Chapter 8

Management considerations of eelgrass (*Zostera marina* L.) populations in Massachusetts

Resource assessment

It is generally agreed that eelgrass beds are important to the ecology of the coastal zone, but there is no consensus on how to manage this resource. The newly realized ecological, economic, and aesthetic value of eelgrass beds and the biological community they support has brought them under some local, state, and federal coastal resource regulations. Because there is no consistent management policy concerning eelgrass beds, it is worth considering how governmental agencies in Massachusetts manage these communities.

In general, the effects of eelgrass bed removal on coastal production and ecology are rarely considered. To date, most decisions in Massachusetts relating to eelgrass beds have centered on physical removal or damage from dredging projects, or pier construction. Rarely are changes in water quality induced by these or other projects considered, but potential changes in water quality may be weighed when the overall "health" of a bay is considered. Often the decision to dredge through an eelgrass bed is ultimately based on whether these beds also coincide with shellfish beds.

Federal, state, and local laws

The coast of Massachusetts is regulated principally by town conservation commissions, local planning boards, the State Department of Environmental Quality Engineering (DEQE), Army Corps of Engineers, Massachusetts Environmental Protection Agency (MEPA), and the State Coastal Zone Management (CZM). Most state regulations concerning coastal impacts are included in the state Wetland Regulations, (310 CMR 10.00).

In these regulations, eelgrass beds may enjoy protection under the law as "land under salt ponds" (10.33) where no project may affect "productivity of plants, and water quality". In "land containing shellfish" (10.34), and "land under the ocean" (10.25), there are broad guidelines protecting "water circulation", "water quality", and "marine productivity". Section 10.26 specifically states: "projects shall be designed and constructed, using best available measures so as to minimize adverse effects on marine fisheries caused by .... b) destruction of eelgrass (*Zostera marina*) beds". Thus, while destroying eelgrass beds is not prohibited, damage should be minimized.

In practice, coastal projects often do not go beyond the local conservation commissions. If they do, most decisions are managed by DEQE at the state level, but other state agencies (e.g. MEPA) may also be involved. In addition, CZM provides an advisory role at all levels of the decision making process and checks for consistency in local and federal regulations. Curiously, CZM policy guidelines (301 CMR 20.00) do not specifically include eelgrass beds as valuable underwater habitat, but in practice, this organization is interested in protecting eelgrass communities.

Large construction projects frequently must be approved by the US Army Corps of Engineers which considers eelgrass beds in there decisions. In recent years, the Corps has sponsored eelgrass transplant studies as a form of mitigation to disturbances (e.g. Fonseca et al., 1979, 1985; Goforth and Peeling, 1979).

Towns often have bylaws which may broadly cover coastal impacts, but no towns in Buzzards Bay have any bylaws specifically protecting eelgrass. Some local bylaws (e.g. Title V Amendments) extend the distance of septic tanks from shore (the "setback"), to further reduce the risk bacterial and viral contamination of shellfish. These laws indirectly benefit eelgrass beds because increased distance of septic tanks from shore reduces nutrient loading of bays (Valiela and Costa, in press).

Town conservation commissions may have broad powers to consider aesthetic and ecological impact of a project. While their decisions are based on both local and state laws, their decision is independent of state decisions, and technically they may prohibit a project even if approved by the state, although in practice, this is infrequent.

Most direct management of eelgrass beds, if any, is conducted by the town shellfish warden. In some towns, the shellfish warden may view existing eelgrass beds as valuable habitat, as is the case in Fairhaven, and harvesting shellfish in eelgrass beds may be discouraged. In other towns the shellfish warden may view eelgrass beds as a nuisance weed that reduce the quantity or quality of shellfish harvested, and the removal of eelgrass has been considered. Methods of eelgrass removal in the past were more extreme, and the application of the herbicide 2,4-D was attempted in Fairhaven in the 1960's (Fiske et al., 1968).

If there is an active policy by environmental managers today, it is usually toward conservation of eelgrass. In Westport, a large parcel of tidal flat, with extensive eelgrass coverage, is set aside as a shellfish refuge. On Nantucket, a multimillion dollar scallop industry is based within extensive eelgrass beds within a coastal lagoon. To reduce physical damage to the eelgrass beds by the scallop dredges, the shellfish warden has persuaded local fisherman to remove some weight from their scallop dredges so that they skim the surface, cropping eelgrass leaves, but leaving behind roots and rhizomes to regenerate.

At all levels of management, lack of knowledge about the importance of eelgrass, eelgrass bed locations, and the effects human impacts, has limited proper management of this resource.

Implications of changing eelgrass abundance

This study raises several questions relating to the management of eelgrass beds and interpretation of their changing abundance. It is apparent that most eelgrass disappeared in Buzzards Bay as a result of the wasting disease, then gradually recovered over many decades. Superimposed on this trend are complex patterns of destruction and recolonization driven by catastrophic storms, ice scour, and anthropogenic disturbance.

One consistent trend observed was the continual expansion of eelgrass on the outer coast and well flushed areas. Here, occasionally moderate declines in eelgrass abundance result from ice scouring and catastrophic storms, but these beds typically recover after several years. In contrast, many poorly flushed bays did not recover appreciably after the wasting disease, or showed major new declines with no subsequent recovery. These areas had known histories of anthropogenic disturbances such as fecal pollution, sediment resuspension, and wastewater loading through either direct discharges or via contaminated groundwater or stream flows. This trend is alarming because, unlike natural disturbances, eelgrass will not recover where human perturbation persists. Furthermore, many of these estuarine areas supported refuge eelgrass populations that facilitated eelgrass recovery after the wasting disease. Because beds in many of these areas have now disappeared, a recurrence of a wasting disease will have a longer lasting impact on the coastline.

This study adds to the growing literature showing seagrasses may disappear because of water quality decline, and that the disappearance of eelgrass may be a early warning sign that important changes are occurring in a coastal ecosystem.

Future monitoring

Throughout much of this report, eelgrass abundance was documented using fragments of information from many sources. A more thorough understanding of eelgrass dynamics can be achieved through continuous monitoring and by analyzing sediment cores.

The easiest way to monitor changes in eelgrass abundance is through periodic aerial surveys together with some field verification. This is a highly desirable approach because other aspects of coastal ecosystems, such as erosion rates, harbor usage, salt marsh bed loss, and drift algae accumulation will be documented as well.

One difficulty of using previous aerial surveys in this study was that the imagery was not taken with submerged features in mind, and field conditions were often unconducive to analysis. It is advisable that any town or agency conducting an aerial survey of the coastal zone, do so using the guidelines in Table 1. Routine vertical aerial surveys should be conducted at least once every 3 years, especially in valuable resource areas or embayments undergoing rapid development.

Sediment core analysis is the most accurate way of assessing past local fluctuations in eelgrass abundance during this and previous centuries. Furthermore, the physical and chemical characteristics of core sections, along with the remains of plants and animals, can document long term changes in nutrient levels, shellfish abundance, sediment depositional rates, rates pollutant inputs, nutrient loading, and macroalgal and periphyton abundance (Brush and Davis, 1984; Fry et al., 1987, unpub. data). Sites for coring should be chosen carefully, and best results are achieved in quiescent, depositional areas, away from erosion and dredging influences (Davis, 1985). Together with aerial surveys and other documentation, sediment core analysis is a powerful tool for understanding the recent ecological history of coastal waters.

One intriguing possibility that needs study is that the depth of eelgrass growth throughout the Bay may have declined slightly. If prior to urban and industrial inputs in Buzzards Bay, eelgrass grew 0.5 m deeper in each habitat throughout the region and was present in coves in which it is absent today, then total eelgrass area may have been 50 % greater than todays cover. This hypothesis is testable because changes in eelgrass depth distribution and relative contribution of eelgrass to primary production can be assessed by analyzing sediment cores.

Table 1. Guideline for taking aerial photographs to maximize interpretation of submerged features.

The guidelines and months are listed in approximate order of desirability.

-during October, September, August, July, June, November, and May

-within 2 hours of low tide

-low sun angle, preferably early morning

-low wind velocity (< 5 kts)

-at least 2 days after any severe storm or rain event

-color photography preferable to black & white, IR is undesirable

-overexposure by 1/2 to 1 f-stop

-polarized filter

Eelgrass can sequester heavy metals in its leaf tissue, and it has been suggested that eelgrass be used as an indicator organism for this type of pollution (Brix et al., 1983).

Mitigation efforts

In recent years there has been considerable effort to mitigate eelgrass habitat loss by transplanting eelgrass into areas where it was removed, or if that proves unfeasible, transplant it to other suitable habitat (Boorman et al., 1978; Churchill et al., 1978; Fonseca et al., 1985; Goforth and Peeling, 1979; Kenworthy et al., 1980; Phillips, 1974, Robilliard and Porter, 1976). There are several problems inherent in mitigation efforts in general. First it may take many years for an eelgrass community to fully recover after initial colonization or transplantation.

Often, coastal dredging increases depths to such an extant that habitat area is permanently lost. In these cases, bare areas nearby may be chosen as the site of transplantation. Because there may be hydrological or physiological reasons for the absence of eelgrass in these areas, transplant efforts to these areas often fail (Ranwell et al., 1978).

Nonetheless, sufficient number of projects have succeeded in reestablishing eelgrass where it has been removed. This approach, while experimental, has a role in coastal management. For example, transplantation may facilitate a more rapid recovery of eelgrass populations where there have been large losses due to storms, disease, or pollution. Transplanting as a form of mitigation, however, should not be used to rationalize incremental permanent loss of habitat.

Future management

Eelgrass beds are not well protected under current Massachusetts regulations, and a coherent management policy regarding eelgrass beds should be formulated, especially because eelgrass is declining in some Bays. Because salt marshes are rigorously protected in Massachusetts, as maps of eelgrass abundance become available, the question will arise: should eelgrass beds be regulated as carefully as salt marshes? To answer this question, comparisons between the two communities can highlight potential management strategies.

Eelgrass beds are more abundant and productive than salt marshes, and are a dominant feature of nearshore waters in Buzzards Bay. These two ecosystems are host to different communities of organisms, and each serves a different ecological role. Salt marshes build dense layers of peat over decades and centuries which become an intrinsic part of the stability and biology of those communities. Eelgrass beds do not form peat mats, and although they change the chemistry and biological components of the sediments (Orth, 1973, 1977), the time to create an eelgrass habitat after initial colonization is shorter than the time to create a mature salt marsh community. Furthermore, the range of habitats that eelgrass can colonize is more diverse and expansive than the habitats available to salt marshes. Some eelgrass beds are seasonal or may appear on marginal habitat only intermittently.

Given these characteristics of eelgrass beds, the main priority in regulating physical disturbances should be to prevent alterations to the environment that permanently eliminates eelgrass habitat. Dredging and construction in shallow, poorly flushed bays is especially critical because water transparency in these areas is usually poor, and channels dredged for boats are often so deep and so disturbed that eelgrass can never grow there, and habitat area is lost. Construction of a single private boat channel may result in the removal of only 5% or less of existing eelgrass cover in a bay, but permitting channels to be dredged to every private dock may result in intolerably large losses.

Small physical disturbances like eelgrass removal during shellfish harvesting with rakes or tongs are probably unimportant for bed survival under low intensity (Costa, 1988, and in prep.), but high intensity shellfishing efforts, or continued dredging from boats can remove large areas of eelgrass beds, as well as increase sediment resuspension and decrease water transparency.

Past declines of eelgrass due to physical removal, however, have been less important in Buzzards Bay as a whole, than losses due to general declines in water quality. This is understandable because eelgrass beds are subtidal, and their distribution is light limited. In contrast, protecting salt marshes from nutrient loading is rarely an issue, because salt marsh production is enhanced by added nutrients (Valiela et al., 1975).

Because water quality declines are often due to many sources, and often difficult to quantify or assess, some managers view protection of eelgrass beds from water quality declines as uneconomical or unworthy. This view is short sighted, because eelgrass beds are closely linked to the ecology of coastal waters. Many other species besides eelgrass are also affected by water quality declines or disappearance of eelgrass. Beaches and shellfish beds may be closed due to fecal coliform contamination. Shellfish habitat may disappear because dense growths of drift algae form an impenetrable layer preventing oxygenated water from reaching the bottom (Lee and Olsen, 1985), smothering bivalves and other infauna. This dense growth may create such a high oxygen demand during quiescent summer periods that anoxic events may occur resulting in fish kills. Excessive algal growth sometimes release displeasing odors or cover beaches, making them unaesthetic. Other synergistic effects are now being realized. Algal growth, decreased water transparency, and nutrient loading facilitates fecal coliform survival or even promotes growth (Heufelder, 1985).

Thus, eelgrass beds are merely one component of coastal waters that are sensitive to declining water quality. In many areas, the loss of eelgrass could have been used as an early warning for more damaging changes that were to occur; that is, eelgrass bed declines may be used as a tool for diagnosing the "health" of a bay. Protecting water quality should be a primary goal of coastal managers, not only because eelgrass beds are protected, but because other valuable resources are protected as well.

Water quality protection

Declines in water quality are due to many sources, some of which are difficult to control. For example, resuspension of sediments caused by boat motor use in shallow bays can only be reduced if either there is less boat traffic, enforced speed limits, or exclusion zones. Dredging projects not only eliminate eelgrass habitat, but generate high sediment loads. Some operations such as "jet-clamming",--the harvest shellfish by resuspending large volumes of sediment--could potentially have strong impacts on water quality because this process creates large sediment plumes and releases nutrients from sediment pore water. Serious questions must be answered before this technique becomes widespread.

Land based sewage disposal nearshore and sewage discharge offshore are two of the most serious problems affecting Buzzards Bay. New Bedford now discharges secondarily treated sewage offshore. The turbid plume from this outfall is conspicuous from air, and the several hundred meter wide plume often stretches 1000's into waters of neighboring towns.

Smaller outfalls from street run-off are common throughout the region. In some bays, nutrient inputs through these is small compared to other sources (Valiela and Costa, in press), but they may be important sources of pathogens and other pollutants (Heufelder, 1985).

A more widespread problem in the region is the siting of septic tanks nearshore. One of the difficulties with coastal management in

Massachusetts is that nutrients are not considered pollutants. Septic tanks and leaching systems are designed to reduce contamination of bacterial pathogens into groundwater; even a properly constructed septic tanks release large volumes of nutrients into the groundwater. When the State considers an application for a septic tank nearshore, it considers only the impact of a single proposed project on public health, rather than the effects of similar projects on water quality and nutrient loading. Because it is difficult to demonstrate that nutrients from a single septic will have a deleterious impact on a bay, such projects are usually approved, even if serious water quality declines would occur if every parcel of land along shore were similarly developed.

Presently, Massachusetts guidelines specify that these systems may not be placed within 15 m (50 ft) of wetlands or bodies of water (the "setback"). Many towns have set their own stringent setback bylaws, because the state regulations are viewed by many as inadequate to protect the publics interest in the coastal system. This is a positive step, but what is needed is town planning boards to set maximum nutrient loading limits for watersheds, and State managers to accept nutrient loading as a form of pollution, and hence regulate it.

Appendix I--Repositories of aerial photographs and nautical charts used in study.

Aero Service Division
Western Geophysical Company
8100 Westpark Dr.
Houston, TX 77063
(713) 784-5800

Col-East, Inc.
Harriman Airport
North Adams, MA 01830
(413) 664-6769

Lockwood, Kesseler & Bartlett, Inc.
1 Aerial Way
Syosset, NY 11791
(516) 938-0600

Lockwood Mapping Inc.
1 Aerial Way
Syosset, NY 14623
WHOI Woods Hole Oceanographic Institution
Woods Hole, MA 02543
(617) 548-1400

James W. Sewall Co.
147 Center St.
Old Town, ME 04468
(207) 827-4456

Town offices in Falmouth, Bourne, Wareham, Dartmouth, New Bedford, Fairhaven, Mattapoisett, and Marion

New Bedford Whaling Museum
New Bedford, MA 02740

Woods Hole Oceanographic Institution
Document Archives
Woods Hole, MA 02543
(617) 548-3705

Agricultural Stabilization and Conservation Service
Aerial Photography Field Office
US Department of Agriculture
2222 W. 2300 South
PO Box 30010

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Salt Lake City, UT 84125
(801) 524-5856

EROS Data Center
U.S. Geologic Survey
Sioux Falls, SD 57198
(605) 594-6511 x151

National Cartographic Information
Center
U.S. Geological Survey
507 National Center
Reston, VA 22090
(703) 860-6336

National Ocean Survey
Coastal Mapping Division, 03415
NOAA
Rockville, MD 20852

Massachusetts Geodetic Survey
Boston, MA

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