THE STATE OF DUXBURY BAY

2009

Prepared by the Duxbury Bay Management Commission

February 25, 2011

Duxbury Bay Management Commission

(as of March 2010)

Ned Lawson (Chairman)
John Brawley
Shawn Dahlen
David Grossman
J.R. Kent
Jon McGrath
Don Merry
Joseph Messina
Corey Wisneski
Jake Emerson (ex-officio)
Betsy Sullivan (Board of Selectman liaison)

Acknowledgments

Special thanks go to John Brawley, Ned Lawson, Jon McGrath, and Corey Wisneski for their work on this report.

Thanks also go to Provincetown Center for Coastal Studies, Massachusetts Division of Marine Fisheries, Gregg Morris, Sara Grady of Massachusetts Bays National Estuaries Program, Duxbury Harbormaster Department, and the Duxbury Bay Maritime School

Introduction

This report is intended to provide information concerning the resources and uses of Duxbury Bay. The document has been prepared by the Duxbury Bay Management Commission (DBMC) as part of an effort to collect and track data relevant to the health of the Bay, to identify trends, to provide a basis for regulatory and management decisions concerning the bay, and to resolve conflicts between bay resources and uses of the bay. The report provides available data for the five year period beginning in 2005.

This report includes data on water quality, eel grass, shellfish, endangered species, invasive species, moorings, recreational boating, and Harbor Master Department activity. The presentation of each data set is preceded by comments concerning the data. The DBMC intends to update this report as additional data become available and will distribute the report to Town officials whose responsibility involves Duxbury Bay.

Duxbury Bay is an unusual natural area with an estimated 1,200 acres of salt marsh and 4,650 acres surface water area (including Duxbury waters adjacent to Kingston). The Bay contains hundreds of acres of productive shellfish beds, eelgrass, a barrier beach, estuaries, and herring and rainbow smelt fish runs to name a few of its attributes. There is a great variety and population of resident and migratory birds supported by the Bay. This includes a tern colony and once was the site of one of the largest heronries at Clarks Island.

Additionally, Duxbury beach and the Bay flats support endangered species including piping plovers. The striped bass, bluefish and flounder fisheries are also thriving. Shellfish aquaculture is an increasingly visible and productive resource in the Bay. The variety and number of species indicates that this is a healthy example of a coastal ecosystem and it is enjoyed by a wide diversity of users.

The natural beauty and pristine quality of our Bay is no accident. It is partly due to the unusual tidal flow, which exchanges it is also due to the citizens of Duxbury who have taken action to preserve the Bay they love. Restoration of the barrier beach, innovative group septic and storm drain systems, proactive runoff management and restoration of an historic herring run are some examples of how the community has acted to protect and preserve the Bay resources.

Geographical history

Duxbury's shoreline is acase study in barrier systems. The geological story begins 15,000 years ago when the last New England glaciation, known as the Wisconsian stage of the Laurentide ice sheet, receded north and uncovered a new Duxbury. As the ice sheet retreated north, sea levels rose. At the height of ice sheet growth, sea level was approximately 350 feet lower than it is today. "You could walk out to Georgia's Bank," said Jim O'Connell, a geologist at the Woods Hole Oceanographic Institution. "The Gurnet and Saquish were much bigger than they are today because the sea level hadn't reached and begun to erode those areas," added O'Connell.

As the glaciers receded, they left boulders, sand, cobble, and clay behind. Clarks Island, Gurnet and Saquish are drumlins under the glaciers that remained as the ice melted. We know this today because of the extensive boulder platform fronting these land forms. Duxbury Beach is known as a coastal barrier beach because the bay borders its landward side, and the open ocean is on its seaward side. A barrier island occurs when a coastal barrier detaches from the mainland. When it remains attached to the mainland, it is called a barrier spit. Duxbury Beach is a barrier spit pinned by a land form, and in this case that land form is Gurnet Point.

The barrier beach, however, is in constant motion. Storms accelerate this movement as storm waves carry and deposit sand into the sheltered waters of the bay, forming a new beach and dunes on the bay side. Storms erode the foreshore, the shore face, and the backshore, and strong waves break through the dunes bringing the sand into the bay. Storm erosion combined with rising sea levels produces a more marked and rapid movement landward. Duxbury Bay is actually shrinking for this reason, although quite slowly. Other factors adding to the beach's front side erosion include the effects of the seawalls along Brant Rock and Marshfield's coastline

Past storms, like the infamous Blizzard of 1978 and the No-Name storm of 1991, have carried sand from the frontside of the beach to the bay side in what geologist call an overwash. These storm overwashings have occurred in several locations along Duxbury Beach over the years. They allow sand to wash over and fill marsh and bay areas, thus moving the barrier landward.

Today, the Gurnet is a glacial drumlin holding Duxbury Beach, but this will change as future storms and climate variations impact the migration of this barrier beach. The International Panel on Climate Change has predicted that sea level will rise at an accelerated rate in the near future so that the current one-vertical foot in 100 years of sea level increase will almost double over the next 100 years. This scenario of increasing sea level rises combined with future storms will have a huge effect on how Duxbury Beach and the Bay will look in the future. Some geologists predict that the barrier beach will migrate past Gurnet Point and attach itself to Clarks Island.

WATER QUALITY

The Impact and Importance of Water Quality

The quality of our Bay water is vital to the life in the bay, to the many citizens whose livelihood directly or indirectly depends on bay resources, to those who enjoy recreational activities on and around the bay as well as everyone living on or near our waters.

The Bay's ecosystem comprises an intricate array of constantly dynamic and interacting elements that renew and regulate the Bay's resources. The large daily tidal cycle replaces about 70% of its volume on average twice each day. Daily cycles of light and temperature stimulate plant as well as other marine life. And seasonal cycles of temperature and plant growth interact to produce a natural rhythm of life within the Bay.

Understanding our Bay's water quality requires an appreciation for the natural behavior of some of its elements. For example, there is a large and unusually rich tidal marsh system in several areas of our bay that are a natural source of organic material to the water. The marsh supplies a constant stream of organic nutrients to the bay but also can cause turbidity. The average depth at low tide is quite shallow so the water temperature in our bay is typically warmer than surrounding waters.

Duxbury is fortunate to have some of the cleanest estuarine water on the Massachusetts coast and is the last major body of water and shellfish resource from Cape Cod to New Hampshire's border not seriously affected by coastal pollution. This is partly due to the high tidal exchange coupled with relatively low population densities in the area which limit the extent of nutrient enrichment and pollution inputs. But it is also due to the concern and proactive responses of the town and its citizens to emerging threats to water quality. Examples of these are the Bluefish River septic system, the town's successful fight against increased discharge from the Plymouth Sewage treatment plant and improved storm drainage on Bay Rd.

Water Quality Indicators and Trends

The DBMC has developed a series of indicators associated with water quality and related ecosystem attributes in Duxbury Bay. These indicators are supported by existing data and will continue to be updated based on new information from external sources. There are several sources of historic data collected by various state and federal agencies, but because the collection locations and methods were not standardized, historic trending is not possible. The best existing source of data comes from an initiative by the Provincetown Center for Coastal Studies, which have established an extensive data collection and analysis effort to monitor numerous water quality parameters in Massachusetts Bay as well as several adjoining estuaries, especially Duxbury Bay. Still, the data have been accumulating for a relatively short time and over a relatively small number of specific areas within the bay. Data gaps are currently being analyzed and a new Duxbury Bay Volunteer Monitoring Program (in cooperation with DBMS) will attempt to fill areas of missing, or desired, information.

The following are the existing water quality and ecosystem indicators:

Bacteria/Pathogen Concentrations

The Massachusetts Division of Marine Fisheries samples the water column at numerous points around the bay for fecal coliform to assure that shellfishing beds are safe for harvest. In addition, the Duxbury Board of Health, supported by the Massachusetts EPA, surveys our beaches to insure the water is safe for swimming. Fecal coliform is an indicator of overall bacterial, or pathogen, presence and abundance.

The DMF follows a monitoring protocol that is consistent with methods described by the National Shellfish Sanitation Program (NSSP). Bay stations are sampled a minimum frequency of five times annually while open to harvesting. Water and shellfish samples are tested for fecal coliform bacteria at two DMF laboratories located in Gloucester and New Bedford using a Most Probable Number (MPN) method in Gloucester (American Public Health Association) for classification purposes and a membrane filtration technique in New Bedford (usually M-tec) for pollution source identification.

Numeric criteria are applied to decisions on whether certain areas should be open or closed to shellfish harvesting (recreational and commercial). In some cases areas are determined to be "conditionally approved" for shellfish harvest during certain times of the year. Shellfishing can be closed based on exceedance of numerous criteria including:

- 3 samples exceeding 31 MPN/100 ml within 3 years for approved or conditionally approved and open
- Geometric mean exceeding 14 MPN/100 ml

According to the NSSP, a minimum of the 15 most recent samples taken during a period when tested area is in the open status are used to determine whether a station is meeting the numeric criteria, listed above. DMF sampling stations are shown in Figure 1. Exceedances were recorded in only two locations through the sampling period: those are summarized in Table 1.

Table 1 Shellfishing Coliform Exceedences

Count of e	Year										
Station	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
11		1	1	3	1	1					
S6	3		2	1		5		1		4	

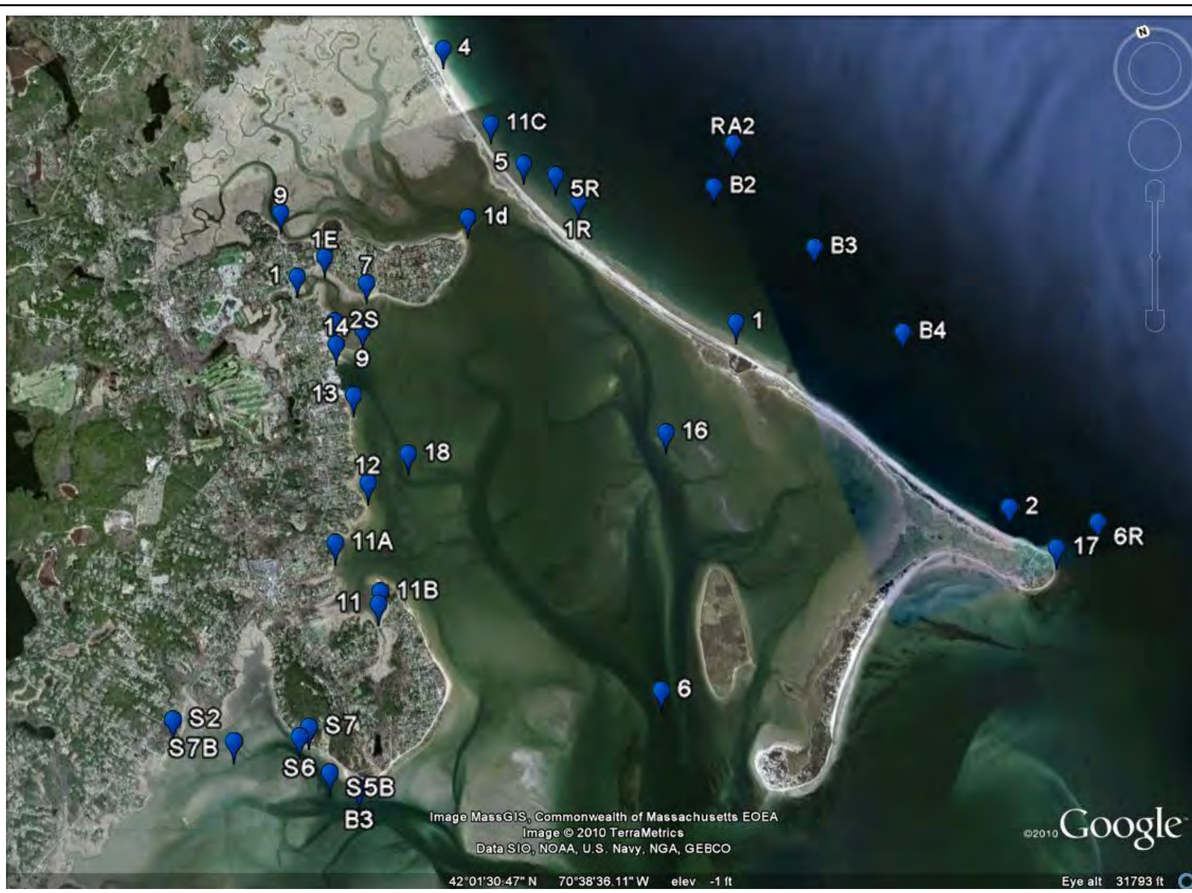

Figure 1. DMF Sampling Locations

The Duxbury Board of Health regularly monitors beaches according to a document published in 1986 by USEPA called "*Ambient Water Quality for Bacteria*", and uses Enterococci as the indicator organism for determining suitability of marine water quality for safe swimming. Swimming beaches are closed based on the following criteria:

- A single sample exceeding 104 CFU per 100ml
- Any five samples over a 30 day period averaging at least 35CFU per 100ml

Table 2 shows the frequency of exceedances according to these criteria and figure 2 shows the test locations.

Table 2. Beach Exceedences

	2003	2004	2005	2006	2007	2008	2009	2010
Gurnett			0	5	0	0	0	0
Landing Road	3	4	1	2	0	3	4	0
Residents Beach	0	0	0	0	0	0	2	0
Shipyard Lane	2	1	0	0	0	0	0	0
West End	2	1	0	0	0	2	0	0

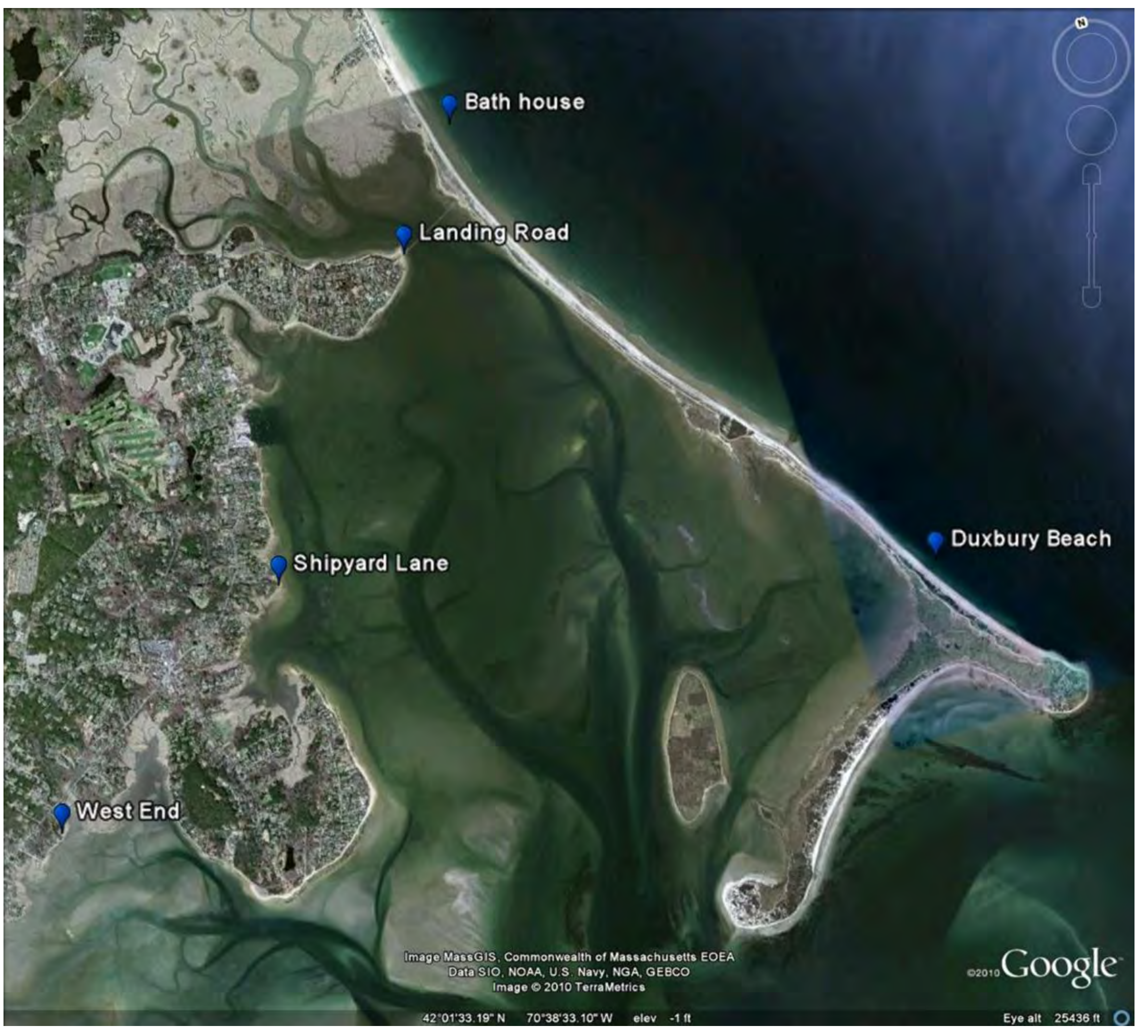

Figure 2. Dept of Health Sampling Locations

Water Clarity

Water clarity is an important indicator of water quality in areas of the bay where natural conditions include the existence of benthic primary producers such as eelgrass and algae. Decreased water clarity limits the availability of light reaching these primary producers and can result in shifts in benthic community structure and condition. Decreases in water clarity can be associated with nutrient enrichment and the resulting increase in phytoplankton standing stock (measured by chlorophyll concentration), terrestrial runoff of particulate matter (e.g., sand, silt, clay, organic matter) and/or dissolved matter (colored dissolved organic matter). Other contributions to changes in water clarity include changes in physical nature (e.g., a breach of the barrier beach), power boats, and storm events (wind and freshwater discharge).

Water clarity can be measured in several ways: The Provincetown Center for Coastal Studies publishes data using a nephelometer, an optical instrument that detect light reflected by particles suspended in a water sample.

Table 3 displays the data collected and the Figure 3 shows the test locations in Duxbury Bay.

Table 3 Turbidity Data

Average of Turbidity (NTU)					
	C1	C2	C3	D1	D3
May 07	1.06	1.16	1.04	2.81	12.44
Jun 07			1.61	5.10	11.77
Jul 07			0.74	1.54	3.86
Aug 07			0.58	2.42	2.86
Sep 07			0.63	2.08	3.16
Oct 07			0.84	1.95	5.04
May 08				7.02	6.29
Jun 08			0.93	4.74	5.40
Jul 08			0.97	3.72	5.92
Aug 08			0.83	2.56	4.59
Sep 08			0.26	0.92	2.71
Oct 08			0.79	1.96	3.45

Average of Turbidity (NTU)					
	C1	C2	C3	D1	D3
2007	1.06	1.16	0.90	2.70	6.08
2008			0.77	3.28	4.70

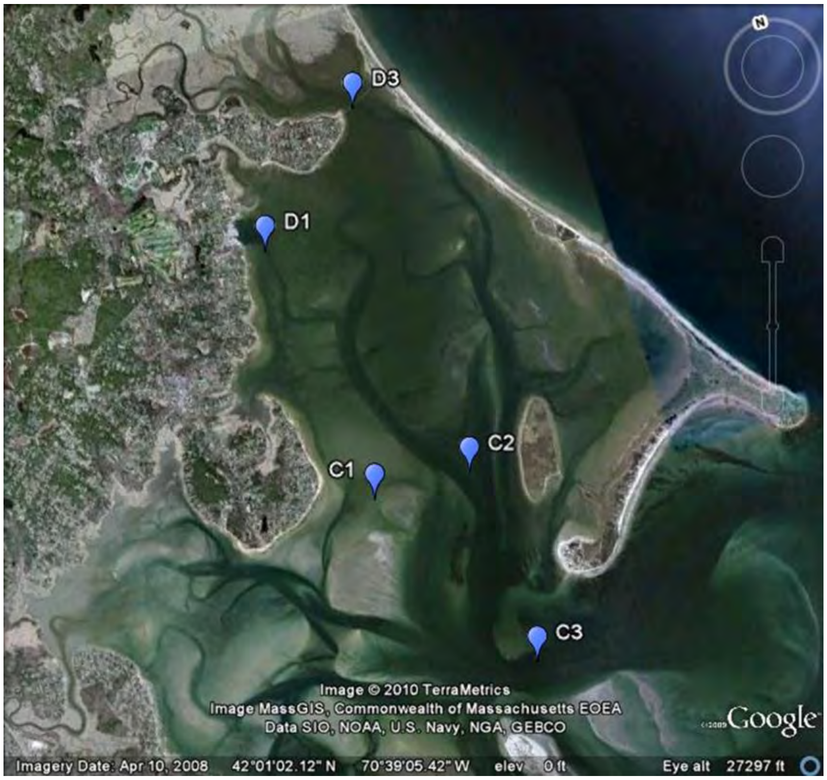

Figure 3 PCCS Sampling Locations

The DBMC received a grant from the Massachusetts Department of Environmental Protection in 2007 to purchase a LiCor PAR sensor instrument to be used to measure and calculate light extinction. One deployment of this instrument has occurred to date.

Phytoplankton Standing Stock (Chlorophyll a)

Phytoplankton are microscopic plants that form the base of the food chain of Duxbury Bay. Because almost all types produce through photosynthesis, their concentration is usually estimated indirectly by measuring chlorophyll levels.

Although, worldwide, the level of phytoplankton has been decreasing (by almost 40% since 1950), the level of phytoplankton in Duxbury Bay has [something missing?] As the water temperature warms and available nitrogen, from fertilization for example, increases, so does the level of chlorophyll. This can have favorable impacts (greater available food for a variety of other organisms including shellfish) and unfavorable impacts (higher turbidity reduces light availability for photosynthesis could have a negative impact on eelgrass and other plant life.

Chart 1. Chlorophyll A

Macroalgae Standing Stock

Macroalgae, or seaweed, is found in most coastal environments and provides food and refuge to a variety of marine organisms. In waters that have excessive nutrient pollution, macroalgae populations can thrive to the detriment of the overall ecosystem, potentially leading to low dissolved oxygen levels in the water column and negatively impacting (or even killing) fish and other organisms.

Currently there are no known monitoring programs associated specifically with macroalgae. The MA DEP include narrative (presence or absence) descriptions as part of their eelgrass monitoring program

Dissolved Oxygen

Many marine organisms are dependent on dissolved oxygen (DO) found in the water column for respiration and metabolism. A decrease in the amount of available DO can lead to negative physiological impacts in these organisms, including massive die-offs if the DO levels are low enough. Other marine ecosystem impacts from low DO levels include increased toxicity of some substances (e.g., lead, copper) and an increase in anaerobic respiration byproducts, such as ammonia and hydrogen sulfide, which are themselves toxic to marine organisms in high concentrations.

In Massachusetts, the Department of Environmental Protection (DEP) has set a minimum DO standard in Class SA waters of 6 mg/L

The Provincetown Center for Coastal Studies (PCCS) includes DO in its existing monitoring program. Table 4 shows individual data and annual average. See Figure 3 for sampling location in Duxbury Bay.

Average of Dissolved Oxygen (mg/L)						
	C1	C2	C3	D1	D2	D3
May 06	9.17	9.39	8.85	8.36	8.35	
Jun 06	8.00	7.90	7.91	7.48	7.59	
Jul 06	7.94	7.99	8.50	7.36	7.81	7.47
Aug 06	7.60	7.46	7.64	7.25		6.92
Sep 06	9.67	9.74	9.20	9.42		8.84
Oct 06	7.74	7.71	7.68	7.78		7.78
May 07	9.24	9.14	9.67	8.51		7.29
Jun 07			9.12	7.41		7.17
Jul 07			8.94	8.03		6.50
Aug 07			8.78	8.32		7.79
Sep 07			8.52	7.72		7.11
Oct 07			8.31	7.49		7.26
May 08				9.03		8.90
Jun 08			9.10	7.62		6.09
Jul 08			8.68	7.52		6.90
Aug 08			7.90	7.50		6.53
Sep 08			8.02	6.86		7.37
Oct 08			9.41	8.46		9.74

Average of Dissolved Oxygen (mg/L)						
	C1	C2	C3	D1	D2	D3
2006	8.39	8.35	8.32	8.01	7.78	7.90
2007	9.24	9.14	8.87	7.90		7.17
2008			8.59	7.66		7.24

Table 4. Dissolved Oxygen

Water Temperature

Water temperature is not an environmental condition that can be managed in Duxbury Bay. However, knowing spatial and temporal trends (including interannual trends) provides valuable information associated with other important bay indicators such as DO and productivity.

Several oyster farmers in Duxbury have been routinely monitoring water temperature for several years. Gregg Morris and John Brawley have deployed temperature data loggers in various areas of the bay since 2006. In addition, the Barnstable County Cooperative Extension service has periodically deployed water temperature dataloggers in Duxbury Bay.

The Provincetown Center for Coastal Studies has been collecting temperature together with the water samples from their Duxbury Bay stations. Chart 2 shows individual data; see Figure 3 for sample locations.

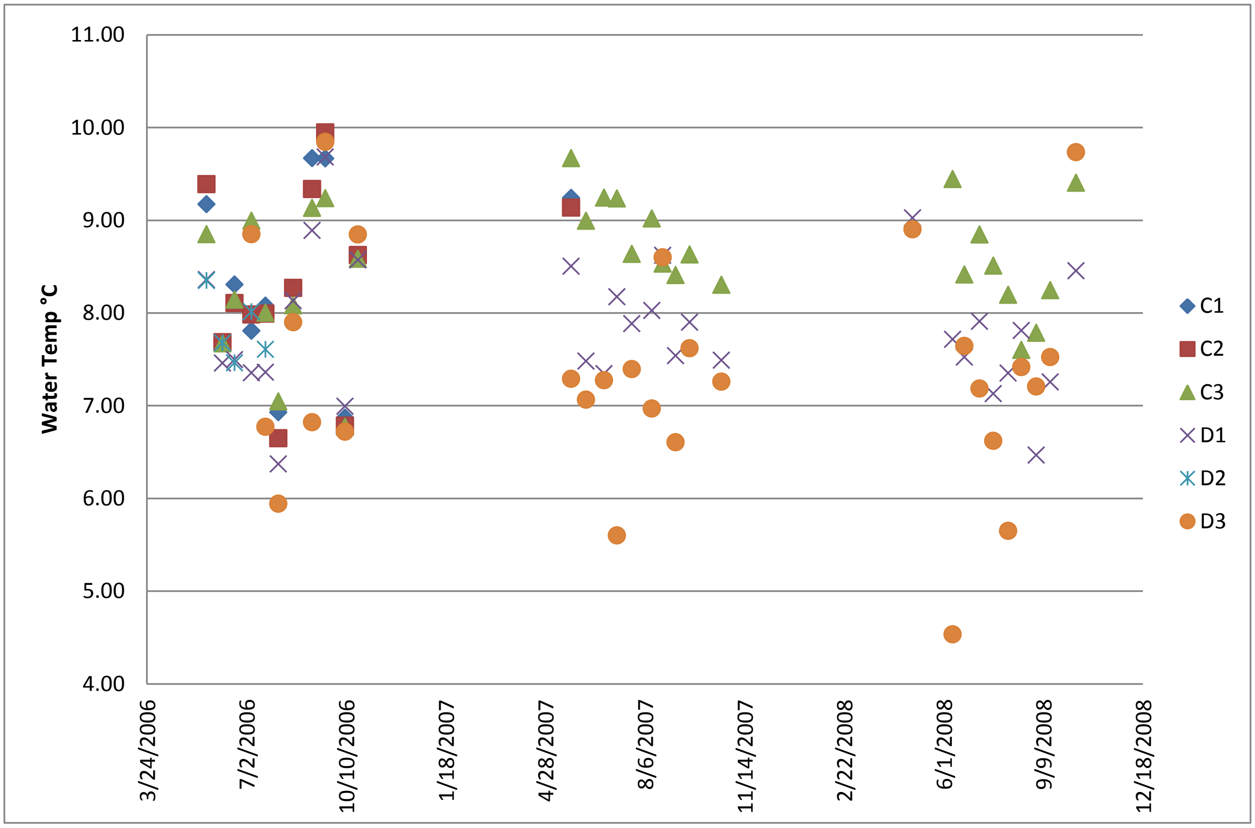

Chart 2. Temperature Data

EELGRASS HABITAT

One of the most important aquatic resources in Duxbury bay is eelgrass (Zostera marina). Eel grass grows in mud, mudy sand , and muddy gravel in estuarine waters that are protected from waves. It may be found in both lower intertidal and subtidal areas. It reproduces through the growth of rhizomes, Both leaves and rhizomes contain air spaces that provide buoyancy. Eel grass beds are significant to the marine environment for several reasons:

- They facilitate sediment disposition and water quality.
- They provide substrate for for epiphytic algae and micro-invertebrates.
- They serve as nursery grounds for many species of fish and shellfish.
- They provide food for waterfowl.

In 1995 aqnd 2001, MA DEP mapped Duxbury Bay eelgrass beds using aerial photography. In 1995, there were 958.4 acres of grass. In 2005, that figure had declined to 803.8 acres, a reduction of 154.6 acres or 16.1%. The changes are shown on the following maps: [inset 3 maps from Aqua. Manag. Plan]

The specific cause[s] of the decline are not well understood. Possible explanations include:

- Increased turbidity and reduced light penetration.
- Natural cyclical changes.

- Disease.
- Motor boat operation resulting in increased wave action and /or uprooting of plants.

The reduction of eelgrass acreage is of concern if it is part of a continuing trend. MA DEP mapping will provide additional information and the need for increased monitoring efforts should be considered.

ENDANGERED SPECIES

Data are available for piping plover, an endangered species that nests on Duxbury Beach. Of the data presented in Table 1, the information on fledglings/nest and number of nests are the most relevant to determining overall annual nesting success. The data show that breeding success was significantly higher in the years 2006 through 2008 than it was in 2005 or 2009. The relatively low production rates in 2005 and 2009 were attributable to overall weather, storm activity, and depredation by other birds and animals.

Table 5. Duxbury Beach Piping Plover Data, 2005-2009.

	2005	2006	2007	2008	2009
# of nests	20	14	11	8	11
# of fledglings	8	20	14	9	4
Total chick mortality	15	28	7	5	8
# of fledglings/nest	0.40	1.43	1.27	1.10	0.36

HORSESHOE CRABS

Horseshoe crab data are available only for 2008 and 2009 and are insufficient to provide an index of population or reproductive success.

Recently, data on Duxbury horseshoe crab populations are collected by volunteers under a program managed by Sara Brady of the North and South Rivers Watershed Association. Data are collected during spawning activity during full moon hight tides in May to early July on the bay side of Duxbury Beach from the bridge to Blakeman's. Crabs found within 10 meter square quadrats are counted. There are about 40 quadrats. Both males and females are counted. Sex can readily be determined because the females are much bigger than the males. The males attach themselves behaind the females with specialized pincher claws and the front of the males' shells are curved to fit over the back of the females' shells. The females bury into the mud/sand to deposit their eggs.

Ancedotal accounts indicate that today's crab populations are smaller than they were 40 years ago. Historically, there was pressure on populations because the crabs predate on clams. There was a bounty on crabs delivered to the town dump (now Transfer Station). More recently, horseshoe crab blood has been used in medical research. Companies that extract the blood claim that they return them to the water with no harm done.

Table 6. Duxbury Bay Horseshoe Crab Data, 2008-2009.

	2008	2009

Horseshoe crab total number surveyed	1,329	1,446
Horseshoe crab density	1.24	0.93
Horseshoe crab spawning index (females/quadrat)	0.20	0.17
Horseshoe crab sex ratio (M/F)	5.2/1	4.9/1

SHELLFISH LANDINGS

The data on shellfish landings reveal two significant trends. The first is the emergence of Duxbury's oyster aquaculture industry as the dominant component of shellfish landings. For example, in 2008, oyster landings were almost five times greater than the combined total for all other species. The DBMC does not believe that the decrease in oyster landings between 2006 and 2007 shown by the following table is real. The decrease is probably the result of errors in the Division of Marine Fisheries record keeping. The second noticeable trend is the absence of blue mussel landings after 2006. This is thought to be the result of natural population cycles rather than the result of over-harvesting or environmental conditions.

Table 7. Duxbury Bay Shellfish Landings, 2006-2008.

	2006	2007	2008
Northern quahog	ND	2,669	169
Razor clam	60,833	121,780	89,579
Softshell clam	47,732	58,509	87,687
Blue mussel	561,857	0	ND
Eastern oyster	951,277	724,245	856,917

ND=No data

COMMERCIAL AND RECREATIONAL SHELLFISH LICENSES

Commercial Licenses

The following data show an increase in the total number of licenses from 58 in 2006 to 73 in 2009. The principal increase has been in the Combination category. Combination licenses permit the harvesting of eels, seaworms, and shellfish as specified. These licenses generate the n. quahog and softshell clam landings noted above and may at least partly explain the recent increase in softshell landings. The increase in commercial licenses may be linked to the difficult economy. The number of Mussel and Razor Clam licenses has remained steady because entry to those fisheries is limited. Note that the number of licenses for harvesting mussels has remained almost unchanged in spite of the fact that mussels have not been harvested since 2006. Evidently those licensees are waiting for the population to rebuild.

Table 8. Number of Commercial Shellfish Licenses.

	2006	2007	2008	2009
Combination	38	34	41	49
Mussel	9	10	10	9
Razor Clam	11	15	15	15
Total	58	59	66	73

Recreational Licenses

All categories of recreational shellfish licenses increased significantly between 2005 and 2009. Total license grew from 1037 to 1408, an increase of almost 36%. The number of residential increased at a higher rate than din non-residential licenses. Non-residential licenses increased at about the same rate: residential licenses increased by 39% while non-residential licenses grew by 25%. The increased number of licenses may be explained by the health of Duxbury Bay's wild shellfish populations and the state of the economy. Other factors may include Duxbury Bay's protection from red tide and the bay's reputation generated by the emergence of the oyster industry.

Table 9. Number of Recreational Shellfish Licenses.

	2005	2006	2007	2008	2009
Residential	322	363	308	401	449
Non-residential	526	538	460	672	658
Senior	189	210	210	ND	301
Total	1,037	1,111	978	1,073	1,408

ND=no data

INVASIVE SPECIES

The presence of invasive species in Duxbury Bay is a relatively new phenomenon and is believed to be principally the result of discharges of discharges of ballast water from vessels traveling to the US from abroad. At this time, the data are scarce and non-specific. The presence of various species of tunicate has been documented beneath floats at the Town Pier and on the cages used by the aquaculture industry. Other species, most notably green crabs, have been observed by shell fishermen. The presence of tunicates is of concern because they have the potential to cover the bay bottom and harm both natural and cultivated shellfish and eelgrass. The aquaculture industry removes and destroys tunicates found on oyster cages, a practice that helps to control their abundance. Green crabs have the ability to feed on young oysters. Invasive species have the ability to multiply rapidly because of the absence of natural predators. The DBMC believes that additional studies of invasive species are needed.

Table 10. Duxbury Bay Invasive Species Data, 2006-2009.

	2006	2007	2008	2009
Solitary club tunicate	common	ND	ND	abundant
Colonial orange sheath tunicate	abundant	abundant	abundant	abundant
Colonial golden star tunicate	common	common	common	common
Colonial tunicate	ND	ND	ND	few
Orange striped anemone	few	ND	ND	ND

ND=no data

MOORINGS

The following data on moorings in Duxbury Bay reflect an increase in the total number of moorings. Virtually all of the increase has occurred in the Basin Flats and Tidal Flats categories because the maximum number of moorings permitted for other areas is fixed. The maximum number of Basin Flats moorings is fixed at 432. The increase in that category from 362 in 2005 to 426 in 2006 is the result of the adoption of a uniform time frame for permitting and an improved fee collection process. The same factor explains the increase in Tidal Flats moorings between 2005 and 2006. The figure of 912 total moorings in 2009 is a drop from a total of 949 in 2008 and may reflect economic conditions. Bayside Marine, Inc. reported having 140 rack spaces in the summer of 2005 and, since then, has had 145 rack spaces every summer. This rack space information is one indicator of traffic in the Bay, but does not have bearing on the number of moorings.

Table 11. Number of Moorings in Duxbury Bay by Anchorage, 2005-2009.

	2005	2006	2007	2008	2009
Clarks Island	20	18	21	22	20
Two Rock	32	32	30	31	32
Howland's Landing	74	84	80	80	68
Basin Deep Water	166	166	166	166	166
Basin Flats	362	426	405	424	406
Tidal Flats	148	214	225	226	220
Total	802	940	927	949	912

RECREATIONAL BOATING ACTIVITY

In the absence of other readily available data, the DBMC elected to use enrollment numbers at the Duxbury Bay Maritime School (DBMS) as an index of changes in recreational boating activity. Between 2005 and 2009, total enrollment increased form 2030 to 2213, an increase of 183 or 9%. It must be noted that a significant component of that growth did not occur on Duxbury Bay. The increase in High School Rowing from 271 in 2005 to 316 in 2009 is mostly attributable to the school's development of a rowing at Billington Sea in Plymouth.

Table 12. DBMS Enrollment Numbers, 2005-2009.

	2005	2006	2007	2008	2009
Junior Sailing three-week sessions	844	807	920	888	910
Adult Sailing	227	199	197	191	263
ACCESSAIL	198	268	261	237	253
Kayaking	132	128	131	113	110
High School Rowing	271	278	243	257	316
Adult Rowing	358	308	352	328	361
Total	2030	1988	2104	2014	2213

HARBORMASTER DEPARTMENT ACTIVITY

The Harbormaster Department did not have a formal record keeping system for its activities prior to 2007. Because the Department lacks a full-time dispatcher, depends on part-time summer help, and lacks a fully automated incident logging system, the data below are not completely reliable. In addition, it will be impossible to draw conclusions from the activity data until there are data from additional years.

Table 13. Duxbury Harbormaster Dept. Reported Incidents, 2008-2009.

	2007	2008
Disabled boats	43	43
Mooring complaints	72	44

Shellfish violations	45	61
Boat accidents	4	2
Motor vessel damage	2	4
Boat overdue	1	3
Vessel broken free	23	26
Vessel violations	33	18
Harbor violations	7	26
Sunken vessels	14	10
Stolen vessels	4	3
Flare sightings	2	3
Hazards to navigation	3	1
Fatalities	1	0
Total	254	244

CONCLUSION

Because the data set for the above are limited, it is difficult to detect any real trends or threats to Duxbury Bay. The one exception to this general conclusion is the documented presence of invasive species, which have the potential to adversely affect the bay's resources if populations continue to grow. As noted above, a better monitoring program is required. On the positive side, the data on water quality show demonstrate that Duxbury Bay continues to be largely unaffected by coastal water pollution. Because the bay's resources and many ways in which the bay is used are dependent on water quality, that should be a focus of future monitoring and data collection.