FINAL REPORT: 2010 Wetland Program Development Grant
BOAT TRAFFIC INTENSITY METRIC
April 4, 2016

Introduction

The development of a metric depicting boat traffic intensity for incorporation into the University of Massachusetts at Amherst Conservation Assessment and Prioritization System (CAPS) model was proposed in the 2010 Wetland Program Development Grant. The original Quality Assurance Project Plan (QAPP) dated May 27, 2010 was updated in 2014 to incorporate a new approach using improved data sources that were developed as part of the mandated Massachusetts Ocean Management Plan, per the Oceans Act (S.C. 1996, c.31). The revised and approved QAPP, dated November 14, 2014 is attached as Appendix A. The development of this metric was proposed to assess the impact of boat traffic on ecological integrity in the nearshore coastal waters of Massachusetts, and to incorporate that information into the CAPS model. MassDEP conducted this work in cooperation with the Massachusetts Office of Coastal Zone Management, and the University of Massachusetts at Amherst. This boat metric is now complete and has been incorporated into the 2015 CAPS run (See Appendix B). This report represents the final documentation of the task approved in the 2010 WPDG.

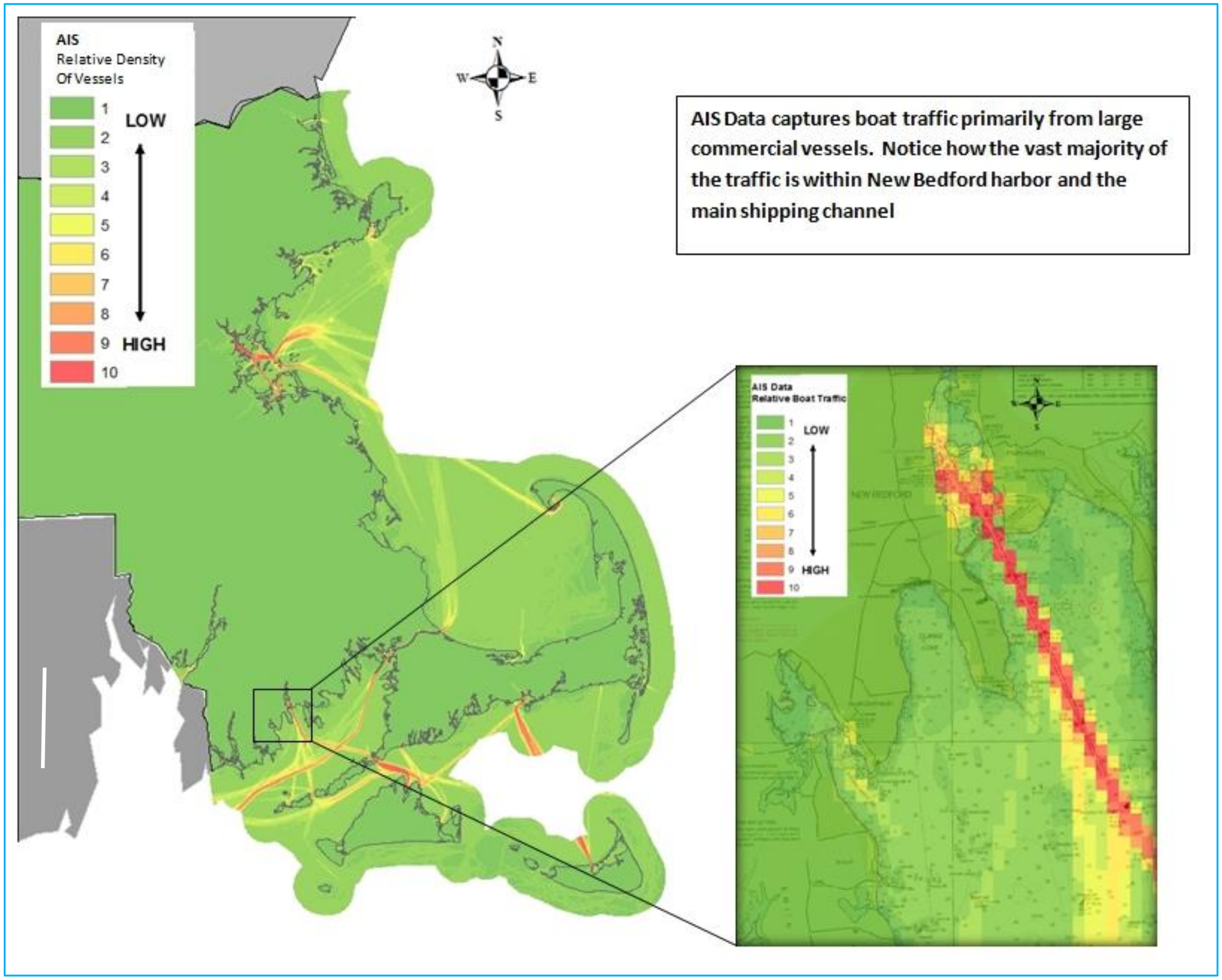
Metric Development

Three types of data depicting commercial and recreational boat traffic were used to develop the final data layer: 1) Automated Identification System (AIS) data; 2) Vessel Monitoring System (VMS) data; and 3) Recreational Boating Routes. These data were combined using sound geo-processing techniques parameterized to account for inherent map error in source data, in accordance with the National Map Standards. By overlaying the three layers and quantifying the density of each, overall boat traffic density was determined. The result is a quantitative assessment of relative boat traffic intensity that uses the most comprehensive data available for inclusion as a metric in the CAPS model. The Source data are described in more detail below.

1) Automated Identification System (AIS) :

Automated Identification Systems (AIS) is a navigation safety device that transmits and monitors the location and characteristics of many large vessels in U.S. and international waters in real-time. The U.S. Coast Guard as well as the shipping industry collects AIS data, which can then be used for a variety of coastal planning purposes. The National Oceanic and Atmospheric Administration (NOAA) has worked in coordination with other federal agencies to re-task and make available the records of the national network of AIS receivers. Information such as location, time, ship type, length, width, and draft have been extracted from the raw data and prepared as track lines. It can then be imported and analyzed in a geographic information system. All vessels over 299 gross tons, as well as all passenger ships, carry an AIS transponder. Figure 1 depicts relative AIS vessel density as processed for CAPS.

Figure 1 Automated Identification System (AIS) Data



The Automated Identification System (AIS) captures location data primarily from large commercial vessels. On the figure to the left, green indicates area with little or no vessel density, yellowish to orange indicates moderate density, and red indicates high density. In this example, New Bedford Harbor has high density; however the vessels mainly travel within the main shipping channel. On the coastwide image, note similar high density in Boston Harbor, Hyannis Harbor, and Nantucket Harbor.

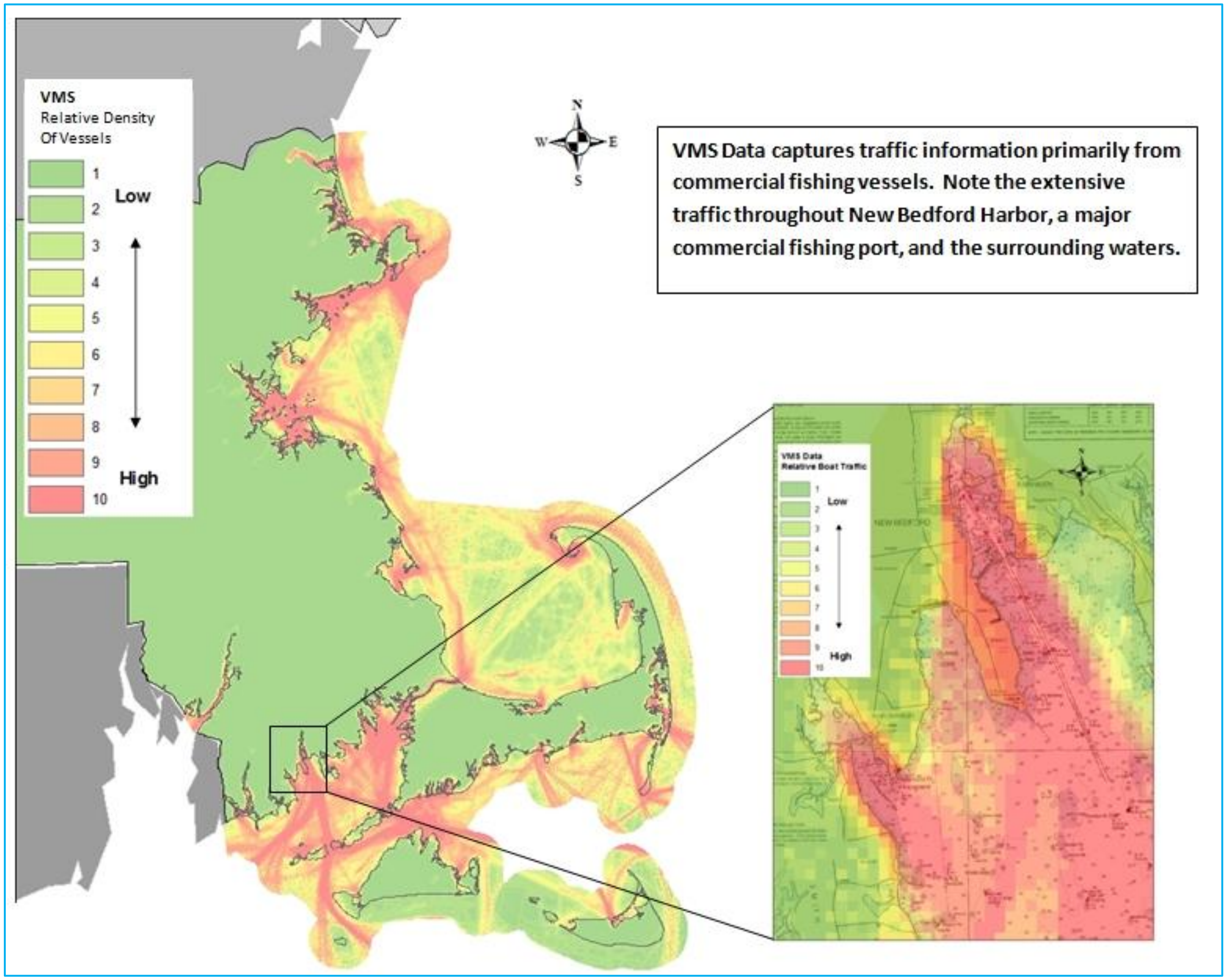
2) The Vessel Monitoring System (VMS)

VMS data are collected by the NOAA National Marine Fisheries Service to track fishing vessel activity for law enforcement, safety, and scientific study. The system is composed of a low cost GPS transmitter package installed on the vessel, and base stations on shore, which receive the signal and record vessel locations. Vessels are counted and tracked as they pass through 250 m x 250 m cells of a regular grid covering the coastal region. Each vessel is counted once as it enters a grid cell and is not counted again unless it has been at least one hour since it was last in a particular grid cell. This allows ships that repeatedly follow the same course over time to be counted properly, while only counting a vessel once even though it may be recorded several times as it passes through a particular cell. These data are available through NOAA. Figure 2 depicts relative VMS fishing vessel density as processed for CAPS.

3) Recreational Boater Routes (RBR)

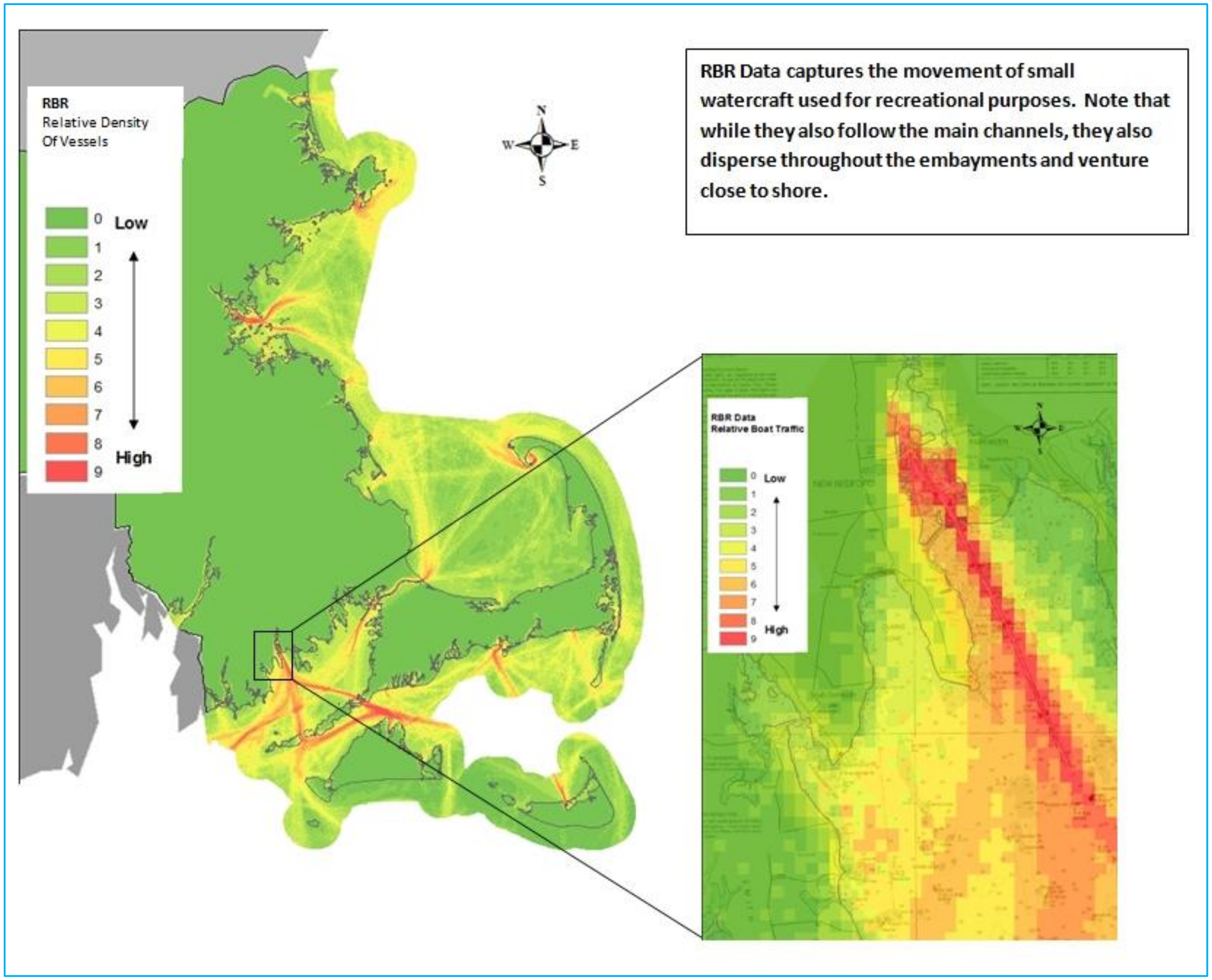
Thousands of recreational boaters in Massachusetts registered and participated in the 2010 and 2012 Massachusetts Recreational Boater Surveys. They provided detailed information through monthly surveys between May and October about their boating trips, including expenditures, recreational activities, and routes. Boaters plotted their spatial data (routes) using an innovative online open source mapping tool. Figure 3 depicts relative recreational boater route density as processed for CAPS.

Figure 2 Vessel Monitoring System (VMS) Data



Vessel Monitoring System (VMS) captures location data primarily from commercial fishing vessels. On the figure to the left, green indicates area with little or no vessel density, yellowish to orange indicates moderate density, and red indicates high density. In this example, New Bedford Harbor has high vessel density and those vessels disperse throughout the embayment. On the coastwide image, note similar density in Gloucester Harbor, Beverly Harbor, Boston Harbor, Marshfield and Plymouth Harbors, Provincetown Harbor, and Chatham Harbor.

Figure 3 Recreational Boater Routes (RBR)



Recreational Boating Routes (RBR) captures location data primarily from recreational boater surveys. On the figure to the left, green indicates area with little or no vessel density, yellowish to orange indicates moderate density, and red indicates high density. In this example, New Bedford Harbor has high density within the harbor (where a boat ramp is), but then disperses throughout the embayment and travels very close to shore. On the coastwide image note similar density in Gloucester Harbor, Boston Harbor, Hyannis Harbor and Provincetown Harbor

Data Development

The three data layers were prepared and geoprocessed in ArcGIS in order to overlay the three data sets onto a uniform grid configuration. This allows for the identification of boat traffic within all given cells. The grid used 250mx250m cells to represent an assessment unit. This grid size was chosen because that is the grid cell sized used in one of the primary source data sets. Any attempt to further refine it into smaller sized cells would have resulted in a false sense of confidence from the illusion of precision. Each of the three source data sets were classified in order to represent the relative density of boat traffic in a uniform manner, that being on a scale of 0-9, where 0 represent no boat traffic and 9 represents the most dense traffic.

The cumulative scores for each grid cell were then calculated using a weighted average. The Automated Identification System (AIS) was weighted at 10%, the Vessel Monitoring System (VMS) was weighted at 10% and the Recreational Boater Routes (RBR) was weighted at 80%. This weight distribution recognizes the impacts that larger commercial and fishing vessels have, but focuses the data on the recreational boater impacts. While large boats would be expected to have large impacts, because of their size they rarely venture into the very nearshore estuarine environments which are the focus of the CAPS assessment. Therefore, recreational boat impacts are not minimized by the lack of large commercial vessel routes in middle and upper estuaries. The final result is a data layer in ArcGrids that characterizes the relative abundance of overall boat traffic with an emphasis on boat traffic that occurs in the nearshore and estuarine environment (See Figure 4).

The boat traffic data was then reviewed and parameterized by an expert team consisting of staff from MassDEP and CZM who have extensive coastal ecology experience and CAPS modeling staff from UMass-Amherst. Parameterization is the process of deciding and/or defining the parameters (i.e. physical properties) that are relevant to the model. In this case, boat traffic was identified as having impacts on tidal flats and salt marshes that are within 30 meters of the identified routes, whereas boat traffic was unlikely to affect solid shorelines such as naturally occurring rocky shores or beaches, which are already subject to extensive wave action due to occurring wind and storm events.

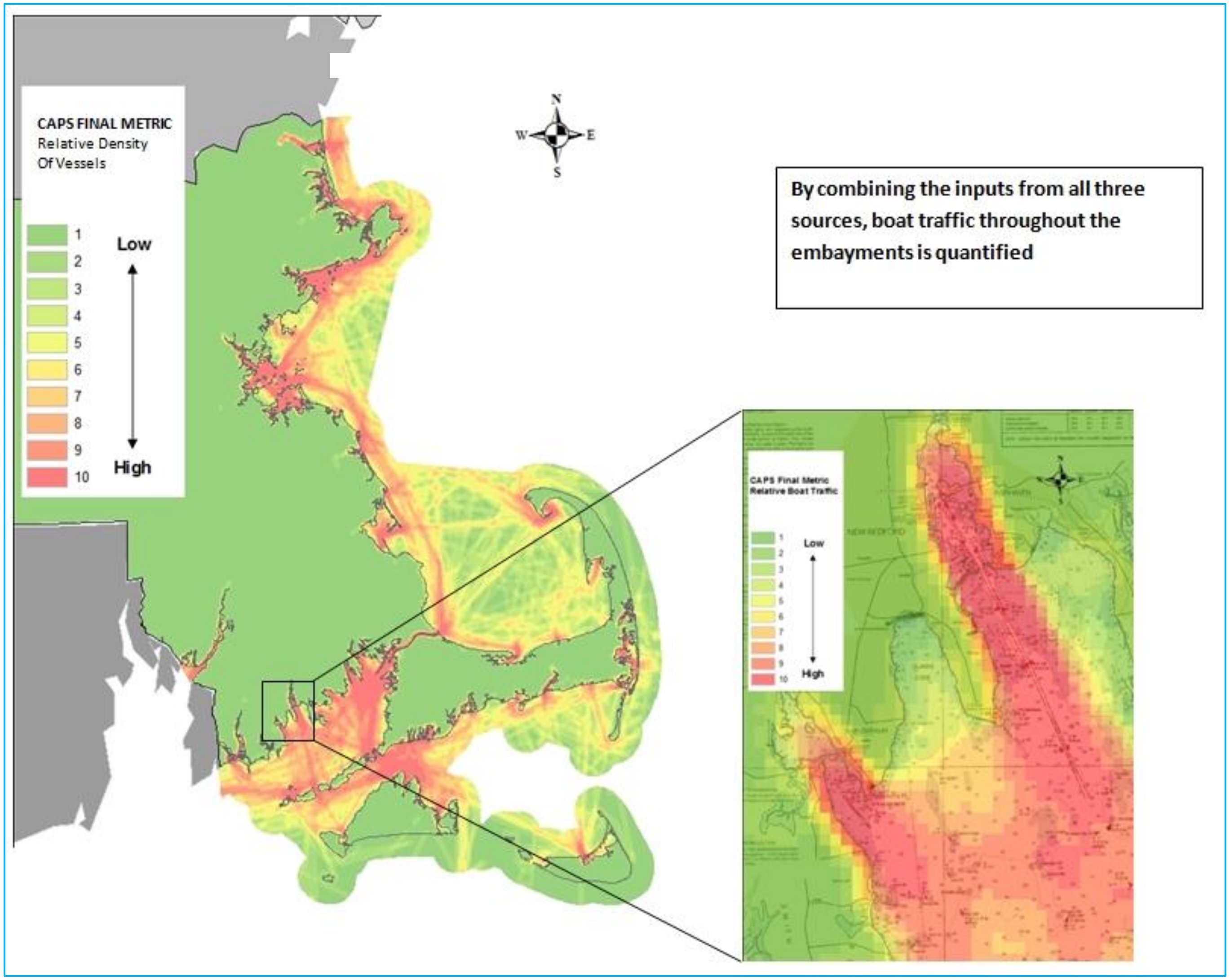
These data have since been incorporated into the CAPS model to help further refine and assess stressors to wetland resources in the nearshore coastal environment. It is available for download at: http://jamba.provost.ads.umass.edu/web/CAPS2015/tiffzips/metricsraw/boats.zip

Conclusion

The boat metric described within the report is one of several coastal metrics that were identified in 2010 and incorporated into the CAPS model to depict stressors that are affecting the coastal environment. Other metrics that have been completed include salt marsh ditching, tidal restrictions, coastal structures, human disturbance (e.g. pedestrian traffic, ORV traffic), and now the boat metric. Links to data developed as a result of this work are included in

APPENDIX B. This work has allowed us to better understand the cumulative impacts of stressors on the coastal environment. While this work has provided a better model to predict coastal resource stress, additional metrics may be needed in the future to improve on this effort, such as an improved nutrient metric, and potentially metrics to assess the impacts of climate change (e.g. sea level rise, water quality etc).

Figure 4 Final Boat Metric using AIS, VMS and RBR Data



The final metric, a compilation of the three vessel density layers, quantifies overall relative density of vessels. On the figure to the left, green indicates area with little or no vessel density, yellowish to orange indicates moderate density, and red indicates high density. In this example, New Bedford Harbor and the embayment it is within have high vessel density. On the coastwide image, note similar heavy density in Cape Ann, the South Shore, Buzzards Bay, Vineyard sound and Provincetown.

APPENDIX A – BOAT TRAFFIC INTENSITY QAPP

Development of a Comprehensive State Monitoring and Assessment Program for Wetlands in Massachusetts

Appendix U[1]

Standard Operating Procedures: Photo Interpretation and Data Development for Coastal Human Disturbance Metrics

Original submitted on: May 27, 2010
Revised submitted on: November 19, 2014

Prepared by:

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[1] This is Appendix A of this 2016 Final Boat Metric Report, AND APPENDIX U of the MA Monitoring and Assessment QAPP. Final EPA QAPP approval rec'd via email July 22, 2014 (DeMattei) and December 4, 2014 (Alafat).

Standard Operating Procedures: Photo Interpretation and Data Development for Coastal Human Disturbance Metrics

Purpose

The Conservation Assessment and Prioritization System (CAPS) is an ecosystem-based (coarse-filter) approach for assessing the ecological integrity of lands and waters and subsequently identifying and prioritizing land for habitat and biodiversity conservation. CAPS is a computer software program and an approach to prioritizing land for conservation based on the assessment of ecological integrity for various ecological communities (e.g. forest, shrub swamp, headwater stream, salt marsh) within an area.

CAPS includes a number of metrics – each representing a different stressor on the landscape (e.g. habitat loss, buffer zone impacts, road traffic intensity, non-native invasive plants) and 3 resiliency metrics (i.e. connectedness, aquatic connectedness and similarity), developed using GIS data and expert teams. The model combines the various metrics to produce an overall value (i.e. Index of Ecological Integrity (IEI)) or it can produce values for each metric separately to gain a greater understanding of which stressors have the greatest impact depending on the scenario.

As part of this project the team is working to develop new CAPS metrics that will represent stressors that specifically affect the coastal environment so that the CAPS model will represent the entire Commonwealth of Massachusetts. Human activity associated with recreational use of coastal ecosystems – including pedestrian traffic, off road vehicle (ORV) use, and boat traffic – is a stressor that affects the ecological integrity of coastal ecological communities.

Although recreational use of coastal beaches do not generally result in long-term alteration of physical characteristics of beach systems, heavy human use of beaches by pedestrians and ORVs cause disturbances that reduce wildlife use of those areas for nesting and foraging. Areas subjected to heavy recreational use consistently over time (e.g. public recreational beaches) are considered to have reduced ecological integrity compared to similar areas that are not subjected to such heavy human use.

Boat traffic in near shore areas of the coastal zone can cause disturbance due to the motion of the boats and noise and wakes produced by those boats. Noise and motion impacts have the potential to affect all coastal ecological communities. Boat wakes are a concern primarily for coastal communities that otherwise form in areas sheltered from ocean waves.

Coastal metrics under development as part of this SOP include:

- Beach pedestrian traffic. This has two components. One is associated with recreational beaches where access is strongly affected by car or other transportation access. The other is related to foot traffic from nearby residential areas.
- ORV use. This metric focuses on coastal beaches that receive heavy use by ORVs including well-established areas of congregation as well as heavily traveled corridors on coastal beaches.
- Boat traffic. The focus of this metric is the impact related to motion disturbance, noise and boat wakes (rather than more local impacts such as propeller wash or discharges of pollutants).

The purpose of this project is to develop data, based on photo-interpretation, to be used in implementing these metrics. Specifically:

- Parking lots serving recreational beaches
- Areas of coastal beach subject to heavy ORV use
- Classification of near-shore environments based on levels of boat traffic

These data will be developed comprehensively for the entire coastal zone of Massachusetts and will be used for the development of the three CAPS metrics described above. Once these metrics are included in CAPS they will be used to assess the overall ecological integrity of coastal shoreline areas. Results of CAPS evaluations (IEI scores) will be used by MassDEP, CZM and other agencies to inform decision-making and set priorities for conservation. There is no intention to use these data for any other purposes.

Definitions

For the purposes of this mapping project we have adopted the following definitions.

Beach Parking Lot – A parking lot or other parking area within 800 m of a recreational beach that provides parking for people accessing that beach.

Coastal Beach – An ecological community used by CAPS and mapped by MassDEP. MassDEP mapping is based on the definition of coastal beach in the Massachusetts Wetlands Protection Act and implementing regulations except that tidal flats (a subset of coastal beaches as defined in the regulations) are mapped separately. As used in this SOP "coastal beach" does not include tidal flats.

ORV Beach – An area of coastal beach that is heavily and regularly used as an area of congregation for ORV users or that is heavily and regularly used by ORVs to move between areas but not for parking.

Recreational Beach –Public or Semi-public (private but open to the public) beach as defined by the BEACH Act and mapped the MA Department of Public Health.

Photo-interpretation and Classification

Beach Parking Lots

The primary source for photo-interpretation will be the most recent statewide orthophotos dated 2008 and 2009. However, photo-interpreters will also consult the black and white imagery (1993-95), the 2001 color orthophotos, the 2005 color orthophotos, and the 2003 and 2008 oblique angle aerial photos (Pictometry) as needed. The primary focus of this project is to accurately capture all parking areas serving recreational beaches. The photo-interpreter will use whatever imagery or scale is necessary to achieve that goal.

Procedure

1. The MA Department of Public Health Marine Beaches data layer available from MassGIS (http://www.mass.gov/mgis/marinebeaches.htm) will be the source for identification of recreational beaches.

2. For each recreational beach the photo-interpreter will identify all parking areas within 800 m that appear to be providing parking for people accessing that beach (e.g. not associated with a business or other purpose). The minimum mapping unit will be 700 m^2.
3. Photo-interpreter will delineation all beach parking lots as polygons in a "Beach Parking Lot" GIS data layer.
4. Based on expert opinion from MassDEP and CZM personnel, and beach managers add additional parking areas that were previously excluded because they either were > 800m away from a recreational beach or appeared to be associated with a business or other purpose.
5. Where appropriate delineated beach parking lots will be removed from the GIS data layer if expert opinion indicates that they do not serve as parking areas for recreational beaches.

Key Personnel

Michael McHugh, MassDEP, Overall coordination; provide training of primary photo-interpreter; some photo-interpretation; perform quality assurance checks to ensure compliance with these mapping standards; solicit expert opinion from MassDEP and beach managers
Bradley Compton, UMass, Review data for compliance with CAPS standards.
Marc Carullo, CZM, Solicit expert opinion from MA CZM and beach managers.
Nathalie Regis, UMass, Primary photo-interpreter.

Quality assurance/Quality control (QA/QC)

Photointerpretation and digitization will be conducted by the primary photointerpreter, Nathalie Regis, who has previous experience in mapping anthropogenic coastal features. Mike McHugh will do Quality Assurance/Quality Control checks that will consist of comparing linework with imagery. All linework will be reviewed and 10 percent will be carefully examined by Mike McHugh to determine whether it meets QA/QC objectives. Brad Compton will review linework after the first day of digitizing, throughout as requested, and at end of project to ensure its usability for CAPS metric development and modeling.

Data Quality Objectives

Parameter	Units	MDL	RDL	Expected Range	Accuracy (+/-)	Precision
Beach Parking Lots	Parking Area polygons	NA	NA	Minimum mapping unit = 700 m^2	90% accuracy in identifying and classifying features	95% of linework will be within 15 m of feature in the image based on 10% QA/QC review

ORV Beaches

The primary sources of information to be used include:

- The most recent statewide orthophotos dated 2008 & 2009
- MassDEP Wetlands data layer
- Information from beach managers and other experts on the location and geographic extent of beaches that are heavily used by ORVs

Procedure

1. Identify appropriate beach managers and experts within MassDEP and MA CZM to provide information

2. Solicit information about the location and geographic extent of coastal beaches that are heavily used by ORVs from beach managers and experts identified in #1 above
3. Using a base map of DEP Wetlands data overlaid onto ortho-photos use information provided by experts to delineate ORV beaches as polygons in an "ORV Beaches" GIS data layer. The minimum mapping unit will be 700 m^2.

Key Personnel

Marc Carullo, CZM, Overall coordination; solicit expert opinion from MassDEP, MA CZM and beach managers
Michael McHugh, MassDEP, Training of primary photo-interpreter; some photo-interpretation; perform quality assurance checks to ensure compliance with these mapping standards
Bradley Compton, UMass, Review data for compliance with CAPS standards.
Nathalie Regis, UMass, Primary photo-interpreter; assist in compiling information from beach managers and other experts

Quality assurance/Quality control (QA/QC)

Photo-interpretation and digitization will be conducted by the primary photointerpreter, Nathalie Regis, who has previous experience in mapping coastal features. Mike McHugh will do Quality Assurance/Quality Control checks that will consist of comparing linework with imagery and information provided by consulted experts. All linework will be reviewed and 10 percent will be carefully examined by Mike McHugh to determine whether it meets QA/QC objectives. Brad Compton will review linework after the first day of digitizing, throughout as requested, and at end of project to ensure its usability for CAPS metric development and modeling.

Data Quality Objectives

Parameter	Units	MDL	RDL	Expected Range	Accuracy (+/-)	Precision
ORV Beaches	ORV Beach polygons	NA	NA	Minimum mapping unit = 700 m^2	90% accuracy in identifying and classifying features	95% of linework will be within 15 m of feature in the image based on 10% QA/QC review

Boat Traffic

Three distinct types of geospatial datasets on commercial and recreational boat/vessel traffic will be used to model the impact of marine traffic on coastal shoreline ecosystems. We intend to use a variety of information to create a coarse data layer that characterizes coastal areas for boat traffic intensity. This will be a quantitative assessment of relative boat traffic intensity that uses the most comprehensive data available.

Primary data sources will include:
Automatic Identification System (AIS)
Source: National Oceanic and Atmospheric Administration, Bureau of Ocean Energy Management, U.S. Coast Guard
Format: Esri file geodatabase - simple feature class

Summary: These data are a geometric representation in polyline format of a vessel track derived from Automatic Identification System (AIS) records at a one minute time interval and logically grouped by an encrypted Maritime Mobility Service Identity value. Observed conditions are for the calendar year 2012.

Description: Automatic Identification Systems (AIS) are a navigation safety device that transmits and monitors the location and characteristics of many vessels in U.S. and international waters in real-time. In the U.S. the Coast Guard and industry collect AIS data, which can also be used for a variety of coastal planning purposes. NOAA and BOEM have worked jointly to re-task and make available some of the most important records from the U.S. Coast Guards national network of AIS receivers. Information such as location, time, ship type, length, width, and draft have been extracted from the raw data and prepared as track lines for analyses in desktop GIS software. The International Maritime Organization requires all vessels over 299 gross tons to carry an AIS transponder. The AIS system records the ships position and course information using GPS and transmits this information, along with details about the vessel over two VHF channels. This signal can be recorded by other ships or land based stations which record the information for navigation, port traffic control, and statistical analysis of vessel traffic.

Vessel Monitoring System (VMS)

Source: NOAA Fisheries via RPS Group (formerly Applied Science Associates)

Format: Esri file geodatabase - raster dataset

Summary: These data document the density of fishing vessels from September 1, 2007 to September 1, 2008 in Massachusetts waters and beyond, using the VMS records available for that time period.

Description: VMS data are collected by the NOAA National Marine Fisheries Service to track fishing vessel activity for law enforcement, safety, and scientific study. The system is composed of a low cost GPS transmitter package installed on the vessel, and base stations on shore, which receive the signal and record vessel locations. ASA processed these data, such that vessels were counted as they pass through 250 m x 250 m cells of a regular grid covering the coastal region. Each vessel is counted once as it enters a grid cell and is not counted again unless it has been at least one hour since it was last in a particular grid cell. This allows ships that repeatedly follow the same course over time to be counted properly, while only counting a vessel once even though it may be recorded several times as it passes through a particular cell.

Recreational Boater Routes (RBR)

Source: SeaPlan, Northeast Regional Ocean Council (NROC)

Format: Esri file geodatabase - simple feature class

Summary: These line data represent recreational boating trip routes in Massachusetts' coastal and ocean waters from May-October 2010 and May-October 2012.

Description: Thousands of boaters of Massachusetts registered and documented vessels participated in the 2010 and 2012 Massachusetts Recreational Boater Surveys. They provided detailed information through monthly surveys between May and October about their boating trips, including expenditures, recreational activities, and routes. Boaters plotted their spatial data (routes) using an innovative online open source mapping tool. Survey data include information on boat size, which will not be incorporated into the boat traffic metric at this time.

Secondary data sources used in review will include:

1. NOAA Raster Navigational Charts (RNCs)
2. Orthophoto Imagery via MassGIS:
    - USGS, 2008-2009
    - DigitalGlobe, 2010-2012

3. DEP Wetlands
4. CZM MORIS Layers:
    - Office of Fishing and Boating Access sites (ramps)
    - Mooring Fields
    - Marinas
5. Other: Google imagery, Bing imagery, Pictometry; used on an as needed basis.

Procedure

Data will be prepared and processed using semi-automated techniques in ArcGIS 10.2 to minimize bias in the final boat traffic dataset. A 250 m x 250 m grid cell will be used to represent one assessment unit of boat traffic since this is the resolution of one of the primary data sources available. Scores will be computed for each cell, ranging from 0 to 9, with 0 representing no or very low boat traffic, and 9 representing very high boat traffic.

A weighted overlay technique will be used to combine the three primary data sources that represent recreational vessels, commercial fishing vessels, and ships. Development steps include:

1. Process boater survey line data: re-project 2010 and 2012 datasets to State Plane Coordinates, Mainland Massachusetts 2001, meters. Merge 2010 and 2012 datasets. Eliminate sections of routes occurring over land using the MassGIS MA Towns (Multi-part Polygons, from Survey Points) data layer and ArcMap's Erase tool.
2. Convert boater survey data from vector lines (representing boat routes) to raster grids: use the Line Density tool in ArcGIS Spatial Analyst to accomplish this with the following parameters: output cell size is 250 m and search radius is 675 m. Cell size matches that of another primary data source (VMS), and search radius accounts for map error in the recreational boater survey data, which were digitized from various NOAA charts, the smallest scale chart being 1:375,000. The National Map Standard stated accuracy of features on a 1:375,000 chart is 375 m. Snap output grid to the VMS grid for a consistent bounding box.
3. Reclassify each of the three primary data sources so that they all use the same scoring scale, 0 to 9, with 0 representing none or relative low traffic and 9 representing the highest relative density of traffic. Use quantiles (deciles) in ArcGIS and output to 10 classes.
4. Use the Weighted Overlay tool to combine the three reclassified grids for an overall boat traffic data layer. Scale will remain 0 to 9, and each input grid will receive the following weight: AIS is 3510%, VMS is 3510%, and RBR is 3080%. This weight distribution prevents recreational boat routes from being overshadowed by the lack of large commercial vessel routes in middle and upper estuaries, which often feature resources of particular concern: salt marshes.

Data Management

The input raster datasets--AIS, VMS, RBR--and the final output raster dataset will be stored in the Esri file geodatabase format. The final, merged raster dataset will be exported as an Esri grid, Erdas Imagine file, or other preferred format. It will then be transferred to UMass project staff, where it will be input into the CAPS model to run the boat traffic metric.

Key Personnel

Marc Carullo, CZM, Coastal GIS and Habitat Analyst with expertise in spatial data development, management, and analysis; image processing techniques and applications, and ecological field data collection, particularly in coastal ecosystems. Marc is responsible for data processing, development, and quality assurance/quality control.

Michael McHugh, MassDEP, 20 years experience identifying and evaluating coastal resources throughout Massachusetts; 15 years experience in offshore fieldwork. Mike is responsible for quality assurance/quality control.

James Sprague, MassDEP, 33 years experience identifying and evaluating coastal resources throughout Massachusetts; former lobsterman; avid small watercraft operator. Jim is responsible for quality assurance/quality control.

Quality assurance/Quality control (QA/QC)

The final dataset will be based on the best available data to-date. All three data sources were developed as part of the mandated Massachusetts Ocean Management Plan, per the Oceans Act. They will be combined to create a boat metric for CAPS, using sound geo-processing techniques parameterized to account for inherent map error in source data, per the National Map Standard. A draft dataset will be reviewed for presumed accuracy by project staff at CZM, Marc Carullo, and DEP, Mike McHugh and Jim Sprague. These analysts will compare the dataset with secondary source data, including mooring fields, marinas, NOAA charts, and various aerial photos.

Data Quality Objectives

Parameter	Units	MDL	RDL	Expected Range	Accuracy (+/-)	Precision
Boat Traffic	Boat Traffic Intensity Classes	NA	NA	0-9	90% of cells accurately characterized*	90% agreement among all three analysts

* There is no way currently to assess the accuracy of this classification. However, our objective for accuracy is that should boat traffic data become available in a form that can be compared with our classification, no more that 10% of cells will fall within a range of overlap for our classes (e.g. cells classified as “high” with traffic volumes that overlap with those that were classified as “medium”).

APPENDIX B – CAPS 2015 GIS DATA

CAPS 2015 Data for Massachusetts

Data organization. All CAPS results and many intermediate results are available for download. This section provides links to the various versions of IEI, the CAPS landcover, results of individual metrics, and settings variables. Data are available in grouped .zip files, listed below. In addition, individual metrics and settings variables are available in separate .zip files.

Data formats. With this release, we're supplying all grids as geoTIFFs as well as ESRI Arc grids. GeoTIFFs have several advantages over Arc grids: they are typically more space-efficient, they can be viewed in most image viewers and browsers as well as with GIS software, they can contain display formats intrinsically rather than requiring a separate application-specific legend, and most importantly, geoTIFF is a public domain format, as opposed to ESRI's proprietary format. As open-source GIS software (such as QGIS) becomes more sophisticated and stable, we anticipate many users will migrate to open source GIS. To support this migration, we plan to make our data available in public domain formats such as geoTIFF.

Scaling. Scaled metrics and IEI are scaled from -1; in geoTIFFs, these grids are expressed in terms of percent (scaled -100). Raw metrics and settings grids are scaled in original units, unique to each grid; in geoTIFFs, these grids are scaled from -255. The CAPS final landcover, capsland, represents landcover classes using integer classes (see Appendix H). GeoTIFF versions are already colored appropriately; legends files for QGIS, ArcView 3.3, and ArcMap are supplied for the Arc grid.

The coordinate reference system for all data is Massachusetts mainland State Plane, NAD83.

Basic results

These are the most basic results, for those who want immediate gratification. This .zip file consists of two files in geoTIFF format:

iei_i	CAPS Integrated IEI (scaled 1-100)
capsland	CAPS landcover grid

GeoTIFFs: http://jamba.provost.ads.umass.edu/web/caps2015/tiffzips/basic.zip (17 MB)

Standard results

These results contain all four versions of the IEI, as well as landcover. In Arc grids, IEIs are scaled -1; In geoTIFFs, they are scaled -100.

iei	CAPS statewide IEI
iei_e	CAPS ecoregion IEI
iei_w	CAPS watershed IEI
iei_i	CAPS Integrated IEI
capsland	CAPS landcover grid

legend files for capsland (QGIS, ArcView 3.3, and ArcGIS)

GeoTIFFs: http://jamba.provost.ads.umass.edu/web/caps2015/tiffzips/results.zip (66 MB)
Arc grids: http://jamba.provost.ads.umass.edu/web/caps2015/arczips/results.zip (104 MB)

Five color integrated IEI

The grid used to produce the IEI town maps ("areas of potential high ecological integrity") are available in a geoTIFF. This grid is the top 50% integrated IEI, displayed in five color gradients (green for forests, orange for shrublands, yellow-brown for coastal uplands, blue for freshwater wetland & aquatic, and cyan for coastal wetland aquatic). The values in this grid encode the color; they are not meaningful otherwise.

GeoTIFF: http://jamba.provost.ads.umass.edu/web/caps2015/tiffzips/iei5color.zip (5 MB)

DEP important habitat

The DEP Massachusetts Habitat of Potential Regional and Statewide Importance data are available in a geoTIFF. This grid is simply the top 40% of integrated IEI (iei_i > .6); cells with a value of 1 are within DEP important habitat.

GeoTIFF: http://jamba.provost.ads.umass.edu/web/caps2015/tiffzips/ieitop40.zip (8 MB)

Raw metrics

These .zip files contain all raw metrics results. See Appendix C for a list of metrics, grid names, and brief descriptions, and Appendix F for the contribution of each metric to each community's IEI. Raw metrics are scaled in original units, unique to each metric; geoTIFF versions are rescaled from -255. Integrity increases with decreasing values of stressor metrics, and increasing values of resiliency metrics.

GeoTIFFs: http://jamba.provost.ads.umass.edu/web/caps2015/tiffzips/metricsraw.zip (157 MB)
Arc grids: http://jamba.provost.ads.umass.edu/web/caps2015/arczips/metricsraw.zip (760 MB)

Scaled metrics

These .zip files contain all scaled metrics results—these are the raw metrics rescaled by percentiles within each community. See Appendix C for a list of metrics, grid names, and brief descriptions, and Appendix F for the contribution of each metric to each community's IEI. Scaled metrics range from to 1 (higher values correspond to higher integrity for all metrics); geoTIFF versions are scaled by percent (-100).

GeoTIFFs: http://jamba.provost.ads.umass.edu/web/caps2015/tiffzips/metricsscaled.zip (106 MB)
Arc grids: http://jamba.provost.ads.umass.edu/web/caps2015/arczips/metricsscaled.zip (169 MB)

Settings variables

These .zip files contain mixed (unscaled) settings variables. See Appendix D for a list and brief description of settings variables, and Appendix G for grid names and weights. Settings variables are scaled in original units, unique to each variable; geoTIFF versions are rescaled from -255.

GeoTIFFs: http://jamba.provost.ads.umass.edu/web/caps2015/tiffzips/settings.zip (85 MB)
Arc grids: http://jamba.provost.ads.umass.edu/web/caps2015/arczips/settings.zip (477 MB)

Individual grids

Metrics (both raw and scaled) and settings variables are also supplied as individual GeoTIFFs. These data are the same as those listed above; we're supplying grids individually for the convenience of those who just want results for a metric or two. Individual grids range in size from <1 to 18 MB.

Metrics

Development & roads

Habitat loss

raw: http://jamba.provost.ads.umass.edu/web/CAPS2015/tiffzips/metricsraw/habloss.zip
scaled: http://jamba.provost.ads.umass.edu/web/CAPS2015/tiffzips/metricsscaled/habloss.zip

Watershed habitat loss

raw: http://jamba.provost.ads.umass.edu/web/CAPS2015/tiffzips/metricsraw/whabloss.zip
scaled: http://jamba.provost.ads.umass.edu/web/CAPS2015/tiffzips/metricsscaled/whabloss.zip

Road traffic

raw: http://jamba.provost.ads.umass.edu/web/CAPS2015/tiffzips/metricsraw/traffic.zip
scaled: http://jamba.provost.ads.umass.edu/web/CAPS2015/tiffzips/metricsscaled/traffic.zip

Mowing & plowing

raw: http://jamba.provost.ads.umass.edu/web/CAPS2015/tiffzips/metricsraw/mowplow.zip

scaled: http://jamba.provost.ads.umass.edu/web/CAPS2015/tiffzips/metricsscaled/mowplow.zip

Microclimate alterations

raw: http://jamba.provost.ads.umass.edu/web/CAPS2015/tiffzips/metricsraw/edges.zip

scaled: http://jamba.provost.ads.umass.edu/web/CAPS2015/tiffzips/metricsscaled/edges.zip

Pollution

Road salt

raw: http://jamba.provost.ads.umass.edu/web/CAPS2015/tiffzips/metricsraw/salt.zip

scaled: http://jamba.provost.ads.umass.edu/web/CAPS2015/tiffzips/metricsscaled/salt.zip

Road sediment

raw: http://jamba.provost.ads.umass.edu/web/CAPS2015/tiffzips/metricsraw/sediment.zip

scaled: http://jamba.provost.ads.umass.edu/web/CAPS2015/tiffzips/metricsscaled/sediment.zip

Nitrogen enrichment

raw: http://jamba.provost.ads.umass.edu/web/CAPS2015/tiffzips/metricsraw/nitrogen.zip

scaled: http://jamba.provost.ads.umass.edu/web/CAPS2015/tiffzips/metricsscaled/nitrogen.zip

Phosphorus enrichment

raw: http://jamba.provost.ads.umass.edu/web/CAPS2015/tiffzips/metricsraw/phosphorus.zip

scaled: http://jamba.provost.ads.umass.edu/web/CAPS2015/tiffzips/metricsscaled/phosphorus.zip

Biotic alterations

Domestic predators

raw: http://jamba.provost.ads.umass.edu/web/CAPS2015/tiffzips/metricsraw/cats.zip

scaled: http://jamba.provost.ads.umass.edu/web/CAPS2015/tiffzips/metricsscaled/cats.zip

Edge predators

raw: http://jamba.provost.ads.umass.edu/web/CAPS2015/tiffzips/metricsraw/edgepred.zip

scaled: http://jamba.provost.ads.umass.edu/web/CAPS2015/tiffzips/metricsscaled/edgepred.zip

Invasive plants

raw: http://jamba.provost.ads.umass.edu/web/CAPS2015/tiffzips/metricsraw/badplants.zip

scaled: http://jamba.provost.ads.umass.edu/web/CAPS2015/tiffzips/metricsscaled/badplants.zip

Invasive earthworms

raw: http://jamba.provost.ads.umass.edu/web/CAPS2015/tiffzips/metricsraw/worms.zip

scaled: http://jamba.provost.ads.umass.edu/web/CAPS2015/tiffzips/metricsscaled/worms.zip

Hydrological alterations

Hydrologic alterations

raw: http://jamba.provost.ads.umass.edu/web/CAPS2015/tiffzips/metricsraw/hydroalt.zip

scaled: http://jamba.provost.ads.umass.edu/web/CAPS2015/tiffzips/metricsscaled/hydroalt.zip

Imperviousness

raw: http://jamba.provost.ads.umass.edu/web/CAPS2015/tiffzips/metricsraw/imperv.zip

scaled: http://jamba.provost.ads.umass.edu/web/CAPS2015/tiffzips/metricsscaled/imperv.zip

Dams

raw: http://jamba.provost.ads.umass.edu/web/CAPS2015/tiffzips/metricsraw/damint.zip scaled: http://jamba.provost.ads.umass.edu/web/CAPS2015/tiffzips/metricsscaled/damint.zip

Coastal metrics

Salt marsh ditching

raw: http://jamba.provost.ads.umass.edu/web/CAPS2015/tiffzips/metricsraw/ditches.zip
scaled: http://jamba.provost.ads.umass.edu/web/CAPS2015/tiffzips/metricsscaled/ditches.zip

Coastal structures

raw: http://jamba.provost.ads.umass.edu/web/CAPS2015/tiffzips/metricsraw/jetties.zip
scaled: http://jamba.provost.ads.umass.edu/web/CAPS2015/tiffzips/metricsscaled/jetties.zip

Beach pedestrians

raw: http://jamba.provost.ads.umass.edu/web/CAPS2015/tiffzips/metricsraw/beachpeds.zip
scaled: http://jamba.provost.ads.umass.edu/web/CAPS2015/tiffzips/metricsscaled/beachpeds.zip

Beach ORVs

raw: http://jamba.provost.ads.umass.edu/web/CAPS2015/tiffzips/metricsraw/beachORVs.zip
scaled: http://jamba.provost.ads.umass.edu/web/CAPS2015/tiffzips/metricsscaled/beachORVs.zip

Boat traffic

raw: http://jamba.provost.ads.umass.edu/web/CAPS2015/tiffzips/metricsraw/boats.zip
scaled: http://jamba.provost.ads.umass.edu/web/CAPS2015/tiffzips/metricsscaled/boats.zip

Tidal restrictions

raw: http://jamba.provost.ads.umass.edu/web/CAPS2015/tiffzips/metricsraw/tr.zip
scaled: http://jamba.provost.ads.umass.edu/web/CAPS2015/tiffzips/metricsscaled/tr.zip

Resiliency Metrics

Connectedness

raw: http://jamba.provost.ads.umass.edu/web/CAPS2015/tiffzips/metricsraw/connect.zip
scaled: http://jamba.provost.ads.umass.edu/web/CAPS2015/tiffzips/metricsscaled/connect.zip

Aquatic connectedness

raw: http://jamba.provost.ads.umass.edu/web/CAPS2015/tiffzips/metricsraw/aqconnect.zip
scaled: http://jamba.provost.ads.umass.edu/web/CAPS2015/tiffzips/metricsscaled/aqconnect.zip

Similarity

raw: http://jamba.provost.ads.umass.edu/web/CAPS2015/tiffzips/metricsraw/sim.zip
scaled: http://jamba.provost.ads.umass.edu/web/CAPS2015/tiffzips/metricsscaled/sim.zip

Settings variables

Temperature

Growing season degree-days

http://jamba.provost.ads.umass.edu/web/caps2015/tiffzips/settings/degdays.zip

Minimum winter temperature

http://jamba.provost.ads.umass.edu/web/caps2015/tiffzips/settings/mintemp.zip

Solar energy

Incident solar radiation

http://jamba.provost.ads.umass.edu/web/caps2015/tiffzips/settings/sun.zip

Chemical & physical substrate

Soil pH

http://jamba.provost.ads.umass.edu/web/caps2015/tiffzips/settings/soilph.zip

Soil depth

http://jamba.provost.ads.umass.edu/web/caps2015/tiffzips/settings/soildepth.zip

Soil texture

http://jamba.provost.ads.umass.edu/web/caps2015/tiffzips/settings/soiltex.zip

Water salinity

http://jamba.provost.ads.umass.edu/web/caps2015/tiffzips/settings/salinity.zip

Substrate mobility

http://jamba.provost.ads.umass.edu/web/caps2015/tiffzips/settings/substrate.zip

CaCO3 content

http://jamba.provost.ads.umass.edu/web/caps2015/tiffzips/settings/calcium.zip

Physical disturbance

Wind exposure

http://jamba.provost.ads.umass.edu/web/caps2015/tiffzips/settings/wind.zip

Wave exposure

http://jamba.provost.ads.umass.edu/web/caps2015/tiffzips/settings/waves.zip

Steep slopes

http://jamba.provost.ads.umass.edu/web/caps2015/tiffzips/settings/slope.zip

Moisture

Wetness

http://jamba.provost.ads.umass.edu/web/caps2015/tiffzips/settings/wetness.zip

Hydrology

Flow gradient

http://jamba.provost.ads.umass.edu/web/caps2015/tiffzips/settings/gradient.zip

Flow volume

http://jamba.provost.ads.umass.edu/web/caps2015/tiffzips/settings/volume.zip

Tidal regime

http://jamba.provost.ads.umass.edu/web/caps2015/tiffzips/settings/tides.zip

Vegetation

Vegetative structure

http://jamba.provost.ads.umass.edu/web/caps2015/tiffzips/settings/structure.zip

Development

Developed

http://jamba.provost.ads.umass.edu/web/caps2015/tiffzips/settings/developed.zip

Hard development

http://jamba.provost.ads.umass.edu/web/caps2015/tiffzips/settings/hard.zip

Traffic rate

http://jamba.provost.ads.umass.edu/web/caps2015/tiffzips/settings/traffic.zip

Impervious

http://jamba.provost.ads.umass.edu/web/caps2015/tiffzips/settings/imperv.zip

Terrestrial barriers

http://jamba.provost.ads.umass.edu/web/caps2015/tiffzips/settings/tbarriers.zip

Aquatic barriers

http://jamba.provost.ads.umass.edu/web/caps2015/tiffzips/settings/abarriers.zip

Additional data

A large collection of additional GIS data for Massachusetts are available from MassGIS (http://www.mass.gov/mgis/massgis.htm). Many of these data layers, such as town boundaries, ecoregions, watersheds, aerial photos, and USGS topographic maps are extremely helpful for viewing and interpreting CAPS results.

Running CAPS for Massachusetts requires a large number of additional intermediate data sources not linked above. These data are available on request.