Chapter 3

The Buzzards Bay Setting: The Bay, Its Drainage Basin and Living Resources

Buzzards Bay is a moderately large estuary located between the western most part of Cape Cod, Southeastern Massachusetts, and the Elizabeth Islands. The bay is 28 miles long (45 kilometers), averages about 8 miles (12 kilometers) in width, and has a mean depth of 36 feet (11 meters). It is approximately 228 square miles (590 square kilometers) in size. The coastline stretches over 280 miles (470 kilometers) and includes 11 miles (18 kilometers) of public beaches that lure thousands of tourists from Massachusetts and neighboring states.

The Buzzards Bay drainage basin (Figure 3.1) covers 432 square miles (1120 square kilometers) and includes all or sections of 17 municipalities[1]. The ratio of land to water surface is 1.9:1; this is low compared to estuaries such as Chesapeake Bay and Delaware Bay, which have land-to-water ratios of 14.5:1 and 17.3:1 respectively. Approximately 236,000 people reside in the drainage basin at an average concentration of 540 per square mile, or 0.84 people per acre. The Bay itself is part of an interconnected hydrologic system that includes several rivers. Groundwater seepage is also part of the inflow to Buzzards Bay.

Along its western shore (west of the Cape Cod Canal) the drainage basin is formed by seven major river basins and a number of smaller ones. The largest river basins include the Agawam, Wankinco, Weweantic, Mattapoisett, Acushnet, Paskamanset, and Westport.

The eastern shore of Buzzards Bay (Cape Cod Canal to Woods Hole) is drained mostly by groundwater. Several river systems smaller than those on the western shore also drain this portion of the basin. The prominent freshwater streams along the eastern shore are the Back , Pocasset, and Wild Harbor Rivers and Herring Brook.

In general, rivers within the drainage basin are slow-moving, meandering streams near their headwaters and for most of their freshwater length. Nearing the coast, the action of the tides rapidly widens the channels as the transition occurs from freshwater stream to tidal estuary. On average, Buzzards Bay rivers are considerably shorter (usually much less than 20 miles (34 kilometers)) and have smaller drainage areas than other rivers within the state.

Physical Features of the Bay

The Bay was formed during the last ice age approximately 15,000 years ago. Before that, Buzzards Bay was periodically submerged as glaciers advanced and retreated through the region, causing sea levels to rise and fall. The southeastern side of the Bay (Bourne,

1 The Buzzards Bay basin includes small portions of two additional communities in Massachusetts and portions of three communities in Rhode Island. Refer to Appendix B for more details.

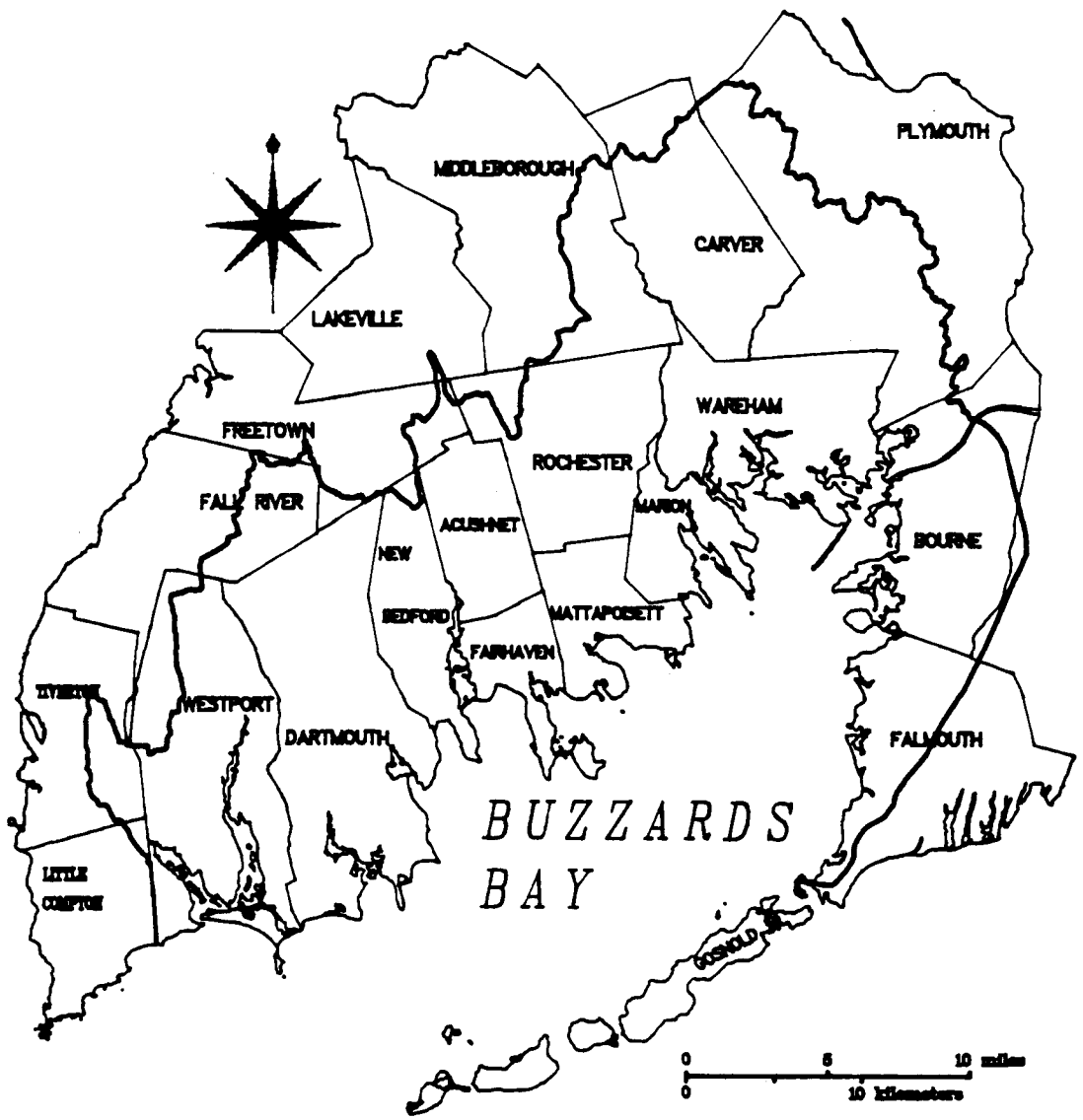
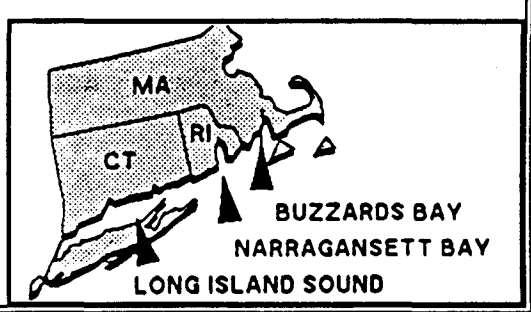


Figure 3.1. Buzzards Bay and its drainage basin

Town boundaries provided by MassGIS and digitized from 1:25000 scale USGS quadrangle maps. Basin boundary compiled by USGS-WRD and digitized by MassGIS. Cape Cod side basin boundary based on interpretation of water table elevation contours published in Hydrologic Atlas No. HA-692.



Falmouth, and the Elizabeth Islands) consists of glacial debris deposited by the glacier's leading edge. Consequently, it has a relatively smooth shoreline composed mostly of sand and gravel particles. The northwestern side (Wareham to Westport), with its numerous elongated bays and inlets, was formed by the glacier's retreat to the north. Many of these bays and inlets have since become sheltered from the ocean through the formation of barrier spits.

The distribution and stability of a bay environment depends on three primary physical characteristics of the water: circulation, salinity, and temperature. Tidal currents and wind are the dominant circulation forces in Buzzards Bay because the Elizabeth Islands protect the bay from large, long-period, open-ocean waves. Complete tidal mixing of Bay water with ocean water is estimated to occur every 10 days (Signell, 1987).

Water temperatures in the Bay range from a summer maximum of 71.6°F (22°C) to 28°F (-3°C) in winter. During colder winters, the upper reaches of the Bay often freeze, whereas during the spring and summer, solar warming keeps surface waters warmer than the deeper waters. The water temperature gradually decreases in relation to depth until a point is reached at which the temperature drops abruptly. Below that point, known as the thermocline, the temperature resumes a gradual drop until the coldest depths are reached at the bottom. The thermocline can act as a barrier to vertical mixing within estuaries and bays. Water turbulence helps to break up the thermocline and diminish layering. The shallowness of the Bay, combined with surface wave mixing and turbulent tidal flow, prevents strong thermal stratification, so that the Bay is well mixed through most of the year.

Salinity has a small annual range and gradually increases offshore. There are few large streams bringing fresh water into the Bay, with the result that salinity offshore is essentially the same as that of other embayments, such as Block Island and Vineyard Sounds, that receive relatively little fresh water. In the semienclosed embayments along shore, salinity is more variable. Overall, the Bay is a tidally dominated, well-mixed estuarine system.

Land Use Within the Bay

Much of Buzzards Bay remains undeveloped, with slightly over 60% of the land classified as forest[2] and 14% of the land classified in the residential/ commercial/ industrial categories (Table 3.1). Much of the forested land is away from the coast. When land use within a half mile of the coast is examined, only 40% is forested, and more than 30% is in the residential/industrial/commercial categories. Within specific embayment drainage basins, there is considerable variation as well. In the Buttermilk Bay drainage basin, 70% of the land is forested and 16% is developed, whereas in the Apponagansett Bay drainage basin, 37% is forested and over 31% is developed (Table 3.1). The large amount of undeveloped land highlights the importance of wise land-use planning to protect Buzzards Bay.

2 Figure as of 1984 from MassGIS database. Aerial surveys were conducted during a "leaf on" period, hence the low density development areas with dense tree cover may be underestimated somewhat and the forest overestimated. Land that has been already subdivided but has not been cleared or had structures built on it will generally fall in the "forest" category. The forest category also includes forested wetlands.

Table 3.1 Comparisons of land use in the Buzzards Bay drainage basin[1]

Land-Use Type	whole basin acreage	%	1/2 mile buffer of whole basin acreage	%	Buttermilk Bay acreage	%	Apponagansett Bay acreage	%
Cropland	9256	3.5	2478	4.6	72	1.0	159	4.6
Pasture	6161	3.4	1092	2.0	27	0.4	320	9.3
Forest	161153	61.5	21927	40.6	4408	70.0	1286	37.2
Non-Forest Wetland	4766	1.8	585	1.1	81	1.3	45	1.3
Mining	1585	0.6	348	0.6	0	0.0	8	0.2
Open Land	12675	4.8	2775	5.1	68	1.1	164	4.7
Particip. Recreation	778	0.3	197	0.4	0	0.0	4	0.1
Spectator Recreation	520	0.2	190	0.4	2	0.0	6	0.2
Water-Based Recreation	2045	0.8	1372	2.5	4	0.0	59	1.7
Resid.,Multi-Family	834	0.3	166	0.3	16	0.2	13	0.4
Resid., 1/4 Ac. Lots	6850	2.6	3858	7.1	272	4.3	82	2.4
Resid., 1/4-1/2 Ac. Lots	14045	5.4	5629	10.4	539	8.6	777	22.5
Resid., 1/2 Ac. lots	12572	4.8	5113	9.5	159	2.5	176	5.1
Salt Marsh	4907	1.9	4505	8.3	8	0.1	286	8.3
Commercial	2415	0.9	1156	2.1	23	0.4	21	0.6
Industrial	1380	0.5	688	1.3	0	0.0	10	0.3
Urban Open	4568	1.7	920	1.7	62.1	1.0	41	1.2
Transportation	3515	1.8	490	0.9	44	0.7	0	0.0
Waste Disposal	822	0.3	70	0.1	4	0.1	0	0.0
Woody Perennial	10993	4.2	501	0.9	500	7.9	2	0.0
TOTALS	261840	100.0	54060	100.0	6293	99.6	3457	100.0

[1] Note that these figures for acreage do not include land-use data for Rhode Island. Inland water area is ommitted from totals.

Habitats Of the Bay

Buzzards Bay is a special coastal region in the Commonwealth. The jagged border of Buzzards Bay bound by the glacial deposits that form the Elizabeth Islands creates many diverse environments around the Bay. The coastal zone of Buzzards Bay is characterized by a variety of important habitats including salt marshes, tidal streams, eelgrass beds, tidal flats, barrier beaches, rocky shores, and a number of subtidal habitats. Buzzards Bay is within the Virginian Biological Province, which means that the species in Buzzards Bay are typical of those found along the east coast between Chesapeake Bay and Cape Cod. The Cape Cod Canal, however, forms a direct tie to the cold-water species found north of Cape Cod. For these reasons, a unique mix of semitropical and arcadian species can be found in Buzzards Bay during different times of year.

Salt Marshes and Tidal Streams

Salt marshes are among the most productive ecosystems in the world—even exceeding most types of agricultural land. Historically viewed as waste land, salt marshes and tidal streams are now valued as an important resource that provides wildlife habitat, produces and exports large quantities of plant material and food to nearby coastal food webs, protects the coastal zone from floods, and absorbs some water-borne contaminants. Salt marshes add greatly to the aesthetic diversity of the coastal landscape, providing a source of recreational enjoyment through fishing, shellfishing, waterfowling, and nature appreciation in all seasons.

Salt marshes typically are located in intertidal areas behind barrier beaches, bordering pools or quiet water, or along the banks of tidal rivers. In 1984, there were an estimated 5,000 acres of valuable salt marshes along Buzzards Bay. Significant salt marsh areas are located in Dartmouth, Wareham, Westport, and Fairhaven (see Table 3.1).

"High marshes" are the areas of salt marshes inundated only during spring tides and characterized by the presence of the grass *Spartina patens*. "Low marshes" are the areas submerged by tides daily and characterized by the grass *Spartina alterniflora*. High marsh is dominated by salt-tolerant plants and terrestrial species of animals. Many shorebirds nest in the high marsh. Estuarine and marine invertebrates and fish are often abundant in low marshes and associated tidal creeks.

Water draining marshes enters coastal waters via streams or groundwater. Because dense layers of peat under marshes impede groundwater flow, groundwater transported from uplands may break out at the surface in springs or travel under the marsh's peat. The specific pathway of transport of waterborne contaminants such as coliforms and nitrogen through and around marshes has management implications because of potential human health risks and rates of attenuation differ depending on whether land drainage passes over or under a marsh.

Ditching of salt marshes has been a common practice since the 1930s as a method of mosquito control. The objective of ditching is to drain pools of water ("pans") in salt marshes as well as to provide fish access to these pools to feed on mosquito larvae. Today, new ditches are not commonly dug but old ditches continue to be maintained.

The practice has come under increased scrutiny and some scientists feel that valuable feeding habitat for shore birds and waterfowl may be lost by ditching efforts. Some open-marsh management programs are developing better ditching patterns to allow enhanced access by fish. The only alternative to ditching for mosquito control is limited pesticide use.

Eelgrass

Beds of subtidal eelgrass (*Zostera marina*), like salt marshes, are important food-production and nursery areas. This perennial plant is found in waters of varying salinity, growing in sand or mud, in depths ranging from just under low-tide level to 20 feet below sea level in places where sunlight penetrates to the ocean floor and current or wave action is not too severe. Eelgrass flourishes in salt ponds, bays, and at the mouths of estuaries and tidal creeks.

Eelgrass beds are important because they serve as a substrate for other plant and animal life, are consumed directly as food by grazing animals, offer protection and security to other marine animals, cycle nutrients in subtidal coastal waters, and provide a habitat for marine animals such as winter flounder. Eelgrass provides a critical nursery area for bay scallops, which often survive their first month of life by attaching themselves to eelgrass stems.

During the 1930s, most eelgrass disappeared in Buzzards Bay (and elsewhere in the Atlantic) because of a "wasting disease." The causes and timing of this event are still not fully understood, but eelgrass subsequently recovered throughout most of the Bay. Some areas showed no recovery, and in others, eelgrass recovered but new declines occurred, particularly during the 1970s and 1980s. The lack of recovery and the losses in these areas appeared to be the result of human disturbance and pollution, particularly from the addition of nitrogen to coastal waters (Costa, 1988). These new losses are a serious concern because, unlike areas affected by natural disasters, these areas will never recover until nitrogen inputs and other disturbances are reduced. Areas in Buzzards Bay where eelgrass has been impacted include New Bedford, Apponagansett Bay, the Wareham River estuary, and portions of West Falmouth Harbor, Buttermilk Bay, and Onset Bay. These areas have histories of human disturbance and pollution such as heavy boat traffic, sizeable nitrogen inputs from septic systems or wastewater treatment plants, and documented impacts such as shellfish bed closures and fish kills.

Because eelgrass beds are ecologically important and are increasingly threatened by human activity and development, there is interest in resource management initiatives to protect the beds. In addition, the now widespread distribution of eelgrass and its sensitivity to pollution qualifies its use as an indicator species to identify water quality degradation and declining health of coastal ecosystems.

Tidal Flats

Tidal flats are found in estuaries and quiet bays, behind barrier beaches, in salt ponds, and, depending on slope, below the depth of wave disturbance along the open shores of Buzzards Bay. These shallow, sloping flats exist in a range of salinities from the coastal areas to the upper reaches of the estuary. The substrate is composed of materials

ranging from very fine silt and clay to coarse sands. It is the combination of salinity, substrate quality, and character of water movement over the flat that determines the species composition of plants and animals.

Because of the lack of suitable substrate and the nature of the sand-mud environment, large plants do not take hold on these tidal flats. Instead, microscopic algae are prevalent. Most tidal-flat animals, such as clams, quahogs, and marine worms, have adapted to daily environmental stress either by burrowing beneath the exposed surface during low tide, or by living there at all times.

There are over 5,000 acres of tidal flats within the Buzzards Bay drainage basin. The largest amounts are found in Westport, Falmouth, Fairhaven, Mattapoisett, and Wareham.

Barrier Beaches

Barrier beaches are formed from sand and gravel transported by waves from a sediment source. Typically, they begin as sand spits that grow out from and parallel to the shore. Barrier beaches are usually long and narrow; they may be barely elevated above the level of high tide, or they may contain high dunes.

Barrier beaches can become islands when their connection to the shore has been breached by storm waves. Buzzards Bay has 209 designated barrier beaches covering 1,689 acres. Building on barrier beaches should be discouraged because these beaches protect the lands behind them from storm damage and because they tend to move over geological time.

Fisheries of the Bay

Lobster

Buzzards Bay lies in the central portion of the North American coastal range of the American lobster, *Homarus americanus*. In the United States, coastal Maine waters produce the greatest annual landings, with Massachusetts ranking second. The Buzzards Bay area records annual landings of approximately 253,000 pounds, or less than 3% of the statewide total. This represents an annual retail value close to $1,000,000. The total value of the lobster fishery for 1988 in Buzzards Bay, including vessels, gear, and lobster, was approximately $2.3 million. Although the lobster fishery is important to the local economy, Buzzards Bay is one of the less productive areas in terms of statewide commercial landings. Overall, lobster catches around the state and in Buzzards Bay have remained relatively constant over the past 10 years.

Lobsters are taken by pots or traps tended several days a week by licensed lobstermen. Massachusetts law prohibits the taking of lobsters by spearing, dipping, or dragging. In 1988, it is estimated that approximately 200 to 250 commercial lobstermen fished Buzzards Bay. In addition to the commercial fishery in Buzzards Bay, lobsters are taken by noncommercial lobstermen who fish up to the 10-trap limit or dive, taking lobsters by hand. There is no estimate of how many of the more than 10,000 noncommercial lobstermen in the state fish Buzzards Bay.

The lobster resource of Buzzards Bay, although not as economically productive as that of other coastal areas in Massachusetts, is extremely important for its production of lobster larvae. Female lobsters in Buzzards Bay mature earlier and at a smaller size than in more northerly coastal areas. This means that the existing legal size limit tends to protect some small mature females, allowing a higher percentage of them to bear eggs. This smaller size at sexual maturity may help account for an abnormally high incidence of egg-bearing lobsters in Buzzards Bay. In 1988, 28% of the female lobsters sampled by state biologists in the commercial fishery of Buzzards Bay were egg-bearing, compared to only 5% in other samples from coastal areas in the Gulf of Maine. Some researchers have attributed this earlier maturity to physical characteristics of the habitat, for example, relatively high water temperatures in the summer and restricted water circulation and exchange, in combination with a high population density of lobsters.

In June and July of each year, very large numbers of lobster larvae hatch in the waters of Buzzards Bay. Researchers have estimated larval concentrations to be 8 times higher in Buzzards Bay than in Block Island Sound during these months. A significant number of these larvae end up in the Cape Cod Canal and further east in Cape Cod Bay, contributing to its lobster population.

The lobster is a bottom-dwelling animal that is affected by and succumbs to disease caused by environmental pollution. In their investigations of 12 coastal sites in the state, the Massachusetts Division of Marine Fisheries found that two conditions, black gill disease and shell disease, were more common in lobsters from Buzzards Bay than in animals from other coastal sites. Lobsters sampled from the New Bedford Inner Harbor had the greatest incidence of the two diseases.

In 1979, PCB contamination prompted the Massachusetts Department of Public Health to close approximately 18,000 acres of fishing grounds surrounding New Bedford to lobstering. Recent investigations by the Division of Marine Fisheries found PCB levels in lobster averaged 0.96 parts per million (ppm). Concentrations in hepatopancreas (tomalley) probably exceed the 2-ppm action level established by the U.S. Food and Drug Administration.

Shellfish

The commercial and recreational shellfisheries of Buzzards Bay include quahog (*Mercenaria mercenaria*), bay scallop (*Argopecten irradians*), soft-shell clam (*Mya arenaria*), and oyster (*Crassostrea virginica*). In 1988, the commercial shellfish harvest in Buzzards Bay was worth $4.5 million, as compared to a statewide value of $18.8 million.

The quahog and bay scallop make up most of the annual commercial shellfish landings. The soft-shell clam and oyster are harvested primarily in the recreational fishery and together constitute a small portion of the total reported landings.

The shellfisheries in Buzzards Bay are managed in accordance with Massachusetts General Laws, Chapter 130, which authorize local control. Methods used by local officials to collect catch data from both the commercial and recreational fisheries vary by community. This makes the catch estimates of recreationally harvested shellfish problematic, particularly for use in implementing new management practices.

Like the rest of Massachusetts, Buzzards Bay is experiencing a dramatic increase in the number of acres of shellfish beds closed as a result of fecal coliform contamination. As of April 1991, there are 13,150 acres of shellfish areas closed. This represents a significant percentage of the Bay's productive areas.

The Division of Marine Fisheries authorizes the relay, or transplant, of quahogs from closed areas to clean areas. After relocation, the quahogs are allowed to depurate for at least three months, and through a spawning period, before the area is opened for shellfishing. Most relayed shellfish are taken out of areas closed because of coliform levels. Relaying of shellfish from toxically contaminated areas is less common but does occur, even out of severely impacted areas like New Bedford Inner Harbor. There is a lack of information on depuration rates of some toxic contaminants such as PAHs. Contaminated shellfish have been relayed to all Buzzards Bay towns in order to increase the utilization of the resource.

Finfish

Buzzards Bay is recognized as a highly valuable resource area for the many species of finfish that inhabit the Bay and also for those species that migrate north during the spring and summer. Its numerous inlets, coves, and freshwater streams are rich with small fish (minnows, sand eels, silversides, alewives) to attract the larger fish. Salt marshes and eelgrass beds offer protection to many species of young fish.

Buzzards Bay as spawning and nursery grounds for many important commercial and recreational species. Because of its recreational fishing values, Buzzards Bay was closed to commercial fishing by nets, seines, and fish traps nearly 100 years ago by an act of Congress. Species such as scup, sea bass, tautog, butterfish, winter flounder, shad, and alewife are the primary species that depend on the Bay for spawning and nursery grounds. During the spring and summer, bluefish, striped bass, and weakfish migrate north.

Other Living Resources

Marine Mammals

The harbor seal is the most abundant marine mammal throughout New England and the only marine mammal species commonly found in Buzzards Bay. Harbor seals are present in the Bay between mid-October and early May. Although a few seals are observed throughout the year, most move north to coastal Maine and eastern Canada prior to the pupping season, which occurs from mid-May through early July. Harbor seals occur throughout the Elizabeth Island chain. The largest single concentration of seals generally occurs at Gull Island; in 1988, about 280 seals were recorded at this location. Approximately 300-400 seals are found throughout the Elizabeth Islands and the remainder of Buzzards Bay throughout the winter.

In addition to the harbor seal, gray seals are occasionally seen on rock ledges in the Bay, but in very small numbers. Buzzards Bay is not considered a high-use habitat for whales, dolphins, or porpoises. However, these species have occasionally been observed or stranded in the Bay, because of its proximity to the southwest Gulf of Maine and Cape Cod Bay.

Marine Turtles

The leatherback turtle is the species most frequently encountered in Buzzards Bay, generally from July through November. Unfortunately, these turtles often are found dead due to entanglement (and subsequent drowning) in lobster gear, collisions with boats, or occasionally due to intestinal blockage after eating floating plastics.

The Kemp's ridley turtle is known to frequent areas adjacent to Buzzards Bay. In fact, it is the most common marine turtle reported (caught in fishing nets or stranded) within Cape Cod Bay. However, sightings within Buzzards Bay are rare, possibly because commercial fishing by nets and seines is prohibited from Buzzards Bay. Given the distribution of the species and the favorable conditions found in Buzzards Bay, the Bay may be a potentially important foraging area for juvenile and subadult turtles of this species during late summer and early fall.

Waterbirds

Although greatly reduced in numbers from previous levels, and somewhat reduced in diversity, birds remain an important component of the Buzzards Bay ecosystem. Because birds accumulate and are often sensitive to certain toxic chemicals, their health and breeding success can reflect the fates and persistence of environmental contaminants within Buzzards Bay.

Three species of terns breed along Buzzards Bay shores in significant numbers: the common tern, roseate tern, and least tern. The roseate tern, a worldwide species, breeds exclusively in only two areas: the northeast coast of the United States (New York to the Canadian Maritimes) and the Caribbean Islands. Buzzards Bay terns have experienced declines largely due to competition with gulls, although human disturbance is also a major factor influencing breeding numbers and distribution. Buzzards Bay roseate terns are currently listed as a federally endangered species. Recently (1988-89), several dead roseate terns and common terns with high levels of PCBs in their body tissue were picked up on Bird Island; these species sometimes feed in the vicinity of New Bedford Harbor. Bird Island in Buzzards Bay serves as the nesting areas for 98% of the North American breeding population of roseate terns (Blodgett, personal communication).

The arrival of herring gulls in the mid-1930s displaced nearly all the terns from several nesting colonies in just a few years. Because herring and (especially) black-back gulls eat tern eggs and chicks, the terns tend to move their colonies in response to influxes of gulls.

The piping plover is listed as a "threatened species" in Massachusetts. Fencing around piping plover habitat to exclude predators has been highly successful, boosting reproductive success significantly. Islands and other isolated areas make ideal nesting habitat for plovers and terns.

Only one species of cormorant breeds in Buzzards Bay: the double-crested cormorant. After being nearly eliminated in the 19th century, this species recolonized the Weepecket Islands in 1946. Since about 1970, this colony has been growing rapidly,

increasing from 150 breeding pairs in 1971 to 1135 in 1984. In 1986, another colony began on Ram Island, perhaps due to spillover from the Weepeckets.

During the 18th and 19th centuries, ospreys undoubtedly were abundant along the shores of Buzzards Bay. It is assumed that the early explorers in Buzzards Bay named this body of water after the osprey ("buzzards"). During the 1950s and 1960s, ospreys decreased by more than 50% due to DDT-related reproduction failure. Local use of DDT ceased after the mid-1960s and osprey reproduction revived about a decade later. By 1979, the Westport population had grown to 20 active nests (all but one on artificial platforms). A decade later, Westport had 69 active nests and ospreys were reappearing throughout the Bay, mostly because local residents put tremendous effort into building nesting platforms. Availability of safe, sturdy nest sites is a key limiting factor for this species.

Two species of wading birds are known to nest along Buzzards Bay shores: black-crowned night herons and snowy egrets. Several other waders roost and feed here, but none have been confirmed as breeders. At least 20 species of waterfowl (swans, ducks, and geese) are found on Buzzards Bay waters. Two broad categories of these waterfowl are sea ducks, such as common eiders, old squaw, and white-winged scooter, and estuarine species such as Canada goose, canvasback, and black duck.