Massachusetts Division of Marine Fisheries

Paul Diodati, Director

Policies, Procedures, and Guidelines

Issue: Eelgrass (*Zostera marina*) Restoration and Monitoring Technical Guidelines
Publication Date: 9/25/2009

Contributing Authors: N. Tay Evans & Alison Leschen

Introduction and Purpose

This document represents *Marine Fisheries'* general recommendations on methods and standards for eelgrass restoration/ mitigation and associated monitoring. We intend that this document be used by local, State and Federal resource and permitting agencies, as well as project applicants and consultants, as a guide in the design and review of eelgrass restoration and 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 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 Corps and DEP to obtain their current mitigation policies.

Background

Dredging and other coastal construction projects are required to first avoid and then minimize any impacts to eelgrass (*Zostera marina*) in the project design. If a determination is made by the permitting agencies (Department of Environmental Protection (DEP) and Army Corps of Engineers (USACE)) that impacts cannot be avoided, damage to eelgrass habitats must be mitigated according to the DEP and USACE regulations, at a ratio greater than 1:1 and in some cases as much as 5:1. According to NOAA's Habitat Equivalency Analysis method (NOAA, 2009), a mitigation ratio accounts not only 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.

Eelgrass mapping

The first step in determining if a project will impact eelgrass is to acquire remote sensing data for the area. If the region was mapped by MA DEP in their eelgrass mapping program (http://www.mass.gov/dep/water/resources/maps/eelgrass/eelgrass.htm), the MassGIS eelgrass layer should be used. DEP has conducted extensive photo interpretation as well as groundtruthing to create this eelgrass datalayer and it is currently the best available information on general eelgrass extent in Massachusetts. The DEP 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 is also required.

To groundtruth the extent of an eelgrass bed, *MarineFisheries* recommends the use of a drop or towed underwater camera or SCUBA divers. The camera or divers should follow transects along the length and/or width of the project footprint continuing beyond the footprint where necessary to map the entire bed and noting 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. If SCUBA divers are used more detailed information may be obtained including the shoot density and percent cover collected at designated intervals along the transect. Transect length, number of transects and number of quadrate samples should be determined on a site specific basis in order to obtain a detailed, groundtruthed map of eelgrass in the area.

<u>Permitting</u>

Eelgrass mitigation or restoration projects require review and environmental permitting. If the method used requires frames or TERFS™, a USACE permit, MA Chapter 91 (DEP) license and approval from the Board of Underwater Archaeological Resources may be required. Otherwise, if hand-planting via the horizontal rhizome or clump methods are used, required permits are usually limited to an Order of Conditions from the municipal Conservation Commission of all towns encompassing the donor bed, reference bed and transplant sites and approval from the municipalities' harbormasters and shellfish wardens (Table 1). Applicants should check with the permitting agencies to confirm requirements at the time of restoration.

Table 1. Summary of permits required for various mitigation methods

Method	**Permits/coordination**
All methods (e.g. TERFS™, Modified TERFS™, Horizontal Rhizome and clump)	• Order of Conditions from local Conservation Commission • Coordination with local harbormasters and shellfish wardens • Approval from the Board of Underwater Archaeological Resources
Frames (e.g.TERFS™ or modified TERFS™) may also require:	• MA DEP Chapter 91 license • Army Corps of Engineers PGP Category II permit

<u>Mitigation Reporting</u>

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 contact for the Massachusetts Eelgrass Coordination Team and *MarineFisheries* is:

Ms. N. Tay Evans, Division of Marine Fisheries
30 Emerson Ave.
Gloucester, MA 01930
tay.evans@state.ma.us

<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 show improvement (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 can repopulate naturally through a combination of seeding and vegetative growth and therefore should be excluded from the site selection. Transplants should target a similar depth contour as existing, natural beds in the same system.

A site selection model, such as Short et al. 2002, or a modification of this model, should be used to identify potential sites based on a transplant suitability rating. Data inputs to the site selection model include sediment characteristics, wave exposure, depth, and water quality. 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* recommend targeting sediment characterized as muddy sand with less than 37% silt/clay (Leschen et al. 2009). If that is not available, a range below 70% silt/clay should be adhered to (Short et al 2002).

At sites that have rated well in the initial model run, additional field groundtruthing should be conducted to identify other 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 and temperature dataloggers, assessment of bioturbation (numbers of green crabs etc.), assessment of conflicting uses (moorings, anchor scars, lobster pots) and an analysis using a drift model such as those used to detect oil spill drift, including GNOME™ (Signell and Butman 1992, Leschen et al. 2009) to assess the possibility of founder eelgrass shoots naturally colonizing a site from a near-by existing bed. These data can be collected before or in tandem with test-plot plantings of 1-6 m^2 areas in selected locations. Test-plots should be transplanted at a depth similar to that of natural eelgrass beds in the area.

<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 DEP 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 the individual (shoot) and population (bed) level. A reference site should have similar water depth, sediment type, and human use (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.

Harvest and Transplant Methods

Several methods have been used to transplant eelgrass. Successful methods include seeding (e.g. Leschen et al. 2009, Granger et al. 2002, Orth et al. 1994), 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 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).

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).

In some cases it may be more efficient to use a small garden trowel to assist with harvesting a small clump of 5-10 plants with intact rhizomes. 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 and successful harvesting method with little detectable impact to the donor bed. Recommended harvesting techniques are further explained in the Short et al 2002 (b) restoration manual and Leschen et al. 2009.

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 minimizing 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 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 the Boston Harbor sites.

More than one transplanting technique can be used at the same site to improve 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* recommends 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 detail on seeding methods please review Leschen et al. (2009).

Impacts from harvesting may include erosion around harvested areas or an overall decline in eelgrass density and percent cover. To ensure that a donor bed will not be over-harvested, the divers should work along a transect tape or otherwise mark (e.g. GPS coordinates, buoys, stakes) where they have previously harvested to prevent repeat harvesting in an area. Long-term impacts were not observed in beds larger than one acre in size, harvested using a non-destructive method (Davis and Short 1997). The donor bed should be monitored throughout the duration of the project to ensure that impacts have been minimized.

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* recommend storage in a subsurface cage or mesh bag tied to a dock or mooring. Transplanting in New England can take place successfully during all seasons. It is often suggested that a project 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. However, other seasonal factors to consider include the timing of green crab or other bioturbating crustacean population peaks in the summer. Additionally, algal biomass, particularly that of *Codium fragile*, is greater in the summer months, 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 March or September, rather than the summer months, is recommended.

Test-transplanting

As mentioned above, test-plots should be planted as part of the site selection process at locations that rate well in the initial site-selection model run. We recommend planting small patches of 1-9m^2 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 (i.e. summer boating and winter ice scour).

Full-Scale Transplant Monitoring

After the full scale transplant, as with test-plots, we recommend obtaining an initial shoot count within one week to obtain a baseline shoot density.

Annual monitoring should be conducted in the same month every year, 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 should be used to determine the number of monitoring samples needed (i.e. a sample is the measurement taken from one quadrate area). At the *MarineFisheries* Boston Harbor sites we randomly monitor 9 samples (quadrates) per planting grid (of 18) at the transplant sites and 9 samples haphazardly in the reference bed.

Full scale monitoring should begin one month after transplanting and again at annual or semi-annual intervals and include:

1. Calculation of the percentage of planting units (clumps or horizontal rhizomes) that survived vs. the total planted.
2. Shoot density (# of shoots vs. baseline shoot density). Shoot density should be measured *in situ* within the 0.0625 m^2 quadrates 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 and Short et al. 2001).

Additional monitoring may include:

7. Biomass and 2-sided leaf area index (2 x shoot length x width x height). 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.

<u>Success criteria</u>

As a rule of thumb 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 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 as follows:

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* recommend 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. *in prep*). *MarineFisheries* together with other resource agencies will, upon reviewing available data, make recommendations on how to proceed.

References:

Evans, N.T, Short F.T. 2005. Functional trajectory models for assessment of transplanted eelgrass, *Zostera marina* L., in the Great Bay Estuary, New Hampshire. Estuaries 28:936-947

Fonseca, M. S., W. J. Kenworthy, And G. W. Thayer. 1998. Guidelines for conservation and restoration of seagrass in the United States and adjacent waters. NOAA/NMFS Coastal Ocean Program Decision Analysis Series, No. 12, NOAA Coastal Ocean Office, Silver Spring, Maryland.

Granger, S., M.S. Traber, S.W. Nixon, R. Keyes. 2002. A practical guide for the use of seeds in eelgrass (*Zostera marina* L.) restoration. Part 1: Collection, processing, and storage. M. Schwartz (ed.), Rhode Island Sea Grant, Narragansett, R.I. 20pp.

Leschen, A.S., R.K. Kessler, and B.T. Estrella. 2009. Eelgrass Restoration Project: 5 Year Completion Report. Massachusetts Division of Marine Fisheries. http://www.mass.gov/dfwele/dmf/programsandprojects/hubline/hubline_5yr_eelgrass_restoration.pdf. Accessed 7/29/09.

Leschen, A.S., K. Ford and N.T. Evans. *In prep*. Successful but restricted eelgrass (*Zostera marina*) restoration in a formerly eutrophic estuary (Boston Harbor): implications and recommendations for management and mitigation of eelgrass loss

Lockwood, J.C. 1991. Seagrass Survey Guidelines for New Jersey; Prepared for the New Jersey Interagency Seagrass Policy Committee. National Marine Fisheries Service, Habitat and Protected Species Division, Sandy Hook Laboratory, New Jersey.

NOAA Coastal Services Center. 2009. Coastal Ecosystem Restoration, Restoration Economics website. http://www.csc.noaa.gov/coastal/economics/index.htm
Date accessed: July 1 2009.

Orth, R.J., M. Luckenbach, K.A. Moore. 1994. Seed dispersal in a marine macrophyte: implications for colonization and restoration. Ecology 75:1927-1939.

Short, F. T., R. C. Davis, B. S. Kopp, C. A. Short, and D. M. Burdick. 2002. Site selection model for optimal transplantation of eelgrass Zostera marina in the northeastern U.S. *Marine Ecology Progress Series* 227:253–267.

Short, F.T., C.A. Short and C.L. Burdick. 2002. (b) A manual for community-based eelgrass restoration. Report to the NOAA Restoration Center. Jackson Estuarine Laboratory, University of New Hampshire, Durham, NH. 54 pp.

Short, FT. and R.G. Coles (eds.). 2001. Global Seagrass Research Methods. Elsevier Science B.V., Amsterdam.

Short, F. T., D. M. Burdick, C. A. Short, R. C. Davis, and P. A. Morgan. 2000. Developing success criteria for restored eelgrass, salt marsh and mud flat habitats. *Ecological Engineering* 15:239–252.

Short, F. T., L. J. McKenzie, R. G. Coles, K. P. Vidler, and J. L. Gaeckle. 2006. SeagrassNet Manual for Scientific Monitoring of Seagrass Habitat. Worldwide edition. Durham, New Hampshire: University of New Hampshire. 75. p. www.seagrassnet.org