# Start making sense! Applying diverse data to track estuarine conditions and trends

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MassBays – large, diverse, complex

The Massachusetts Bays National Estuary Program (MassBays) region encompasses all coastal waters from the Massachusetts - New Hampshire border to the tip of Cape Cod, including three major bays (Ipswich Bay, Massachusetts Bay and Cape Cod Bay) across 1650 square miles and bordered by a 1100 mile shoreline. The Bays are located at the southern end of the Gulf of Maine which is characterized by relatively cool water and large tidal ranges. The watershed area draining into the bays is approx. 7000 square miles (50% within Massachusetts). 1.7 million people reside within the planning area's 50 coastal communities.
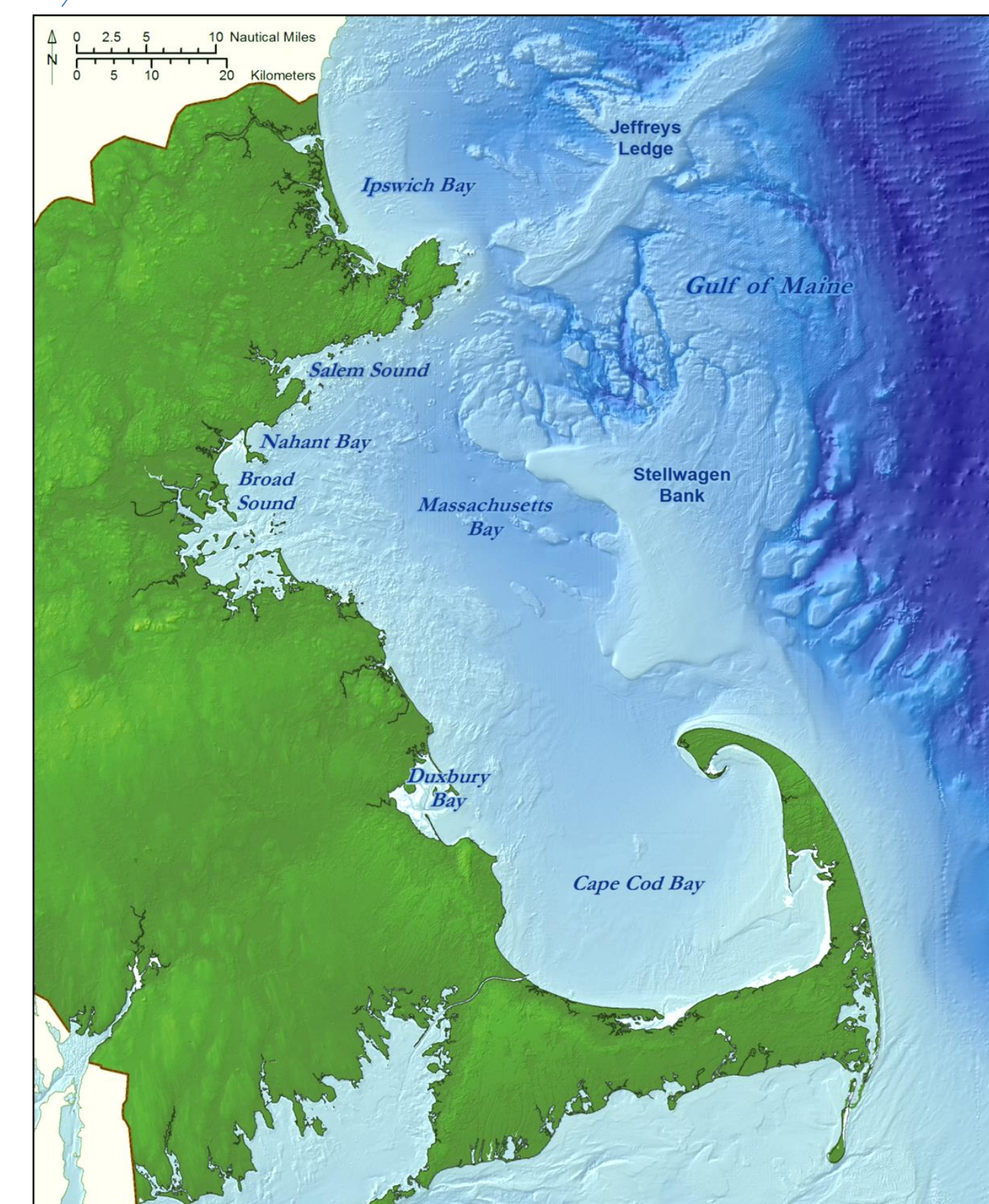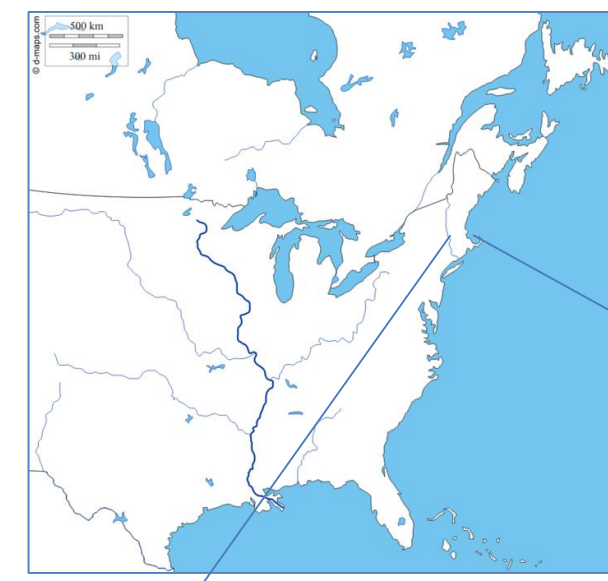
Estuaries

Estuaries are highly diverse and dynamic zones where different systems come together and where most human activities take place.

And here, at the estuaries, is where some of the most difficult environmental challenges take place: discharge of pollutants from stormwater and wastewater, habitat loss, tidal barriers restricting streamflow and tidal flushing (and fish passage), erosion, spread of invasive species resulting from loss of native communities, and impacts of recreational and commercial activities. These areas are also where climate change impacts are felt more strongly.

How is MassBays meeting the challenges?

Develop a plan
MassBays' Comprehensive Conservation and Management Plan (CCMP) goal: to provide regular and locally informed State of the Bays reporting that documents improvement in estuarine ecosystem conditions.

How will MassBays do it?
- Develop and implement methodology for comparison across embayments
- Establish target conditions for each embayment type
- Guide local action to increase habitat and improve water quality

What is the overall outcome?
Targets for future embayment conditions that will guide and inform implementation of the CCMP across the region.

Goals and tasks

- Identify coastal/estuarine embayments and inter-estuarine areas and develop landward and seaward boundaries.

- Develop a list of attributes to characterize each embayment and inter-estuarine area.

- Develop an analytical approach using select attributes to define embayment types.

- Identify type-specific estuarine embayment conditions that will help prioritize protection and restoration priorities and inform management decisions.

Estuary Delineation and Assessment

Methodology: (1) Selection of boundaries

- Determined a seaward boundary that encompassed the estuary and major estuarine ecological habitats.
  - 305(d) delineation of waterbody
  - Expand boundary to include seagrass, tidal flats, shorebirds, shellfish habitat
  - 10m bathymetry contour

- Determined a landward boundary based on tidal influence within the estuary.
  - MassDEP Wetlands (salt marsh)
  - Ch.91 Tidal Jurisdiction

- Special case: Cape Cod
  - Sandy aquifer, groundwater-dominated
  - Used results of MODFLOW groundwater model and other USGS sources
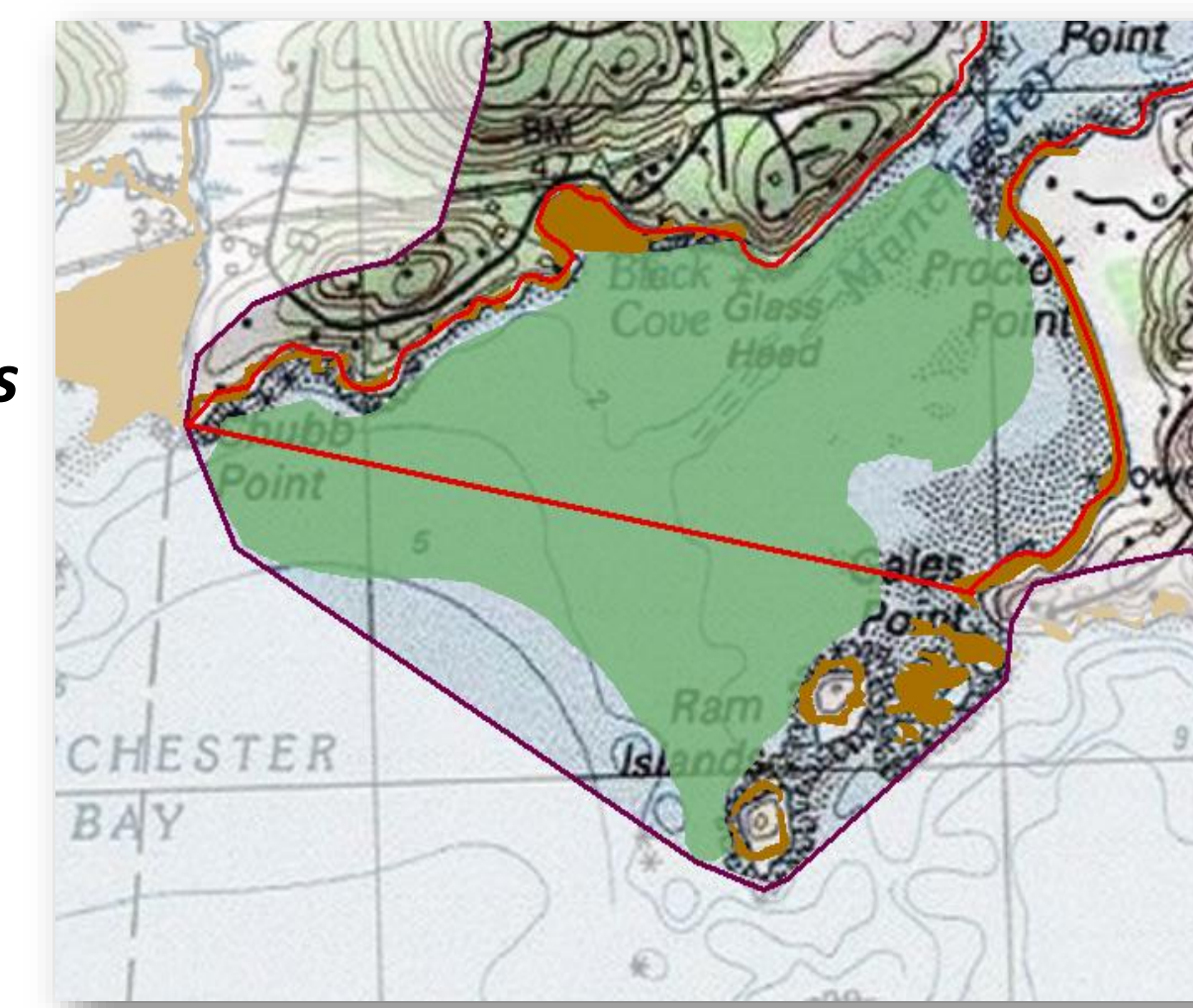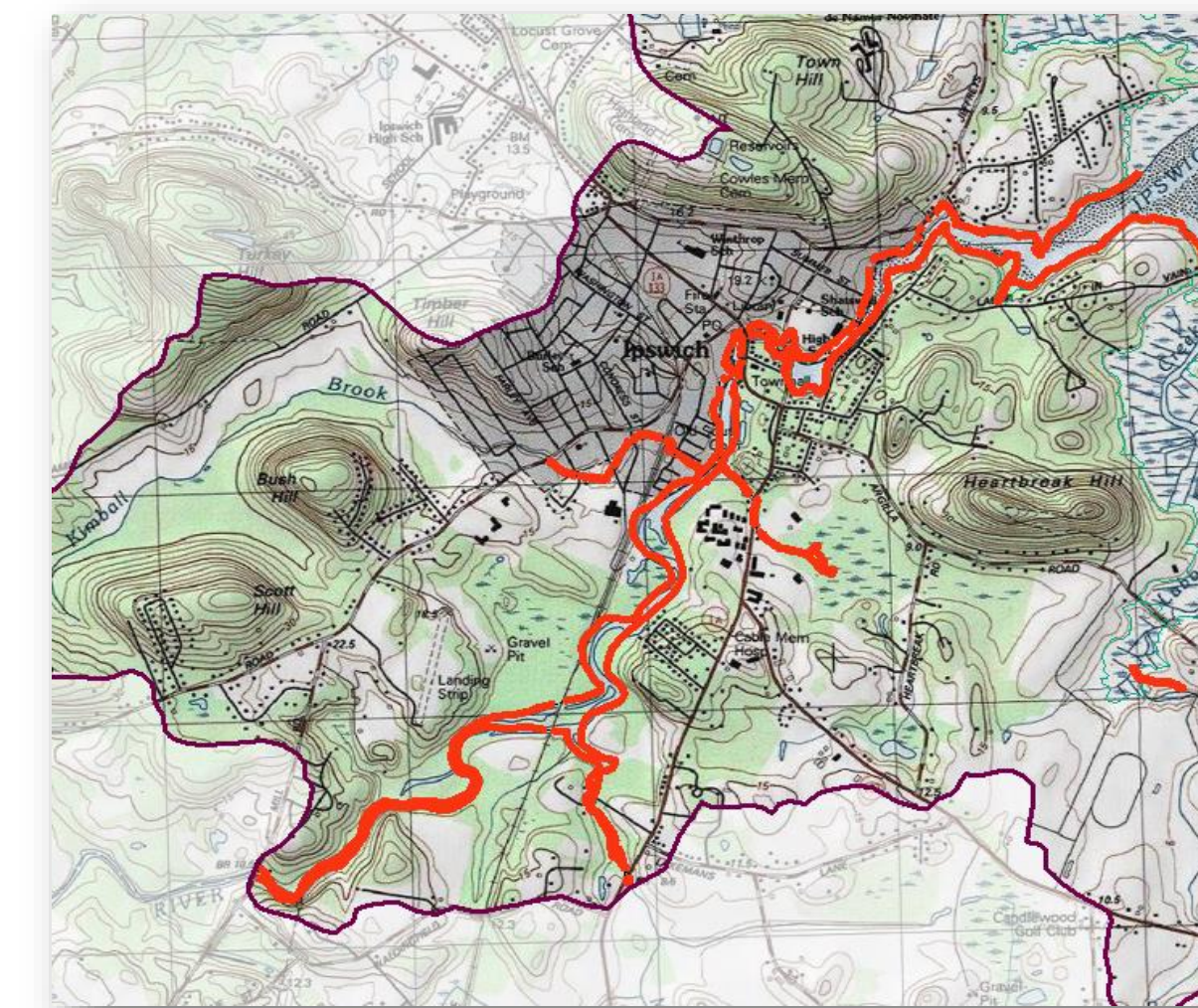
(2) Selection of attributes to characterize embayments

- Developed a list of attributes that can be used to characterize and evaluate the condition of estuarine embayments and inter-estuarine areas with respect to MassBays management priorities.

- Attributes were selected based on a set of criteria including data quality and availability.

- Attribute data were normalized to the area of open water (e.g. eelgrass, shellfish habitat) or to the area of land (e.g. population density, impervious area), or to the total area (e.g. salt marsh, tidal flats) within the watershed boundary.
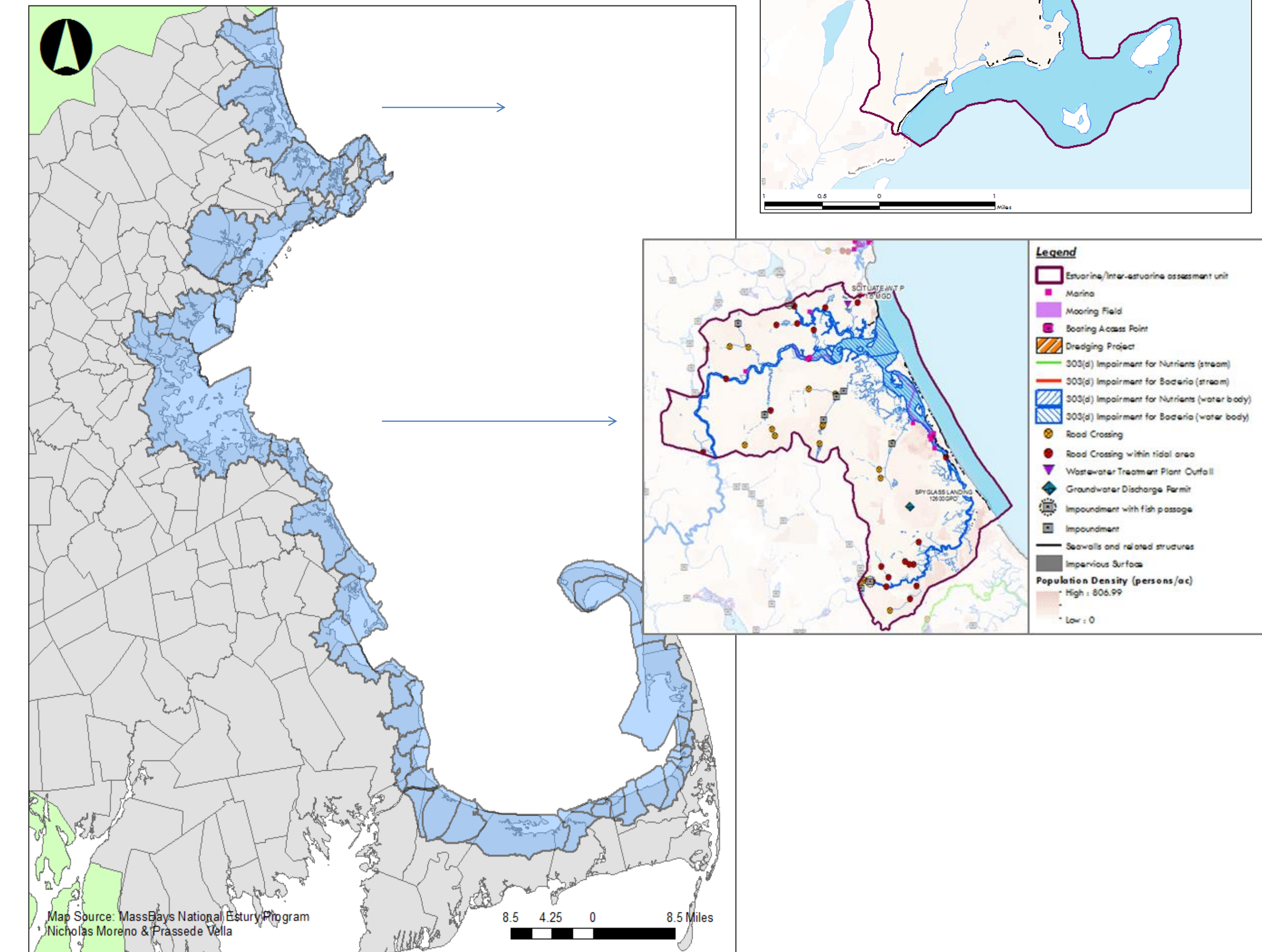
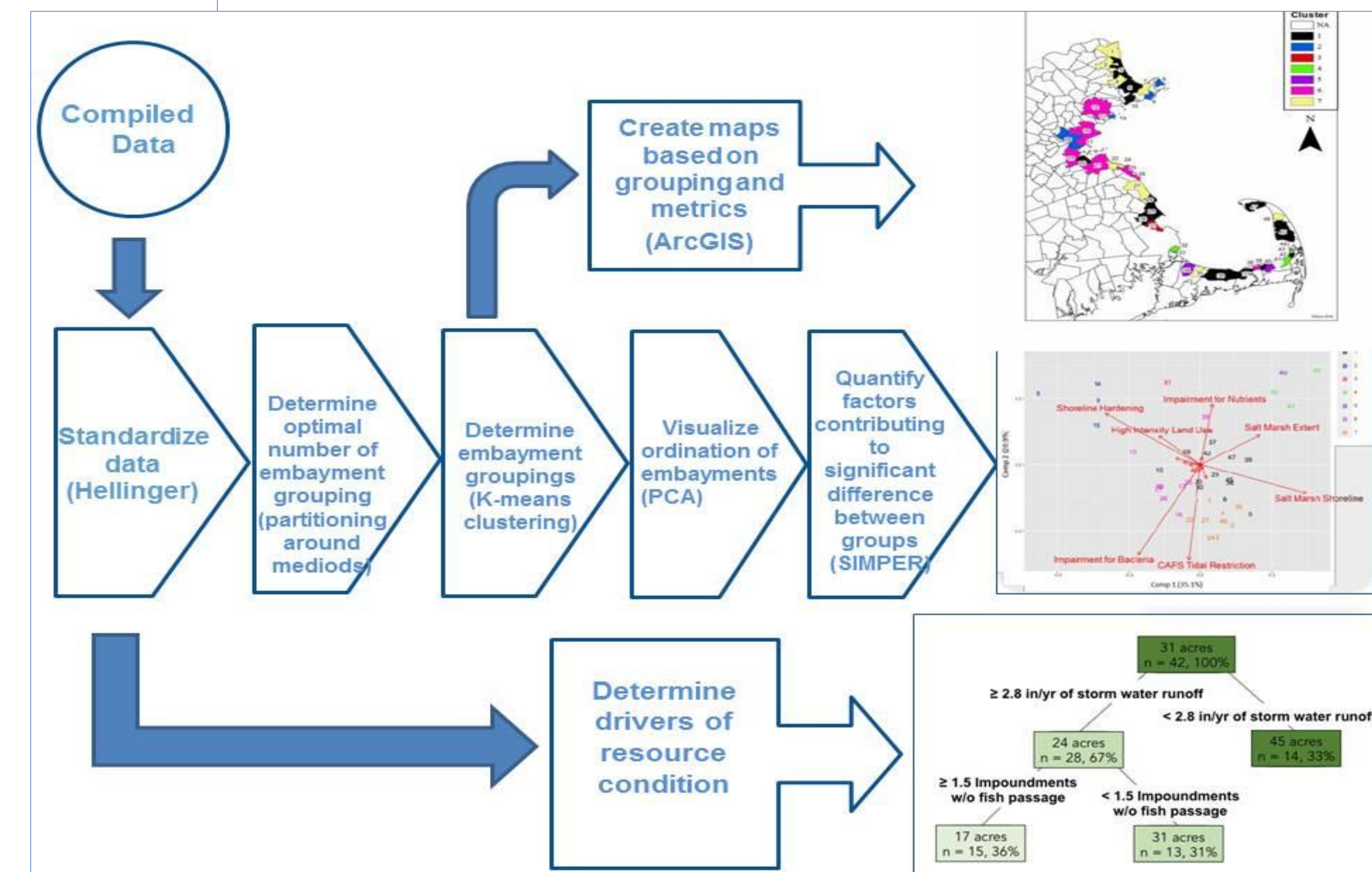| ESTUARINE ATTRIBUTES FOR CHARACTERIZATION	
• High Intensity Land Use	• Salt Marsh Extent
• Stormwater Discharge	• Tidal Flat Extent
• Impervious Area	• Seagrass Extent
• Population	• Shellfish Habitat
• Wastewater (Treatment Plants, Discharges to Groundwater, Septic Systems)	• Shorebird Habitat/Nesting Sites
• 303(d) Impairments	• Length of Anadromous Fish Runs
• Designated Shellfish Growing Area	• Sandy beaches/dunes
• Impoundments/Fish Passage Barriers	• Rocky intertidal shoreline
• Stream Crossings	
• Mooring fields	• Public coastal beaches
• Marinas	• Beach quality
• Dredge projects	• Coastal boat access
• Seawalls and related structures	

Output:
69 assessment areas including:
- 47 Embayments
- Rocky shorelines/headlands
- (Barrier) beaches

Results

MassBays Assessment Areas (2017)

Map Source: MassBays National Estuary Program
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Identification of embayment types and associated target conditions

Compiled Data → Standardize data (Hellinger) → Determine optimal number of embayment grouping (partitioning around medoids) → Determine embayment groupings (K-means clustering) → Visualize ordination of embayments (PCA) → Quantify factors contributing to significant difference between groups (SIMPER) → Create maps based on grouping and metrics (ArcGIS)

Determine drivers of resource condition

Next steps

- Develop proposed specific target conditions for embayment types and present to stakeholders for discussion and feedback.
- Apply a Biological Condition Gradient (EPA, 2017) to help track improvement in ecosystem conditions in the embayments.
- Incorporate monitoring and assessment of embayment conditions to assess the effectiveness of management actions under the CCMP.
- Develop a reporting system (e.g. report cards) - State of the Bays reporting, as required under the Clean Water Act, will provide regular, up-to-date information on the conditions of the bays.

Are waters safe to fish?

WARNING WET WEATHER SEWAGE DISCHARGE CITY OF CAMBRIDGE OUTFALL NO. CAM017

Is the condition of habitats and living resources improving?

Are waters safe to swim?

Massachusetts Bays NATIONAL ESTUARY PROGRAM