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HABITAT RESTORATION  
ENVIRONMENTAL MANAGEMENT



## MANAGING BAYSIDE EROSION: 22 ALTERNATIVES

*This publication provides educational information on Erosion Management Alternatives for limited fetch, Bayside Erosion in the Cape Cod Region. The Alternatives Analysis considers relevant Ecological, Financial and Social values. Storms are interactions of energy and mass. Innovative alternatives in the emerging field of Storm Energy Management are included; Always consider combining erosion management systems. Limited Coastal Process descriptions, recommendations, costs and techniques described here may be locally representative and are not intended to be completely comprehensive. [www.SafeHarborEnv.Com](http://www.SafeHarborEnv.Com) By Gordon Peabody, Director, Safe Harbor, 2019 [gordonpeabody@gmail.com](mailto:gordonpeabody@gmail.com)*

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**I. INTRODUCTION:** Safe Harbor is a small, environmental consulting group on Cape Cod. Our focus includes developing experimental coastal restoration systems powered by storm energy. We provide no charge, initial site consultations. These management strategies are intended for Bayside erosion generated by short fetch, 4-40 mile waves.

**Background:** Bayside landforms are predominantly *Coastal Banks*, from 6 to over 100 feet high. Banks are glacially compacted sand, stones and clay, referred to as "*consolidated sediments*". *Sand Dunes* are "*unconsolidated sediments*" created by wind deposition, found only on limited sections of coastline. Dunes are discussed under Biomimicry and Sand Fencing. Learn to recognize Sand Dunes from Coastal Banks.

**COASTAL BANK PROFILES** include: the top of the bank (**Bluff**); the **Face**, sometimes referred to as a **Scarp** when eroding; and the **Toe** of the Bank where the bank meets the beach. **Beaches** are usually designated by seasonal erosion patterns: **upper** (winter) and **lower** (summer). **Intertidal zones** and near shore **sandbars** play a role in the bayside coastal process and are discussed here. **Safe Harbor views adjacent resources:** bluff area on top of bank; sloped face; eroding scarp; toe of bank; beaches; intertidal zone; and sandbars, as **“Linked Systems”**, because **they respond to storm energy as systems**. **Interactions between storm energy and these linked, coastal resource systems define the Coastal Process, specific for each section of coastline.**

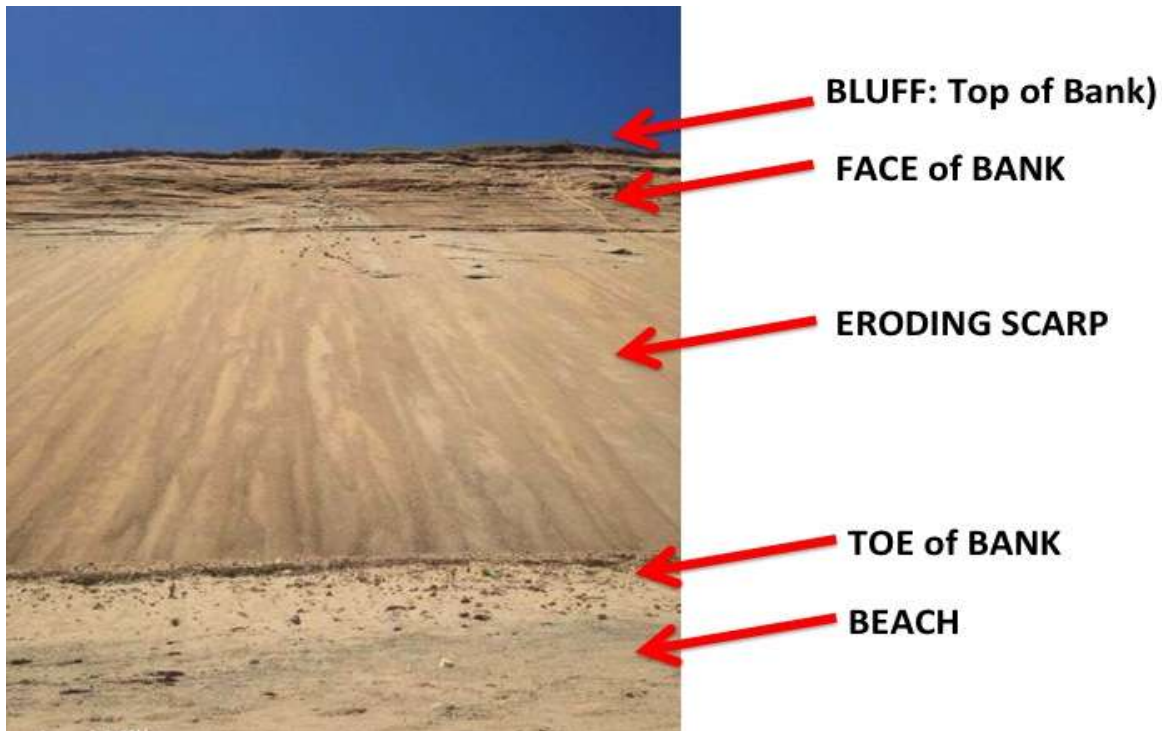


Image by Janci Miller. Coastal bank components are “Linked Systems”.

**COASTAL BANK PROFILES** include: the top of the bank (**Bluff**); the **Face**, sometimes when eroding, referred to as a **Scarp**; and the **Toe** of the Bank where the bank meets the beach. **Beach profiles** may be characterized by seasonal erosion patterns: the shorter, **winter beach** and the longer, **summer beach**. Between the high tide line and low tide line, the **intertidal zone** includes **near shore sandbars**. Sandbars play an important role in the bayside coastal process. We consider **adjacent resources:** bluff above bank; sloped bank face or eroding scarp; toe of bank; beach; intertidal zone; and sandbars, as **“Linked Resource Systems”**. Resources don’t respond to storm energy individually but as systems. They are linked by energy, defining the Coastal Process.



*Image by Odessa Bricault. Wave energy removing sand, Cape Cod.*



*Image by G. Peabody. When wave energy synergizes with incoming tidal energy, the potential exists for large amounts of sand mass transport downdrift.*

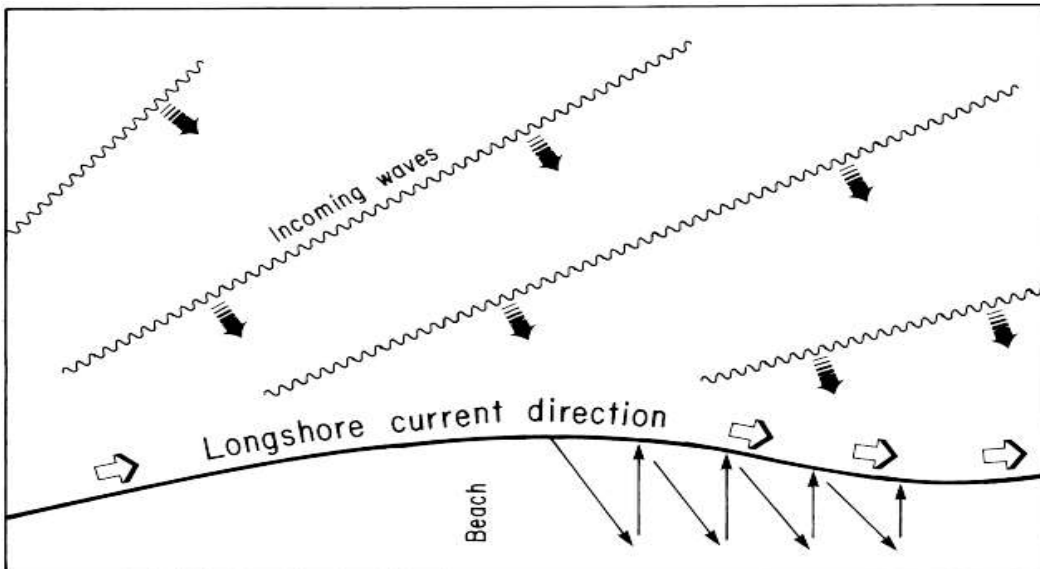


Image above: Seasonal storms, waves and tide currents, move sand from **up-drift to downdrift** along beaches and back-and-forth between beaches and bars.

Wave erosion and tide currents contribute to the creation and movement of **Sandbars**, transporting sand updrift to downdrift. The **Benthic Profile** (underwater shape) of sandbars contributes to storm protection because **Benthic Friction** absorbs energy, reducing wave height. We believe beaches and sandbars are linked by storm energy because sand and energy are exchanged as they respond to storms as a system.



Image by Google Earth. Above image shows a near shore sandbar in a longshore **Transit Corridor** (path) of moving sand. Sand is transported over time, updrift to downdrift.

**Coastal beaches absorb and diminish storm wave energy**, providing erosion protection for the coastal bank. On a sloping beach, wave energy will remove sand, transforming the beach to a more horizontal profile. Horizontal beach profiles allow direct wave access to the toe of the coastal bank. A coastal bank with a toe has an extra layer of protection to absorb wave energy. When the toe absorbs wave energy, erosion moves toe materials seaward, onto the beach. This process transitions the toe profile to horizontal, exposing the lower coastal bank to wave energy. When the lower coastal bank absorbs wave energy, erosion moves bank materials onto the beach. Often, a section of unsupported upper bank will now collapse, creating a new toe, restoring the coastal profile.

The **Coastal Process reflects synergistic interactions between Cofactors**: Coastal profiles (topographic and benthic); Tidal cycles; Directional wind and wave energy; Directional storm energy; storm duration and surge. The synergistic probability of **cofactor interaction is based on uncertainty**. During these, limited, synergistic periods, exponential erosion and deposition events are possible.

Long term, erosion and deposition trends may be categorized as: **dynamic equilibrium** (balanced); **overall net loss**; **overall net gain**. Most Bayside coastal areas can be characterized as overall net loss. This can be the sum of annual variables. **Annual variables** may collectively result in decadal, zero net loss, followed by single year of cumulative net loss. Bayside area erosion can be referenced using the image on page 8.



*Image by G. Peabody.* Coastal bank has collapsed to restore the eroded (missing) toe.

**Downdrift deposition** requires **available sand updrift**. Updrift, Bayside sand availability may be influenced by: Seasonal or annual variables resulting in net loss; Perpendicular, coastal erosion control structures such as groins and jetties; Coastal bank sea walls and revetments. The resulting lack of available sand in transit corridors may also contribute to lower profile sandbars, potentially reducing storm wave protection. These cumulative, updrift factors set the stage for chronic, net loss along many Cape Cod Bayside coastal bank and beach systems. Activities, structures and policies diminishing available sand supply, or any physical changes to transit corridors, may contribute to higher rates of Bayside bank collapse. Bayside erosion management systems are usually required to renourish, to maintain “**Performance Standards**” of the resource system but this is often difficult to track.

**Review:** Let’s review some of the relevant principles of the **Bayside Coastal Process: Coastal Profile** bluff, face, scarp, toe, beaches, intertidal zone and sandbars, may respond to storm energy as **Linked Resource Systems**; Different coastal profiles may erode at **differential rates, over time**; Significant erosion is more likely during the high tide cycle and most likely during a storm surge; Coastal bank erosion occurs at the toe of the coastal bank; Over time, “updrift” sections of coastal bank will continue to contribute new sand to “downdrift” deposition sites; Erosion events can be influenced by **a synergy of variables, constants and uncertainty**; Storms are interactions of energy (wind/wave/tide) and mass (sand); **Storm energy, a driving force of the Coastal Process**, integrates process with profile. **Evaluations** should be site-specific. **Coastal Communities** and **Coastal Resources need each other** to remain sustainable.



*Image by G. Peabody.* Naturally resilient vegetation should be encouraged and protected. Vegetated shorelines are the most sustainable form of natural, erosion management.

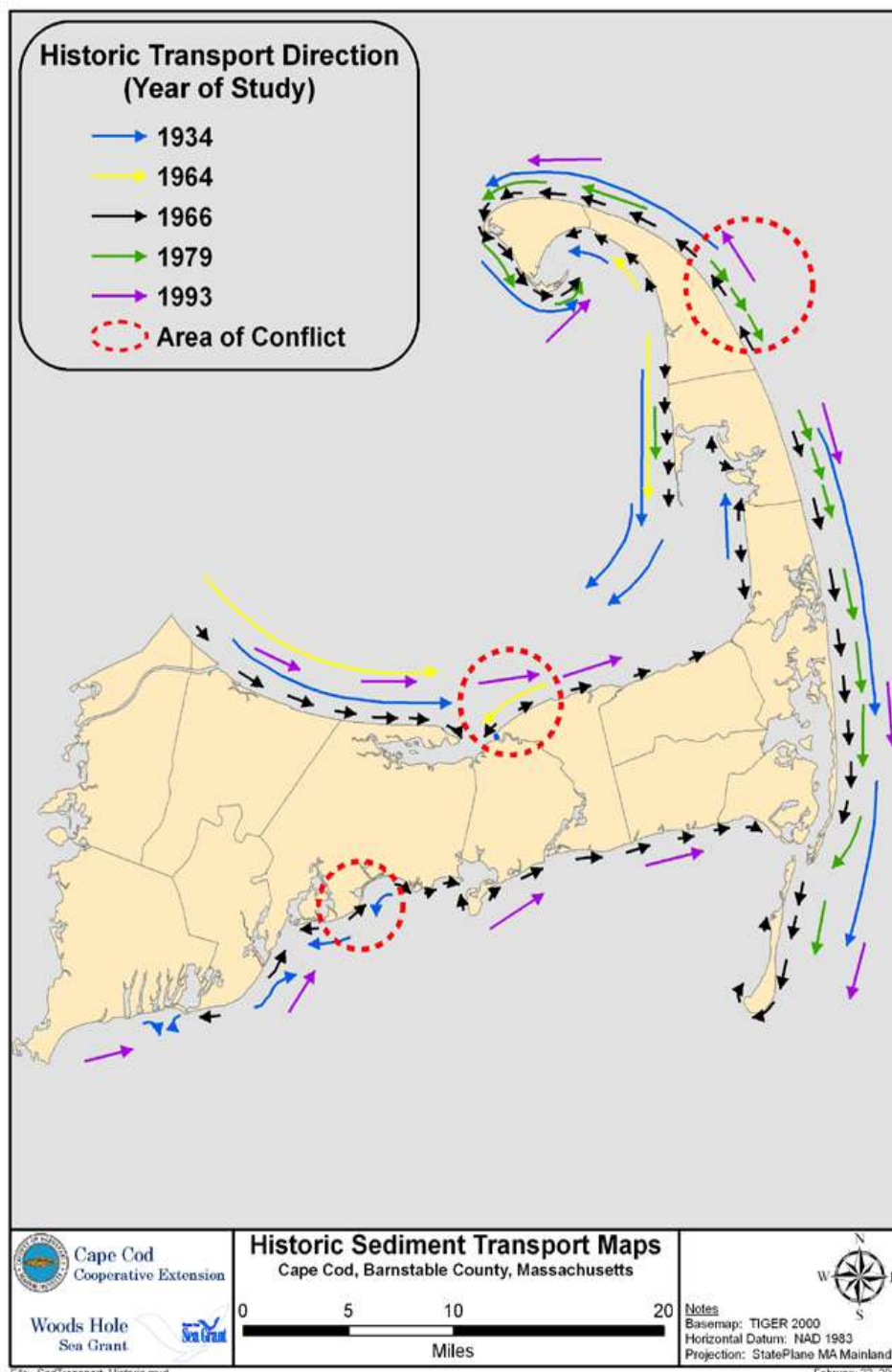


Image above by G. Berman, 2012. Overall Cape Cod sand transport patterns.

When we carefully review the above image, it becomes clear that several **Sediment “Sinks”** or destinations, exist on Cape Cod. Harbors may experience stronger incoming tidal currents than adjacent areas; these factors may influence erosion or deposition when storm events occur on a particular portion of the tidal cycle. Surges may influence the tidal prism by delaying low tide. In recent years, sudden sea level rise (SLR) events followed breaches on barrier beaches.



## II. NO-ACTION ALTERNATIVE



*Image by G. Peabody.* Increases in SLR or storms will increase erosion rates.

a). Costs: No costs until jurisdictional entities require removal (approx. \$20K).



*Image by Cape Cod Times.* A few years prior, this house had been moved back from dune.

b). Consequences: Continuing pattern of coastal erosion along adjacent coastline will determine timeline for property loss and structure risk. Removal of debris may be costly and include fines. Heavy equipment vibrations create secondary risks when activity approaches edge of eroding bank; crane is safer but expensive.

### III. STRUCTURAL ALTERNATIVES

#### **1. Structural Alternatives: Bulkhead**



*Image by G. Peabody.* Surging waves with nowhere to dissipate their energy.



*Image by G. Peabody.* Bulkheads change erosion patterns on site.

a). Costs: High; several hundred dollars/linear ft.; sheathing systems less expensive.

b). Consequences: Major impacts to beach and coastal banks during implementation. There may be restrictions on materials. Bulkheads are only permitted where they have been pre-existing or when the home was built before 1978. Continued nourishment is required to offset downdrift, Coastal Process sediment flow. End scour often a problem.



Image above: Classic “End Scour” from redirected wave energy and failure to nourish.

## 2. Structural Alternatives: Revetment



*Image by G. Peabody.* Revetments impact the coastal process by interrupting bank-to-beach sediment flow. The stones should be covered with nourishment and renourished when storm energy removes the sand. This has impacts on alongshore sand transport.



*Image by G. Peabody.* Installing revetment components requires heavy equipment usage and subsequent impacts to the resource area and Buffer Zone.

- a). Costs: High; up to \$700/ft.; boulders; nourishment; heavy equipment access.
- b). Consequences: Significant construction impacts to beach and coastal bank. Ongoing nourishment; neighboring property may “end scour”. Interruption of longshore transport may impact downdrift resource area coastal processes.



*Image by Google Earth.* Stone revetments may create “end scour” on adjacent property.

### **3. Structural Alternatives: Gabions**

- a). Costs: Medium \$200/ft.; stones; nourishment; installation equipment access.
- b). Consequences: Stones in wire baskets not recommended for all exposures. Wire containers prone to rust and breakouts from movement of contained stones.



*Image by K. Andres. Gabions installed in Chatham, MA.*

#### **IV. SEMI-SOFT ALTERNATIVES**

##### **1. Semi-Soft Alternatives: Step Blocks**



*Image by G. Peabody. This Riverine Erosion system is being used experimentally.*

**a). Costs:** Medium; complex implementation requirements. Sand/soil contained in jute/geo mat logs require cover of sand nourishment and native vegetation plantings. Labor-intensive installation (approx. \$400/linear ft.).

**b). Consequences:** Not rated for wave impacts in velocity zones. When storm events remove nourishment, logs can deteriorate rapidly during wave impact in subsequent storm events; renourishment and replanting may be required.



*Image by G. Peabody. Exposed step blocks are vulnerable to deterioration.*

## **2. Semi-Soft Alternatives: Coir Rolls**



*Image by G. Peabody. Coir are coconut husks wrapped in heavy fiber, wire or both.*

a). Costs: Medium; coir material; helical anchors; nourishment sand; plants. Requires equipment and materials access and activity on beach.

b). Consequences: Coir is not recommended for velocity zones (waves) or use without nourishment. Ongoing renourishment and replanting may be necessary. Improper installation can allow detachment of coir from anchoring system during storm event wave impacts. Some Towns require escrow to warranty continuing renourishment following erosion events.



*Image by G. Peabody.* Storm events remove nourishment, exposing coir.



*Image by Kayla Anderson, Safe Harbor.* Detached coir following storm event may impact adjacent or downwind beaches and may remove vegetation while being washed ashore.

### 3. Semi-Soft Alternative Hybrid: Ballasted Coir, Beneath Living Shoreline

Coir absorbs wave energy but when exposed, chronically floats onto adjacent properties. This Hybrid system, recently approved by Jim Mahala of DEP, solves the problem of unintentional coir migration by using limited ballast stones to counteract coir flotation. The coir and stones are placed together in light to medium weight wire baskets. Baskets may be clipped to each other and buried beneath compatible sand nourishment, which is then planted with diverse Native grasses.

The hybrid configuration of ballasted Coir may utilize rectangular, square or tubular profiles. The image below, by Aline Architects of Orleans, MA, depicts one profile.

This is an innovative, hybrid erosion management system, designed for areas occasionally impacted by multi-tide Mega-Storms, with accompanying surge duration. Extended surge periods extend wave fetch duration and wave impacts.

The system would still be anchored in place, with the addition of stone ballast to prevent unintentional migration and performance failure. The living shoreline above the system would perform effectively during most coastal storm events.

- a). Costs: Materials and labor, medium cost, \$100-150/linear ft, without vegetation.
- b). Consequences: may require renourishment and replanting.

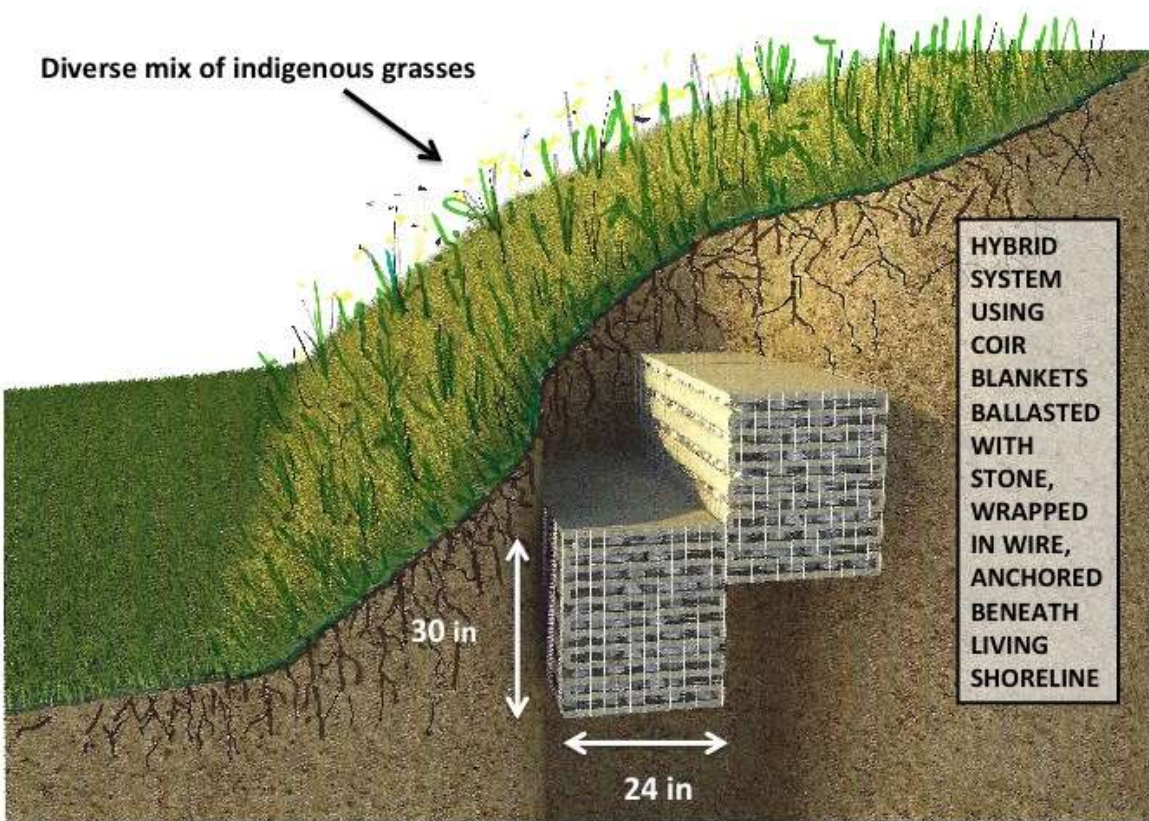


Image courtesy of Aline Architects, Orleans, MA and Safe Harbor, 2018



#### 4. Semi-Soft Alternative Hybrid: Coir beneath Geo Mats

a). Costs: High; this combination, a labor-intensive system for covering a tall bank, may be approx. \$700+/linear ft. of shoreline; mats; nourishment; helical anchors; coir; vegetation; cables; watering system.



*Images by Andrew Barr. Vegetation, stakes and cables secure Geo Mat over coir.*

b). Consequences: Coir helical anchoring system is labor-intensive; coir may require bank excavation; storm event may remove nourishment and vegetation, which would require replacement. It is labor-intensive to secure geo mat system.

#### 5. Semi-Soft Alternatives: Drift Fence

a). Costs: Medium-low; fence materials; monitoring and continuing sand nourishment is a requirement; vegetation. Excavation is required.



*Image by G. Peabody. Treated posts require excavation to support typical Bayside drift fence.*



*Image by G. Peabody. Drift fences also require sand nourishment and beach grass planting.*



*Image by G. Peabody. Drift Fence may restrict overwash outflow, contributing to outwash of sand.*



*Image by G. Peabody. Sand accumulation seems unaffected by drift fence.*



*Image by G. Peabody. Sand loss seems unaffected by drift fence.*

**b). Consequences:** Fence slats may create resistance to outflow during overwash events; this may result in accelerated outflow of water, allowing accelerated transport of additional sand. This alternative was originally intended to provide a degree of protection and performance which have not been fully realized; the popularity has resulted in permitting protocols facilitate implementation of a semi-soft response.



*Image by G. Peabody. Drift fencing may also interfere with natural patterns of sand movement.*

## **V. SOFT ALTERNATIVES: Sand is the currency of the coastal process.**

Coastal Towns often facilitate *Soft-solution Nourishment* with reduced permitting requirements. “*Nourishment*” refers to intentional placement of *sacrificial sand* in eroding coastal areas, usually along the *Toe of Coastal Banks*. Cape Cod’s landform is composed of glacially compacted (consolidated) sediments known as coastal banks. The Coastal Process erodes the *Toe of Coastal Banks*, causing upper sections to collapse, depositing new unconsolidated (uncompacted) sediment at the base of the bank, or “*Toe*”. Once a storm event erodes the coastal bank, lost consolidated sediments can never be restored (reconsolidated) because the conditions of their creation cannot be recreated; however, they can be *Renourished* with sand (unconsolidated sediment).

We consider the toe as “the ATM” of coastal erosion, because storm energy in the form of wind, waves and currents, removes or builds up materials at the toe. In net loss areas, where erosion rates are greater than deposition rates, net loss at the toe will continue unless the owners nourish, redepositing sand in the ATM (toe).

*Nourishment Strategy* is that future erosion may erode the sacrificial (unconsolidated sand) nourishment at the toe but the consolidated sediments of the coastal bank may remain intact. This is most effective with linkage to scale.

### **1. Soft Alternatives: Over Bank Nourishment**

In some circumstances, following more significant erosion events, larger scale, full bank renourishment may be considered. From top to bottom, along the length of the bank, nourishment is applied to the scarped face of the bank. If any additional erosion takes place at the toe, new nourishment slides down to create a new toe; this mimics the natural coastal process and is more sustainable.

a). Costs: Low; permitting may be minimal; renourishment sand \$30/cu. yd.; Beach grass

b). Consequences: Only fully eroded areas of banks are appropriate for this strategy. Native revegetation on bank and bluff requires secured ladders to plant.



*Image by G. Peabody.* Nourishment can be sourced from adjacent foundation excavations.



*Image by G. Peabody.* “Full bank” nourishment. To reduce impact, sand is delivered to dump box from sand storage area. Application equipment transfers nourishment laterally and diagonally from planned transfer areas along the full height of the bank. Full bank nourishment provides longer term, more sustainable, protection.



*Image by G. Peabody.* Full bank nourishment is most effective when possible.

## **2. Soft Alternatives: Toe of Bank Nourishment**

Toe nourishment is a soft solution focused where erosion actually occurs.



*Image by Safe Harbor.* Conveyor being used to deliver sand to toe of bank.



*Image by Safe Harbor.* Renourishment at toe of bank requires beach access.

a). Costs: Low; many Towns support this “soft solution”; \$25/cu. yd.; vegetation.

b). Consequences: Restricted activity periods; seasonal renourishment and replanting may be necessary, following coastal erosion events.

### **3. Soft Alternatives: Nourishment and Geo Mats**

a). Costs: Low; sand \$25/cu. yd.; heavy mats are more labor-intensive than jute.

b). Consequences: Hand labor may be required; heavy mats make plantings problematic. Mat may change shape with moisture and temperature changes, pulling vegetation with it. Mats not properly secured are removed by waves.



*Image by G. Peabody.* Geo Mats are prone to bunching if not well secured.



*Image by G. Peabody.* Heavier mats mark the change between lower and higher effort sand cladding systems because they need labor-intensive securing systems.

#### **4. Soft Alternatives: Nourishment and Jute Netting**

Jute temporarily replaces the stem/surface root/litter layer, an important co-factor in restoring natural vegetation, offering more sustainable erosion protection.

a). Costs: Low; sand and application costs; jute is inexpensive and uses 6" biodegradable, cornstarch ground staples; native vegetation.

b). Consequences: Jute provides temporary surface stability but native grasses should be planted and seeded for most sustainable protection.



*Image by G. Peabody.* Affordable Jute provides temporary surface stability.



*Images by G. Peabody.* Jute netting easily accommodates plantings of soft stem and woody stem Native vegetation. Cornstarch staples secure jute net.

### **5. Soft Alternatives: Nourishment and Sisal Mats**

Sisal is a long, natural fiber processed from Central American vegetation. These relatively lightweight mats are utilized with inland stabilization and revegetation projects. Coastal applications are still being evaluated for performance.

a). Costs: Low; labor should include secured, ladder access systems to reduce additional erosion on bank, proper securing and planting.

b). Consequences: It is important to realize that banks erode from the toe; placement of any system above the toe may not change the erosion rates.



*Image by G. Peabody.* Erosion management systems require careful implementation protocols and continuing inspections and management.



## 6. Soft Alternatives: Nourishment and Plantings



*Image by G. Peabody.* Native beach grass should be part of nourishment.

**a). Costs:** Low; sand costs approx. \$30/cu. yd.; ladder planting requires labor but protects the new nourishment; grass costs approx. \$1/ sq. ft., spaced 12" on-center.

**b). Consequences:** This sustainable, soft solution system mimics the natural coastal process by utilizing easily replaceable sand and native vegetation.



*Image by G. Peabody.* Using secured ladders to plant beach grass protects new nourishment from additional erosion.

## 7. Soft Alternatives: Nourishment and Biomimicry

Biomimicry primarily stabilizes nourishment, pending successful revegetation. On most sites, the system also collects additional sand in amounts ranging from 8" to several feet during the winter storm season, reducing net loss from erosion.

a). Costs: Low; sand approx. \$30/cu. yd.; grass \$1/cu. ft.; biomimicry \$20/100 sq. ft.

b). Consequences: This low impact, affordable, green technology offsets net loss. Shims require adjustment. Erosion events require downdrift recovery of shims.



*Image by G. Peabody. Articulated dunes are created on nourishment.*

Beachgoers destroyed vegetation and storms blew the protecting dune into the parking lot, and the municipal lot was threatened with imminent loss. Sand was moved back to the dune area; parallel lines of biomimicry created areas of turbulence for sand collection.



*Image by G. Peabody. One month later, we kept adjusting these up.*



*Image by Safe Harbor. Two months later, ready for grass planting.*



*Image G. Peabody. Biomimicry at base of newly nourished bank.*



*Image by G. Peabody. A few weeks later, ready for adjustment.*

## **VI. WIND MANAGEMENT ALTERNATIVES**

### **1. Managing Wind Energy: 24" Sand Fence (Snow Fence)**

This traditional system is often incorrectly used 4' tall, and in single or double rows, it is more effective when multiple rows are parallel to the shoreline. We use chainsaws to create 24" fencing because the 4' fence requires structural support with posts or stakes. 4' high fencing alters predator prey relationships of Eastern Cottontails & Foxes, Coyotes.



*Image G. Peabody. 24" Sand fence at Bayside restoration site, works with wind energy.*

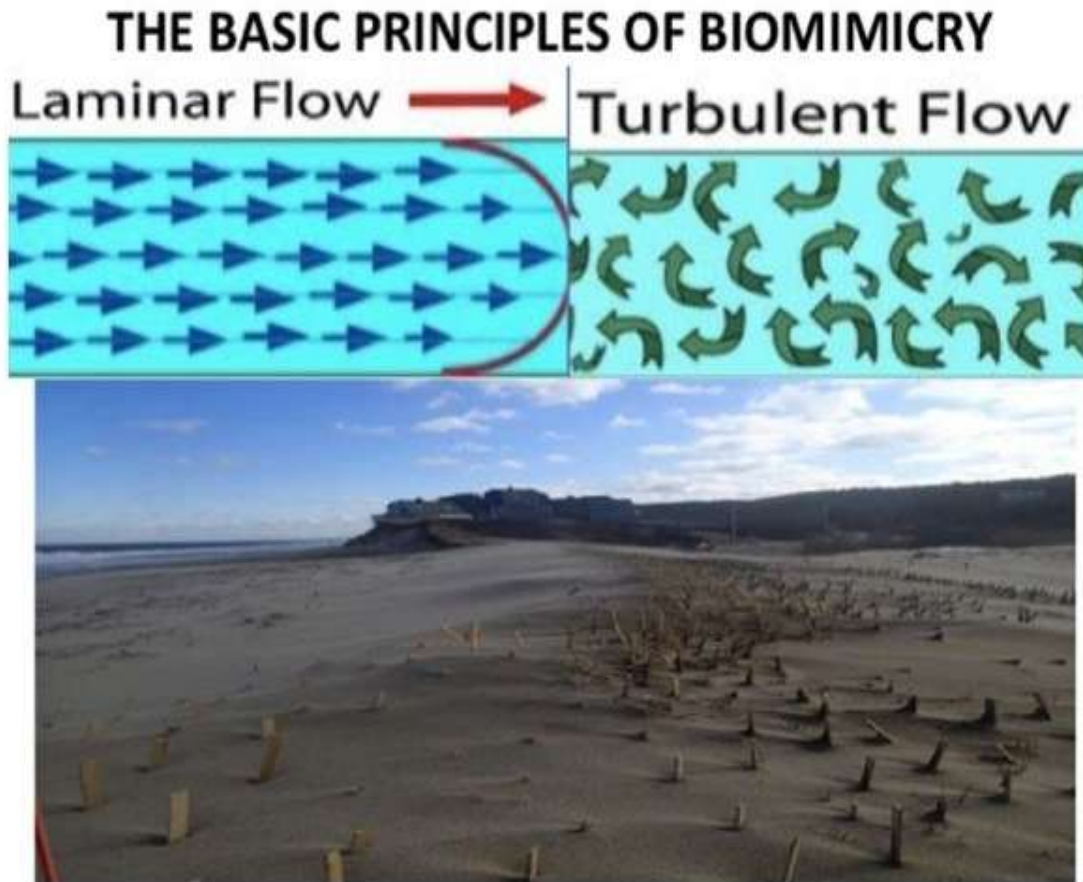
a). Costs: Low; when the rolls are cut in half they don't require support posts. Space rows parallel to the shore 5 ft. apart; plant Beach grass as new sand stabilizes. 1,000 sq. ft. (x 2 ft. deep) would cost approx. \$750 for fencing and vegetation approx. \$900.

b). Consequences: As new sand is collected, new fences need to be installed. A rubber mallet drives in slats easily; no stakes or posts are required to secure fencing. Beach grass plantings can be made around the fencing areas. Several layers of fencing may end up being buried by collected sand. Usage of educational signage redirects beachgoers.



*Images G. Peabody. Rubber mallet installation. 4' roll cut in half provides 100' -24" fence.*

## 2. Managing Wind Energy: Biomimicry (making *land* from *air*)



*Image by G. Peabody.* Biomimicry wind management principles: Laminar & Turbulent Flow. This effective, innovative, sand collection and stabilizing system is powered by storm winds. Recommended for restoring dunes. Ocean dunes have been restored 10 vertical feet a year.



*Image by G. Peabody.* Safe Harbor's minimal, random matrix, restoration system. As storm blown sand collects, the shims can be lifted up higher to control sand collection platform. Collection rates vary based on nearby sand supply.



*Image above by G. Peabody. After a storm. Biomimicry collects sand from storm winds.*

***Biomimicry manages wind energy, mimicking the “Performance”*** of native coastal vegetation to stabilize and collect storm blown sand. This non-disruptive green technology uses readily available, 14 in. long, narrow Cedar shims. Shims are randomly inserted by hand, several inches into the sand, spaced from 8-14 inches apart, in a 4-6 foot wide random matrix along eroded areas. This matrix stabilizes existing sand while collecting new sand from onshore storm energy. As sand levels rise, shims are pulled up, to continue collecting. The height of the sand collection platform is controlled by adjusting shims upward; width of the collection area is controlled by placement of new shims alongside the matrix.

a). Costs: Low; 100 sq. ft. of restoration area costs approx. \$3.50 for a pack of cedar shims. During storm season, adjust up (8-10”) once a week as new sand collects. Labor and materials for collecting sand in 100 sq. ft. dune, two feet high \$75.

b). Consequences: This system will only work during winter storms, with a wide enough beach to provide a sand source. In areas where dunes have existed, this system can usually restore dunes in a just a few years.



*Images above by G. Peabody. Eroded beach pathways use Biomimicry in winter.*



*Image by G. Peabody. Biomimicry sand collection restores eroded pathway.*



*Image G. Peabody. Biomimicry barrier dune restoration before planting. Dune gained approx. 10-12 vertical ft./yr. Zig-zagged pedestrian pathway provides access and prevents wind blow outs.*



*Image G. Peabody. Above image, same site as previous image. Three days later, following Nor'Easter. Approx 16" new sand on top.*

## VII. WAVE ENERGY MANAGEMENT ALTERNATIVES

### 1. Managing Wave Energy: Biomimicry

(making *land* from *water*, using *wave overwash*).

This strategy is based on our model of “*Linked Coastal Resource Systems*”.

**STORM ENERGY MAKES BIOMIMICRY SUCCESSFUL BY  
MOVING SAND BETWEEN LINKED RESOURCE AREAS**  
STORM ENERGY LINKS RESOURCE SYSTEMS



Image above by J. Fitzgerald, Safe Harbor Coastal Resiliency Intern, Tulane Univ.

When no apparent sand source seems available, a **Modified Biomimicry System** may be considered. Biomimicry can be modified by rotating the insertion plane by 90 degrees. Instead of flat side facing the water, the thin side faces the water. This reduces the hydrological profile and reduces potential for washouts. This alignment creates minimal hydrological turbulence, collecting sand from waves. As large storm waves cross near shore sandbars, bathymetric friction interacts with wave energy and sand is carried shoreward. On an eroded shoreline, the wave energy overwashes. When overwash (wave energy transporting sand) encounters Biomimicry, turbulence results and sand is collected by the shims.



Image by G. Peabody. Small barrier beach has lost barrier dune to foot traffic.





*Image by G. Peabody. Mixed alignment of shims prior to overwash.*



*Image by Safe Harbor. Image from video shows storm waves encountering bathymetric friction while crossing near shore sandbars; this sand is then transported shoreward as overwash.*



*Image by G. Peabody. Following overwash event, barrier beach exhibits 6-7 in. of new sand. Shims pushed back by overwash were reset towards water.*

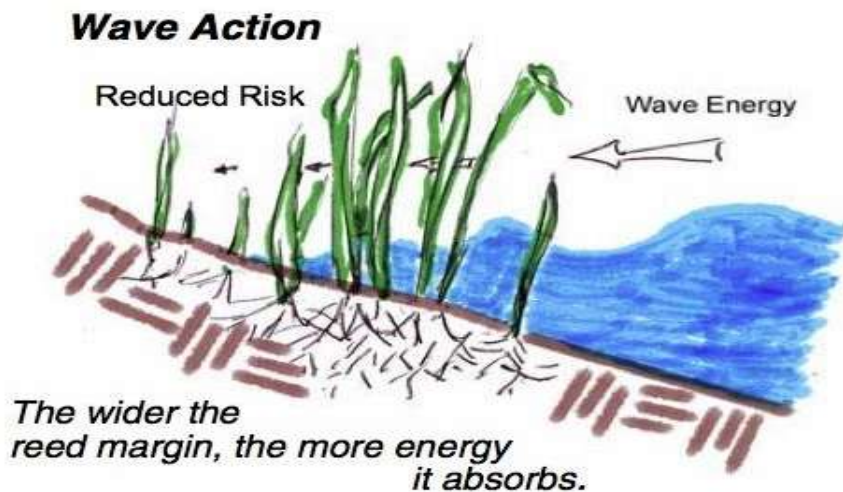


*Image by G. Peabody. Second year of restoration with Beach Grass planting; 2-3 ft. of new sand was accumulated from nearshore sandbars during storm events.*

## **2. Managing Wave Energy: Green Infrastructure – Fringe Marsh**



*Above image shows Fringe Marsh absorbing wave energy.*



Spartina Fringe Marshes are a green infrastructure that contribute to coastal resiliency by absorbing wave energy. They also may be vulnerable to Sea Level Rise.



*Images by C. Wetherbee, Safe Harbor. Top image shows Fringe Marsh at low tide. Lower image shows Fringe Marsh absorbing wave energy at high tide.*



*Image by Safe Harbor. Connecting fragmented Fringe Marsh on backside of barrier beach. This is a gradual project, phased over several years.*



*Image by G. Peabody. Spartina plantings fill in coastal Fringe Marsh.*

### 3. Managing Wave Energy: Interactive Pilings



*Image above G. Peabody.*



*Image by A. Martinez. Coastal restaurant, storm.*



*Image G. Peabody. A line of protective pilings had been unsuccessful in stopping waves. The original, solid line of pilings was pushed against the restaurant by storm waves.*

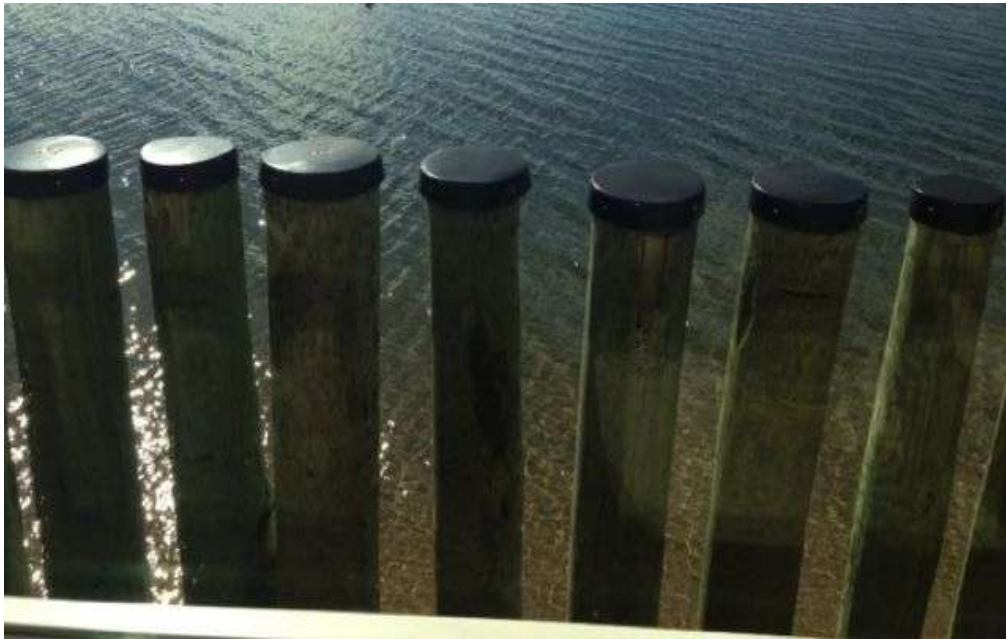


Image by G. Peabody. We replaced the pilings but allowed space between them for waves. There have been storms and hurricanes but no erosion and no wave damage since installation.

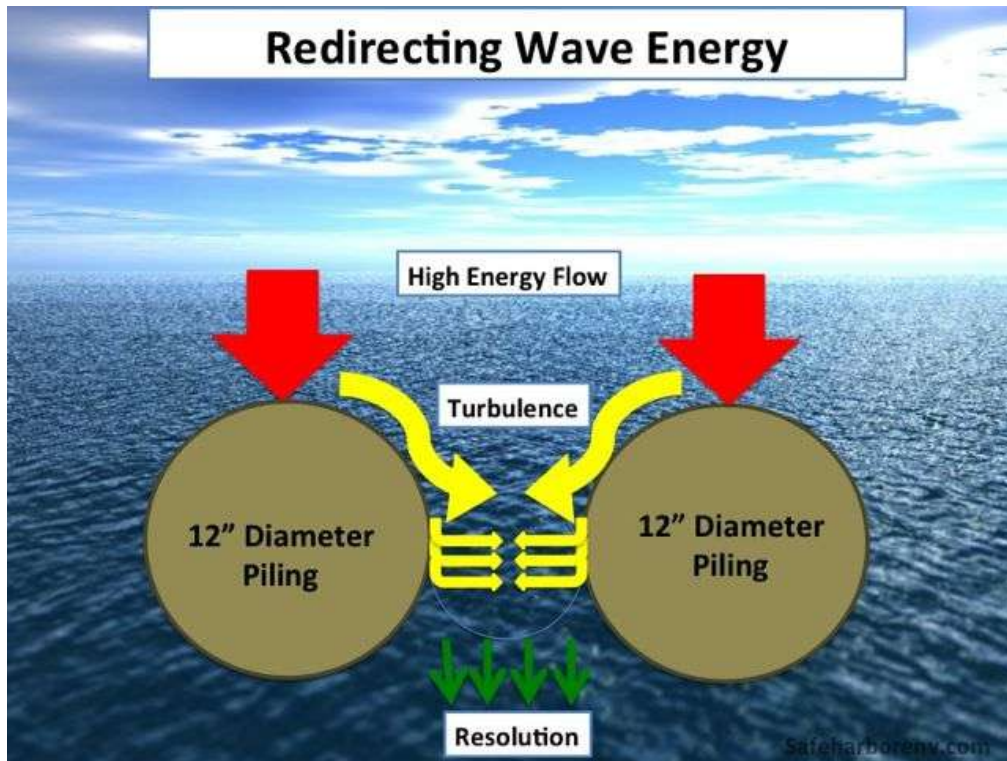


Image by Nadia Bricault, Safe Harbor. Storm energy (momentum) drives waves into the pilings. The pilings divide the hydromass and the energy, directing energy around the pilings and into a mixing area, where the equal amounts of energy are dispersed by turbulence. There have been no changes in erosion or deposition; no change in the vertical alignment of the pilings. This is how we think this system manages wave energy. ***This is an experimental system.***



*Image by Paul Fanizzi. Image showing wave energy resolution as turbulence, behind piling area.*

#### **4. Managing Wave Energy: Benthic Friction**



*Image by G. Peabody. This home, subject to changing storm surge levels, was being destroyed by wave action.*



*Image by G. Peabody. A temporary experiment: using piles of stones from the beach, with open spaces, to manage along shore tide current. Pointed in a "V" towards destructive storm fetch.*



*Image by G. Peabody. During winter storms, as waves encountered benthic friction from stone lines, they began bending. This redirected waves 90 degrees, into each other,*

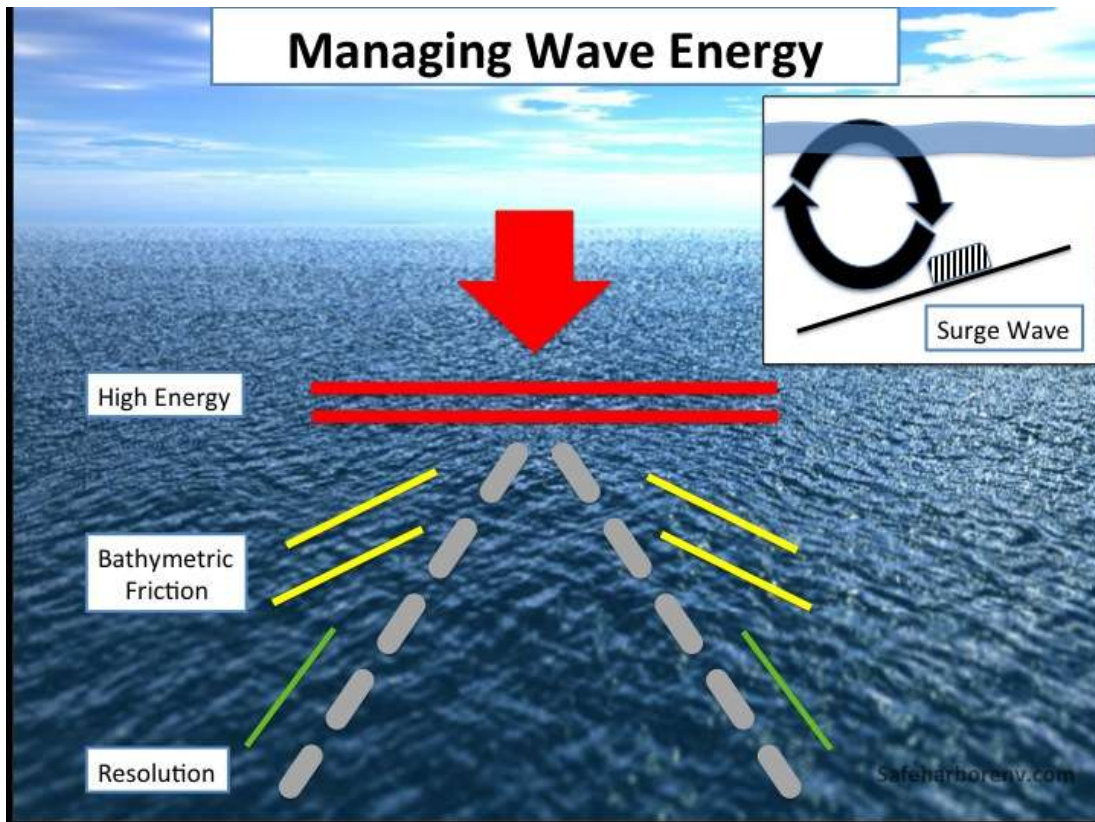


Image by Nadia Bricault, Safe Harbor. This is how we believe the system performed. The home mentioned above had no further wave damages. ***This is an experimental system.***

### VIII. RETREAT ALTERNATIVES

Retreat is easily understood and empirically popular, but pragmatically complicated. Many communities attempt to facilitate the process with streamlined permitting and variances. The uncertain pace of coastal erosion events tend to compress the already stressful decision making process. Moving a coastal home under any circumstances is a complex and risk fraught venture. Rumbling demolition equipment and eroding sandy coastal banks create high risks. New homes with updated septic systems are considered to be an environmental betterment.





Image by G. Peabody. Time does run out. Home will be rebuilt inland.

**Three Retreat Alternatives** include: **Moving** entire structure back from the eroding coast; **Lifting** and elevating entire structure to comply with FEMA revisions for Surge, V-Zones and SLR; and **demolition with Rebuild** further inland from coastline.

a). Costs: Significant for all these; many retreat models are Ocean Coast.

b). Consequences: Disruptive; structures moved are required to comply with new FEMA elevations and current building, plumbing and electric codes.



Image above by G. Peabody. Retreat: Relocating a residence away from a coastal bank.



Image above shows structure being re-set on elevated foundation. Neighboring homes not elevated may direct flood waters inland.



*Image by Frank Carini, Eco RI News. Vertical retreat alternative.*



*Image by G. Peabody. Old home on bluff to the left, replacement on right.*



*Image by G. Peabody. Sensitive area demolition should consider deconstruction. Reverse engineering allows sectional removals, with final demolition occurring off site. This significantly reduces impacts to the Resource Area and Buffer Zone.*

## **IX. ALTERNATIVES ANALYSIS**

1. The permitting process evaluates the ability of your management system to meet “**Performance Standards**” (how the resource area “**Performs**” under the Wetlands Protection Act, to **Protect the Public Interests**: Flood Control; Storm Damage Protection; Habitat, Fin and Shell fisheries).
2. **MA Conservation Commissions are required to protect these Jurisdictional Public Interests**, inherent in coastal resources, under the Act and local By Laws.
3. Underwater/bottomland, intertidal and shore habitats all require protection.
4. Incorporating native vegetated buffers improves mitigation, habitat protection.
5. Coastal plants need to capture sediment to gain elevation with sea level rise.
6. Naturally vegetated coasts provide resilient and sustainable erosion management.
7. Hard alternatives may prohibit shoreward migration of salt marsh and coastal grasses and therefore prevent establishment of resilient plant communities.
8. Hard alternatives may reflect or re-direct wave energy to other nearby areas.
9. Alternatives should address site specific, coastal erosion and deposition trends.
10. Our bayside coast is linked by up drift coastal erosion and down drift deposition.
11. Response efforts should not focus on attempting to stop erosion.
12. **Coastal erosion is a process that should be *managed* using alternatives.**
13. Installing coastal erosion management system may also require nourishment.
14. Consider Natural System responses by using Nourishment and Native vegetation.
15. Combined, Hybrid systems should be considered, creating lower risk solutions.
16. We are experiencing changing energy patterns on our coastline (more intense storms, altered tidal prism). Assess your changing coast profiles (**Geomorphology**)
17. **Erosion occurs at the bottom of any bank** and whatever you do on the bluff, face or scarp will not change the rate of erosion. Erosion is best managed at the toe.

## **RECOMMENDATIONS:**

1. Conclusively, when we look 30 years into the future, **Retreat (Relocation) is most sustainable investment for long-term interests.**
2. Storm energy (wind/wave) management strategies may offer site specific solutions
3. Hybrid systems may reduce risk, where changing conditions increase risk.
4. If relocation is not practical, **nourishment is a cost effective, more sustainable choice to protect medium term interests.**
5. Our working definition of managing erosion “protects” coastal banks by providing sacrificial nourishment which can be eroded, not allowing the bank itself to erode,

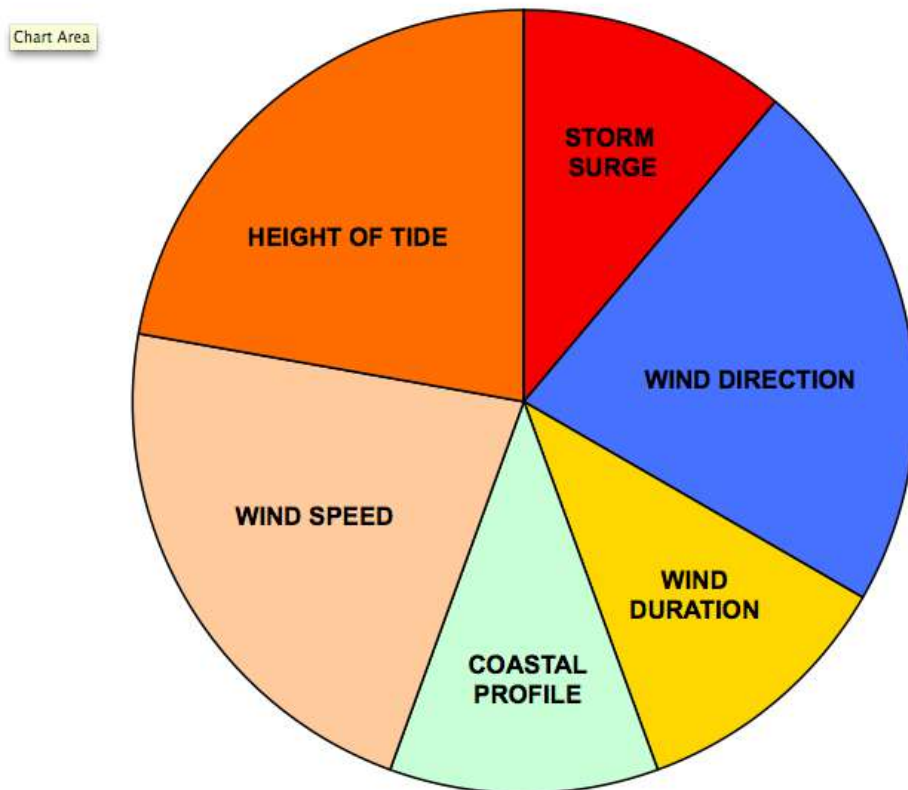
6. In considering the costs and consequences of hard or semi hard alternatives: Bulkheads; Revetment; Coir Rolls; and Drift Fence): renourishment would still be required and then also re-required following storm erosion events.
7. Nourishment on adjacent properties would be recommended.
8. **Biomimicry is a cost effective**, sustainable strategy for restoring coastal dunes.

**Additional reading:**

- 1.“Long Fetch Erosion Alternatives” 2010, Siasconset Beach Preservation Fund, by OCC, <http://safeharborenv.com/wp-content/uploads/2015/04/SIASCONSET-COASTAL-BANK-ALTERNATIVES-ANALYSIS-BY-OCC.pdf>
- 2.“Coastal Process”: <http://safeharborenv.com/wpcontent/uploads/2015/04/COASTAL-PROCESS.pdf>
- 3.“Biomimicry”: <http://safeharborenv.com/wp-content/uploads/2015/04/BIOMIMICRY-MAKING-LAND-FROM-AIR-2015.pdf>
- 4.“Steep Slope Stabilization Using Natural Systems“: <http://safeharborenv.com/wp-content/uploads/2015/04/STEEP-SLOPE-STABILIZATION.pdf>
5. :Beach Grass Planting Guidelines“: <http://safeharborenv.com/wp-content/uploads/2015/04/BEACH-GRASS-GUIDELINES1.pdf>
6. <http://safeharborenv.com/wpcontent/uploads/2015/04/COASTAL-EROSION-ANOMALIES.pdf> for “Anomalous Erosion”:

**X. COASTAL EROSION COFACTORS**

**COASTAL EROSION CO-FACTORS**



Theoretical image above by Safe Harbor, 2018. For purpose of discussion.

Coastal erosion is an Uncertainty driven, pulse event. Understanding the critical cofactors which need to synergize (occur at the same time), provides an insight into Risk Assessment. Successful erosion response plans should find models in Municipal Management Plans. Inclusive strategies would reflect Risk Assessment; Alternatives Analysis; Facilitated Permitting; Linkage to Scale principles and some degree of support for Innovative Techniques. Though coastal erosion is perceived to focus on a minority of property owners, impacts of erosion events ripple throughout the Communities. Enhancing and protecting the resiliency of Coastal Resources, enhances Social, Financial and Ecological Community values. We believe that Coastal Resources and Coastal Communities need each other's protection to survive.

Safe Harbor offers free Municipal and group presentations illustrating portions of this booklet. Safe Harbor also offers no-cost educational consultations for property owners. [gordonpeabody@gmail.com](mailto:gordonpeabody@gmail.com) For more information, go to [www.SafeHarborEnv.com](http://www.SafeHarborEnv.com)

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