March 2015

Moorings

A Preliminary Guide to Mooring Systems, Mooring Choices and Mooring Selection

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Consideration for Moorings

A Preliminary Guide to Mooring Systems, Mooring Choices and Mooring Selection

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This report was prepared by The Musson Group under award CZM NA13NOS4190045 to the Maine Coastal Program from the National Oceanic and Atmospheric Administration, U.S. Department of Commerce. The statements, findings, conclusions, and recommendations are those of the author(s) and do not necessarily reflect the views of the National Oceanic and Atmospheric Administration or the Department of Commerce.

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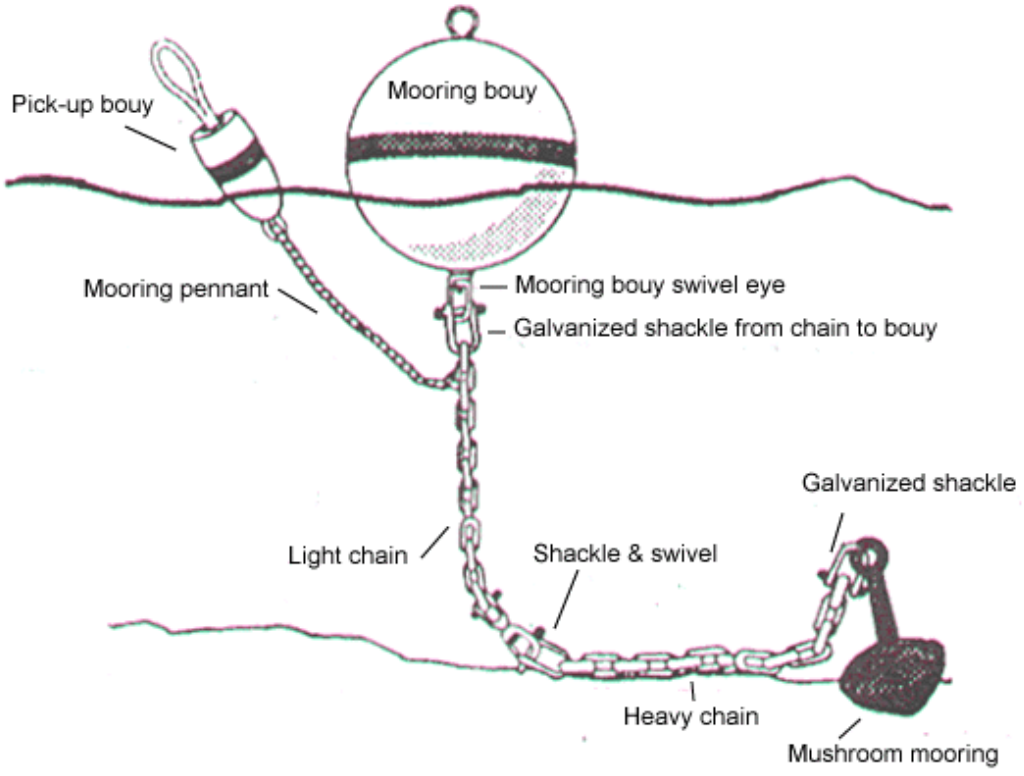
Acknowledgements

This report was prepared with assistance of several knowledgeable individuals. The author would like to thank the members of the Maine Harbor Masters Association Board of Directors for their suggestions, input and guidance. Specifically Katherine Pickering, Dave Schmanska, Jim Hayes, Chris Mayo, Jay Pinkham, Charlie Phippen, Dave Corbeau, Shawn Hebert, and Ed Glaser. We would like to thank Wayne Hamilton, Owner of Hamilton Marine and Searsport Harbormaster for his previous research and training on moorings. We would also like to thank Josh Willard from Chalmers Enterprises, Jay Clement from the Army Corps of Engineers, Matthew Nixon from the Maine Coastal Program, and Ruta Dzenis from the Municipal Planning Assistance Program for their contributions to this document.

Introduction and Purpose

FOR MOST BOATERS, SHORESIDE DOCKAGE IS NOT POSSIBLE OR PRACTICAL. Therefore, most use some type of mooring. While much can be written about moorings, the focus of this report is to provide an overview tool that can be referred to when considering alternative moorings options. While specifications on equipment are not addressed in this report, the reader, whether a Harbor Master, local committee member, or interested citizen, can refer to this report as a preliminary guide when considering a mooring for their individual boat, as part of an overall harbor planning effort, or when considering new ways to protect sensitive harbor resources such as eelgrass, shell fish beds, and lobster habitat. There are many design considerations when establishing a reliable mooring system. One must consider the depth of water (in Maine, tides commonly range 12 feet or more), size of the vessel, the exposure of the location, current, the type of bottom, the swinging room available, the chain and pennant size needed, and the vessel hardware layout. This report will touch on many of those considerations. However, as Wayne Hamilton, Harbor Master for the Town of Searsport and owner of Hamilton Marine, said in his training packet to the Maine Harbor Masters Association, "The most reliable mooring systems are those tested by time and gradually improved with technology." In addition, all harbors have unique characteristics which must be considered and many communities have specific requirements set out in Harbor Ordinances. Therefore, it is extremely important to consult with local experts such as Harbor Masters and marine professionals who regularly install moorings.



Overview of a Mooring System

A MOORING REFERS TO ANY PERMANENT STRUCTURE to which a vessel may be secured. A "mooring system" refers to the various components – an anchor, a rode (typically a rope, chain, or cable), a buoy, and a pennant.

THE ANCHOR

An anchor is used to fix a vessel to a point on the bottom of the seafloor without connecting it to land. There are four basic types of anchors used in moorings:

Deadweight Anchors. Deadweight anchors are the simplest type of anchor and, in many harbor settings, provide the greatest reliability. Their holding power is through weight. Once the heavy weight settles on the bottom, the anchor becomes embedded and the suction effect helps to increase its holding power. Deadweight anchors can be made of most any heavy object but are typically a large stone block or concrete. Due to their size and weight, these anchors typically require a barge to set.

Top: Deadweight Anchors; Bottom: Mushroom Anchors

Mushroom Anchors. Mushroom anchors get their name from their shape, which looks like an upside down mushroom. They work best in mud, sand, silt or other soft ocean bottoms where they can be easily buried. Once buried, a mushroom mooring is typically thought to be able to hold up to 10 times its weight. In certain conditions, mushroom anchors that are not properly embedded in the bottom can dislodge and lose holding power. This is commonly referred to as "spin out." Additionally, mushroom anchors run the risk of having the chain wrap around the shaft of the anchor when not properly set. This can reduce the scope of the mooring.

Pyramid Anchors. As the name implies, these one piece cast iron anchors are shaped like a pyramid. Pyramid anchors are essentially a redesigned version of a mushroom anchor. They are comparable in terms of holding strength, but their smaller size pyramid shape helps them penetrate the bottom more rapidly. Pyramid anchors have a shorter anchor shaft which helps to minimize the potential for chain wrap and also makes then useful in more shallow water settings. These anchors are used in hard, rocky or sandy bottoms. Sometimes these anchors are call "Dor-Mor" anchors after one of their manufacturers.

Helix Anchors. Helix (or screw-in) anchors are made of high tensile steel with an attachment eye at the top and large threads at the lower end. These anchors come in long (8 ft.) lengths with

varying diameters of threads (10", 14"). To set the anchor, they are screwed in until the top eye is essentially flush with the bottom connected to traditional ground tackle. While screw-in or helix anchors have been used by the offshore oil industry for well over 20 years, they are a relatively new technology in anchoring systems for the yachting and smaller commercial vessel markets. Recent industry tests are showing that these anchors can offer significantly more holding power that traditional anchors when set property and in the right conditions. These anchors may also help eliminate or minimize damage to sensitive benthic resources like eel grass, shellfish beds and lobster habitat. *(See discussion on conservation moorings)*

Top: Pyramid Anchors; Bottom: Helix Anchors

TABLE 1. ANCHOR SUMMARY TABLE

	HOLDING POWER	ADVANTAGES	DISADVANTAGES	NOTES
Deadweight	An 8,000lb. concrete mooring has approximately 4,000lb. of holding power	• Simple design • Good for most bottom types • Still holds position even if dragged during storm	• Heavy, bulky, requires assistance for installation	• Better suited for rock bottoms than other anchors • Deadweight moorings made from concrete can lose over half their weight when submerged in water • Deadweight moorings made from granite can lose over a third of their weight when submerged in water • Fault lines in stone anchors can crack when putting in staples
Mushroom	A 500lb. mushroom anchor has approximately 1,200lb. of holding power	• Has a high holding power-to-weight ratio	• Limited success in rocky areas • Prone to spin out and chain wrap	• Better suited for muddy bottom conditions • Limited success in rocky areas • Prone to spin out and chain wrap • Better suited for muddy bottom conditions • Generally, weight of mushroom anchors would be 10-20 lbs per foot of boat in mud bottom • Proper installation is important to assure it is buried
Pyramid	A 650lb. pyramid anchor has approximately 6,500lb. of holding power	• Has high holding power to weight ratio • Simple design	• Limited succeess in rocky areas • Higher cost	• Better suited for muddy bottom conditions • Size and shape help it penetrate the bottom more rapidly • Generally, weight of pyramid anchors would be 10-20 lbs per foot of boat in mud bottom
Helix	A 10" screw Helix anchor has approximately 10,000lb. of holding power	• High holding power to weigh ratio • Small size • Longevity • More environmentally sensitive	• Specialized installer needed • Difficult in rock • Heavy, bulky, requires assistance for installation • More difficult to move	• Better suited for softer bottom conditions and don't perform as well in rocky bottom conditions • Type of helix used might differ with condition of bottom. • Requires diver to set and maintain

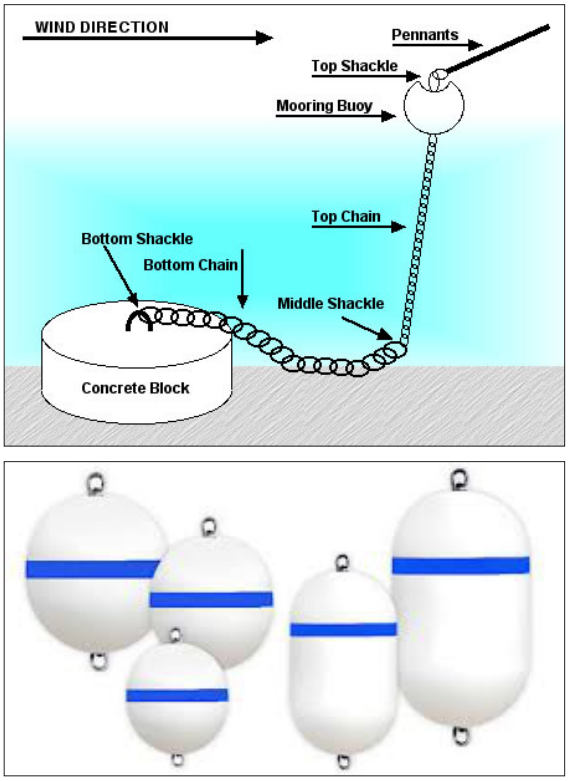
THE RODE SYSTEM

The Rode system, which runs from the anchor to the mooring buoy, has two basic parts – a ground line and a riding line. The ground line, which lies on the bottom, is traditionally made up of heavy chain (bottom chain). The riding line is typically a smaller sized chain called "top chain." The rode can also be made of line or cable.

The rode system is normally several times longer than the depth of the water (typically 1 1/2 times maximum water depth but varies depending on harbor conditions) to assist in the angle of forces that are placed on an anchor. The longer the rode, the lower the angle of force will be on the anchor. As more of the force is pulled horizontally, the holding power of a traditional anchor improves. A longer rode also increases the swinging circle (scope) of each mooring. By adding weight to the bottom of

the rode, such as using a length of heavy bottom chain, the angle of force can be decreased further. Heavy bottom chain can scrape the harbor bottom around the anchor. Newer technologies have been designed to help alleviate this. *(See discussion on Conservation Moorings in the next section.)*

Shackles and swivels are used to connect the anchor, bottom chain, top chain and mooring buoy together. Shackles and swivels can become weak links in the mooring system. Therefore high quality parts are an important consideration.



Top: Illustration showing mooring rode; Bottom: Typical buoy

THE MOORING BUOY

The mooring buoy has two functions. First, it serves to support the rode and floats it off the bottom. Second, it absorbs the shock of heavy waves and wind which helps to increase holding power. US Coast Guard and many Harbor Ordinances have regulations around the type and color of mooring buoys. Many buoys are constructed of polyethylene plastic filled with polyurethane foam and treated with UV inhibitors. However, air inflated net buoys are also commonly used due to their lower costs.

PENNANTS

The pennant ties the boat to the mooring. The pennant should run as straight as possible to avoid chaffing. The sharper the angle of the pennant the greater pressure on the line which increases chaffing. Some harbors ordinances require a secondary or "safety" pennant which is typically longer than the primary pennant and used as a back-up in case the primary fails.

Mooring System Layout

SWING MOORINGS

Swing moorings, also known as "single-point" moorings, are the simplest and most common kind of mooring. For these types of moorings systems a boat is attached to a single anchor and swings about in a circle around that anchor. The boats swing can vary depending on the length of the boat and depth of water. In many harbors, the swing moorings are sited so that the scope or "circle of influence" of each boat does not overlap. In some harbors it might be possible to increase the number of moorings by siting them so that the swing circles overlap. This is very effective in areas where boats of similar size and character are moored. In mixed harbors it becomes more difficult since a 30 foot lobster boat will behave differently than a 30 foot sail boat.

MULTIPLE ANCHOR MOORINGS

There are several options for multiple anchoring moorings. A double mooring system uses a pair of anchors with an additional rode between the two primary rodes. The anchors can be set fore and aft to fix a vessels position more precisely or spaced apart at twice the water depth to reduce the scope of a traditional single point mooring. In some situations a third anchor can be added.

PILE MOORINGS

Pile moorings use a wooden or steel pile driven into the sea bottom to act as the anchor. These moorings are not typically used but can be effective in some harbor setting. Multiple piles can be used to fix the boats position.

MOORING FLOATS

These are actually narrow floating docks which are long enough for boats to tie up to each side of the float. Because each boat and the float rides on the mooring, the mooring must have a strong enough anchor. In many harbors this means that two or more anchors are required. The users of the float are sometimes the owners of the float. In other situations, the owner is the municipality and the floats are leased to the boat owners. Moorings floats work well in more sheltered harbors.

Mooring Planning Considerations

HABITAT

Many harbors and mooring areas are home to eel grass beds and other significant habitat resources that are important to our marine environment and coastal economies. Eel grass, for example, plays an important role in providing spawning and nursery ground as well as serving as foraging grounds, areas of refuge, and food sources. In areas where these sensitive habitats exist, communities should consider the effectiveness of Conservation Moorings to help minimize the impacts moorings can have. The Maine Department of Marine Resources has an eel grass inventory for current/historic extent of eel grass along Maine's coast. This information can be accessed at **http://www.maine.gov/dmr/maps/mapindex.html**.

HARBOR BOTTOM

The type of harbor bottom (rocky, muddy, sandy, etc.) is an important consideration for what type of anchor is used. As noted above, some anchors are well suited for soft muddy bottoms, but will not function as needed in hard rock bottoms.

EXPOSURE

Exposure to open sea and fetch, which is the distance traveled by wind or waves across open water, allows wave and wind strength to build enough force to drag gear around. Therefore more exposed areas require heavier gear while more sheltered location requires less hefty ground tackle.

HOLDING CAPACITY

There are many variables in determining appropriate holding capacity - the wind, depth of water, bottom conditions, currents, and seas, all have influences. Holding capacity of a mooring depends on factors such as the strength of the rodes, the deck hardware, the shackles, and the resistance of the anchor. Additionally, the size and type of vessel make a big difference. A sailing vessel is more streamline, where power vessels are usually wider. Even if both vessels were the same weight, the power vessel might stress the mooring a lot more on a windy day. Swells and storm surges can cause water levels to rise which will have an effect on the holding capacity the anchor. Anchors are designed to hold best when pulled on at an angle. On a traditional mooring, as water rises, the boat is pulled toward the anchor. If the scope is too short, or if water levels rise enough, the boat may end up directly over the anchor. This would cause the boat to pull up on the anchor which would compromise its holding capacity.

MAINTENANCE

The holding capacity and effectiveness of any mooring system is directly related to the maintenance of its various components. Buying quality chain and hardware is an important aspect of a functional mooring system. Most harbor regulations have specific timeframes for inspections and replacement. Moorings of any type should be maintained at least annually to ensure safety. In many harbors, the issue of electrolysis eroding mooring hardware is becoming more of a concern. In these areas mooring systems should be inspected more often.

ECONOMIC CONSIDERATIONS

The cost of a mooring involves several factors including installation costs (which could range from $200.00 for a simple installation to $500.00 or more depending on location), equipment costs, maintenance, insurance, and mooring fees. These costs can vary depending on the complexity of the installation, location of the mooring, and bottom conditions. Helix anchors can be more expensive to install due to the specialized installation requirements.

The information below is provided as a means of comparing costs. Actual prices should be verified.

- 400 lb. mushroom anchor: Ranges from approximately $500.00 to $800.00
- 3,000 lb. concrete block anchor: Ranges from approximately $400.00 to $700.00
- Helix anchor: Ranges from approximately $400.00 to $700.00
- 5/8" chain: Approximately $9.50/foot = $134.85 for 15'
- 3/4" chain: Approximately $16.00/foot = $467.70 for 30'

REGULATORY CONSIDERATION

Moorings are regulated by Federal, State and Local rules.

Army Corp of Engineers (ACOE). Performing work in coastal waters, including placing moorings, is regulated by the ACOE under the Rivers and Harbors 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." Permits are also required under Section 404 of the Clean Water Act for the discharge of dredge or fill material into all waters – tidal and freshwater – and their adjacent wetlands. For more information from the Army Corps visit their website at **http://www.nae.usace.army.mil/**.

State of Maine. The State plays an important role in many coastal projects including moorings, floats, piers and wharfs. State agencies to consult include the Maine Department of Environmental Protection and the Department of Agriculture, Conservation and Forestry's Bureau of Submerged Lands. For more information from the Maine Department of Environmental projection visit their website at **http://www.maine.gov/dep/land/index.html**. Additional information from the Department of Agriculture, Conservation and Forestry Bureau of Submerged Lands can be found at **http://www.maine.gov/dacf/parks/about/submerged_lands.shtml**.

Municipalities. The State of Maine has the right to confer authority over some coastal regulations directly to municipalities. This includes the power to issue temporary and annual permits to the public for mooring of vessels and related structures under such terms, conditions and restrictions as the municipality may deem necessary. Local municipalities should have outlined these rules in their Harbor or Coastal Ordinances.

Conservation Moorings

A CONSERVATION MOORING IS SIMPLY A MOORING SYSTEM that is designed to minimize impacts to habitat. This can be achieved by reducing the contact between the bottom chain and the ocean bottom, by minimizing the potential for the bottom chain to scour the seafloor around the mooring anchor, or by providing added habitat through the anchor system itself.

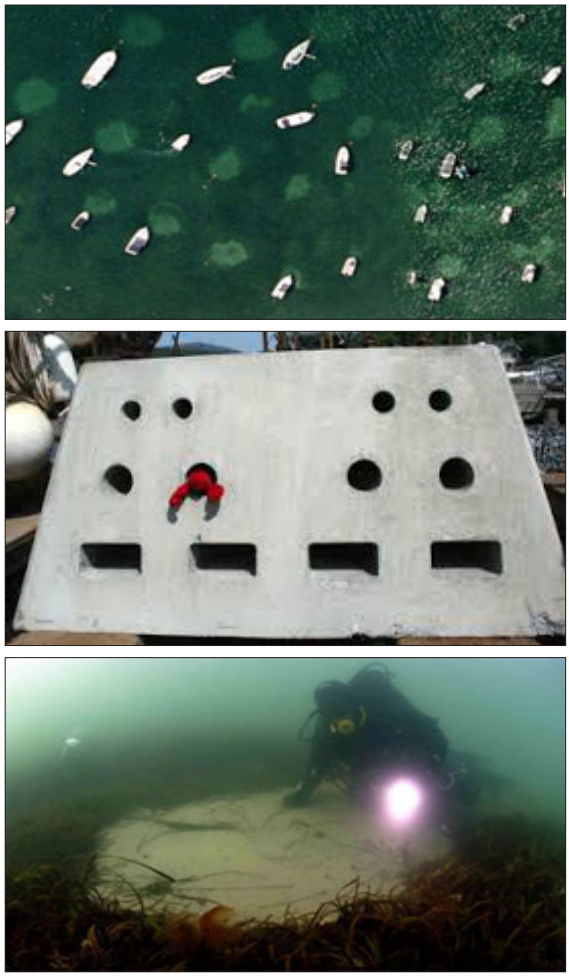
THE ANCHOR

Appropriate anchoring is largely determined by the bottom condition (mud, rock, cobble, etc.). Most conservation mooring systems work well with any type of anchor. The helix anchor is typically preferred due to its minimal footprint. Newer deadweight anchors such as the Habitat Mooring have been designed to provide homes for marine organisms.

THE RODE

The main component of any conservation mooring is to keep the bottom chain off the sea floor. In some applications a float is used to keep the heavy bottom chain from making contact with the bottom. In most applications, an elastic/floating rode system is used. For these systems, the flexibility of the rode replaces the buffering function of a traditional heavy bottom chain and the rode is able to float off the bottom. An extra line is often used to reinforce the lines and safeguard against overstretching and breakage.

Conservation style rodes also have added benefits during storm events. While the lines used on a conventional moorings has some stretch, conservation rodes are specifically designed to stretch, generating more horizontal holding force earlier in the boats movement.

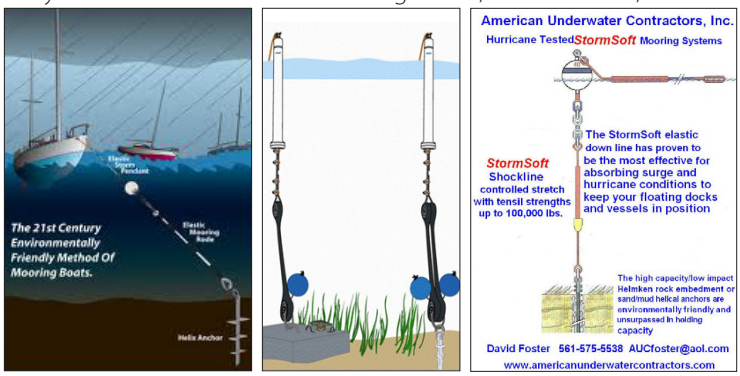


Top: Aerial view showing mooring chain effect on eelgrass bed; Middle: Habitat mooring; Bottom: Diver looking at damage to eelgrass bed from mooring

One concern is that the elastic component of the rode that floats near the surface could become tangled in boating activities. Therefore it is important to make sure they are submerged beyond the reach of boat propellers.

COMMON MANUFACTURERS

A recent study by the Urban Harbors Institute indicated that there are three (3) common conservation mooring systems used in New England. They are: the Eco-Mooring System made by boatmoorings.com, the Hazelett Elastic Mooring System made by Hazelett Marine, and the Stormsoft Elastic Boat Mooring System. These systems seem to be primarity used in Massachusetts including Salem, Provincetown, Gloucester, Nantucket and Chatham. Some harbors in Maine have started to explore the use of conservation mooring components. Wells Harbor, for example, has begun to install a limited number of helix anchors. The Town of Mount Desert has installed a Habitat Mooring as a test mooring in Seal Harbor. According to the Urban Harbors Institute, several Harbors in Massachusetts .



Left: Illustration of Eco-Mooring; Middle: Illustration of Hazelett Elastic Mooring System; Right; Illustration of Stormsoft Elastic Boat Mooring System

TABLE 2. COMMON CONSERVATION MOORING SYSTEMS

SYSTEM	ANCHOR	BUOY	RODE
Eco-Mooring System	Uses various anchor types (helix recommended)	Uses any buoy	Poly fiber rope surrounds a stretchable elastic rubber component. The surrounding rope stretches to provide strength (similar to a Chinese finger trap).
Hazelett System	Helical anchor or deadweight (specifically a concrete or granite block)	Company has developed a spar buoy that can slip below the ice during the winter. It is a standard part of the mooring system	A polymer elastic rode (or series of rodes). The rode system is held off the bottom with trawl floats.
Stormsoft System	Uses various anchor types, helix recommended	Uses any buoy	A "downline" consisting of rubber multi-strand cords surrounded by a braided polyester shell/rope. An inner core maintains the position of the shock absorbing rubber.

Source: Urban Harbors Institute, Conservation Mooring Study, 2013

Considerations for Harbor Committees

MOORINGS IN THE OFF SEASON

When reviewing the harbor ordinance municipalities may want to consider adding rules onappropriate off season storage. In harbors where the moorings stay in place, this couldinclude language on sinking moorings just under the water line or in some cases simplyremoving the mooring.

PLANNING FOR OUTER HARBOR AREAS

According to several harbor masters, the demand for mooring space is increasing. In manyharbors this has led to lengthy wait lists in the tradition harbors (or inner harbor) due tolimited space. Often, many communities begin to look toward outer harbor areas foradditional mooring space. These areas are often more exposed and require additionalthought with regard to mooring system requirements.

SHORE SIDE ACCESS CAN BE A LIMITING FACTOR FOR ADDING MOORINGS

In several harbors, it is not the space in the harbor itself that is limiting the ability to issue new moorings. Instead it is the shoreside access facilities. Several municipal docks are small, have informal parking layout, and have limited room for expansion within existing property boundaries. The result is parking areas and dinghy tie-ups can get full.

REFERENCE YOUR COMMUNITY'S COMPREHENSIVE PLAN OR STATE HABITAT INFORMATION

When considering whether to expand an existing or develop a new mooring field location, consider whether or not your municipality has goals or criterion for the geographic area in question. Additionally, it may be helpful to investigate the State's habitat information (eelgrass/clamming flats, etc) in order to mitigate environmental impacts to the seafloor.

ENGAGE YOUR USERS

The Maine Coastal Program and the Maine Department of Transportation offer grant opportunities, not just for engineering, design, and construction purposes, but for community engagement purposes. Work with your users to figure out what, if any, changes need to be made to your municipality's existing mooring field, access, or amenities.

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