Marine Extension Bulletin

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Woods Hole Sea Grant Program
Cape Cod Cooperative Extension

A Primer on Beach Raking

Introduction

Beaches are important for recreational use, and a big reason why so many visit and/or live near the water, however they also provide a host of services that may not be as obvious. Coastal beaches and dunes reduce storm damage flooding by dissipating wave energy, by reducing the height of storm waves, and by providing sediment to other coastal areas. A number of birds also nest and/or forage for food in coastal dunes and beaches.

Beach raking is practiced in many communities on Cape Cod, throughout the US, and the rest of the beach-going world. The term describes a variety of methods of grooming, raking, sieving, and cleaning sand to remove material (e.g., litter, seaweed, rocks) from a beach. While most beach-goers appreciate a nice patch of sand devoid of cobbles and seaweed, these things come naturally to the beach and the entire coastal system requires these materials to function normally. Removal of these natural beach ingredients from the shoreline can have significant impacts to aesthetics, economics, sanitation, shoreline stability, the ecosystem, and threatened/endangered species.

Cleaning activities such as mechanized sand rakes pulled behind tractors and other larger scale beach management actions require local and state permitting. Even small scale shoreline management activities done by hand or with hand tools (e.g. raking, shoveling) may require authorization from your local conservation commission. Driving any vehicle on the beach can have negative effects. Off-Road Vehicle (ORV) tires can crush plant roots (and burrowing crustaceans) up to a depth of 8" (Leatherman and Godfrey, 1978). This is why the state (CZM, 1994) recommends that ORV beach driving be restricted to at least 10' away from the Spring High Tide Line, which is typically located near the toe of the dune. Note that some areas that allow ORVs, such as Duxbury Beach, require that the ORV drive at least 20 feet from the base of dune or vegetation line to protect the fragile root system (rhizomes).

A mechanical sand rake being pulled behind a tractor, along with the tracks made by this system.

Left to right: trash/marine debris, rocks, seaweed/wrack.

Tractors that pull mechanical beach rakes will have tires that would affect the beach in a similar fashion, in addition to the rake tines which can extend >6" below the beach surface. Mechanical raking is one of the most destructive forms of human actions to beach vegetation. According to a New Jersey study (Kelly, 2014) mechanical raking removes more (-99%) beach vegetation than ORV use (-86%) or even beach scraping (-91%). This is particularly concerning as coastal plants reduce wave height, provide wildlife habitat, the roots reduce erosion, and reduce storm surge by absorbing water, then slowly releasing it.

The buildup of seaweed on the shore can cause a foul odor and large cobbles may not be as comfortable as soft sand, but these materials are desirable to the beach and dune environment. Less desirable are the man-made debris (e.g., soiled diapers, cigarette butts, plastic bags, straws, aluminum cans, etc.) that arrive with the tide or are directly left behind by beach-goers. These three types of materials on the beach (marine debris, rocks, and wrack) are most often what people want off the beach.

Top Ten Debris Items for 2015

Rank	Debris Item	Amount
1	Cigarettes/Cigarette Filters	31,965
2	Plastic Beverage Bottles	11,240
3	Food Wrappers	10,131
4	Plastic Bottle Caps	8,301
5	Other Plastic Bags	5,170
6	Straws/Stirrers	3,622
7	Beverage Cans	3,324
8	Other Plastic and Foam Packaging	2,782
9	Metal Bottle Caps	2,265
10	Glass Beverage Bottles	1,847

This list of the top 10 items found along the Massachusetts coast in 2015 (the latest data available) shows the typical types of debris commonly collected during COASTSWEEP. Source: http://www.mass.gov/eea/agencies/czm/program-areas/communications/coastsweep/about.html

Managing Marine Debris

What is it?

Marine Debris is anything made by humans and either left at the beach by visitors or washed up on the beach from offshore. More than half of marine debris comes from the land, such as when trash blows or is washed into the ocean or into rivers, streams, and storm drains that run to the sea. Only about 10 percent of the marine debris comes from ocean-based activities, such as boating and fishing (COASTSWEEP, 2015).

Value to beach?

There is no value to the coastal system from this material. Much of this material, such as plastics, do not biodegrade and can last for hundreds of years. This material can be dangerous to a variety of species (through ingestion and entanglement), destructive to habitats, as well as a hazard to navigation.

Recommendations

Trash should always be removed from the beach and dunes. Care should be taken not to disturb natural habitat or vegetation during removal. Beach staff should be trained to avoid damaging beach grass when entering the dune to remove trash by hand. It would only be on long stretches of beach, with large amounts of trash, that a mechanical rake would be worth the potential environmental damage to remove trash. For smaller beaches volunteer clean-ups (such as COASTSWEEP) can be effective.

For more information on marine debris go to the NOAA Marine Debris Program website (https://marinedebris.noaa.gov/)

Managing Seaweed (Wrack)

What is it?

Seaweed is any plant that grows in the ocean, including vascular plants (e.g. eelgrass) and macroalgae (ex. kelp, sea lettuce, codium). Note that while there are many types of algae, any algae that would form a visible pile on the beach would be considered macroalgae. When seaweed is ripped from the bottom (often during storms) rafts of dead floating plant material form, called wrack. This material can wash up onto the beach and form a wrack line, which can also incorporate shells, seeds, dead fish, shellfish, bugs, and other debris. A hazard to health may occur when wildlife, waterfowl, and domestic animal waste becomes incorporated in the wrack (Buzzards Bay CCMP, 1991.

Value to beach?

Wrack is an important source of food for small crustaceans and a preferred feeding habitat for many species of coastal water birds including piping plovers. There can be significant ecological effects from the disturbance and removal of organic material, food resources, and habitat that are associated with beach grooming (Dugan et al, 2003). Additionally, the wrack line catches wind blown sand which helps build beaches and dunes, increasing their ability to provide storm damage and flood protection. Wrack can contain plants and/or seeds. This along with the decomposition of wrack helps to "fertilize" the area promoting growth of beach grass. These incipient dunes increase topographic variability and thereby the number and types of habitats for plants and animals (Nordstrom et al, 2012).

There are some forms of invasive seaweed that seem to have more negative aesthetic and recreational impacts on the beach than native species (ex. codium vs. eelgrass). For example, while eelgrass tends to grow in a sandy substrate, the invasive macroalgae *Codium Fragile* tends to anchor to shells (ex. slipper shells). When codium washes up onto the beach it can drag a significant number of live slipper shells (*Crepidula fornicata*) along for the ride. As these animals die off the odors can be quite noxious. Codium itself can be quite high in nitrogen (up to 0.5 lbs per cubic yard in a 2003 Cape Cod Cooperative Extension analysis) and decomposition and flow back into a restricted water body can affect water quality.

Recommendations

Due to its value to the coastal system seaweed should be left in place if possible. There are two main reasons to remove wrack from the beach: 1) to improve the recreational value; and 2) to decrease the potentially harmful bacteria that can become incorporated in the wrack. Beaches are a huge economic driver in Massachusetts (for 2012 domestic and international tourism in Massachusetts amounted to $28.2 billion, MOMP 2015), however the reduction in beach space and smell may drive tourist dollars away from designated recreational beaches. If wrack removal can be performed with minimal negative impacts to the coastal system, it might be permitted in some cases depending on volumes, odor, etc. Laboratory experiments and field observations clearly show the potential for wrack to be a significant factor influencing fecal coliform levels. Studies have indicated that trying to improve water quality (i.e. human pathogen) by removing wrack is questionable (likely only to show major water quality improvement in poorly flushed areas) and probably impractical on a large scale, it does not appear that this is a priority management option (Buzzards Bay CCMP, 1991). However, if the local Health Department determines that the bacteria associated with the wrack constitutes a threat to public health and/or safety the seaweed should be removed. In many cases this can be addressed without mechanized equipment.

For more information and valuable recommendations on removal and disposal of wrack read the 2013 MassCZM guidance document "Managing Seaweed Accumulations on Recreational Beaches".

Managing Rocks

What is it?

Boulders, rocks, sand, silt, and clay are all size fractions of sediment that are moved along the coast by wind, waves, and/or currents. Sediment is typically classified by grain size according to the Wentworth scale (see a simplified scale to the right). Much of the sediment along the shoreline in southeast Massachusetts is glacial in origin. Thousands of years ago flowing ice transported all of these various grain sizes from as far away as Canada to what is now our present shoreline. Along the historic melt edge of these glaciers one can find the large size classes, such as boulders, cobbles, pebbles, etc. Floodplain deposits are found away from the melt edge and comprised of smaller particles (gravel to clay) as the glacial streams could only transport the smaller particles. Beaches and dunes are typically composed of well-sorted sand sized particles, however some cobble beaches and berms do form. Also represented are mixed sediment beaches, where the grain size ranges from sand to gravel and cobble. Due to the glacial origin of the beaches

< 0.125 mm
Silt and Clay

0.0625 – 0.125 mm
Very Fine Sand

0.125 – .025mm
Fine Sand

0.25 – .05mm
Medium Sand

0.5 – 1.0mm
Coarse Sand

1.0 – 2.0mm
Very Coarse Sand

2 – 15mm
Fine Gravel

15 – 64mm Coarse
Gravel

of Massachusetts they have a relatively low (typically <10%) shell content, compared to other states (i.e. some Florida beaches have > 90% shell). While shell fragments are considered sediment, and may fit within the size classification of sand, they typically deteriorate more quickly.

Value to system?

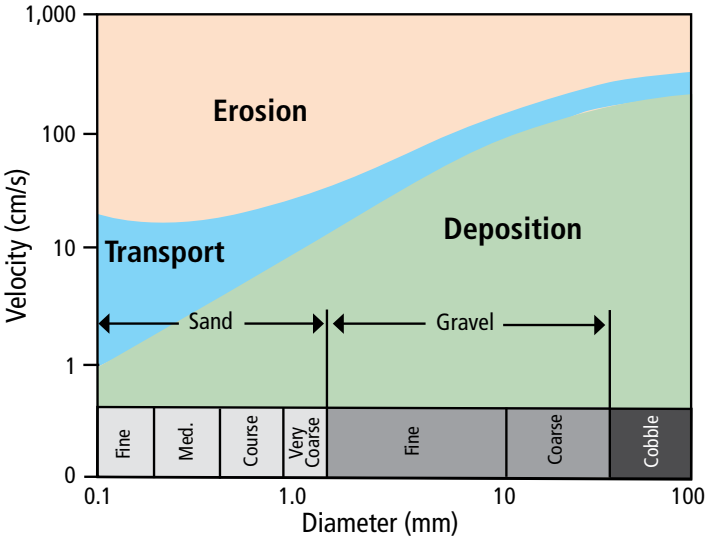
The erosion of glacial material is the primary source for beaches and dunes in southeast Massachusetts. Many of the different grain sizes may be present, however over time the wave energy at a location will winnow out smaller material and leave behind the coarser grain sizes appropriate to that beach's wave energy. The sediment that comprises the beaches and dunes of a coastal system provide storm damage and flooding protection to inland properties and infrastructure, as well as being important wildlife habitat. When more sediment is leaving than is coming in to a specific location it is called erosion. Sediment compaction can be significantly lower at raked compared to unraked beaches (Center for Coastal Studies, 2012-2015). Lowered compaction, along with associated drier conditions, leads to fine grain sediment being eroded and more easily lost to the beach system (Nordstrom et al, 2010). Rocks and sand reduce wave energy thereby providing storm damage protection. Removing rocks decreases the volume of the beach making it more vulnerable to storm damage and erosion. The longer sediment (i.e. rocks and sand) stays on a managed beach the less often expensive beach nourishment efforts must be undertaken to maintain the same level of protection provided by the coastal system to the upland.

Recommendations

Removing the large size particles (coarse gravel and cobbles) from the beach can reduce the level of storm damage protection. Also, this removal effectively reduces the grain size of the beach which may allow for more rapid erosion (even during non-storm conditions) of the remaining sediment and therefore make the beach more costly to maintain. Nourishing a beach with material that is slightly coarser than existing conditions will likely last longer than finer sediment, however there may be a negative recreational or aesthetic impact.

64 – 256mm Cobble

> 256mm Boulder



Hjulstrom's diagram, shorthened to typical beach grain sizes. Note that erosion occurs at lower velocity with smaller grain size while deposition can occur at higher velocity with larger grain size.

Removing sediment during raking artificially erodes the beach, however it preferentially removes the larger rocks and cobbles, as opposed to natural erosion, where the smaller grain size is removed first. Natural erosion can leave behind a lag deposit of larger grain size, which makes the beach more resistant to additional erosion. Raking away the rocks makes the beach more vulnerable to erosion.

There is almost never a good reason to remove sediment from an eroding beach. A rare case might be made if nourishment material is placed on a beach and the grainsize is significantly larger than the existing beach, however it would be better to screen out the larger rocks before placing it on the beach to begin with. If a smaller grain size is desired for recreational purposes it is usually better to add a veneer of the desired material on top of the existing beach (knowing it may not last as long as the naturally sorted grain size), instead of removing volume from the beach. This material should be added at the beginning of the recreation beach season, as much of the veneer would be expected to erode away during winter storms.

For more information on the beach compatibility of sediment read the 2007 document "Beach Nourishment: MassDEP's Guide to Best Management Practices for Projects in Massachusetts".

Monitoring Raking Impacts

Removal of rock is not recommended and therefore monitoring recommendations are not provided. Trash removal by hand would likely have minimal environmental impacts and therefore not require monitoring. It is the large-scale hand raking of wrack and the mechanical raking of trash and/or wrack from the beach that would require monitoring to show no adverse impact to the coastal system. Each site is different, however some parameters that might be included in monitoring are: beach morphology (profiles), sediment compaction, wrack cover, invertebrate counts, and bacterial counts. Beach profiles may suggest that the morphology of raked sites evolves differently from the unraked sites, however many years of study (pre and post raking) would be needed to definitively show that the beach raking has had a negative impact that would require mitigation or other management response (Center for Coastal Studies, 2012-2015).

Summary

Raking can be appropriate in some locations to serve safety, sanitary, aesthetic, and economic purposes, but the challenge is to find a balance that serves those needs as well as takes into account the value of the shoreline stability and environment. Raking should not change the form or function of the coastal beach and dune system.

General BMPs

[Rule of Thumb]: In general, it is always OK to remove marine debris, sometimes OK to remove seaweed, never OK to remove rocks.

Always obtain the required permits. At a minimum, approval from the local Conservation Commission would be required under the state Wetlands Protection Act to ensure that any raking will not have an adverse effect by increasing erosion, decreasing the volume, changing the form or disturbing the vegetative cover of the beach/dune system. If the site is mapped as priority or estimated habitat, then Massachusetts Endangered Species Act (MESA) review may be required to ensure that the raking will not have an adverse effect on state and federally listed species and their habitats. For example, if plovers or terns are present, beach raking will require MESA approval and will very likely require shorebird monitoring during the raking operation. Raking will be limited to areas outside of symbolically fenced nesting habitat and there may be seasonal restrictions that prohibit or limit raking when unfledged chicks are present. Additionally, preservation of some wrack would be required in nesting/feeding/sheltering areas.

It is highly recommended to create a beach management plan for any beach where beach raking might occur. Areas that are intensively used for recreational purposes might not have the same potential for environmental damage as more natural areas. Most plans keep the proposed area to be raked to a minimum (e.g. only high use recreational sections of beach). With a plan, and all applicable permits, in place before the recreational beach season begins there should be little question as to the appropriate management method for a given situation.

If feasible, raking by hand is preferred over mechanical raking due to the additional environmental impacts associated with larger machines and driving on the beach. Even when hand raking, try not to walk on vegetation and only rake as deep as needed.

Raking typically occurs from the MHW line to 10' from the spring high tide (which is usually near the seaward toe of the dune) in order to allow for dune migration and vegetation to grow. Some beach management plans have a 20' buffer from vegetation in order not to impact the existing plants and allow room to grow.

Keep the depth of mechanical raking (i.e. how far the tines extend) to above the surface of the beach to minimize disturbance. The frequency and area of raking should also be minimized to the minimum needed to allow mixed-use of the beach. Heavy machine operators (often municipal DPW staff) should be made aware of ecologically sound procedures to rake the beaches

Additional Information

Managing Seaweed Accumulations on Recreational Beaches, Guidance from the Massachusetts Office of Coastal Zone Management, May 2013.

Guidelines for Barrier Beach Management in Massachusetts, Massachusetts Office of Coastal Zone Management, February 1994.

Beach Nourishment: MassDEP's Guide to Best Management Practices for Projects in Massachusetts, March 2007.

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https://marinedebris.noaa.gov/

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Sources

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Woods Hole Sea Grant
Woods Hole Oceanographic Institution
193 Oyster Pond Road, MS #2
Woods Hole, MA 02543-1525
508.289.2398
www.whoi.edu/seagrant
www.facebook.com/woodsholeseagrant
www.twitter.com/woodsholeseagnt
www.youtube.com/woodsholeseagrant

Cape Cod Cooperative Extension
P.O. Box 367, Barnstable, MA 02630-0367
508.375.6849
Fax 508.362.4923
www.capecodextension.org

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