Technical Report

Massachusetts Division of Marine Fisheries
Technical Report TR-43

Technical Guidelines for the Delineation, Restoration, and Monitoring of Eelgrass (*Zostera marina*) in Massachusetts Coastal Waters

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Continued on inside back cover

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Abstract: Eelgrass (*Zostera marina*) meadows are an important subtidal resource forming critical forage and refuge habitat for many marine fisheries species. Due to eelgrass' function as a coastal resource, proponents of dredging and other coastal construction projects are required by permitting agencies to avoid and minimize impacts to eelgrass and finally mitigate for any unavoidable damages. This technical report presents *MarineFisheries*' recommended methods to delineate eelgrass at a project site, conduct a restoration/mitigation effort by transplanting eelgrass into a carefully selected location, and monitor the restored habitat to ensure that it has met success criteria. Eelgrass surveys should be conducted before the project design is finalized. Surveys should include an assessment of available resource maps, followed by a field survey to more accurately define the perimeter of the existing meadow. If mitigation is required, the use of a GIS-based site selection model is recommended to assess sediment type, wind and wave energy, water quality, and light availability in order to identify an appropriate site for eelgrass planting. Once a site is selected, an eelgrass mitigation/restoration project requires environmental permits and approvals from several regulatory and review authorities including the Army Corps of Engineers and the municipalities' Conservation Commissions. The suitability of selected restoration methods is outlined with recommendations for their use, followed by a monitoring schedule including annual or semi-annual assessment of planted eelgrass density, percent cover, and areal extent of the meadow compared to natural reference meadows for five years after the initial restoration. Clearly defined success criteria should be met at pre-determined monitoring intervals via bed expansion rates or based on a comparison of the mean value of measured indicators at transplant sites with a benchmark value calculated at nearby natural reference sites. If success criteria are not met then a contingency plan should be considered including additional plantings by a different method, additional plantings at a new location, or an alternative mitigation project based on the recommendations of *MarineFisheries* and other resource and permitting agencies.

Introduction

This document represents the Massachusetts Division of Marine Fisheries' (*MarineFisheries')* general recommendations on the standards and methods for eelgrass (*Zostera marina*) delineations, restoration/mitigation, and monitoring associated with coastal alteration projects in Massachusetts waters. We intend that this document be used by local, state, and federal resource and permitting agencies, and also project applicants and consultants, as a guide in the design and review of eelgrass monitoring and restoration/mitigation projects. The technical guidance below does not address any specific project or action and is intended only as a supplement to regular reviews and consultations with resource and permitting agencies. In all cases eelgrass mitigation must be determined appropriate by the Army Corps of Engineers (USACE), MA Department of Environmental Protection (MassDEP) and other permitting agencies.

Technical guidance presented here was developed to be consistent with that required by the above agencies. However, we recommend that project proponents contact the USACE and MassDEP to obtain their current mitigation policies.

The following sections outline *MarineFisheries* recommendations on methods to conduct eelgrass delineations at a proposed project site as well as restoration/mitigation of lost eelgrass habitat.

Eelgrass Surveys and Delineation

Mapping surveys are an essential step when designing a project that may be located near eelgrass. Surveys provide baseline information on the extent of eelgrass before and after an impact. The survey process involves an assessment of aerial photography or existing eelgrass maps followed by data collection in the field.

Existing eelgrass maps. The first step in determining if a project will impact eelgrass is to acquire remote sensing data for the area. If the target region is covered by MassDEP's eelgrass mapping program (http://www.mass.gov/dep/water/resources/maps/eelgrass/eelgrass.ht), then the MassGIS eelgrass data layer should be used. MassDEP has conducted extensive photo interpretation as well as ground truthing to create this eelgrass datalayer and it is currently the best available information on general eelgrass extent in Massachusetts. The MassDEP eelgrass datalayer should be used as an initial guide to gauge the extent of eelgrass in the project vicinity. If eelgrass is mapped near the project site or if the habitat characteristics suggest that there could be eelgrass present near the proposed project, an on-site investigation may also be required.

On-site ground truth delineation. At shallow sites where the water is clear and eelgrass is easily observed over the side of the boat, the perimeter of the bed can be mapped using single GPS position fixes recorded approximately every 15 meters (Short and Coles 2001). In that case, snorkelers or a view scope can be used to confirm the edge of eelgrass and provide cover estimates. However, in deeper or more turbid water, *MarineFisheries* recommends the use of a drop or towed underwater camera and/or SCUBA divers. The camera or divers should follow transects perpendicular to shore or a depth gradient continuing beyond the project footprint where necessary to map the edge of the bed and note any eelgrass in adjacent areas that may be directly or indirectly impacted by project work. Specific attention should be given to mapping the deep and shallow edges of the eelgrass bed as these locations may be most vulnerable to impacts from project work.

In many cases the edge of the bed is difficult to determine as eelgrass is often patchy and less dense at the edge. To account for this transition area we define the edge of the bed as having two points; 1) the distance to the end of the continuous meadow and 2) the distance to the last shoot (Short et al 2006). GPS coordinates should be recorded for all points defining the edge of the bed.

If SCUBA divers are used instead or in addition to the drop camera, more detailed data and information can be collected through quadrat-based measurements. We recommend that divers collect plant and habitat characteristics including shoot densities, percent cover, sediment type, and presence of other species, within $0.25m^2$ quadrats at designated intervals along the transect. Transect length, number of transects, and number of sample stations (i.e. quadrats) should be determined on a site-specific basis in order to obtain a detailed map of eelgrass in the area. More stations are required where the habitat is heterogeneous.

Eelgrass Mitigation Through In-Kind Restoration

Proponents of dredging and other coastal construction projects are required to first avoid and then minimize any impacts to eelgrass in the project design. If a determination is made by the permitting agencies (MassDEP) and USACE) that impacts cannot be avoided, damage to eelgrass habitats must be mitigated according to the MassDEP and USACE regulations, at a ratio of 3:1 (three restored to one impacted). A mitigation ratio not only accounts for the area lost, but also for the temporal loss of resource benefits during the time elapsed between impact and completion of restoration (NOAA 2009).

One mitigation option is the in-kind creation or restoration of one eelgrass bed to off-set the loss of another. This is most commonly accomplished by transplanting eelgrass shoots into a restoration site. Out-of-kind mitigation alternatives that improve the protection of existing beds or potential eelgrass habitat may also be considered. All forms of mitigation will require monitoring and an evaluation of the success of the technique employed. The following guidelines and references are specific to eelgrass transplant mitigation and monitoring.

Permitting and reporting for an eelgrass mitigation project.

Permitting. Eelgrass mitigation or restoration projects require agency review and environmental permitting. Both the harvest of shoots from a donor bed and the transplant to the new site will be reviewed. Applicants should check with the permitting agencies to confirm requirements at the time of restoration. For most restoration projects in Massachusetts, permits will be limited to:

- an Order of Conditions from the municipal Conservation Commission of all towns encompassing the donor bed, reference bed, and transplant sites,
- approval from the municipalities' harbormasters and shellfish constables,

- approval from the Board of Underwater Archaeological Resources, and
- an ACOE Category I Notification Form (http://www.nae.usace.army.mil/reg/MA_GP012110.pd) for projects <5,000 sf or a PGP Category II application for projects >5,000 sf.
- If the method used requires frames or other structures left in the water, additional permitting may include a MA Chapter 91 (MassDEP) license.

Reporting. A schedule that details a) when and where test and full scale transplants will occur, and b) when and how transplant monitoring will occur, shall be provided to *MarineFisheries*, project managers at the relevant permitting agencies, and other agencies upon request for review prior to the initiation of the transplant. Monitoring reports shall be provided in a timely manner after the completion of each required monitoring period. The current Massachusetts *MarineFisheries* seagrass biologist and Coordinator of the Massachusetts Interagency Seagrass Group is:

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<u>Transplant site selection.</u> Site selection is critical to the success of an eelgrass transplant and is likely the most important part of a restoration project. Poor site selection has been attributed to several failed transplant attempts (Short et al. 2002; Fonseca et al.1998). A potential restoration site should be located in an area where the factors that caused eelgrass loss (e.g. eutrophication, disease) have since been resolved or at least improved (e.g. waste water treatment plant improvements, etc.), but transplant sites should not contain eelgrass. Eelgrass may naturally shift as patches increase in some areas and decrease in others at the same site. If physical and biological conditions are favorable, areas within 100 meters of existing vegetation are expected to repopulate naturally through a combination of seeding and vegetative growth. Therefore, in most cases, sites within 100 meters of eelgrass should be excluded from the site selection. Finally, transplants should be conducted at a similar depth contour as existing, natural beds in the same system.

Site selection model. A site selection model, such as that described in Short et al. 2002, or a modification of this model, is a useful tool to identify potential sites based on a transplant suitability rating. Initially a suitability model is run as a desk top exercise to provide an objective way to narrow down potential sites within an entire embayment or region. Using a Geographical Information System (GIS), numerical scores are assigned to each ecological criterion. Data may include pre-existing geographically referenced data, GIS calculations on existing spatial and non-spatial data and data collected in any preliminary field surveys. In general, data inputs to the preliminary site selection model should include wave exposure, depth, salinity, water quality (measured as TSS or Secchi depth, if available, historic eelgrass presence, current eelgrass presence, sediment characteristics and drift modeling (Signell and Butman 1992, Leschen et al. 2009) to assess the possibility of founder eelgrass shoots naturally colonizing a site from a nearby existing bed.

Field ground truthing and final site selection scoring. At sites that rate well in the initial model run, additional field ground truthing should be conducted to collect more site-specific data and identify any factors that may adversely impact transplant success. Further data collection may include more detailed sediment grain-size analysis, more specific water-quality data collection using light dataloggers, assessment of bioturbation (e.g. numbers of green crabs, etc.), and assessment of conflicting uses (e.g. moorings, anchor scars, lobster pots, weekend anchoring).

Light availability is measured as (% surface irradiance (SI) or attenuation coefficient (Kd)). We recommend that transplant sites have at least an average of 18% SI (K.S. Lee et al. 2007). Sediment grain size at a potential transplant site ideally should be free of cobble and characterized as muddy sand. Based on success in Boston Harbor, *MarineFisheries* recommends targeting sediment characterized as muddy sand with less than 37% silt/clay (Leschen et al. 2009). However, other studies note successful transplants in sediments with as much as 70% silt/clay as long as sufficient light is available (Short et al 2002).

Test-plots. These data can be collected before or in tandem with test-plot plantings in selected locations. Test-plots consist of 1 to 3, small (1-6 m^2) patches planted at selected sites that rated high in the initial site selection process. Test plots are useful as a pilot transplant effort to assess the planned transplant methods, site characteristics such as the degree of bioturbation, and the overall survivability of plants. Test plots should be planted at the edges and middle of the area that would be potentially used for large-scale restoration and at similar depths as that of natural beds in the system. We recommend test planting using similar methods and during the same season as is proposed for the large scale restoration project. Test-plots should be monitored initially within 1-10 days after transplanting to obtain a baseline shoot density of actual mean numbers of shoots per $0.25m^2$ in each plot, as well as the length and width (areal cover) of planted plots. Test-plot monitoring for survival, shoot densities and areal cover should continue one month after planting and at pre-determined intervals for one year to ensure that the site can support eelgrass through different seasonal conditions (e.g. summer boating and winter ice scour).

<u>Donor bed selection.</u> Ideally, a donor bed should be located within the same embayment or portion of the coastline as the transplant site, both for ease of plant transportation and similarity of site characteristics. The donor bed must be a natural bed that has been established for 10 or more years, as mapped by MassDEP or anecdotally, with a minimum of one acre of continuous growth and at a density greater than 50% cover. Larger beds may be desirable for bigger transplant projects. Where possible, as in the case of a dredging project that will remove eelgrass, the impact site should be considered in the donor bed selection process. Harvesting the future impact site may minimize or eliminate the need for another donor bed. However, timing is essential if the project footprint is proposed to be used as a donor bed.

<u>Reference bed selection.</u> A nearby natural bed, ideally in the same embayment or portion of coastline, should be chosen as a reference site (also known as a control site) to control for any regional changes in seagrass density, areal coverage, and other characteristics at the individual (shoot) and population (bed) level. A reference site should have similar water depth, sediment type, and human use (e.g. boating, docks, moorings) as the transplant site for post-transplant comparison. The same reference bed may be used for multiple transplant sites provided that it is close to all transplant sites. The reference beds should be monitored at the same time and for the same parameters as the transplanted beds.

<u>Harvest and transplant methods.</u> Several methods have been used to transplant eelgrass. Successful methods include bare root methods such as stapling individual bare shoots and rhizomes to the sediment using bamboo skewers (Davis and Short 1997), stapling small clumps of about 5-7 shoots with an intact rhizome matrix (Leschen et al. 2009), and tying plants to temporary frames as in the TERFS™ method (Short et al. 1999) and the modified TERFS method using PVC frames (Leschen et al. 2009). Other successful methods include seeding (e.g. Leschen et al. 2009, Granger et al. 2002, Orth et al. 1994), and peat pot plugs (Fonseca et al. 1996). Recommended harvesting and transplanting techniques are further explained below. For more detail see the Manual for Community Based Eelgrass Restoration, Short et al. (2002b) and Leschen et al. (2009).

For all methods eelgrass may be held for up to 72 hours after harvest and before transplanting, but must be kept submerged and in a low light environment to prevent desiccation and algal growth. Plants should remain wet during transport (e.g., use a tote or cooler filled with water) and if held overnight, *MarineFisheries* recommends storage in a subsurface cage or mesh bag tied to a dock or mooring.

Harvest tracking. To ensure that a donor bed will not be over-harvested, divers should work along a transect tape or with a designated area marked with GPS coordinates, buoys, and/or stakes to prevent repeat harvesting of a location. Long-term impacts were not observed in beds larger than one acre in size when using a non-destructive harvest method (Davis and Short 1997). The donor bed should be monitored throughout the duration of the project to ensure that impacts have been minimized.

Bare root method. *MarineFisheries* recommends the bare root method outlined in Davis and Short (1997) or the clump method described in Leschen et al. (2009), depending on the donor bed site characteristics, as the most efficient methods from a cost, time and environmental impact perspective. The bare-root method is prescribed as a low impact method in Davis and Short (1997) and is recommended in lower density donor beds because it is the method resulting in the least impact to the donor site. In the low impact method, divers or snorkelers harvest plants by picking them with their fingers two to three nodes (3-5 cm) down the rhizome. In a University of New Hampshire restoration effort, 5 harvesters collected 1,000 shoots per hour using this method (Short et al. 2002b).

Clump method. In some cases it may be more efficient to use a small garden trowel to remove larger sections or "clumps" of intact root and rhizome matrix for transplant in a peat pot or alone in a clump of 5-10 shoots. The clump method is recommended in cases where eelgrass will be harvested from the impact site or in extensive, high density beds. *MarineFisheries* found that this was an efficient harvesting method in a high density donor bed. However, it has also been observed that the clump method may result in some detrimental impacts to the donor bed as well as to the newly transplanted shoots. Impacts from this method may include erosion around the hole in the donor bed, scour around the planted clump, competition between transplanted shoots, and plant level effects from exposed rhizome at the donor bed and decaying rhizome around the newly transplanted shoots.

Frames. Frames are the recommended transplanting method if a project has an outreach component as this method enables shore-side volunteer help. Frames are also a preferred method when the minimization of dive time is a priority, as they can be deployed over the side of a boat with only one or two snorkelers or divers needed to quickly guide the frame into place. If a frame method is selected, *MarineFisheries* recommends using PVC frames as in the Modified TERFS method. PVC frames have several advantages over the original TERFS™: they are lighter and easier to work with, take up less room on a boat, and did not attract burrowing crabs at Boston Harbor restoration sites (Leschen et al. 2009).

More than one transplanting technique can be used at the same site to improve the odds of success. In Boston Harbor, *MarineFisheries* utilized TERFS™, modified TERFS, clumps, Horizontal Rhizome method and seeding. For all of the above methods except seeding, *MarineFisheries* suggests that planted plots be arranged in a checkerboard pattern with 50 shoots planted in each ¼ meter square planting unit, alternating with unplanted units of the same size. For details on seeding methods please review Leschen et al. (2009).

Transplant time of year. Transplanting in New England can take place successfully during all seasons. It is often suggested that project proponents target early spring (March-June). At that time of year, day length, light, and temperatures are increasing, signaling plants to increase growth which may aid transplant establishment. Other seasonal factors to consider include the timing of green crab or other bioturbating crustacean population peaks in the summer. Also, algal biomass, particularly that of *Codium fragile*, is greater in the summer, and in some areas excessive algae may smother newly planted shoots. If bioturbating crustaceans or invasive algae may be a problem at a given site, planting in early spring or early fall (March or September), is recommended.

<u>Restoration monitoring.</u> After the full scale transplant is completed, as with test-plots, we recommend obtaining an initial shoot count within two

weeks to establish a baseline shoot density. If using TERFS™ or modified TERFS, return to the site to remove the frames in 3-5 weeks, or when the plants have rooted into the sediment. The time may vary depending on the site. If you wait too long plants may grow up and over the frame and risk being uprooted when the TERF is removed.

Full-scale monitoring should be conducted at the same time every year, at annual, semi-annual, or quarterly intervals at both the transplant site and the reference site. We recommend 5 years of monitoring. This period is based on the expected time it takes many ecological functions in a transplanted eelgrass bed to reach parity with reference levels (Evans and Short 2005).

Statistical power analysis or other statistical method for determining sample size should be used to set the number of monitoring replicates needed (i.e., a sample or replicate is the measurement taken from one quadrat area). At the *MarineFisheries* Boston Harbor sites we randomly monitor 9 samples (quadrats) per planting grid (of 18) at the transplant sites and 9 samples defined haphazardly or randomly in the reference bed.

Full scale monitoring should include:

1. Initial calculation of the percentage of planting units (clumps or horizontal rhizomes) that survived vs. the total planted. This may be done 1-4 months after planting.

2. Shoot density (# of shoots vs. baseline shoot density). Shoot density should be measured *in situ* within the 0.0625 m^2 quadrats for each planting grid and within the reference area.

3. Percent cover.

4. Canopy height (80% of the average of the tallest leaves).

5. Presence and number of reproductive shoots.

6. Areal extent of the bed (determined as the total area of continuous eelgrass and patches at the project site, excluding grass that is 100m away (Short et al 2006; Lockwood et al 1991). The extent of the bed can be mapped using a drop camera or divers recording GPS readings at several points along the edges of the continuous bed and at the last shoot (Short et al 2006; Short and Coles 2001).

Additional monitoring may include:

7. Biomass and 2-sided leaf area index ($m^2 m^{-2}$, equal to density multiplied by 2-sided leaf area). We recommend harvesting 10 shoots from a $1m^2$ area, or in the case of low densities, each planting grid, and within the reference area. See Evans and Short (2005) for more detail on the low density harvest method.

8. Depending on the project, it may also be beneficial to measure fish and invertebrate densities, species richness and diversity by using a shallow water fish sampling method such as a beach seine and a benthic core.

Success criteria. Success criteria should be clearly defined and agreed to by all parties before commencement of the mitigation project. In general a successful transplant should demonstrate at least 25% expansion of areal coverage within 1 year of transplanting. Evans and Short (2005) discuss the trajectory of the development of function in a transplanted bed and point to a timeline of approximately 3-4 years for functional equivalence. Therefore, after the first 2-3 years the parameters should be on a trajectory approaching reference levels.

Short et al. (2000) describes a method to determine success based on monitoring selected indicators of function in the transplanted and reference eelgrass beds (e.g. eelgrass biomass, density). According to the Short method, the chosen indicators measured at each restoration site should be compared to a bench mark of success calculated from the reference site data wherein:

Success Criteria (SC) = 100(mean of all reference sites – 1 standard deviation/mean of all reference sites).*

Measured indicators at the restoration and reference sites are then compared in the following equation:

Success Ratio (SR) = 100(mean of one restoration site/ mean of selected reference sites).*

When the SR for a given indicator equals or exceeds the SC, the restoration is considered successful for that indicator.

If the beds are not expanding at a desired rate, and success, as measured by the above or a comparable method is not met, then a contingency plan should be considered.

<u>Contingency.</u> Clearly defined expectations for all parties responsible for the mitigation success should be agreed upon in writing before commencement of the mitigation project. An applicant may be responsible for a defined number of acres of eelgrass or a certain dollar amount put toward a restoration effort. If a transplant effort fails, *MarineFisheries* recommends additional attempts at transplanting eelgrass only after an assessment of the expected reasons for failure. The use of different transplant methods or a new site may be necessary. If there are no additional feasible sites, alternative mitigation strategies should be considered to fulfill mitigation goals (Leschen et al. 2010). *MarineFisheries*, together with other resource agencies, will, upon reviewing available data, make recommendations on how to proceed.

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