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

Appendix R

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Standard Operating Procedures: Using Aerial Photo Interpretation for Identifying and Characterizing Tidal Restrictions Affecting Salt Marsh

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PURPOSE

Many of the coastal wetlands in Massachusetts are degrading due to infrastructure crossings such as roads and railroads that, when improperly designed, restrict tidal flow down gradient. Except for Cape Cod, we lack good records of tidal restriction locations or the magnitude of the restrictions in Massachusetts' coastal wetlands. This project will generate a point data set of potential restriction locations and restriction severity affecting salt marshes in Massachusetts.

DEFINITION

A tidal restriction is defined as a man-made feature (e.g. roads, railroads, bridges, culverts, dams or other barriers) that constrains the natural flooding and ebb flow of salt water through up-gradient marsh habitat historically inundated by the tide. For this project, potential tidal restrictions will be limited to locations where roads and railroads cross tidal waters and marshes. These features cross water using either a culvert or a bridge. For purposes of this project a culvert is a structure with a bottom and bridge has no bottom leaving the natural streambed intact.

DELINEATION AND CHARACTERIZATION

The source imagery for characterizing potential restrictions will be the MassGIS 2005 and 2008 color orthophotos (technical specifications and metadata available at MassGIS), and the MassDEP Wetlands Data layer (technical specifications and metadata available at MassGIS). Oblique images from Bing.com and Google Earth will be used to assist in identifying the presence of a culvert or bridge.

All photointerpretation will occur at a nominal scale of 1:1200. Only features that are visible at this scale on the source imagery will be used to characterize potential restrictions. Photointerpreters will not zoom in to more accurately characterize potential restrictions, nor will they zoom out to increase the work rate.

Two researchers at the University of Massachusetts will be responsible for photointerpretation. Both researchers will be using ArcGIS 9.2 and a 14 inch LCD screen to identify potential restrictions. Please refer to the procedure below for further details on the process of characterization. All data will be recorded in the attribute table of the potential restriction point layer. The scenario number will be recorded in the attribute table for abruptness of change in wetland salinity. A ratio will be recorded in the attribute table for the difference in channel width, relative width of impounded water/scour pool, and fill.

KEY PERSONNEL

Kevin McGarigal, UMass Amherst, Project oversight
Scott Jackson, UMass Amherst, Project coordination and develop characterization protocol
Brad Compton, UMass Amherst, Identification of potential tidal restrictions
Maili Page, UMass Amherst, Develop characterization protocol and photo interpretation, QA/QC
Dennis Babaasa, UMass Amherst, Develop characterization protocol and photo interpretation, QA/QC
Michael McHugh, MassDEP, Training and advice on photo interpretation and characterization protocol
Marc Carullo, MA CZM, Advice on photo interpretation and characterization protocol
Jan Smith, MA CZM, Advice on photo interpretation and characterization protocol

PROCEDURE

Potential Tidal Restriction Identification

Potential tidal restrictions will be identified in GIS using the CAPS bridge and culvert layer by digitizing a point over the location where a road or railroad crosses a stream centerline. This will create a point layer identifying potential restriction locations to be used for characterizing restrictions. Only bridges and culverts within 150 m of a marine or estuarine wetland polygon (from DEP wetlands) will be used (this distance is to capture potential tidal restrictions despite misalignment of GIS layers). Note that this layer omits restrictions at tide gates, berms, unmapped abandoned railroad grades, and other restrictions not associated with mapped roads and railroads. The Cape and islands are being omitted from this process, as they lack centerline data.

Characterization of Potential Tidal Restrictions

Two research assistants, Dennis Babassa and Maili Page, will characterize potential tidal restrictions identified by Brad Compton. Because we are only concerned with tidal restrictions affecting salt marsh, potential restrictions will only be evaluated if the wetland directly down-gradient is classified by DEP Wetlands as salt marsh. These potential tidal restrictions will ultimately be incorporated into a metric for inclusion in CAPS.

The researchers will use ArcGIS version 9.2. Resources that will be used to characterized potential tidal restrictions include:

- Orthophotos from 2005 and 2008 downloaded from MassGIS,
- Oblique images from Bing.com,
- Aerial images from Google Earth,
- DEP wetland layer,
- CAPS roads and land cover grid,
- USGS topo maps, and
- USGS Scour assessment

Potential tidal restrictions will be characterized using the following five variables.

- Abruptness of change in wetland salinity
- Difference in channel width up-gradient vs. down-gradient of the potential restriction
- Relative width of impounded water/ scour pool up-gradient of the potential restriction
- Relative width of impounded water/ scour pool down-gradient of the potential restriction
- Amount of fill associated with a potential restriction
- Culvert or bridge

Organization of Data

Each of the characterization variables will be listed as a column heading within the attribute table of the tidal restriction point layer. Data will be recorded as either nominal, ordinal scale (0-3), or continuous data. The final classification of the restriction severity will be based on a statistical analysis of variables associated with restrictions of known severity determined from field assessments. The attribute table will also include; presence of culvert or bridge, the name of the researcher that defined the characterization for the potential restriction, the name of the researcher that reviewed the characterization, the data that were used to make the assessment, the date of the data used, the source of the data used, if there is another potential restriction up and/or down-gradient from the focal potential restriction, the date of characterization, and the restriction road type (Table 3) .

Variables for Use in Assessing Potential Tidal Restrictions

It is expected that the ultimate classification of potential tidal restrictions will be based on the five variables listed below. These variables will be assessed in the following manner.

Abruptness of Change in Wetland Salinity

This variable will be based on the degree to which DEP wetland types (freshwater vs. salt water) are different down-gradient vs. up-gradient of the potential restriction and the presence of plants that could indicate the influence of fresh water. The most abrupt change possible would be represented by salt marsh below a potential restriction and a freshwater wetland without indicators of brackish conditions above.

Phragmites is being used as an indicator of brackish water and shrubs (except where they occur near the upland border of a salt marsh) are being used as indicators of freshwater. The rubric assumes a change in water salinity based on the DEP wetlands classification and on the percent cover of Phragmites and shrubs within a 100m arc up-gradient and down-gradient from a potential restriction.

Scenario number (Table 1) will be recorded for each potential tidal restriction. Scenarios 1-5 assume relatively pure salt marsh down-gradient of a potential restriction without indicators of fresh or brackish water (no Phragmites; no shrubs). Scenarios 6-10 are for salt marshes down-gradient of a potential restriction with indicators of freshwater influence (presence of Phragmites and/or shrubs).

Table 1: Rubric for characterizing abruptness in change between wetland resource types.

Scenario	DOWN-GRADIENT				UP-GRADIENT			
	Salinity*	Phragmites		Shrubs	Salinity*	Phragmites		Shrubs
1	Salt	None**	And	None	Fresh	None		
2	Salt	None	And	None	Fresh	5% - 50%		
3	Salt	None	And	None	Fresh	50% - 100%		
4	Salt	None	And	None	Salt	None	And	None
5	Salt	None	And	None	Salt	5% - 50%	And/Or	5% - 50%
6	Salt	5% - 50%	And/Or	5% - 50%	Fresh	None		
7	Salt	5% - 50%	And/Or	5% - 50%	Fresh	5% - 50%		
8	Salt	5% - 50%	And/Or	5% - 50%	Fresh	50% - 100%		
9	Salt	5% - 50%	And/Or	5% - 50%	Salt	None	And	None
10	Salt	5% - 50%	And/Or	5% - 50%	Salt	5% - 50%	And/Or	5% - 50%

*Based on DEP Wetlands data layer

**None is < 5%

Difference in channel width up-gradient vs. down-gradient of the potential restriction

This variable will compare the width of the channel above to the width of the channel below the potential restriction. The natural stream width will be determined by measuring the stream width every 50 meters away from the potential restriction up to 200 meters away or until another water body is encountered (e.g. confluence with another creek or river), including the width immediately at the restriction at 0m. The mean will then be taken of the five natural stream width measurements to give the average natural stream width for each side of the restriction. A ratio will be recorded by dividing the down-gradient width by the up-gradient width. A result greater than 1 indicates that the down-gradient side of the potential restriction is wider than the up-gradient side.

Relative width of impounded water/ scour pool (two variables: one up-gradient and one down-gradient of the potential restriction)

This will assess the ratio between the width of the impounded water or scour pool compared to the width of the natural channel on each side of the potential restriction. Impoundments and scour pools will be treated together because it is not clear that we will be able to readily distinguish from aerial photographs scour pools from small impoundments. This will be treated as two variables and represented as separate columns for up-gradient and down-gradient in the attribute table.

If there is a visible impoundment or scour pool just up-gradient or down-gradient of the potential restriction, the width of the impoundment/scour pool will be compared to the natural channel width on the same side (up-gradient or down-gradient) of the potential restriction. The natural stream width will be determined by measuring the stream width every 50 meters past the end of the impoundment/scour pool up to 200 meters away. The mean will then be taken of the four natural stream width measurements to give the average natural stream width. The impoundment/scour pool width will be measured by taking one measurement at the widest part of the impoundment/scour pool. The impoundment/scour

pool width will then be divided by the natural stream width to calculate the difference expressed as a ratio.

Amount of fill associated with a potential restriction

The type of fill that will be assessed will include only areas where a road, railroad or other linear anthropogenic feature crosses through a salt marsh preventing flow of water through the marsh outside of the natural confines of the channel. It is expected that such fill has the potential to disrupt salt marsh hydrology during high spring tides but that the affect on salt marsh ecology will be substantially less than restrictions affecting channels. This will be measured as a ratio. The ratio will be based on the distance of the marsh the fill crosses in relation to the width of the marsh. Expressed another way it is the length of road, railroad or other linear feature crossing a marsh (crossing length) minus the opening for water movement (culvert or bridge), divided by the width of the marsh at the crossing (crossing length). Fill created by the digging or maintenance of ditches through the marsh will not be included in this evaluation.

Additional Information

One additional variable will be included in the attribute table and assessed to the extent possible but will not be included in the final assessment of severity for potential tidal restrictions. We decided to exclude these variables from the assessment of potential restrictions because of questions about how reliably they could be evaluated using the resources available.

Culvert or Bridge

For our purposes a "bridge" has no bottom leaving the natural streambed intact. A culvert is a crossing structure that has a bottom, even if that bottom is embedded. A culvert will be identified by the presence of a headwall or by direct visual identification from source imagery. A bridge crosses over the channel allowing free flow of water beneath. Bridges often throw shadows in aerial photographs while culverts do not. The MassDEP wetlands data layer will also be used as a source to help differentiate between the presence of a culvert or bridge. DEP identified a bridge by passing the wetland delineation line "through" the road, thereby mapping the wetland under the road. They identified a culvert by stopping the wetland delineation line at the road and depicted the culvert as a hydrologic connection. This is not 100% accurate; however, it gives insight as to what other photo-interpreters thought.

Data Analysis/Development of Tidal Restriction Metric

Development and parameterization of the Tidal Restriction metric for CAPS will be based on available field data on tidal restrictions and statistical analyses of the five variables derived from aerial photo-interpretation.

An expert team will be convened to interpret existing field data and determine how they should be used to assess potential tidal restrictions. Field data will include historical data collected or compiled by CZM and the MA Wetlands Restoration Program that is determined by them to be of sufficient quality for assessing restriction severity, as well as field data collected at 50 sites as part of this project during the summer of 2009. Using the system developed by this expert team we will assign a tidal restriction severity score to all sites for which we have sufficient data.

Analysis of photo-interpreted data (five variables) will focus on those sites for which we have severity scores based on field data. Single parameter, multiple parameter and classification tree analyses will be used to construct a model for assessing the severity of tidal restrictions. This model will be applied to all potential tidal restrictions evaluated by aerial photo-interpretation and will serve as the basis for the tidal restriction metric in CAPS.

Quality Assurance/Quality Control (QA/QC)

Two research assistants, Dennis Babassa and Maili Page, will characterize potential tidal restrictions previously identified by Brad Compton. One researcher will characterize the even numbers and the other will characterize the odd numbers based on the TR_ID column of the potential tidal restriction layer to prevent systematic bias within the data. To ensure uniformity in characterization between researchers, the researchers will do the first 10 together. The second 10 (5 each) will be done individually and then assessed by the other to ensure agreement in the process of characterization. With the remaining 724 data points, for every 50 tidal restrictions characterized, the researchers will re-check the last 10 of each others' characterizations to ensure uniformity and agreement in characterization between the researchers.

Table 2. Data Quality Objectives

Parameter	Units	MDL	RDL	Expected Range	Accuracy (+/-)	Precision
Abruptness of Change in Wetland Salinity	Scenario #	NA	NA	1-10	100% of sites accurately characterized	100% agreement between two photo-interpreters
Difference in channel width up-gradient vs. down-gradient of the potential restriction	Ratio	NA	NA	0.1 – 10.0	Within 10% of actual ratio if it were measured in the field	Independent assessment by two photo-interpreters within 10% of each other
Relative width of impounded water/ scour pool	Ratio	NA	NA	1-500	Within 10% of actual ratio if it were measured in the field	Independent assessment by two photo-interpreters within 10% of each other
Amount of fill associated with a potential restriction	Ratio	NA	NA	0-100	Within 10% of actual percentage if it were measured in the field	Independent assessment by two photo-interpreters within 10% of each other
Culvert or Bridge	"culvert" or "bridge"	NA	NA	NA	75% of sites accurately characterized	90% agreement between two photo-interpreters

Table 3. Attribute Table

Wetland_Ch	Width_Rat	Impnd_Up	Impnd_Dn	Fill	Researcher	Date_	Data_used	Data_Date	Source	Comments	C_or_B	Road_type	Reviewer	Rev_date	OthrR_UpGd	OthrR_DnGd
0	0	0	0	0		<Null>		0						<Null>	0	0
0	0	0	0	0		<Null>		0						<Null>	0	0
0	0	0	0	0		<Null>		0						<Null>	0	0

NOTE: These are only the additional columns added to the original restriction point layer provided by Brad Compton.

Description of each column in attribute table:

Wetland_Ch- Abruptness in Wetland Change scenario number based on Rubric in Table 1: 1-10 (ordinal)

Width_Rat – Ratio of width of stream on either side of potential restriction: ratio: downgradient / upgradient (continuous)

Impnd_Up- Up-gradient ratio of natural stream width to impoundment or scour pool width: ratio (continuous)

Impnd_down- Down-gradient ratio of natural stream width to impoundment or scour pool width: ratio (continuous)

Fill- ratio: (length of fill-length of fill that crosses channel) / total marsh length (continuous)

Researcher- Researcher that characterized the potential restriction- text

Date_- Date the potential restriction was characterized- date

Data_used- type of data- text

Data_date- date of data used- date

Source- Source of data- text

Comments- text

C_or_B- Culvert or Bridge- C or B (nominal)

Road_type- Type of potential restriction/ size of road- text

OthrR_UpGd- any other potential restrictions up-gradient

OthrR_DnGd- any other potential restrictions down-gradient

Reviewer- Researcher that reviewed a characterized potential restriction- text

Rev_date- Date that a characterization was reviewed- date