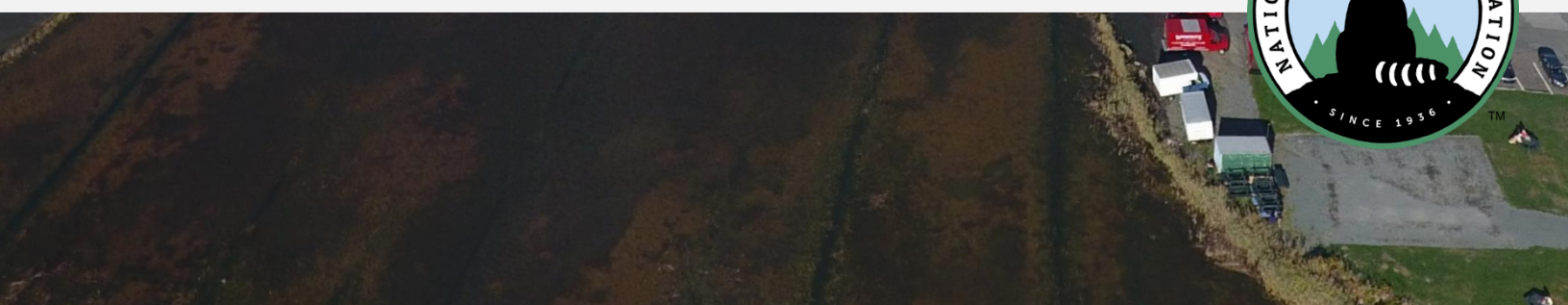
Great Marsh Hazard Atlas & Project Compendium

Prepared by the National Wildlife Federation | June 2018



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June 2018

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Contents

Introduction

The goal of the *Great Marsh Hazard Atlas and Project Compendium* is to provide local decision makers with easy access to the data and resources that they need to take informed action when making the communities and ecosystems within the Great Marsh ACEC resilient to the impacts of climate change. The hazard atlas provides data on the current and future physical, biological and built environments within this region. The project compendium details the coastal resilience projects that are completed, ongoing or planned in the region. This collection of project can serve to inspire or guide local officials as they consider their options in addressing the threats posed by climate change.

Hazard Atlas

The hazard atlas data is organized by category and presents each category in a table format. Each table consists of five columns: *data layer, description, metadata, source, online viewer,* and *keywords*. The ***data layer*** field contains the title of the dataset and also functions as a hyperlink to access the data. Where the data is available in an online map, the link will go directly there. ***Description*** is a brief description of the linked dataset. A link to the metadata is provided in the **m*etadata*** column. In some cases the metadata is accessible via the same link provided in the data layer column; in these cases the ***metadata*** cell reads "see data layer". ***Source*** is the name of the agency or entity that created the dataset. The ***online viewer*** column notifies the reader if this data is accessible in an online map. For data that exists in existing online mapping tools, e.g. the Massachusetts Ocean Resource Information System (MORIS), the column reads "Y". For data which was uploaded to ArcGIS Online by NWF the column reads Y* and is a hyperlink to accessing the mapped data. A blank cell means that the dataset is not currently viewable via an online mapper, but can be downloaded by the user and imported into any desktop GIS system. Finally, ***keywords*** provides users with several one-word summaries of the datasets to facilitate quicker browsing and/or searching of this document.

The hazard data for this atlas was combined from a number of sources, including the Plum Island Ecosystems LTER, State of Massachusetts, and the North Atlantic Landscape Conservation Cooperative among others.

PHYSICAL ENVIRONMENT

This section provides data on the current, and past, physical and geologic environment including, shorelines, tides, erosion, and beach profiles.

Data Layer	Description	Metadata	Source	Online Viewer	Keywords
Shoreline Characterization	These data present the occurrence and distribution of coastal landforms (e.g., dune, beach, and bank), wetland and upland habitats (e.g., forest, salt marsh, and rocky intertidal shore), developed lands (e.g., residential, commercial, and industrial), and shore parallel coastal engineering structures (e.g., bulkheads/seawalls and revetments) at the immediate exposed shoreline that encompasses 57 Massachusetts communities.	LINK	Massachusetts CZM	Y	Shoreline, Beach, Wetlands
Tide Range & Wave Climate	General depiction of transition from microtidal to mesotidal along the Massachusetts coast along with wave roses (1976 - 1995) from two overshore wave hindcast stations.	See Data Layer	Massachusetts CZM		Tide, Waves
Tide Range at Boston, MA	Tidal/water level and meteorological data from Boston, MA Tide Station.	LINK 1 LINK 2	NOAA	Y	Tide, Sea-level Rise, Weather
Tide Range at Seavey Island, ME	Tidal/water level data from Seavey Island, ME Tide Station (1926 -2003)	LINK 1 LINK 2	NOAA	Y	Tide, Sea-level Rise, Weather
Shoreline Rate of Change	Massachusetts CZM's Shoreline Change Project illustrates how the shoreline of Massachusetts has shifted between the mid-1800s and 2009. Using data from historical and modern sources, up to eight shorelines depicting the local high water line (i.e., the landward limit of wave runup at the time of local high tide) have been generated with transects at 50-meter (approximately 164-feet) intervals along the ocean-facing shore.	LINK	Massachusetts CZM	Y	Erosion, Shoreline Change
Beach Profile	Beach profile survey points and sediment samples collected by UMass Amherst/State Geologist	LINK	Massachusetts Geological Survey		Beach Profile, Sediment

BIOLOGICAL ENVIRONMENT

Relevant data on the presence of bird species, health of shellfish populations, and extensive data on the location and health of the marsh vegetation.

Birds

Data Layer	Description	Metadata	Source	Online Viewer	Keywords
Surveys of salt marsh wading birds and shorebirds at Plum Island Sound and portions of Essex Bay	The results of count surveys of wading birds in the salt marshes of the Plum Island Estuary and parts of adjacent Essex Bay. Surveys were carried out from May to October in 2012 and 2013. One additional sampling occurred in July 2014. Bird counts took place from 37 observation points around the bay and documented species, estimated distance from observer, habitat of each individual bird counted and its behavior (feeding, resting, etc.).	LINK	PIE-LTER	Y	Birds, Wading Birds, Snowy Egret
Averages of the three highest counts per decade for selected birds in Plum Island Sound	Averages of the three highest counts per decade (1930's, 1040's, 1950's and 1990's) for a variety of birds including: four shorebirds (black-bellied plover, greater yellowlegs, semipalmated plover, and semipalmated sandpiper), six waterfowl (American black duck, common loon, green-winged teal, mallard, red-breasted merganser, and white-winged scoter), one gull (Bonaparte's gull), and one tern (common tern) in Plum Island Sound., Massachusetts.	LINK	PIE-LTER		Birds, Shorebirds, Waterfowl, Gulls, Tern

Shellfish

Data Layer	Description	Metadata	Source	Online Viewer	Keywords
Water column chlorophyll concentrations associated with clam flat surveys during year 2010 in the Plum Island Sound estuary, Newbury, Rowley and Ipswich, MA.	Six to eight sites in the Plum Island Sound estuary, the mainstem of the Parker River and Rowley River, in areas close to where other clam samples were being taken for other studies, were selected for monthly chlorophyll sampling to determine the concentration of phytoplankton at these sites.	LINK	PIE-LTER	Y*	Shellfish, Clam

Shellfish Suitability	The polygons delineate areas that are believed to be suitable for shellfish based on the expertise of the Massachusetts Division of Marine Fisheries (Marine Fisheries) and local Shellfish Constables, input from commercial fishermen, and information contained in maps and studies of shellfish in Massachusetts. The areas covered include sites where shellfish have been observed since the mid-1970's, but may not currently support any shellfish. Therefore, these maps represent potential habitat areas. Site specific surveys may be necessary to ascertain current distribution and abundance but will not be used to alter the designation of potential habitat without Marine Fisheries input. Additionally, because of the changing habitat and water quality conditions, lands containing shellfish likely exist in areas not identified on these maps. As such, these layers should not be used as a primary source to make site specific assessments for impact or mitigation.	LINK	MassGIS, Division of Marine Fisheries	Y	Shellfish, Clam
Sediment grain characteristics and clam densities for clam flat surveys during 2010 in the Plum Island Sound estuary, Newbury, Rowley and Ipswich, MA.	In 2010 a study was conducted at five sites in the Rowley and Parker Rivers, Northeast Massachusetts, to determine the distribution and density of soft shell clams along a transect from the high to low tide line, as well as the sediment grain size distribution a t each of the sites.	LINK	PIE-LTER	Y*	Shellfish, Clam
Age and annual growth of clams (*Mya arenaria*) during 2010 to 2011 in the Plum Island Sound estuary, Newbury, Rowley and Ipswich, MA.	Age and annual growth of soft shell clams (*Mya arenaria*) were estimated using internal growth lines. The accuracy of these estimates was assessed by comparing them to a δ18O analysis of shell carbonate at six sites in the Plum Island Sound estuary	LINK	PIE-LTER	Y*	Shellfish, Clam
Length, weight and organic content of clams (*Mya arenaria*) during 2010 in the Plum Island Sound estuary, Newbury, Rowley and Ipswich, MA.	Softshell clams from 5 sites from the mainstem of the Parker River, Plum Island sound estuary and adjacent tidal creeks were measured for length, wet weight, dry weight and organic content in 2010.	LINK	PIE-LTER	Y*	Shellfish, Clam

Marsh

Data Layer	Description	Metadata	Source	Online Viewer	Keywords
MassDEP Wetlands	Wetland features from MassDEP including open water, marshes, swamps, tidal flats, etc.	See Data Layer	MassGIS	Y	Wetland, Marsh
Marsh vegetation cover data from quadrats along transects through two hayed and two reference sites near Stackyard Rd, Rowley, MA	Marsh vegetation cover data from quadrats along transects through two hayed and two reference sites in the vicinity of Stackyard Road and Patmos Road, Rowley, MA.	LINK	PIE-LTER		Wetland, Marsh, Rowley
Aboveground biomass data from control sites in a Spartina alterniflora-dominated salt marsh at Law's Point, Rowley River, Plum Island Ecosystem, MA.	Aboveground biomass is determined non-destructively at permanent, high marsh control (non-fertilized) plots in a Spartina alterniflora-dominated salt marsh on the Rowley River within the Plum Island Ecosystem (PIE) LTER site, MA.	LINK	PIE-LTER		Wetland, Marsh, Spartina
Marsh surface elevation data from control plots in a Spartina alterniflora-dominated salt marsh at Law's Point, Rowley River, Plum Island Ecosystem (PIE) LTER, MA.	A Surface Elevation Table (SET) is used to measure changes in the elevation of the marsh platform at a Spartina alterniflora-dominated marsh on the Rowley River in the Plum Island Ecosystem (PIE) LTER site, MA.	LINK	PIE-LTER		Wetland, Marsh, Spartina
Annual productivity in control plots at a Spartina alterniflora-dominated salt marsh at Law's Point, Rowley River, Plum Island Ecosystem, MA.	Annual productivity is determined from aboveground biomass data at permanent, high marsh, plots in a Spartina alterniflora-dominated salt marsh on the Rowley River within the Plum Island Ecosystem (PIE) LTER site, MA.	LINK	PIE-LTER		Wetland, Marsh, Spartina, Rowley
Aboveground biomass of Spartina alterniflora at Law's Point salt marsh on the Rowley River.	Aboveground biomass is determined non-destructively during the growing season at a Spartina alterniflora-dominated salt marsh on the Rowley River within the Plum Island Ecosystems (PIE) LTER site.	LINK	PIE-LTER		Wetland, Marsh, Spartina, Rowley
Annual primary productivity of Spartina alterniflora at Law's Point salt marsh on the Rowley River.	Annual productivity is determined from aboveground biomass data in a Spartina alterniflora-dominated salt marsh plots on the Rowley River within the Plum Island Ecosystems (PIE) LTER site. Aboveground biomass is determined non-destructively.	LINK	PIE-LTER		Wetland, Marsh, Spartina, Rowley

Above- and belowground biomass of S. alterniflora in elevational marsh planter experiments	Spartina is grown in experimental elevation planters placed in draining ponds on the salt marsh platform. The planters are constructed from PVC pipes of varying lengths. All of the PVC pipes are open at the bottom, and flush to the mudflat surface of the pond, resulting in the tops of the pipes being situated at various relative elevations within the tidal range. Plants growing in the shorter PVC pipes are flooded for a longer duration of each tidal cycle than plants growing in the taller PVC pipes. The growth response of S. alterniflora when exposed to different flood frequencies is monitored by monthly estimates of biomass (determined non-destructively from plant heights) and by destructive 'harvesting' of all above- and belowground plant material at the end of the growing season.	LINK	PIE-LTER		Wetland, Marsh, Spartina
Aboveground biomass data from control plots in a Spartina patens-dominated salt marsh at Law's Point, Rowley River, Plum Island Ecosystem, MA.	Aboveground biomass is determined destructively during the growing season at a Spartina patens-dominated salt marsh on the Rowley River within the Plum Island Ecosystem (PIE) LTER site.	LINK	PIE-LTER		Wetland, Marsh, Spartina, Rowley
Marsh surface elevation data from control plots at a Spartina patens-dominated salt marsh at Law's Point, Rowley River, Plum Island Ecosystem (PIE) LTER, MA.	A Surface Elevation Table (SET) is used to measure changes in the elevation of the marsh platform at a Spartina patens-dominated marsh on the Rowley River in the Plum Island Ecosystem (PIE) LTER site, MA.	LINK	PIE-LTER		Wetland, Marsh, Spartina, Rowley
Annual productivity in control plots at a Spartina patens-dominated salt marsh at Law's Point, Rowley River, Plum Island Ecosystem, MA.	Aboveground biomass data collected destructively from control plots during the growing season at a Spartina patens-dominated salt marsh on the Rowley River within the Plum Island Ecosystem (PIE) LTER site, MA.	LINK	PIE-LTER		Wetland, Marsh, Spartina, Rowley
Aboveground biomass of Spartina patens at Law's Point salt marsh on the Rowley River.	Aboveground biomass is determined destructively during the growing season at a Spartina patens salt marsh on the Rowley River within the Plum Island Ecosystems (PIE) LTER site.	LINK	PIE-LTER		Wetland, Marsh, Spartina, Rowley
Wetland Areas - Ipswich Watershed - Idrisi Raster File	This map shows the location of wetland areas inside of the Ipswich River watershed study area.	See Data Layer	PIE-LTER		Wetland, Marsh, Ipswich

Above- and belowground biomass of S. patens in elevational marsh planter experiments	Spartina patens is grown in experimental elevation planters placed in draining ponds on the salt marsh platform. The planters are constructed from PVC pipes of varying lengths. All of the PVC pipes are open at the bottom, and flush to the mudflat surface of the pond, resulting in the tops of the pipes being situated at various relative elevations within the tidal range. Plants growing in the shorter PVC pipes are flooded for a longer duration of each tidal cycle than plants growing in the taller PVC pipes. The growth response of S. patens when exposed to different flood frequencies is monitored by destructive 'harvesting' of all above- and belowground plant material at the end of the growing season.	LINK	PIE-LTER		Wetland, Marsh, Spartina, Rowley
Marsh surface elevation data from three marsh fertilization experimental research sites.	A Surface Elevation Table (SET) is used to measure changes in the elevation of the marsh surface at three long term marsh fertilization experimental research sites. The sites include one Typha-dominated brackish marsh, one Spartina alterniflora-dominated salt marsh, and one S. patens-dominated salt marsh. Sites are located on the Rowley and upper Parker Rivers in the Plum Island Ecosystem (PIE) LTER site.	LINK	PIE-LTER		Wetland, Marsh, Spartina, Rowley, Parker River
Marsh surface elevation data from three marsh fertilization experimental research sites.	A Surface Elevation Table (SET) is used to measure changes in the elevation of the marsh surface at three long term marsh fertilization experimental research sites. The sites include one Typha-dominated brackish marsh, one Spartina alterniflora-dominated salt marsh, and one S. patens-dominated salt marsh. Sites are located on the Rowley and upper Parker Rivers in the Plum Island Ecosystem (PIE) LTER site.	LINK	PIE-LTER		Wetland, Marsh, Spartina, Rowley, Parker River
Marsh surface marker horizon measurements at each Surface Elevation Table (SET) site.	Marker horizon depth measurements at each Surface Elevation Table (SET) site. Marker horizons are commonly used in conjunction with the SET. Marker horizons measure vertical accretion which predominantly incorporates surface processes.	LINK	PIE-LTER		Wetland, Marsh, Surface Elevation Table

Surface elevation table (SET) raw data from six marsh sites along the Rowley River.	Surface elevation table (SET) measurements (raw data) from 6 marsh sites along the Rowley River, Rowley, MA. SET measurements are useful for determining the relative elevation change of marsh sediments. Precise measurements of sediment elevation in marshes is useful for determining rates of elevation change in response to changes in sea level.	LINK	PIE-LTER		Wetland, Marsh, Surface Elevation Table
Marsh boundary of marsh bordering Plum Island Sound at Refuge North, Rowley, MA.	We present high-resolution field measurements of five sites along the United States Atlantic Coast, and cellular automata simulations, to investigate the erosion of marsh boundaries by wave action.	LINK	PIE-LTER		Wetland, Marsh, Erosion
Marsh boundary of marsh bordering Plum Island Sound at Refuge South, Rowley, MA.	We present high-resolution field measurements of five sites along the United States Atlantic Coast, and cellular automata simulations, to investigate the erosion of marsh boundaries by wave action.	LINK	PIE-LTER		Wetland, Marsh, Erosion
Marsh boundary of marsh bordering Plum Island Sound at the end of Stackyard Road, Rowley, MA.	We present high-resolution field measurements of five sites along the United States Atlantic Coast, and cellular automata simulations, to investigate the erosion of marsh boundaries by wave action.	LINK	PIE-LTER		Wetland, Marsh, Erosion

WATER QUALITY

Eighteen years of water quality data from Plum Island Sounds along with measured and estimated nutrient loading in the watershed.

2000 – 2017 water quality measurements near the mouth of Plum Island Sound, Massachusetts					
Data Layer	**Description**	**Metadata**	**Source**	**Online Viewer**	**Keywords**
Year 2000, 15 minute interval, water quality measurements of water column temperature, salinity, oxygen, and depth near the mouth of Plum Island Sound, Massachusetts	15 minute measurements of water column temperature, salinity, oxygen and depth in Plum Island Sound at the Ipswich Bay Yacht Club, Ipswich, MA.	LINK	PIE-LTER		Water Quality

Year 2001, 15 minute interval, water quality measurements of water column temperature, salinity, oxygen, and depth near the mouth of Plum Island Sound, Massachusetts	15 minute measurements of water column temperature, salinity, oxygen and depth in Plum Island Sound at the Ipswich Bay Yacht Club, Ipswich, MA.	LINK	PIE-LTER		Water Quality
Year 2002, 15 minute interval, water quality measurements of water column temperature, salinity, oxygen, and depth near the mouth of Plum Island Sound, Massachusetts	15 minute measurements of water column temperature, salinity, oxygen and depth in Plum Island Sound at the Ipswich Bay Yacht Club, Ipswich, MA.	LINK	PIE-LTER		Water Quality
Year 2003, 15 minute interval, water quality measurements of water column temperature, salinity, oxygen, and depth near the mouth of Plum Island Sound, Massachusetts	15 minute measurements of water column temperature, salinity, oxygen and depth in Plum Island Sound at the Ipswich Bay Yacht Club, Ipswich, MA.	LINK	PIE-LTER		Water Quality
Year 2004, 15 minute interval, water quality measurements of water column temperature, salinity, oxygen, and depth near the mouth of Plum Island Sound, Massachusetts	15 minute measurements of water column temperature, salinity, oxygen and depth in Plum Island Sound at the Ipswich Bay Yacht Club, Ipswich, MA.	LINK	PIE-LTER		Water Quality
Year 2005, 15 minute interval, water quality measurements of water column temperature, salinity, oxygen, and depth near the mouth of Plum Island Sound, Massachusetts	15 minute measurements of water column temperature, salinity, oxygen and depth in Plum Island Sound at the Ipswich Bay Yacht Club, Ipswich, MA.	LINK	PIE-LTER		Water Quality
Year 2006, 15 minute interval, water quality measurements of water column temperature, salinity, oxygen, and depth near the mouth of Plum Island Sound, Massachusetts	15 minute measurements of water column temperature, salinity, oxygen and depth in Plum Island Sound at the Ipswich Bay Yacht Club, Ipswich, MA.	LINK	PIE-LTER		Water Quality
Year 2007, 15 minute interval, water quality measurements of water column temperature, salinity, oxygen, and depth near the mouth of Plum Island Sound, Massachusetts	15 minute measurements of water column temperature, salinity, oxygen and depth in Plum Island Sound at the Ipswich Bay Yacht Club, Ipswich, MA.	LINK	PIE-LTER		Water Quality
Year 2008, 15 minute interval, water quality measurements of water column temperature, salinity, oxygen, and depth near the mouth of Plum Island Sound, Massachusetts	15 minute measurements of water column temperature, salinity, oxygen and depth in Plum Island Sound at the Ipswich Bay Yacht Club, Ipswich, MA.	LINK	PIE-LTER		Water Quality
Year 2009, 15 minute interval, water quality measurements of water column temperature, salinity, oxygen, and depth near the mouth of Plum Island Sound, Massachusetts	15 minute measurements of water column temperature, salinity, oxygen and depth in Plum Island Sound at the Ipswich Bay Yacht Club, Ipswich, MA.	LINK	PIE-LTER		Water Quality

Year 2010, 15 minute interval, water quality measurements of water column temperature, salinity, oxygen, and depth near the mouth of Plum Island Sound, Massachusetts	15 minute measurements of water column temperature, salinity, oxygen and depth in Plum Island Sound at the Ipswich Bay Yacht Club, Ipswich, MA.	LINK	PIE-LTER		Water Quality
Year 2011, 15 minute interval, water quality measurements of water column temperature, salinity, oxygen, and depth near the mouth of Plum Island Sound, Massachusetts	15 minute measurements of water column temperature, salinity, oxygen and depth in Plum Island Sound at the Ipswich Bay Yacht Club, Ipswich, MA.	LINK	PIE-LTER		Water Quality
Year 2012, 15 minute interval, water quality measurements of water column temperature, salinity, oxygen, and depth near the mouth of Plum Island Sound, Massachusetts	15 minute measurements of water column temperature, salinity, oxygen and depth in Plum Island Sound at the Ipswich Bay Yacht Club, Ipswich, MA.	LINK	PIE-LTER		Water Quality
Year 2013, 15 minute interval, water quality measurements of water column temperature, salinity, oxygen, and depth near the mouth of Plum Island Sound, Massachusetts	15 minute measurements of water column temperature, salinity, oxygen and depth in Plum Island Sound at the Ipswich Bay Yacht Club, Ipswich, MA.	LINK	PIE-LTER		Water Quality
Year 2014, 15 minute interval, water quality measurements of water column temperature, salinity, oxygen, and depth near the mouth of Plum Island Sound, Massachusetts	15 minute measurements of water column temperature, salinity, oxygen and depth in Plum Island Sound at the Ipswich Bay Yacht Club, Ipswich, MA.	LINK	PIE-LTER		Water Quality
Year 2015, 15 minute interval, water quality measurements of water column temperature, salinity, oxygen, and depth near the mouth of Plum Island Sound, Massachusetts	15 minute measurements of water column temperature, salinity, oxygen and depth in Plum Island Sound at the Ipswich Bay Yacht Club, Ipswich, MA.	LINK	PIE-LTER		Water Quality
Year 2016, 15 minute interval, water quality measurements of water column temperature, salinity, oxygen, and depth near the mouth of Plum Island Sound, Massachusetts	15 minute measurements of water column temperature, salinity, oxygen and depth in Plum Island Sound at the Ipswich Bay Yacht Club, Ipswich, MA.	LINK	PIE-LTER		Water Quality
Year 2017, 15 minute interval, water quality measurements of water column temperature, salinity, oxygen, and depth near the mouth of Plum Island Sound, Massachusetts	15 minute measurements of water column temperature, salinity, oxygen and depth in Plum Island Sound at the Ipswich Bay Yacht Club, Ipswich, MA.	LINK	PIE-LTER		Water Quality

Nutrients

Data Layer	Description	Metadata	Source	Online Viewer	Keywords
Annual estimates of nitrogen loading to the Ipswich River Watershed, 1931 - 2014.	The nitrogen budget of the Ipswich River watershed was reconstructed to explore trends over time, 1931 to 2014, in gross N inputs, net N inputs, riverine exports. Various sources were used to reconstruct major N budget terms for atmospheric deposition, fertilizer, food imports, sewage N exports, riverine N exports.	LINK	PIE-LTER		Water Quality, Nutrients
Dissolved nutrient and particulate concentrations of freshwater inputs to the Plum Island estuarine system, taken approximately monthly.	Multi-year data of water chemistry including nutrient concentrations for various forms of N, P, C, as well as suspended sediments, was determined from monthly grab samples taken at watershed inputs to the Plum Island Sound Estuary. Sampling sites were the Ipswich River (Sylvania Dam, Ipswich, MA), Parker River Dam (Central St, Newbury, MA), Egypt River (Ipswich, MA) Mill River (Newbury, MA), Muddy Run (Ipswich, MA), Little River (Newbury, MA). These nutrient concentrations are then used in conjunction with USGS discharge data (recorded at gages in the Parker River at Byfield, MA and the Ipswich River at Ipswich, MA) to calculate annual nutrient loading to the Plum Island Sound Estuary, coming over each dam. Annual yield is also calculated for both dams. Refer to file WAT-VA-Load for loading data.	LINK	PIE-LTER	Y*	Water Quality, Nutrients
Annual nutrient loading and yield to Plum Island Estuary, as measured at the Ipswich and Parker Dams	Nutrient concentrations for various forms of N, P, C, as well as suspended sediments, are determined from monthly grab samples taken at the Ipswich and Parker dams. These nutrient concentrations are then used in conjunction with USGS discharge data (recorded at gages in the Parker River at Byfield, MA and the Ipswich River at Ipswich, MA) to calculate annual nutrient loading to the Estuary, coming over each dam. Annual yield is also calculated for both dams.	LINK	PIE-LTER		Water Quality, Nutrients

Nutrient samples collected by Sigma Autosampler between 2001 and 2015 in three headwater sites of contrasting land use, and at the Parker and Ipswich River Dams as they enter into the estuaries.	Total organic nitrogen, total organic phosphorus, and nitrate concentrations collected frequently by Sigma autosampler (or volunteers in winter) from 5 sites. Sites include three headwater sites of contrasting land use (CC= Forest, SB = suburban, CS = wetland) and at the mouth of the Ipswich and Parker Rivers where they flow into the estuary.	LINK	PIE-LTER		Water Quality, Nutrients

WIND & WEATHER

Meteorological data from 2005 - 2017 in Ipswich and 2000 – 2017 in Newbury.

2005 – 2017 wind sensor data from Ipswich Bay Yacht Club pier in Ipswich, MA

Data Layer	Description	Metadata	Source	Online Viewer	Keywords
Year, end of 2005 thru 2006, wind sensor data, 15 minute intervals, from the Ipswich Bay Yacht Club pier located in Ipswich, MA	Wind sensor measurements (wind speed and wind direction) at the Ipswich Bay Yacht Club, Ipswich, MA, 15 minute instantaneous measurement.	LINK	PIE-LTER		Wind, 2005, Ipswich
Year 2007, wind sensor data, 15 minute intervals, from the Ipswich Bay Yacht Club pier located in Ipswich, MA	Wind sensor measurements (wind speed and wind direction) at the Ipswich Bay Yacht Club, Ipswich, MA, 15 minute instantaneous measurement.	LINK	PIE-LTER		Wind, 2006, Ipswich
Year 2008, wind sensor data, 15 minute intervals, from the Ipswich Bay Yacht Club pier located in Ipswich, MA	Wind sensor measurements (wind speed and wind direction) at the Ipswich Bay Yacht Club, Ipswich, MA, 15 minute instantaneous measurement.	LINK	PIE-LTER		Wind, 2007, Ipswich
Year 2009, wind sensor data, 15 minute intervals, from the Ipswich Bay Yacht Club pier located in Ipswich, MA	Wind sensor measurements (wind speed and wind direction) at the Ipswich Bay Yacht Club, Ipswich, MA, 15 minute instantaneous measurement.	LINK	PIE-LTER		Wind, 2008, Ipswich
Year 2010, wind sensor data, 15 minute intervals, from the Ipswich Bay Yacht Club pier located in Ipswich, MA	Wind sensor measurements (wind speed and wind direction) at the Ipswich Bay Yacht Club, Ipswich, MA, 15 minute instantaneous measurement.	LINK	PIE-LTER		Wind, 2009, Ipswich
Year 2011, January to September, wind sensor data, 15 minute intervals, from the Ipswich Bay Yacht Club pier located in Ipswich, MA	Wind sensor measurements (wind speed and wind direction) at the Ipswich Bay Yacht Club, Ipswich, MA, 15 minute instantaneous measurement.	LINK	PIE-LTER		Wind, 2010, Ipswich
Year 2011, September-December, wind sensor data, 15 minute intervals, from	Wind sensor measurements (wind speed and wind direction) at the Ipswich Bay Yacht Club, Ipswich, MA, 15 minute instantaneous measurement.	LINK	PIE-LTER		Wind, 2011, Ipswich

the Ipswich Bay Yacht Club pier located in Ipswich, MA					
Year 2012, wind sensor data, 15 minute intervals, from the Ipswich Bay Yacht Club pier located in Ipswich, MA	Wind sensor measurements (wind speed and wind direction) at the Ipswich Bay Yacht Club, Ipswich, MA, 15 minute instantaneous measurement.	LINK	PIE-LTER		Wind, 2012, Ipswich
Year 2013, wind sensor data, 15 minute intervals, from the Ipswich Bay Yacht Club pier located in Ipswich, MA	Wind sensor measurements (wind speed and wind direction) at the Ipswich Bay Yacht Club, Ipswich, MA, 15 minute instantaneous measurement.	LINK	PIE-LTER		Wind, 2013, Ipswich
Year 2014, wind sensor data, 15 minute intervals, from the Ipswich Bay Yacht Club pier located in Ipswich, MA	Wind sensor measurements (wind speed and wind direction) at the Ipswich Bay Yacht Club, Ipswich, MA, 15 minute instantaneous measurement.	LINK	PIE-LTER		Wind, 2014, Ipswich
Year 2015, wind sensor data, 15 minute intervals, from the Ipswich Bay Yacht Club pier located in Ipswich, MA	Wind sensor measurements (wind speed and wind direction) at the Ipswich Bay Yacht Club, Ipswich, MA, 15 minute instantaneous measurement.	LINK	PIE-LTER		Wind, 2015, Ipswich
Year 2016, wind sensor data, 15 minute intervals, from the Ipswich Bay Yacht Club pier located in Ipswich, MA	Wind sensor measurements (wind speed and wind direction) at the Ipswich Bay Yacht Club, Ipswich, MA, 15 minute instantaneous measurement.	LINK	PIE-LTER		Wind, 2016, Ipswich
Year 2017, PIE LTER wind sensor data, 15 minute intervals, from the Ipswich Bay Yacht Club pier located in Ipswich, MA	Wind sensor measurements (wind speed and wind direction) at the Ipswich Bay Yacht Club, Ipswich, MA, 15 minute instantaneous measurement.	LINK	PIE-LTER		Wind, 2017, Ipswich

2000 – 2017 Meteorological Data from Newbury, MA

Data Layer	Description	Metadata	Source	Online Viewer	Keywords
Year 2008, meteorological data, 15 minute intervals, from the MBL Marshview Farm weather station located in Newbury, MA	Meteorological measurements at MBL Marshview Farm of air temperature, humidity, precipitation, solar radiation, photosynthetically active radiation (PAR), wind speed and direction and barometric pressure. Sensors conduct measurements every 5 secs and measurements are reported as averages or totals for 15 minute intervals.	LINK	PIE-LTER		Weather, Meteorology, Wind, Temperature, Humidity, Precipitation, Wind, Pressure
Year 2009, meteorological data, 15 minute intervals, from the MBL Marshview Farm weather station located in Newbury, MA	Meteorological measurements at MBL Marshview Farm of air temperature, humidity, precipitation, solar radiation, photosynthetically active radiation (PAR), wind speed and direction and barometric pressure. Sensors conduct measurements every 5 secs and measurements are reported as averages or totals for 15 minute intervals.	LINK	PIE-LTER		Weather, Meteorology, Wind, Temperature, Humidity, Precipitation, Wind, Pressure

Year 2010, meteorological data, 15 minute intervals, from the Marshview Farm weather station located in Newbury, MA	Meteorological measurements at MBL Marshview Farm of air temperature, humidity, precipitation, solar radiation, photosynthetically active radiation (PAR), wind speed and direction and barometric pressure. Sensors conduct measurements every 5 secs and measurements are reported as averages or totals for 15 minute intervals.	LINK	PIE-LTER		Weather, Meteorology, Wind, Temperature, Humidity, Precipitation, Wind, Pressure
Year 2011, meteorological data, 15 minute intervals, from the Marshview Farm weather station located in Newbury, MA	Meteorological measurements at MBL Marshview Farm of air temperature, humidity, precipitation, solar radiation, photosynthetically active radiation (PAR), wind speed and direction and barometric pressure. Sensors conduct measurements every 5 secs and measurements are reported as averages or totals for 15 minute intervals.	LINK	PIE-LTER		Weather, Meteorology, Wind, Temperature, Humidity, Precipitation, Wind, Pressure
Year 2012, meteorological data, 15 minute intervals, from the Marshview Farm weather station located in Newbury, MA	Meteorological measurements at MBL Marshview Farm of air temperature, humidity, precipitation, solar radiation, photosynthetically active radiation (PAR), wind speed and direction and barometric pressure. Sensors conduct measurements every 5 secs and measurements are reported as averages or totals for 15 minute intervals.	LINK	PIE-LTER		Weather, Meteorology, Wind, Temperature, Humidity, Precipitation, Wind, Pressure
Year 2013, meteorological data, 15 minute intervals, from the Marshview Farm weather station located in Newbury, MA	Meteorological measurements at MBL Marshview Farm of air temperature, humidity, precipitation, solar radiation, photosynthetically active radiation (PAR), wind speed and direction and barometric pressure. Sensors conduct measurements every 5 secs and measurements are reported as averages or totals for 15 minute intervals.	LINK	PIE-LTER		Weather, Meteorology, Wind, Temperature, Humidity, Precipitation, Wind, Pressure
Year 2014, meteorological data, 15 minute intervals, from the Marshview Farm weather station located in Newbury, MA	Meteorological measurements at MBL Marshview Farm of air temperature, humidity, precipitation, solar radiation, photosynthetically active radiation (PAR), wind speed and direction and barometric pressure. Sensors conduct measurements every 5 secs and measurements are reported as averages or totals for 15 minute intervals.	LINK	PIE-LTER		Weather, Meteorology, Wind, Temperature, Humidity, Precipitation, Wind, Pressure
Year 2015, meteorological data, 15 minute intervals, from the Marshview Farm weather station located in Newbury, MA	Meteorological measurements at MBL Marshview Farm of air temperature, humidity, precipitation, solar radiation, photosynthetically active radiation (PAR), wind speed and direction and barometric pressure. Sensors conduct measurements every 5 secs and measurements are reported as averages or totals for 15 minute intervals.	LINK	PIE-LTER		Weather, Meteorology, Wind, Temperature, Humidity, Precipitation, Wind, Pressure
Year 2016, meteorological data, 15 minute intervals, from the	Meteorological measurements at MBL Marshview Farm of air temperature, humidity, precipitation, solar radiation, photosynthetically active radiation (PAR), wind	LINK	PIE-LTER		Weather, Meteorology, Wind, Temperature,

Marshview Farm weather station located in Newbury, MA	speed and direction and barometric pressure. Sensors conduct measurements every 5 secs and measurements are reported as averages or totals for 15 minute intervals.				Humidity, Precipitation, Wind, Pressure
Year 2017, meteorological data, 15 minute intervals, from the PIE LTER Marshview Farm weather station located in Newbury, MA	Meteorological measurements at MBL Marshview Farm of air temperature, humidity, precipitation, solar radiation, photosynthetically active radiation (PAR), wind speed and direction and barometric pressure. Sensors conduct measurements every 5 secs and measurements are reported as averages or totals for 15 minute intervals.	LINK	PIE-LTER		Weather, Meteorology, Wind, Temperature, Humidity, Precipitation, Wind, Pressure
Daily meteorological data (2000-2017) from PIE LTER weather stations located in Byfield/Newbury, MA	Meteorological data daily averages and daily fluxes for stations located at Governor's Academy and MBL Marshview Farm, Newbury, MA. Data includes air temperature, precipitation, relative humidity, solar radiation, PAR, wind and air pressure measurements. Years 2000 to 2007 the station was located at Governor's Academy, Newbury, MA and was moved July 30, 2007 to the MBL Marshview Farm field station property where it is currently located.	LINK	PIE-LTER		Weather, Meteorology, Wind, Temperature, Humidity, Precipitation, Wind, Pressure

LAND USE & LAND COVER

Local and statewide land use, land cover, and land use change datasets covering 1951 -2013.

Local Land Use Pre-2000

Data Layer	Description	Metadata	Source	Online Viewer	Keywords
Land Use, Anderson Level I - Ipswich Watershed - 1999 - Idrisi Raster File	This layer shows land use for the Ipswich River Watershed based upon MassGIS classification and grouped in accordance with the Anderson: Level I convention. It is intended to be used in connection with other Ipswich Study Area maps.	See Data Layer	MassGIS		Land Use
Land Use, Anderson Level I - Ipswich Watershed - 1991 - Idrisi Raster File	This layer shows land use for the Ipswich River Watershed, based upon MassGIS classification and grouped in accordance with the Anderson: Level I convention. It is intended to be used in connection with other Ipswich Study Area maps.	See Data Layer	MassGIS		Land Use

Land Use, Anderson Level I - Ipswich Watershed - 1985 - Idrisi Raster File	This layer shows land use for the Ipswich River Watershed, based upon MassGIS classification and grouped in accordance with the Anderson: Level I convention. It is intended to be used in connection with other Ipswich Study Area maps.	See Data Layer	MassGIS		Land Use
Land Use, Anderson Level I - Ipswich Watershed - 1971 - Idrisi Raster File	This layer shows land use for the Ipswich River Watershed, based upon MassGIS classification and grouped in accordance with the Anderson: Level I convention. It is intended to be used in connection with other Ipswich Study Area maps.	See Data Layer	MassGIS		Land Use
Land Use, Anderson Level I, 7 Categories - Ipswich and Parker River Watersheds - 1971 - Idrisi Raster File	This layer shows the land use, 7 categories, for the towns in the Ipswich River Watershed and the Parker River Watershed for 1971. This data layer has complete information.	See Data Layer	PIE-LTER		Land Use
Land Use, Anderson Level I, 7 Categories - Ipswich and Parker River Watersheds - 1985 - Idrisi Raster File	This layer shows the land use, 7 categories, for the towns in the Ipswich River Watershed and the Parker River Watershed for 1985. This data layer has complete information.	See Data Layer	PIE-LTER		Land Use
Land Use, Anderson Level I, 7 Categories - Ipswich and Parker River Watersheds - 1991 - Idrisi Raster File	This layer shows the land use, 7 categories, for the towns in the Ipswich River Watershed and the Parker River Watershed for 1991. This data layer has complete information.	See Data Layer	PIE-LTER		Land Use
Land Use, Anderson Level I, 7 Categories - Ipswich and Parker River Watersheds - 1999 - Idrisi Raster File	This layer shows the land use, 7 categories, for the towns in the Ipswich River Watershed and the Parker River Watershed for 1999 This data layer has complete information.	See Data Layer	PIE-LTER		Land Use
Land Use, 21 Categories - Ipswich and Parker River Watersheds - 1971 - Idrisi Raster File	This layer shows the land use, 7 categories, for the towns in the Ipswich River Watershed and the Parker River Watershed for 1985. This data layer has complete information.	See Data Layer	PIE-LTER		Land Use
Land Use, 21 Categories - Ipswich and Parker River Watersheds - 1985 - Idrisi Raster File	This layer shows the land use, 21 categories, for the towns in the Ipswich River Watershed and the Parker River Watershed for 1971. This data layer has complete information.	See Data Layer	PIE-LTER		Land Use

Land Use, 21 Categories - Ipswich and Parker River Watersheds - 1991 - Idrisi Raster File	This layer shows the land use, 21 categories, for the towns in the Ipswich River Watershed and the Parker River Watershed for 1985. This data layer has complete information.	See Data Layer	PIE-LTER		Land Use
Land Use, 21 Categories - Ipswich and Parker River Watersheds - 1999 - Idrisi Raster File	This layer shows the land use, 21 categories, for the towns in the Ipswich River Watershed and the Parker River Watershed for 1991. This data layer has complete information.	See Data Layer	PIE-LTER		Land Use
Land Use, 37 Categories - Ipswich and Parker River Watersheds - 1985 - Idrisi Raster File	This layer shows the land use, 37 categories, for the towns in the Ipswich River Watershed and the Parker River Watershed for 1999 This data layer has complete information.	See Data Layer	PIE-LTER		Land Use
Land Use, 37 Categories - Ipswich and Parker River Watersheds - 1991 - Idrisi Raster File	This layer shows the land use, 37 categories, for the towns in the Ipswich River Watershed and the Parker River Watershed for 1985. This data layer has complete information.	See Data Layer	PIE-LTER		Land Use
Land Use, 37 Categories - Ipswich and Parker River Watersheds - 1999 - Idrisi Raster File	This layer shows the land use, 37 categories, for the towns in the Ipswich River Watershed and the Parker River Watershed for 1985. This data layer has complete information.	See Data Layer	PIE-LTER		Land Use

Statewide Land Use Pre-2000

Data Layer	Description	Metadata	Source	Online Viewer	Keywords
Statewide Land Use 1951 – 1999	This MassGIS Land Use data layer contains polygons with 37 land use classifications interpreted from 1:25,000 aerial photography. Coverage is complete statewide for 1971, 1985, and 1999. Additionally, more than half the state was interpreted from aerial photography flown during 1990, 1991, 1992, 1995 or 1997. The 15 towns on Cape Cod also contain land use data for 1951.	LINK	MassGIS	Y	Land Use

Statewide Land Use Change Pre-2000

Data Layer	Description	Metadata	Source	Online Viewer	Keywords
Land Use Change 1971 - 1985	Statewide land use change 1971 - 1985	LINK	MassGIS	Y	Land Use, Land Use Change
Land Use Change 1971 – 1999	Statewide land use change 1971 – 1999	LINK	MassGIS	Y	Land Use, Land Use Change
Land Use Change 1985 - 1999	Statewide land use 1985 - 1999	LINK	MassGIS	Y	Land Use, Land Use Change

Local Land Cover Post-2000

Data Layer	Description	Metadata	Source	Online Viewer	Keywords
Land Cover (2005), Ipswich and Parker Watershed, Ipswich, Massachusetts - Raster	This is a seven-category land-cover map of Ipswich, Massachusetts. The seven categories are: bare soil, coniferous trees, deciduous trees, grass, impervious surface, water, and wetlands.	See Data Layer	MassGIS		Land Cover
Land Cover (2005), Ipswich and Parker Watershed, Ipswich, Massachusetts - Vector	This is a seven-category land-cover map of Ipswich, Massachusetts. The seven categories are: bare soil, coniferous trees, deciduous trees, grass, impervious surface, water, and wetlands.	See Data Layer	MassGIS		Land Cover
Land Cover (2005), Ipswich and Parker Watershed, Rowley, Massachusetts - Raster	This is a seven-category land-cover map of Rowley, Massachusetts. The seven categories are: bare soil, coniferous trees, deciduous trees, grass, impervious surface, water, and wetlands.	See Data Layer	MassGIS		Land Cover
Land Cover (2005), Ipswich and Parker Watershed, Rowley, Massachusetts - Vector	This is a seven-category land-cover map of Rowley, Massachusetts. The seven categories are: bare soil, coniferous trees, deciduous trees, grass, impervious surface, water, and wetlands.	See Data Layer	MassGIS		Land Cover

Land Cover (2005), Parker Watershed, Newbury, Massachusetts - Raster	This is a seven-category land-cover map of Newbury, Massachusetts. The seven categories are: bare soil, coniferous trees, deciduous trees, grass, impervious surface, water, and wetlands.	See Data Layer	MassGIS		Land Cover
Land Cover (2005), Parker Watershed, Newbury, Massachusetts - Vector	This is a seven-category land-cover map of Newbury, Massachusetts. The seven categories are: bare soil, coniferous trees, deciduous trees, grass, impervious surface, water, and wetlands.	See Data Layer	MassGIS		Land Cover
Land Cover (2005), Parker Watershed, Newburyport, Massachusetts - Raster	This is a seven-category land-cover map of Newburyport, Massachusetts. The seven categories are: bare soil, coniferous trees, deciduous trees, grass, impervious surface, water, and wetlands.	See Data Layer	MassGIS		Land Cover
Land Cover (2005), Parker Watershed, Newburyport, Massachusetts - Vector	This is a seven-category land-cover map of Newburyport, Massachusetts. The seven categories are: bare soil, coniferous trees, deciduous trees, grass, impervious surface, water, and wetlands.	See Data Layer	MassGIS		Land Cover
Level of Protection for Areas Designated Protected and Open Space - Ipswich Watershed - Idrisi Raster File	This data layer shows the level of protection for areas that are defined as Protected and Recreational Open Space by MassGIS (www.state.ma.us/mgis (link is external)). This layer is derived from the Protected and Recreational Open Space layer provided by for each town.	See Data Layer	PIE-LTER		Protected Areas, Land Use
PIE LTER Land Cover (2005), Plum Island Sound estuary, Massachusetts - Raster	This is a seven-category land-cover map of the Plum Island Sound estuary, Massachusetts. The seven categories are: water, tidal flats and soils, Spartina alterniflora, Spartina patens, trees, grass, impervious surface.	See Data Layer	MassGIS		Land Cover
Status and Custodianship of Designated Open Space - Ipswich Watershed - Idrisi Raster File	This data layer is part of a group of layers used for research in the Ipswich River Watershed. This data layer shows the Status for areas that are defined as Protected and Recreational Open Space by MassGIS (www.state.ma.us/mgis (link is external)). This layer is derived from the Protected and Recreational Open Space layer provided by for each town. The values are from the status field (status_fee) field in the data table.	See Data Layer	PIE-LTER		Open Space, Land Use

PIE LTER Land Cover (2013), Plum Island Sound estuary, Massachusetts - Raster	This is a seven-category land-cover map of the Plum Island Sound estuary, Massachusetts. The seven categories are: water, tidal flats and soils, Spartina alterniflora, Spartina patens, trees, grass, impervious surface.	See Data Layer	MassGIS		Land Cover

Statewide Land Use Post-2000

Data Layer	Description	Metadata	Source	Online Viewer	Keywords
Statewide Land Use 2005	A seamless digital dataset of land cover / land use, created using semi-automated methods, and based on April 2005 digital ortho imagery.	LINK	MassGIS	Y	Land Use

Digital Elevation Models

Data Layer	Description	Metadata	Source	Online Viewer	Keywords
Digital elevation model for the Plum Island Sound estuary, Massachusetts (Raster)	This data set consists of a one meter Digital Elevation Model (DEM) of the lower portion of the Plum Island Sound, Massachusetts estuary in ESRI GRID file format based upon last filtered grid (bare-earth) data from the LIDAR flights.	See Data Layer	PIE-LTER		DEM, Elevation
Digital Elevation Model - Ipswich Watershed - Idrisi Raster File	This is Digital Elevation Model data for the Ipswich River Watershed in a 30-meter grid.	See Data Layer	PIE-LTER		DEM, Elevation
Topography Aspect - Ipswich Watershed - Idrisi Raster File	This is aspect data for the Ipswich River Watershed.	See Data Layer	PIE-LTER		DEM, Elevation
Topography: Slope - Ipswich Watershed - Idrisi Raster File	This is slope data for the Ipswich River Watershed.	See Data Layer	PIE-LTER		DEM, Elevation
Water Network (2005), Plum Island Sound estuary, Massachusetts - Vector	Plum Island Sound estuary water network created from 2005 LIDAR data, includes ditches, rivers, tidal creeks, streams and ponds.	See Data Layer	PIE-LTER		DEM, Elevation

STRUCTURES & DAMAGE

Current structures along the coast and throughout the water network as well as projected risk and observed damage from coastal storms.

Data Layer	Description	Metadata	Source	Online Viewer	Keywords
Coastal Storm Damage Reports and King Tide Events	The Massachusetts king tides initiative documents the effect that extreme tide events have on the state's beaches, coastal waterways, private property, and public infrastructure.	N/A	MyCoast	Y	King Tide, Flood, Damage
Coastal Engineering Structures	Inventory of private and public shoreline structures.	LINK	Massachusetts CZM	Y	Shoreline Armoring, Bulkhead, Seawalls
Hydrobarriers assessment	The Ipswich River Watershed Association (IRWA) inventoried and assessed 1,026 potential barriers across the 280 square mile region as part of the most comprehensive such effort in this portion of New England. The inventory included an extensive desktop GIS analysis, thorough review of information from previous reports and on-the-ground surveys of more than 500 road-stream crossings to supplement existing IRWA data sets.	See Data Layer	Ipswich River Watershed Association		Hydrobarriers
Aquatic Connectivity	A combination of datasets for use in a case study using the Nature's Network and NALCC partners' tools to compare aquatic barriers for upgrades targeted at improving habitat for anadromous fish. Given as part of Nature's network workshops.	See Data Layer	North Atlantic Landscape Conservation Cooperative	Y	Connectivity, Hydrobarriers, Fish, Habitat
FEMA National Flood Hazard Layer	The National Flood Hazard Layer (NFHL) dataset represents the current effective flood risk data for those parts of the country where maps have been modernized by the Federal Emergency Management Agency (FEMA).	LINK	FEMA	Y	Flood, Insurance, FEMA, NFIP

CLIMATE CHANGE & GROWTH

Projected impacts of climate change and pressure from development on coastal hazards and exposure.

Data Layer	Description	Metadata	Source	Online Viewer	Keywords
Hurricane Surge Inundation Zones	This layer represents worst-case Hurricane Surge Inundation areas for Category 1 through 4 hurricanes striking the coast of Massachusetts.	LINK	Massachusetts Emergency Management Agency	Y	Climate Change, Hurricane, Storm, Flooding, Inundation
Storm Susceptibility – Coastal Storm Surge Elevations	Modeled tropical storm peaks, 100 year storm water and wave height from North Atlantic Coast Comprehensive Study data for New England	LINK	U.S. Army Corps of Engineers	Y	Climate Change, Tropical Storm, Flooding, Water Height, Wave Height
Extreme Precipitation & Total Precipitation	Projected changes in seasonal or annual precipitation, including consecutive dry days. Changes are relative to the 1971-2000 mean, calculated for four periods 2020-2049 (2030s), 2040-2069 (2050s), 2060-2089 (2070s), 2080-2099 (2090s).	LINK	University of California, San Diego	Y	Climate Change, Precipitation, Drought, Dry, Extreme
Change in Temperature	Projected changes in annual or seasonal temperatures. Changes are relative to the 1971-2000 mean, calculated for four periods 2020-2049 (2030s), 2040-2069 (2050s), 2060-2089 (2070s), 2080-2099 (2090s).	LINK	University of California, San Diego	Y	Climate Change, Temperature
Sea-Level Rise	Future sea level projections are provided for the Massachusetts coastline at established tide gauge stations with long-term records at Boston Harbor, MA; Nantucket, MA; Woods Hole, MA; and Newport, RI.	LINK	University of Massachusetts, Amherst	Y	Climate Change, Sea-Level Rise
Probability of Development, 2080, Version 3.1, Northeast U.S.	This index represents the integrated probability of development occurring sometime between 2010 and 2080 at the 30 m cell level. It was based on models of historical patterns of urban growth in the Northeast, including the type (low intensity, medium intensity and high intensity), amount and spatial pattern of development, and incorporates the influence of factors such as geophysical conditions (e.g., slope, proximity to open water), existing secured lands, and proximity to roads and urban centers.	LINK	North Atlantic Landscape Conservation Cooperative	Y	Development, Modeling, Land Use, Land Use Change

Marsh Migration	Northeast Region Marsh Migration is one of a suite of products from the Nature's Network project. Based on sea level rise (SLR) analysis by NOAA, this dataset depicts potential marsh migration zones at various sea level rise scenarios from 0-6'. Identification of suitable uplands adjacent to tidal wetlands is based on topography, habitat type, land use, and development, and can be used for facilitating marsh migration through land protection and/or management.	LINK	North Atlantic Landscape Conservation Cooperative	Y	Wetland, Marsh, Migration, Climate Change, Sea-Level Rise

Great Marsh Project Compendium

The project compendium provides users a list of planned, ongoing, and completed projects within the Great Marsh ACEC. The goal of this compendium is to demonstrate the wide variety of projects that have been or are planned to be implemented to improve the climate resilience of the ecosystems and communities of the Great Marsh. As communities make decisions about what to do in the face of a changing climate, local decision makers are encouraged to use this compendium as a starting point to see what other communities have done. For further information on an individual project please contact the person listed under ***project lead*.**

Project Title	Project Description	Project Lead	Municipality	Status	Start	End
Site selection of oyster reefs to mitigate salt marsh erosion in Essex Bay, Massachusetts	This study aimed to determine if suitable sites exist in Essex Bay for the construction of oyster reefs to act as living breakwaters to erosive wave energy. Our first goal was to determine if oysters could survive and grow in locations vulnerable to erosion. This study hypothesizes that a successful site for living shoreline restoration would not only require shoreline stabilization, but also experience low predation, low levels of sediment deposition, high oyster survival and growth, and ideally natural recruitment. This study aims to inform the Town of Essex on solutions to marsh retreat in The Great Marsh and provide a methodology for selecting suitable sites for living shorelines aimed at reducing marsh retreat.	Alison Frye, Northeastern University	Essex	Completed	2017	2017
Ox Passage Brook Dam Removal	Restored fish passage and tidal hydrology to Ox Pasture Brook in Rowley. Project opened up one mile of freshwater stream and restored a several-acre impoundment to freshwater tidal wetland.	Alex Hackman, MA DER	Rowley	Completed	2006	2009
PIE Rivers Stream Continuity Survey	Very few road-stream crossings were designed with the movement of fish and wildlife in mind and many present partial or complete barriers to migration for a variety of species. Additionally, many bridges and culverts are undersized, improperly placed or blocked such that they can pond water in much the same way dams do, especially on smaller tributaries. It is important to know which bridges and culverts block migration and impair habitat as we increase efforts to restore fish and wildlife populations in the region.	Brian Kelder, Ipswich River Watershed Association	Multi	Completed	2006	2014

Project Title	Project Description	Project Lead	Municipality	Status	Start	End
Salt Marsh Haying Assessment	Beginning in 2011, Mass Audubon scientists evaluated the impact of traditional salt marsh haying on saltmarsh accretion and ecology and concluded that such activity has a negative effect on both.	Robert Buchsbaum, Mass Audubon	Multi	Completed	2011	2012
Saltmarsh Ditch Restoration	In 2012 -2013, the Parker River National Wildlife Refuge and scientists from the University of New Hampshire conducted a novel research project which filled mosquito ditches originally constructed in the 1930's to restore natural hydrology and marsh function.	Nancy Pau, USFWS	Newbury and Rowley	Completed	2012	2013
Essex Wastewater System	In 2011, the downtown area of Essex was sewered for the first time ever to address chronic septic system contamination of the Essex River. The project resulted in a significant improvement in water quality as the wastewater is being discharged offshore via the City of Gloucester outfall.	Brendhan Zubricki, Town of Essex	Essex	Completed	2011	2011
Rough Meadows Sanctuary	In 2013, several hundred acres of saltmarsh and adjacent upland acreage was protected by Mass Audubon creating the New Rough Meadows Sanctuary. The project protects significant areas of upland suitable for accommodating sea level rise.	Chris Layey, Mass Audubon	Rowley	Completed	2013	2013
Notre Dame Land Protection	After a 3 year process, the Essex County Greenbelt protected a 70-acre portion of the Sisters of Notre Dame property on Jeffrey's Neck Road in Ipswich. Consisting of saltmarsh, freshwater ponds & wetlands and agricultural Field, this project protects a wide range of ecological resources and will provide a significant amount of area to accommodate marsh migration.	Essex County Greenbelt	Ipswich	Completed	2010	2013
Invasive Phragmites Removal	Ten acres of phragmites monoculture were eradicated using herbicide surrounding Clark Pond in Ipswich in 2011. The control seems to be taken hold but spot follow up treatments will be necessary to maintain success	Cricket Wilbur, Association of Great Neck	Great Neck	Completed	2011	2011
Newburyport Dune Enhancement and Restoration	Ten acres of sand replenishment and dune stabilization at State Beach using imported sand.	MA Dept. of Conservation and Recreation	Newburyport	Completed	2014	2014

Project Title	Project Description	Project Lead	Municipality	Status	Start	End
Great Marsh Hydrodynamic Modelling	We will develop a hydrodynamic model of the estuarine flow regime of the Great Marsh ecosystem that assesses sediment transport and erosional forces on the barrier beaches and deposition patterns of sediment into the marsh and tidal creeks. The model will identify barriers to sediment transport and assess the effect of salinity on invasive plant proliferation in the marsh, predicting salinity regimes that will promote healthy, native vegetation and identify vulnerable erosion zones. Scenario planning will allow managers to model restoration options to assess long-term success and costs.	Peter Phippen, Great Marsh Partnership	Multi	Completed	2015	2017
Castle Neck Salt Marsh Restoration and Mosquito Management Project	The project involved removal of gravel obstructions from four locations within the tidal creek system of the Castle Neck River. The project was intended to reduce impoundment, improve tidal flushing and drainage, and reduce documented mosquito breeding within the impounded marsh.	Franz Ingelfinger, MA DER	Essex	Completed	2013	2013
Newman Road Salt Marsh Restoration	The Newman Road project replaced a deteriorating under-sized 36-inch culvert with a 6 by 12-foot box culvert to enhance tidal flow to 33 acres of salt marsh. In addition to the environmental benefits of tidal restoration, the project also benefitted the town by replacing infrastructure that would have required replacement in the near future.	Georgeann Keer, MA DER	Newbury	Completed	2010	2011
LTER-PIE: External Drivers, Humans and Ecosystems	Our overarching goal is to understand how external drivers, ecosystem dynamics, and human activities interact to shape ecological processes in a mosaic of coastal landscapes and estuarine seascapes. Understanding how landscapes and seascapes evolve and change, and how those changes control ecosystem processes, is both a fundamental science question and a critical management question.	Anne Giblin, Marine Biological Library	Multi	Completed	2012	2017
Great Marsh Resiliency Planning Project	Recognizing that public and private assets in the Great Marsh are at increasing risk from climate change events, including coastal storms, sea level rise, inland flooding, and erosion, the planning project is two-fold: assessing those risks and vulnerabilities, and developing plans to reduce those risks.	Chris Hilke, National Wildlife Federation	Multi	Completed	2015	2017

Project Title	Project Description	Project Lead	Municipality	Status	Start	End
Ipswich River Resiliency and Coastal Bank Stabilization Project	This project identified vulnerable areas along the Ipswich River between the Ipswich Mills dam downtown to the Town Wharf on Water Street. A team of coastal geologists and engineers has been hired by the town to inspect erosion and other areas that have deteriorated due to both tidal and inland flooding. The focus of the study will be areas of the river bank adjacent to town infrastructure such as water, sewer, and roads. The project also considered the long-term impacts of climate change, including sea level rise and heavier storms, in its recommended improvements, prioritizing "nature-based solutions" to combat the erosion and provide long-term stabilization of the bank. The Ipswich River Watershed Association partnered with the Town to further public education on these topics, through signage and public presentations next spring. Additionally, the team assessed the feasibility of constructing a public access area for launching non-motorized boats behind the Ipswich Town Hall.	Kristen Grubbs, Ipswich River Watershed Association	Ipswich	Completed	2016	2017
Heterogeneity in a suburban river network: Understanding the influence of fluvial wetlands on oxygen conditions and biogeochemical processes in the Ipswich River Watershed.	The project proposes to measure stream metabolism in natural and anthropogenically altered portions of a river network to better understand the factors controlling dissolved oxygen content and metabolism rates observed throughout the river system. We will look at the effects of road crossings, beaver dams/ponds, anthropogenic dams/reservoirs, floodplains, natural fluvial wetlands and stream channels in different parts of the watershed. Our goal is to quantify the influence of fluvial wetlands and alterations from the channelized stream reach on dissolved oxygen content and metabolism within the stream.	Wil Wollheim, PhD	Multi	Completed	2014	2017
Addressing Impaired Salt Marsh Hydrology	USFWS leads a multi-disciplinary team that will be working toward restoring more natural wetting-drying hydrology to tidal marshes.	Nancy Pau, USFWS		Ongoing	2017	

Project Title	Project Description	Project Lead	Municipality	Status	Start	End
Lower Ipswich Bacteria Source Tracking	The Ipswich River Watershed Association is working in close partnership with the Town of Ipswich to isolate sources of bacterial contamination that are contributing to shellfish bed closures in the Ipswich Estuary. Ongoing sampling by the Mass. Division of Marine Fisheries (DMF) has indicated a source of bacterial contamination from downtown Ipswich that is threatening the shellfish beds in the river. IRWA staff and volunteers are using multiple methods to test for contamination sources in tributaries near the mouth of the Ipswich including Saltonstall, Kimball and Farley Brooks. The Ipswich Wastewater Treatment Plant is providing water testing services to support the project.	Ryan O'Donnell, Ipswich River Watershed Association	Ipswich	Ongoing		
Parker River - North and South Pool Restoration	Since 2008, the Parker River National Wildlife Refuge has been restoring the north and South pool freshwater impoundments back to its original saltmarsh. The pools were originally constructed in the 1950's by filling saltmarsh to encourage waterfowl.	Nancy Pau, USFWS	Plum Island, Newbury and Rowley	Ongoing	2008	
Invasive Phragmites Eradication – Stage Pool, Plum Island	Ongoing since 2008, the Parker River National wildlife Refuge has been eradicating phragmites form an 80 acre artificial freshwater wetland (formally saltmarsh) with a variety of methods (plastic, fire, herbicide, hydrology). Location: near bluff point state park on the refuge in Ipswich.	Nancy Pau, USFWS	Ipswich	Ongoing	2008	
Invasive Green Crab Removal	The invasive European green crab (*Carcinus maenes*) has been a destructive force in the northern Gulf of Maine for several years, clearing estuaries of eelgrass as they dig up clams, and destabilizing marsh banks with their burrows. Initiated in 2013 by PIE-Rivers partner MassBays and the "Eight Towns and the Great Marsh" program, the Towns of Ipswich, Rowley, Essex, Newbury, and Gloucester have engaged in trapping of the green crabs based on a $0.40 per pound bounty funded by the MA Division of Marine Fisheries and the Town of Ipswich.	Peter Phippen, Great Marsh Partnership	Plum Island, Essex	Ongoing	2013	
Kent's Island Creek Restoration	This project will improve tidal flow to over 45 acres of salt marsh in the William Forward Wildlife Management Area.	Georgeann Keer, MA DER	Newbury	Ongoing	2015	

Project Title	Project Description	Project Lead	Municipality	Status	Start	End
Greenscapes North Shore	Greenscapes Massachusetts is a multi-partner outreach effort that promotes water conservation and protection. This collaborative education and outreach effort is sponsored primarily by partner cities and towns and seeks to educate citizens and professionals about landscaping practices (particularly irrigation and chemical use) to have less impact on the environment; create an informed and proactive citizenry that acts as environmental stewards in their own backyards; and generate broad support for the responsible public management of water resources (quality and quantity).	Cynthia Ingelfinger, Ipswich River Watershed Association	Multi	Ongoing	2007	
Beach Dune Restoration	Phase 1: Dune nourishment and re-vegetation in Newbury, MA using innovative fencing and native vegetation methods. Conducted following severe erosion cycle of 2011-13 which resulted in 5 homes being lost to the sea. Phase 2: The Great Marsh Resiliency Partnership's efforts to restore the sand dunes of Newbury, Newburyport and Salisbury, MA got a boost in December from PIE-Rivers partners at the University of New Hampshire.	Gregg Moore, University of New Hampshire	Newbury, Newburyport, Salisbury	Ongoing	2011	
Farley Brook Stormwater BMPs	During late 2014, the Town was awarded a 319 Nonpoint Source Pollution Grant to investigate potential sources of pollutants detected in Farley Brook. Work on the related project has been ongoing through the year and has included continued sampling within Farley Brook and the contributing stormwater collection system, planning meetings of a recently established Farley Brook advisory committee, a public project update presentation to the Board of Selectmen, and the development of a design for an engineered wetland.	Richard Clarke, Town of Ipswich	Ipswich	Ongoing	2014	
Invasive Pepperweed Removal	The pepperweed control project is designed to increase the health of salt marshes in the Great Marsh Region by reducing the invasive plant, perennial pepperweed.	Liz Duff, Mass Audubon	Multi	Ongoing	2006	

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Ipswich Mills Dam Removal Study	The Town of Ipswich recognizes the long-term maintenance, liability and environmental costs associated with the dam. On March 29, 2010 the Ipswich Board of Selectmen voted unanimously to begin exploring the environmental, technical, logistical and economic factors surrounding the removal of the Ipswich Mills Dam. A preliminary feasibility study was funded by the Conservation Law Foundation and NOAA. A full feasibility is now being planned for 2015-2017	Brian Kelder, Ipswich River Watershed Association	Ipswich	Ongoing	2014	
Tidal Creek Fertilization Experiment	Increased nutrient input to estuaries from human activities has been a concern to scientists for many years. In addition to stimulating plant and algal growth, nutrient fertilization can alter plant species composition and change the sedimentation and erosion rates that regulate marsh accretion and decomposition. The presence of higher order animals, such as fish, can also affect the balance of marsh accretion and loss by influencing the flow of nutrients within the marsh ecosystem. Through their feeding and behavior, fish can increase or decrease plant and algae production, increase decomposition and move nutrients into or out of the marsh ecosystems through migration. The TIDE project is long-term experimental ecology at the scale of the ecosystem and unique in the world. An ecosystem-level approach is used to understand the effects of eutrophication and altered food webs on saltmarsh ecosystems in the Plum Island Estuary, Massachusetts.	Anne Giblin, PIE-LTER	Multi	Ongoing	2002	
Marsh Bank Erosion Monitoring	Twenty-four bank erosion monitoring stations have been established to determine rates and causes of loss. The Partnership will continue to expand the network of monitoring stations and implement mitigation strategies to protect the marsh from future loss.	Peter Phippen, Great Marsh Partnership	Multi	Ongoing	2014	
Thin Layer Deposition at Essex Marsh	The Town of Essex is interested in utilizing materials from the dredging of the channel to add sediment to the marsh, thereby helping the marsh keep pace with rising sea levels.	Brendhan Zubricki, Town of Essex	Essex	Planned	2016	

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Marsh Detritus Removal Experiment	Over 400 hectares of Plum Island Sound marsh are regularly hayed by commercial farmers, most on a biennial basis. Haying used to be common and extensive throughout New England marshes; however, the operation in Plum Island Sound is one of the last operations remaining. Haying of the salt marsh is analogous to large-scale removal of detritus or herbivory. Haying removes >90% of annual aboveground production and biomass. This represents a significant loss of nutrients and organic matter that would otherwise be available for marsh detritivores and microbes, export or peat accumulation. A long-term experiment is being carried out by PIE LTER scientists to study the effects of marsh detritus removal on a variety of ecological processes in the Plum Island Sound marsh ecosystem.	Anne Giblin, PIE-LTER	Multi	Ongoing	2000	
Marsh Fertilization Experiment	The Ipswich Wastewater Treatment Plant located on Fowlers Lane receives wastewater from approximately 2,000 customers. The treatment plant, originally constructed in 1959, was upgraded in 1963, 1972 and 1996. The plant is a secondary treatment plant and is designed to treat 1.8 million gallons of wastewater per day, with an instantaneous peak flow of 5.4 million gallons per day. Treated effluent is discharged to Greenwood Creek, Ipswich, MA. PIE-LTER has set up transects to study the impacts on the salt marsh vegetation from nutrients discharged from the Ipswich Wastewater Treatment Facility. The marsh around Clubhead Creek in Rowley, MA is used as a reference.	Anne Giblin, PIE-LTER	Ipswich	Ongoing	2004	
Newburyport Dune Restoration and Beach Access Improvement Project	The City of Newburyport will prepare design plans for dune restoration and an elevated beach access structure to provide critical storm buffering to low-lying neighborhoods while maintaining beach access. Educational signage will also be installed to communicate the importance of vegetated dunes and maintain dune integrity.	Tony Furnari, City of Newburyport	Newburyport	Ongoing	2018	

Project Title	Project Description	Project Lead	Municipality	Status	Start	End
Plot-Level Marsh Fertilization Experiment	We have long-term experiments in 2 major marsh types where plant census and porewater nutrient data are collected monthly. Plots receive monthly factorial N and P additions to determine nutrient controls on primary production and sediment accretion. The SET measurements and end of season biomass measurements in fertilized plots will be used to track long-term trends in primary production. Complementary work on marsh productivity in North Inlet, South Carolina is being supported by NSF's LTREB program. The monthly census of plant heights is giving us unparalleled temporal resolution of salt marsh production that is not corrupted by spatial variability (Morris and Haskin 1990).	Anne Giblin, PIE-LTER	Multi	Ongoing	2004	
Jeffrey's Neck Road	The Town is in the process of developing a preliminary design (approximately 30% complete) to raise the road surface approx. 2' in areas in an attempt to reduce the occurrence of flooding and roadway closures during major storms. The 30% design is due to FEMA by the end of June 2016. Assuming that the 30% design is approved by FEMA, the remaining grant funding will be released to the Town for the completion of the roadway design and for construction	Frank Ventimiglia, Town of Ipswich, DPW Operations Manager	Ipswich	Ongoing	2016	
Great Marsh Barriers Project Identification	The recently completed Great Marsh Barriers Assessment provides a comprehensive regional assessment of barriers to streamflow and tidal exchange in the Great Marsh. With grant funding, IRWA will work with communities to identify 15-20 projects to reduce impacts of these barriers. This effort will forward on-the-ground restoration actions to increase habitat and community resilience to climate change impacts. IRWA will hold training workshops focusing on lessons learned and opportunities to implement the approach beyond the region.	Kristen Grubbs, Ipswich River Watershed Association	Multi	Ongoing	2018	
Ipswich River Coastal Resiliency: Area of Concern 4	Living shoreline at County Street in Ipswich, MA to address bank erosion.	Alicia Geilen, Town of Ipswich	Ipswich	Planned	2017	

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Old Town Hill Marsh Restoration	This project involves field work in the Parker River Estuary to reduce the negative impacts of past "ditching" on marsh habitat, to restore the marsh's ability to buffer neighboring communities from storm surge and rising sea levels. Targeting 85 acres of salt marsh at Old Town Hill in Newbury, the project will implement a new and innovative, nature-based technique to reverse some ditching. If successful, this method will help existing coastal marsh ecosystems keep pace with sea level rise.	Caleb Garone, Trustees of Reservations	Newbury	Ongoing	2018	
Great Marsh Revitalization and Phragmites Management	The Great Marsh Revitalization Task Force, chaired by the state senator representing the Great Marsh communities, is dedicated to the management and control of invasive *Phragmites australis* in the Great Marsh salt marsh. The Task Force, comprised of federal, state, municipal, not-for-profit, and private business stakeholders, has been working together for several years on long-term and short-term goals to manage the Phragmites. Short-term goals include curbing the spread of Phragmites (chemical treatment) while long-term solutions (hydrodynamic modeling, salinity influx, restriction removal, etc.) can be developed and implemented.	Peter Phippen, 8 Towns and Great Marsh	Multi	Ongoing	2005	
Essex, Ipswich and Newbury Municipal Vulnerability Project Action Grant Proposal	Essex, Ipswich and Newbury are seeking to study the long-term effects of a large-scale, natural sediment deposit. The combined effects of extreme cold, astronomical high tides and major winter storms back in early January, seem to have been the primary cause of the sediment.	Brendhan Zubricki, Town of Essex	Multi	Planned	2018	