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Conservation Mooring Study

Urban Harbors Institute, University of Massachusetts Boston

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EXECUTIVE SUMMARY

Eelgrass is a critical component of Massachusetts' coastal habitat, providing ecosystem services such as shore and sediment stabilization, food provisioning, and water quality improvement. Despite the tremendous ecological and economical significance of eelgrass, the State has documented widespread declines in eelgrass from 1994-2007; and the trend of loss is continuing in many parts of State waters.

While there are multiple factors contributing to eelgrass loss, this study focuses on the impacts of boat moorings in eelgrass beds, looking at (1) the impacts of conventional moorings, which have substantial contact with the seafloor, and which have been shown to create denuded areas, depressions in the seafloor, and impaired water quality related to increased turbidity; and (2) the potential of conservation moorings, which reduce contact with the seafloor, to prevent loss of eelgrass and to restore benthic habitats. This study also considers the economic, functional, and regulatory aspects of conservation and conventional moorings, making the following conclusions:

- Conservation moorings may hold vessels better than conventional moorings when designed and installed properly.
- Conservation moorings are likely to cost more than conventional moorings in terms of upfront costs, but may be more economical over the lifetime of a mooring.
- Conservation moorings appear to cause minimal impacts to eelgrass beds.
- It is less expensive to install a conservation mooring in an eelgrass bed to minimize eelgrass loss than it is to try to restore the eelgrass of a mooring scar once it has been lost.

Though they are not appropriate for all harbors due to harbor conditions, conservation moorings may have many benefits, especially when installed on helical anchors. Additionally, despite the potential to reduce impacts to eelgrass, there are many barriers to encouraging the use of conservation moorings. Some of those barriers include the upfront costs of conservation moorings, reluctance within the boating community to make changes, lack of independent verification of manufacturer claims regarding holding abilities, and insufficient boater education regarding the importance of eelgrass and the impacts of moorings.

This study presents several recommendations to better understand and promote the appropriate use of conservation moorings in Massachusetts. More specifically, this study makes the following recommendations:

- Include conservation moorings in State-approved harbor plans (310 CMR 23) so that State decisions are consistent with town visions for low-impact moorings.
- Educate boaters about the importance of eelgrass and the impacts of conventional moorings versus conservation moorings.
- Educate boaters about the long-term cost comparison of conservation and conventional moorings.
- Develop and share better information regarding the holding capacities of conservation moorings.
- Identify and/or provide incentives or funding to off-set some of the upfront expenses associated with conservation moorings.
- Enforce compliance with Army Corps regulations for activities in eelgrass.
- Encourage local mooring installers to offer services for conservation moorings.
- Monitor the installation of conservation moorings in eelgrass to improve scientific evidence regarding environmental impact, and continue to support projects that already monitor the installation of moorings in eelgrass.

INTRODUCTION

Most boaters who moor their vessels in Massachusetts waters have traditionally employed free swinging moorings that use heavy bottom chain. In important sensitive habitats such as eelgrass beds, these types of moorings often have negative impacts on the benthic habitat – from the circular movement of the chain around the anchor point, and/or from the anchor itself.

This document objectively describes the different characteristics of conventional moorings versus conservation moorings designed to minimize disruption to the benthic habitat. This report includes discussions on the following topics:

- Technologies available
- Ecological impacts
- Functional differences
- Economical differences
- Regulatory issues

These comparisons, along with concluding recommendations, will help boaters and communities decide whether or not conservation moorings are appropriate for their mooring and conservation needs.

MOORING SYSTEM OPTIONS

Typically, mooring systems are made up of an anchoring system on the seafloor, a floatation device on the sea surface which connects to the vessel, and a rode mechanism connecting the anchor(s) to the floatation device. There are a variety of ways that a mooring can be structured; and there are also differences in moorings depending on how they function with regard to the surrounding environment. Moorings can be broken into two categories with regard to their impact on the environment: conventional moorings and conservation moorings.

Conventional Moorings

Conventional, or "traditional," moorings generally use an anchor or a system of anchors designed to set into the sea floor, such as mushroom or pyramid anchors. An alternative to this drag type of anchoring system are gravity anchors where the sheer weight of the anchor, (e.g., a concrete or granite block) is intended to keep moored boats in place Anchors designed to set into the seafloor are most appropriate for soft bottoms, while the deadweight anchors are common in areas with rocky or hard bottoms. Helix anchors (also known as augur anchors or screw anchors), provide yet another anchoring option. Used in both marine and terrestrial applications (e.g., to anchor telephone poles and transmission towers (Sleeman, 1992)), a helical anchor is a steel screw-like shaft with

Figure 1: Mushroom anchor, granite block, helix, pyramid. Photo from: http://www.coastalbarge.com/products.html

welded bearing plates which is installed directly into the seafloor. Helix anchors can be used in a variety of bottom types, though their installation method and design differ depending on the substrate. Helical anchors are not suited for harbors where sediment is highly mobile and where the anchor may be exposed over time.

The means by which the anchor of a conventional mooring is attached to the floatation device on the waters' surface varies, but is usually comprised of heavy bottom chain (which sits on the seafloor and serves to dampen the strain on the anchor as currents, wind, and waves exert force on vessels) attached to light chain or nylon line. One end of the bottom chain attaches to the anchor and the other end attaches to either a lighter-weight chain or nylon line (see Figure 2). The lighter chain or line is attached to a float which brings it to the surface. The boat is attached to the mooring by a pennant, typically made of line.

Conservation Moorings

Conservation moorings can be thought of as moorings designed to minimize habitat impacts, primarily by reducing contact between the mooring components (i.e., chain or rope) and the seafloor. Some conservation moorings also minimize habitat impacts by reducing the scouring caused by the anchor system. While some boaters use floats to keep conventional mooring chain and rope from making contact with the seafloor (as found in sheltered locations such as Little Harbor, NH and Lake Tashmoo on Martha's Vineyard (Colarusso, 2012)), this report focuses on those conservation moorings that substitute a flexible floating rode for the traditional heavy chain/light chain rode of a conventional mooring.

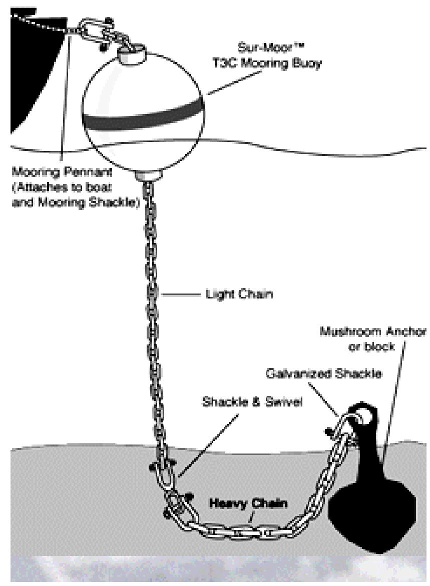


Figure 2: A Conventional mooring that consists of heavy and light chain. (Image from: http://www.lazyemotorinn.com/docking.htm)

Elastic/flexible systems in the marine environment, though relatively new for mooring vessels, have also been used to secure docks, wave monitoring buoys, and navigational buoys. The stretching feature of a mooring is usually reinforced with some type of line or rope to ensure that the stretching component does not exceed its capacity and break. In some cases, floats are used to keep the flexible line suspended in the water column so that it does not come in contact with the bottom. The stretching of the flexible rode replaces the buffering function performed by the heavy bottom chain in a conventional mooring.

Most conservation moorings can function on a gravity or helix anchor, though the smaller footprint of the helix anchor is preferred to the larger footprint of the gravity anchor for conservation purposes.

In New England, at least three of these types of conservation mooring products are being used in the marine environment: the Eco-Mooring System (made by boatmoorings.com), the Hazelett Elastic Mooring System (made by Hazelett Marine), and the StormSoft Elastic Boat Mooring system. The Hazelett System is in use in several Massachusetts harbors including Provincetown, Manchester, Nantucket, Gloucester, Beverley, and Chatham. The Eco-Mooring System is currently in use in Nantucket, Provincetown, Falmouth, Hingham, and Beverly. The StormSoft system is installed in Lake Champlain (VT), Dartmouth, MA, and Vineyard Haven, MA. A fourth system, the Seaflex System, is most commonly used to secure docks in the U.S., but has also been used to secure boats on moorings.

Seaflex moorings are currently in use in the U.S. in Lake Tahoe; Yokeko Point, WA; Long Beach, CA; and in Santa Barbara, CA, however the company is based in Sweden where thousands of boats have been using their mooring system – some for as many as three decades.

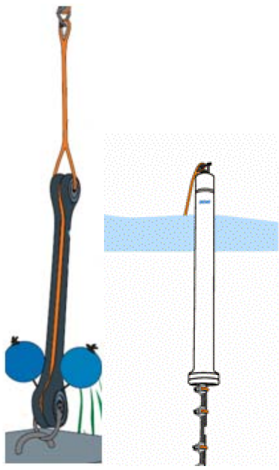
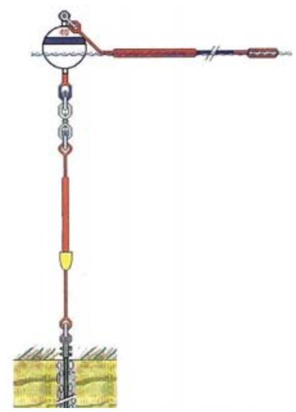
Hazelett Mooring and Spar Buoy	Eco-Mooring System	Seaflex Mooring	StormSoft boat mooring
			

Figure 3: Images of four types of conservation moorings (Images taken from manufacturer websites or provided by manufacturers)

While the general concept behind each of the technologies is similar, each does have some unique traits as described in Table 1.

In Australia, two additional types of conservation moorings, the EzyRider and the Seagrass Friendly Mooring systems, exist and offer alternative approaches to elastic moorings. On the EzyRider mooring system, the mooring buoy moves up and down a stainless steel shaft with the waves and tides. The Sea Grass Friendly Mooring System uses a steel-enclosed shock absorbing system attached to a screwed-in mooring post at the seafloor, and attached to a line at the top which runs to the water's surface. These two systems have been reviewed (Department of Employment, Economic Development and Innovation, 2011), and while some technical issues arose with holding abilities of the EzyRider system, both showed negligible impacts to the benthic habitat. (The Seaflex Mooring is also being tested as part of this study, which is described in greater detail below).

Table 1: Descriptions of four different types of conservation mooring systems.

System	Anchor	Buoy	Rode	Other
Seaflex System	Any anchor type, but a helical anchor or deadweight are recommended	Any, however, the company is in the process of testing a surface buoy (in Long Beach, CA) with an integrated thimble, with the intent to reduce the potential for hardware failure. The company anticipates having the buoy on the market in 2013.	Elastic rode (or rodes for greater holding strength). The system is specifically designed to become stronger as it elongates.	System often includes an “integrated by-pass” (a line made of a material called “Spectra 2000”, which has a breaking strength of 50,000 lbs.). The by-pass system engages as the rode reaches 80% elongation, preventing the Seaflex system from reaching 100% elongation.
Eco-Mooring System	Various anchor types will work, but a helix is recommended	Any	Polyfiber rope that encapsulates an elastic rubber component. As the elastic component stretches, the surrounding rope (woven in a way reminiscent of a Chinese finger trap) also stretches and provides strength to prevent the rubber from breaking.	The elastic component may be attached to the surface buoy directly, or chain or line may be added to reach the necessary length.
Hazelett System	Helical anchor or deadweight (specifically a concrete or granite block)	The company has developed a spar buoy that can slip below the ice during the winter. This buoy is a standard part of the mooring system.	A polymer elastic rode (or series of rodes for greater holding strength). The rode system is held off the bottom with hard trawl floats.	A “limit line” (the orange line in figure 3) may be incorporated into the system to prevent the elastic from breaking.
StormSoft System	Various anchor types will work, but a helix is recommended	Any	A “downline” consisting of industrial rubber multi-strand cords surrounded by a braided polyester shell/rope. A continuous inner core of braided polyester maintains the position of the shock absorbing rubber.	The system has a very tight braid designed to keep marine life out of the interior of the assembly and the system has no complex metal connections.

ECOLOGICAL ISSUES

Eelgrass (*Zostera marina*) plays a significant role in the health of the marine and coastal environment in Massachusetts and throughout New England. An important spawning and nursery ground, eelgrass plays a critical role in the lifecycles of many fish and shellfish species (Heck, et al., 1989; Hughes, et al., 2002), serving as foraging grounds, areas of refuge, settlement substrate, and a food source.

From an economic perspective, eelgrass supports commercially and recreationally harvested fish species in Massachusetts including bay scallops, winter flounder, American lobster, scup, Atlantic cod, white hake, cunner, tautog, American eel, and striped bass (Heck, et al., 1989; Hughes, et al., 2002). Commercial fishing for these species in Massachusetts in 2011 brought in more than $100 million (see Table 2). In addition to the direct financial contribution from the sale of commercially harvested species, these fisheries also have indirect economic impacts (e.g., employment for those who service and supply fishing vessels, and spending on fishing equipment by recreational fishermen) which can contribute further to the coastal economy.

Beyond the services provided to fish and shellfish, the roots and rhizomes of eelgrass help to stabilize the seafloor, while its leaves slow the movement of water, trap sediment and decrease the eroding impact of waves. These wave attenuation and shoreline stabilization features undoubtedly save communities and homeowners money by minimizing erosion and dampening the impacts of storm events.

While the general importance of eelgrass is well understood, studies show widespread declines in coastal eelgrass acreage throughout Massachusetts from 1994-2007 (Costello et al., 2011). Thirty of the thirty-three embayments studied showed loss from 1994-2007, with a median loss rate of 2.94% per year (Costello et al., 2011).

Some of the stressors on eelgrass include increased nutrients in the water from road runoff and septic systems, disruption and sedimentation from coastal development projects, and damage from boating activities, including the mooring of boats.

Table 2: Massachusetts commercial fisheries landing data for 2011 indicates that commercially harvested species which may utilize eelgrass habitat during their life histories brought in more than $100 million dollars. (Data from NOAA Office of Science and Technology Annual Commercial Landing Statistics (http://www.st.nmfs.noaa.gov/commercial-fisheries/commercial-landings/annual-landings/index).)

Species	Landings (lbs.)	Value (2011)
American lobster	13,717,192	$54,858,962
Scup	1,243,705	$801,05
Bay scallop	157,593	$1,957,430
Striped bass	1,163,875	$3,188,341
Atlantic cod	15,009,249	$27,580,595
Winter flounder	4,474,275	$7,767,398
White hake	5,283,966	$4,809,234
Cunner	960	$937
Tautog	57,788	$179,689
American eel	365	$496
Total	**41,108,968**	**$100,343,082**

Eelgrass tends to grow best in protected quiescent waters – yet these calm protected conditions are also highly sought after by boaters looking to safely moor their vessels. For this reason, it is fairly common for mooring fields to overlap with eelgrass beds.

Conventional moorings, as described above, rely on a heavy chain to dampen the impacts of various forces (e.g., wind, waves, and currents) on a moored vessel. The heavy chain moves along the seafloor as the boat moves, disrupting the living organisms in its path (Hastings, et al., 1995; Betcher, et al., no date; MER Assessment Corporation, 2008; Terramar Environmental Services, Inc., 2011). Bare space around a traditional mooring is referred to as a "mooring scar" (see Figures 4 and 5). The degree of scarring and the extent of the scar are dependent upon factors such as the length and weight of chain and the nature of vessel movement (e.g., currents, tidal range, prevailing wind, storm exposure).

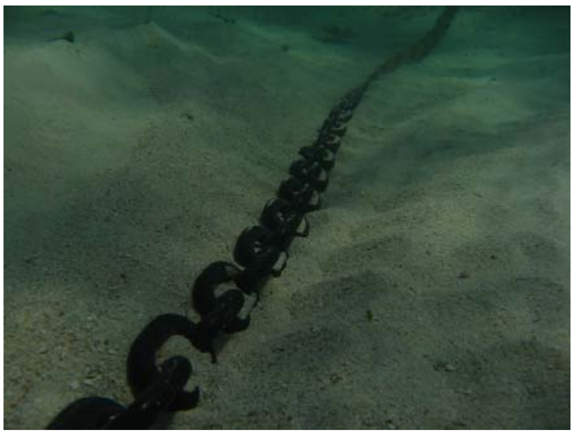


Figure 4: Close-up of mooring scar. (Image from Lefebvre, 2008)

Figure 5: Mooring scars in eelgrass. (Image taken from NOAA, no date)

In addition to denuding an area of marine life, the chain sweep of a traditional mooring and the vertical movement of the chain as water levels rise and fall can suspend sediment in the immediate and surrounding areas. This increase in turbidity can impair photosynthesis and disrupt an animal's behavior and physiological functioning.

While the mooring scar from the chain sweep is the primary impact on eelgrass in terms of areal extent of impact, the method of anchoring a mooring can also negatively affect eelgrass beds. During storms, anchors such as mushroom moorings, can become dislodged from the sediment, and may drag through eelgrass beds, destroying plants as they move. Additionally, the presence of large deadweight anchors, such as concrete and granite blocks, can lead to significant scouring around a mooring; and in the case of concrete blocks, they may introduce a new substrate on which invasive or opportunistic tunicates and algae might attach.

The impacts of moorings on eelgrass have been well documented in a variety of studies. In Massachusetts, the Division of Marine Fisheries measured moorings in eelgrass in several harbors and found a range in scar size of 40 m^2 to more than 200m^2 (Baker and Evans, 2012). In Rocky Bay, Western Australia, researchers were able to analyze aerial photographs of moorings in eelgrass beds. Those researchers found a 13% loss in eelgrass coverage between 1981 and 1992. This loss corresponded with an increase from 81 moored boats (in 1977) to 191 moored boats (in 1992) (Hastings et al., 1995). A study in the San Juan Islands in Washington State in 1996 also reported negative impacts to eelgrass around moorings that employed a bottom chain or bottom rope that dragged along the seafloor. The magnitude of the impact in that study appeared to be related to factors such as the weight of the chain or rope (the heavier the chain or rope, the more damage) (Betcher, no date). This study also noted that moorings which employed a midline float or solely relied on rope rather than chain had the least impact on nearby vegetation (assuming that the weight of the rope was not significantly increased by the colonization of barnacles and mussels).

Mooring scars increase the length of exposed edges of eelgrass beds in an area, and those edges are more vulnerable to the impacts of currents and scouring than interior areas of eelgrass beds. In some cases, mooring scars can enlarge along their edges, and combine with other scars, causing greater fragmentation within eelgrass beds (Hastings, et al., 1995). Loss of eelgrass in semi-isolated embayments is of particular concern because recovery in these areas may be limited as a result of a lack of nearby source populations and access to propagules (Orth, et al., 2006b; Erftemeijer, et al., 2008- as cited in Costello, et al., 1995).

The impacts of replacing traditional moorings with conservation moorings have been observed in various places on various types of benthic habitats, with generally favorable results. In Manchester Harbor, the Massachusetts Bays Program and the Massachusetts Division of Marine Fisheries replaced 8 traditional moorings (a combined impacted area of approximately 3,521 square feet) with conservation moorings (Baker and Evans, 2012). Four of the eight mooring scars also received eelgrass transplants. The project used the Hazelett conservation mooring system, and included a mix of helix anchors and concrete blocks. Though the conservation moorings have only been in place since 2010, monitoring shows slight re-colonization along the edges of some scars. Seedling survival within the scars has been limited by the gathering of detritus in the depression left by the previous mooring, but the outlook is more optimistic in areas where depressions do not exist (Evans,2012). The transplanted shoots had low survival rates (44%) due in part to storm activity, and in part to the detritus in the scars, but researchers anticipate that the areas that received the transplants will recover more quickly than those areas without any transplants (Baker and Evans, 2012; Evans, 2012). That same project also involved installing conservation moorings in Provincetown Harbor, but monitoring has not been conducted to determine the impacts of the new moorings. Currently the Massachusetts Division of Marine Fisheries is working on a similar effort in West Falmouth Harbor. To date, moorings causing scars in an eelgrass meadow in the outer harbor have been identified, and five moorings in the same area will be changed over to conservation mooring designs in the spring of 2013.

Another study in Shoal Bay, Port Stephens (Australia) examined the impacts of the Seagrass Friendly Mooring System in terms of re-establishing seagrass (specifically *Zostera capricorni*, and *Halophila*, and *Posidonia australis*) in former mooring scars. Monitoring from 2008-2010 indicated a recovery of *Zostera capricorni* and *Halophila* spp. to levels similar to surrounding seagrass beds. These species are relatively fast growing seagrasses. The re-growth of *Posidonia australis* in mooring scars was inconclusive (the rate of re-growth has been shown to take longer than the monitoring phase of the study) (Gladston, 2011).

In Moreton Bay, Queensland (Australia), another study tested three different conservation moorings (the Seagrass Friendly Mooring System, EzyRider Mooring, and Seaflex Mooring) in four locations in Moreton Bay, for a total of 12 trial moorings. The Seagrass Friendly Mooring uses a screwed-in mooring post as its anchor; the EzyRider mooring was set on concrete blocks; and the Seaflex Moorings were set on concrete blocks (where sediment was silty) and Manta Ray anchors (soil anchors hydrolically driven into the substrate) in sandy locations. Rather than place the conservation moorings in existing mooring scars, this study looked at the impacts of placing conservation moorings in previously unused areas within established mooring fields. Researchers found no detectable impacts of installing the moorings themselves (Department of Employment, Economic Development and Innovation, 2011); and while monitoring of long-term impacts has not been completed, preliminary findings suggest that there is no difference between the benthic habitat at the conservation mooring, and benthic habitats at similar sites within the mooring field (Skilleter,2012).

The Friends of the San Juans (in Washington State) have also engaged 10 citizens to voluntarily switch their existing block and chain moorings with different types of mooring technologies, including helical anchors (Whitman, 2012). While the Friends of the San Juans had hoped to have multiple sites in close proximity to understand the impacts, the volunteer participants were fairly dispersed and the impacts have not been assessed. It is worth noting, however, that 75-100 people reached out to the organization about wanting to participate in the study but were eliminated because they were not located in eelgrass or were already employing relatively harmless mooring designs. Many of those who did not qualify for the study but were not already using environmentally friendly moorings have taken their own steps to install more environmentally friendly mooring technology, and programs are underway in the area to create no-anchoring-zones in eelgrass.

Although these projects were implemented using different technologies in different environments, they make a compelling case for the elimination of chain scour as a means to minimize damage to benthic habitats resulting from boat mooring activities; and suggest that anchors with small footprints can further reduce impacts to benthic habitat.

Whether or not conservation moorings and anchors with small footprints can be used in Massachusetts to help restore eelgrass beds previously damaged by moorings remains to be seen. Factors such as the extent of damage to the benthic habitat, presences of other stressors, and additional efforts to restore eelgrass (e.g., transplants and seeding) may all influence the success rate of mooring scar re-colonization.

FUNCTIONAL CONCERNS AND COMPARISON

Functional Concerns include strength and holding capacity of the various mooring elements, maintenance of the mooring elements, life expectancy, and implications for mooring field design.

Holding Capacity

A mooring's ability to securely hold a boat is of upmost concern to boaters and harbormasters; and depends on factors such as the adequacy of the deck hardware, the strength of the rodes, the capabilities of the shackles, the resistance of the anchor(s), and the proper installation of equipment.

For purposes of this report, the features of primary interest are the holding potential for anchor types, and the holding potential for rode types. Most issues with mooring components such as shackles and pennant lines are equally applicable to both conservation and conventional moorings.

Formal and informal tests have been conducted comparing the holding abilities of different types of mooring anchors. In Vineyard Haven, MA, a pull test showed that the helix anchor provided the greatest holding power, followed by a 3,000lb. concrete block. The helix anchor also provided the best holding power in a test conducted by Boat US Insurance (See Tables 3 and 4). It is worth noting that conditions (e.g., sediment type and scope) were not uniform among all tests and types of anchors, and may have some impact on test results. Additionally, it is important to note that the nature of these tests do not replicate the actual forces applied to anchors as they moor boats. That being said, anecdotal reports from boaters and harbormasters confirm that the helix anchor, if installed properly, is very capable of holding a vessel at a mooring (Fronzuto, personal communication; Cormier, personal communication).

Table 3: Boat US Insurance pull-test results comparing five different types of anchors shows that the helix anchor had the greatest resisting force. (Source: http://www.boatmoorings.com/hm.php). It should be noted that the helix also used the greatest scope, which tends to increase holding power.

Anchor Type	**Helix**	**Dor-Mor Anchor (650 lbs.)**	**Mushroom (500 lbs.)**	**Single Block (2,000 lbs.)**	**Double Block (8,000 lbs.)**
Resisting Force (lbs.)	12,000 (did not break out)	4,500	1,200	800	4,000
Water Depth	20	18	15	14	35
Scope	4:1	3:1	3.5:1	3:1	3:1

Table 4: Results from the Vineyard Haven Pull Test also indicate that the helix had the highest breakout force of those anchors tested. It should be noted that the bottom conditions were not consistent among the different types of anchors, and additional testing should be done to compare the capabililties among sediment types. (Source: http://helixmooring.com/thebenefits.html).

Anchor Type	**Bottom Condition**	**Breakout Force (lbs.)**
350 lb. Mushroom	5 ft. deep in mud	2,000
500 lb. Mushroom	In sand bottom	1,700
3,000 Concrete USCG Block	Set in mud	2,100
6,000 lb. Cement Block	On sand bottom	3,200
8/10 Helix	In soft clay mud	20,800 (did not break out)

Although the force applied to the anchor is a significant factor in an anchor's holding capabilities, the angle of the force is also important to consider. Most anchors are designed to hold best when pulled on at an angle. During storms, swells and storm surges can cause water levels to rise rapidly. On a traditional mooring, as water levels rise, the boat is pulled back toward the anchor, and if the scope is short enough or the water levels rise enough, the boat may ultimately come to be directly over the anchor. This would cause the boat to pull vertically on the anchor – which may compromise its holding capabilities. While the line used on conventional moorings has some stretch capacity, conservation moorings are specifically designed to stretch (for example, the Eco-Mooring System is designed to stretch from 12 feet to 19 feet, and the Hazelett system can stretch up to 200% of its length), generating more horizontal holding force earlier in the boat's movement.

In addition to the issues related to the holding capabilities of the anchor, it is also important to understand the holding capabilities of the rode system itself. Mooring chain strength varies depending on factors such as the materials used to make it, the size of the chain, the condition of the chain, and the grade of the chain. One chain manufacturer (Peerless-Acco) lists various working load limits ranging from 800 lbs. (for a 3/16" Boatman's Pride Anchor Lead Chain) to 7.5 tons (for a 3/4" Long Link Mooring Chain) (Peerless-Acco, no date). Working load limits, which are the recommended limits, are not the same as minimum breaking load limits (where the applied force causes the chain to become distorted).

A working load limit is usually 1/3rd to 1/4th the minimum breaking load limit, meaning that the minimum breaking load for a chain with a working load limit of 7.5 tons might be as many as 30 tons.

No study exists to compare the holding capabilities of the different conservation mooring technologies; however manufacturer claims for the Hazelett mooring, the Eco-Mooring System, the StormSoft mooring, and the Seaflex mooring are presented in Table 5. It is important to note that some manufacturers refer to the “holding power” as the breaking load (e.g., the Seaflex System) while others refer to the holding power as the breaking load (e.g., the Eco-Mooring System), and others refer to the holding power in terms of the weight of the boat being held, not the force being applied (e.g., the Hazelett Mooring) making it somewhat difficult to accurately compare technology holding powers. When a boater decides to use a specific technology, the manufacturer will work with the boater to ensure that he/she has the appropriate system to safely secure his/her vessel.

Accurate and verified calculations for the required holding power of moorings for vessels of different sizes under different conditions is not available, yet anecdotal reports suggest that conservation moorings, if adequately designed for vessel size and mooring location features, have the ability to securely hold a vessel under extreme conditions.

Table 5: Holding power of various conservation mooring types, based on manufacturer claims. *The term "holding power" means different things to different manufacturers, and should not be compared among the different manufacturers. For example, the Hazelett holding power refers to the weight of the boat; the Eco-Mooring System's holding power refers to its breaking strength; and the Seaflex System's holding power refers to its working load. All manufacturers will work with boat owners to determine the system most appropriate for the vessel and site conditions.

Manufacturer	Description	Holding Power*
Hazelett Mooring[1]	8' x 1.75" rode	4 tons (boat weight)
	10' x 1.75" rode	5 tons (boat weight)
	A pair of 5' x 1.75" rodes	10 tons (boat weight)
	A pair of 8' X 1.75" rodes	15 tons (boat weight)
	A pair of 10' x 1.75" rodes	16 tons (boat weight)
	Three 8' x 1.75" rodes	22 tons (boat weight)
	Three 10' x 1.75" rodes	25 tons (boat weight)
	Four 8' x 1.75" rodes	31 tons (boat weight)
	Four 8' x 1.75" rodes	35 tons (boat weight)
Eco-Mooring System[2]	8' x 5/8"	5 tons (breaking strength)
	10'x3/4"	6 tons (breaking strength)
	12'x1"	10.5 tons (breaking strength)
	12'x1- 5/16"	16.585 tons (breaking strength)
	12'X 1 -5/8"	50,000 lbs.
	12'x2"	69,000 lbs.
Seaflex Mooring[3]	Any arrangement with its bypass system	16 ton (breaking strength of bypass system).
	1 rod system (2 to 75' long)	1 ton (breaking strength
	2 rod system (2 to 75' long)	15 ton (breaking strength) boats from 1 ton to 10 ton
	4 rod system (2 to 75' long)	15 ton (breaking strength) boats from 10 ton to 40 ton
	6 rod system (2 to 75' long)	15 ton (breaking strength) boats from 10 ton to 60 ton
	8 rod system (2 to 75' long)	15 ton (breaking strength) boats from 10 to 100 ton
	10 rod system (2 to 75' long)	15 ton (breaking strength) boats from 10 ton to 200+ ton
StormSoft Elastic Boat Mooring[4]	Approximately 10 foot system (5 feet of rubber surrounded by one braided rope)	9-12 tons (tensile strength)

[1] From http://www.hazelettmarine.com/pdf/HM%20Hazelett%20Elastic%20Mooring%20Systems.pdf
[2] Data from Merrill, personal communication
[3] Data from Hylland, personal communication. It should be noted that the Seaflex system is designed to become stronger as it elongates, and that the breaking point is not what the company advertises as the holding capacity. Instead, Seaflex focuses on the working load and force to elongation ratio to ensure that the mooring is appropriate for the intended vessel and conditions.
[4] Data from Lefebvre, personal communication

Another point to consider is that, in addition to force, the steady pressure applied to a rode and anchor, conventional moorings can also experience shock loads unless they are equipped with special shock absorbing components. A properly designed conventional mooring without an additional shock absorber generally minimizes the risk of a shock load by ensuring that the dampening effect created by the weight of the bottom chain is enough to absorb the quick movement of a boat on its mooring, but under extreme conditions, this may not be sufficient. The elasticity of a conventional mooring, however, is designed to minimize shock loading.

It should be noted, as well, that holding capacity is directly related to the proper installation and maintenance of a technology so that it can function as intended. In the research project in Moreton Bay, 3 of the 12 moorings failed. One product (EzyRider) failed at two separate moorings due to the failure of shackles. One of the Seaflex systems used also failed due to an issue with a plastic grommet on the buoy, unrelated to the Seaflex system itself. The Seagrass Friendly Mooring was the only system that did not experience any failure (Department of Employment, Economic Development and Innovation, 2011). Issues with the Seaflex system in Santa Barbara, CA have also been noted, though they can most likely be attributed to failures not associated directly with the Seaflex System (Hylland, 2012), and are the reason why the company is in the process of testing a buoy to incorporate into its system.

One concern with regard to mooring systems where the elastic component floats near the surface is that the rode could be damaged by boating activity, as occurred with the Hazelett system in Chatham Harbor (MA) (Smith, personal communication; Baker, personal communication). This could be avoided by making sure that the elastic component is submerged beyond the reach of boat propellers, though doing so might require some modifications to the mooring systems, such as the addition of sub-floats.

Maintenance

Moorings of any type should be maintained at least annually; and most towns in Massachusetts require mooring inspections every 1-3 years, conducted by a town-approved inspector. During annual and official inspections, gear (e.g., shackles, chain, thimbles, lines, rodes, etc.) may need to be replaced.

Maintenance will vary depending on factors such as exposure to current and waves, biofouling organisms, highly corrosive environments, electrolysis, and high frequency/intensity of storm events. Maintenance will also vary depending on the type and quality of mooring equipment being used.

Helical anchors are drilled into the seabed where they are not likely to corrode, and many helical anchors removed ten years after installation show no signs of corrosion (Lefebvre, personal communication). When comparing conventional and conservation moorings, therefore, the primary difference in terms of maintenance needs is the frequency of having to change or repair the rode.

Chains, or segments of chain, require replacing approximately every two to four years (this will vary depending on factors such as those mentioned above). Conservation mooring rodes such as the Seaflex, Eco-Mooring System, StormSoft moorings, and Hazelett moorings, on the other hand, require fewer replacements over the life of the mooring. All four companies noted that their systems could be in place for more than seven years without losing their design capacity, but the technology is still relatively new in the United States, and exact life expectancies under various conditions have not yet been determined.[5]

[5]Seaflex noted that they have had a dock mooring system in place for approximately 32 years, and it still continues to function as designed. They have also had boat mooring systems in place for more than 30 years in Sweden

Mooring Field Design and Function

The layout of moorings fields is directly impacted by the scope required to safely moor a vessel. For conventional moorings, scope is generally about 3:1 or 4:1. The technology for conservation moorings is still quite new, and scope lengths have not been widely established, but could be as short as 1:1 (Hazelett Marine website, no date), with the understanding that the elastic component will stretch, creating a larger scope overall. (Scopes of flexible mooring systems are measured from the top of the anchor to the top of the buoy at high tide. The pennant will increase the scope to 1.5:1 or more (Lefebvre, personal communication).) According to Hazelett Marine, their system can increase mooring field density by 40% due to the sorter scope, without compromising holding power. Figure 6 compares the gridding of mooring fields using conventional moorings and the gridding of mooring fields using conservation moorings, showing that the use of conventional moorings would allow 36 vessels to moor safely; while the use of conservation moorings would increase that number to 64 (Hazelett Marine website, no date).

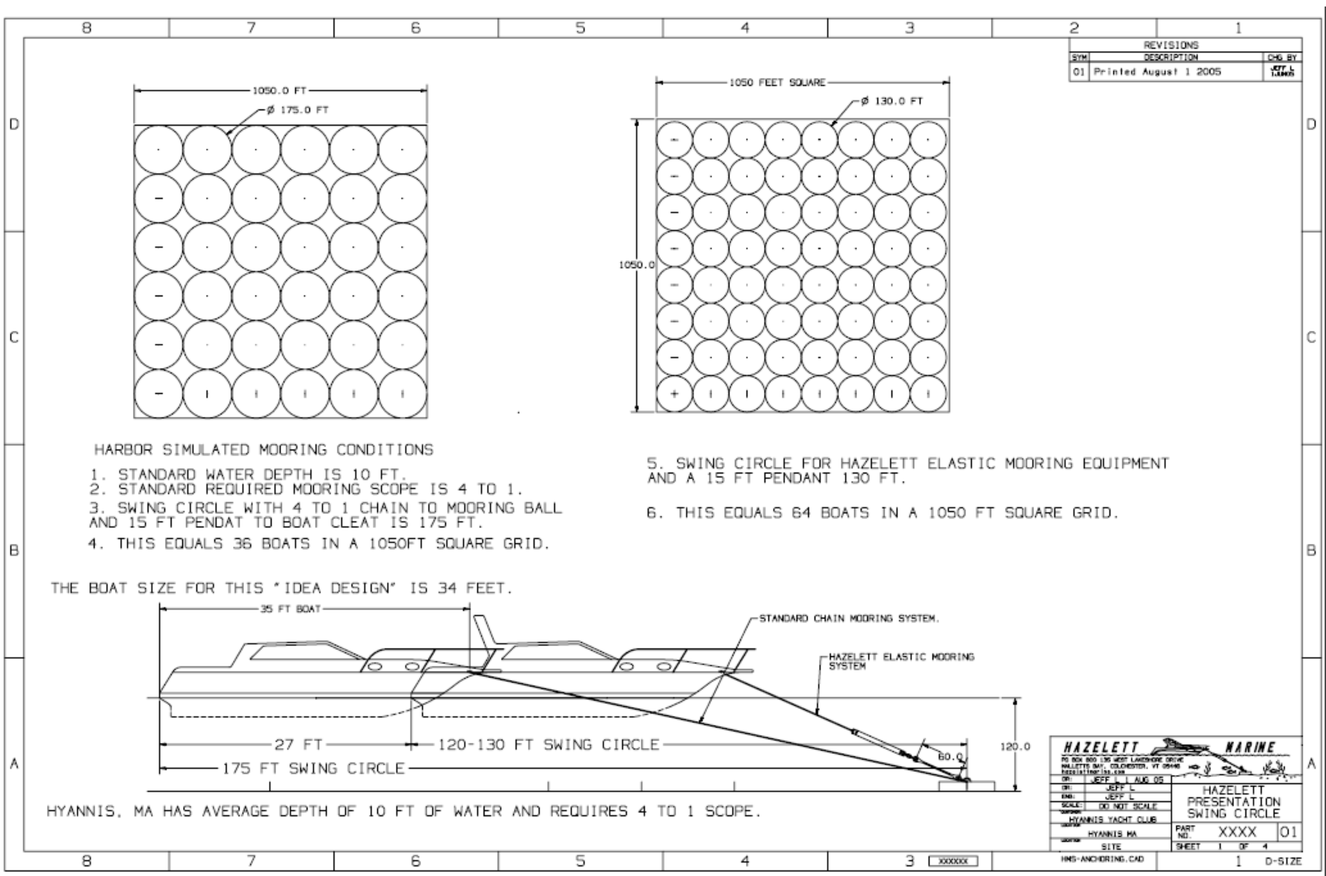


Figure 6: The use of conservation moorings may present an opportunity to increase the density of boats in a mooring field, as demonstrated by this mooring field graphic from Hazelett Marine comparing densities

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(Hylland, personal communication). StormSoft products have been used for more than 10 years in Florida without needing to be replaced (Lefebvre, personal communication). Hazelett offers a two year warranty, but noted that the life expectancy is about ten years, with some systems in place for 20 years without significant wear and tear. Hazelett did suggest, however, that the rode be replaced after unusually large storm events to ensure that it hasn't lost its ability to stretch. Eco-Mooring Systems have only been installed within the last seven years, but inspections indicate that they continue to function well.

of a mooring field using conventional moorings and conservation moorings (mooring plan online at: http://www.hazelettmarine.com/pdf/Mooring%20Grid%20Plans.pdf).

The layout of mooring fields is also determined by the size of the vessels in the mooring field. In some cases, as boat sizes change over time, anchors need to be re-located or replaced. While all anchors require some level of effort to remove and replace, some harbormasters have expressed concerns that helical anchors would be more difficult and costly to replace than other types of anchors.

While increased mooring field density might be a practical theoretical application of conservation moorings, the State of Massachusetts discourages increasing the density of moorings in eelgrass because of the impacts of shading caused by the additional boats (Boeri, personal communication).

ECONOMIC CONSIDERATIONS

The costs associated with a traditional mooring and a conservation mooring vary, and can be thought of in terms of equipment costs, installation costs, maintenance costs, and other associated costs (e.g., insurance and mooring permit fees).

Equipment Costs:

The cost of mooring equipment depending, at least in part, on the features of the vessel and the environment in which it is moored (presumably, a larger boat in deep water is going to cost more to moor than a smaller boat in more shallow water), as well as the type of equipment being used (e.g., chain vs. line; type of pennant, etc.).

When comparing the cost of conservation moorings and conventional moorings, the primary differences are once again found in the anchor system and the rode system.

Anchor size will vary depending on the vessel size, town regulations, etc. For the purpose of comparing costs, a 30' vessel might require a 400 lb. mushroom anchor, a 3,000 lb. concrete block anchor, or a helix anchor with a holding capacity of 5,000-7,000 lbs. Prices for those three anchor systems vary depending on specific site requirements and retailers, but the following prices were provided by retailers (these prices do not include installation):

- 400 lb. mushroom anchor: $500.00 (price from Anchor, Gear, and Line) - $800.00 (price from Inland Marine)
- 3,000 lb. concrete block anchor: $370.00 (price from Gilbert Block) - $630.00 (price from Willard and Sons)
- Helix anchor = $400-700 (prices from Anchor, Gear, and Line, Burr Brother Boats, Inc., and Baker, personal communications)

These quotes suggest that, in terms of anchor costs alone, a conservation or conventional mooring that uses a concrete block would likely be the least expensive option of the three, while the cost of a conventional mooring on a mushroom anchor would be comparable to the cost of a conservation mooring on a helix anchor. (As explained below, however, the cost associated with anchors differs greatly in terms of installation.)

In addition to the cost of the anchor, there is also the cost of the rode system. Again, for the purpose of comparing costs, a 30' vessel moored in 15' of water might require 30' of heavy (3/4") chain and 15' of light (5/8") chain to achieve a 3:1 scope and adequate holding power. Prices will vary depending on the materials used and the retailer, but the following prices were provided by Defender (http://www.defender.com/):

- 5/8” chain (Acco Mooring Chain) $8.99/foot = $134.85 for 15’
- ¾” chain (Acco Mooring Chain) 15.59/foot = $467.70 for 30’

The chain cost for this vessel, then, would be $602.55.

That same 30’ vessel in 15’ of water might require a conservation mooring capable of holding 4 tons. Depending on the type of conservation mooring used, the cost of the elastic rode system might range from $245 (8’ long Eco-Mooring System) to $1,849 (Hazelett’s 10’, 5 ton mooring). The Hazelett price includes the entire mooring system (everything above the anchor to the cleat of the boat). With the Eco-Mooring System, some sort of line or chain would have to be incorporated into the system to make up the remainder of the length of the system (i.e., if an 8’ long elastic component was used, at least 7 feet of chain or line would be needed to reach a scope of 1:1). That extra chain or line, as well as any additional hardware, would add to the overall cost of the rode system. Assuming the ¾” chain was used to make up the remaining distance, it could add $60 (again, assuming a 1:1 scope[6]), thus bringing the rode cost for that vessel to approximately $305 (*not* including the cost of the anchor and anchor installation, any shackles or other hardware, which, according to one installer, may add an additional $1,300 to the cost of a system (Lefebvre, personal communication)).

Table 6: The costs of various types of mooring technologies ranges from $245-$4,223; however, it is important to note that the Seaflex and Eco-Mooring System prices reflect the price of the rode system only. The Hazelett prices are for their whole system, including the buoy and pennant as well as the rode system, but not the anchor; and the StormSoft prices are for the whole system as sold to the Town of Vineyard Haven, MA. Prices do not include installation.

Conservation Mooring Type	Cost
Hazelett 5 ton system	$1,849[7]
Hazelett 16 ton system	$2,552
Hazelett 25 ton system	$3,453
Hazelett 35 ton system	$4,223
Seaflex 10 ft. strand	$456[8]
Seaflex 2 strand system with by-pass system	$1,136
Eco-Mooring System 5/8 in. dia. X 8 ft. long	$270[9]
Eco-Mooring System ¾ in. dia. X 10 ft. long	$320
Eco-Mooring System 1 in. dia. X 12 ft. long	$350
Eco-Mooring System 1-5/16 in. dia. X 12 ft. long	$375
Eco-Mooring System 1-5/8 in. dia. X 12 ft. long	$425
Eco-Mooring System 2 in. dia. X 12 ft. long	$475
StormSoft system for boats up to 25 ton or 40 ft.	$1,500[10]

These prices are difficult to understand in the abstract, especially when taking into consideration the facts that (1) each conservation mooring is designed to meet the needs of a specific boat in a specific location; and (2) each system includes different components (e.g., some include just the rode while

[6] It is important to note that, while a 1:1 scope might be appropriate for some vessels, most will likely require a scope greater than 1:1, thus raising costs of the rode system for a conservation mooring.
[7] Hazelett prices from Inland Marine: http://www.mushroommooring.com/index.html (Note that the weight refers to the boat weight, not the break strength)
[8] Seaflex prices from Manufacturer (Hylland, Personal Communication)
[9] Eco-Mooring System prices from Manufacturer (Merrill, Personal Communication) and www.boatmoorings.com)
[10] StormSoft prices provided by New England Marine, LLC (Lefebvre, Personal Communication)

others include the pennant and buoy as well). To better illustrate the true costs of conservation moorings, a series of hypothetical boat and mooring site conditions, along with pricing information, is presented in Appendix A.

Installation Costs:

One of the primary differences in cost between a conservation mooring and a conventional mooring is the cost of installing a helix anchor. According to estimates, a helix anchor can be hydraulically installed by a mooring installer for approximately $400-$500, depending on factors such as water depth and substrate, which affect the amount of time it takes to install the anchor (Anchor, Gear, and Line, personal communication; Baker, personal communication; Burr Brothers Boats, Inc., personal communication). A gravity anchor or drag anchor can be installed in far less time than a helical anchor, and the cost can be less than $100 in many instances.

The cost of installing the rest of the mooring varies depending on the mooring installer. Some seem to charge a flat rate for installing moorings, while others charge by the hour – in which case cost is directly related to how much of the mooring is pre-assembled before installation. The less assembly required at the time of installation, the lower the cost. This is true for both conservation moorings and conventional moorings, which can both be pre-assembled and installed for less than $100.

For those switching a conventional mooring to a conservation mooring, the old tackle can typically be removed by a SCUBA diver in approximately 30 minutes (Lefebvre, personal communication). If charged by the hour, the removal of the old mooring tackle may add approximately $50 to the cost of installation.

Maintenance Costs:

As with installation costs, maintenance costs (and schedules) vary greatly depending on the equipment being used and the conditions. The biggest difference in maintenance costs between conservation moorings and traditional moorings has to do with replacing the rode system. The need to replace chain will differ depending on the size of the chain and the wear and tear from movement underwater; but it seems that many people in Massachusetts replace at least part of their chain every 2-4 years. Using the example of the 30' boat above, the worst-case scenario would be that the owner of the 30' vessel could spend as much as $602.55 every 2 years to replace all of his/her chain.

As mentioned above, the life expectancy of a conservation mooring in any given setting is not yet widely known, but could easily exceed 7-10 years in many cases. During a ten year period, for example, a boat owner would likely have to replace any chain or line used in the mooring every 2-4 years, but would probably not need to replace the elastic component itself.

The condition of the mooring is most often established during the inspection, and while methods of inspection vary from inspector to inspector, the costs of inspecting a conservation mooring and a conventional mooring are roughly comparable. The inspection of a conservation mooring on any type of anchor, and a conventional mooring on a helix anchor might be slightly more expensive than the inspection of a conventional mooring on a non-helical anchor because a diver may be needed to inspect the condition of the anchor connection, rather than bringing the anchor to the surface for inspection.

Other Associated Costs:

Insurance companies do not seem to adjust rates based on the type of mooring technology employed (Kilby, personal communication). Additionally, nothing indicated that mooring fees in any town were based on whether or not a boat was on a conservation mooring or a conventional mooring.

Economic Value of Eelgrass:

When making a decision about whether or not to use a conservation mooring, boaters and harbormasters might also want to consider the economic impacts of the different technologies in terms of the costs associated with protecting and/or losing eelgrass beds.

While there is no study which provides the economic value of eelgrass in New England, one study estimated the value of Florida's eelgrass, including the values of nutrient cycling and recreational fishing, to be $20,500/acre/year (Seagrass Recovery, no date). Another study more broadly estimated that the value of the world's macrophyte (macroalgae and seagrasses) ecosystems was approximately $19,000/hectare/year (or $7,692.31/acre/year), calculating the value based on nutrient cycling and raw materials (Costanza, et al., 1997). A third study considered the value of eelgrass in the Puget Sound, based on the value of its nutrient cycling, to be between $5,507 and $15,421/acre/year (Batker, et al., 2008).

The size of mooring scars will vary depending on factors such as the chain size and scope and the tidal range. The project in Manchester Harbor (MA), for example, dealt with mooring scars with an average largest diameter across the scar of 6.9 meters (22.64 feet), meaning the average area of a scar was approximately 37.38 meters^2 (402.328 feet^2). Using the above studies as a guide, the lost economic value of a mooring scar in Manchester, MA may range from approximately $51/year to $189/year.

Table 7: Given the various potential economic values of eelgrass, the estimated economic loss caused by the average mooring scar in the Manchester, MA mooring study ranged from approximately $51/year to $189/year.

Estimated Economic Value of Eelgrass (acre/year)	**Cost of Average Manchester Mooring (scar/year)**
$20,500	$189
$15,421	$142
$7,692	$71
$5,507	$51

These economic valuation studies likely undervalue the true economic significance of eelgrass because they do not include the value related to food production, commercial fishing, or storm buffering. As mentioned previously in this report (see Table 2), the habitat services that eelgrass provides supported Massachusetts commercial fishing activities in 2011 in excess of $100 million dollars, not including any indirect economic impacts of commercial fishing activities (e.g., spending on boat repair, fuel, etc. needed for fishing activities).

These studies also do not address the cost of restoring eelgrass. While restoration costs will vary from project to project, staff from The Nature Conservancy and EPA Region 1 suggest $100,000/acre, or $2.30/square foot (which includes some follow-up monitoring and labor) as an appropriate estimate for the implementation of one restoration project (Kachmar, personal communication; Colarusso, personal communication). Using the average scar size from Manchester, MA as an example, it would cost approximately $925 to try to restore each individual scar. Successful restoration could require more than one try, thus increasing the cost.

Similarly, the Massachusetts Division of Marine Fisheries, working with the Army Corps of Engineers, has developed an In-Lieu Fee Habitat Mitigation Program for projects with habitat impacts. Based on the costs of other restoration projects, they have established a $10/square foot base value for habitat, and have applied a compensatory mitigation ratio of at least 3:1 for projects impacting submerged aquatic vegetation (Army Corps of Engineers and MA Division of Marine Fisheries, 2011). Applying this base value and multiplier to the average mooring scar in Manchester Harbor, the fee associated with each scar would be approximately $12,069.

Should boaters and harbormasters wish to consider the economic value of eelgrass when making their decisions about whether or not to use conservation moorings, the above numbers may help put the cost of conservation moorings into context.

Cost Conclusions:

Given the fact that many factors play a role in determining the cost of a mooring, it is difficult to provide specific numbers for a cost comparison of conservation moorings and conventional moorings. However, assuming that a conventional mooring and a conservation mooring used the same anchor type (a helix or a block for example), pennant, and buoy, the cost of the two systems, depending on the brand of conservation mooring, could be comparable in terms of upfront equipment costs, installation costs, and inspection costs.

Maintenance costs are more difficult to compare. A chain may need to be replaced in-part or in whole every 2-4 years, while it is possible that a conservation mooring's rode system could last more than 10 years. Assuming that more chain would need to be replaced on a conventional mooring than on a conservation mooring (which may have no chain at all) over the lifetime of a mooring (simply because there is more chain on a conventional mooring than on a conservation mooring), the conventional mooring could be the more expensive option, long term.

In order to understand the cost of a conservation mooring relative to the value of eelgrass, a new conservation mooring installed on a helix anchor could cost as much as $5,523 for all equipment and installation (or $789/year)[11]. Compared to the annual values of eelgrass noted above (which, again, likely greatly underestimate the value of eelgrass), the cost of this mooring is greater than the economic value of eelgrass within the likely resulting eelgrass scar. However, the annual cost of this most expensive conservation mooring option is far less than the cost of having to replace eelgrass lost as a result of impacts from the mooring. This suggests that, from an economic perspective, any mooring installed in eelgrass should be a conservation mooring so as to save money on having to try to restore the eelgrass bed in the future.

REGULATORY ANALYSIS

Conservation moorings are not as widely used in Northern New England (Massachusetts, New Hampshire, and Maine) as conventional moorings; however their use appears to be growing. The following information describes federal and state regulations relevant to conservation moorings and their use.

Army Corps of Engineers

The placement of moorings into coastal waters is regulated by the Army Corps of Engineers (ACE) under the Rivers and Harbors Appropriation Act of 1899 (33 U.S.C. 401, 403, 407). Section 10 (33 U.S.C. 403) prohibits "…the creation of any obstruction not affirmatively authorized by Congress, to the navigable capacity of any of the waters of the United States". The construction of any structure in or over these

[11] This estimate uses the most expensive option of the 35 ton Hazelett System, proving an estimate for the more costly conservation mooring.

waters requires the recommendation of the Chief of Engineers, as delegated by the Secretary of the Army, in the form of a Section 10 permit.

The ACE Regulatory Office in New England makes permitting decisions for marinas and moorings throughout the region. In the New England District, the Army Corps has instituted a system of State General Permits (GPs) for minor projects of many activities, including mooring placement. The goal of this permit system is to reduce duplicative review by the state and Army Corps and to expedite the permit review process for the project applicant. These State General Permits use a tiered structure, with different categories for varying levels of impact from a given project. The levels of impact are based on specific criteria and determine the degree of review required by the Army Corps. The State General Permits are different for each state; however, all permits incorporate state specific coastal and wetland protection laws. These State General Permits are currently in effect; however, efforts are underway to develop one General Permit for the entire New England region. Draft language for that regional General Permit is included in a later section of the report.

Massachusetts General Permit

All quoted regulatory language below can be found in the Army Corps of Engineers General Permit for the Commonwealth of Massachusetts (Army Corps of Engineers, 2011).

"Under this GP [General Permit], projects may qualify for the following:

- Category 1: Category 1 Notification Form required.

  Submittal of the Category 1 Notification Form at Appendix B to the Corps is required.

- Category 2: Application required.

  Submittal of an application to the Corps is required and written approval from the Corps must be received.

Projects not meeting Category 1 require an application for review as a Category 2 or Individual Permit project. All Category 1 and 2 projects must comply with all of this GP's applicable terms and general conditions.

Category 1:

1. New, private, non-commercial, non-rental, single-boat moorings authorized under MGL Chapter 91 Section 10A. Provided:
    - Authorized by the local harbormaster.
    - Not associated with any boating facility, including those in a Federal Anchorage.
    - Not located within the buffer zone of the horizontal limits of a Federal Channel.
    - No interference with navigation.
    - Not located in SAS. Prior to installation of moorings, a site-specific eelgrass survey should be conducted to document that eelgrass is not present.
2. Minor relocation of previously authorized moorings and moored floats. Provided:
    - Authorized by the local harbormaster.
    - Cannot be relocated into a Federal Navigation Project other than a Federal Anchorage.
    - No interference with navigation.

- Existing moorings not in SAS may not be relocated to SAS.
- When existing moorings in SAS are replaced or upgraded, low impact mooring technology that eliminates contact with the bottom substrate at all tides, such as helical anchors and elastic or other floating mooring tackle (i.e., no dragging chains), shall be employed.

Category 2:

1. Moorings that don't meet the terms of Category 1 and don't require an Individual Permit.
2. Moorings associated with a boating facility.
3. Moorings located such that they, and/or vessels docked or moored at them, are within the buffer zone of the horizontal limits of a Federal Channel. (See Appendix G.) The buffer zone is equal to 3 times the authorized depth of that channel.
4. Moorings and/or their moored vessels within the horizontal limits of a Federal Channel … are not eligible for Category 2 and require an Individual Permit.
5. Any work in the area of the Cape Cod Canal located west of the vertical lift railroad bridge … is not eligible for Category 2 and requires an Individual Permit.

Note: Special Aquatic Sites (SAS): Includes wetlands and saltmarsh, mudflats, riffles and pools, vegetated shallows, coral reefs, and sanctuaries and refuges which consist of areas designated under State and Federal laws or local ordinances to be managed principally for the preservation and use of fish and wildlife resource. All SAS within the project area shall be delineated on the plans for Category 2 and IP applications. SAS are identified at 40 CFR 230.40 – 230.45 and defined at 40 CFR 230.4 (q-1) as 'significantly influencing or positively contributing to the general overall environmental health or vitality of the entire ecosystem of a region.'"

Overall the Massachusetts General Permit provides a streamlined permit system for private, no-fee, new moorings in Category 1. If these moorings meet basic qualifications, such as receiving Harbormaster approval, are not associated with any boating facility, do not interfere with navigation, and are not located in SAS, the owner must provide notification only (no application) to the Army Corps. To maintain this basic notification-only process for minor relocation of an existing mooring, however, requires that the mooring not be relocated into SAS. In addition, if a mooring already exists in SAS and is replaced or upgraded, low impact mooring technology, including helix anchors and elastic rodes, are required.

In contrast, an owner seeking a Category 2 mooring must submit an application to the Army Corps for a mooring permit. Category 2 moorings include those moorings, usually commercial, that are associated with a boating facility, or that interfere with navigation in various ways. Category 2 includes a mooring that failed to meet the requirements of Category 1, but does not require a more stringent Individual Permit. There are no specific requirements in Category 2 for the use of low impact mooring technology, including helix anchors and elastic rodes, although these may be called for by the Army Corps in the permit application review.

<u>New Hampshire General Permit</u>

All quoted regulatory language below can be found in the Army Corps of Engineers Programmatic General Permit for the State of New Hampshire (Army Corps of Engineers, 2012).

"Projects not meeting the Minimum Project criteria must apply/report to the Corps as either a Minor/Major Project or Individual Permit project. All Minimum or Minor/Major projects must comply with all of this PGP's [Programmatic General Permit] applicable terms and General Conditions.

Minimum Projects:

- Private, non-commercial, non-rental, single-boat moorings. Provided:
    - Proper/eco-friendly moorings are used so chains or other connections do not rest on the bottom in vegetated shallows.
    - Authorized by the local harbormaster.
    - Not associated with a boating facility.
    - Moorings in Federal Anchorage not associated with a boating facility.
    - Not located within the buffer zone of the horizontal limits of a Federal Channel.
    - No interference with navigation.

Minor & Major Projects:

- Moorings not meeting the terms of a Minimum project.
- Moorings located such that they, and/or vessels docked or moored at them, are within the buffer zone of the horizontal limits of a Federal Channel.

Individual Permit (IP):

- Moorings and/or their moored vessels within the horizontal limits of a Federal Channel."

Overall the New Hampshire General Permit provides a streamlined permit system analogous to Massachusetts and Maine. All 3 states utilize the Individual Permit category. Instead of Category 1 and 2, however, New Hampshire uses the categories Minimum Impact Projects and Minor & Major Impact Projects. In addition to meeting the Army Corps's criteria for this General Permit, mooring projects must also meet several state approvals, including: (1) Water Quality Certification (WQC) or waiver under Section 401 of the Clean Water Act (CWA) (33 U.S.C. §1341) from the state water pollution control agency (Watershed Management Bureau, under the Department of Environmental Services); and (2) Coastal Zone Management Act (CZMA) Federal Consistency Concurrence under Section 307 of the CZMA (16 U.S.C. §1451-1465).

A private, no-fee, single-boat mooring meets the Minimum Impact Project requirement if an eco-friendly mooring (for example, an elastic rode) is used to prevent scour damage to vegetated areas. In addition, this Minimum Impact standard requires that the mooring be authorized by the Harbormaster, is not associated with a boating facility, does not interfere with navigation, as well as other requirements. Minimum Impact Projects that meet all other state and federal requirements may proceed following approval from the DES Wetlands Bureau.

Minor and Major Impact Projects are those projects that do not meet the requirements of a Minimum Impacts Project or are located within a given distance of a Federal Channel. Minor Impact Projects may proceed 30 days after a DES Wetlands Bureau decision, unless further action is taken by the Arms Corps. Major Impacts Projects may proceed only after written authorization from the Army Corps, following the DES Wetlands Bureau decision. There are no specific requirements for Minor and Major Impact Projects to use eco-friendly moorings, although these may be called for by the Army Corps or DES Wetlands Bureau.

<u>Maine General Permit</u>

All quoted regulatory language below can be found in the Army Corps of Engineers General Permit for the State of Maine (Army Corps of Engineers, 2010).

"Under this GP [General Permit], projects may qualify for the following:

- Category 1: Category 1 Notification Form required.

  Submittal of the Category 1 Notification Form at Appendix B to the Corps is required.

- Category 2: Application required.

  Submittal of an application to the Corps is required and written approval from the Corps must be received.

Projects not meeting Category 1 require an application for review as a Category 2 or Individual Permit project. All Category 1 and 2 projects must comply with all of this GP's applicable terms and general conditions.

Category 1:

1. Private, non-commercial, non-rental, single-boat moorings, provided:
   - Authorized by the local harbormaster/town.
   - Not associated with any boating facility.
   - Boat or mooring not located in a Federal Navigation Project other than a Federal Anchorage. Moorings in Federal Anchorage not associated with a boating facility and are not for rent.
   - No interference with navigation.
   - No new moorings located in SAS. Prior to installation of moorings, a site-specific eelgrass survey should be conducted to document that eelgrass is not present.
   - When existing, authorized moorings in SAS are going to be replaced, they shall be replaced with elastic mooring systems that prevent mooring chains from resting or dragging on the bottom substrate at all tides and helical anchors, or equivalent SAS protection systems where practicable.
2. Minor relocation of previously authorized moorings and moored floats, provided:
   - Authorized by the local harbormaster/town.
   - Not located in SAS.
   - No interference with navigation.
   - Cannot be relocated into a Federal Navigation Project other than a Federal Anchorage.

Category 2 projects include:

1. Moorings associated with a boating facility. An eelgrass survey may be required.
2. Moorings that don't meet the terms in Category 1 and don't require an Individual Permit. This includes private moorings with no harbormaster or means of local approval.
3. Moorings located such that they, and/or vessels docked or moored at them, are within the buffer zone of the horizontal limits of a Federal Channel…The buffer zone is equal to 3 times the authorized depth of that channel.

4. An IP is required for moorings within the horizontal limits, or with moored vessels that extend, into the horizontal limits of a Federal Navigation Project, except those in Federal Anchorages.

For 1-4 above, siting of new individual moorings in SAS, including eelgrass, should be avoided to the maximum extent practicable. If SAS cannot be avoided, plans should show elastic mooring systems that prevent mooring chains from resting or dragging on the bottom substrate at all tides and helical anchors, or equivalent SAS protection systems, where practicable.

Special Aquatic Sites: Includes wetlands and saltmarsh, mudflats, riffles and pools, and vegetated shallows (predominantly comprised of eelgrass in Maine)."

Overall the Maine General Permit provides a streamlined permit system for private, no-fee, new and minor relocation moorings in Category 1. If these moorings meet basic qualifications, such as receiving Harbormaster approval, are not associated with any boating facility, do not interfere with navigation, and are not located in SAS, the owner must provide notification only (no application) to the Army Corps. To maintain this basic notification-only process, however, no new mooring may be located in SAS. The absence of SAS should be confirmed via an eelgrass survey. Also, if a mooring already exists in SAS and is replaced or upgraded, helix anchors and elastic mooring systems that prevent substrate damage are required.

In contrast, an owner seeking a Category 2 mooring must submit an application to the Army Corps for a mooring permit. Category 2 moorings include those moorings, usually commercial, that are associated with a boating facility, do not have Harbormaster approval, or that interfere with navigation in various ways. Category 2 includes a mooring that failed to meet the requirements of Category 1, but does not require a more stringent Individual Permit. There are no specific requirements in Category 2 for the use of low impact mooring technology, including helix anchors and elastic rodes, although these may be called for by the Army Corps in the permit application review. In addition, an eelgrass survey may be required.

Proposed New England General Permit (Draft)

While the current system is functional, the Army Corps seeks to provide greater regulatory uniformity across the New England region. The Army Corps is in the process of reshaping the State General Permit system to create one standardized General Permit for New England, instead of a unique State General Permit for each state.

This redrafting process is ongoing and the language has not been finalized. The Army Corps generously shared the draft language included below. When the draft is final, the Army Corps will issue a Public Notice and allow for public comment on this General Permit.

"A pre-construction notification (PCN) is required when:

- Moorings interfere with navigation.
- Moorings are not authorized by the local harbormaster/town when applicable. Lack of local oversight requires a PCN.
- Moorings accommodate more than one boat or have an associated float.
- Moorings are associated with an existing or expanded boating facility, including those that extend into a Federal Anchorage.
- Moorings are associated with a new or expanded mooring field that is not a boating facility (e.g., a town mooring field).

- New or relocated moorings are located in SAS. Applicants must consider the avoidance and minimization sequence in the notes below and submit that justification to the Corps along with the PCN. (navigable waters that are tidal only)
- Existing, authorized moorings (i.e., anchors or tackles) in SAS are replaced or upgraded and do not use low impact mooring technology[2]. Proponents must consider the avoidance and minimization sequence in the notes below and submit that justification to the Corps along with the PCN. (navigable waters that are tidal only).

Notes:

- The TOY restrictions in GC 19 do not apply to this activity.
- Avoidance and minimization sequence: 1) avoid SAS, 2) helical anchor with floating/buoyant tackle, 3) block anchor with floating/buoyant tackle. See Footnote 13.

[1] Boating facilities provide, rent or sell mooring or docking space, such as marinas, yacht clubs, boat yards, dockominiums, town facilities, land/home owners associations, etc. Not classified as boating facilities are piers shared between two abutting properties or town mooring fields that charge an equitable user fee based on the actual costs incurred.

[2] Low impact mooring technology eliminates or minimizes contact with the bottom substrate at all tides. This consists of helical anchors instead of traditional anchors (e.g., concrete block) and floating/buoyant tackle (e.g., elastic) instead of chains that drag on the bottom and impact SAS and the substrate. The PCN review process could determine that a traditional anchor with floating/buoyant tackle may be used if substrate conditions make helical anchors impractical."

Overall the proposed New England General Permit provides a more efficient and unified permit system for all of New England and eliminates the permit differences between states. This proposed permit includes requirements similar to the existing State General Permits, but expands on these criteria. To avoid triggering a PCN, a mooring must be approved by the Harbormaster, unassociated with any boating facility, provide no interference with navigation, and not located in SAS.

In addition, this proposed permit makes requirements for the use of low impact mooring technology, including helix anchors and elastic rodes, more explicit and robust. Both a new or relocated mooring seeking to locate in SAS, as well as an existing mooring in SAS that is replaced or upgraded must consider specific avoidance and minimization requirements. These requirements include outright avoidance of SAS, combined use of a helix anchor and elastic rode, or the use of a block anchor and elastic rode. A project must meet these requirements or face the significant task of providing justification to the Army Corps why these requirements cannot be met. The use of expanded definitions in this proposed permit clarifies the specific equipment that qualifies as low impact mooring technology.

State and Municipal Regulations

In addition to the potential requirement for a permit from the Army Corps of Engineers, the placement of a mooring must meet state and municipal permit requirements and standards found in local mooring regulations. Due to practical limitations of contacting all harbormasters in the 3 state study area, the following analysis is based on information found in the available written local mooring regulations, and supplemented where possible by information from individual harbormasters and mooring manufacturers and installers.

<u>Massachusetts</u>

Pursuant to the general authority under Mass. Gen. Laws ch. 91, § 10A; Mass. Gen. Laws ch. 102, § 19 *et seq.*; Mass. Gen. Laws ch. 43B, § 13; 310 CMR 9.07, and all other applicable legal authority the Commonwealth has the right to confer authority to the municipalities, and the municipalities have the power to exercise such authority to issue temporary, annual permits to the public for the mooring of vessels and related structures under such terms, conditions, and restrictions that may be deemed necessary.

Two Massachusetts municipalities, the Town of Manchester-by-the-Sea and the Town of Marion require the use of helix anchors in certain circumstances. In the Town of Manchester-by-the-Sea, Massachusetts, a "[h]elix-type mooring system or other mooring system that will have less impact on eel grass fields" is required for any newly permitted moorings or replacement mooring tackle located in eelgrass areas (Town of Manchester-by-the-Sea, 2012). The Town of Marion, Massachusetts requires the use of helix anchors for all boats 25 feet or longer and includes helix anchors as a designated mooring anchor type option for boats less than 25 feet (Town of Marion, 2007). In Massachusetts, approximately 16 municipalities include the use of helix anchors (also called screw or auger anchors) either as a designated mooring anchor type option or as allowed at the discretion of the harbormaster in the local mooring regulations. These municipalities include: Barnstable, Chatham, Dennis, Falmouth, Gloucester, Hingham, Ipswich, Manchester, Marion, Marshfield, Mashpee, Nahant, New Bedford, Quincy, Wareham, and Weymouth. Among those municipalities, approximately 5 (Barnstable, Dennis, Ipswich, Marion, Nahant) include specific standards for the size and placement of helix anchors.

New Bedford, Massachusetts does not require the use of helix anchors, but does indicate "helix anchors are preferred mooring systems" (Port of New Bedford, 2010). In contrast, the Town of Truro, Massachusetts is the only municipality found to expressly prohibit the use of helix anchors in their local mooring regulations.

In Massachusetts, the use of an elastic rode system is not required by any municipality; however, approximately 4 municipalities (Falmouth, Hingham, Marshfield, and New Bedford) include the use of the elastic rode as an option or as allowed at the discretion of the Harbormaster in the local mooring regulations. These systems are described in mooring regulations in various ways, including as "environmentally friendly mooring systems designed to keep the chain off the ocean floor" (Town of Falmouth, 2007), "high performance shock absorber type systems" (Port of New Bedford, 2010), or by their manufacturer, e.g., Hazelett Marine, Synergy Marine. Several other municipalities, including Chatham, Dartmouth, Nantucket, Provincetown, Tisbury, and Vineyard Haven, may use elastic rode systems in some locations, but do not reference this specific equipment in their town mooring regulations.

Many other municipalities do not mention either the helix anchor or elastic rode system in their regulations. These municipalities will often allow and/or prohibit certain anchor types, or only list mooring standards for a particular anchor type. Several municipalities, including Bourne and Marblehead, indicate that alternate mooring systems may be allowed at the discretion of the harbormaster.

In addition, several municipalities include conservation-oriented language in their regulations regarding the placement of moorings. In Brewster, all vessels must be "properly moored" which includes maintaining "a minimum of 25 feet from all aquatic vegetation, including but not limited to sedge (Spartina) or eelgrass (Zosteria) (*sic*)" (Town of Brewster, 2008). Similarly, in Eastham, "[i]n the waters of Cape Cod Bay …No mooring shall be located such that the vessel when aground at low tide is a minimum of twenty-five (25) feet from all aquatic vegetation including but not limited to sedge (Spartina) or eelgrass (Zosteria) (*sic*)" (Town of Eastham, 2011).

In Chatham, mooring tackle specifications include the following: (1) "No new concrete blocks are permitted in protected areas. Existing blocks will be replaced with alternative systems through attrition"; and (2) "All concrete mooring blocks located within environmentally sensitive resource areas shall be removed and replaced by an approved alternative anchor within 5-years from the date the areas is designated and approved by the Harbormaster" (Town of Chatham, 2011). The phrase "alternative anchor system" has been used in other projects in New England to mean the combined use of a helix anchor and elastic rode; however, this phrase is not defined formally in the Chatham regulations. Likewise, the Gloucester Harbormaster may require "alternate mooring specifications for areas that have been designated as environmentally sensitive", although these alternate systems are not defined (City of Gloucester, 2012). As described previously, for moorings located in specific environmentally sensitive areas, Manchester requires the use of helix anchors or "other mooring system that will have less impact on eel grass fields." (Town of Manchester-by-the-Sea, 2012). The elastic rode system is not listed specifically in the regulations, but could be considered as an option under this definition.

In all regulations, any required mooring specifications are a minimum standard and the harbormaster may require different specifications at his discretion.

New Hampshire

Pursuant to the general authority under N.H. Rev. Stat. Ann. §12-G; N.H. Rev. Stat. Ann. §270:60; Pda 500 Moorings and Anchorages rules; and all other applicable legal authority, the State has the right to confer authority to the municipalities, and the municipalities have the power to exercise such authority to issue temporary, annual permits to the public for the mooring of vessels and related structures under such terms, conditions, and restrictions that may be deemed necessary.

The Pease Development Authority, Division of Ports and Harbors (PDA-PH) is responsible for permitting, locating and managing moorings in New Hampshire coastal waters. The Pda 500 Moorings and Anchorage rules include only a block weight as a mooring anchor. The use of helix anchors or an elastic rode is not mentioned in the Pda 500 rules. In addition, there is no conservation-oriented language in these regulations regarding mooring placement; however, other necessary State approvals, such as by the DES Wetlands Bureau, will include environmentally-based requirements.

Maine

Pursuant to the general authority under Me. Rev. Stat. Ann. tit. 38, § 1-13; Me. Rev. Stat. Ann. tit. 30-A, § 3001; Me. Rev. Stat. Ann. tit. 12, § 13072; Me. Const. art. VIII, pt. 2, § 1, and all other applicable legal authority, the State has the right to confer authority to the municipalities, and the municipalities have the power to exercise such authority to issue temporary, annual permits to the public for the mooring of vessels and related structures under such terms, conditions, and restrictions that may be deemed necessary.

A few municipalities, including Brunswick, Falmouth, and Freeport, specifically include helix anchors as a designated mooring type option; however, helix anchors are not required. The use of an elastic rode is not mentioned in any municipal mooring regulations. Due to the large tidal range in many Maine harbors, installation of elastic rode systems is challenging and this equipment may be exposed at low tide (Lefebvre, personal communication). A few municipalities allow only a particular type of mooring anchor, such as a mushroom anchor or granite block, or list mooring tackle requirements only for that anchor type. Meanwhile, other municipalities may expressly prohibit a particular mooring type. If a mooring anchor type is specified, many municipalities indicate that another anchor may be used at the harbormaster's discretion. In all cases the harbormaster makes the final decision whether a mooring anchor and rode system is adequate for the vessel and local conditions.

A few municipalities, including Brunswick and Sebago (draft regulations), indicate that moorings should be placed in a location that does not “unreasonably affect natural resources” (Town of Brunswick, 2012) or “materially adversely affect great pond vegetation, lake wildlife, or any natural aquatic habitat” (Town of Sebago, 2011).

Summary of State and Municipal Regulations

Overall the local mooring regulations in Massachusetts municipalities contain the greatest number of references to helix anchors and elastic rodes, as compared to New Hampshire and Maine.

In Massachusetts, 2 municipalities require the use of helix anchors in specific circumstances, 16 municipalities allow the use of helix anchors, and 5 municipalities include specific requirements for size and use of helix anchors. In contrast, no municipalities in Maine require the use of helix anchors, 3 municipalities allow the use the helix anchors, and no municipalities include specific requirements for size and use of helix anchors. In New Hampshire, State mooring regulations do not include helix anchors in any capacity.

In Massachusetts, 4 municipalities allow the use of elastic rodes but do not require it. In contrast, neither Maine nor New Hampshire explicitly allow the use of elastic rodes as stated in their local mooring regulations.

RECOMMENDATIONS, IMPLEMENTATION STRATEGIES, AND CONCLUSIONS

Research has shown that, correctly installed, conservation moorings minimize impacts to benthic habitats as compared to the impacts caused by conventional moorings; and are less expensive than the cost associated with trying to restore eelgrass. Furthermore, continued local monitoring of the re-growth of *Zostera marina* is expected to provide more information about the potential for re-colonization of mooring scars through the installation of conservation moorings.

In addition to the ecological benefits of conservation moorings, there is very little evidence to suggest that conservation moorings are any less capable of securely mooring a vessel than conventional moorings. The few reports of conservation mooring failures had to do with improper installation and parts, possible interference with the mooring from debris (Department of Employment, Economic Development and Innovation, 2011; Hylland, personal communication), and/or end-user misuse (Lefebvre, personal communication) – factors that can also jeopardize the holding capabilities of conventional moorings.

Anecdotal reports from harbormasters and manufacturers of conservation moorings suggest that many boaters in New England are generally adverse to adopting conservation mooring technologies – in part because information about the holding capabilities of conservation moorings is not widely accessible, in part because of the potential increased upfront cost of conservation moorings compared to conventional moorings (especially when boaters or towns already own mooring equipment), and in part because changing technologies might require relocating moorings to a new location in the mooring field that may be less convenient for a boater than his previous location. Additionally, in town-managed mooring fields, some harbormasters may be reluctant to adopt conservation moorings because of the increased costs associated with relocating a helix anchor (e.g., in the case that the fleet size changes), the push-back they may encounter (from the public as well as mooring service companies) if they require conservation moorings, the lack of third-party verification of manufacturer claims regarding holding power, and the abilities of local mooring installers to correctly install the technology.

While the Army Corps of Engineers already requires a permit in Massachusetts for any mooring proposed in eelgrass, and mandates the conversion from conventional moorings to conservation moorings when moorings in eelgrass change ownership or are replaced, there is no information on the compliance level of this regulation due to a lack of resources for adequate enforcement. Recommendations for increasing the use of conservation mooring in Massachusetts waters include:

- *Write the need for conservation moorings into State-approved harbor plans (310 CMR 23) so that State decisions are consistent with the town visions for low-impact moorings.*
  Harbor plans are documents produced by towns to better address activities, uses, and natural resources along a town's coast and waterways. A harbor plan contains a series of recommendations to help promote a town's goals and visions; and when a harbor plan is approved at the State level, State decisions with regard to the harbor planning area must be consistent with the town's harbor plan. For example, if a town recommends that any project affecting eelgrass beds should offer mitigation in the form of conservation moorings, then a project requiring a Chapter 91 license from the State must be in compliance with this recommendation if eelgrass is affected.
- *Educate boaters, including fishermen, about the importance of eelgrass and the impacts of conventional moorings vs. conservation moorings.*
  One of the barriers to increased use of conservation moorings is a lack of boater awareness regarding both the value of eelgrass, and the impacts of moorings on eelgrass. Increased boater education (through demonstration projects, presentations, posters, and publications) about the significance of eelgrass and the impacts of moorings may encourage boaters and fishermen to consider the use of conservation moorings.
- *Educate boaters about the long-term cost comparison of conservation and conventional moorings*.
  The upfront cost of conservation moorings can discourage boaters from investing in the technology. However, over the life of a mooring, a conservation mooring may be less expensive than a conventional mooring. Real-world examples of the average costs of different types of moorings in New England (from purchase and installation to maintenance and replacement) should be gathered and incorporated into a publication or presentation that clearly demonstrates the comparative costs experienced by actual boaters. This information could be made available to other boaters and harbormasters to help clarify actual cost differences over the life of a mooring.
- *Develop and share better information regarding the holding capacities of conservation moorings.*
  One of the most significant issues with regard to promoting the use of conservation mooring technology to the public is the fact that there are no independent reviews of conservation mooring technologies. The existing information comes from manufacturers and from anecdotal reports of boaters, installers, and harbormasters familiar with the mooring systems. An independent third-party evaluation of the capabilities (e.g., longevity/life expectancy, holding abilities, performance under storm conditions, ecological impacts) of conservation moorings would help to alleviate hesitation within the boating community with regard to trying a relatively new technology. This third party review would also help to clarify and provide uniformity to the different terminology used by each manufacturer in terms of holding strength. As information exists currently, it is very difficult to compare the different technologies in terms of holding power and cost because they are each using different language to describe their products' abilities. Manufacturers should play an active role in working to have this comparative analysis completed (including providing financing for the test of needed) as it may increase boaters' faith in the holding powers of the technologies.

- *Identify and/or provide incentives or funding to off-set some of the upfront expenses associated with conservation moorings.*
  One of the barriers to the use of conservation moorings is the upfront cost associated with purchasing and installing the equipment. Incentives such as reducing mooring fees or movement up the waiting list may help encourage individual boaters to use conservation moorings. Other funding opportunities and incentives might come from grants, mitigation funds, or by buying mooring technologies in bulk.
- *Enforce compliance with Army Corps regulations.*
  The Army Corps of Engineers does not have the resources to ensure compliance with all regulations. They (the Army Corps) rely on the assistance of harbormasters to ensure that moorings do not negatively impact eelgrass. Improved communication with harbormasters on the part of the Army Corps may lead to a better understanding of regulations and may assist harbormasters in ensuring compliance with Army Corps regulations.
- *Encourage local mooring installers to offer services for conservation moorings.*
  Conservation moorings, especially those on helical anchors, must be installed by professional mooring installers. Proper training and incentives for installers to work with conservation moorings may increase their use in sensitive habitats by providing boaters with a reliable installer who can also assist when issues arise.
- *Monitor the installation of conservation moorings in eelgrass to improve scientific evidence regarding environmental impact.*
  Some of the existing conservation mooring installation projects (e.g., Manchester Harbor and Provincetown Harbor) have decent information regarding site conditions prior to installation. These harbors should continue to be monitored to understand the ecological impacts to the eelgrass beds. Future installations, especially those conducted as part of a mitigation project, should include long-term monitoring plans to build scientific data regarding the ecological impacts of conservation moorings. Creating partnerships with Universities such as the University of Massachusetts Boston, which has academic and student resources (including a SCUBA diving club), might be a way to maintain monitoring programs.

Some things for communities to consider when adopting conservation moorings are:

- The ecological benefits of conservations moorings may be most noticeable in concentrated areas, rather than dispersed throughout existing mooring fields.
- The ecological and economical benefits of installing conservation moorings are largest when installing moorings in existing eelgrass, as opposed to installing conservation moorings as a means to try and restore lost eelgrass.
- New boaters or boaters interested in new mooring fields may be more willing to adopt conservation mooring technologies than boaters who have been using the same mooring in the same location for generations.
- There may be increased costs associated with using helix anchors if they need to be regularly relocated in mooring fields. If possible, initial placement should be part of a larger mooring field design effort as opposed to opportunistic or ad hoc placement in order to reduce the need to relocate helix anchors.
- Town mooring regulations may need to be changed to include information pertaining to conservation moorings, specifications on scope, the type(s) of approved conservation mooring technologies, and specific details about helical anchors (e.g., holding capacity limits, approved installation methods, how to address potential conflicts with other water uses such as scalloping, how to inspect helical anchors, etc.).

- In the event that conservation moorings are introduced into mooring fields, it will be important to make sure that any increase in boat density does not result in excessive shading of eelgrass beds or additional environmental damage stemming from increased boating activity.
- When placing conservation moorings, special attention should be given to ensuring that vessels on a shorter scope with a conservation mooring do not restrict the safe movement of nearby vessels moored on conventional moorings with longer scopes.

RESOURCES

American Boat and Yacht Council. 2003. Anchoring, Mooring, and Strong Points. Online at: http://epcomarineproducts.com/pdfs/H-40.pdf. Last viewed 01/23/2013.

Anchor, Gear, and Line. 2012. Personal communication regarding the installation of helix anchors.

Army Corps of Engineers. 2010. General Permit: State of Maine. Online at: http://www.nae.usace.army.mil/Regulatory/SGP/ME_GP.pdf. Last viewed 01/23/2013.

Army Corps of Engineers. 2011. General Permit: Commonwealth of Massachusetts. Online at: http://www.nae.usace.army.mil/Regulatory/SGP/MA/Modification_Final_110728.pdf. Last viewed 01/23/2013.

Army Corps of Engineers. 2012. Programmatic General Permit. State of New Hampshire. Online at: http://www.nae.usace.army.mil/Regulatory/SGP/NH_PGP.pdf. Last viewed 01/23/2013.

Army Corps of Engineers and MA Division of Marine Fisheries. 2011. Massachusetts In-Lieu Fee Mitigation Program Fact Sheet. Online at: http://www.nae.usace.army.mil/Regulatory/Mitigation/In-Lieu/MA-Factsheet.pdf. Last Viewed 1/23/2013.

Baker, Jay, Evans, Tay. 2012. NEP/CRP Partnership Progress Report Form: Use of "Conservation Moorings" as a Component of Eelgrass (*Zostera marina*) Restoration and Rehabilitation in Two Massachusetts Harbors.

Baker, Tom. 2012. Personal Communication regarding experience with conservation moorings.

Batker, David, Swedeen, Paula, Costanza, Robert, de la Torre, Isabel, Boumans, Roelof, Bagstad, Kenneth. 2008. A New View of the Puget Sound Economy: The Economic Value of Nature's Services in the Puget Sound Basin. Online at: http://www.floods.org/ace-files/documentlibrary/committees/A_New_View_of_the_Puget_Sound_Economy.pdf. Last viewed 01/23/2013.

Betcher, Chris, Williams, Brian. No date. Impact of Mooring Buoy Installations on Eelgrass and Macro Algae.

BoatU.S. No date. What Works: A Guide to Preparing Marinas, Yacht Clubs, and Boats for Hurricanes. A Marine Insurance Publication. Online at: http://www.boatus.com/hurricanes/assets/pdf/hurr_prep_guide.pdf. Last viewed 01/23/2013.

Boeri, Bob. 2012. Personal Communication regarding feedback on the report and the State's perspective on conservation moorings.

Burr Brother Boats, Inc. 2012. Personal Communication regarding the cost of installing moorings and anchors of various types.

City of Gloucester. 2012. Waterways Policies, Rules and Regulations, Article IV: Mooring Regulations. Online at: http://gloucester-ma.gov/DocumentCenter/Home/View/457. Last viewed 01/23/2013.

Colarusso, Phil. 2012. Personal Communications regarding location and value of conservation moorings and the anticipated cost/acre of an eelgrass restoration project.

Cormier, Michael. 2012. Personal communication regarding the Town of Marion's experience with helix anchors.

Costanza, Robert, d'Arget, Ralph, de Groot, Rudolf, Farber, Stephen, Grasso, Monica, Hannon, Bruce, Limburg, Karin, Naeem, Shahid, O'Neill, Robert V., Paruelo, Jose, Raskin, Robert G, Sutton, Paul, van den Belt, Marjan. 1997. *The value of the world's ecosystem services and natural capital. Nature. Vol. 387. May 15, 1997.* Online at: http://www.esd.ornl.gov/benefits_conference/nature_paper.pdf. Last viewed 01/23/2013.

Costello, Charles T., Kenworthy, William J. 2011. Twelve-Year Mapping and Change Analysis of Eelgrass (Zostera marina) Areal Abundance in Massachusetts (USA) Identifies Statewide Declines. Estuaries and Coasts. 34(2): 232-242.

Department of Employment, Economic Development and Innovation. 2011. *Environmentally-friendly moorings trials in Moreton Bay: Report to SEQ Catchments*, Brisbane, Queensland.

Evans, Tay. 2012. Personal Communication regarding monitoring at conservation mooring sites in Manchester Harbor.

Fronzuto, Dave. 2012. Personal communication regarding the Town of Nantucket's experience with helix anchors and conservation moorings.

Gladstone, Bill. 2011. Monitoring of Seagrass Friendly Moorings in Shoal Bay: Report of 2010 Monitoring.

Hazelett Marine website. Online at: http://www.hazelettmarine.com/. Last viewed 01/23/2013.

Heck, K.L., Jr., Able, K.W., Fahay, M.P., Roman, C.T. 1989. Fishes and Decapod Crustaceans of Cape Cod Eelgrass Meadows: Species Composition, Seasonal Abundance Patterns and Comparison with Unvegetated Substrates. Estuaries. 12(2) June 1989. Pages 59-65.

Hughes, Jeffrey E., Deegan, Linda A., Wyda, Jason C., Weaver, Melissa J., Wright, Amos. 2002. *The Effects of Eelgrass Habitat Loss on Estuarine Fish Communities of Southern New England.* Estuaries. 25(2). April 2002. Pages 235-249.

Hylland, Brian. 2012. Personal communication regarding the Seaflex Mooring product.

Hylland, Brian. 2012. Reader Rant: Moorings Didn't 'Fail' in Santa Barbara – Connecting Components Failed. *The Log* 2/16/2012. Online at: http://www.thelog.com/Opinion/Article/Moorings-Didn-t--Fail--in-Santa-Barbara----Connecting-Components-Failed. Last viewed 01/23/2013.

INAMAR. No date. Moorings: Important recommendations for safe moorings from INAMAR. Online at: http://ocw.tudelft.nl/fileadmin/ocw/courses/OffshoreMoorings/res00027/Moorings.pdf. Last viewed 01/23/2013.

Kachmar, Jon. 2012. Personal Communication regarding document review and the estimated cost/acre of an eelgrass restoration project.

Kilby, Karlton. 2012. Personal Communication regarding insurance company rates for different types of moorings. (Mr. Karlton works for Seaworthy Insurance Company)

Lefebvre, Jeff. 2012. Personal communication with Jeff (of New England Marine) regarding Hazelett and StormSoft moorings.

Malkoski, Vincent J. 2008. Guide to the Massachusetts In-Lieu Fee Habitat Mitigation Program (Draft). Massachusetts Division of Marine Fisheries.

MER Assessment Corporation. 2008. Feasibility of mitigating physical disturbances to eelgrass in northern Casco Bay: Impacts and Options. Online at: http://www.cascobay.usm.maine.edu/pdfs/eelgrass_feasibility_of_mitigating_report_022808.pdf. Last viewed 01/23/2013.

Merrill, Dave. 2012. Personal Communication regarding the Eco-Mooring System and helix anchors (www.helixanchors.com).

National Oceanic and Atmospheric Administration. No Date. Protecting eelgrass habitat through the use of conservation moorings. Online at: http://www.atlanticfishhabitat.org/Documents/21981ProtectingEelgrassHabitat-2_000.pdf. Last viewed 01/23/2012.

Peerless-Acco Chain catalog. No date. Online at: http://www.peerlesschain.com/catalogs/catalog-2010/. Last viewed 01/23/2013.

Port of New Bedford. 2010. Official Mooring & Anchoring Regulations. Online at: http://www.portofnewbedford.org/documents/HDC_MooringRegs2010.pdf. Last viewed 01/23/2013.

Seagrass Recovery. No date. Online at: http://www.seagrassrecovery.com/resources/florida-seagrass-facts/. Last viewed 01/23/2013.

Skilleter, Greg. 2012. Personal communication regarding monitoring efforts in Moreton Bay, Queensland.

Sleeman, G.S. 1992. Boat Owners' Sprits Buoyed by New Development. New Bedford Standard Times. Thursday Oct. 1, 1992. Online at: http://www.helixanchors.com/index.php/Historical-News/boat-owners-spirits-buoyed-by-new-development.html. Last viewed 01/23/2013.

Smith, Stuart. 2012. Personal Communication regarding experience with conservation moorings in Chatham Harbor.

Swan, Brian M. 2012. Eelgrass and Moorings. Maine Department of Marine Resources. Online at: http://www.maine.gov/dmr/crd/hmo/eelgrassmoorings.pdf. Last viewed 01/23/2013.

Terramar Environmental Services, Inc. 2011. Vessel Mooring Study - Boca Chica Harbor - Monroe County, Florida. Final Project Report. Online at: http://www.monroecounty-fl.gov/DocumentCenter/Home/View/1398. Last viewed 01/23/2013.

Town of Brewster. 2008. Mooring Regulations. Online at: http://www.town.brewster.ma.us/images/stories/mooring_regs_7.29.2008.pdf. Last viewed 01/23/2013.

Town of Brunswick. 2012. Chapter 11: Marine Activities, Structures and Ways. Online at: http://www.brunswickme.org/wp-content/uploads/2011/12/Ch011.pdf. Last viewed 01/23/2013.

Town of Chatham. 2011. Regulations for Mooring, Mooring Permits and Anchoring. Online at: http://www.town.chatham.ma.us/public_documents/chathamma_harbor/regulations/MOORINGREGS2011.pdf. Last viewed 01/23/2013.

Town of Eastham. 2011. Mooring Regulations and Policies. Online at: http://www.eastham-ma.gov/Public_Documents/EasthamMA_Resources/mooring.pdf. Last viewed 01/23/2013.

Town of Falmouth. 2007. Chapter 269: Mooring Regulations. Online at: http://www.falmouthmass.us/harbor/website%20chapter%20269.pdf. Last viewed 01/23/2013.

Town of Manchester-by-the-Sea. 2012. Manchester Harbor: Mooring & Waterway Regulations. Online at: http://www.manchester.ma.us/pages/manchesterma_harbor/Amended%20Regs.pdf. Last viewed 01/23/2013.

Town of Marion. 2007. Waterways Regulations. Online at: http://www.marionma.gov/pages/marionma_harbormaster/waterwaysregs.pdf. Last viewed 01/23/2013.

Town of Sebago. 2011. Draft Mooring Ordinance. Online at: http://www.townofsebago.org/Pages/SebagoME_Ordinances/mooring?textPage=1. Last viewed 01/23/2013.

West Marine. No date. Wind Load Tables. Online at: http://www.westmarine.com/webapp/wcs/stores/servlet/WestAdvisorView?langId=-1&storeId=11151&catalogId=10001&page=Mooring-Systems. Last viewed 01/23/2013.

Whitman, Tina. 2012. Personal Communication regarding the work of the Friends of the San Juans.

APPENDIX A – HYPOTHETICAL PRICING

Manufacturers and installers work closely with boat owners and harbormasters to select the conservation mooring system most appropriate for a given boat in a given location, resulting in a price tailored for each boat. While this arrangement is important for the safety of the vessel, it presents challenges in terms of understanding the costs of conservation moorings.

To help clarify the costs of conservation moorings for the boating community, one installer and three manufacturers were asked to provide estimates for mooring hypothetical boats at specific locations. The way each system is designed, along with the boat-specific and site-specific nature of pricing, prevents a true cost comparison between different technologies; but the following information provides a better sense of the potential costs of a conservation mooring.

The manufacturers and installer received the following information about the hypothetical boats and mooring site conditions:

Boat length/type	Water depth (mean low water)	Tidal range	Maximum wind speed	Maximum wave height	Current	Predominant wind direction	Bottom type
12’ sail boat	8’	4’	50 mph	3’	1 knot	SW	Sand/silt
18’ power boat	12’	4’	50 mph	3’	1 knot	SW	Sand/silt
30’ sail boat	15’	4’	50 mph	3’	1 knot	SW	Sand/silt
30’ power boat	15’	4’	50 mph	3’	1 knot	SW	Sand/silt
55’ power boat	20’	4’	50 mph	3’	1 knot	SW	Sand/silt
55’ sailboat	20’	4’	50 mph	3’	1 knot	SW	Sand/silt

It was assumed that all moorings would be installed on a helix anchor, making that element of price uniform among all vessels. Very rough estimates from one installer of helical anchors (Jeff Lefebvre of New England Marine, LLC) suggested that the 12’ and 18’ vessels might require a helix anchor costing approximately $450 for parts and installation; the 30’ vessels might require helix anchors costing approximately $1,200 for parts and installation; and the 55’ vessels might require helix anchors costing approximately $1,300 for parts and installation. Less expensive block anchor options may also be available, but prices for those are not included because those anchors would not maximize the conservation aspect of the moorings.

Pricing information for the moorings themselves, which include everything between the mooring anchor and the boat cleat (except in the case of Seaflex, which does not include the pendant or buoy), are below.

StormSoft System (Estimates provided by Jeff Lefebvre of New England Marine LLC)

These estimates include everything between the mooring anchor and the boat cleat.

Boat	StormSoft System Description	Estimate (not incl. anchor)	Cost of installation (not incl. anchor)
12’ sail boat	Single 10-ft StormSoft, 3-ft connection line, Gilman drum buoy, ¾” X 10-ft pennant-24,000-lb test, Rigged by New England Marine LLC	$1,500	$100
18’ power boat	Single 10-ft StormSoft, 7-ft connection line, Spar buoy, ¾” X 10-ft pennant-24,000-lb test, Rigged by New England Marine LLC	$1,500	$100
30’ sail boat	Single 10-ft StormSoft, 10-ft connection line, Spar buoy, ¾” X 10-ft pennant-24,000-lb test, Rigged by New England Marine LLC	$1,500	$100
30’ power boat	Single 10-ft StormSoft, 10-ft connection line, Spar buoy, ¾” X 10-ft pennant-24,000-lb test, Rigged by New England Marine LLC	$1,500	$100
55’ power boat, (non-commercial vessel)	Double 10-ft StormSoft assembly, 15-ft connection line, Spar buoy, 7/8” X 12-ft pennant-35,000-lb test, Rigged by New England Marine LLC	$2,250	$100
55’ sailboat	Double 10-ft StormSoft assembly, 15-ft connection line, Spar buoy, 7/8” X 12-ft pennant-35,000-lb test, Rigged by New England Marine LLC	$2,250	$100

Hazelett System (Prices provided by Tom Hill of Hazelett)

Selecting the appropriate Hazelett system is highly dependent on the weight of a vessel. Since vessel weights vary tremendously depending on the type of boat (which was not provided for this hypothetical pricing exercise), exact prices cannot be determined. That being said, each of the hypothetical vessels would use the 10’ rode system (which includes everything between the mooring anchor and the deck cleat). Prices for the 10’ systems are as follows:

Mooring Description	Price (equipment only)	Boat Weight
Single 10’ system	$1,849	5 ton
Double 10’ system	$2,552	16 ton
Triple 10’ system	$3,453	25 ton
Quad 10’ system	$4,223	35 ton

Seaflex System (Prices provided by Brian Hylland of Seaflex)
These estimates only reflect the price of the Seaflex rode. They do not include the price of the pendant or the buoy; and they assume a 1:1 scope.

Boat	**Seaflex System and List Price (rode only)**
12' sail boat	1015 TS : $449
18' power boat	2020 TS BP or 1015 TS: $1,162 or $449
30' sail boat	2020 TS BP: $1,243
30' power boat	2020 TS BP: $1,243
55' power boat	4020 TS BP: $1,729
55' sailboat	4020 TS BP: $1,729

Eco-Mooring System (Prices provided by Dave Merrill of boatmoorings.com)
These estimates include everything between the mooring anchor and the boat cleat.

Boat	**Eco-Mooring System Description**	**Estimate (not incl. anchor)**
12' sail boat	5/8 in. dia. Eco Mooring rode rated at 9,900 lbs breaking load, chain, swivel, shackles, sized accordingly, 12 in. Carolina buoy, 5/8 in. dia. pendant rated at 15,500 lbs	$ 1,000
18' power boat	Same as above	
30' sail boat	1 in. dia. Eco Mooring rode rated at 21,000 lbs breaking load, chain, swivel, shackles, sized accordingly, 18 in. Carolina buoy, 3/4 in. dia. pendant, rated at 21,500 lbs	$ 1,300
30' power boat	Same as above	
55' power boat	1-5/16 in.dia. Eco Mooring rode rated at 32,800 lbs breaking load, chain, swivel, shackles, sized accordingly, 24 in. Carolina buoy, 1-1/4 in. dia. pendant, rated at 49,000 lbs	$ 1,850
55' sailboat	Same as above	