# HUMAN USES

## COMMERCIAL FISHING

One of the dominant uses of the Ocean Planning area is commercial fishing by means of mobile and fixed gear (trawls, dredges, longlines, pots, weirs, and gill nets). The major fisheries in Massachusetts are shellfish (including scallops, conch, quahogs, and surf clams), finfish, lobsters, crabs, and urchins. Commercial seafood was a $1.6 billion industry in Massachusetts in 2004 which includes the combined inshore/offshore landings (UMass 2006). The most valuable port in the United States is New Bedford, which has held this designation for the past eight years (NMFS 2008a). Gloucester, Provincetown, and Boston also harbor major commercial fleets, and virtually all harbors and inlets support some type of commercial fishing activity (Comm. Mass. 2004). The species with more than $5 million in annual landed value in 2007 are sea scallop, lobster, monkfish, cod, haddock, winter flounder, Atlantic sea herring, yellowtail flounder, skates, and witch flounder. The value of scallop and lobster approach 50% of the total landed value of all species.

Through an analysis of vessel trip reports and landings data, the dominant fishing effort and value of catch are found around Cape Ann, between Boston and Plymouth, Wellfleet Harbor, the western side of Monomoy Island, Vineyard Sound, and New Bedford Harbor. In nearly all fisheries, effort and landings are not homogenously distributed within a particular reporting area. Therefore, it is possible for distinct portions of a "low" activity area to support fishing effort and landings on par with "high" activity areas and vice versa.

The Department of Fish and Game's, Division of Marine Fisheries (*MarineFisheries*) is the state agency responsible for managing commercial fishing. *MarineFisheries* works closely with the New England Fishery Management Council (NEFMC) and Atlantic States Marine Fisheries Commission (ASMFC) to manage species on a consistent basis on interstate and federal scales.

Further analysis could be done to examine the breakdown of landings outside of the planning area (both landside and seaside), where the majority of landed shellfish and sea scallops is caught. The most critical planning need for better managing commercial fishing uses is the development of comprehensive trip reporting. This effort has been underway through the state Standard Atlantic Fisheries Information System (SAFIS) since 2005 as well as the federal Vessel Tracking Service (VTR) requirements for some species which both require trip level data.

### Recreational Fishing *Major contributors: Bradford Chase and Mark Rousseau*

One of the major uses of the planning area is recreational fishing by over a million recreational anglers. Recreational fishing is dominated by hook and line fisheries, but a small component of recreational fishermen also utilize pots, nets, and spears. Recreational fishing is conducted from the shore, using individually owned vessels, and using charter boats (including "party boats") for a variety of species including Striped Bass, Blue Marlin, White Marlin, Swordfish, Black Sea Bass, Bonito, Bluefish, Cod, Cusk, False Albacore, Haddock, Halibut, Mackerel, Pollock, Scup, Sharks, Smelt, Fluke, Tautog, Bluefin Tuna, Yellowfin Tuna, Weakfish, Winter Flounder, and Wolffish (MA DMF 2008). Recreational fishing evolved from subsistence fishing which was an important cultural tradition in coastal Massachusetts. The modern sportfishery includes a component of subsistence fishing, although in a reduced role that is not well documented. Additionally, there are indigenous fish rights on some creeks and streams. Since 1983, *MarineFisheries* has conducted intercept and random telephone surveys to estimate recreational saltwater catch and effort. However, the area fished components to this survey is not of sufficient resolution to identify areas important to the recreational fishery. All Massachusetts ports have access to excellent recreational fishing. The groundfisheries off Cape Ann and the flounder fishery off Boston Harbor are well known attractions that bring in visitors and support local business. The Cape and Islands striped bass fisheries are world reknowned and a valuable contribution to the local tourist economy. The assessment of this industry is currently in transition with the implementation of a new licensing system.

Recreational lobster fishing could be further analyzed in tandem with commercial fishing effort utilizing the statistical reporting areas for the lobster fishery.

Recreational shellfishing requires a permit in Massachusetts. This is a major activity, but likely occurs entirely outside of the planning area. Exceptions may exist in the Wellfleet Harbor area.

## AQUACULTURE

*Major contributors: Mike Hickey, Jerome Moles, and Sean Bowen*

Aquaculture is defined in Massachusetts as "the farming of aquatic marine organisms, but not limited to fish, mollusks, crustaceans, echinoderms, and plants. Farming implies some sort of intervention in the rearing process to enhance production including, but not limited to controlled propagation, feeding, protection from predators, *etc*." (322 CMR 15.02). About 304 permits are issued each year by *MarineFisheries*. Aquaculture is generally divided into three main types: commercial, research, and municipal propagation.

The exclusive form of commercial marine aquaculture engaged in Massachusetts is bivalve molluscan culture, employing several methods of cultivation to grow quahogs (*Mercenaria mercenaria*), oysters (*Crassostrea virginica*), bay scallops (*Argopecten irradians*), soft shell clams (*Mya arenaria*), and to a lesser extent surf clams (*Spisula solidissima*) and blue mussels (*Mytilus edulis*). The Massachusetts aquaculture industry is comprised of 374 aquaculture farms on 378 hectares (935 acres) of tidelands worth an estimated $6.3 million (MA DMF 2006). The shellfish aquaculture industry in Massachusetts has been steadily growing at a rate of 10% each year for the past decade (NOAA 2007). Permit holders utilize both on-bottom and off-bottom culturing techniques in twenty-seven coastal communities throughout the state: Aquinnah, Barnstable, Brewster, Chatham, Chilmark, Dennis, Duxbury, Eastham, Edgartown, Essex, Fairhaven, Falmouth, Gosnold, Ipswich, Marion, Mashpee, Mattapoisett, Nantucket, Oak Bluffs, Orleans, Plymouth, Provincetown, Rowley, Wareham, Wellfleet, Westport, and Yarmouth. By encouraging municipal oversight with technical assistance by *MarineFisheries*, Massachusetts has been successful at encouraging aquaculture while controlling for the introduction of shellfish diseases, non-native/exotic shellfish species and other pests or predators into Massachusetts waters. There are 30 hectares (75 acres) of blue mussel aquaculture sites in the early licensing stage at four locations within state waters located on Martha's Vineyard in Aquinnah, West Tisbury, and Chilmark. These sites will then be subdivided into individually licensed sites. Since the planning area largely excludes tidelands, aquaculture within the planning area is limited to within Wellfleet Harbor which contains 47 licensed sites in the planning area as of 2006. Offshore aquaculture has been proposed for Massachusetts, but due to market pressures, use conflicts, and the possibility of environmental impacts, there are currently no offshore commercial aquaculture activities within the planning area. However, due to technological advances and improved understanding of oceanographic conditions, offshore aquaculture has considerable promise for the future (NH SeaGrant 2006).

There are two research aquaculture activities in Massachusetts: the Salem State experimental mussel aquaculture off of Gloucester and Rockport and the Wellfleet oyster restoration project by the Town of Wellfleet, The Nature Conservancy, and the Audubon Society. The Salem State facility is a research activity. The Wellfleet project is a restoration project and will be open to harvest in the future.

In addition to commercial and research aquaculture activities, municipal propagation of shellfish is also regulated by *MarineFisheries*. Propagation is a method by which shellfish seed are grown out in town waters and then distributed for the benefit of recreational and commercial fishermen. It is similar to the stocking of lakes with trout, so is not considered a commercial aquaculture activity.

## OTHER RECREATIONAL USES

### Marine Mammal and Bird Viewing

*Major contributors: Erin Burke and Robert Buchsbaum*

Wildlife viewing is a significant component of coastal recreation and tourism opportunities in Massachusetts. Whale watching is the most prolific of these ventures and Massachusetts is often referred to as the "Whale Watching Capital of the World." From April through October, humpback, fin, and minke whales congregate to feed on dense patches of schooling fish. The Race Point area off of Provincetown is an important large whale feeding area in late April and often throughout the summer months. Because the summer tourist season coincides with a time when whales are abundant in the planning area and in nearby federal waters, commercial and recreational whale watching has become a significant use in the planning area and in Stellwagen Bank National Marine Sanctuary. Approximately 10 whale watch companies operate out of Massachusetts and most conduct two trips per day targeting humpbacks and fin whales. The industry mainly operates out of Newburyport, Gloucester, Boston, Plymouth, Barnstable, and Provincetown (Figure 6.1). The population of whales that visit Stellwagen Bank each year is fairly consistent and thus, over the course of a season and the course of a whale's life (known to be at least 50 years), they are exposed to frequent interactions with this industry.

The Marine Mammal Protection Act (MMPA) prohibits harassing, hunting, capturing, or killing any species of marine mammal. Each of these acts is considered a "take." The humpback and fin whales, which are targeted by the whale watch industry, are also listed as endangered species under the

Endangered Species Act (ESA). Voluntary federal guidelines exist that govern how commercial whale watch vessels can operate around large whales. Right whales are highly endangered, and it is a violation of state and federal law to approach a right whale closer than 457 m (500 yd). Right whales are common in the late winter and spring, and are not a species targeted by the whale watch industry. Incidental vessel strikes have occurred between other large whale species and whale watch vessels. Between 1980 and 2004, nine whale strikes were reported due to collisions with whale watch boats (NMFS 2008).

In addition to whales, gray and harbor seals are also the subject of wildlife viewing, particularly the population residing on Monomoy Island off Chatham. This is the only active seal watching area in the state. However, access to this site is particularly challenging.

Birding is a popular activity in the United States, with an estimated 45 million people in the United States considering themselves birders, and 18 million saying that they travel to watch birds (USFWS 2001). Massachusetts has a long tradition as a birding destination and draws not only its own residents but also birders from across the county. Although not specifically quantified, tourism-related birding does have an economic benefit to the Commonwealth, particularly to those communities that are located near birding hot spots, such as Newburyport. Unlike whale watching, birding is an all year activity; in fact some of the most interesting birding along the coast occurs in winter.

In state waters, the consistent draws are wintering seaducks and other diving birds (loons, grebes), pelagic species (shearwaters, gannets, petrels, *etc.*), migratory and nesting shorebirds, and nesting terns. In addition to these species, birders are legendary for their willingness to travel across the country at any time of the year to see a rarity. The 1975 appearance of a Ross's Gull in Newburyport and the subsequent massive crowds it drew is considered to have spawned the modern popularity of birding.

Much seabird viewing by birders takes place from vantage points on the shore. Popular locations include Plum Island, Halibut and Andrews Point on Cape Ann, Manomet Point in Plymouth, Sandy Neck in Barnstable, First Encounter Beach in Eastham, Race Point in Provincetown, and Nantucket. Monomoy National Wildlife Refuge and South Beach (Chatham) are popular destinations for boat tours, particularly in mid July through September during the height of shorebird migration. Birding clubs will occasionally offer charter boat tours to view pelagic birds, heading beyond state waters to Stellwagen Bank and even the continental slope. Birders will also go on their own on whale watch cruises in hopes of seeing pelagic species.

### Diving

*Major contributor: Vincent Malkoski*

Recreational SCUBA diving is a popular activity with a long history in Massachusetts. Dive clubs such as the Boston Sea Rovers, the South Shore Neptunes, and the North Shore Frogmen have been established for 50 years or more and continue to flourish. Massachusetts is home to the nation's longest running dive symposium, the Sea Rovers' Underwater Clinic, started in 1954. Ardent wreck divers and organizations such as the Historic Maritime Group of New England have discovered and identified many wrecks of significance to Massachusetts' maritime history and aided in the conservation of artifacts. Massachusetts' recreational divers have also aided in the development of oceanographic equipment such as remote operated vehicles (ROVs), and assisted in numerous research projects conducted by Woods Hole Oceanographic Institution, MIT, Harvard, Stellwagen Bank Marine Sanctuary, and the Massachusetts Board of Underwater Archeology. Massachusetts' divers also conduct underwater fish censuses for Project REEF and invasive species monitoring conducted by the Office of Coastal Zone Management (CZM).

Diving is done throughout the planning area. Local dive shops can be found in all coastal areas to provide equipment sales, service, air fills, and instruction. Many people dive from private vessels of all sizes and charter boats catering to divers can be found in most of the major harbors. Most recreational diving takes place in the inshore waters at depths ranging from 3-40 m (10-130 ft). Exceptional shore-based diving can be found off Cape Ann, Marshfield, Plymouth, and Sandwich.

Most diving activities tend to fall into one of five categories: instructional/training, research, wreck diving, photography, and the harvest of lobster and scallops. Some divers are content to simply explore and enjoy the diverse and productive marine environment. The more common diving activity by regions within the Commonwealth is as follows:

- Cape Ann – Instruction/training, fish census, lobster harvest, photography, wreck diving
- Boston Harbor Islands – Wreck diving, lobster and sea scallop harvest
- Massachusetts Bay – Wreck diving, technical instruction
- Cape Cod Bay – Instruction/training, photography, lobster harvest, and wreck diving
- Outer Cape – Wreck diving, technical instruction, and lobster harvest.
- Elizabeth Islands, Martha's Vineyard, and Nantucket – Photography and wreck diving
- Buzzards Bay – Wreck diving and shellfish harvest

Harvest of lobster and shellfish is regulated and managed by the Division of Marine Fisheries and to a lesser extent by the municipalities. Wreck diving on commonly known sites is an open activity, although exploration of new sites is regulated by the Board of Underwater Archeology. Instructional activities are organized through dive shops, college programs, and independent instructors; instructional standards are regulated through national training agencies. The economic contribution of recreational diving is not well known.

### Hunting

Massachusetts has world-class sea duck hunting (Figure 6.2). Shooting and falconing for sea ducks (scoters, eiders, mergansers, and long-tailed ducks) and Atlantic brant is done from land and from vessels from November 1-February 15. Other species that are hunted include green and blue-winged teal, american widgeon, mallards, black ducks, wood ducks, gadwalls, pintails, shovelers, ring-necked ducks, lesser and great scaup, harlequin ducks, common and barrows goldeneye, bufflehead, ruddy duck, Canada goose, snow goose, and ross's goose (Massducks.com 2008). This activity occurs along the coast, in the planning area (generally close to land), and likely on and near the islands contained within the planning area (such as Noman's Land). Additionally, hunters may pass through the planning area in vessels. There are no indigenous hunting rights in Massachusetts.

Data on bird populations can be informed by hunting data, but abundance can be hard to measure due to vulnerability of a species to hunting (Stott and Olson 1972).

Hunting is regulated by the Department of Fish and Game, Division of Fish and Wildlife. The entire planning area is adjacent to the Coastal Waterfowl Hunting Zone as defined in Migratory Game Bird Regulations. Waterfowl are protected by the federal government under the Migratory Bird Treaty Act of 1918 and all bag limits are set by the U.S. Fish and Wildlife Service.

### Gambling Boats

There are currently only two gambling boats in Massachusetts. Atlantic Casino Cruises (125 gaming machines, nine tables) operates out of Gloucester and runs daily from Rowes Square in Gloucester's Inner Harbor and the City of Lynn has Horizon's Edge Casino Cruises (225 gaming machines, 11 tables) operating out of Marina Boulevard in Lynn Harbor.

## TRANSPORTATION

The ocean planning area provides access for a variety of commercial transportation uses. The Ports of Boston, New Bedford, Fall River, and Gloucester, while technically outside of the planning area, are the destination and origin of vessels transporting people, food, fuel, liquid and dry bulk cargoes, and container goods through the planning area. The construction and maintenance of navigational pathways in the planning area to ensure the safe transit of these vessels and how these navigational lanes interact with other uses of the planning area is an important component of the ocean management plan.

### Shipping—containers, bulk products, fish

#### Boston (including Everett, Chelsea, Revere, Quincy and Weymouth)

The Port of Boston, which extends into Everett, Chelsea, Revere, Quincy and Weymouth, is the most northerly large deep-draft port on the U.S. eastern seaboard with a container terminal and is the closest port on northern shipping routes to Europe. The Port of Boston generates approximately 34,000 jobs and an annual economic impact of $2.4 billion and provides infrastructure and value-added services to enhance the competitiveness of New England's trade-dependent companies.

Approximately 22 public and private cargo terminals operate within the Port of Boston and annually handle more than 15 million tons of liquid and dry bulk, containerized, and general cargo worth more than $10 billion. Bulk products, principally petroleum fuels, natural gas, cement, scrap metal, gypsum, and salt, are processed through facilities in the Mystic River, Chelsea Creek, and South Boston. Autos are imported and exported at the Boston Autoport on the Mystic River. Cruise ships call on the Black Falcon Terminal on the Reserved Channel in South Boston. Containerized cargo, which makes up about five percent of the Port's volume, is handled at the Massachusetts Port Authority's (Massport's) Conley Terminal, which is also on the Reserved Channel in South Boston. In 2007 this containerized cargo had a value of more than $4.2 billion. The Port of Boston also includes key support facilities including the U.S. Coast Guard station on Commercial Street in

Boston, Dry Dock #3 in South Boston, cargo warehouse facilities in South Boston, the East Boston Shipyard, the Boston Harbor Pilots, several tug companies, and the Boston Fish Pier. The Stellwagen Bank National Marine Sanctuary Program reported in its Draft Management Plan (U.S. Dept. of Commerce 2008) that in 2005, the U.S. Coast Guard recorded 58,559 commercial deep draft and other vessel transits entering and/or leaving the Port of Boston (Table 6.1) of which, shipping directly comprised about 6% and fishing vessels 87% of the transits.

**Table 6.1.** Commercial vessels and other traffic entering / leaving the Port of Boston in 2005 (adapted from Table 23 in Stellwagen Bank National Marine Sanctuary Draft Management Plan. 2008. U.S. Dept. of Commerce. NOAA. National Marine Sanctuary Program).

| Type of Vessel | Displacement in tonnes (tons) | Top speed in km/hr (knots) | Transits per year |
|---|---|---|---|
| Container ship | 64,000 (70,400) | 46 (25) | 455 |
| Bulk cargo carrier | 32,000 (35,200) | 28 (15) | 244 |
| Tanker | 64,000 (70,400) | 28 (15) | 1,160 |
| Liquid natural gas (LNG) carrier | 108,000 (118,800) | 37 (20) | 126 |
| LNG deep water port support vessel | <1,000 (< 1,100) | 24 (13) | 240 |
| Roll on-Roll off ship | 37,500 (41,250) | 46 (25) | 41 |
| Dredging tug | 3,700 (4,070) | 9 (5) | 365 |
| Petroleum barge tug | 3,700 (4,070) | 9 (5) | 1,420 |
| Fishing trawler | 2,600 (2,860) | 22 (12) | 11,885 |
| Lobster boat | <1,000 (< 1,100) | 28 (15) | 39,000 |
| Cruise ship | 56,000 (61,600) | 60 (32.5) | 295 |
| Whalewatch boat | <1,000 (< 1,100) | 74 (40) | 3,328 |
| | | Total | 58,559 |

Massport has spent more than $100 million over the past decade to maintain and improve its public terminals in the Port of Boston. Massport recently completed a $25 million repaving and equipment purchasing program to improve productivity and efficiency at the Conley Terminal, and they are actively pursuing the acquisition of the abutting former Coastal Oil terminal to accommodate supporting uses such as empty container storage and chassis maintenance and repair in the short term and preserve future expansion options. A private developer plans to redevelop 12 hectares (30 acres) at the nearby Massport Marine Terminal as an approximately 46,451 $m^2$ (500,000 $ft^2$) state-of-the-art intermodal cargo logistics, bulk and break bulk facility. Massport's efforts, as well as the Army Corps of Engineers' proposal to increase the depth of the navigational channels approaching, and some berths in Boston Harbor, point to an anticipated increase in commercial vessels transiting through the planning area to reach the Port of Boston.

#### Fall River

Fall River and Mt. Hope Bay see a small amount of shipping activity with the coal and oil that are imported to support Brayton Point and Somerset Power Plants. There is also an oil terminal in North Tiverton, R.I., adjacent to Fall River. At the time of this writing, Weaver's Cove Energy has proposed to place a Liquid Natural Gas terminal in Mt. Hope Bay. In addition, the Fall River State Pier has been identified as a site to meet the Commonwealth's needs for short sea shipping infrastructure. Short sea shipping is shipping that does not transit the ocean; rather, it uses coastal and inland waterways. Short sea shipping is viewed as a way to reduce truck traffic on roadways and thus meet goals to make shipping more economical and to reduce greenhouse gases and roadway congestion. The Commonwealth will be providing additional berthage and other infrastructure at the pier to support new bulk and container cargo handling. While Fall River and the surrounding waters are not in the ocean planning area, commercial vessel traffic through the Cape Cod Canal and the adjacent planning area currently exists and the proposed activities suggest that commercial traffic in this region may soon increase.

#### Gloucester

Gloucester Harbor is one of the most important commercial fishing ports in the United States. In 2007, the commercial fishery brought in 42.8 million kg (94.4 million lbs) of fish valued at $46.8 million (NMFS 2008). Commercial fishermen bring their catch directly to the port, from the planning area and beyond, to be sold and processed.

As groundfishing stocks decreased over the last two decades, the number of fishing vessels transiting the planning area to/from Gloucester Harbor also decreased. However, Gloucester is still the state's second largest fishing port and is now the state's leading port for lobster landings. Additionally, some businesses around Gloucester Harbor have diversified into other, non-fishing related marine industrial activities. The Port of Gloucester supports approximately 225 deep water commercial fishing vessels up to 92 m (300 ft) in length (U.S. Department of Commerce 2008). Gloucester's working waterfront, workforce, and proximity to offshore locations also make it a viable port for the staging and support of any future ocean development (City of Gloucester Harbor Plan 2006) which may increase vessel traffic through the planning area.

#### New Bedford

The Port of New Bedford is one of the most vibrant commercial/industrial ports in the Commonwealth. New Bedford has a history of seafaring traditions that continue today with one of the largest active fishing fleets on the east coast, freight ferry service, and cruise ship docking. The port offers deepwater access for maritime vessels and has an authorized channel depth of 9.1 m (30 feet). New Bedford Harbor is one of the nation's major fishing ports, having ranked first in the U.S. since 2000 based on value of product landed, and in the top five U.S. ports for weight of product landed (NMFS 2008b). In 2007, 67.8 million kg (149.5 million lbs) of fish and shellfish worth $268 million were landed in New Bedford (NMFS 2008b). Currently there are approximately 500 fishing vessels, rigged for catching groundfish and scallops, operating out of the port. In recent years, the port's seafood processing industry has grown to become a nationally and internationally recognized industry center, having direct service from Norway calling at New Bedford's Maritime International Terminal every two weeks to satisfy the needs of Massachusetts fish processors and distributors.

The Port of New Bedford is the largest breakbulk (goods packed in small, separable units) handler of perishable items in Massachusetts and adjacent states. In addition to fresh and frozen fish, refrigerated vessels also transport fresh fruit from around the world to New Bedford. New Bedford's, Maritime International Terminal is home to one of the largest U.S. Department of Agriculture-approved cold treatment centers on the East Coast for the use of restricted imported fruit, receiving approximately 25 vessels a year. Each vessel carries between 1360-3629 tonnes (1,500 and 4,000 tons) of fish or 1814-2722 tonnes (2,000 to 3,000 tons) of fruit. New Bedford is also home to a barge service, Packer Marine, that moves large and heavy materials such as aggregate and fuel between the mainland and the Islands. The Fairhaven side of New Bedford Harbor has extensive marine service and vessel repair industries that service not only the fishing fleet but also other large recreational and commercial vessel needs. The state is currently in the permitting process for upgrading the infrastructure at the New Bedford State Pier to better serve freight activities, short sea shipping activities, and cruise ship activities.

#### Salem

Salem Harbor is largely a recreational boating harbor but sees some commercial shipping activity with the importation of coal and petroleum products to support Salem Power Station. The harbor supports a fleet of approximately 44 commercial vessels.

### Cruise Ships and Coastal Lines

#### Boston

The Port of Boston has a vibrant and growing cruise business that generates over $115 million annually toward the regional economy and provides numerous employment opportunities for vendors, suppliers, tour operators, hotels, restaurants and others. Cruise operations are managed by Massport at the Black Falcon Cruise Terminal in South Boston. This terminal handled 101 vessel calls and approximately 234,000 passengers in 2007. The projection for the 2008 cruise season is a slight increase to 250,000 passengers and 115 vessel calls. Cruise activity in 2009 is expected to be similar, as 103 vessel calls are already booked for the season. Future cruise ship calls to the Port of Boston are likely to increase in the long-term as several cruise lines have expressed interest in expanding vessel calls beyond the current May through early November season.

Boston is a very desirable location for ports of call as well as home port cruise vessels. Homeport calls typically include weekly Boston-Bermuda cruises, spring, summer and fall Canada/New England cruises, seasonal repositioning cruises to Miami and the Caribbean and occasional transatlantic cruises to Europe. Cruise lines providing homeport calls from Boston in 2006 are Norwegian Cruise Line, Holland America Line and Royal Caribbean Cruise Line. Port of call visits include Carnival, Princess, Celebrity, Cunard, Crystal Hapag Lloyd, Saga Holidays and P&O Cruises.

The Black Falcon Cruise Terminal, which was constructed in the mid-1980s, does not have the capacity or amenities to accommodate modern cruise ships. To better serve the Port of Boston cruise customers and allow the cruise business in Boston to continue to grow, Massport is seeking to construct a second terminal in the warehouse portion of Building 119 and to refurbish the existing terminal. Massport estimates that with a new cruise terminal capable of handling today's larger ships, the current passenger level would likely increase to over 400,000 passengers within two years of the opening of a new cruise terminal. With the expected improvements to the cruise terminals, cruise ships transiting the planning area will increase in both size and frequency.

#### Fall River

The City of Fall River and the Commonwealth are in the process of a multi-million dollar rehabilitation and expansion of the Fall River State Pier. One intended future use is to provide berthing and passenger loading/offloading for ferries and large cruise ships.

#### Gloucester

In 2007, the City of Gloucester saw two ports of call by international cruise ships per year. The 208-passenger Seabourn Pride of Seabourn Cruise Lines calls in the Port of Gloucester in September and October for its historic waterfront community and New England character. Gloucester Marine Terminal can accommodate cruise ships up to 152 m (500 ft) in length and drawing up to 5.5 m (18 ft). Larger Vessels, up to 244 m (800 ft) in length and drawing up to 7.9m (26 ft), can be accommodated in the harbor inside the breakwater, while still larger vessels can be accommodated in outside the breakwater. The 2006 Gloucester Harbor Plan suggested that the Port of Gloucester could receive several dozen cruise ship calls per year and that the Gloucester Harbor Plan Office has been actively promoting Gloucester as a cruise ship destination and seeking funds to improve infrastructure to facilitate cruise ships visits (City of Gloucester Harbor Plan 2006).

#### New Bedford

The Port of New Bedford saw 25 ports of call from cruise ships in 2007. Like cruise ships calling in Gloucester, American Cruise Lines delivers its passengers to New Bedford for its dynamic working waterfront and its iconic historic district.

### Ferries and Commuter Boats

#### Boston

Passenger water transportation in Boston Harbor includes commuter boats, Inner Harbor ferries, on-call water taxis, and charter/excursion vessel operations. Rowes Wharf and Long Wharf are the primary hub facilities for commuter boat and ferry services in the Inner Harbor. Most services transit among locations within Boston Harbor, however at least three services transit the ocean planning area regularly. The first is a privately operated, seasonal (May-November), daily ferry from Long Wharf in downtown Boston to Blarney Street landing in Salem, serving commuters and tourists. The second is the Bay State Cruise Company, which operates a seasonal ferry (mid-May to mid-October) from the World Trade Center in South Boston to Provincetown. Bay State Cruise company offers both a fast ferry and an excursion ferry. Third is Boston Harbor Cruises, offering a seasonal (May to early October) fast ferry from Long Wharf in downtown Boston to Provincetown. Lastly, the Island Alliance, a non-profit entity, provides service to various islands within the Boston Harbor Islands National Park, the outermost of which are in the planning area.

#### Cape Cod

Hy-Line Cruises, Freedom Cruise Line, and the Steamship Authority, offer ferry services that transit the planning area from Cape Cod to Nantucket and Martha's Vineyard. Hy-Line Cruises runs a year-round high speed ferry, the Grey Lady, from Hyannis to Nantucket. It also operates a traditional ferry called the Brant Point that transits from Hyannis to Oak Bluffs from May to October. At the time of this writing, the Hy-Line's high speed ferry from Hyannis to Martha's Vineyard, Lady Martha, was out of service. The Freedom Cruise Line runs one vessel out of Harwich Port that passes through the planning area from May to October on its way to Nantucket Harbor. The Steamship Authority has a fleet of nine vessels. Table 6.2 below describes the Steamship Authority's fleet and its capacity.

**Table 6.2.** Passenger vessels transiting the ocean planning area between Cape Cod and the Islands.

| Vessel Name | Vessel Length | Route | Route Length | Vessel Speed |
|---|---|---|---|---|
| Iyanough | 47 m<br>(154 ft) | Hyannis-Nantucket | 42 km<br>(26 miles) | 65 km/hr<br>(35 knots) |
| Island Home | 78 m<br>(255 ft) | Woods Hole-Martha's Vineyard | 11 km<br>(7 miles) | 30 km/hr<br>(16 knots) |
| Martha's Vineyard | 70 m<br>(230 ft) | Woods Hole-Martha's Vineyard | 11 km<br>(7 miles) | 26 km/hr<br>(14 knots) |
| Eagle | 70 m<br>(230 ft) | Hyannis-Nantucket | 42 km<br>(26 miles) | 26 km/hr<br>(14 knots) |
| Nantucket | 70 m<br>(230 ft) | Woods Hole- Martha's Vineyard<br>Hyannis-Nantucket | 11 km<br>(7 miles)<br>42 km<br>(26 miles) | 26 km/hr<br>(14 knots) |
| Governor | 74 m<br>(242 ft) | Wood's Hole-Martha's Vineyard | 11 km<br>(7 miles) | 22 km/hr<br>(12 knots) |

| | | | | |
|---|---|---|---|---|
| Katama | 72 m<br>(235 ft) | Wood's Hole-Martha's Vineyard<br>Hyannis-Nantucket | 11 km<br>(7 miles)<br>42 km<br>(26 miles) | 25 km/hr<br>(13.5 knots) |
| Gay Head | 72 m<br>(235 ft) | Wood's Hole-Martha's Vineyard<br>Hyannis-Nantucket | 11 km<br>(7 miles)<br>42 km<br>(26 miles) | 25 km/hr<br>(13.5 knots) |
| Sankaty | 60 m<br>(197 ft) | Wood's Hole-Martha's Vineyard<br>Hyannis-Nantucket | 11 km<br>(7 miles)<br>42 km<br>(26 miles) | 23 km/hr<br>(12.5 knots) |

#### Fall River

The City of Fall River and the Commonwealth are in the process of a multi-million dollar rehabilitation and expansion of the Fall River State Pier. One intended future use is to provide berthing and passenger loading/offloading for ferries. It is not clear at this moment if these services would enter the planning area.

#### Gloucester

The City of Gloucester currently has two passenger vessels: the Bostonian II and the James J. Doherty. The James J. Doherty is a 35 m (114 ft) vessel run by Boston Harbor Cruises that can accommodate up to 350 people. In 2008, Boston Harbor Cruises ran a fast ferry from Gloucester's cruiseport to MacMillan Wharf in Provincetown from June 28 to August 31. Plans for 2009 are to expand the dates of operation from Memorial Day to Labor Day.

#### New Bedford

The New England Fast Ferry operates out of the New Bedford State Pier and brings passengers to Vineyard Haven and Oak Bluffs on Martha's Vineyard on two vessels named the Whaling City Express and the Martha's Vineyard Express. These ferries pass through the planning area in Buzzards Bay and near the Islands. In addition, the M/V Cuttyhunk provides regular ferry service between New Bedford and Cuttyhunk Island located across Buzzards Bay. The Harbor is also home to the Steamship Authority's maintenance and repair facility located on the Fairhaven side of the harbor.

## Navigational Aids and Lanes

Navigational aids and designated shipping channels and lanes are important infrastructure components that are necessary to maintain the diverse commercial transportation uses of the Commonwealth. The products and passengers that transit the navigational lanes contribute significantly to the economic portfolio of the Commonwealth. In many cases, most other uses considered by the ocean plan will not be compatible with maintaining a functional navigational lane, although some transient uses (*e.g.*, recreational vessel passage) may be compatible.

### Boston

The central, deep water harbor in Boston is comprised of the waterways of the Main Ship Channel, Reserved Channel, Mystic River and Chelsea River. These channels provide access at a depth of 12.2 m (40 ft) at mean lower low water (MLLW) to the Port's principal terminals, except for the Chelsea River which currently has an authorized depth of 11.6 m (38 ft) MLLW. Deep water access to the harbor is provided by three entrance channels constructed and maintained by the Army Corps of Engineers: the Broad Sound North Channel in two lanes at 10.7 m and 12.2 m (35 and 40 ft), the Broad Sound South Channel at 9.1 m (30 ft), and the Narrows Channel at 8.2 m (27 ft). The Broad Sound Channel extends into the planning area roughly 2.4 km (1.5 miles) and is demarcated by four pairs of lit buoys.

The Army Corps of Engineers and Massport have worked together for many years to plan and implement several dredging projects, and others are currently under construction or in the planning process. These projects include:

- (1997-2001) The Boston Harbor Navigation Improvement Project (BHNIP) included maintenance dredging and deepening of the Reserved Channel, Mystic River, and portions of the main shipping channel to -12.2 m (-40 ft), Chelsea River to -11.6 m (-38 ft), and Massport and certain private deep water berths throughout the port to depths ranging from 10.7-12.2 m (-35 to -45 ft).
- (2005-2006) The Outer Harbor Maintenance Dredging Project restored portions of the North Channel and Broad Sound Channels to -12.2 m (-40 ft).
- (2007 through present) The Inner Harbor Maintenance Dredging Project, which is currently underway, will restore the main ship channel from beyond Castle Island into the Inner Confluence to its Congressionally-authorized to -12.2 m (-40 ft). Maintenance dredging will also be conducted in the Reserved Channel and the access channel to the Navy Dry Dock in South Boston will also be conducted as part of this project.
- Massport and the Corps are also working on a feasibility study and Environmental Impact Study/Report to deepen the navigation channels serving Conley Container Terminal to -14.6 m (-48 ft) and the Conley berths to at least -15.2 m (-50 ft) to accommodate the larger post Panamax ships, some of which are already calling Boston. The project also includes deepening Chelsea River and the channel to Massport's Medford Street Terminal in Charlestown to -12.2 m (-40 ft), the channel serving the Massport Marine Terminal to -13.7 m (-45 ft). The current schedule (if the project is found to be economically justified and funding is secured) is for dredging to begin in 2011.

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These commitments to ensuring that Boston maintains its stature as a deepwater port in the northeast suggest that larger vessels will be transiting the planning area waters in the future.

Within the planning area, and seaward of the planning area, is a traffic separation scheme that includes two directed traffic shipping lanes (one inbound and one outbound form Boston Harbor), a defined separation zone, and two precautionary areas. The separation scheme has been designed to aid in the prevention of collisions. The outbound traffic lane (to the south and west) is 2.4 km (1.5 miles) wide and 200 km (124.5 miles) long. The inbound traffic lane is 2.4 km (1.5 miles) wide and 204 km (126.5 miles) long. The separation zone, a 1.6 km (1 mile) wide and 205 km long (127.5 miles) zone between the lanes, is intended to be free of ship traffic and is demarcated by lit buoys. The separation zone is centered on 42º 20.73' N, 70º 39.0' W, 42º 18.28' N, 70º 01.14' W, and 40º 49.25' N, 69º 00.81' W. There are two precautionary areas. One is south of Nantucket, well outside the planning area, with a radius of 30 km (15.5 miles) centered on 40° 35.01' N, 68° 59.96' W. The second has a radius of 9.9 km (6.17 miles) centered on 42º 22.71' N, 70º 46.97' W and is in the planning area in the approach to Boston Harbor.

#### Cape Cod Canal

The Cape Cod Canal is the world's widest sea-level canal at 146 m (480 ft). It is approximately 28 km long (17.4 miles) and has authorized depth of 9.8 m (32 ft) at mean low water. The swift running current changes direction every six hours and can reach a maximum velocity of 8.4 km/hr (4.5 knots), during the ebb (westerly) tide. The three bridges that span the Canal were designed to allow for 41 m (135 ft) of vertical clearance above mean high tide.

The canal is operated by the U.S. Army Corps of Engineers (ACE), and according to their website more than 20,000 vessels pass through the canal annually. Many of these vessels are smaller recreational vessels, but in a busy 24 hour period, perhaps 30 to 60 larger transport vessels including tankers, barges, tugs, ferries, fishing vessels, container vessels, cruise ships, and other transport vessels pass through the canal. ACE data from 2006 show more than 2600 large vessels reported passing through the canal that year. Vessels over 20 m (65 ft) in length must report while those less than 20 m (65 ft) are not required to report. Vessels up to 251 m (825 ft) in length are permitted to use the canal. In 2002, the Army Corps noted that 7.2-7.6 x $10^6$ $m^3$ to (1.9 to 2.0 billion gallons) of petroleum products were shipped through the Cape Cod Canal annually.

Use of the canal saves mariners an average of 217 km (135 miles) of coastwise travel instead of circumnavigating Cape Cod. The canal itself is not in the planning area but the channel approaching the canal extends into the planning area approximately 6.5 km (4 miles) into Buzzards Bay and about 0.5 km (0.3 mile) into Cape Cod Bay. The location of the canal between the Buzzards Bay and Cape Cod Bay regions of the planning area and its importance as a safety and time-saving measure, ensures that significant commercial vessel traffic will continue to traverse the waters in this part of the planning area.

#### Fall River

The approach channel to Fall River is not in the planning area.

### Gloucester

The approach channel to Gloucester Harbor is not in the planning area.

### Lynn

Approximately 1.3 km (0.8 mile) of the Lynn Harbor channel is in the planning area. The channel is 46 m (150 ft) wide and is dredged to a depth of 5 m (16 ft). The channel is demarcated by a series of lit and unlit buoys.

### New Bedford

The navigational channel for New Bedford/Fairhaven Harbors extends into the planning area about 4 km (2.5 miles). The channel is approximately 9.1 m (30 ft) deep and 107 m (350 ft) wide and is demarcated by a series of lit buoys.

### Salem

The navigational channel for Salem Harbor extends approximately 0.4 km (0.25 mile) into the planning area. The channel is 46 m (150 ft) wide and is dredged to a depth of 9 m (29 ft). The channel is demarcated by a series of lit and unlit buoys.

## ENERGY GENERATING FACILITIES

There are 11 fossil fuel energy generating facilities and one nuclear facility adjacent to the planning area. The majority of these facilities use once-through cooling technology to cool their condensers (Table 6.3). The total generating capacity of these facilities is 7,942 megawatts (MW) and the total average permitted cooling water discharge is 1.48 $x10^7$ cubic meters per day ($m^3d$) or 3,897 million gallons per day (mgd). It should be noted that the Brayton Point facility will be required by the U.S. EPA and MassDEP to install natural draft cooling water technology, in effect decreasing its cooling water flow from 3.50 x $10^6$ $m^3d$ (925 mgd) to 2.12 x $10^5$ $m^3d$ (56 mgd), within three years of receiving all of the necessary construction and operating permits. In addition to the power plants in Massachusetts, there is also the 1200 MW Seabrook Nuclear Power Station in Seabrook, NH that is permitted to discharge 2.73 x $10^6$ $m^3d$ (720 mgd) into waters directly adjacent to the Massachusetts ocean planning area.

**Table 6.3.** Energy generating facilities adjacent to the ocean planning area.

| Facility | Location | Fuel | Capacity (MW) | Cooling Type | Permitted Flow ($m^3d$) (mgd) |
|---|---|---|---|---|---|
| Brayton Point | Somerset | Coal, oil | 1600 | Once-through; air-cooled in future | 3.50 x $10^6$<br>925 |
| Braintree Electric Light | Braintree | Natural gas | 85 | Air-cooled | 151<br>0.04 |
| Canal Electric | Sandwich | Oil | 1120 | Once-through | 1.96 x $10^6$ |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | 518 |
| General Electric River Works | Lynn | Oil | 56 | Once-through | $3.48 \times 10^5$<br>92 |
| Kendall | Cambridge | Oil, Jet Fuel | 242 | Once-through | $2.65 \times 10^5$<br>70 |
| Mystic | Everett | Natural gas, oil | 2217 | Air-cooled, once-through | $1.58 \times 10^6$<br>418 |
| New Boston | South Boston | Oil | 778 | Once-through | $1.85 \times 10^6$<br>490 |
| Pilgrim Nuclear Power Station | Plymouth | Nuclear | 670 | Once-through | $1.69 \times 10^6$<br>447 |
| RESCO | Saugus | Waste | 35 | Once-through | $2.27 \times 10^5$<br>60 |
| Salem | Salem | Coal, oil | 775 | Once-through | $2.53 \times 10^6$<br>669 |
| Somerset | Somerset | Coal | 229 | Once-through | $7.57 \times 10^5$<br>200 |
| Taunton Municipal Lighting Plant | Taunton | Oil, natural gas | 135 | Once-through, air-cooled | $3.03 \times 10^4$<br>8 |

## RENEWABLE ENERGY

Recent warnings by the International Panel on Climate Change on the looming effects of climate change, high energy prices and diminishing oil and natural gas resources, have instigated a dramatic increase in focus on renewable energy in the United States over the last few years. Rising interest in alternative energy from renewable resources such as wind, solar, hydrokinetics and ocean thermal energy conversion has shifted focus onto ocean sources (Table 6.4). A comprehensive approach to developing marine renewable energy projects is crucial to the United States as rapidly evolving technology is aiming to make possible and facilitate offshore installations. Massachusetts has no fossil fuel reserves but has substantial renewable energy resources. The Massachusetts coast offers considerable wind power potential, classified as excellent to outstanding by the U.S. Department of Energy National Renewable Energy Laboratory (NREL) (Figure 6.3).

### Energy Production, Consumption, and Needs in Massachusetts

Massachusetts is the most densely populated state in New England but overall per capita energy consumption is low, 243 million Btu (48 U.S. Rank - DOE 2008 *need this reference*). Massachusetts is vulnerable to fuel oil (used by 40% of households) shortages and price spikes during winter due to high demand for home heating. Natural gas is used mainly by electrical power generators and by more than 40% of the residential sector. It is received by pipeline from the U.S. Gulf Coast and Canada, and imported via liquefied natural gas (LNG) import terminals in Boston.

The Everett and Gateway LNG import facilities serve the Northeast, while a third facility (Neptune LNG) was recently approved. Natural gas-fired power plants generate more than two-fifths of energy in Massachusetts, while coal accounts for 25% of net electricity production. The Pilgrim nuclear power plant in Plymouth also contributes to energy generation (~12% - DOE, 2008). Massachusetts has several small hydroelectric facilities and is one of the nation's leading producers of electricity from landfill gas and municipal solid waste (200,000 MWh). Massachusetts generates 123 trillion Btus annually (0.2% of total U.S.), with a net electricity generation of 3.8 GWh. Figure 6.4 shows existing and proposed offshore energy facilities in Massachusetts.

Massachusetts' increasing dependence on natural gas and lack of fuel resources, its high population density along the coast and lack of land resources for development of utility-scale land-based renewable energy facilities, make it a prime candidate in the pursuit of sustainable development of offshore wind resources. Utility deregulation legislation (M.G.L. 1997) mandates a Renewable Portfolio Standards (RPS) and System Benefit Charge setting targets for the amount of electricity generated from renewable sources to be sold on the retail market (4% by 2009 - Division of Energy Resources (DOER)). This translates into the need to develop up to 1100 MW of new renewable energy capacity by 2009 (Rogers *et al.* 2003).

### Offshore Wind Development

Offshore wind turbines harness the kinetic energy of moving air over the oceans and convert it to electricity. Offshore winds are less turbulent and tend to flow at higher speeds than onshore, making them more attractive options to industry. The U.S. Department of Energy (DOE) estimates that more than 900 GW (close to the total current installed U.S. electrical capacity) of potential wind energy exists off the coast of the United States, with more than 50% located off the North Atlantic coastline. The biggest assets that make New England an ideal location for wind farm development are: 1) a high wind resource in shallow waters close to major electrical load, and 2) difficulties in developing large onshore wind farms (DOE estimates technically realizable onshore renewable energy resource in Massachusetts is 70% of electrical consumption, including areas with wind resource ≥class 3, excluding urbanized and environmentally sensitive areas).

NREL has determined wind resources between 5 and 20 nautical miles off the New England coast to be 9,900 MW and 41,600 MW in <30m and ≥ 30m respectively, and in areas 20 to 50 nautical miles to be 2,700 MW and 166,300 MW at the same depths (Musial and Butterfield 2004). These amounts are compelling even after excluding significant areas likely to be development-prohibitive due to environmental concerns and competing ocean uses, and may potentially provide up to 70,000 MW of domestic generating capacity to the nation's electric grid by 2025 (Thresher 2005).

Mesoscale modeling developed by *TrueWind Solutions* provides estimates of wind resources 93 km (50 nm) offshore ranging between 7.0-8.4 m/s (23-28 ft/s)(Class 5, 6 and 7) at 60 m (197 ft) heights (Musial and Butterfield 2004, Westgate and DeJong 2005). Water depths less than 20 m (66 ft) extend up to 15km (9.3 miles) in Cape Cod Bay, and up to 2-4 km (1.2-2.4 miles) in Buzzards Bay and Nantucket Sound. Offshore wind projects could thus produce up to 55,000 GWh (116%) of the state's energy needs (Rogers *et al.* 2003, Westgate and DeJong 2005). For offshore wind turbine design, wave conditions are an important factor to consider. To date, there are no well-defined wave data for New England. Wave speeds of 1.3 $ms^{-1}$ (2.5 knots) have been measured in Nantucket Sound, while maximum wave heights of 9.1 m (30 ft) were measured at the buoy at the mouth of Boston Harbor (Rogers *et al.* 2003).

### Hydrokinetic Energy Development – Wave Energy and Tidal Energy

Hydrokinetic refers to technologies for wave, current and in-stream tidal energy. Hydrokinetic projects are in early stages of development. Pilot projects capture hydrokinetic energy by various technologies (buoys, attenuators, overtopping devices, terminators) varying in size, anchoring, spacing, interconnection, array patterns and depth limitations.

Offshore wave energy potential is estimated to be 250-260 TW/yr at 15% resource use, twice the potential estimated for tidal and ocean current. According to the Electrical Power Research Institute (EPRI) hydrokinetics' current renewable energy potential meets 10% of national demand. Annual average power density on the East Coast of the U.S. is 5-15 KW/m for wave energy. In 2006 six sites in Massachusetts with flood and ebb peak tidal current surface velocities averaging at least 1.5 $ms^{-1}$ (3 knots) were assessed by EPRI to identify the most promising site for a feasibility demonstration project, rated at 500 kW (producing 1,500 MWh/yr at 40% capacity) later to serve as the site for a first commercial plant, producing 30,000 MWh/yr at 40% capacity).

Although Cape Cod was found to have the highest power density of any potential tidal stream energy conversion site in Massachusetts, the site has insufficient space for the Tidal In-Stream Energy Conversion (TISEC) devices to fall within the navigation safety margins specified by the U.S. Army Corps of Engineers (EPRI 2006). Hence, Muskeget Channel, located between Martha's Vineyard and Nantucket, was deemed most appropriate from an annual average extractable power. The currents through the channel have a velocity of 7.0 km/hr (3.8 knots) and 6.1 km/hr (3.3 knots) on the flood and ebb respectively, providing an average of 13.8 MW of kinetic power. About 2 MW (15%) can be extracted, reaching a peak capacity of just over 4 MW. According to EPRI, the relatively small generation potential could make the site appropriate as a distributed renewable energy source that benefits the local economy.

### Factors Influencing Utilization of Renewable Energy Resources

Issues affecting the siting and operation of offshore renewable energy generators in the waters of Massachusetts include physical and technical constraints, environmental issues, public acceptance and conflicts with other activities and economic considerations.

#### Physical

Increasing distance from land and increasing water depth raise the costs of building wind turbines and transmitting power back to shore. Shallow waters in southern Massachusetts extend to a distance offshore that make it viable for installing generators, particularly for wind turbines. To capture the wind power and attain the economies of scale needed to make far offshore sites financially viable, 5-MW turbines will be needed (MMS 2006). Moreover, in recent years, technology research is moving towards developing technologies that will allow turbines and other renewable energy generation infrastructure to be sited in deeper water (>30m or 98 ft) and further offshore, thereby decreasing visual impact while remaining cost effective.

The composition and structure of the seabed has a significant influence on the cost effectiveness of various foundation options for anchored wind turbines. The U.S. Geological Survey is conducting an extensive sea floor mapping exercise that will help characterize further the benthic geology and rugosity of plan area. Sea floor composition around Cape Cod changes from sand to a sand-mud mixture to mud with increasing depths, with boulders, rocks and outcrops scattered throughout. Nantucket Sound is characterized by numerous shifting sandy shoals which can make installation challenging (Westgate and DeJong 2005).

A good in-stream tidal site for tidal energy conversion needs to have a large amount of fast moving water, good bathymetry and seabed properties for installation of a TISEC device, has minimum or no conflicts with other uses of the sea space and is close to a grid interconnection (EPRI 2006). Muskeget Channel is somewhat small (17,500 $m^2$ or 4.3 acres), has low power density (0.95 $kWm^2$ or 10 $kWft^2$) and would present challenges to be interconnected to a grid for capacities greater than 500kW. Bathymetry is an important consideration in siting tidal turbines, balancing depth needed for turbine operations with costs. Muskeget Channel has enough depth and water exchange to support a TISEC project.

#### Technical

Grid connection availability in close proximity to where the power lines come ashore affects costs. There are significant grid connections along the coast in Massachusetts though this could be limited by grid capacity. In the case of any tidal installation in Muskeget Channel, the nearest distribution line is on Chappaquidick Island (4 km or 2.5 miles) which could handle 3.5 MW provided the interfaces are properly designed and necessary upgrades are made. Installation and operation of offshore renewable energy generators involves support craft, heavy barge mounted cranes, cable lying vessels, staging areas, and others. Massachusetts has significant dock, dry-dock and shipyard facilities in New Bedford and in Quincy, just south of Boston that would meet these needs. The two harbors on Martha's Vineyard could provide shoreside support for servicing tidal projects in Muskeget Channel (EPRI 2006). Tidal and wave energy technology is still largely under development and further research is needed to assess the size at which these technologies will make it cost effective.

#### Environmental

There are various ongoing studies on potential effects of renewable energy generators on marine flora and fauna, such as noise and vibration from construction and operation, contact with turbines, impingement, and entanglement (Madsen *et al.* 2006). These could cause alteration to benthic habitats, changes to migration patterns of birds and marine mammals and other potential effects on living resources. The waters of Massachusetts harbor endangered whale populations that come to feed, protected species such as eel grass and sea turtles, as well as unique and sensitive habitats such as areas used as nursery or feeding grounds. Moreover, several avian species on the endangered/protected list use the coast for nurturing and foraging on their migratory routes (*e.g.*, roseate tern, common tern, least tern).

#### User Conflicts

The main potential conflicts with other users are fishing, shipping and navigation, underwater archaeological artifacts and impacts on natural ecosystems. Commercial and recreational fishing occur along the Massachusetts coast, both in state and federal waters. Conflicts may arise with fishing boats and fishing areas regarding siting of installations and cables. There are major shipping lines into Boston Harbor, through Buzzards Bay and Nantucket Sound, as well as smaller channels and routes used by fishing boats, ferries, whale watch boats and recreational craft. The locations of most of the numerous shipwrecks and underwater archaeological sites in Massachusetts are known and can be avoided, especially on the east coast of Cape Cod and on the shoals around Monomoy Island. Visual impact is another factor that needs to be addressed. A 64-m (210 ft) high wind turbine is visible above the horizon from a distance of 36.6 km (22.7 miles) (Rogers *et al.* 2003). Current FAA regulations require that structure taller than 61 m (200 ft) must have a beacon. Any potential effects of such lights and structures on the flight patterns of migrating birds through the planning area need to be addressed.

#### Economic

The economic viability of offshore wind facilities depends on whether the costs are offset by high-quality wind resources and high productivity. Massachusetts promises to be a very good resource of high-quality wind. Costs of wind generated energy have dropped over the last decades ($0.40/kWh to $0.04/kWh) to be comparable with natural gas ($0.04/kWh), though still higher than hydropower ($0.03-0.04/kWh) and coal ($0.02-0.03/kWh) (MMS 2006). Offshore wind generation in shallow waters (<30m or 98 ft) are twice as much as onshore (OWCOG 2005) but expected to decrease by 2012 to about $0.05/kWh for a 5-MW and higher generator, according to the DOE (MMS 2006).

**Table 6.4.** Proposed and approved renewable energy projects in Massachusetts.

| Type | Name | Location | Date Issued |
|---|---|---|---|
| Preliminary Project Permit (FERC) | Cape Cod Tidal Energy Project | Cape Cod Canal | 11/16/07 |
| Preliminary Project Permit (FERC) | Cuttyhunk/Elizabeth Islands Tidal Project | Atlantic Ocean/Canapitsit Channel | Pending |
| Preliminary Project Permit (FERC) | Cape and Islands Tidal Energy Project | Vineyard Sound | 5/31/07 |

| | | | |
|---|---|---|---|
| Preliminary Project Permit (FERC) | Edgartown-Nantucket Tidal Energy Plant | Nantucket Sound | 3/31/08 |
| Army Corps of Engineers/MMS | Cape Wind Energy Project | Nantucket Shoals (Fed.) | Pending |
| MEPA | South Coast Wind Project | Buzzards Bay | Pending |
| Proposed | Hull Offshore Wind Project | Nantasket Beach and Harding Ledge | Pending |

## WASTEWATER, STORMWATER, AND INDUSTRIAL DISCHARGES

There are 57 significant outfalls (*i.e.,* outfalls discharging greater than 757 $m^3d$ (0.2 mgd)) that discharge millions of $m^3d$ of wastewater (greater than 2 billion gallons per day) to the waters adjacent to the planning area. There are 28 municipal wastewater facility discharges, 12 thermal discharges from power plants, six discharges from commercial/industrial facilities, and 11 stormwater discharges from oil terminals. The largest outfall is the Massachusetts Water Resources Authority's (MWRA) 15 km (9.5 mile) pipe that discharges on average 1.38 x $10^6$ $m^3d$ (365 mgd) of treated municipal effluent and stormwater. Data are not currently stored in a manner where monthly average discharge rates can be quantified and sorted by sector, so the most recent data come from a targeted inquiry into the discharges to Massachusetts Bay, including the tidal waters of the Merrimack River to the Cape Cod Canal (Table 6.5).

**Table 6.5**. Permitted discharges to Massachusetts Bay by sector and their actual (as opposed to permitted) monthly discharge flow from August 2007-July 2008. Note that these data do not include discharges from facilities located in Buzzards Bay, Nantucket Sound, or Mt. Hope Bay. There are an additional three commercial/industrial discharges, eight municipal wastewater systems, and three power plant discharges in Buzzards Bay and Mt. Hope Bay.

| Facility Type | Monthly Average Discharge Volume ($m^3d$) | Monthly Average Discharge Volume (mgd) |
|---|---|---|
| Municipal wastewater (n = 18) | 1.94 x $10^6$ | 513.09 |
| Power Plant (n = 9) | 6.43 x $10^6$ | 1,695.95 |
| Commercial/Industrial (n = 2) | 2.38 x $10^5$ | 62.81 |
| Oil terminal stormwater (n = 11) | 1.37 x $10^4$ | 3.61 |
| **Total (n = 40)** | **8.62 x $10^6$** | **2,275.46** |

### Combined Sewer Overflows

A combined sewer is one that carries both stormwater and sewage in the same pipe. Under normal operating conditions, the combined effluent is carried to a sewage treatment plant. During heavy rains, when stormwater flows at double or triple the normal rate, the collection system becomes overloaded and must be relieved through one or a series of outfalls to the nearest waterbody. These outfalls are called combined sewer overflows or CSOs.

In 2007, a year that saw 37 inches of rain in the Boston area, the Boston Water and Sewer Commission (BWSC) reported that its 37 CSOs activated 277 times for a total volume of 7.28 x $10^5$ $m^3$ (192 million gallons) discharged to Boston Harbor. In the same year, MWRA reported that its 28 outfalls (some jointly operated with the cities of Chelsea, Cambridge, and Somerville), discharged 93 times for a total volume of 1.32 x $10^6$ $m^3$ (348 million gallons). Forty percent of the BWSC and MWRA CSO discharges went untreated in 2007.

The MWRA and BWSC CSO abatement plan would close 11 of these outfalls, and another six outfalls would have no activations during the typical year. This leaves 20 outfalls that are projected to discharge 84 times for a total annual volume of 3.2 x $10^5$ $m^3$ (83 million gallons) in the future. Eighty percent of the expected future discharge volume will occur through four outfalls in Reserved Channel in Inner Boston Harbor. The greatest local change is that 10 outfalls (BOS 081- BOS 090) adjacent to the South Boston beaches will be eliminated.

The Lynn Water and Sewer Commission operates four CSOs, one to the Saugus River, two to Lynn Harbor, and one to Nahant Bay. In 2006, about 11% of the service area (Lynn, Saugus, Swampscott, and Nahant) was served by combined sewers. In 2007, there were 19 activations of outfall 003, 21 activations of 004, 56 activations of 005, and 12 activations of 006 for an annual total of 4.13 x $10^5$ $m^3$ (109 million gallons). Lynn is in the process of implementing a long-term control plan for its CSOs. The plan includes separating stormwater and wastewater infrastructure.

In 2000, the City of Fall River had 19 CSOs, seven that discharged to Mt. Hope Bay, eight to the Quequechan River, and four to the Taunton River.

The City of New Bedford has 27 CSOs, eight that discharge to Clarke's Cove, six that discharge to New Bedford Outer Harbor (Buzzard's Bay), and 13 that discharge to New Bedford Inner Harbor/Acushnet River. Between 2004 and 2008, the City reduced the number of active CSOs from 37 to 27. In 1996, after wastewater treatment plant and collection system upgrades, there was an annual total of 29 CSO activations to Clarks Cove 5.04 x $10^5$ $m^3$ (133 million gallons), there were continuous discharges to the Outer Harbor for a total of 1.55 x $10^6$ $m^3$ (409 million gallons), and continuous discharges to the Inner Harbor, for a total of 7.99 x $10^6$ $m^3$ (2.11 billion gallons). In 2005 (the most recent year of data), there was a slight reduction to 27 CSO activations to Clarks Cove 4.13 x $10^5$ $m^3$ (109 million gallons), there was a 94% reduction to 9.1 x $10^4$ $m^3$ (24 million gallons) from 37 activations to the Outer Harbor, and a 84% reduction to 1.27 x $10^6$ $m^3$ (334 million gallons) from 50 activations to the Inner Harbor. CSO discharge volume is expected to decrease by about another 25% by the end of the long-term CSO abatement implementation (2030).

In 2005, the City of Gloucester had five CSOs that, based upon computer modeling, discharged 113 times per year for a total volume of 9.5 x $10^4$ $m^3$ (25 million gallons) to Gloucester Inner Harbor. The long-term CSO management plan is to perform sewer separation from stormwater infrastructure in the areas tributary to three of the CSOs (resulting in three new stormwater-only outfalls to Gloucester Harbor) and to modify the regulators in the other two drainage systems. Once the plan is implemented, the expected number of CSO activations is five, for a total annual volume of 1,327 $m^3$ (0.35 million gallons). This is roughly a 96% reduction in activation frequency and 99% reduction in volume. Under a consent decree, the City of Gloucester must have the plan implemented by June 2012.

## MILITARY EXERCISES

A diverse suite of military activities, from bombing to dredging to ports of call, have occurred in and over the planning area in the past. The amount of live ordinance used in the planning area has decreased or completely ceased, but military training exercises continue. The Air National Guard, Army Corps of Engineers, Coast Guard, and Navy all continue to conduct activities in the planning area.

### Air National Guard

The airspace over the planning area is an active training area for pilots of aircraft originating from the Otis Air National Guard base and the U.S. Coast Guard air station on the Massachusetts Military Reservation in Sandwich.

### Army Corps of Engineers

The Army Corps of Engineers is responsible for maintaining the navigational pathways to and from the ports that surround the planning area waters. In addition, the Corps is responsible for reviewing and permitting dredging and disposal projects (*e.g.*, underwater pipelines, cables) that occur within planning area waters and beyond.

### U.S. Coast Guard

The U.S. Coast Guard has a regional Marine Safety Office (MSO) in Boston Harbor. While the MSO office is outside of the planning area, routine training activities (*e.g.*, homeland security and emergency preparedness) occur within the planning area. The Coast guard also has a primary role in search and rescue, vessel regulation and natural resource protection enforcement, oil spill response, assistance with marine mammal entanglement events, and navigational aid maintenance efforts within the planning area.

### U.S. Navy

Between the 1950s and the 1970s, the Navy performed target practice on the James Longstreet, a 127 m (417.7 ft) steel ship that now resides under 6 m (20 ft) of water off of Eastham. The waters around the Longstreet are listed as a "restricted area" on charts due to unexploded ordinance.

South of Martha's Vineyard, on Noman's Island, the Navy conducted bombing practice from aircraft between 1943-1996. Following an effort to clear the island of ordinance in 1997 and 1998, the entire island was transferred to the U.S. Fish and Wildlife Service for use as a wildlife refuge, primarily for migratory birds. Due to danger from unexploded ordinance, access is not permitted, and the island is closed to the public. In addition, two restricted airspace areas, R-4105A and R-4105B, currently occur over the island.

In addition to these remnants of past activities, the Navy has a presence in the planning area via ports of call visits to Massachusetts by various Navy vessels calling in Boston and Gloucester. The Navy tests and modifies new vessels, and trains staff on vessels that traverse Massachusetts waters. The Navy is also involved in research activities in Massachusetts coastal waters. For example, the Navy is a partner in the Martha's Vineyard Coastal Observatory and has been involved in the whale acoustic monitoring program off the Massachusetts coast.

## OCEAN DISPOSAL *Major contributor: Vincent Malkoski*

The disposal of solid materials in Massachusetts' waters can be characterized within one of the following categories: dredge material, nearshore disposal for shore protection, fish waste from processing, derelict vessels, and hazardous waste and ocean dumping.

Clean dredge material of appropriate grain size may be used for other purposes such as beach fill, dune enhancement, and habitat restoration projects. Clean material may also be used *in situ* as a "cap" for areas of contamination such as has been done in New Bedford Outer Harbor to contain areas with low-level PCB contamination. Clean material unsuitable for other uses or with no identified beneficial use may be taken offshore to designated areas and dumped. In Massachusetts, these areas are the Massachusetts Bay Disposal Site (MBDS) which is adjacent to the planning area and the Cape Cod Bay Disposal Site (CCBDS) which is within the planning area. Designated disposal sites receive an extensive review before designation and their use in New England is monitored by the U.S. Army Corps of Engineers (ACE) Disposal Area Monitoring System (DAMOS). A third site in Buzzards Bay was used for many years, but was not designated for this use. It is no longer in use since disposal is not permitted under the Ocean Sanctuaries Act and Buzzards Bay is in the Cape and Islands Ocean Sanctuary.

In addition to the two permitted Massachusetts disposal areas, several locations are or have been used by the ACE for offshore disposal. These sites are located off Newburyport, Marshfield, Bourne, Dennis, and Cleveland's Ledge. These sites are and have been used by the ACE for small amounts of dredge material taken from municipal navigation channels or the Cape Cod Canal. These sites generally lack a comprehensive review of habitat impacts.

One alternative to direct placement of fill material on beaches is to dispose of it in nearshore waters so that it may be dispersed by natural forces. With sufficient data, sediment transport models can be created to estimate the likelihood of success of this practice for a selected beach or coast line. This technique has been used to good effect in Rhode Island using research from the University of Rhode Island (Goulet, personal communication). The development of regional sediment management plans supported by data and modeling could be used to promote this beneficial reuse.

There have been incidents of waste from fish processing operations (gurry) being disposed of at sea. However, this practice is very limited and requires careful evaluation as it can result in high organic loading in the area of disposal. As with nutrient loading in embayments, a large mass of organic material can overwhelm the buffering capacity of the receiving waters and result in anoxic conditions.

At-sea disposal of derelict vessels has been used as a means to relieve congestion and open dock space in municipal harbors. As an example, the Office of Waterways in the Department of Conservation and Recreation cleaned and disposed of several abandoned vessels from New Bedford Harbor at Coxes Ledge located at the mouth of Buzzards Bay. Future efforts may not be permitted in Massachusetts waters since the New England office of the EPA has enacted a requirement that such vessels be sunk in water depths of 91 m (300 ft) or greater. The practice of at-sea vessel disposal has often been described as artificial reef development. This practice does not commonly involve the monitoring necessary to evaluate the habitat value of these structures.

## PROTECTED AREAS

*Fig 6.5 Insert figure of Protected Areas from MORIS*

### Areas of Critical Environmental Concern

There are 14 Areas of Critical Environmental Concern (ACECs) in the Commonwealth of Massachusetts (Table 6.6) totaling 29,908 hectares (73,900 acres). ACECs are areas designated by the Secretary of the Executive Office of Energy and Environmental Affairs where unique clusters of natural and human resource values exist. The purpose of the designation process is to determine if the nominated area is of regional, state, or national importance or contains significant ecological systems with critical interrelationships among a number of components. Once an ACEC is designated, regulations (301 CMR 12.00) require state agencies to preserve, restore, and enhance resources within ACECs. Agencies are charged with giving closer scrutiny to activities proposed within the planning area that are adjacent to ACECs to ensure that environmental impacts within ACECs are avoided or minimized.

**Table 6.6.** Areas of Critical Environmental Concern adjacent to the ocean planning area.

| ACEC | Hectares (Acres) | Location/Communities |
|---|---|---|
| Bourne Back River | 749 (1,850) | Bourne |
| Ellisville Harbor | 243 (600) | Plymouth |
| Herring River Watershed | 1,801 (4,450) | Bourne, Plymouth |
| Inner Cape Cod Bay | 1,032 (2,550) | Brewster, Eastham, Orleans |
| Neponset River Estuary | 526 (1,300) | Boston, Milton, Quincy |
| Parker River/Essex Bay | 10,320 (25,500) | Essex, Gloucester, Ipswich, Newbury, Rowley |

| | | |
|---|---|---|
| Pleasant Bay | 3,662 (9,050) | Brewster, Chatham, Harwich, Orleans |
| Pocasset River | 61 (150) | Bourne |
| Rumney Marshes | 1,133 (2,800) | Boston, Lynn, Revere, Saugus, Winthrop |
| Sandy Neck/Barnstable Harbor | 3,581 (8,850) | Barnstable, Sandwich |
| Waquoit Bay | 1,032 (2,550) | Falmouth, Mashpee |
| Weir River | 385 (950) | Cohasset, Hingham, Hull |
| Wellfleet Harbor | 4,998 (12,350) | Eastham, Truro, Wellfleet |
| Weymouth Back River | 385 (950) | Hingham, Weymouth |

### Cape Cod National Seashore

The Cape Cod National Seashore is a 17,646 hectare (43,604 acre) park that extends across the boundaries of Provincetown, Truro, Wellfleet, Eastham, Orleans, and Chatham. This national park includes wooded uplands, dunes, fields, recreational trails, salt and freshwater wetlands, many freshwater kettle ponds, and miles of shoreline, including a 64 km (40 mile) long stretch of pristine sandy beach. The authorized National Seashore boundary extends offshore into coastal waters roughly 0.4 km (0.25 mile). This leaves the park boundary just outside the planning area.

### National Estuarine Resource Reserve

The Waquoit Bay National Estuarine Research Reserve is located within the towns of Falmouth and Mashpee. The reserve is outside the planning area.

### National Wildlife Refuges and National Wildlife Areas

The Mashpee, Monomoy, Nantucket, Nomans Land, and Parker River National Wildlife Refuges are all adjacent to the planning area and the Thacher Island National Wildlife Area off of Rockport is actually in the planning area. Monomoy Island on the Cape and Plum Island on the North Shore, have received recognition internationally for their ecological diversity and importance to migrating shorebirds.

### No Discharge Areas

The Clean Water Act allows states to prohibit the discharge of sewage, whether treated or not, from vessels in navigable coastal waters. In Massachusetts there have been No Discharge Areas designated for Waquoit Bay, Chatham's Stage Harbor, all of Cape Cod Bay and Buzzards Bay, Salem Sound and adjacent coastal waters, Boston Harbor and adjacent coastal waters out to The Graves, the coastal waters from Scituate to Hull, and the coastal waters of Nantucket, Barnstable, and Harwich. The Commonwealth has a goal of designating all state waters as No Discharge by 2010.

### Ocean Sanctuaries

There are five designated ocean sanctuaries in the ocean planning area (Figure 6.X *make sure this figure has all of the individual sanctuaries labeled*). Under MGL c. 132A, Section 14, the CZM office serves as a trustee of the resources of the ocean sanctuaries and is charged with ensuring that the sanctuaries are protected from exploitation, development, or activity that would significantly alter or otherwise endanger the ecology or appearance of the ocean, the seabed, or subsoil, except as stated below. Certain activities are prohibited in the Ocean Sanctuaries including: the building of any structure on the seabed or under the subsoil, the removal of any minerals and the drilling for oil or gas; the discharge of commercial, municipal, domestic, or industrial wastes; commercial advertising; and the incineration of wastes. The construction of off-shore or floating electric generating stations is also prohibited except: a) on an emergency and temporary basis for the supply of energy when the electric generating station is otherwise consistent with an ocean management plan; or b) for appropriate-scale renewable energy facilities, as defined by an ocean management plan promulgated pursuant to M.G.L. c.21C, section 4C, in areas other than the Cape Cod Ocean Sanctuary; provided, however, that (i) the renewable energy facility is otherwise consistent with an ocean management plan; (ii) siting of all such facilities shall take into account all relevant factors, including but not limited to protection of the public trust, compatibility with existing uses, proximity to the shoreline, appropriateness of technology and scale, environmental protection, public safety and community benefit; and (iii) in regions where regional planning agencies have regulatory authority, a regional planning agency may review the appropriate-scale renewable energy facilities as developments of regional impact and the applicant may seek review pursuant to the authority of the Energy Facilities Siting Board to issue certificates of environmental impact and public interest pursuant to M.G.L. c.164, secs. 69K through 69O.

Allowed activities include: industrial cooling water intakes and discharges (except in the Cape Cod Ocean Sanctuary); municipal, industrial, or commercial facilities or discharges existing before December 30, 1976; electric and telephone cables; channel and shore protection projects, navigational aids, and projects authorized under Chapter 91, deemed to be of public necessity and convenience; harvesting and propagation of shellfish and finfish; temporary scientific or educational projects; extraction of sand and gravel if used for shore protection; wastewater treatment facilities in the South Essex Ocean Sanctuary if they are the only feasible alternative; and wastewater treatment facilities in the North Shore Ocean Sanctuary, only if construction of the facility commenced or the municipality received a federal or state grant for construction before January 1, 1978.

### Outstanding Resource Waters

Massachusetts DEP has designated certain waterbodies (*e.g.*, Class A public water supplies and their tributaries, certain wetlands) based on their outstanding socio-economic, recreational, ecological and/or aesthetic values to be Outstanding Resource Waters (ORWs). State regulations (314 CMR 4.04) require that the quality of these waters be protected and maintained. At the time of the regulation's inception, owners of discharges to ORWs were required to connect to a publicly owned wastewater facility, if feasible, or demonstrate that the discharges were treated with the highest and best practical method of waste treatment. New discharges to ORWs are prohibited unless: 1) the discharge is for the express purpose and intent of maintaining or enhancing the resource for its designated use, or 2) the discharge is dredged material for qualifying activities in limited circumstances. There are seven ORWs adjacent to the planning area (Figure 6.5).

## EDUCATION AND RESEARCH

The goal of outreach and education is the effective dissemination of information, research and technology. This makes significant contributions to the citizens and organizations by reaching out to audiences, increasing environmental awareness, improving science literacy, and bridging the gap between scientific researchers and an informed and knowledgeable public about ecosystem goods and services.

### Education

Massachusetts is the home of some of the top universities and colleges in the world as demonstrated by the number of students that enroll and graduate each year, compared to the national average. There are over 120 universities and colleges in Massachusetts, with more than 430,000 students enrolled in these institutions offering degrees in a plethora of disciplines including business, health, arts, engineering, law, theology and sciences. The public higher education system includes 29 community colleges, nine state colleges and five university campuses, serving about 260,000 students annually. In 2006, for example, 30,000 students were awarded degrees and certificates from state colleges. The total number of degrees awarded in 2006 by public and private institutions was just under 100,000, well above the national average of 68,322 (USDE 2006).

Environmental education is aimed to enhance environmental literacy, a necessary prerequisite to developing a solid understanding of resilient and sustainable environmental resources. In the U.S., the 1990 National Environmental Education Act (Public Law 101-619) has brought environmental education to the attention of environmental educators and environmentalists (Disinger and Roth 1992). Over the last years, increasing awareness of environmental change and the interaction between humans and natural ecosystems has instigated the establishment of environmental programs within colleges and universities. Over 25% of institutions in Massachusetts offer specialized environmental programs. The most pressing problems facing our natural environment are complex and most environmental education programs are made up of a community of teachers and researchers from diverse fields including chemistry, biology, earth and planetary sciences, economics, policy and law. For example, the Environmental, Earth and Ocean Sciences Program at the University of Massachusetts Boston is an interdisciplinary program that grew out of the Department of Biology. It provides students with a background in natural and social sciences, as well as the opportunity for research experience in a range of important areas - environmental policy, ecology, environmental law, coastal physical oceanography, coastal and ocean management, and human influence and environmental change. Similarly, the Harvard University Center for the Environment encourages research and education about the environment and its interactions with human society and draws upon the expertise of scholars from diverse fields including chemistry, earth and planetary sciences, engineering and applied sciences, biology, public health and medicine, government, business, economics, religion, and the law (Harvard 2008).

### Research

Massachusetts is the location of some of the best research institutions in the U.S., indeed globally, especially for oceanography, biology, biomedical research, and technology. Thousands of scientists visit institutions such as Woods Hole Oceanographic Institution (WHOI), the Marine Biological Laboratory (MBL), Harvard University, Massachusetts Institute of Technology (MIT), Boston University and others in order to make use of the scientific and technological resources available, as well as experience innovative research techniques in their work.

Woods Hole is a veritable mecca of research institutions, offering opportunities to college students and scientists. The Marine Biological Laboratory (MBL) offers advanced, graduate-level courses in embryology, physiology, neurobiology, microbiology, and parasitology. This institution maintains year-round research programs in cell and developmental biology, ecology and environmental science, neurobiology, sensory physiology, microbiology, marine biomedicine, molecular evolution and aquaculture. In addition, hundreds of distinguished biologists from around the world come to the MBL each summer to use marine organisms as model systems for biomedical research. The Woods Hole Oceanographic Institute (WHOI) is comprised of research departments (physical oceanography, biology, marine chemistry, geology and geophysics, and applied ocean physics and engineering), ocean institutes (coastal ocean, deep ocean exploration, ocean life and climate change), centers (COSMOS, Marine Policy, Ocean and Human Health, Marine Mammals, and NOAA), and laboratory facilities. The institution owns several research vessels and builds and operates underwater vehicles for ocean exploration. In 2006, WHOI housed 148 scientists, 206 technical staff, 183 scientific support staff, 107 marine crew, 152 graduate students and 249 administrative staff (WHOI 2006). In addition, these institutions offer opportunities for elementary and secondary classes. For example, MBL offers a wide range of programs and resources for K-12 students and faculty that can be used to supplement a curriculum, as extracurricular activities, field trips, or to enhance the classroom experience. WHOI provides professional development workshops for middle and high school teachers, resources for students, and links to local opportunities including science fairs and access to libraries. The Woods Hole Science and Technology Education Partnership, established in 1989, is a partnership of schools, scientific institutions, businesses, and community resources. Its purpose is to support, promote, and expand science and technology education and science literacy in the participating communities. Two other institutions with an oceans focus are the NOAA MIT and Woods Hole Sea Grant programs which provide research and education on a variety of topics vital to human and environmental health (water quality, coastal hazards and biotechnology).

Boston University (BU) is a comprehensive institution dedicated to research in various disciplines (science, medical, history, archaeology, law, religion, the classics) through about 100 research centers and institutes housed with almost 4,000 faculty members and about 30,000 enrolled students (BU 2007). Boston University received more than $336 million in external funding for FY2008 (BU 2007).

The University of Massachusetts (UMass) is a state institution consisting of five campuses "to provide to provide an affordable and accessible education of high quality and to conduct programs of research and public service that advance knowledge and improve the lives of the people of the Commonwealth, the nation, and the world" (UMass Mission Statement) to approximately 60,000 undergraduate and graduate students (UMass 2006). UMass is the third largest research university in Massachusetts, with over $400 million in annual research in environmental and marine science, biomedical, food science, engineering and disease funded by the National Science Foundation, the National Institute of Health, corporate partners and other federal and private foundations. Over the last two years, new programs have been developed to address emerging issues in life science, clean energy, advanced materials and information technology and communication (UMass 2008).

### MINING *Major contributor: Vincent Malkoski*

No large-scale mining activity has yet been permitted in the planning area, but the possibility of this use is of particular interest with the increase threat of coastal erosion and inundation (MCZM 2007). The current, proposed, and future uses, activities, and functions of mining in the planning area include: sand and gravel mining for shoreline protection or beach nourishment, mining for mineral extraction, and mining for commercial construction or fill material. The two most sought after materials are sand and gravel (also known as aggregate). Identifying these resources should be straightforward with the recent advances in seafloor mapping technology. However, there is a paucity of data to describe the ecological services provided by these substrates and related biological communities. Therefore, it is currently not feasible to evaluate the potential impacts of removal, or estimate recovery of habitat functions and values.

Aggregate material is comprised of coarse sand, gravel, and small cobbles and is an important material for the construction of commercial buildings, roads, and other pieces of infrastructure. As a function of the limits of cost of aggregate material from land-based sources, developers have been seeking marine sources for this material for many years. The potential for offshore mining was first explored in the New England Offshore Mining Study (NOMES) (Willet 1972) by Raytheon as part of the Massachusetts Coastal Mineral Inventory Survey conducted for the Massachusetts Department of Natural Resources, Division of Mineral Resources. Although substantial biological studies were planned as part of that effort, they were not conducted due to lack of funding. The need for better biological information was further emphasized in a study sponsored by MCZM (Byrnes *et al.* 2000). Therefore, a better understanding of the biological tradeoffs associated with mining sites is well recognized and remains a need for the planning area. Species that are found at various life stages associated with coarse sediment include Atlantic cod, yellowtail flounder, sea scallops, and American lobster. The best-known study that looked at fish as well as benthic infauna over multiple years was conducted by the Corps of Engineers off the coast of New Jersey (ACE 2001). Recovery of the fish habitat in the mining site was documented over a three-year period; however, the application of such data to projects in Massachusetts must take into account local conditions.

Commercial and residential development of the beaches and coastal areas, combined with the dynamic nature of these exposed shorelines has created a need for replacement material to fill beaches no longer nourished by natural processes. Armoring techniques and the placement of structures such as groins and jetties has mostly served to exacerbate erosion along most beaches. At this time, the construction of new groins and coastal armoring is virtually prohibited in most areas by the regulations of the MassDEP. Although beach fill is considered a temporary fix for shoreline erosion from a geologic standpoint, it is probably more environmentally sensitive than armoring. Offshore mining of sand for shore protection and beach fill (also known as beach nourishment and beach recycling) is a common practice off Florida and the Mid-Atlantic States where much of the substrate located offshore of the beaches is sand. In some areas, the sand can be reused within the same system as natural transport mechanisms move it back to the mining area. However, in New England the sediment transport processes are complicated due to variability in underlying geology. In Massachusetts, several small-scale mining projects have been permitted, with varying degrees of success. In Rhode Island, sediment transport modeling based on 30 years of beach profile data contributed to successful nearshore disposal and beach fill activities there (ref Boothroyd work). The first large project (765,000 cubic meters or 1 million cubic yards) has been proposed and is under review to mine sand from Bass Rip Shoals for placement on Siasconset Beach on Nantucket.

## AESTHETICS *Major contributor: Dennis Duscik*

Compared to ocean-based resources and activities that can be directly observed, measured, and mapped, enjoyment of ocean scenery does not lend itself easily to data collection and analysis; indeed, it does not even take place for the most part within the ocean planning area, but from the adjacent shorelands. Scenic enjoyment is also an important part of the recreational boating experience, but has not yet been examined. Although we do not know how best to analyze the ocean's scenic services, we do know that views of water are almost always the most highly rated natural factor among various scenic qualities, coastal or otherwise. Recognition of the value of visual services is hardly new; Massachusetts was a pioneer in the field of land-based visual assessments with the Massachusetts Department of Environmental Management (DEM) Scenic Landscape Inventory effort in 1981/82. The Massachusetts Department of Conservation and Recreation (DCR, formerly DEM) engages in similar ongoing work with communities through the Heritage Landscape Inventory program. The visual environment of the ocean has been afforded an enhanced legal status by the state Ocean Sanctuaries Act, the core mandate of which is that "all ocean sanctuaries shall be protected from any exploitation, development, or activity that would significantly alter or otherwise endanger the ecology or appearance of the ocean, the seabed, or subsoil thereof, or the Cape Cod National Seashore" (M.G.L. c.132A, section 14).

With the global interest in the development of wind farms in particular, other countries and coastal states in the U.S. are starting to develop visual impact analyses based upon traditional studies of viewsheds across landscapes, adapting them to the seascape context and exploring ways to identify visual resource areas of high value (Maritime Ireland 2001, UK Department of Trade and Industry 2005). In the United States, some agencies are exploring the use of GIS tools to model viewsheds and assign values to them for mapping purposes through a variety of means (State of Connecticut 2007, BLM undated). Within Massachusetts, the Boston Harbor Islands have recently been the subject of a scenic analysis and assessment (Ryan and Taupier 2007).

Use of the ocean as a scenic resource occurs primarily in three ways: visitation to federal, state, and town beaches and other recreation properties open to the public; patronage of waterfront hotels, restaurants and other commercial facilities of public accommodation (FPAs); and ownership of private waterfront property. Currently, efforts are directed toward a better understanding of the first "vantage point," because government and NGO lands presumably provide the most public viewing opportunities in the aggregate and have been the subject of reasonably thorough data development efforts.

## TELECOMMUNICATION AND POWER CABLES

Due to the number of islands in Massachusetts water, there are several submarine communications and electric cables in Massachusetts waters.

### Telecommunication Cables

Modern telecommunications cables consist of a "transmission core" of glass fibers with outer layers of various materials to strengthen insulate and protect the fibers. The degree of cable protection depends on the nature of the underwater environment. Shallow waters are generally more hazardous and cables in these waters have additional armoring, depending on the protection needed from fish and abrasion.

#### Hibernia Atlantic Project

This is a transatlantic submarine communications cable system connecting Canada, the U.S., Ireland and England. The cable system transports fiber optic Terawave DWDM system transporting 10Gbit/s SDH/SONET signals and provides secure international network connections. The cable became operational in 2001. At the end of 2004, the 12,200-km (7,581-mile) cable had a transmission capacity of 160 Gbit/s and can be upgraded to 1.920 Gbit/s. Two separate cables traverse the Atlantic with four landing points, including Lynn, Massachusetts. The two-inch thick, shielded cable is buried about four feet under the seabed. When making landing in Lynn, it enters a manhole and connects to existing wires running beneath the Lynnway towards Commercial Street. In 2007, Hibernia Atlantic upgraded its submarine data transport span between Halifax and Boston from 10G to 40G (TRC 2006).

### Power Cables

There are two types of cables that transfer electricity: 1) High Pressure Oil Filled pipe-type (HPOF) installed inside a protective steel pipe, and 2) Low Pressure self-contained and extruded dielectric (LPOF).

Submarine cables are installed using cable ships or barges and cables may need to be buried in inshore shallower areas as protection from destructive wave action, damage from boats, ships and anchors, to avoid instability due to bottom currents and to allow unimpeded recreational use of beaches. This involves the digging of trenches in the seabed, excavating and backfilling with various methods, depending on submarine morphology and bathymetry.

#### Nantucket Cable Projects

There are two separate projects to improve the reliability of electric supply and stabilize rates on Nantucket. The first project, connecting Harwich on Cape Cod to Nantucket through Nantucket Sound, made it possible for a generating facility on Nantucket to be dismantled. This is a 42-km (26-mile), 46 kV submarine cable buried 2.4 m (8 ft) below the seabed using a jet plow. The second cable, linking Barnstable to Nantucket, consists of a 53-km (33-mile) long, 46 kV submarine cable designed to increase capacity on the island as we as act as a back up in case the first cable was damaged or needed servicing (Figure 6.x).

#### Cape Wind Energy Project

Cape Wind is the first proposed offshore wind energy project in the U.S. The proposed wind farm will be located in Nantucket Sound and will consist of 130 turbines to generate 420 MW of energy. The cables from the individual turbines connect to the electrical service platform which serves as the main connection point and the offshore maintenance facility. Power will be conducted through two undersea cables that will make landfall on Cape Cod and connect to the electric grid via a NSTAR right-of-way in Yarmouth. Using hydroplowing, the undersea cables will be buried several feet under the ocean floor.

### Potential Effects

Location of the cable may cause negative impacts on habitats and their species, especially as a result of physical disturbance during installation and fragmentation of habitat. Some species of flora and fauna may be lost during the process of laying the cables. Increased turbidity from excavation and backfilling may be harmful to various benthic species as well as seagrasses and algae.

Installation of undersea pipelines and cables is believed to have relatively limited impacts. However, damaging impact on the marine environment, even if minimal, is inevitable. The degree of impact will depend mainly on the type and size of the pipeline or cable, whether buried or laid on the surface, and the type of equipment used. Typical impacts include damage/destruction of fisheries resources, seagrass meadows, coral reefs and mangroves, temporal/permanent displacement of other users, and noise and congestion from installation activities (Lyn undated). Burying cables prevents accidents from snagging with anchors and fishing equipment. In general, cable installation is not permitted in sensitive habitats such as sea grass, kelp forests or coral reefs. If a coral reef cannot be avoided, a bore 3 m (10 ft) deep is made. In deeper waters, cables are simply laid on the ocean floor, as in transatlantic cables, unless traversing ocean sanctuaries.

Oil-cooled cables can cause environmental damage if accidentally damaged. Apart from this, if cables are adequately buried they should have no significant operational impact in passing through the coastal zone (Lyn undated). Fiber optic cables use pulses of light to carry data instead of electricity but most still carry some electric current to supply amplifiers and research on these and other potential disturbances are ongoing. Research is ongoing about any potential deleterious effects from magnetic/electric fields on organisms living in close proximity to a cable, as well as effects of recolonization after disturbance. A study of the environmental impact of the electric ATOC/Pioneer Seamount Submarine Cable that lay partly within the Monterey National Marine Sanctuary between 1995 and 2003 indicated that the cable was colonized by anemones, with echinoderms and sponges close by, the main difference with control sites (Kogan *et al.* 2003).

Submarine cables may also interfere with archaeological artifacts, both during installation as well as by location.  Other conflicts may arise with maritime traffic, both with the cable laying vessels as well as in shallow waters with smaller craft.  Operational noises may cause disturbance to nearby residents.

### List of Telecommunication and Power Cables

Nantucket to Harwich

Nantucket to Barnstable

Martha' Vineyard to Cape Cod

Hibernia Atlantic to Lynn

Proposed: Cape Wind - landfall close to Yarmouth

Proposed: Hull – landfall in Hull

## SHORELINE PROTECTION AND FLOODPLAIN MANAGEMENT

The natural forces of wind and waves continuously shape the shorelines of Massachusetts, seeking to achieve a dynamic equilibrium between land and sea. Dynamic coastal environments shift and change in response to increases in energy (wind and waves), alterations to regional sediment resources (sand, gravel, and cobble), and rising sea levels. The balance between these factors is critical. A change in the nature or amount of one factor triggers corresponding changes to the others until a temporary equilibrium is once again established. This tendency for shorelines to seek equilibrium is central to its relevance to the Ocean Management Planning Area, especially activities adjacent to the near shore boundary.

Climate change and sea-level rise are persistent contributors to coastal land loss in the Northeast. Increased volumes of water in the oceans due to thermal expansion of water as it warms and the addition of fresh water from melting ice sheets and glaciers result in the rise of sea surface levels. Records of tide gauges around Boston, Woods Hole, and Nantucket indicate that our relative sea level (the combination of a rising water surface with land subsidence) has risen approximately 10 inches over the past 100 years. Furthermore, the Intergovernmental Panel on Climate Change (IPCC) predicts that sea-level rise and its risk to coastal resources will accelerate over the next 100 years (IPCC, 2007). Conservative projections of sea-level rise by the end of the century range from four to 21 inches, while projections given a higher emissions scenario range from eight to 33 inches (Union of Concerned Scientists, 2006). With an accelerated rate of sea-level rise, low-lying coastal areas will be particularly vulnerable to increased erosion, flooding, and inundation. In addition, these impacts will extend further inland, resulting in greater loss of land and damage to development along the coast of Massachusetts. The combination of rising sea levels, more frequent and intense storms, and increased coastal development will result in greater erosion and flooding impacts over time.

The risk to coastal communities from erosion and flooding continues to present major challenges at all levels of government. Erosion and flooding, which are the primary coastal hazards that lead to the loss of lives or damage to property and infrastructure in developed coastal areas, may be exacerbated by some activities in the Planning Area and alleviated by others. Policymakers recognize this delicate balance between development and natural resource protection. Managers generally employ many different measures to reduce the risks posed by coastal hazards along developed coasts. Regulations are implemented to ensure that adverse impacts of projects are minimized. Review of proposed projects in the Planning Area must consider affects on ocean circulation, marine sediment transport, and water levels, and their related impacts on coastal areas.

The Commonwealth considers non-structural measures such as beach nourishment (*i.e.*, the active addition of sediment to a beach system) viable alternatives to protect coastal development while also maintaining recreational beaches. Beach nourishment projects require an adequate volume of compatible sediment. Massachusetts successfully completed a beach nourishment project on Revere Beach State Reservation in 1992 using an upland source of approximately 768,000 cubic yards of sediment. Smaller nourishment projects were also completed on Dead Neck Beach in Osterville (1998) and Long Beach in Plymouth (1999) using sediment from offshore sources. Two major beach nourishment projects using offshore sources of sediment have been proposed for Winthrop Beach and Siasconset Beach. CZM recommends that sediments that are actively being worked by waves should not be targeted for removal due to the potential to contribute significantly to shoreline changes. Therefore, sediment sources further from shore and in the ocean planning area are likely to be considered. While successfully nourished beaches can minimize property and infrastructure damages, restore the vitality of communities, and energize local economies, maintenance of artificial beaches does require continued placement of sediment. These projects and the need to periodically re-nourish previously nourished beaches, demonstrate that the demand for offshore sediment sources from the ocean planning area will likely increase and that conflicts and compatibilities between nourishment sites and other uses within the planning area will need to be considered..

*Please see the report released by the Massachusetts Coastal Hazards Commission in May 2007, Preparing for the Storm: Recommendations for Management of Risk from Coastal Hazards in Massachusetts, for related information* http://www.mass.gov/czm/chc/recommendations/chc_final_report_2007.pdf.

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# Figures

**Figure 6.1** Marine mammal viewing operations in Massachusetts.

**Figure 6.2**. Thousands of seaducks (from http://www.capecodsportsmen.com/seaduckhunts).

**Figure 6.3**. Wind power potential on the Massachusetts coast.

**Figure 6.4**. Existing and proposed offshore energy facilities in Massachusetts.

**Figure 6.5** Protected areas in the Massachusetts coastal zone.