Jill Carr **5/9/2018**
Final Project Summary **GPH904**

Introduction

Eelgrass (*Zostera marina*) is an important marine fisheries habitat as well as an indicator of general ecosystem health (Dennison et al. 1993). Currently, eelgrass beds in Massachusetts are mapped using remote sensing methods that collect low resolution spatial extent information but little else in terms of meadow or plant-level metrics. Remote sensing methods include fixed-wing aerial photography analysis (Costello and Kenworthy 2011) which takes place every five years in select coastal Massachusetts embayments, and sidescan acoustic surveys (MA DMF, unpub data) which occur on an ad-hoc basis and include underwater photo groundtruthing. In a hierarchical (or "tiered") mapping design, these remote sensing studies are considered Tier 1 (aerial photography) and Tier 2 (acoustic mapping) programs. At Tier 1, gross changes to eelgrass extent can be tracked. In addition to fixed-wing aerial photography, other methods include analysis of Landsat satellite imagery (Hogrefe et al. 2014, O'Neill and Costa 2013), and drone imagery (Duffy et al. 2018). At Tier 2, meadow-level changes in eelgrass quality can be detected, like changes in density and percent cover. In some cases, canopy height and sediment characteristics can be observed. Examples of Tier 2 monitoring include acoustic surveys (Vandermeulen 2014, Sonoki et al. 2016), randomized quadrat-based surveys (Neckles et al. 2012, Raposa and Bradley 2010), underwater camera and benthic grab surveys (McKenzie 2003), and towed video surveys (Berry et al. 2003). Tier 3 is the highest resolution monitoring, and can help identify plant-level changes and responses to stressors, which can inform system-wide trends. These programs often require SCUBA or snorkel work at permanent monitoring sites, which cover a very small study area in comparison to Tiers 1 and 2 (Short et al. 2006, Neckles et al. 2012).

In one Massachusetts embayment in particular, the Duxbury-Kingston-Plymouth (DKP) complex (Figure 1), Tier 1 and limited Tier 2 surveys have detected extreme declines in eelgrass extent and density over the last several decades (Costello and Kenworthy 2011, Ford and Carr 2016). In DKP, there is a need to incorporate more frequent meadow-level and plant-level data collection to supplement existing mapping programs and inform the overall understanding of the embayment. To help fill both the spatial and temporal gaps in current eelgrass monitoring efforts, this study will develop a protocol that enhances Tier 2 and Tier 3 data collection in DKP and incorporates engaged locals (citizen scientists) in data collect. While the monitoring protocol will be written as a pilot specific to DKP, the methodology could be applied to any estuary if found to be successful.

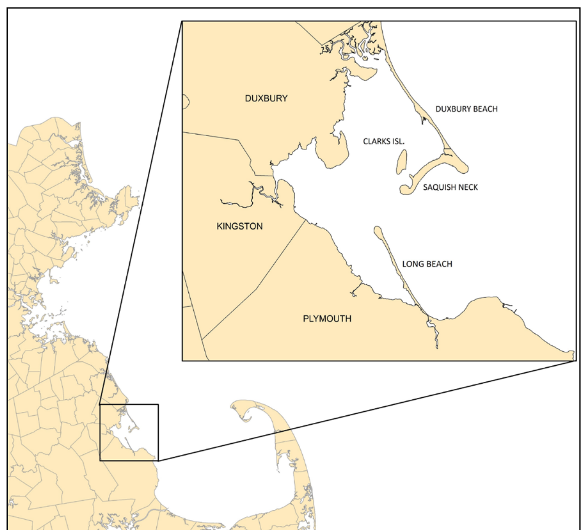

Fig 1. Lotus map of the DKP embayment

Methods

Investigation of habitat suitability using GIS

A suitable habitat layer was generated by overlaying appropriate data layers including historic eelgrass extent, water depth, and sediment data. Other important datasets that were not incorporated due to time and access constraints include fetch, temperature and water quality.

Historic eelgrass extent processing

Historic eelgrass polygons from MA DEP were downloaded from MassGIS. In-house unpublished data from MA DMF acoustic surveys were also used. Polygons generated from both data sources were combined using the Union tool and dissolved into a single polygon representing the maximum eelgrass extent in all survey data combined.

LIDAR processing

USGS LIDAR data were downloaded from www.sciencebase.gov as a raster with elevation point data. The ArcGIS 3D Analyst "Create Contour" tool was used to generate 1.0m depth contours from the raster. Based on eelgrass literature and historical extent in DKP, depth suitability was limited to depth from -1m to -5m Mean Low Water (MLW) in DKP. The contour polylines were converted to polygons using the ET GeoWizard extension "polyline to polygon" tool. Three separate depth polygons were created so that the site selection could later be depth-stratified. Depth categories were -1m to -2m, -2m to -4m, and -4m to -5m. A fourth category was created, where historically mapped eelgrass fell deeper than -5m in one discrete area. The majority of historically mapped eelgrass exists in the middle strata (Figure 2).

Sediment data processing

USGS usSEABED Sediment data were downloaded from https://pubs.usgs.gov/ds/2005/118/htmldocs/data_cata.htm and symbolized by sediment type. Areas where sediment is generally thought to be unsuitable for eelgrass (e.g. grave or clayey silt) were identified. Of the 294 point-samples collected in DKP, only 21 (7%) could be categorizes as "unsuitable", and this layer was therefore not consequential in the site selection process. The Nature Conservancy "Soft Sediments by Grain Size" data were downloaded from www.northeastoceandata.org, however the survey was of very low resolution and categorizes nearly the entire embayment as sand, which is considered suitable.

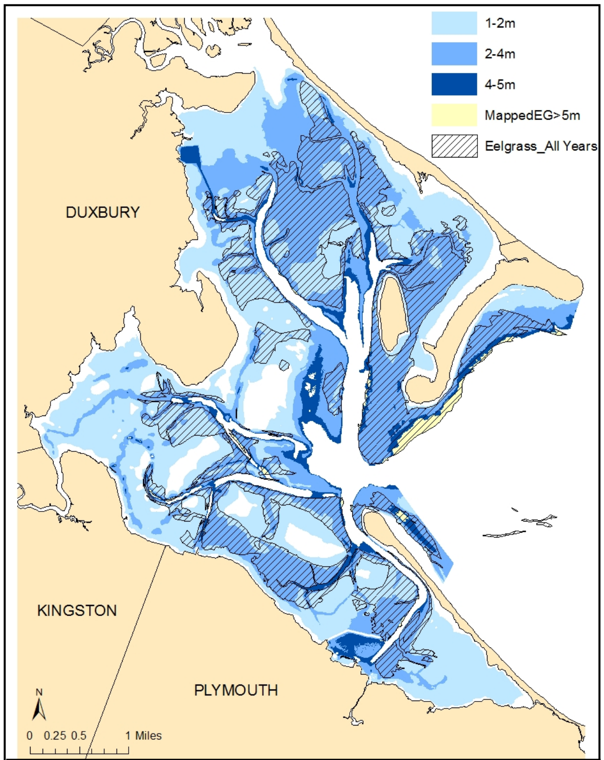

Fig 2. Depth strata and historically mapped eelgrass in DKP.

Site selection

Depth and historic eelgrass were the primary layers contributing to the suitable habitat layer (Figure 2). To determine what sites within the embayment would be monitored for eelgrass by citizen scientists, the following three site selection processes were tested and assessed for site distribution and repeatability:

1. Using "Generate Tessellation" across the suitability area and then "Create Random Points" within each cell;
2. Using "Create Random Points" tool across the entire suitability area; and
3. Using "Create Random Points" at different concentrations in each stratum.

To be considered a satisfactory site selection, distribution must be random, not overly clustered, and must sufficiently sample existing and suitable eelgrass habitat. Repeatability is also important, as volunteers will be expected to sample the same locations annually. Considerations for access and safety factor into satisfaction with each site selection. Finally, given that volunteers will be used for data collection, it is important that the number of sampling sites is achievable.

Results

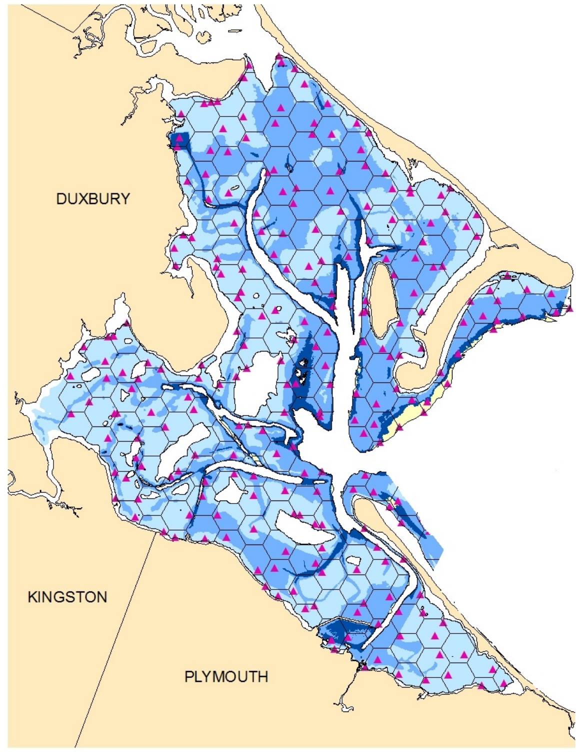

Figure 3. Tessellation site selection using 50acre hexagonal cells, yielding 290 randomly placed sampling points (pink triangles)

While the tessellation method has been successful in other studies (Neckles et al. 2012), we found that in order to use a proportionally similar hexagon size (approximately 50 acres per hex) to those used by others, we would need to sample 290 cells (Figure 3), an effort we do not have the resources to achieve. Furthermore, it was discovered during the habitat suitability data exploration that the majority of eelgrass in DKP exists in the middle stratum, and a weighted sampling design could help ensure that stratum received the majority of our limited resources.

When random points were created across the entire unstratified suitability layer, distribution was not ideal because a large proportion of sites landed in very shallow areas, and almost none fell within the deepest stratum (Figure 4). Shallow areas, which technically may be suitable, may pose a hazard to sampling by watercraft and more than likely have no eelgrass since they are outside of the historically mapped areas. Deeper areas have historically been a challenge for remote-sensing monitoring, and are an important part of this project.

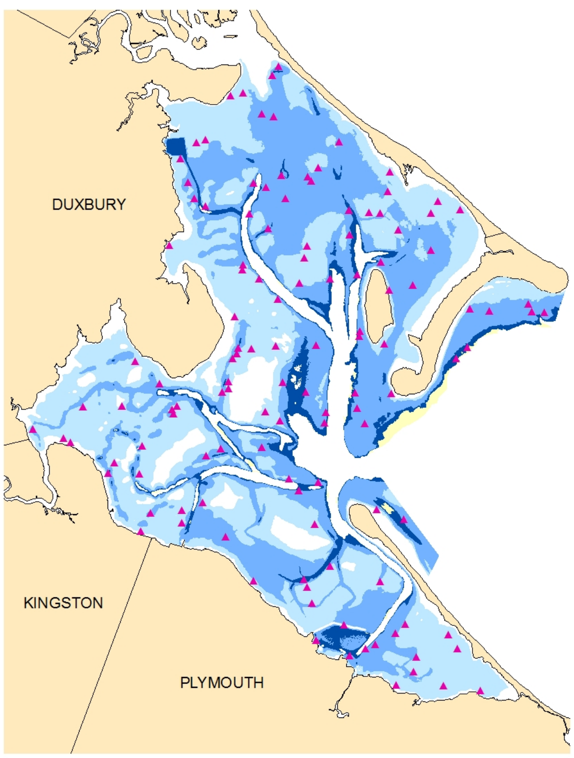

Figure 4. Randomly placed sampling points (pink triangles) across the entire suitability area, without assigning strata.

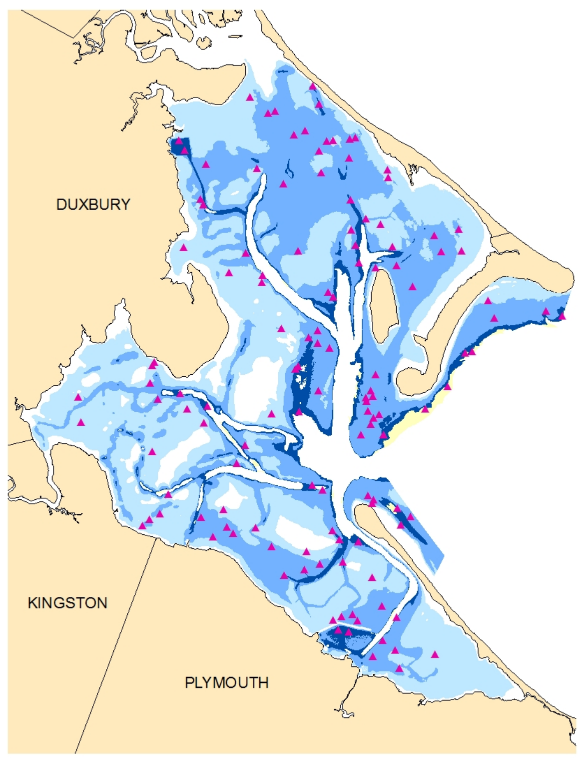

Figure 5. Stratified sampling design with randomly placed sampling points (pink triangles) assigned by strata

The preferred site selection process resulted from using the Sampling Design Tool (ArcGIS10.4.1) developed by NOAA Biogeography Branch (http://www.arcgis.com/home/item.html?id=28f08ca526ae44e8ac107a2a0d5f50e3). A single Sampling Frame shapefile was created by merging the three depth strata with a shapefile of areas that were previously mapped as eelgrass but fall outside of the contour strata (this was limited to several small fringing deep edges, as seen in Fig 2). Knowing that we could reasonably accomplish sampling of roughly 125 sites, sites-per-strata were assigned as follows within the tool: 25 sites in the shallow strata, 75 sites in the larger middle strata, 25 sites in the deeper strata, and 3 sites in the fringing deepest strata. The resulting sampling sites (n=128) appear well distributed and meet our goals for safety, access and randomness (Figure 5).

Future Steps

Sampling Design

This site selection process will be reviewed by a team of eelgrass experts involved in this grant. Additionally, the written monitoring protocol is in its final draft phase and will be distributed to stakeholders for input. A final version will be field-tested in early summer. In August 2018, the protocol will be carried out during a week-long sampling event in DKP.

After the first year of data collection, the site selection will be reviewed and edited as needed, but the hope is that the majority of sites will be accessible and can therefore remain in the survey for future years. Data collected from year one will be mapped spatially as baseline data, but will also be used to compare results of historic remote sensing surveys. As data are collected in subsequent years, spatial analyses can be conducted to look for changes in eelgrass presence, coverage, and health.

References

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