Chapter 2. Buzzards Bay: Its Watershed, Living Resources, and Governance

Buzzards Bay Setting

Buzzards Bay is a moderately large estuary located between the western most part of Cape Cod, Southeastern Massachusetts, and the Elizabeth Islands (Figure 4). The bay is 28 miles long (45 kilometers), averages about 8 miles (13 kilometers) in width, and has a mean depth of 36 feet (11 meters). The Buzzards Bay NEP jurisdictional area of Buzzards Bay is approximately 250 square miles or 650 square kilometers in size[5]. The coastline stretches over 350 miles (563 kilometers)[6] and includes over 13 miles (21 kilometers) of public beaches that lure thousands of residents and tourists.

The Buzzards Bay watershed or drainage basin (defined also in this document as the NEP study area[7], Figure 4) covers 435 square miles (1209 square kilometers) and includes portions of 21 municipalities in two states, although 5 towns, including the two in Rhode Island, have relatively small areas (<14%) within the Buzzards Bay watershed. A complete list of all the communities and their area and population within the watershed are shown in Table 1.

The ratio of watershed land area to water surface is 1.9:1. This ratio is low compared to other National Estuary Program watersheds, and low compared to large east coast estuaries such as Chesapeake Bay and Delaware Bay, which have land-to-water ratios of 14.5:1 and 17.3:1 respectively. Approximately 250,000 people reside in the drainage basin at an average concentration of 572 per square mile, or 0.9 people per acre.

The bay itself is part of an interconnected hydrologic system that includes some rivers, but mostly a large network of small perennial streams totaling nearly 700 linear miles. Groundwater seepage accounts for a large part of the freshwater inflow to Buzzards Bay, particularly in Wareham, Bourne, and Falmouth that have large sandy soiled glacial outwash plains and till areas. Along its western shore (west of the Cape Cod Canal), the drainage basin is formed by seven major river basins and numerous smaller ones. The largest river basins include the Agawam, Wankinco, Weweantic, Mattapoisett, Acushnet, Paskamanset, and Westport. These rivers, including their tributaries, total roughly 100 miles[8].

As noted above, the eastern shore of Buzzards Bay (Cape Cod Canal to Woods Hole) is drained mostly by groundwater, but there are several small groundwater-fed streams. The most prominent of these freshwater streams along the eastern shore are the Back, Pocasset, Wild Harbor Rivers, and Herring Brook.

In general, rivers within the Buzzards Bay drainage basin are relatively slow-moving, meandering streams near their headwaters and for most of their freshwater length. Nearing the coast, particularly on the western shore, past glacial erosion of the bedrock created wide river valleys that are today submerged, creating a network of broad, elongated, fringing tidal estuaries. On average, Buzzards Bay rivers are considerably shorter, (only a few exceed 20 miles or 34 kilometers) and have smaller drainage areas than other rivers within the state.

Physical Features of the Bay

Geologic Formation

For millions of years, the shore and continental shelf of southern New England was periodically submerged and exposed by the ocean as the climate repeatedly warmed then cooled, and glaciers advanced and retreated across the northern hemisphere, causing sea levels to rise and fall. The foundation for the modern configuration of Buzzards Bay was formed by the last ice age.

During the last ice age, over many tens of thousands of years, great masses of glacial drift, chiefly boulders, gravel, sand, and clay were deposited at the leading edge of the Laurentide ice sheet. When the ice cap began receding 19,000 years ago[9], these moraines of unstratified glacial drift formed large hills on the eastern and south-

[5] Other agencies and publications define different boundaries for Buzzards Bay. The Buzzards Bay NEP jurisdictional area and the EPA approved No Discharge Area is a straight line drawn from the Rhode Island Border to Cuttyhunk Island. The boundary based on nautical chart and US Coast Guard definitions (a line drawn from Gooseberry Point to Cuttyhunk Island, and which excludes the Cape Cod Canal), is approximately 233 square miles. If all state waters to the south of the Buzzards Bay NEP line are included (as employed by the Division of Marine Fisheries), the area is roughly 280 sq. miles. See the municipal boundaries in Figure 4.

[6] This total is includes 310 miles of coast, including embayment coastlines, for the mainland portion and Cape Cod coast of Buzzards Bay, and 40 miles of coastline on the bay facing side of the Elizabeth Islands. This total does not include the 9 miles of coastline along the Cape Cod Canal within the NEP study area.

[7] The NEP study area, land watershed area, and bay boundary adopted in this Management Plan are quite similar to the original NEP study area used throughout the 1990s and early 2000s, and the Buzzards Bay boat waste No-Discharge Area adopted by the U.S. EPA in 2000. The watershed area changed mostly in the Cape Cod and Plymouth/Carver portions of the basin based on new groundwater models. An explanation of these changes can be found at: buzzardsbay.org/buzzards-bay-boundary.htm.

[8] Based on MassGIS "major stream" coverage, which includes key tributaries and small pond connections.

[9] The most rapid melting began about 15,000 years ago.

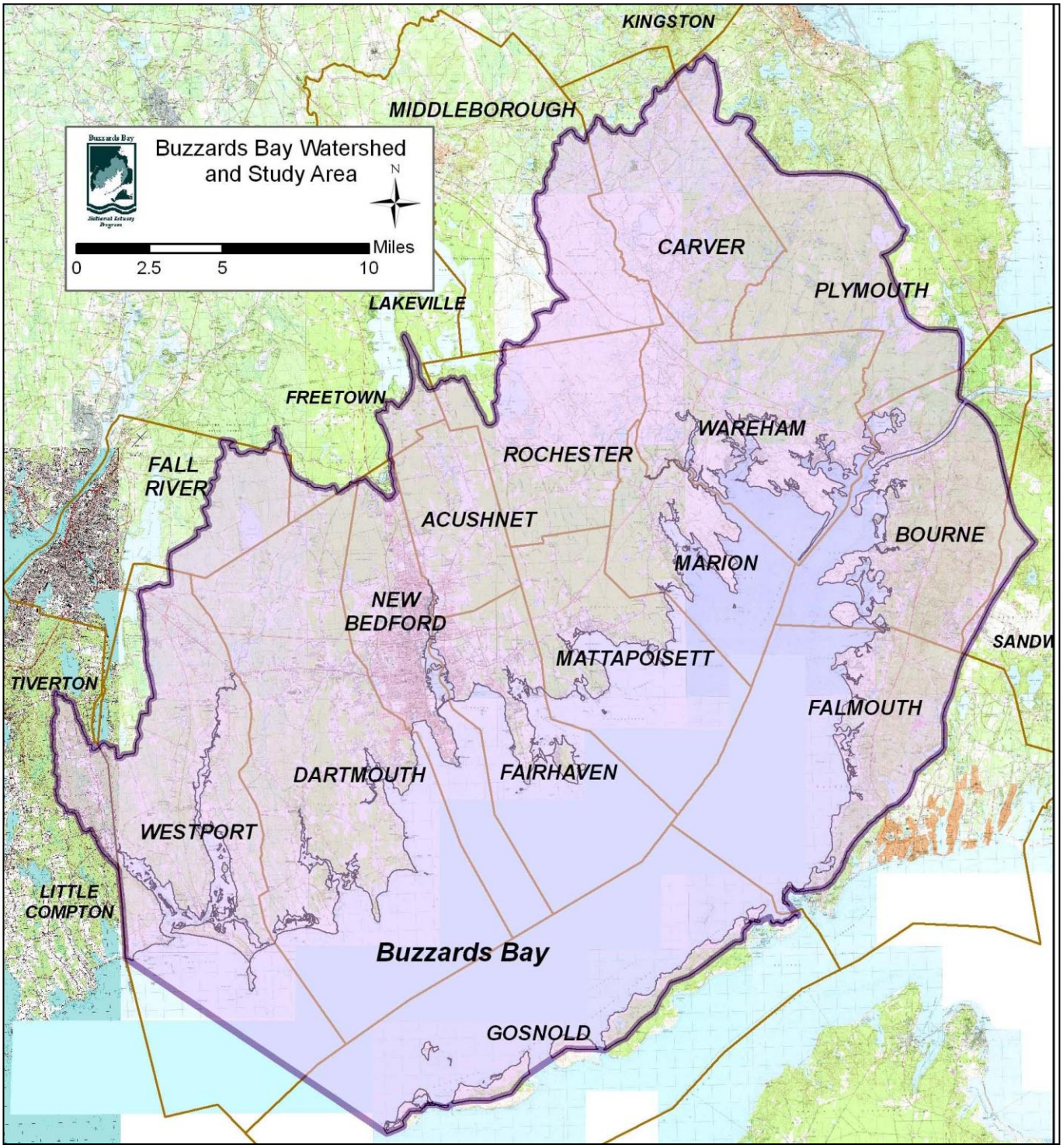


Figure 4. Buzzards Bay topographic map showing watershed (purple line) and municipal boundaries.

ern sides of a large valley, and formed what are Bourne, Falmouth, and the Elizabeth Islands today.

As the ice cap continued to recede across Canada, sea level rose hundreds of feet with the greatest increases occurring during the first 10,000 years of ice cap melting. Still, as late as 8,000-9,000 years ago, Buzzards Bay remained an upland valley (Shaw, 2006), with rivers flowing into the sea along the western side of the bay in various configurations that would later form the irregular coastline of the bay as the rising sea drowned these ancient river valleys.

Five thousand years ago, sea level was likely at least 21 feet lower in southern New England than today[10]

[10] Donnelly (1998) concluded (based on radiocarbon dating of buried salt marsh sediments) that 5,000 years ago, sea level was

Table 1. Summary of town areas and year-round population (U.S. 2010 Census) within the Buzzards Bay watershed.

Town	Total municipal area including coastal waters sq. mi (1)	Coastal Waters (sq. miles)	"Land" sq. miles (2)	Total municipal "Land" acres	% in the watershed	sq miles in watershed	US Census 2010 population	2010 population estimate in watershed (3)	% of 2010 population in the watershed
Acushnet	18.9	0.1	18.9	12,082	100.0%	18.88	10,303	10,303	100%
Bourne	57.3	16.2	41.1	26,293	83.2%	34.17	19,754	14,850	75%
Carver	39.8	0.0	39.7	25,422	84.3%	33.50	11,509	9,211	80%
Dartmouth	96.2	34.3	62.0	39,653	100.0%	61.95	34,032	34,030	100%
Fairhaven	40.9	28.5	12.4	7,942	100.0%	12.41	15,873	15,873	100%
Fall River	40.0	1.5	38.5	24,668	27.6%	10.65	88,857	506	1%
Falmouth	103.2	57.7	45.5	29,135	41.8%	19.05	31,531	9,700	31%
Freetown	36.4	0.9	35.5	22,699	13.7%	4.88	8,870	1,619	18%
Gosnold	135.0	121.6	13.4	8,604	52.3%	7.04	75	30	39%
Lakeville	36.1	0.0	36.1	23,116	0.6%	0.21	10,602	48	0%
Marion	28.0	13.9	14.1	9,036	100.0%	14.12	4,907	4,907	100%
Mattapoisett	42.3	24.8	17.5	11,196	100.0%	17.49	6,045	6,045	100%
Middleborough	72.2	0.0	72.2	46,209	23.5%	16.99	23,116	2,091	9%
New Bedford	33.4	13.1	20.3	12,979	96.1%	19.48	95,072	92,964	98%
Plymouth	176.7	74.1	102.6	65,683	43.6%	44.73	56,468	7,190	13%
Rochester	36.1	0.1	36.0	23,062	91.5%	32.96	5,232	4,709	90%
Sandwich	67.7	23.8	43.9	28,108	4.3%	1.88	20,675	0	0%
Wareham	46.4	9.2	37.1	23,772	100.0%	37.14	21,822	21,822	100%
Westport	89.8	37.7	52.1	33,351	85.3%	44.46	15,532	11,969	77%
Little Compton RI	NA	NA	22.6	14,469	1.2%	0.28	3,492	279	8%
Tiverton, RI	NA	NA	30.4	19,448	8.2%	2.49	15,780	1,855	12%
Watershed Totals			**811.1**	**519,086**	**53.7%**	**435.24**	499,547	249,999	50%

Notes: (1) data source = bondyp1.shp from MassGIS, (2) Includes ponds and fresh surface waters, (3) U.S. 2010 Census tiger files census blocks (391 of 8,950 total blocks in the watershed) were clipped to Buzzards Bay watershed and population and housing units were presumed proportional to clipped area in the watershed. This analysis was based on the Buzzards Bay study area in Figure 4. Similarly, within the watershed boundary there are 116,204 housing units (both year round and seasonal/vacant).

(Donnelly, 1998; Engelhart et al., 2011), and the northern end of Buzzards Bay would have defined by a shoreline extending from Sippican Neck in Marion, to Scraggy Neck in Bourne.

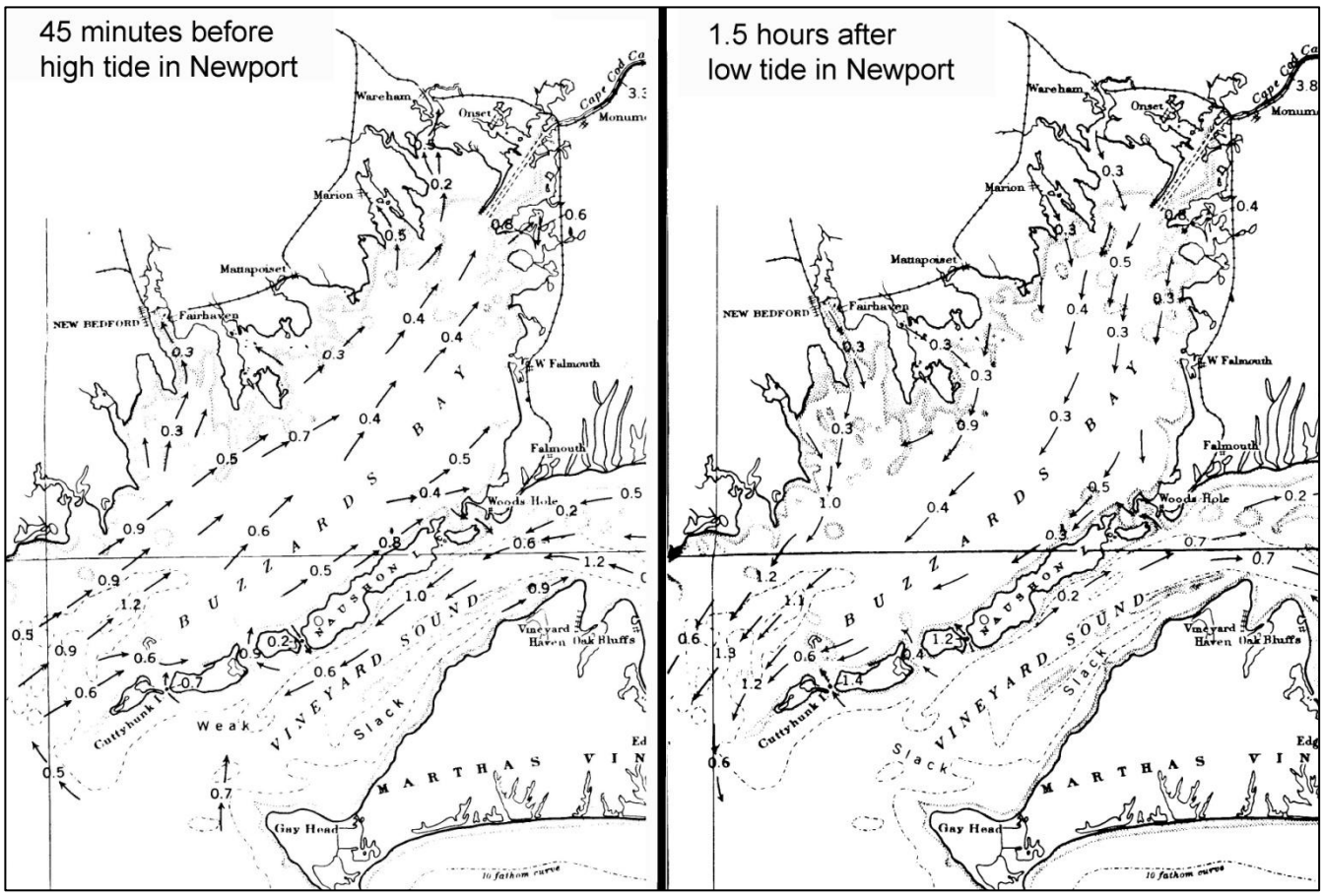
The rate of sea level rise subsequently slowed appreciably. Engelhart et al. (2011) estimated an average rate a bit over 5 inches per century during the last 4,000 years. During the past 3,300 years, sea level rose in a Revere, MA marsh 8.5 feet, or an average of 3 inches per century (Donnelly, 2006), with a higher rate in southern New England[11]. All during this period, sea level rose, and bluffs were eroded by waves and storms, many of the bays and inlets that formed became sheltered from the ocean through the formation of barrier spits and islands.

Salinity, Temperature, and Hydrology

The hydrology of Buzzards Bay and its embayments is driven by winds, tidal circulation, freshwater flow, salinity stratification, 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. Tidal exchange

about 39 feet lower in southern New England (=9.4 inches per century increase for the entire period), and 13 feet lower around Boston (=3.1 inches per century average). However, Engelhart et al. (2011) estimated a rate of only 5 inches per century during the last 4,000 years in the area New York. Extrapolating this rate for 5,000 years suggests that sea level was at least 21 feet lower.

[11] The sea level rise around Boston is slower than southern New England (Donelly, 1998; Engelhart et al., 2011). In addition, the rate was variable even during brief periods. For example, during the cold period known as the Little Ice Age (1300-1850), sea level rise in southern New England was less than 3 inches per century and higher in the preceding period (Donnelly et al., 2004).



Modified from Eldridge Tide and Pilot Book 1985. Robert Eldridge White, Publisher, and derived from a NOAA tidal currents chart.

Figure 5. Tidal currents in Buzzards Bay.

and currents flow back and forth between the southern entrance of the bay and Rhode Island Sound, through "holes" in the Elizabeth Island chain and Vineyard Sound, and to and from Massachusetts Bay through the Cape Cod Canal (Figure 5). Complete tidal mixing of bay water with ocean water is estimated to occur every 10 days (Signell, 1987).

Water temperatures in the bay, are on average, typically warmest from mid-July to mid-August (72º F or 22º C in Woods Hole), and coldest in January (34º F or 1º C)[12]. Temperatures nearshore and within embayments heat up more in the summer (Figure 6), and cool more in the winter, and thus exhibit more extreme ranges and fluctuations.

Like most of southern New England, Buzzards Bay shows dramatic differences between summer and winter water temperatures. During colder winters, embayments and large portions of the outer bay can freeze, usually with ice banking for a mile or more on the eastern and

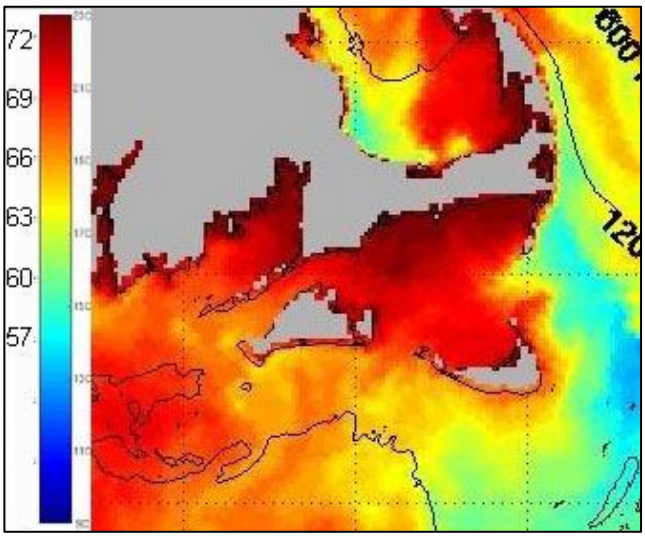


Figure 6. Satellite image showing estimated water temperatures in Buzzards Bay and around Cape Cod, June 2013.

NOAA-18 satellite, July 05, 2013, 4 AM local time, modified from marine.rutgers.edu/cool/sat_data/.

[12] Long-term averages as reported by NOAA at www.nodc.noaa.gov/dsdt/cwtg/all_meanT.html, last accessed October 1, 2013. For comparison, the average August maximum water temperature for the WHOI temperature data set from 1898-2006, is 73.2º, or 22.9º C (calculated by the BBNEP).

Photo by Joe Costa.

Figure 7. Ice on Buzzards Bay.
Photo taken January 1985 at Stony Beach in Woods Hole, looking southwest to Dartmouth.

northern shores (Figure 7). During the spring and summer, solar warming keeps surface waters warmer than the deeper waters. Temperatures in embayments can become quite warm, and in the daytime commonly exceeding 75º F (24º C) during heat waves in July and August. During the summer, Buzzards Bay is somewhat stratified, mostly due to changes in water density from temperature differences. In the central bay, water temperature gradually decreases with depth until a point where the temperature drops more abruptly. Below that point, known as the thermocline, the temperature resumes a gradual drop until the coldest depths are reached at the bottom.

Salinity within central Buzzards Bay has a small annual range, and is typically between 30.5 and 31.5 ppt (PSU values are approximately equivalent). It is lowest at the north end of the bay (it can drop to 28 ppt in northern Buzzards Bay in the spring during the period of greatest river flow[13]). Because of the relatively small watershed land area in relation to water area (few large streams bringing fresh water into the bay) and good tidal flushing, salinity in the south and central bay is nearly the same as that of the adjoining Rhode Island and Vineyard Sounds. In the semi-enclosed embayments alongshore, salinity can be more variable and is typically lower at the heads of the bays and during periods of greatest stream and groundwater discharge (winter and spring). Salinity is generally highest in late summer because of reduced freshwater inputs.

The thermocline and salinity stratification can act as a barrier to vertical mixing within deeper estuaries and the bay as a whole. Under certain weather conditions, when winds are calm and freshwater inputs are high, stratification can lead to brief hypoxic or anoxic conditions at night in some estuaries, resulting in fish kills. However, in general, wind-caused water turbulence, surface wave mixing, and turbulent tidal flow prevent strong stratification. A more thorough discussion of salinity, temperature, and tidal circulation in Buzzards Bay can be found in Howes and Goehringer (1996).

Land Use within the Bay

Much of Buzzards Bay remains undeveloped, with nearly 58% of the land classified as forest (Figure 8 and Table 3, from 2005 MassGIS data). A large portion of

[13] This is the result of freshwater discharges from the Weweantic, Wankinco, and Agawam rivers and the lesser flushing in the upper bay.

this undeveloped land is wetlands (Table 4), including notable forested wetlands like the Haskell Swamp of Mattapoisett and Rochester and Deerfield Swamp of Dartmouth. Strictly speaking, estimates of undeveloped lands from the MassGIS forest categories represent an overestimate of undeveloped land for several reasons. First, the MassGIS land use 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. Second, some portions of the watershed have 1 to 3 acre zoning, and where homes are located close to roads, the back portions of these developed lots would be lumped into the forest category. Finally, since the 2005 survey, hundreds of acres of land have been developed.

Despite these caveats, most buildout studies of Buzzards Bay communities suggest there are large amounts of undeveloped land with development potential. This fact highlights the importance of wise land-use planning, and the need for protection of sensitive open space areas to protect Buzzards Bay.

Figure 8 shows that the greatest density development is found in the greater New Bedford area (New Bedford, Dartmouth, Fairhaven, and Acushnet) where nearly half the watershed population lives. Dense development is also found in Wareham, Buzzards Bay village in Bourne, and other areas around the bay.

Within specific embayment drainage basins, there is considerable variation in land use. 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.

Cranberry bogs are widespread in the northern portion of the Buzzards Bay watershed, particularly in Wareham, Carver, Rochester, and Middleborough. Other agricultural land, particular dairy farms, and crops like corn are found in Westport and Dartmouth.

Much of the forested land is away from the coast, and most of the residential land is near the coast. When land use within a half mile of the coast is examined, only 36% is forested, and more than 34% is in the residential/industrial/commercial categories. The concentration of development nearshore is also evident in U.S. Census statistics. In Buzzards Bay coastal towns, 22% to 81% of the population lives within 1/2 mile of shore, and for the entire watershed, 41% of the population lives within a half mile of the bay (Table 2).

Table 2. Percent of Buzzards Bay watershed municipal population living within 1/2 mile of Buzzards Bay.

Town	population within 1/2 mile of Buzzards Bay	% of population 1/2 mile of Buzzards Bay
Acushnet	2,326	22%
Bourne	9,569	66%
Carver	0	0%
Dartmouth	6,970	22%
Fairhaven	12,552	77%
Falmouth	5,613	62%
Freetown	0	0%
Gosnold	66	77%
Lakeville	0	0%
Marion	4,295	81%
Mattapoisett	4,007	62%
Middleborough	0	0%
New Bedford	40,001	44%
Plymouth	937	8%
Rochester	0	0%
Wareham	14,715	69%
Westport	2,826	24%

Analysis by Buzzards Bay NEP based on 2000 U.S. Census statistics and MassGIS files. The Falmouth, Bourne, and Plymouth statistics are shown only for those areas of the town within the Buzzards Bay watershed.

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 semi-tropical and Arcadian species can be found in Buzzards Bay during different times of year. Giblin and Foreman (1990/2013) provide a good summary of the different habitat types found in Buzzards Bay.

Salt Marshes and Tidal Streams

Salt marshes are among the most productive ecosystems in the world even exceeding most types of agricultural land. For a long time salt marshes and tidal areas were considered unproductive land to be filled. Today they are among the most highly protected wetland types in Massachusetts and enjoy stringent protections. They are recognized as an important resource that provides wildlife habitat, produces large quantities of plant and animal biomass, exports food to nearby coastal food webs, protects the coastal zone from floods, and absorbs some water-borne contaminants. Salt marshes add great-

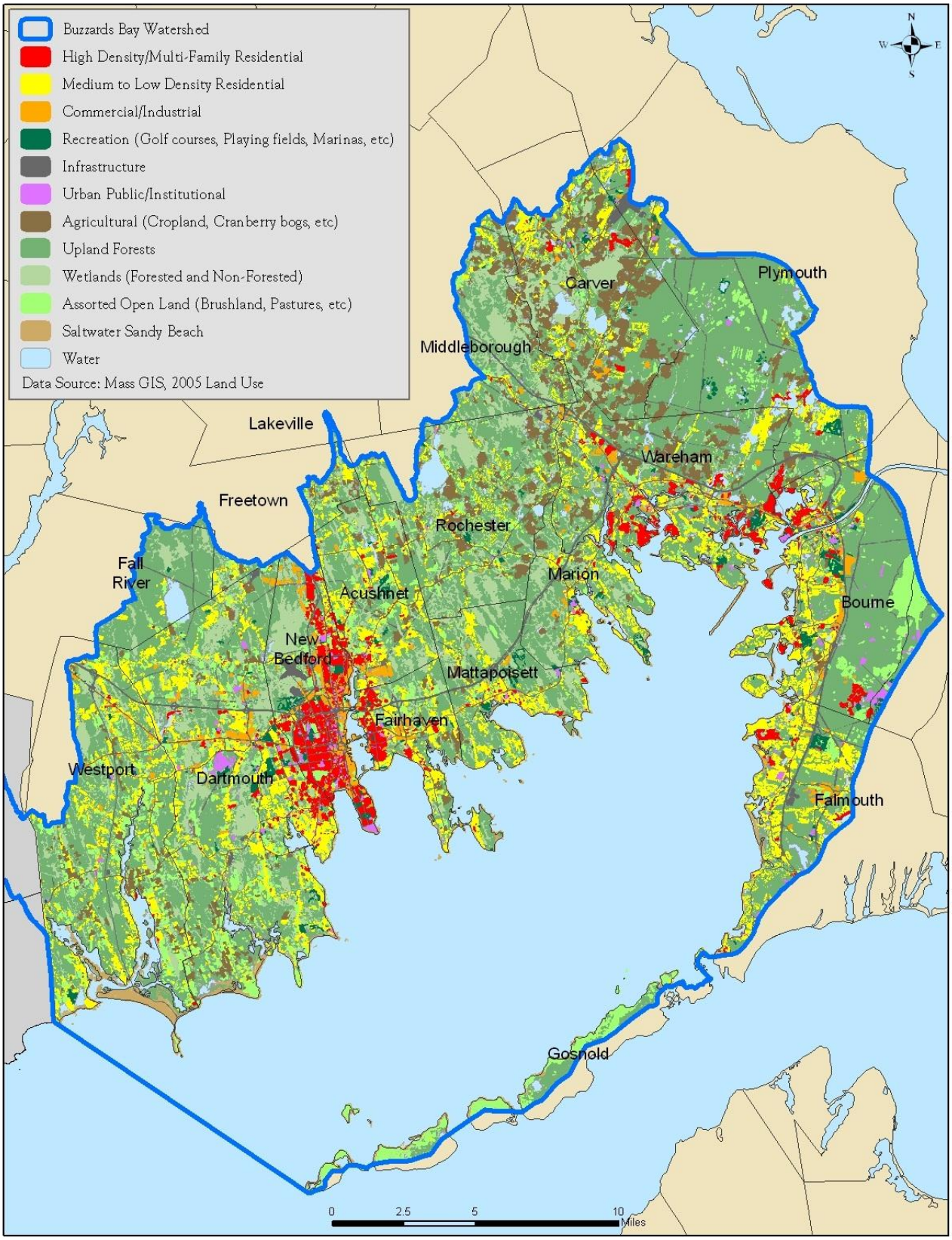


Figure 8. Land use in the Buzzards Bay watershed based on 2005 interpretation by MassGIS.

Comparable land use for the watershed area in Rhode Island is not available.

Table 3. Summary of land use in the Buzzards Bay watershed, summarized by municipality.

Land use description / Acres	Acushnet	Bourne	Carver	Dartmouth	Fairhaven	Fall River	Falmouth	Freetown	Gosnold	Marion	Mattapoisett	Middlebor-ough	New Bedford	Plymouth	Rochester	Wareham	Westport	Grand Total
Brush land/Successional	30	68	36	494	72	2	58	12	1,749	6	19	10	86	23	31	60	285	3,078
Cemetery	25	117	15	67	32		2	3		16	14	5	260		10	41	30	635
Commercial	70	349	75	603	256	1	62	29		55	83	20	738	24	67	343	226	3,000
Cranberry bog LU category area	236	198	5,358	156			48	256		258	92	1,398	16	1,136	2,107	2,571		13,829
Cranberry bog production area	68	147	3,323	57			24	130		164	67	861	13	623	1,212	1,701		8,290
Cropland	237	11	50	918	381	4	11	31	2	35	114	19	8	0	576	9	1,153	3,558
Forest	5,644	13,608	8,093	17,863	2,266	5,089	7,470	1,604	1,480	4,239	5,812	5,155	2,191	17,729	9,681	11,318	14,198	134,447
Forested Wetland	1,532	116	1,946	6,072	671	894	113	450	88	1,610	2,083	2,759	1,701	165	3,698	762	3,241	27,917
Golf Course	125	170	14	359			96			120	193		108	152	56	114	47	1,574
High Density Residential	170	439	231	697	583		317			43	44		2,081	285		1,221	57	6,167
Industrial	54	90	90	154	134		77	8		42	44	32	818	14	22	248	52	1,879
Junkyard	17	7	25	40			7			4		4	14		12	32	39	201
Low Density Residential	1,153	1,146	1,000	2,842	244	103	1,205	267	17	478	729	319	84	411	830	1,059	2,405	14,298
Marina		17		7	20		7		1	4	4		14			12	3	89
Medium Density Residential	528	1,082	403	1,717	1,127	14	1,227	34	19	528	581		296	423	0	1,007	574	9,561
Mining	158	190	74	36			151			31	10		8		13	21	19	711
Multi-Family Residential	116	368	44	313	204	1	73			29	70	24	1,701	4	24	200	11	3,187
Non-Forested Wetland	384	193	1,487	559	196	22	175	111	115	229	130	548	260	331	899	797	321	6,757
Nursery	177			115	41		28	3		1	5	1	10		32	11	40	463
Open Land	187	1,215	127	963	103	15	116	66	221	69	119	84	202	539	157	256	642	5,525
Orchard	8			99										2		2	151	262
Participation Recreation	43	205	63	199	95	7	55	2		58	40	8	232	123	58	100	50	1,356
Pasture	499	69	54	1,409	252	27	30	51	124	103	85	83	7	44	589	92	1,510	5,026
Power line/Utility	115	365	157	144	20	41	147	17		30	43	80	23	406	144	175	16	1,958
Saltwater Sandy Beach	3	418		535	281		378		465	179	213		89	0		347	1,149	4,057
Saltwater Wetland	29	359		1,145	608		246		26	419	257		4	1		892	987	4,971
Spectator Recreation			1															1
Transitional	26	158	193	216	28		116	10	1	2	7	54	62	41	102	53	83	1,153
Transportation		311	115	159	141		161			85	126	118	648	318	22	456	155	2,828
Urban Public/Institutional	49	277	65	505	104		125	3	5	84	52	4	557	49	54	135	68	2,292
Very Low Density Residential	277	204	273	791	121	6	413	116	20	281	230	172	19	144	695	343	971	5,082
Waste Disposal		8		99	9		76	0					87		37	25	35	376
Water-Based Recreation	3	14	1	6	2		4	1			9		7	3		23	5	77
Sub-Total (land only)	11,892	21,772	19,989	39,279	7,990	6,225	12,992	3,072	4,332	9,037	11,207	10,897	12,328	22,367	19,915	22,722	28,521	266,314
Water (fresh and some marine)	222	803	1,261	1,524	352	578	770	29	277	136	129	129	712	1,689	1,213	2,154	3,169	15,145
OFFSHORE WATERS		6,630		20,755	17,820		22,498		36,876	8,736	15,714		7,811			4,789	10,650	152,279
Grand Total	12,114	29,204	21,250	61,559	26,163	6,803	36,260	3,101	41,485	17,909	27,049	11,025	20,851	24,056	21,128	29,665	42,340	433,737

Based on Mass GIS 2005 land use data, and only within the Buzzards Bay NEP 2010 watershed boundary. Analysis does not include land use analysis for Rhode Island. Not shown, but included in column totals, are lands in Lakeville (135 acres), and Sandwich (1,641 acres). Cranberry bog note (a): top acreage is the land use category and includes berms, farm roads, sand storage, etc.; bottom is the bog production acreage (from a DEP GIS coverage, updated by the Buzzards Bay NEP).

Table 4. Summary of types of wetland resource areas within the watershed summarized by municipality

Wetland Resource Area Description	Acushnet	Bourne	Carver	Dartmouth	Fairhaven	Fall River	Falmouth	Freetown	Lakeville	Marion	Mattapoisett	Middleborough	New Bedford	Plymouth	Rochester	Wareham	Westport	Grand Total
Barrier Beach System		49		65	94		28			47	86					36	455	860
Barrier Beach-Coastal Beach		20		81	8		53									9	121	292
Barrier Beach-Coastal Dune		9		94	12		77									9	200	401
Barrier Beach-Deep Marsh																	2	2
Barrier Beach-Marsh		2					2										12	15
Barrier Beach-Salt Marsh																	0	0
Barrier Beach-Shrub Swamp							2										5	7
Barrier Beach-Wooded Swamp Deciduous																	2	2
Bog		10	129	4			1	0				44	26	37	1	21		274
Coastal Bank Bluff Or Sea Cliff	0	73		20	7		16			10	7		25	0		44	14	217
Coastal Beach	2	123		100	64		94			71	56		36			148	43	739
Coastal Dune		88		37	30		35			6	18		5			90	19	327
Cranberry Bog	66	134	2,954	57			24	131		163	66	750	13	561	1,080	1,591		7,592
Deep Marsh	139	42	415	70	5	9	20	44		34	3	211	8	141	218	296	7	1,661
Rocky Intertidal Shore		21		45	31		36			21	29		14			9	47	254
Salt Marsh	29	360		1,144	607		246			419	402		4	1		886	987	5,084
Shallow Marsh Meadow Or Fen	134	29	252	243	140	3	58	16		77	32	36	144	54	209	186	212	1,824
Shrub Swamp	111	109	676	242	51	10	92	49		119	95	269	82	95	469	294	83	2,845
Tidal Flat	1	39		93	34		43			26	20		1			2	249	508
Wooded Swamp Coniferous	17	6	342	211	1	83	19	17		31	131	67	265	54	264	65	15	1,589
Wooded Swamp Deciduous	1,060	86	692	4,385	570	335	81	227		1,029	1,189	1,080	773	39	2,147	435	3,052	17,180
Wooded Swamp Mixed Trees	637	18	897	1,478	100	475	13	205	16	551	729	1,602	662	71	1,311	261	171	9,197
Grand Total	2,195	1,217	6,356	8,371	1,755	914	938	691	16	2,604	2,863	4,060	2,058	1,053	5,700	4,383	5,697	50,871

Table is based on Mass GIS 2007 wetlands conservancy program data. Includes only the Buzzards Bay watershed portions of the town, and excludes open water types (salt and fresh). Cranberry bog acreage in the wetland conservancy maps may include berms, and is somewhat older than the data set used in Table 3 for the production area.

Photo by Joe Costa.

Figure 9. Spartina salt marshes are an important habitat and nursery around Buzzards Bay.

ly to the aesthetic diversity of the coastal landscape, providing a source of recreational enjoyment through fishing, shellfishing, water fowling, and nature appreciation in all seasons.

Salt marshes typically are located in intertidal areas behind barrier beaches, bordering quiet water, or along the banks of tidal rivers (a typical Buzzards Bay marsh is shown in Figure 9). Significant salt marsh areas are located in Dartmouth, Wareham, Westport, and Fairhaven (see Figure 8).

Salt marshes have been well protected in Massachusetts under state and local laws for decades, and the acreage of salt marsh in Buzzards Bay has been relatively constant. The MassGIS land use analyses, where the methodology has been relative consistent, show that between 1971 and 2005, there has been negligible change in marsh area (1971: 4,950 acres; 1985: 4,945 acres, 1999: 4,941 acres; 2005: 4,971 acres). Hankin et al. (1985), using somewhat simpler methods, estimated that in 1984 there were 5,000 acres of salt marshes in Buzzards Bay. Using DEP's 2007 wetland conservancy program data, which uses a somewhat different methodology and larger scale mapping than the land use studies, there are 5,084 acres of salt marsh in Buzzards Bay (Table 4)[14].

"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*. The 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 from 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 (typical shallow bed shown in Figure 10), 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

Photo by Joe Costa.

Figure 10. Photograph of a healthy eelgrass bed in a shallow sandy habitat in the Elizabeth Islands.

[14] The 2005 data includes many small and fringing marsh areas that were likely omitted from the 1984 estimate, hence the apparent small increase in marsh area 20 years later.

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.

Based on sediment cores, historical records, anecdotal information, and observations in pristine areas in the Elizabeth Islands, Costa (1988) speculated that in predevelopment times, eelgrass likely colonized most shallow areas with salinities above 10 ppt in Buzzards Bay (Figure 11). During the early 1930s, most eelgrass disappeared in Buzzards Bay (and elsewhere in the Atlantic) because of a "wasting disease." Scientists do not fully understand the causes and timing of this event, but eelgrass subsequently recovered throughout most of the bay. Some initially recovering beds were likely to have been destroyed during the hurricane of 1938. Between the 1960s and 1980s, eelgrass appeared to have recovered in most parts of the bay, but between the 1980s and 2000s, new declines were occurring. These new declines, and the apparent lack of recovery after the wasting diseases in some parts of the bay, appeared to be the result of human disturbance and pollution.

The new losses in particular appeared to be related to the addition of nitrogen to coastal waters. (These eutrophication-related losses are described further in Action Plan 1 Managing Nitrogen Sensitive Embayments). These new losses are a serious management concern because, unlike areas affected by natural disasters, these areas will never recover until nitrogen inputs and other disturbances are reduced. Eelgrass has been lost in many parts of Buzzards Bay, with some of the more prominent historical losses occurring in and around New Bedford, Apponagansett Bay, the Wareham River estuary, Weweantic River, upper West Falmouth Harbor, Sippican Harbor, the Westport Rivers, Buttermilk Bay, and Onset Bay, among others.

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

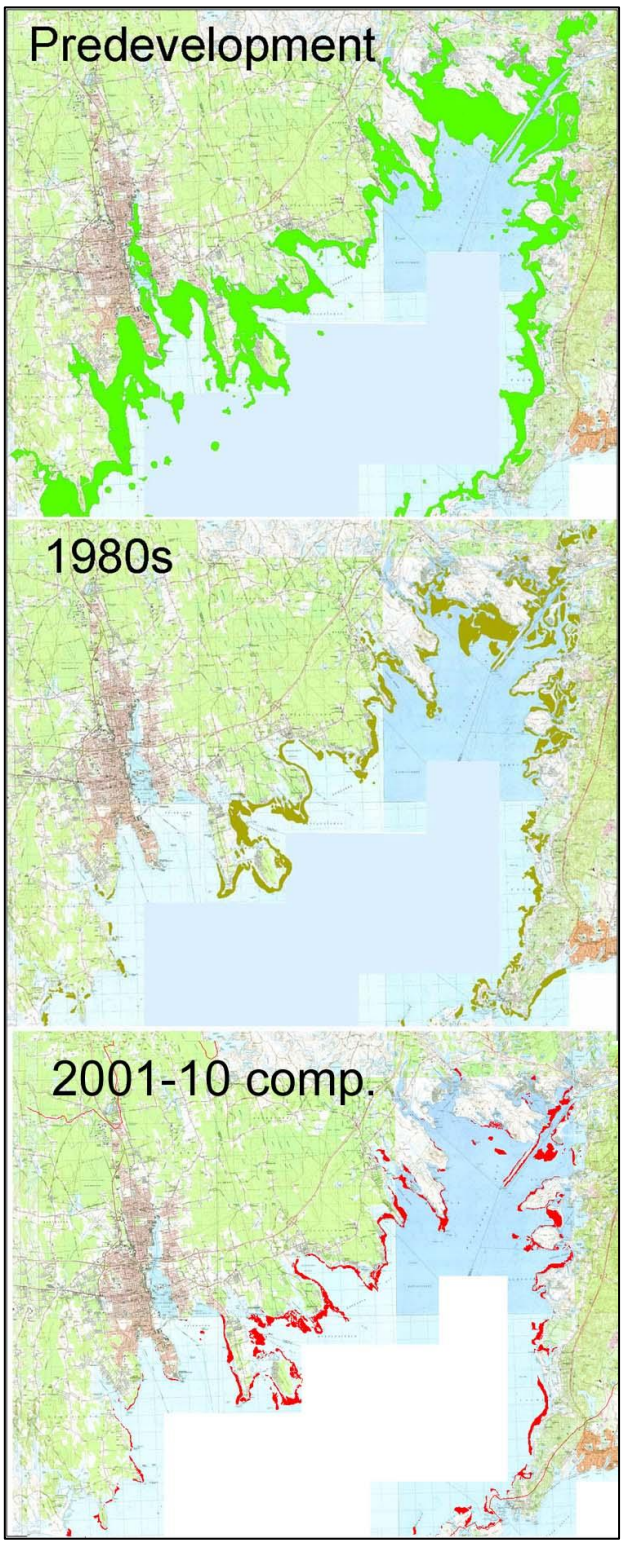


Figure 11. Conjectural estimate of eelgrass in predeveloped Buzzards Bay based on bathymetry and presumed water quality as compared to mapped 1980s and 2001-2010 composite view of eelgrass distribution.

(Note: the last complete baywide eelgrass map was 2001, but this composite map includes the most up-to-date mapping from various sources including DEP 2006 and 2010 coverages. Additional maps and explanations can be found at buzzardsbay.org/eelgrass-historical.htm.)

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. In general, tidal-flat animals are those that live in sediments, or bury themselves there with the outgoing tide. These include bivalves and various species of marine worms and crustaceans.

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 storms breach their connection to the uplands.

Barrier beaches have moderately strong protection under the state Wetlands Protection Act (WPA) and Title 5 sanitary wastewater regulations[15]. CZM has mapped and designated 233 barrier beaches in Buzzards Bay covering 1,431 acres[16] (Figure 12). Building on or stripping of vegetation on barrier beaches is discouraged or prohibited because these beaches protect the lands behind them from storm damage and because they tend to move over geological time. The exact application of the law depends upon the particulars of the site. For example, construction in barrier beach primary dunes within a FEMA mapped velocity zone is prohibited by Massachusetts Executive Order 181. Signed in 1981, this executive order also discourages development on barrier beaches by limiting state and federal funding for sewer and water lines, buildings, and coastal engineering structures; and encourages public acquisition of barrier beaches for recreational purposes.

Barrier beaches are offered much less protection under federal law because they are not considered wetlands. The exception to this rule of thumb is that many of the larger barrier beach systems in Buzzards Bay are protected under the Coastal Barrier Resources Act (CBRA) of 1982. The law encourages the conservation of these sensitive areas and restricts federal expenditures that encourage development, and limits federal flood insurance through the National Flood Insurance Program[17].

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. In the 1991 Buzzards Bay CCMP, lobster landings in 1988 for Buzzards Bay were estimated to be $2.3 million. In 2002, 13,745,537 pounds of lobster were reported landed by commercial lobstermen in Massachusetts (Dean et al., 2002[18]). Based on an average price of $3.72 per pound, the commercial catch was valued at $51,133,397. In that year, Buzzards Bay accounted for only 1.6% of the state total, but this still represented an annual retail value close to $817,000. 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 in Buzzards Bay increased somewhat in the 1980s and 1990s, but have declined appreciably after 1999 (Figure 14).

Licensed lobstermen take lobsters by pots or traps that are set for several days or longer. Massachusetts law prohibits the taking of lobsters by spearing, dipping, or dragging. In addition to the commercial fishery in Buzzards Bay, there are noncommercial lobstermen who purchase the 10-trap limit or 10 hand takings by scuba diving recreational permit. There is no estimate of how many of the more than 10,000 noncommercial lobstermen in the state fish Buzzards Bay.

In 1988, approximately 200 to 250 commercial lobstermen fished Buzzards Bay (Grice, 1990b/2013). In 2004, 149 fishermen reported landing 788,247 pounds of lobster from 224,926 trap hauls in the Massachusetts portion of Southern New England (MASNE) stock (Glen et al., 2007; Figure 14). As noted by Massachusetts

[15] Barrier beaches are considered a wetland resource area under the state WPA, and Title 5 prohibits mounded septic systems in barrier beaches within FEMA designated velocity zones.

[16] Buzzards Bay NEP calculation from MassGIS shapefile coverage State Designated Barrier Beaches dated April 1997. This CZM designation has no statutory implication under the state WPA which has its own definition of barrier beaches, and smaller unmapped areas may meet the regulatory definition for this wetland resource area.

[17] According to the U.S. Fish and Wildlife Service that oversees the program, "CBRA is a free-market approach to conservation. These areas can be developed, but Federal taxpayers do not underwrite the investments. CBRA saves taxpayer dollars and encourages conservation at the same time. CBRA has saved over $1 billion and will save millions more in the future." (from: www.fws.gov/coastal/docs/785.pdf. Last accessed October 11, 2013.

[18] Retrieved from www.mass.gov/eea/docs/dfg/dmf/publications/lobster-report-2002-tr20.pdf. Last accessed October 11, 2013.

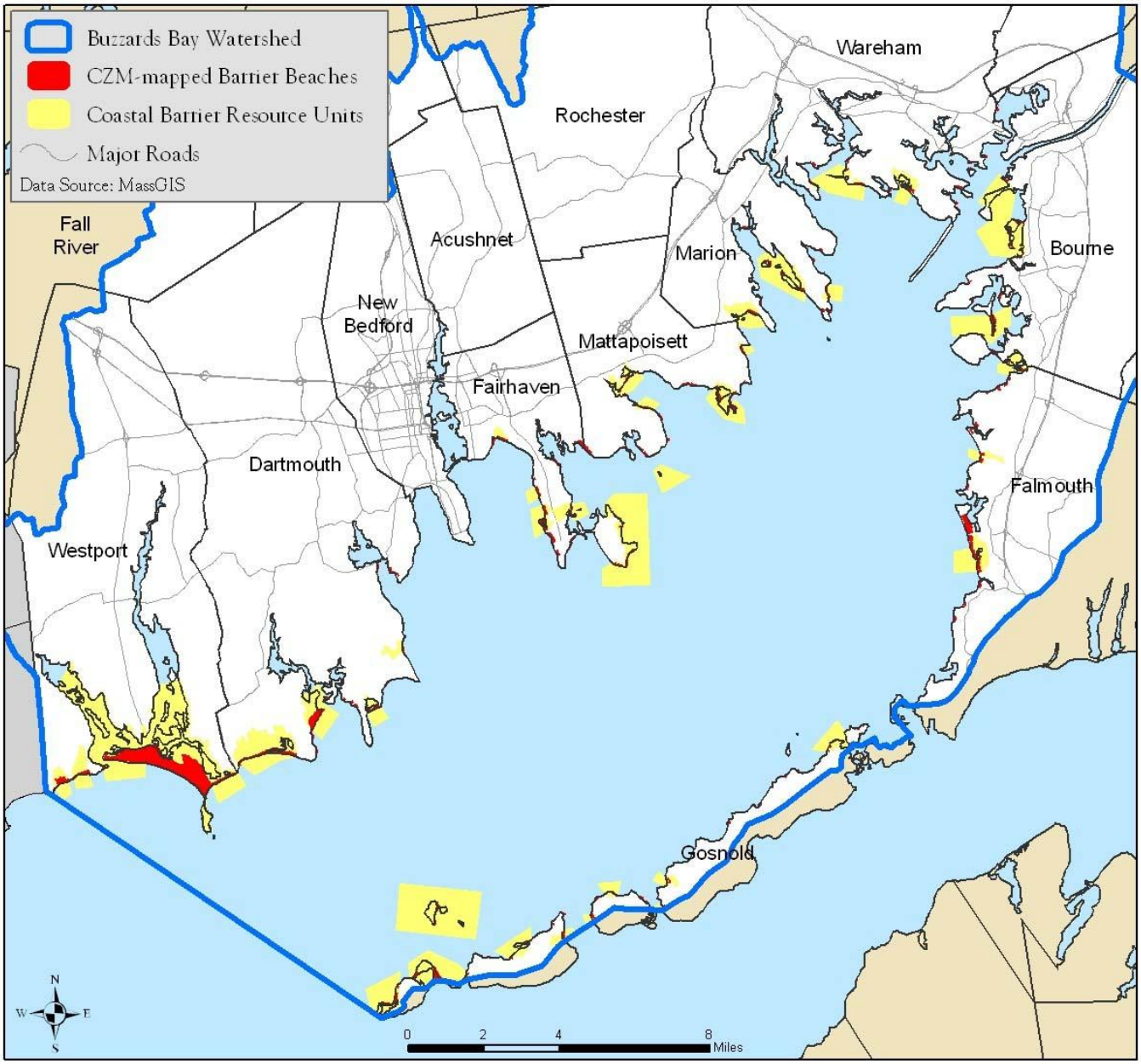


Figure 12. Massachusetts CZM designated barrier beaches and federal CBRA designated areas in Buzzards Bay.

DMF, these were the lowest recorded landings, trap hauls, since 1981.

The lobster resource of Buzzards Bay, although not as economically productive as 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.

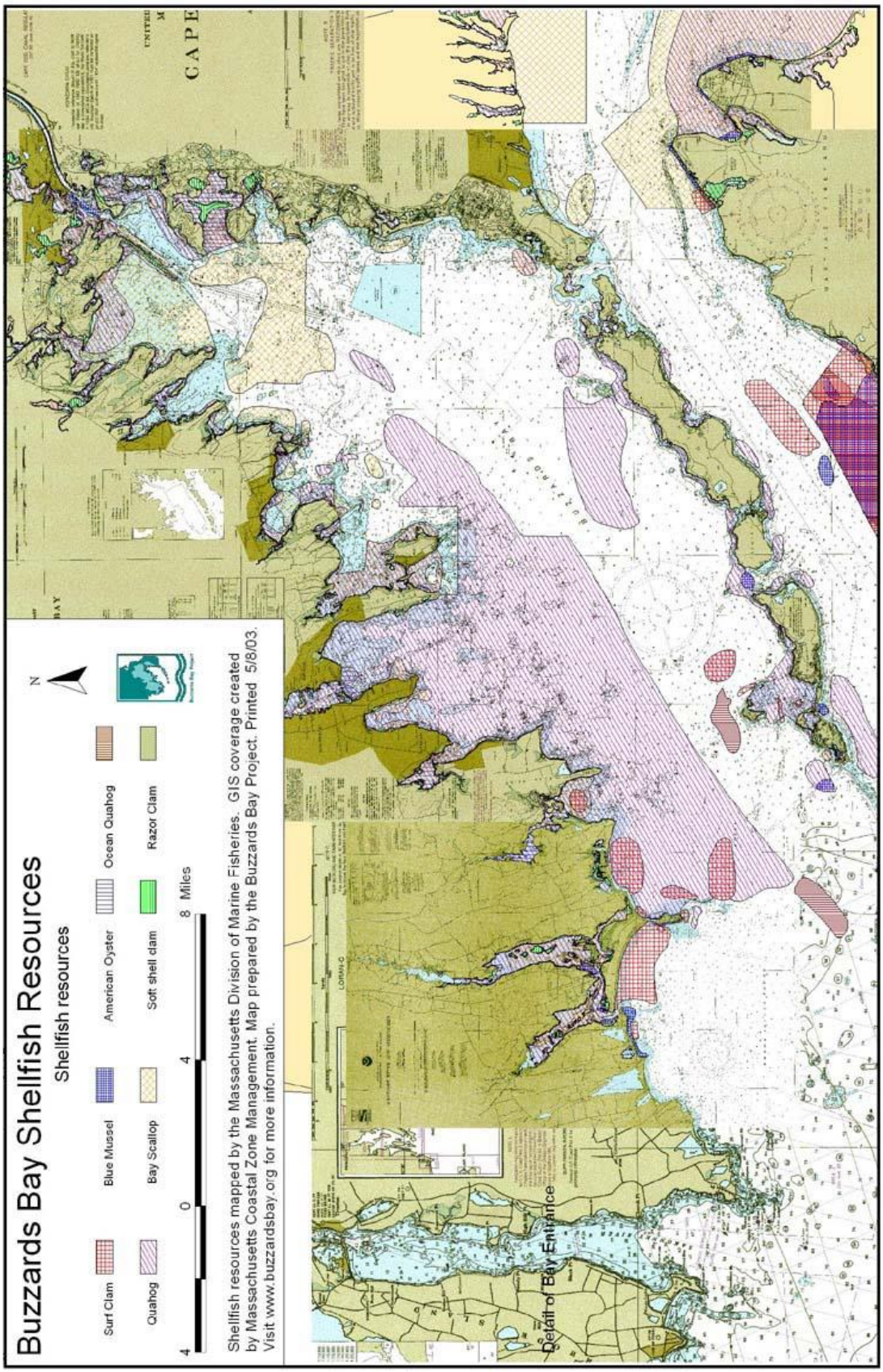


Figure 13. Buzzards Bay shellfish resources.

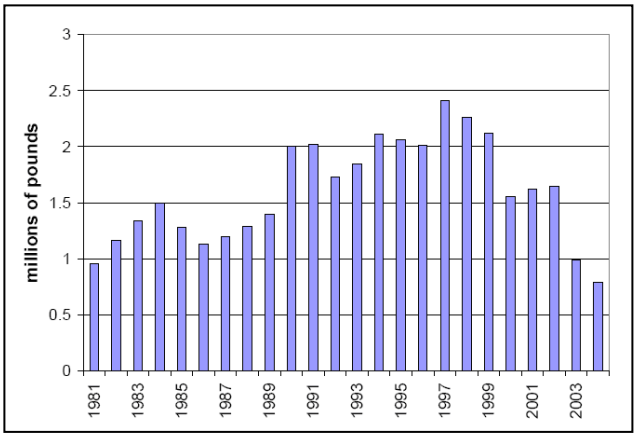


Figure 14. Lobster catch in the Massachusetts portion of the Southern New England lobster stock area.

Data shown is principally for Buzzards Bay and Vineyard Sound. Data only available to 2006.

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. Subsequent 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. These areas remain closed today.

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*; see Figure 13).

In 2003, Mass DMF estimated[19] the annual value of shellfish harvested from Buzzards Bay was $4 million. Using an economic multiplier effect of 4.5, this catch contributed $18 million to the local economy. Historically, landings of quahog and bay scallop constitute the majority of the commercial shellfishery in Buzzards Bay, although in recent years, bay scallop populations have collapsed in most areas.

Soft-shell clams and oysters are harvested primarily in the recreational fishery, and together constitute a small portion of the total reported landings. Like the bay scallop, productive soft-shelled clam beds have disappeared from most parts of Buzzards Bay.

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, in the 1970s and 1980s, Buzzards Bay experienced a dramatic increase in the number of acres of shellfish beds closed due to fecal coliform contamination. Although there have been appreciable improvements since that time, as of 2013, roughly 5,700 acres remain permanently closed, with an additional 2,700 acres of mostly seasonal closures. While this represents only 5% of the area of Buzzards Bay, it represents a significant percentage of the bay's productive nearshore shellfishing areas frequented by recreational and commercial shellfishermen.

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 is a habitat 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, and alewives) that attract the larger recreational species. Salt marshes and eelgrass beds offer protection to many species of young fish, some of which are commercially important.

Buzzards Bay is a spawning and nursery ground for many important commercial and recreational species. Species such as scup, sea bass, tautog, butterfish, winter

[19] Reported in DMF NEWS Third Quarter 2003, "Update on Buzzards Bay Oil Spill" newsletter at www.mass.gov/eea/docs/dfg/dmf/publications/dmfnq303.pdf. These values are less than the 1988 estimate for the 1991 CCMP. The CCMP estimate for 1988 was $4.5 and $18.8 million respectively, which when adjusted for inflation, equals $6.9 and 28.9 million in 2003 dollars (using inflation calculator at data.bls.gov/cgi-bin/cpicalc.pl).

Table 5. Fisheries species where Buzzards Bay is designated as Essential Fish Habitat and their applicable life stages.

Species [1]	Eggs	Larvae	Juveniles	Adults
American plaice *(Hippoglossoides platessoides)*			X	X
Atlantic butterfish *(Peprilus triacanthus)*	X	X	X	X
Atlantic cod (*Gadus morhua*)	X	X	X	X
Atlantic herring *(Clupea harengus)*			X	X
Atlantic mackerel *(Scomber scombrus)*	X	X	X	X
Atlantic wolffish* (*Anarhichas lupus*),	X	X	X	X
black sea bass *(Centropristis striata)*	n/a	X	X	X
bluefin tuna *(Thunnus thynnus)*			X	
bluefish *(Pomatomus saltatrix)*			X	X
cobia *(Rachycentron canadum)*	X	X	X	X
haddock *(Melanogrammus aeglefinus)*	X	X		
king mackerel *(Scomberomorus cavalla)*	X	X	X	X
little skate (*Leucoraja erinacea*)			X	X
red hake *(Urophycis chuss)*		X	X	X
sandbar shark *(Carcharhinus plumbeus)*				X
scup *(Stenotomus chrysops)*	X	X	X	X
Spanish mackerel *(Scomberomorus maculatus)*	X	X	X	X
summer flounder *(Paralichthys dentatus)*	X	X	X	X
windowpane flounder *(Scophthalmus aquosus)*	X	X	X	X
winter flounder *(Pseudopleuronectes americanus)*	X	X	X	X
winter skate (*Leucoraja ocellata*)	X	X	X	X
Molluscs				
long-finned squid *(Loligo pealei)*			X	X
short-finned squid (*Illex illecebrosus*)			X	X
surf clam *(Spisula solidissima)*	n/a	n/a	X	X

[1] Modified from ARCADIS (2012) and with additions (*) from www.habitat.noaa.gov/protection/efh/efhmapper/index.html. Last accessed October 30, 2013. List may not be complete for unmapped species; NOAA EFH mapper inconsistencies with fact sheets ignored.

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. Buzzards Bay is also designated as essential fish habitat (EFH) pursuant to the Magnuson-Stevens Act[20]. A list of EFH designated species and their relevant life stages are found in Table 5.

Because of its recreational fishing and nursery values, Buzzards Bay was closed to commercial fishing by nets, seines, and fish traps by Chapter 192 of the Massachusetts Acts of 1886[21]. A detailed summary of The Finfish Resources of Buzzards Bay is also provided by Grice (1990c/2013).

Other Living Resources

Marine Mammals

The harbor seal (*Phoca vitulina*) 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. In Buzzards Bay, the largest single concentration of seals

[20] In 1996, Congress passed the Sustainable Fisheries Act (Public Law 104-297) which amended the habitat provisions of the renamed Magnuson-Stevens Act. The amendments called for direct action to stop or reverse the continued loss of fish habitats. It also required identification of those habitats to protect, conserve, and enhance "essential fish habitat." Congress defined essential fish habitat for federally managed fish species as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity."

[21] The constitutionality of this law was affirmed by the U.S. Supreme Court in the case Commonwealth of Massachusetts v. Arthur Manchester, 1890.

Photo by Bill Byrne, Massachusetts FWS NHESP

Figure 15. The diamondback terrapin (*Malaclemys terrapin*).

generally occurs at Gull Island[22]. In 1988, about 280 seals were recorded at this location and approximately 300-400 seals were found throughout the Elizabeth Islands and the remainder of Buzzards Bay throughout the winter. Since the late 1980s, in New England as a whole, harbor seal populations have nearly doubled.

In addition to the harbor seal, gray seals (*Halichoerus grypus*) are occasionally seen on rock ledges in the bay, but generally in small numbers. Harp seals (*Pagophilus groenlandicus*) and hooded seals (*Cystophora cristata*) are rarer, but have been reported on the south side of Cape Cod (Waring and Wood, 2008), and in Buzzards Bay[23] in recent years.

Buzzards Bay is not considered a high-use habitat for whales, dolphins, or porpoises. However, these species are occasionally observed passing through the bay. Species observed include the Atlantic bottlenose dolphin (*Tursiops truncatus*), harbor porpoise (*Phocoena phocoena*), long-finned pilot whale (*Globicephala melas*), humpback whale (*Megaptera novaeangliae*), and the finback whale (*Balaenoptera physalus*).Their presence is partly due to the proximity of their habitat in the southwest Gulf of Maine and Cape Cod Bay and areas south, and sometimes cetaceans enter the Cape Cod Canal. For example in January 2012, the Army Corps of Engineers closed the Cape Cod Canal because of the passage of two North Atlantic right whales apparently travelling from Buzzards Bay to Cape Cod Bay[24]. Later that year, a pilot whale became stranded in New Bedford Harbor[25]. Other unusual mammal visitors include lone

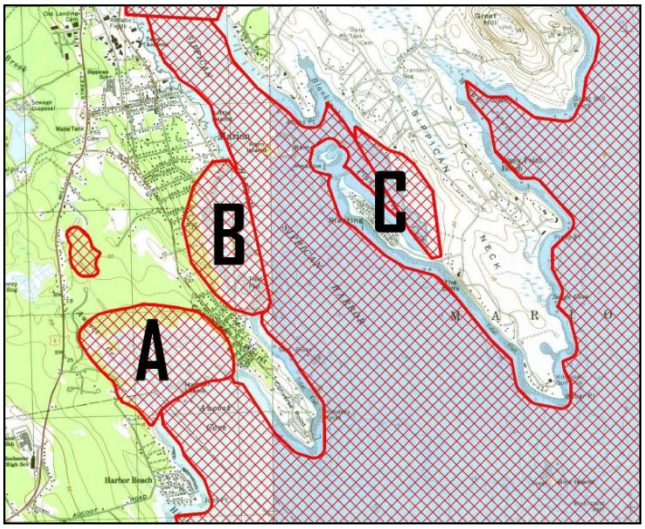


Figure 16. Map of terrapin turtle egg laying habitat in outer Sippican Harbor, Marion.

Large areas of Buzzards Bay, principally areas of salt marsh, are defined as terrapin turtle nursery areas. The areas, marked A, B, and C, are known to be egg laying habitat for this species. MassGIS NHESP coverage.

manatees appearing in Buzzards Bay and on Cape Cod in both 2006 and in 2008[26]. A detailed historical summary of marine mammals found in Buzzards Bay is provided by Payne et al. (1990/2013), and more recent information is contained in Leeney et al. (2010). Action Plan 9 Protecting Bio-Diversity and Rare and Endangered Species Habitat contains a species list of rare and threatened marine mammals and other species.

Marine Turtles

Five species of sea turtles can be found in Buzzards Bay waters: the loggerhead, Kemp's ridley, leatherback, green turtle, and hawksbill. The leatherback is the marine turtle species most frequently reported in Buzzards Bay due to its immense size. In August 2008, more than 100 sightings were reported in southeastern Massachusetts. The turtles purportedly were attracted by high standing stocks of jellyfish, their main food source. Generally present from July through November, this endangered turtle is sometimes found dead on beaches because of entanglement (and subsequent drowning), collisions with boats, or occasionally due to intestinal blockage after eating floating plastics.

The Kemp's ridley turtle, the rarest sea turtle in the world, is known to frequent Buzzards Bay and the south shores of Cape Cod, although it is most likely to be found in Cape Cod Bay. In fact, despite its rarity, it is

[22] The site attracts seal watch charters out of New Bedford Harbor.

[23] See nmlc.org/2011/01/hooded-seal-in-buzzards-bay/. Last accessed October 18, 2013.

[24] Bragg, M. A. 2012. Right whale sighting closes Cape Cod Canal. Cape Cod Times, January 3, 2012. Retrieved from www.capecodonline.com/apps/pbcs.dll/article?AID=/20120103/NEWS/201030307/-1/NEWS01. Last accessed October 1, 2013.

[25] Urbon, S. 2012. Pilot whale stranded in New Bedford Harbor. The Standard Times. Retrieved from www.southcoasttoday.com/apps/pbcs.dll/article?AID=/20120412/NEWS/120419961. Last accessed October 1, 2013.

[26] These visits and their relation to water temperature are described at buzzardsbay.org/buzzards-bay-manatees.htm.

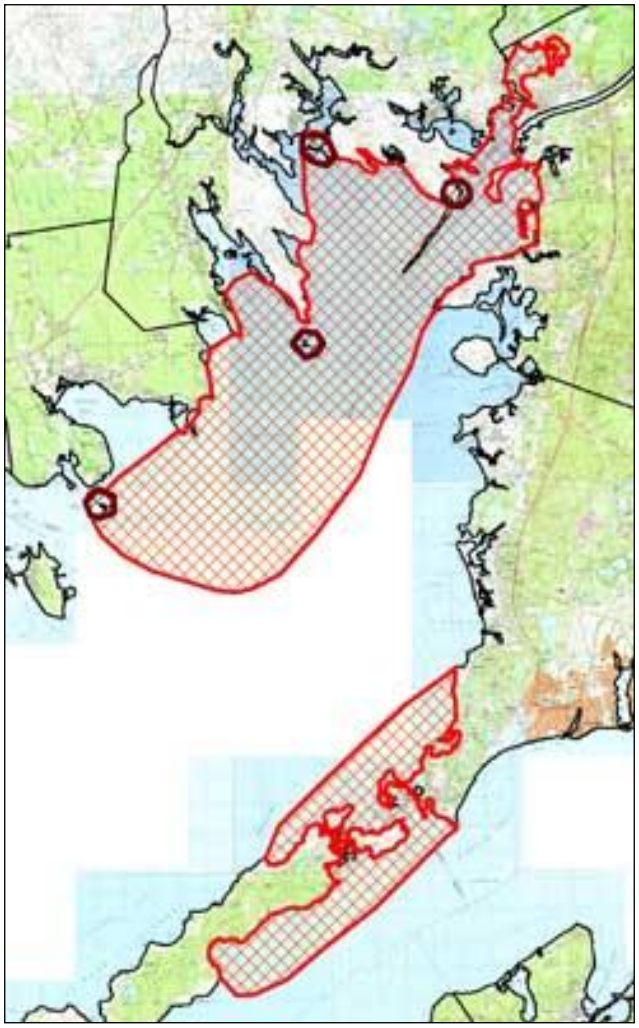
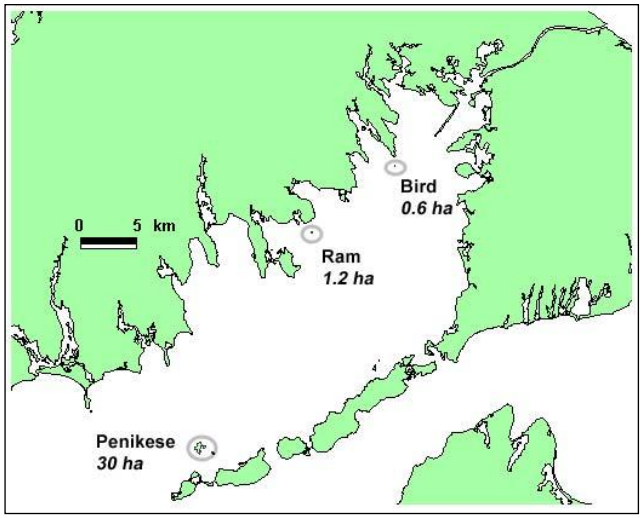


Figure 17. Buzzards Bay colonial bird (Roseate Tern) nesting and feeding areas.

Summary map created from a 1991 USF&WS report titled Northeast Coastal Areas Study Significant Coastal Habitats.

one of the most common marine turtles reported (caught in fishing nets or stranded) within Cape Cod Bay. Sightings within Buzzards Bay are rare, possibly in part because commercial fishing by nets and seines is prohibited in the bay's waters. Given the distribution of the species, Buzzards Bay may be a potentially important foraging area during late summer and early fall, for juvenile and subadult individuals.

Besides sea turtles, a coastal marine turtle, the diamondback terrapin (*Malaclemys terrapin*, Figure 15) makes its home in Buzzards Bay. The species is a threatened reptile in Massachusetts, and for that reason, the presence of the species has important regulatory implications, particularly because it feeds and lays eggs in salt marshes (Figure 16). Diamondback terrapins have a medium-sized wedge-shaped carapace (top shell) variably colored gray, light browns, greens and blacks. It has concentric ring patterns on the carapace and a pronounced ridged or bumpy mid-line keel. Both sexes have



Graphic from the MA Natural Heritage & Endangered Species Program.

Figure 18. Locations and sizes of the major tern nesting islands in Buzzards Bay, MA.

1 hectare [ha] = 2.5 acres

grayish to black skin, spotted with dark green flecks and light colored upper and lower jaw. This turtle has very large, paddle like hind feet with thick webbing.

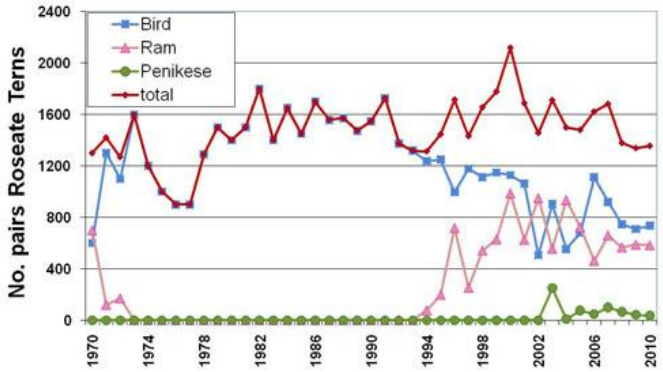
The species is threatened by salt marsh habitat loss and changes in marsh hydrology including tidal restrictions. Human activity and off road vehicles may disturb egg laying activities, or injure or kill nesting females, nests, and hatchlings. Diamondback terrapins may be trapped and drown in improperly discarded "ghost" netting, and can be a by-catch in estuarine crab traps. Nesting females sometimes get injured crossing roads to reach appropriate nesting habitat.

A detailed historical summary of marine turtles found in Buzzards Bay is provided by Payne et al. (1990/2013) and more recent observations and information is contained in Leeney et al. (2010).

Waterbirds

Although greatly reduced in number and diversity from colonial times, birds remain an important component of the Buzzards Bay ecosystem. Because birds congregate and are often sensitive to habitat loss and certain toxic chemicals, their health and breeding success can reflect the fates and persistence of environmental contaminants and the quality of nesting habitat within Buzzards Bay.

Three species of terns breed along Buzzards Bay shores in significant numbers: the Common Tern, Roseate Tern, and Least Tern. Two large areas of Buzzards Bay have been identified as important feeding areas for these tern species (Figure 17). The Roseate Tern, a worldwide species that is listed as a U.S. federally endangered species, breeds exclusively in only two areas worldwide: the northeast coast of the United States (New York to the Canadian Maritimes) and in the Caribbean



Graphic courtesy of the MA Natural Heritage & Endangered Species Program.

Figure 19. Peak Roseate Tern breeding pairs in Buzzards Bay, MA, 1970-2007.

Data from the Buzzards Bay Tern Restoration Project.

Photo and graphic from Mass Wildlife staff.

Figure 20. A Piping Plover.

Islands. In the northeast U.S., Bird Island and Ram Island in Buzzards Bay (Figure 18) serve as the nesting areas for about 50% of the North American breeding population of Roseate Terns[27].

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 (Poole, 1990/2013). 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 increased population of these gulls devastated the Roseate Tern population in Massachusetts in particular, resulting in a 70% decline between the 1940s and 1960s (Blodget and Melvin, 1996; Mostello, 2007). These threats and additional impairments led to protection and restoration efforts, including a gull control program on Ram Island in 1990-1991. This effort led to the successful recolonization of Roseate Terns there after a 20-year hiatus (Figure 19).

In 1988 and 1989, several dead Roseate Terns and Common Terns were found that also had high levels of PCBs in their body tissue. Because these species sometimes feed in the vicinity of New Bedford Harbor, this raised concerns among managers and led to the use of some superfund restoration dollars dedicated to the design and restoration and protection of Bird and Ram Islands (only in the design phase as of 2010).

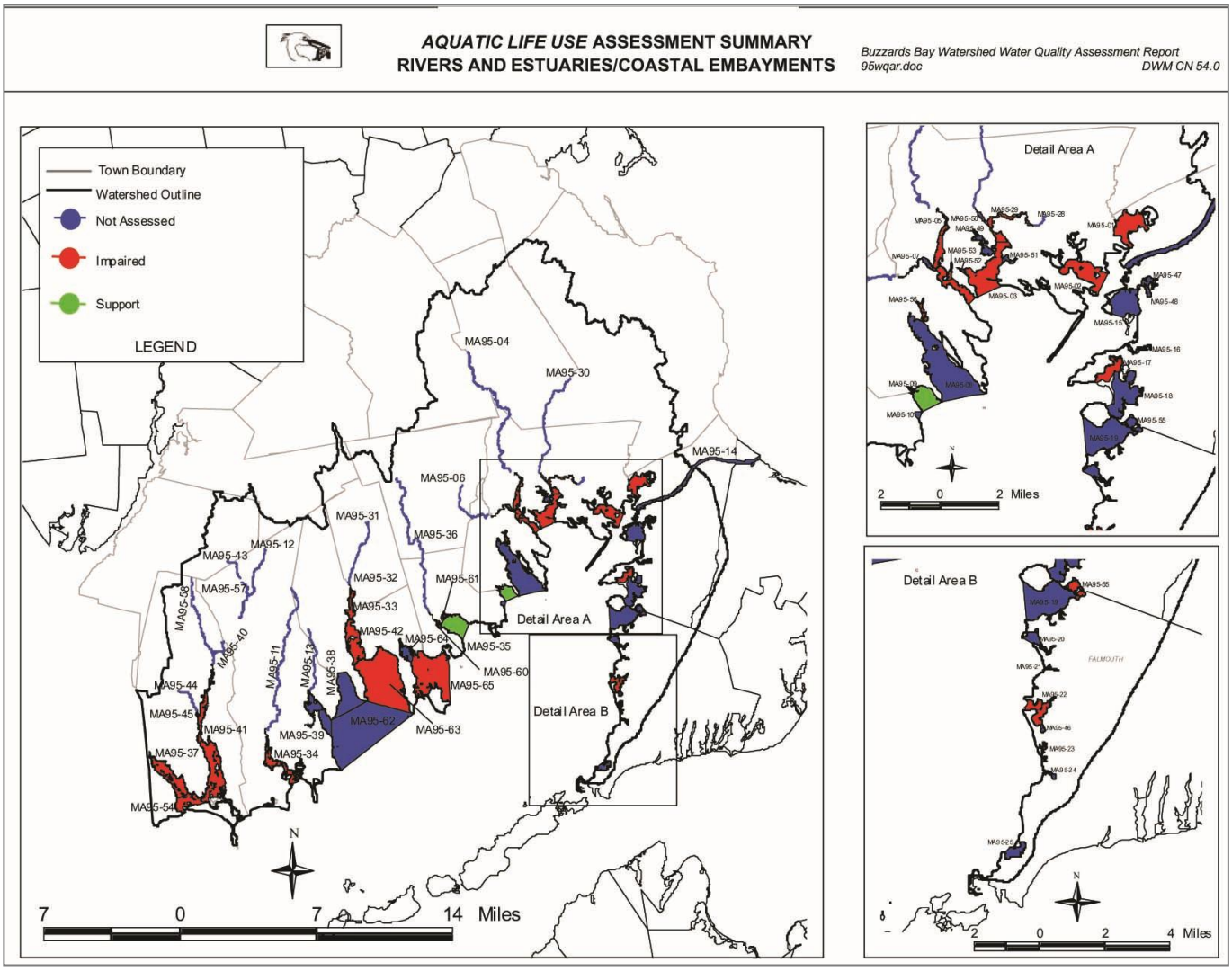
Similarly in 2003, oil from the Bouchard oil spill landed on Ram and Bird Islands, exposing some terns (three were found dead with oil on them), and also disrupting nesting because of cleanup activities. These impacts will be address by the oil spill trustees sometime in 2014 as part of the Natural Resource Damage Assessment for the spill.

The Piping Plover (Figure 20) is listed as a "threatened species" in Massachusetts, and another bird that is the focus of management action in Buzzards Bay. 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. Poole (1990/2013) reported an average of 30 nesting pairs in Buzzards Bay for the period 1984-89. In the 2009 Massachusetts Piping Plover census, Melvin (2010) reported 47 pairs in Buzzards Bay.

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. Currently cormorants have become so abundant in states the federal government has allowed for their depredation (destruction) because of impacts on fisheries.

During the 18th and 19th centuries, ospreys undoubtedly were abundant along the shores of Buzzards Bay. It is often stated 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

[27] See Massachusetts Fish and Wildlife fact sheet at: www.mass.gov/eea/docs/dfg/nhesp/species-and-conservation/nhfacts/roseate-tern.pdf and www.mass.gov/eea/agencies/dfg/dfw/natural-heritage/species-information-and-conservation/rare-birds/buzzards-bay-tern-restoration-project.html. Last accessed October 11, 2013.



Data from DEP (2003) Buzzards Bay Watershed 2000 Water Quality Assessment.

Figure 21. Aquatic life assessment for coastal embayments and rivers in the Buzzards Bay watershed.

69 active nests, and in 2006, Westport had 88 nests[28]. The availability of safe, sturdy nest sites is a key limiting factor for this species, and throughout Buzzards Bay, osprey populations returned dramatically during the past two decades, mostly because local residents built nesting platforms.

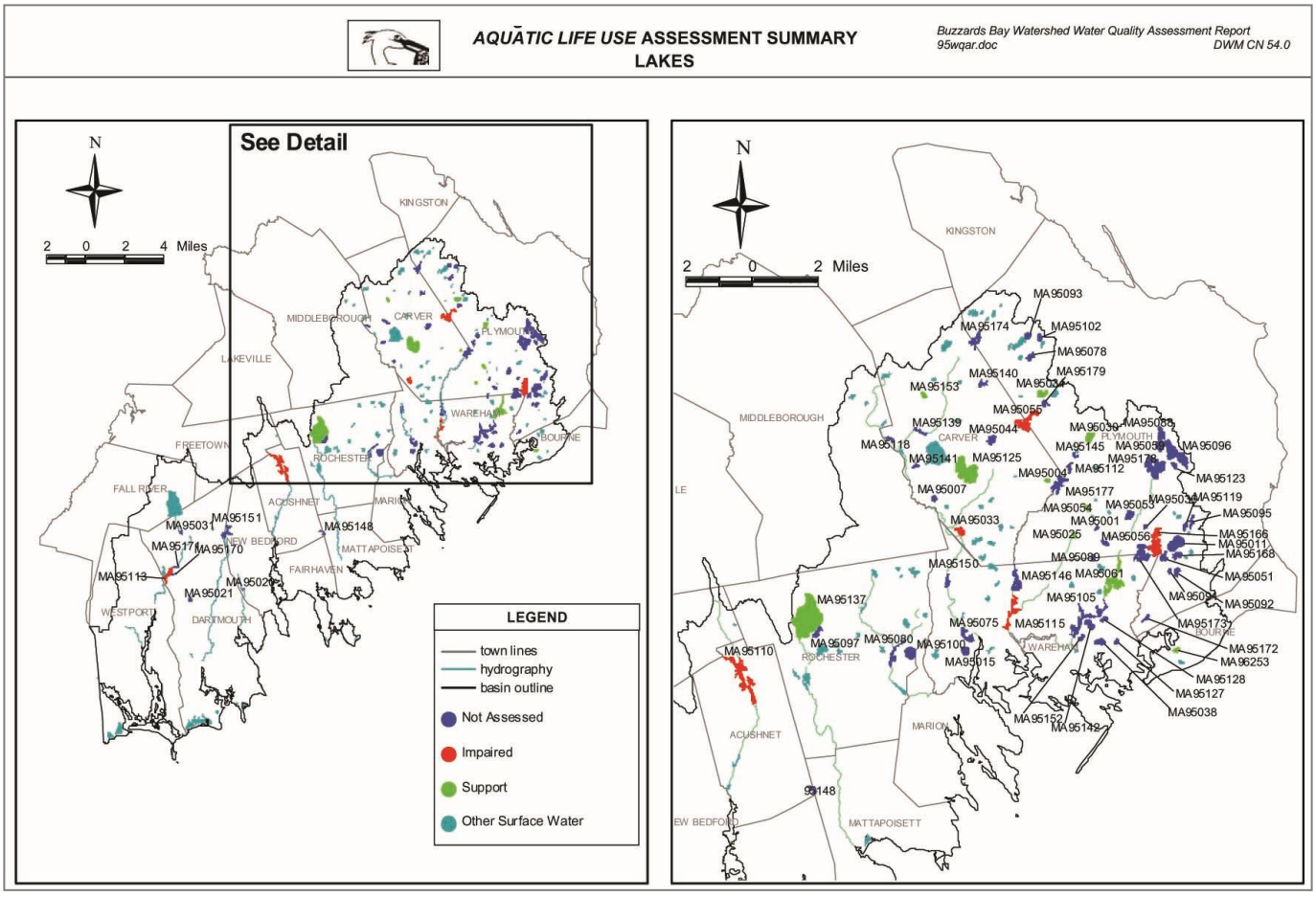
Two species of wading birds are known to nest along Buzzards Bay shores: Black-crowned Night Herons and Snowy Egrets. Several other waders roost and feed here, but none has been confirmed as breeders. At least 20 species of waterfowl (swans, ducks, and geese) are found on Buzzards Bay waters. Two broad 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.

Assessment of Impairments

The most recent and robust regulatory assessment of living resource impairments in Buzzards Bay and its surrounding watershed are contained in DEP's Buzzards Bay Watershed 2000 Water Quality Assessment.[29] The document was completed in 2003 by the Massachusetts Department of Environmental Protection (DEP) which is responsible for the assessment of current water quality conditions pursuant to reporting requirements under the Federal Clean Water Act (section 305(b)) and the Massachusetts Surface Water Quality Standards. Every two years DEP creates a new integrated list of impaired waters. Although a new watershed assessment has not been completed for Buzzards Bay since 2003, DEP considers new data collected and evaluated since the 2003 assess-

[28] Westport Shorelines article published November 30, 2006.

[29] See the DEP Buzzards Bay water quality assessment report (O'Brien and Langhauser, 2003)



Data from DEP (2003) Buzzards Bay Watershed 2000 Water Quality Assessment.

Figure 22. Aquatic life use assessment for fresh water ponds in the Buzzards Bay watershed.

ment report. For example, the draft 2008 proposed integrated list includes new sites based on the Buzzards Bay Coalition monitoring program.

The DEP watershed assessment reports designate the most sensitive uses for which surface waters in the Commonwealth shall be protected, forms the basis of watershed management programs at DEP, and are the foundation of many goals in the Buzzards Bay CCMP. They identify to what degree water quality supports (support status) the "designated uses" of each water body. The assessment reports classify water bodies in the categories (support, impaired, or not assessed) for meeting those goals. The reports also provide basic information and action needed to focus resource protection and remediation activities in watershed management and planning efforts.

The Buzzards Bay assessment report presents a summary of water quality data and information as of November 2003. The status of designated uses as defined in the Massachusetts Surface Water Quality Standards: aquatic life, fish consumption, drinking water, shellfish harvesting, primary and secondary contact recreation, and aesthetics. Each use, within a given segment of the Buzzards Bay watershed, was individually assessed as support or impaired. When too little current data/information exists or no reliable data are available the use is not assessed. However, if there is some indication of water quality impairment, which is not "naturally occurring," the use is identified with an "alert status."

It is important to recognize neither the DEP Buzzards Bay water quality assessment report, nor the Buzzards Bay CCMP, characterize conditions of all rivers, streams, ponds, and coastal embayments in the Buzzards Bay watershed (Figure 21). In fact, most of the smaller freshwater streams and ponds have never been assessed (Figure 22).

For example, as noted in the report, DEP considers "aquatic life use" supported when suitable habitat and water quality are available for sustaining a native, naturally diverse, community of aquatic flora and fauna. Impairment of the aquatic life use may result from anthropogenic stressors that include point and/or nonpoint source(s) of pollution and hydrologic modification. Due to the lack of current quality-assured chemical and biological data, none of the rivers in the Buzzards Bay watershed have been assessed for the aquatic life use (Figure 21). However, the 2003 report does identify specific conditions that may affect aquatic life such as flow

manipulation, which may adversely affect fish passage in the Agawam, Wankinco, Weweantic, and Sippican Rivers and water withdrawals that may adversely affect the Mattapoisett, Paskamanset, Copicut, and the Shingle Island Rivers. The report also noted "the Acushnet River is designated an "Alert Status" due to the potential negative effects of elevated nutrients and oxygen depletion as evidenced in the Buzzards Bay Coalition's poor health index score. Since then, more embayments have been added because of the results of the Buzzards Bay Coalition efforts.

Watershed Demographics

Based on the 2010 Census, there are approximately 250,000 people living in the Buzzards Bay watershed, and of these, nearly 50% live in the greater New Bedford area. Although most residents within the region have been born in the United States, Portuguese was reported as the most dominant ancestry, with Irish a close second. The majority of people in the area who are foreign-born are descended from Europeans. English is the dominant language spoken in households. In the 2000 Census, approximately 30% of the residents within the area are employed as management professionals. Other predominant occupations include sales (26%), service (16%), transportation (17%), construction (10%) farming, and fishing (0.4%).

According to the 2010 U.S. Census, Bristol County, which accounts for 69% of the watershed population[30], has a median age of 40, a 2.54 person average household size, and a median household income of $55,813 (Table 6). This is a similar demographic makeup as the rest of Massachusetts and the U.S., except for the average age, which is somewhat higher than the U.S. average. There are, however, more significant differences in population, age, and race among cities and towns in the watershed. In particular, the greater New Bedford area, one of the largest urban centers in the region, maintains the highest population of the region at 95,072 persons, and has a high proportion of environmental justice populations[31].

These demographics contrast with most other communities, and many of the surrounding towns have much smaller populations (Marion is the smallest at 4907 persons). There are some sharp contrasts among household income among Buzzards Bay watershed communities. New Bedford, with the highest Portuguese, Hispanic, and other minority populations, also has the lowest median household income in the region ($37,493), while Rochester, which has one of the lowest minority populations also, has one the highest median household income ($99,129). These factors present some considerations for regional planning efforts when forecasting growth, planning for transportation improvements, accommodating businesses, as well as protecting natural resources.

Maintaining a balance between a healthy environment and changing land uses caused by population increases is always a challenge. Increases in population also prompts cities and towns to provide more services, causing strains in municipal budgets that often exceed new tax revenues. From 1980 to 1990, the population among principal watershed municipalities grew by 10.3%, appreciably higher than the statewide average (4.3%). The population growth was accompanied by a considerable conversion of forested land to residential development (see statistics in Action Plan 4 Improving Land Use Management and Promoting Smart Growth). During this time, the majority of new jobs that appeared in the region were service-sector jobs that included professional services, small businesses, repair, food, entertainment, recreation, health, and education, while many manufacturing jobs disappeared.

In subsequent decades, population growth slowed, with declines even occurring in the City of New Bedford. Between 2000 and 2010, the cumulative rate of population increase among the same principal Buzzards Bay watershed municipalities was only 4.7%. Like most of Massachusetts, changes in population growth rates may have been affected by the recession of 2009. Variations exist among communities. For example, Rochester and Dartmouth had double-digit population rate increases in all three decades.

Besides population, other trends are evident in the U.S. Census data. For example, Boston Metropolitan Planning Organization's household forecasts predicted that: "*the number of households in the region will continue to grow faster than the population through 2025 as lifestyle changes toward a smaller average household size persist*." This prediction appears to be borne out by the 2010 census, which saw average household size decline in every Buzzards Bay municipality.

It should be noted that the seasonal influx of tourists to some communities and seaside villages within the Buzzards Bay watershed could raise their populations by almost three-fold during the summer, increasing pressures to environmental systems (Howes and Goehringer, 1996).

[30] Value calculated from 2010 U.S. Census block data of blocks within the watershed, where census blocks bisected by the watershed divide are assigned a population proportional to the area of the block within the watershed. Based on this methodology, there are 250,003 persons in the Buzzards Bay watershed, with 167,263 within Bristol County.

[31] Principally, minority, low income, and "household English isolation" in the 2010 U.S. Census.

Table 6. Census 2010 demographic composition: Bristol County, Massachusetts, and U.S.

Parameter	Bristol County	MA	United States
Average Age	40	39	37
Average Household Size	2.54	2.49	2.58
Average Household income	$55,813	$65,981	$51,144

Economic Setting

The Buzzards Bay watershed includes a diverse assemblage of businesses and industries, and the cities and towns within the region are leaders in a number of Massachusetts industries such as tourism, biotechnology, and fishing and shellfishing. The approximate economic value of the largest of these are shown in Table 7 and described in the sections below.

Tourism

Tourism remains the most important industry for southeastern Massachusetts (Table 7). Table 8 shows 2004 travel expenditures (the last date Bristol County data) in southeastern Massachusetts counties, including travel-generated payroll and employment, and state and local tax revenues. One of the top five counties in the state for tourism expenditures was Barnstable County (Bourne and Falmouth), which posted $746 million in domestic expenditures to rank third in the state. These expenditures generated nearly $208 million in payroll as well as approximately 9,300 jobs within the county. Bristol and Plymouth counties made their marks with approximately $300-400 million in expenditures, generating close to $20 million in payroll and 3,000 jobs per county.

The beaches and historic seaside communities of southeastern Massachusetts are central to tourism and are advantageous to attracting and retaining qualified employees. Employment in the two major tourist sectors--lodging and restaurants--has roughly doubled in the Buzzards Bay region since 1970, and the growth in tourism numbers has been sharply increasing (Howes and Goehringer, 1996).

Access to open water, beaches, and parklands varies from town to town and by ownership (see Figure 8 and Table 3 showing different types of public land uses per community). There are approximately 13.4 miles of public beaches (municipal and state owned) in the Buzzards Bay watershed, with an additional 32 miles of "semi-public" beaches. Semi-public beaches include some large tracts of public coastal lands (state, municipal, and private conservation owned), beach association, community beaches, private pay-to-use beaches, club and resort beaches, and other stretches of coastline where more than a single owner is allowed use. Generally, boat ramps and launches that are owned by the state or municipal government are open for use to anyone.

There are approximately 19,311 acres of public parks, forests, trails, paths, campgrounds, and play-

Table 7. Annual value of some marine-related and other industries in Massachusetts.

Category	Millions[1]	Date of info
All Rec. Angler Trip Expend. [2]	$1,164	2011
Tourism, direct spending [3]	$16,900	2011
Coastal Tourism & Recreation[8]	$2,300	2004
All Agriculture [4]	$471	2011
Cranberries (21% of total)[5]	$99	2012
Aquaculture [4,5]	$18.5	2007
Commercial Fishing Landings [6]	$565	2011
Mining (sand, gravel, stone) [7]	$214	2009
Marine Constr. & Infrast. Jobs [8]	$949	2004
Marine Science & Technology [8]	$419	2004
Marine Transportation [8]	$93	2004
Bio-pharma Industries payroll[9]	$6,036	2011

1 Figures represent most current data available and do not reflect associated economic multipliers.

2 NOAA (2012) Fisheries Economics of the United States, 2011. Economics and Social Analysis Division Office of Science and Technology National Marine Fisheries Service. New England Statistics supplement. From table "Angler Trip & Durable Expenditures."If just direct sales generated are considered, the total is $726 million.

3 Massachusetts Office of Travel and Tourism (2012) The Economic Impact Of Travel on Massachusetts Counties 2011. U.S. Travel Association Washington, D.C. September 2012.

4 Includes farm animals. Statistics from 2011 State Agricultural Overview, U.S. Department of Agriculture, National Agriculture Statistics Service. Aquaculture separated from state totals. Cranberry production from NASS New England Agricultural Statistics, 2011, and Massachusetts Cranberries February 8, 2013. USDA, NASS New England Field Office.

5 From (4), but note that MA DMF estimates 2006 aquaculture as only $6.2 million as reported at www.mass.gov/eea/agencies/agr/about/divisions/aquaculture-industry-generic.html.

6 National Marine Fisheries Service, Annual Commercial Landings Statistics (2011), the port of New Bedford accounts for $369M.

7 USGS (2013) The 2009 Minerals Yearbook Massachusetts [advance release].

8 Fact Sheet: The Massachusetts Ocean Act: Sustaining the Commonwealth's Marine Economy Through Fact Based Coordination. Retrieved from www.massoceanaction.org/docs/MOAfactsheet.pdf. See also University of Massachusetts Donahue Institute (2000).

9 Biopharma Industry Snapshot 2012 - Massachusetts Biotechnology Council. Retrieved from www.massbio.org. Last accessed August 27, 2013.

Table 8. 2004 Domestic travel impact on southeastern Massachusetts.

County	Expenditures ($ Mil)	Payroll ($ Mil)	Employment (Thousands)	State Tax Receipts ($ Mil)	Local Tax Receipts ($ Mil)
Barnstable	$745.61	$207.92	9.28	$32.45	$43.12
Bristol	$311/64	$71.93	3.00	$17.24	$5.88
Plymouth	$384.19	$87.60	3.65	$19.44	$17.05
Subtotal	$1,441.44	$367.45	15.93	$69.22	$66.05
State Totals	$10,975.45	$2845.83	110.47	$451.59	$268.50

Data from Massachusetts Office of Travel and Tourism, www.massvacation.com/wp-content/uploads/2013/09/econ-impact-12.pdf.

grounds within the Buzzards Bay watershed. Providing public access to natural resource areas and protecting open spaces in the region are key requirements for maintaining tourism. Open spaces provide critical habitat and corridors for wildlife and plants, protect important water supplies, provide areas for recreational activities, protect historically significant places, and preserve the charm and character of the area in which we live. Open space protection contributes to the regional economy by making the region attractive to businesses, farmers, and tourism. It stabilizes differences between tax revenues and government expenditures because it is generally true that government expenditures for services supporting residential development exceed tax revenues generated by new residential development. Undeveloped protected land costs the towns little, since community services, such as schools, police, and road services, are not required.

Unfortunately, land preservation efforts are uneven around the Buzzards Bay watershed. Some communities such as Acushnet and Wareham have only 10% and 12% respectively of their town's land-base protected from development. Many others have more than twice that amount.

Agriculture

Many people associate southeastern Massachusetts with cranberry bogs, their ripening red berries, and harvest in the fall. Most of the state's 13,000-plus acres (2012 estimate) of cranberry bogs are located within the Buzzards Bay watershed and the region still hosts the North American headquarters of Ocean Spray Cranberries. In 2012, Massachusetts was second in the nation in cranberry production, which exceeded $99 million in product value[32]. Based on 1996 estimates, there were in 5,500 jobs and two million dollars in payroll to Commonwealth residents in the cranberry industry. Cranberry growing is also intricately tied to several wetland and water quality issues discussed in the CCMP. It is thus essential that growers manage their land to minimize environmental degradation.

According to a 2002 USDA Agricultural Census of Buzzards Bay, there are approximately 474 farms in the Buzzards Bay region, accounting for approximately 8% of the total number of farms in Massachusetts (6,075 total farms) and 27% of the total farms in the region's counties: Bristol, Plymouth and Barnstable (1,703 total farms). The crops typically grown within the region include vegetables, fruits, and berries (including cranberries, as described above), as well as nursery and greenhouse plants. (Aside from the Towns of Carver, Wareham, and Middleborough, most farms in other cities and towns generate less than $50,000 in revenue from their crops). In addition, Westport is the only town that has farms that generate a wide variety of crops, ranging from nursery to livestock. Dairy farming was once a more prominent agricultural activity within the watershed, and has been identified as a major water pollution source to some systems. However, the number of dairy farms has greatly diminished during the past twenty years, especially in the Dartmouth/Westport area.

The southeastern Massachusetts Agricultural Partnership's (SEMAP) "Buy Local" campaign works to raise consumer awareness about the benefits and importance of buying fresh, locally grown farm products and to increase and identify opportunities for purchasing these products. In 2003, SEMAP conducted a regional survey to assess the effectiveness of the campaign, and to understand the food buying habits of the region's consumers. The results of this survey indicated that local residents prefer to buy locally grown or raised foods (approximately 68% reported that they are more likely to buy local and 88% buy at farmers markets). Furthermore, the survey concluded that residents are more likely to buy locally grown or raised products at roadside stands than at large supermarkets because they taste better. This indicates a clear interest by regional residents to preserve and protect local agriculture. According to the Woods Hole Research Center, there has been approximately a 40% loss of agricultural lands in the region and more than a 60% increase in residential, industrial, and commercial properties since that time. Growth management, comprehensive planning, and agricultural land

[32] USDA NASS. 2013. New England Agricultural Statistics, 2012.

preservation are essential tools that government needs to employ to help protect agriculture in the region.

Biotechnology/Marine Sciences

Southeastern Massachusetts is currently the center of marine science and marine science-related industries, including marine instrumentation, fishing, and aquaculture. The University of Massachusetts at Dartmouth, Woods Hole Oceanographic Institute, Marine Biological Laboratory, and the Massachusetts Maritime Academy are all located within the region and promote education and research in marine science, technology, and environmental technology. These educational institutions, through programs like UMass Dartmouth's Advanced Technology & Manufacturing Center, School for Marine Science and Technology, and the federally designated Northeastern Regional Aquaculture Center, provide specialized training to help marine industries expand and modernize. Fall River's South Coast Research and Technology Park is located in the region's only research and development overlay district. This zoning district portrays an interesting example of the use of zoning to attract a particular type of industry.

The entire southeastern portion of Massachusetts benefits from its proximity to two major metropolitan areas--Boston, Massachusetts and Providence, Rhode Island. The region's extensive highway network provides excellent access to the deep-water ports in southeastern Massachusetts, particularly in Fall River and New Bedford. These ports, which offer access to world markets, currently compete with major metropolitan areas such as Boston and New York. According to the Massachusetts Alliance for Economic Development, New Bedford has been designated as a Foreign Trade Zone, as it serves as a direct port of entry to Europe and Latin America.

Fishing and Shellfishing Economies

Commercial and recreational shellfishing in Buzzards Bay is important to the economy of the Buzzards Bay watershed. A large number of commercial and recreational permits are sold by Buzzards Bay municipalities, but the number has been declining in recent years (Figure 23) because of depleted shellfish populations and to a lesser degrees, increasing shellfish bed closures. Still, in recent years, Buzzards Bay has accounted for 20-40% of the entire state catch of commercial shellfish (Figure 24).

In Buzzards Bay, five major species of shellfish are harvested: quahogs (or hard-shelled clams), oysters, soft-shelled clams ("steamers"), surf clams, and bay scallops. Quahogs represent the largest portion of the shellfishery in terms of poundage (Figure 25), yet significant numbers of the other major species are harvested each year, many of which have a higher market value per pound.

Nearly every harbor in Buzzards Bay has shellfish beds; however, many shellfishing areas within the region

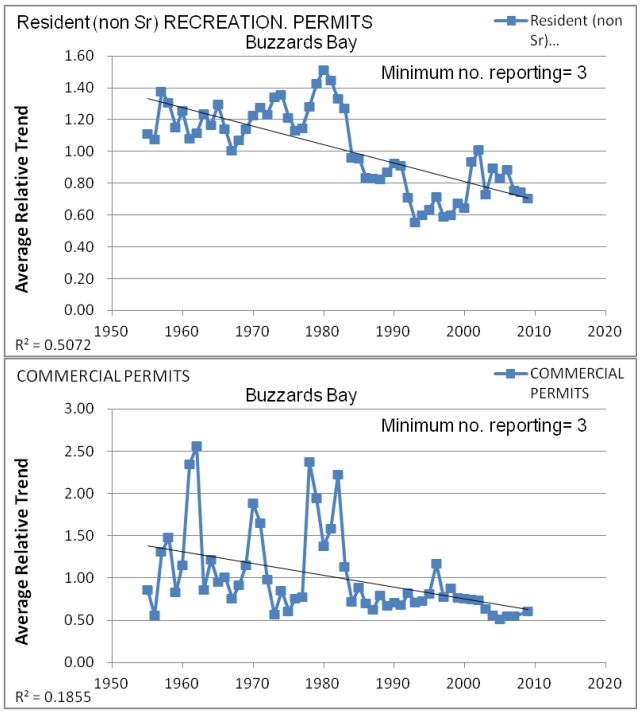


Figure 23. Relative trends of commercial and recreation permits issued in Buzzards Bay.

Includes data from Westport, Dartmouth, Fairhaven, Mattapoisett, Marion, Wareham, Bourne, and Falmouth (including non-Buzzards Bay waters). New Bedford excluded because shellfish beds were not reopened until the 1980s. Data courtesy of MA DMF with additional analysis by Buzzards Bay NEP, data and information at: buzzardsbay.org/shellfish_catch_trends_bb_ma.htm.

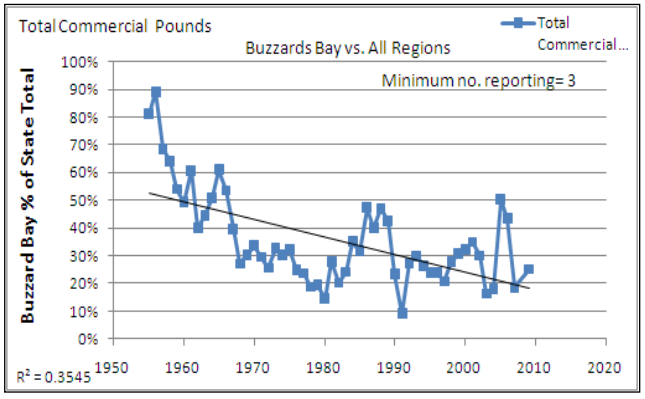


Figure 24. Commercial catch in Buzzards Bay as a percentage of state catch over time.

Based on pounds caught for the period 2000-2005, for all species. Data and findings posted at: buzzardsbay.org/shellfish_catch_trends_bb_ma.htm.

are restricted due to bacterial closures. Some of these closures are permanent (year-round), seasonal (summertime), or rainfall conditioned. For example, the closures at the end of Clarks Point in New Bedford and east of Mishaum Point in Dartmouth are permanent closures because of municipal sewage treatment facility discharges in those areas. Other areas like those in Sippican Harbor in Marion, and West Falmouth Harbor in Falmouth,

are closed because of elevated bacteria levels or high densities of boats moored during the summer. Most closures around Buzzards Bay are the result of "nonpoint" land-based pollution sources, often conveyed by stormwater runoff. Therefore, it is vital to control nonpoint sources of pollution (contaminants, nutrients from fertilizers and sewage, and chemicals from pesticide use and other sources) in the Buzzards Bay watershed in order to preserve this important industry. A high priority of this Comprehensive Conservation Management Plan is to provide abatement and long-term management solutions for nonpoint source pollution.

Although commercial finfishing is prohibited within central Buzzards Bay waters, finfishing outside of this prohibited area accounts for a large portion of the region's marine economy as well as shellfishing. Recreational fishermen, shore-based recreational anglers, vessel-based anglers, and participants in charter vessel excursions, tend to conduct their activities in the warmer months of the year. Local residents have always considered the area around the Elizabeth Islands as a prime sport fishing area, particularly for the fishing of striped bass, bluefish, and black sea bass. These waters are frequented often during the summer months. Most anglers agree that the presence of a variety of habitats, and the strong currents flowing into and out of the Canal, create ideal conditions for fishing for the following species: scup, striped bass, bluefish, tautog, weakfish, black sea bass, and fluke (Colburn et al., 2002).

Watershed Municipalities

Community Profiles

Seventeen municipalities are located either totally or partially within the Buzzards Bay watershed, ten of which front directly on the bay. These municipalities are briefly described below, with town-specific demographic data presented in Table 9.[33]

Acushnet

At the headwaters of the Acushnet River, the Town of Acushnet has a business and commercial area near its borders with the Town of Fairhaven and City of New Bedford, but much of the town has retained a centuries old rural atmosphere of country roads, farms, and apple orchards. It covers 18.9 square miles, but has one of the smaller populations in the watershed, with 10,303 persons counted in the 2010 U.S. Census.

In the 19th century the town was the site of water powered factories and boat yards; and today construction and manufacturing remain important industries. Notably, the town is the home of the Acushnet Company, makers of Titleist brand golf balls, clubs and accessories.

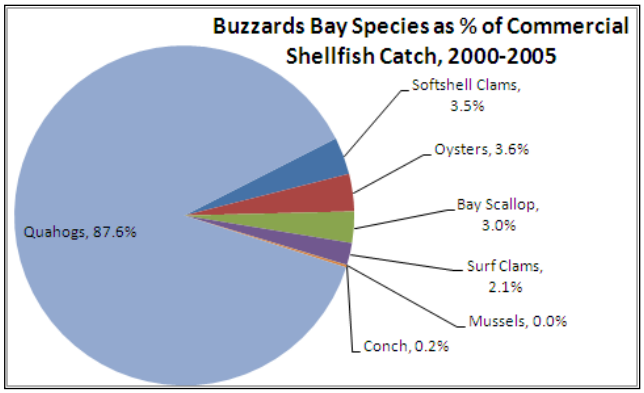


Figure 25. Relative commercial catch by species in Buzzards Bay.

Based on pounds caught for the period 2000-2005. Data and findings posted at: buzzardsbay.org/shellfish_catch_trends_bb_ma.htm.

Bourne

The Town of Bourne is a medium-sized residential and rural community at the gateway to Cape Cod, with most of the town in the Buzzards Bay watershed. The Cape Cod Canal bisects the community, with both the Bourne and the Sagamore bridges and the lift railroad bridge all located in Bourne. The town's development and character are defined by its village centers, which include the town's main business and government center in the village of Buzzards Bay on the west side of the canal, and the villages of Gray Gables, Monument Beach, Pocasset, and Cataumet on the Cape Cod side of the canal. The Bourne Scenic Park campground is located beneath the Bourne Bridge and is a perfect location for fishing and scenic bike rides. Bourne has numerous harbors and inlets for boating and swimming, and shellfishing has always been an important commercial and recreational activity in the town. The National Marine Life Center, which provides hospital and care facilities for stranded or injured marine animals, has undergone an expansion and will help drive ecotourism to the Buzzards Bay village, which has been economically depressed. A large area of the western part of the town is within the Massachusetts Military Reservation, and is undeveloped open space.

Carver

The Town of Carver today is largely a suburban commuter community. In colonial times, the discovery of bog iron ore in the region stimulated the development of iron foundries, which supported the town's economy. Later cranberry bog production dominated the local economy. Today, the town is one of the few in the state where most of the land is still in agricultural production, in this case, and cranberry growing is the single most important industry in the community.

[33] Elements of these community profiles were excerpted from or modified from the community profiles prepared by the Massachusetts Department of Housing and Community Development at Mass.gov. Last accessed March 16, 2011.

Table 9. Buzzards Bay watershed municipal demographics from 2000 and 2010 U.S. Census fact sheets.

Municipality	2000 census population	2010 census population*	2010 median age	2010 average household size	2010 median household income	2010 Total Housing Units	2010 % vacant	2010 % owner occupied
Acushnet	10,161	10,303	43.6	2.62	$64,695	4,118	4.5%	84.5%
Bourne	18,721	19,754	44.1	2.30	$62,531	10,805	27.2%	75.7%
Carver	11,163	15,059	42.3	2.68	$70,608	4,600	6.6%	91.4%
Dartmouth	30,666	34,032	39.6	2.54	$73,007	12,435	9.6%	78.5%
Fairhaven	16,159	15,873	45.3	2.33	$60,179	7,475	10.7%	71.9%
Fall River	91,938	88,857	38.0	2.27	$34,789	42,750	10.0%	35.7%
Falmouth	32,660	31,531	50.5	2.21	$61,244	21,970	36.0%	76.1%
Freetown	8,472	8,870	42.4	2.78	$61,244	3,317	4.7%	88.8%
Gosnold	86	75	48.5	1.92	$52,813	215	81.9%	41.0%
Marion	5,123	4,907	46.8	2.45	$87,793	2,445	22.5%	82.4%
Mattapoisett	6,268	6,045	47.7	2.41	$82,065	3,262	23.2%	78.6%
Middleborough	19,941	23,116	41.2	2.67	$73,490	9,023	6.2%	77.7%
New Bedford	93,768	95,072	36.6	2.40	$37,493	42,933	9.7%	42.1%
Plymouth	51,701	56,468	41.4	2.55	$76,631	24,800	14.2%	78.0%
Rochester	4,581	5,232	43.3	2.88	$98,728	1,885	3.8%	92.8%
Wareham	20,335	21,822	44.4	2.38	$52,556	12,256	25.8%	77.0%
Westport	14,183	15,532	45.6	2.52	$73,736	7,193	14.4%	81.2%

*Data taken from 2000 and 2010 fact sheets at http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml. Last accessed October 11, 2013.

Both the iron foundries and later cranberry bogs drew immigrant workers from the Cape Verde Islands and Finland, who settled in the community. In the 1940s, the town produced more cranberries than any town in the world, and today this agricultural industry remains as important to the town's economy as it had in the past, with bog acreage actually increasing in recent decades. Because so much of the land is owned by cranberry growers, the town retains its rural flavor.

Dartmouth

The Town of Dartmouth covers 62.0 square miles, and had a population of 34,032 in the 2010 U.S. Census. The town has a scenic coastline that borders Buzzards Bay with three large estuaries (the Slocum River, Little River, and Apponagansett Bay), and a large cove it shares with New Bedford (Clarks Cove). The town has appreciable farmlands, particular in the southern half of the town. The town has undertaken significant efforts to preserve the rural and agricultural character of the community through land protection. The northern portion of the town contains the Town Forest and other significant land holdings that serve as both passive and active recreational uses in order to meet the needs of the growing community. Dartmouth has multiple industrial parks with considerable areas of land available for development. The more densely developed parts of town are serviced by municipal water, sewer and gas, all at a tax rate that is one of the lowest in Massachusetts. The community is home to the University of Massachusetts at Dartmouth, a four-year higher educational institution. The town also has a number of malls and large retail stores that are patronized by residents of neighboring areas.

Falmouth

In the early 1800s Falmouth was a fishing and farming community, as well as a homeport for a significant fleet of whalers. Ships were built at Woods Hole, Quissett, and West Falmouth. From about 1870 onwards, the population increased, largely because of the growing number of summer homes, summer resort hotels, and the opening of the railroad through to Woods Hole in 1872. The increasing size and worldwide renown of the scientific institutions at Woods Hole have contributed to the growth and importance of the town. Expanding amenities have also made Falmouth attractive as a retirement community.

Falmouth is a large town geographically (approximately 49 square miles), and has one of the longest coastlines in the state (approximately 57 miles). Large tracts of land, amounting to over 1,000 acres, have been set aside for public conservation areas, not exclusively waterfront, but some woodland and back land areas that contain natural habitat for wildlife, that enhance the attractiveness of the community. Private conservation land also exists, owned by several land trusts, the largest of which is The 300 Committee.

Fall River

The City of Fall River straddles the Buzzards Bay watershed, with the developed portion of the city in the Taunton River watershed, and the mostly undeveloped portion of the city, including a protected forest inside the Buzzards Bay watershed. The city covers 38.5 square miles and had a population of 88,857 in the 2010 U.S. Census, just somewhat less than the City of New Bedford. It is located approximately 50 miles from Boston and 15 miles from Providence, Rhode Island. It is an industrial community on the banks of the Taunton River in Bristol County, formerly an important textile mill town, like New Bedford. In fact, from the 1870s until the 1920s, Fall River was the largest center in the U.S. for the manufacture of cotton textiles. The city's geography and port facilities make it both a transfer point for passenger and freight traffic to New York and the site of intense industrial development. Its diverse residential population is made up of immigrants from Portugal and Great Britain, drawn to the mill jobs in the city. While most of the textile mills closed by the 1970s, the modern city maintains a highly diversified industrial profile with chemical operations, electrical and food product manufacture, along with the remaining garment and textile industries. The city also attracts tourists with the largest factory outlet district in New England.

Fairhaven

The Town of Fairhaven is a seaside community on the shore of Buzzards Bay with 15,873 persons (2010 U.S. Census) in a 12.4 square mile area. Through the middle of the 18th century the town's economy was agricultural until a shift toward maritime activities such as shipbuilding, whaling and foreign trade occurred. By 1838, Fairhaven-New Bedford Harbor was the second busiest whaling port in the country. To date, the town's most notable features are the European-style public buildings built between 1885 and 1906 by Standard Oil Company millionaire Henry Huttleston Rogers, a native of the town. The community began taking on the character of a suburban town in the late 1870s when the street railway connected Fairhaven to New Bedford. During this time, Fairhaven began to develop as a summer resort area with significant rural areas and working farms. During the 20th century, the economy of Fairhaven was affected by the expansion then decline of manufacturing in the City of New Bedford. Today the town is known to be a suburban/fishing/resort community.

Marion

The Town of Marion covers 14.1 square miles with a population of only 4,907 (2010 U.S. Census). The town was first settled as a village known as Sippican, a part of Rochester. Rochester, Mattapoisett, and Sippican, widely separated villages under the domain of Rochester, gradually developed different interests and economies. Marion is a town that captures the essence of a classic New England village. The streets in the village section are tree lined with historic homes and white picket fences. There is a General Store in the center of the village and the Post Office is directly across the street. Marion is also home to Tabor Academy, a well-known preparatory school. Marion's Sippican Harbor, hosts a variety of waterfront programs, including swimming at the town beaches, pleasure boating and fishing. Forested swamps and wetlands that drain into the Sippican and Weweantic Rivers dominate the northern portions of the town. Today the town has a stable year-round population with a moderate summertime increase.

Mattapoisett

The 17.5 square mile Town of Mattapoisett has a population of 6,045 (2010 U.S. Census). The town was part of Rochester until 1857, when it was incorporated into a separate town. In addition to settlement by European explorers, archeologists have also found Native American burial sites in town indicating co-habitation. Forested swamps and wetlands that drain into the Mattapoisett River dominate the northern portions of the town. Shipbuilding was established around 1740, and approximately four shipyards were in operation by 1800. Mattapoisett was one of the most important shipbuilding towns on the East Coast, building some 400 ships over a period of 100 years. Prior to the Civil War, the principal business in the town was whaling. Following the decline of the whaling and shipbuilding industries, an influx of wealthy summer residents built summer homes on large estates in town. Mattapoisett became a summering place for residents of New York and Boston.

Middleborough

The Town of Middleborough is the second largest town by land area in Massachusetts. It is a 70-square mile historic industrial town on the Nemasket River, with a population 23,116 in the 2010 U.S. Census. The town is one of only a handful of southeastern Massachusetts communities that retained a sizeable Native American population throughout the colonial period. Although the iron industry dominated the federal period, Middleborough also made shovels and textiles. After the Civil War, the town became a rail center attracting industrial development, lumbering, box mills, brick making, and the Maxim Motor Company, which has been producing fire trucks since 1914. Today, cranberry agriculture is the most important single industry, with other important industries being silviculture, and the manufacture of calendars and brass goods. The town has zoned land as an industrial park to encourage additional development in the community. Tourism is driven by historic museums and antique shops.

New Bedford

The City of New Bedford is the most populous Buzzards Bay watershed municipality, with a population of 95,072 in the 2010 U.S. Census in an area covering only 20.3 square miles. The city was the whaling capital of the world in the 18th century, and has evolved to become the home of many major industries, which manufacture products used throughout the United States and abroad. The city continues to rank as the nation's number one commercial fishing port in terms of value of landed catch, and has long held title as the nation's leading supplier of sea scallops. The working waterfront is home to several national seafood-processing plants, which produce a wide array of products shipped around the world. The New Bedford Business Park, located in the far north end of the city, employs over 2500 people and accounts for approximately $650 million in sales revenue. Tourism is also a fast-growing segment of the local economy. New Bedford's rich history, its national park status and its authentic working waterfront draws increasing numbers of tourists annually. In addition, a continued increase in the number of galleries, museums, and cultural events is earning New Bedford recognition as "a city of art, "attracting professional artists, art patrons and visitors of all interests drawn to the city's growing artistic vibrancy.

Rochester

The Town of Rochester had a thriving coastal trade from its harbors on Buzzards Bay. Its coastline was lost when Marion and Mattapoisett, originally within the borders of Rochester, were made separate towns in 1852 and 1857, respectively. Parts of Rochester were also given to Fairhaven and Wareham. Rural Rochester retains many of the farms that began in the town over 300 years ago. Rochester's agricultural character, winding roads, and open space are evident as one travels throughout the town, and the landscape reflects the fact that it has one of the largest areas of any town (36.4 sq. mi.) in the watershed, but it also has one of the smallest populations (5,232 in the 2010 U.S. Census) of the mainland communities. Historic Rochester Center is still a busy central location that includes the Town Hall, First Congregational Church, Town Library, Post Office, a bakery, and the Plumb Corner Mall. Currently, there are several riding stables in town, the Rochester Golf Club, and a park in the town center that serves as the home for several sports teams. Rochester is one of only two communities in the watershed with neither municipal water nor sewer services.

Wareham

The Town of Wareham, once termed the: "Gateway to the Cape", is situated at the head of Buzzards Bay and offers easy traveling distance to the Boston and Providence metropolitan areas. The town covers 46.3 square miles, and had a population of 21,822 in the 2010 U.S. Census. The town has over 54 miles of coastline enhanced by diverse assemblage of beaches, estuaries, rivers, and ponds. These features, together with large areas of undeveloped land around a large network of cranberry bogs, create visually distinct vistas throughout the town. From its early beginnings of farming and shipbuilding in the 1700s, Wareham has evolved a diversified industrial and commercial economy, with cranberry cultivation remaining an important economic driver in the community. The town has a number of seaside villages that are mostly occupied only during the summer, but like most towns in the region, many of these seasonal residences are being converted to year-round dwellings.

Westport

The Town of Westport had long been considered a rural and largely residential community known for its beaches, cornfields, and dairy farms, but the character of the town is rapidly changing and only four dairy farms remain. Covering 52.1 square miles, the town's population was 15,532 in the 2010 U.S. Census. Westport's landscape features diverse estuarine and freshwater habitats, many of which are identified as important habitat supporting rare and endangered species. While fishing and agriculture were once important livelihoods in town, today many residents engage in service trades, and many are retirees. In the summer months, thousands of tourists visit Horseneck Beach, a state beach that contains approximately 600 acres of barrier beach and salt marsh. Nearby Gooseberry Island, accessible by a causeway, is a popular place to fish. Several Westport businesses have made national names for themselves in the past few years, such as the Westport Rivers Vineyard and Winery and the Buzzards Bay Brewing company.

Seasonality and Occupancy

There are a number of interesting trends that can be illustrated by the demographic data in Table 9, such as the relationship between owner occupancy (the inverse of rental occupancy) and vacancy rates (Figure 26). For example, the Cities of Fall River and New Bedford have relatively low vacancy rates and high rental occupancy rates. Some communities, like Falmouth, Wareham, and Bourne have high vacancy rates because a large fraction of the homes are seasonal summer use only, so these homes were either vacant during the time of the census taking (March), or they may have winter renters. At the other end of the spectrum are towns such as Carver and Rochester, whose residents tend to be year-round, and nearly all these residents own their own home. There is also a very strong correlation between median income and the percentage of renters in a community (not shown).

Municipal Governance

Of the municipalities within the Buzzards Bay watershed, only the cities of New Bedford and Fall River have mayors forming the executive branch and city councils forming the legislative branch, passing ordinances. All other municipalities have the town form of government, with boards of selectmen forming the executive branch, and town meeting forming the legislative branch, passing bylaws. Within this town form of government, there is further variation as to how many selectmen serve, whether town meeting is open to the public, or only elected representatives, and which boards have elected members or political appointments (Table 10). These variations in governance can have a profound effect on how rapid or easily a municipality can adopt environmental laws and regulations.

From an environmental management point of view, the capacity of municipal government to address environmental issues, whether through internal staffing, hiring of contractors, or its political capacity to fund programs through taxes, bonds, and fees, depends, to a very large degree, on existing tax rates, bond commitments, and the affluence of the community. The ability of a town to adopt certain measures also depends whether certain financial accounts are established, such sewer enterprise accounts, or if the town has adopted the Community Preservation Act. These specific financial strategies are touched upon, where applicable, in each action plan, and in Chapter 6 Resources for Financing the Buzzards Bay CCMP.

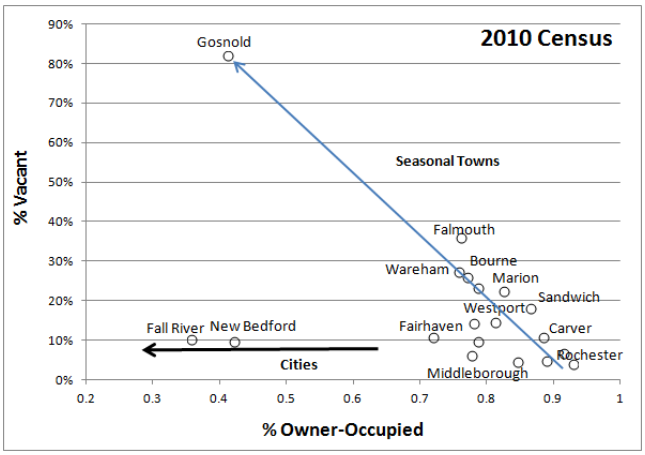


Figure 26. Census 2010 vacancy versus owner occupancy for Buzzards Bay municipalities.

Table 10. Buzzards Bay watershed municipal governance.

Municipality	Executive Branch	Legislative Branch	Administration	Health	Planning	Conservation
Acushnet	3 Selectmen	Open Town Meeting	Town Administrator	3 elected	5 elected	7 appointed
Bourne	5 Selectmen	Open Town Meeting	Town Administrator	5 elected	9 elected, 2 alts	7 appointed
Carver	5 Selectmen	Open Town Meeting	Town Administrator	3 elected	5 elected	7 appointed, 3 alts
Dartmouth	5 Selectmen	Elected Town Meeting	Executive Administrator	3 elected	5 elected, 1 alt	7 appointed
Fairhaven	3 Selectmen	Open Town Meeting	Executive Secretary	3 elected	8 Elected	7 appointed, 2 alts
Fall River	Mayor	City Council	Mayor	3 appointed	5 appointed	3-7 appointed
Falmouth	5 Selectmen	Elected Town Meeting	Town Manager	5 appointed	7 Elected	7 appointed, 3 alts
Gosnold	3 Selectmen	Open Town Meeting	Executive Secretary	3-selectmen serve as the Board of Health and Planning Board		5 appointed
Marion	3 Selectmen	Open Town Meeting	Town Administrator	3 elected	7 elected	5 appointed, 2 alts
Mattapoisett	3 Selectmen	Open Town Meeting	Town Administrator	3 elected	6 elected	5 appointed
Middleborough	5 Selectmen	Open Town Meeting	Town Manager	5 elected	5 elected	7 appointed
New Bedford	Mayor	City Council	Mayor	3 appointed	5 appointed	3-7 appointed
Plymouth	5 Selectmen	Elected Town Meeting	Town Manager	5 elected	5 elected, 1 alt	7 appointed
Rochester	3 Selectmen	Open Town Meeting	Town Administrator	3 elected	7 elected	7 appointed
Wareham	5 Selectmen	Open Town Meeting	Town Administrator	3 appointed	5 appointed 1 alt	7 appointed, 2 alts
Westport	5 Selectmen	Open Town Meeting	Executive Secretary	3 elected	5 elected	7 appointed

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