastal communities, represents the leading cause of environmental degradation that is primarily due to increased eutrophication from increased nutrient inputs. This degradation may threaten the economic viability of some traditional agricultural and marine activities. Agricultural activities are likely to be more restricted as they are implicated as sources of contamination, while marine activities (fishing and recreational uses) are directly affected by water quality. Although the cost of lost revenues caused by poor or restricted fish and shellfish catch can be directly determined, the value placed on aesthetics and recreation is more difficult to quantify, even though these are the source of much of the current demand for improved environmental quality.

Terkla et al. (1990) reported that the Buzzards Bay watershed supports five primary economies: residential, manufacturing, tourism, agriculture, and fishing, all in some way influencing the health of the bay.

Residential. As with many coastal communities, the Buzzards Bay watershed has seen significant increases in residential development in recent decades, as evidenced by the changes in population. The region as a whole has seen an average increase of 31 people/km^2 since 1970, with 50% more housing units in 1988 than in 1980. This growth in the residential component affects the environment of the bay through increased use of on-site septic treatment of wastes and lawn fertilizers, the primary nonpoint sources of nutrients (via groundwater transport) to the bay. In fact, only New Bedford and Fairhaven support significant public sewer systems, with most of the homes in the rural areas and much of the major towns of Falmouth, Bourne, and Wareham depending on private, on-site treatment (see Chapter 6).

Residential nutrient loading is magnified because many summer communities that were originally built close to bay waters and developed at high densities have been or are now being converted to year-round residences. Regulations frequently permitted this type of intense development with limited leaching field area (one-fifth of that required for year-round occupation) under the rationale that summertime water tables were lower, allowing for increased filtration of contaminants, and that the leaching fields would "cleanse themselves" during the balance of the year when not in use. Considering that nitrogen (a major potential contaminant to coastal waters) is not significantly altered in groundwater transport, the concurrent increase in nutrient loading as these summer homes are converted to full-time occupancy may substantially increase the potential for eutrophication in the bay's shallower coves and embayments without an obvious increase in housing stock.

The desirability of an area for residential development is dependent to a significant extent on aesthetics. Although most of Buzzards Bay and its associated coves and harbors are still relatively clean, increased frequency of eutrophic events and increased closures caused by coliform bacteria are becoming a factor. The towns surrounding Buzzards Bay face ever-increasing challenges to maintain the delicate balance between increased revenues from growing development versus the potentially significant economic impacts of overdevelopment.

Manufacturing. Traditional manufacturing industries around Buzzards Bay include textiles, printing, building materials, primary metals, and paper, as well as marine-related industries such as boat building and repair. In recent years manufacture of advanced oceanographic instrumentation, partially related to the proximity to Woods Hole research institutions, has become an expanding industry. With 8.3% of the area's total manufacturing jobs, instrument production is the third largest employer in the region, replacing older industries such as rubber, plastics, and primary and fabricated metals.

Although experiencing a decline, New Bedford remains the region's major manufacturing center, with 80% of the total related employment. Historic manufacturing practices severely impacted the environmental health of New Bedford Harbor, specifically the so-called "inner harbor," which had significant textile and metal-related industries. The production of electrical equipment and machinery, the second-largest manufacturing sector in New Bedford, has historically been a major polluter specifically to New Bedford Harbor. With new environmental regulations in the late 1970's, the two major electronics firms using PCB's were required to replace them with other materials. Because of their persistence in the environment, however, PCB's discharged into the Acushnet River and New Bedford Harbor still remain at levels well in excess of EPA guidelines in the water column (parts per billion vs. EPA standards of 1 part per trillion). Sediment contamination with PCB's has resulted in the closure of thousands of hectares to the harvest of shellfish and lobsters since 1979. Although PCB's have been replaced in the manufacturing industry, municipal wastewater continues to contain significant levels. Metal wastes from fabrication and primary metal industries contribute wastewater contaminated with heavy metals, acids, and other materials. Separation of metals "in-house" and land-based disposal of contaminated sludges have lessened the impact of these discharges on Buzzards Bay waters. Although Federal guidelines and discharge restrictions have reduced industrial waste inputs into Buzzards Bay, contaminants still continue to enter through the city's sewerage system. Because of the dominance of New Bedford as an industrial center, the environmental impact by industrial pollution to Buzzards Bay is largely confined to the Acushnet River and New Bedford Inner and Outer harbors.

Tourism. Tourism provides a major economic resource to Buzzards Bay communities, especially the towns of Falmouth, Bourne, and Wareham. Those same qualities that make the Buzzards Bay region attractive for residential growth are also responsible for attracting tourists. Maintaining the natural resources on which the tourism industry is based requires a careful balance between protection of natural resources and accommodating the demands for access, especially to some of the most sensitive yet desirable areas. Employment in the two major tourist sectors, lodging and restaurants, has roughly doubled in the Buzzards Bay region since 1970, and the growth in tourist numbers has been even larger. With this surge in tourism comes a parallel increase in water activities such as boating, fishing, and shellfishing and growth in marine-related businesses.

The seasonal influx of tourists to communities in the Buzzards Bay region raises their populations by almost three-fold, increasing nutrient loading at a time when nearshore coastal waters are most susceptible to additional inputs. Parallel increases in recreational boating activities can increase turbidity in shallow, nearshore waters, decreasing light penetration with negative ecological consequences, notably the potential loss of valuable eelgrass beds. In addition, boat septic discharges add pollutants (although major efforts are underway to increase the availability of pump-out facilities and to restrict nearshore discharge), and small oil and gasoline spills are associated with power boat operation. The natural scenic beauty and recreational resources, as with most coastal environments, are in essence the basic cause of their own potential degradation by increasing the demand for access to these resources.

Agriculture. Cranberry growing is the dominant agricultural activity in the Buzzards Bay watershed, with dairy cattle farming second. There are 12 times more cranberry growers than dairy farmers, with economic revenues outstripping dairy production 30 to 1 (Terkla et al. 1990). Although both have been identified as potential sources of pollution to Buzzards Bay, recent evidence indicates that cranberry production contributes only very small amounts of toxic contaminants from pesticides (Gil 1988) and minimal amounts of nitrogen from fertilizers (Howes and Teal 1992). The dairy industry, however, is a major generator of fecal pollution through runoff, primarily in the Westport River area.

With increasing concern over excessive nutrient inputs, it is commonly believed that agriculture represents an important nonpoint source of these pollutants to coastal waters. In the drainage area around Buzzards Bay, cranberry growing is by far the largest agricultural land use, occupying some 2,695 ha around the head of the bay. Cranberry bogs are classified as wetlands; although highly modified from natural wetlands and managed so the plants are growing in well-drained soil, there are still periods when the soils are completely saturated (Fig. 5.1). Bogs, frequently created from swamps or low-lying areas, are sited near readily available water, usually with a stream flowing through them which then flows into coastal waters. Cranberry bogs are flooded during certain times of year, in conjunction with insect and disease control, harvesting, and frost protection. Although some of this water may be pumped back into reservoirs when the bogs are drained, eventually it all reaches the coast.

Cranberry bogs located within the Buzzards Bay watershed contribute about half of Massachusetts cranberry production. Although concentrated in Carver, Rochester, and Wareham (about 80% of the total hectarage in the watershed), bogs are

Fig. 5.1. Aerial view of a cranberry bog within the Buzzards Bay watershed. Photo by B. Howes.

predominant in the watershed contributing to the head of the bay (Fig. 5.2). Two primary methods are used in cranberry harvest: water harvesting, whereby bogs are flooded during the harvest season and the floating berries can easily be gathered on the surface of the water, and dry harvest, where the berries are mechanically scooped dry, which tends to damage the vines. The disadvantage of wet harvest is more rapid deterioration of the berries, with these generally processed for juice or sauce (90% of the national cranberry market). Dry-harvested berries are generally sold fresh or frozen, making up the balance of the market.

Cranberry cultivation has often been scrutinized for its potential as a source of pollution to coastal waters in that fertilization and pesticide application are common practices in this agriculture (Fig. 5.3). Increased demand for cranberry products has generally resulted in more efficient agricultural practices rather than overall areal growth, with chemical application methods becoming increasingly sophisticated to maximize yields. A constant concern has been the potential for coastal eutrophication resulting from nutrient losses through runoff and groundwater flow. However, measurements of inputs and losses from a major cranberry bog into the head of Buzzards Bay (Buttermilk Bay) indicate that losses are small, comparable to those generated by low-density (0.4 ha) residential development and certainly less than those of other dominant shoreline uses around the bay (Howes and Teal 1992). Nutrient retention by the bogs is consistent with crop management practices to prevent overfertilization, which tends to reduce yields by encouraging excessive vegetative growth. Generally, growers in the Buzzards Bay watershed apply only enough fertilizer to compensate for the nitrogen lost in berry harvest. Pesticides generally used in cranberry agriculture have been approved by EPA for application, and most have short life spans in the environment. With the increased use of recycled bog water (primarily due to limited water supplies), residual pesticides and nutrients are given additional opportunity to become sequestered within the bog before the potential for loss to adjacent coastal waters. Although fertilized, the bog loses about one-half to one-third of the amount of dissolved inorganic nitrogen (DIN, a readily bioavailable form of nitrogen) per unit area compared to detailed studies of a natural wetland, Great Sippewissett Salt Marsh (Valiela and Teal 1979). The pattern of loss is roughly the same for both systems, with greatest losses occurring during the coolest parts of the year when the receiving coastal waters are less sensitive to inputs.

The dairy industry has been identified as a potentially important source of agriculturally based pollution to Buzzards Bay waters. The towns of Carver, Rochester, and Westport are the primary sites within the watershed, with only Westport located directly on the bay. All of these towns have seen a decrease in agricultural activities in recent decades as residential development has replaced farmland. Of the three towns, Westport supports most of the dairy industry, although it has declined by more than half in the past two decades. However, closures of shellfish areas because of bacterial contamination have become more frequent even while the total number of dairy cows has decreased because the density of cattle per hectare in many areas has increased. The greater density has increased manure concentrations in some places, causing higher inputs in runoff from pastures and feedlots to streams entering the river and bay. As more land is converted from agricultural to residential housing, pollutant inputs from the dairy industry will be replaced, most likely with somewhat different but nevertheless significant inputs from humans.

Marine Economy. The marine economy in Buzzards Bay consists primarily of commercial finfishing and shellfishing, although commercial finfishing is prohibited in the central bay. Much of the commercial fishing fleet is based out of New Bedford, with most fishing activities concentrated offshore. The shellfishing industry, however, is centered primarily within Buzzards Bay. Four major species of shellfish are harvested—quahogs (or hard-shelled clams, *Mercenaria mercenaria)*, oysters, soft-shelled clams (or steamers), and bay scallops (see also Chapter 4). Quahogs represent the largest portion of the shellfishery, yet significant numbers of the other major species are harvested each year.

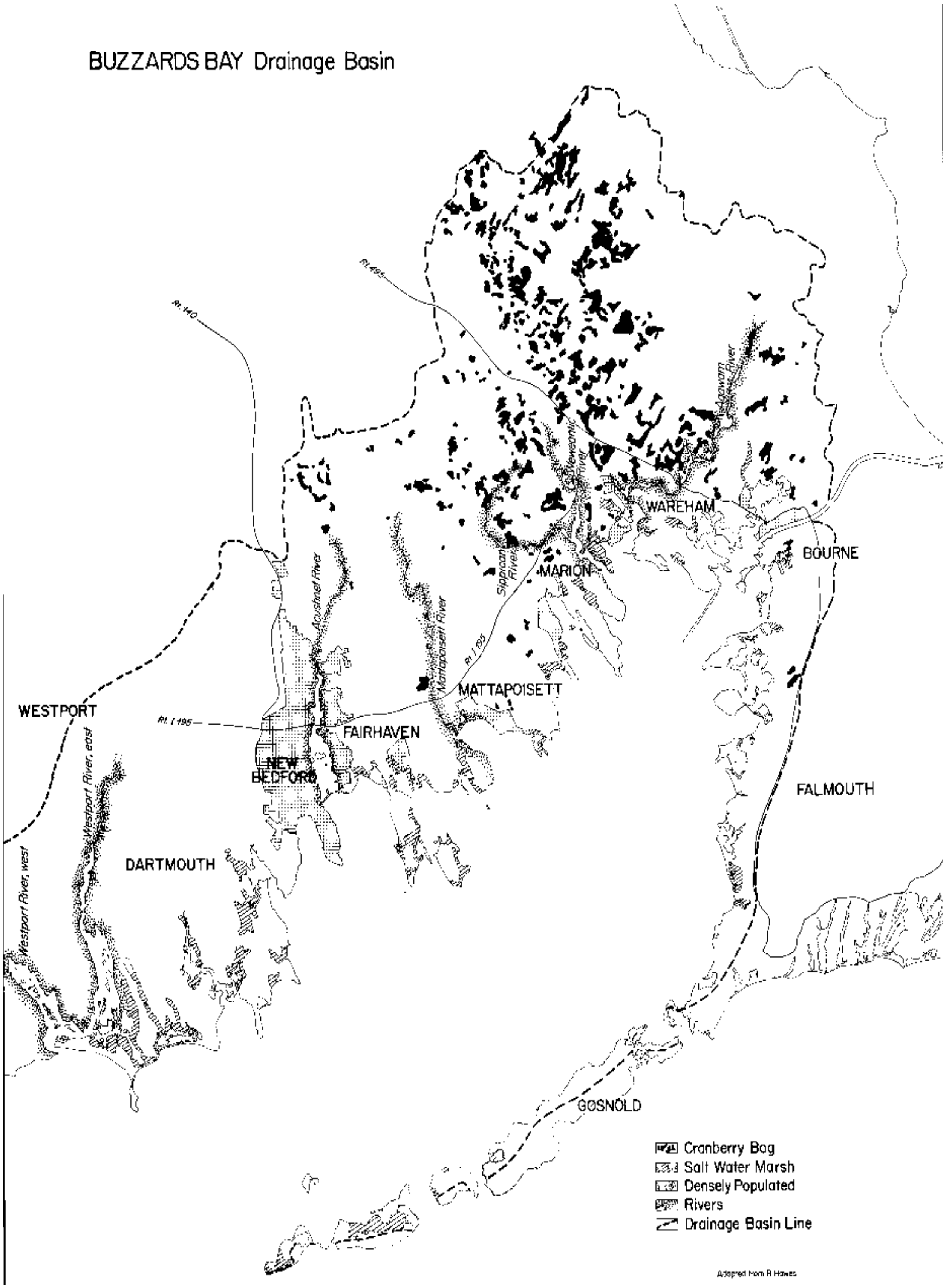

Fig. 5.2. Location of major cranberry bogs around Buzzards Bay.

Fig. 5.3. Spray irrigation on cranberry bogs, the primary method for application of fertilizer and pesticides, although flooding is also used for pest control. Photo by B. Howes.

As commercial finfishing is prohibited within Buzzards Bay waters, the marine economy most impacted by poor water quality conditions is the shellfishing industry. Unfortunately, only limited long-term information is available on local catches, and much of these data are of marginal quality for our purposes. The lack of information restricts our ability to look at long-term trends in economic losses caused by pollution or overfishing. Closures of shellfish beds because of coliform contamination, however, provide a general idea of the increased impact of anthropogenic activities within the watershed (cf. Chapter 6).

Although commercial marine activities do contribute some pollution to the bay, they also tend to be the most affected by pollution. This is particularly evident in the steady increase of shellfish bed closures caused by fecal coliform contamination, originating from road runoff, damaged septic systems, and wildfowl and other animal wastes. The average of 1,764 ha closed to shellfishing in 1970 has steadily increased, reaching an average of 4,452-4,856 ha in 1988 and nearly 6,070 ha in 1990. Although only a moderate portion of the overall shellfishery (primarily through recreational harvest), soft-shelled clams are particularly affected by bed closures since they are concentrated in areas most susceptible to bacterial contamination such as shallow nearshore embayments. The impact of the shellfishery (and recreational finfishery) on the marine economy is much greater than value of the annual catch because both support secondary industries and tourism.

5.3. Fisheries

Although early records of fish catches in Buzzards Bay are quite limited, it is clear that fish represent one of the most important resources of the bay. After the initial establishment of farming to ensure an adequate food supply, the early settlers turned toward the bay to supplement their diets. Salted and dried fish, primarily cod and mackerel, kept well and are frequently referred to in the historic literature, although many other species were also caught in the bay for immediate consumption. Schools of mackerel, bluefish, sea bass, butterfish, scup, and menhaden historically provided a significant catch in the deeper open bay waters (Belding 1916). In the late 1800's, the bay was also a source of menhaden, alewives, tautog, squeteague (also known as weakfish), and eels (Baird 1873). The extent to which Cape Cod's namesake, the codfish, was plentiful in Buzzards Bay waters is unclear; however, it has historically been part of the catch within the bay during late winter through early spring before it moves offshore during the warm summer months. The value of codfish to early settlers is evidenced by the fact that in 1639 the General Court of the Massachusetts Bay Colony ordered that these fish no longer be used as fertilizer. Cod landings for coastal Massachusetts vary widely, from a record high of 133,000 t in 1880 to 16,000 t in 1965, and 18,000 t in 1972 (Clayton et al. 1978).

Natural within-species variability compounds the difficulties with identifying long-term changes in fish populations within Buzzards Bay waters. For instance, scup were abundant when the early settlers arrived, notably from 1621 to 1642, but at some point toward the end of the century they virtually disappeared. They reappeared in abundance about 1794 and decreased again around 1864 but did not disappear completely (Baird 1873). Scup must have been an important resource, especially in the late 1800's, as many petitions were introduced to control certain fishing methods to protect their apparently declining stocks. Often the declines of many fish species were blamed on the voracious and relatively nonselective feeding of bluefish, which are frequently found to have not only scup in their stomachs but also rock crabs, eels, sand lances, and a whole variety of other species. Remarks presented by a gentleman named Atwood at the 1870 Conference of the United States Commissioner of Fisheries stated that "all present" (including the commissioners of Rhode Island and Massachusetts) at those meetings agreed "scup, tautog, sea-bass and striped bass had within a few years diminished in Buzzards Bay," (Atwood 1820:117) but that overfishing was not a clear cause of this decline. These petitions also referred to concern over the threat of overfishing to mackerel. Mackerel are migratory and, swimming in large schools, provide a substantial catch if found. Their transient nature, however, made them somewhat unreliable as a sustainable fishery, and although mackerel were easier to cure than codfish, anglers were often more inclined to fish for other more dependable species. Nevertheless, mackerel were abundant, and their surface swimming behavior made them a frequent catch in fish weirs.

A representation of historical changes in catch compiled for the Buzzards Bay Comprehensive Conservation and Management Plan by Moss and Hoff (1989) is shown in Fig. 5.4. Records prior to 1920 indicated about 190 species of finfish spent some portion of their life cycle in Buzzards Bay. Unfortunately, few data exist from 1920 to 1960; however, for the post-1960 period 100 species of finfish have been identified. Combining the two periods, over 203 species of fish have been recorded in Buzzards Bay (Moss and Hoff 1989). This information indicates that Buzzards Bay fisheries were dominated previously by Atlantic mackerel, butterfish, silver hake *(Merluccius bilinearis)*, alewives, herring, and scup (Fig. 5.4). Today the most abundant fish species in Buzzards Bay are scup, winter flounder, and butterfish (Table 4.2). Bluefish, striped bass, and Atlantic mackerel are also seasonally prevalent in the bay, using it in summer and fall as a nursery ground. Young-of-the-year butterfish, sea bass, and scup numerically dominate the fauna each year.

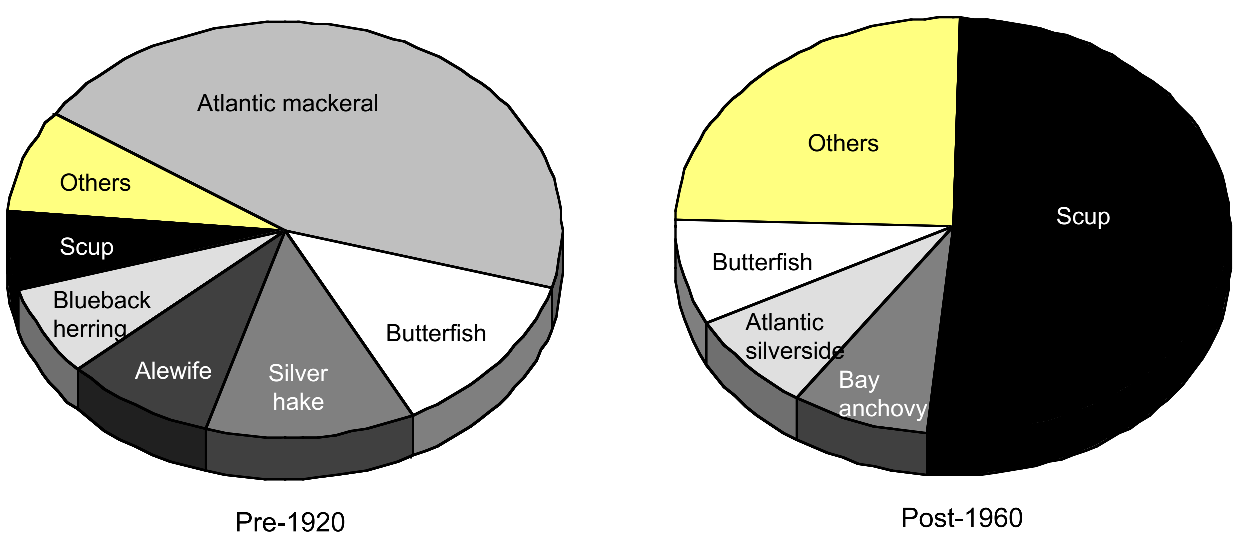

Fig. 5.4. Changes in reported fish catches for Buzzards Bay. From Buzzards Bay Project (1987).

The cause for the apparent species changes is unclear but may only reflect sampling differences from various fishing methods (i.e., traps vs. lines) and sampling locations as well as methods of recordkeeping (Moss and Hoff 1989). Trap fishing, for instance, was common before 1920 yet is not used to any great extent today. Although most of the species abundant in the pre-1920 data were present after 1960, there are some real differences in dominance. Shad, abundant in earlier years, are not abundant today (Davis 1989). Historic records disagree occasionally, as they do for instance with scup. Scup are identified as being important (but not dominant) before 1920 (Moss and Hoff 1989); however, substantial catches of scup were also reported in 1888, appearing in such numbers "as to bring down the price so that it hardly paid to ship them to New York" (Nye 1889:160). Also, testimony from Theodore Lyman, the Massachusetts Commissioner of Inland Fisheries in 1872, stated that "no representative (of the `white fishes') has been more abundant on the south shore of Cape Cod than the scup" (Lyman 1872:112). Lyman attributed the decline in scup populations in these waters, including Buzzards Bay, to want of food, traps, and bluefish. He dismissed pollution as a cause, referring to the large numbers of fish and shellfish living in proximity to industries (Baird 1873).

Anadromous fish utilize Buzzards Bay for an important stage in their life cycle, the migration from salt water to brackish or freshwater areas for the purpose of spawning (see also Chapter 4). Several species dominate the anadromous fish populations in Buzzards Bay: alewives, blueback herring, white perch, rainbow trout (*Oncorhynchus mykiss*), and rainbow smelt. Of these, alewives have been historically dominant, most notably in the regions of the Acushnet, Mattapoisett, and Wareham rivers. Arriving earlier in the year than herring, alewives were usually caught for local consumption, with herring often exported (Wilcox 1887).

Blueback herring historically have been abundant in the bay; they were so plentiful that the early settlers would spread them on the land for fertilizer, a practice they learned from the Native Americans. The Pilgrims would bury two or three herring in each hill of corn, a practice known as "spot fertilizing." The success of corn cultivation by the early settlers was attributed to this practice, since no other source of manure was available to them. Many of the fields the Pilgrims worked had previously been cleared and cultivated by the Native Americans and had become depleted in nutrients. The herring were abundant, and the practice continued even after animals were imported from England, especially for corn, to preserve manure for other crops. As is true for alewives, herring were so important for food and fertilizer that laws were passed in the early 1700's to prevent grist mills, saw mills, and other water-powered industries from interfering with the upstream migration of these fish (Fawsett 1990).

The productive shellfish resources of Buzzards Bay have long represented a readily accessible and abundant source of food and income for residents living on or near the bay. The four primary shellfisheries are quahogs (or hard-shelled clams), scallops, soft-shelled clams, and oysters, with a relatively small fishery in surf clams and mussels (see also Chapter 4). The catch from recreational fishing of these species generally meets or exceeds that of the commercial fishery in all cases except for quahogs. Quahogs represent the largest commercial shellfish industry for Buzzards Bay, with commercial catch generally exceeding the catch of all other species combined (Table 5.1).

The hardiness of this bivalve with its rugged shell and ability to close tightly when disturbed or faced with low oxygen conditions results in a relatively long lifetime for individuals of this species. Littlenecks and cherrystones are the smallest of the allowable harvest, and they are favored for steaming, as well as for eating whole and raw. Chowder clams are generally chopped and used in chowders or other seafood dishes. Although catch statistics generally do not break down into size classes, each class maintains a somewhat distinct market (even though most methods of harvest do not discriminate among sizes). As the most important commercial shellfishing industry in Buzzards Bay, the steadily increasing harvests of this clam reflect their value to the

Table 5.1. Recreational versus commercial shellfish landings for Buzzards Bay by year (in kilograms). 1977-1982 data from Massachusetts Division of Marine Fisheries in Terkla et al. 1990 (data not available on bay scallops and surf clams); 1983-1990 data from Steven Cadrin, Massachusetts Division of Marine Fisheries, Sandwich, Mass.

	Quahogs		Soft-shelled clams		Oysters		Bay scallops		Surf clams		Mussels	
Year	**Rec.**	**Com.**	**Rec.**	**Com.**	**Rec.**	**Com.**	**Rec.**	**Com.**	**Rec.**	**Com.**	**Rec.**	**Com.**
1977	517,068	358,888	198,814	0	30,046	35,562	179,444	1,244,134				
1978	530,458	531,801	204,084	726	57,662	26,490	48,858	1,701,326				
1979	564,460	490,251	199,439	2,830	6,260	15,422	320,350	1,022,378				
1980	593,998	637,108	224,224	75,334	71,233	19,414	37,848	91,409				
1981	607,316	1,352,381	232,570	29,684	70,326	38,683	34,619	153,825				
1982	570,266	2,671,160	247,230	45,578	81,212	64,774	550,053	573,641				
1983	290,259	2,309,659	61,182	12,481	28,658	14,098	17,908	90,482	0	7,348	2,859	6,151
1984	125,479	2,209,204	85,585	43,524	13,608	92,453	5,906	69,466	1,497	44,144	2,722	4,191
1985	1,444,135	1,723,616	112,647	31,968	38,320	42,811	315,787	1,384,791	4,627	0	6,396	14,179
1986	476,089	2,044,956	119,315	83,771	30,945	42,947	10,777	29,393	0	0	4,491	4,844
1987	570,447	2,138,111	122,758	106,768	32,221	52,282	0	6,559	1,497	0	0	8,573
1988	438,749	1,474,046	96,445	75,660	17,609	45,233	0	816	163	0	136	490
1989	404,647	1,566,907	92,553	59,189	10,435	11,009	272	6,341	327	0	218	925
1990	316,114	1,079,268	55,069	109,675	3,388	0	0	1,959	272	0	272	1,170

fishery. They are the only one of the four major shellfish species found in water deeper than about 3 m. Before 1982, there were few deepwater quahog dredge boats in Buzzards Bay, with harvesting primarily conducted in shallow waters. The abrupt expansion of the deepwater fishery resulted in a large increase in quahog landings (Terkla et al. 1990), along with a parallel increase in landed value prices.

The highly prized bay scallop makes up an important fishery, especially in the shallower reaches of the bay. Although generally carrying a relatively high market price in comparison to other species, the significant year-to-year variability of scallop populations makes them a less dependable commercial resource relative to the more stable quahogs, soft-shelled clams, and oysters. The scallop has only one spawning season and is relatively short lived (only a couple of years on average); therefore, year-to-year populations can fluctuate substantially depending on the success of the previous set. In addition, scallops may grow to marketable size before they reach sexual maturity (Walsh et al. 1978), potentially reducing the number of individuals available for spawning (Capuzzo and Taylor 1979). The fishery began in the 1870's, focusing primarily on the western shore embayment of New Bedford and the Acushnet River; however, because of industrial contamination this area no longer provides the scallop resource of the past. West Falmouth harbor on the eastern shore has historically been an area of high scallop production. Increased interest and activity have been directed toward managing the scallop fishery in recent years, with attempts to increase natural production by transplanting or seeding scallops from productive beds and commercial hatcheries. The apparent decline in the population, as defined by the annual landings (Table 5.1), has all but removed this fishery from the bay in recent years; the cause of the decline is not known.

Oysters, being somewhat limited in distribution around the bay, represent only a small portion of the total shellfishery. Although found on both shores, oyster populations are not abundant. Anecdotal historical information and the presence of shell middens left by the Native Americans indicates oysters were once very prevalent in the bay. Most indications are that overfishing of this resource is the cause of long-term changes in the population, as supported by declining commercial and recreational catches over the past few years (Table 5.1). The apparently declining populations of this and the other shellfish species have resulted in attempts to seed areas such as New Bedford with stock from other areas within the bay. The requirement for suitable substrate for the settling of oyster spat has resulted in the establishment of new oyster beds in areas where artificial structures have been constructed, such as the spillway for the hurricane barrier in New Bedford Harbor.

One of the primary threats to the Buzzards Bay shellfishery (although not the shellfish) is the ever-increasing number of shellfish bed closures because of bacterial contamination. Routine monitoring of fecal coliform bacteria is conducted by the State of Massachusetts Division of Marine Fisheries; high levels of coliforms (greater than 14 colonies/100 ml) in a shellfish area will result in bed closure. Closure is done primarily to protect public health; however, the method has come under scrutiny in past years, as it does not necessarily reflect the ecological health of the environment. Coliforms are easily measured and although not directly harmful to humans are sometimes associated with other enteric pathogens harmful to human health. Shellfish bed closures that are due to the presence of coliform bacteria have increased dramatically over the past decade, paralleling the increased population growth experienced in the Buzzards Bay watershed (see also Chapter 6).

Although methods of estimating shellfish catch vary from town to town, total catch for Buzzards Bay in 1983 was estimated at over 91,000 bushels (36.3 kg/bushel). Of this, 76,000 bushels were commercial landings. In 1987, catch estimates increased to over 136,000 bushels, 94,000 of which were from commercial landings. This increase was in spite of declining fishable areas available due to increased closures from coliform bacteria. The value of the Buzzards Bay shellfishery in 1985 was estimated at

$6,575,000 (S. Cadrin, Massachusetts Department of Marine Fisheries, personal communication).

In contrast to their reputation as a high priced delicacy today, lobsters historically were so abundant they were considered "poor man's food." Records from the early days of the Plymouth Colony described occasional "plethoras" of the species thrown up onto the beach after a storm, sometimes several layers deep and often considered a nuisance. In some parts of the country, especially the south, lobsters were fed to the servants and slaves so frequently that a colonial Virginia government granted a petition that lobsters were not to be fed to these individuals more than twice a week. Cape Cod appears to be one of the first areas to actually pursue the lobster as a true fishery in its own right in the late 1700's; the well known Maine fishery did not support a lobster fleet until around 1940 (O'Brien 1990). What was once considered a nuisance species has now turned into a multimillion dollar industry (see also Chapter 4).

The reason for the apparent decline in lobster populations for the past few hundred years is not totally clear, but overfishing and in some cases coastal pollution are generally identified as the primary causes. In 1841 the average catch for Buzzards Bay was one lobster per day per pot. Today, the average catch per 3-day set is 0.8 lobsters per day (Davis 1989). Compared with 1841, today's rate of 0.8 lobsters per day per pot appears low, but the per unit catch in Buzzards Bay is still relatively high when compared to that of northshore fishing areas (Estrella and McKiernen 1988, 1989). Buzzards Bay today remains a very productive lobster area (Davis 1989). The lobster fishery originally began around 1807 along the Elizabeth Islands, primarily in Cuttyhunk. In 1880 the lobster catch from the New Bedford district (84, 155 kg) was as follows: New Bedford, 22,919 kg; Fairhaven, 20,412 kg; Mattapoisett, 1,361 kg; Dartmouth, 34,020 kg; and Westport Point, 5,443 kg. Lobster catch statistics from the period of 1981 through 1991 show the annual catch to be relatively stable over this period (Table 5.2) and similar to that of 100 years ago. The lobster fishery also provides a small recreational fishing industry. Lobster traps require some attention and must be checked frequently, especially in areas with higher lobster populations, to avoid cannibalism. In contrast to fishing, lobstering is not generally considered a recreational activity for the transient tourist; however, the increased demand for lobster in fish markets and restaurants around Buzzards Bay during the tourist season often results in inflated prices, frequently inspiring residents who do not routinely maintain pots to set out a few traps to catch lobsters for their own consumption.

Table 5.2. Commercial lobster landings for Buzzards Bay from 1981 to 1991. Data from Steve Cadrin, Massachusetts Division of Marine Fisheries, Sandwich, Massachusetts, personal communication.

Year	Landings (kg)
1981	97,088
1982	124,161
1983	144,033
1984	125,203
1985	107,653
1986	108,289
1987	113,298
1988	134,674
1989	143,401
1990	148,102
1991	131,868

Buzzards Bay is important to the regional lobster fishery as a productive spawning area and source of larvae for Massachusetts Bay via the Cape Cod Canal (Clayton et al. 1978; Davis 1989). The percentage of gravid females caught in 1987 in Buzzards Bay (31%) was significantly higher than those of regions north of Cape Cod. In comparison, areas north of Buzzards Bay maintained the following averages: Cape Ann, 4.5%; Beverly-Salem, 1.8%; Boston Harbor, 1.7%; Cape Cod Bay, 3.9%; and Outer Cape, 16.9% (Estrella and McKiernan 1988, 1989).