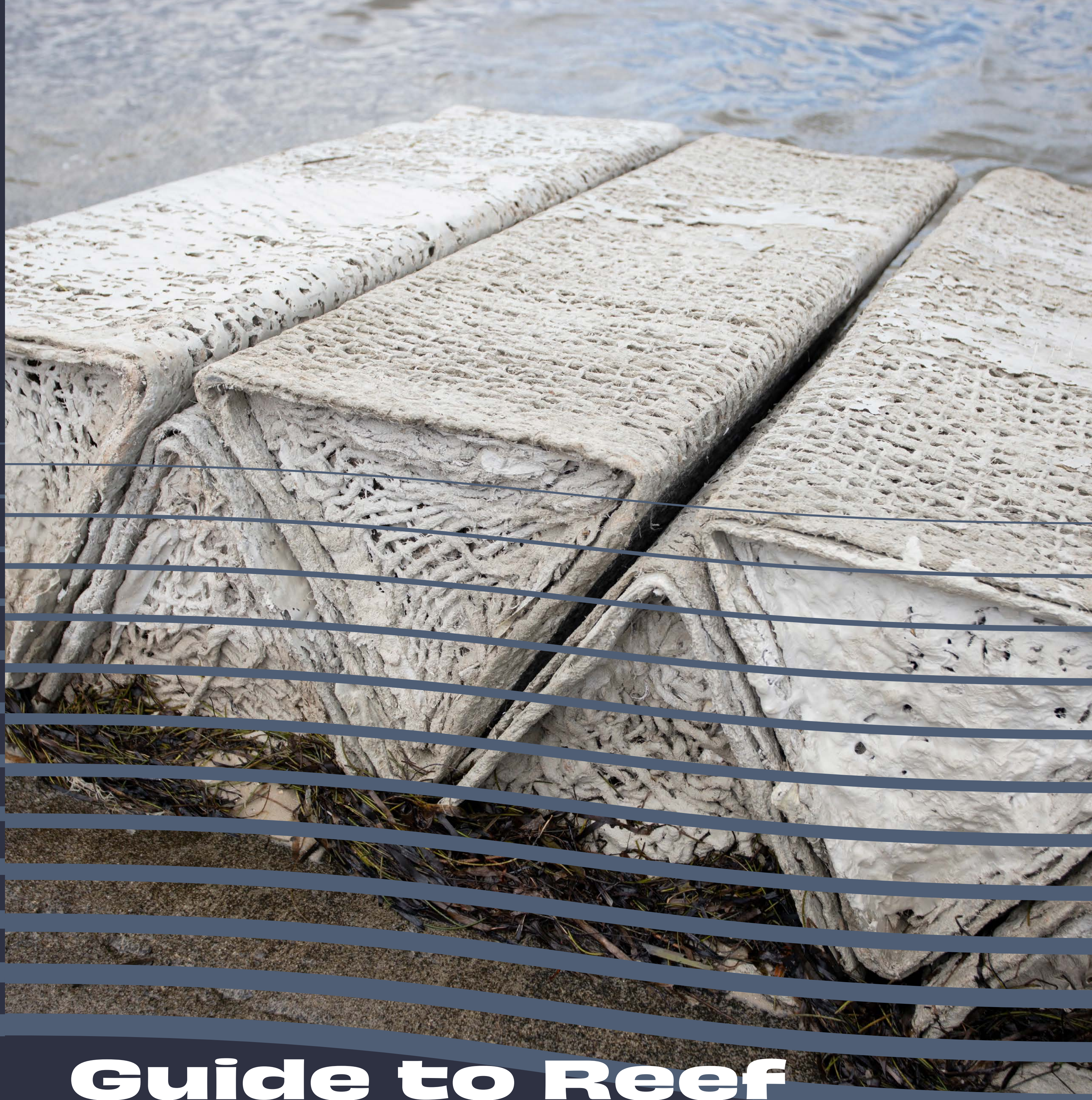

# Guide to Reef Prisms and Panels

## Guidance for the construction and monitoring of plastic-free oyster restoration materials

Mark Clark, Savanna Barry, Elix Hernandez, Laura Reynolds, Ashley Smyth, Haley Cox, Emily Colson

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# Background

Nature-based solutions for coastal erosion, such as living shorelines, are increasing in popularity as practitioners and homeowners learn about the ecosystem services they provide. In addition to native vegetation, many living shoreline designs include an oyster reef component that serves as a natural breakwater. However, one of the most common living shoreline approaches—creating reefs by stacking up rows of “shell bags” (oyster shell contained in polyethylene or nylon mesh sacks)—is problematic for shoreline restoration applications. This is due to the likelihood that the plastic mesh releases harmful microplastics into the marine environment and the concern that wildlife could become entrapped or entangled in the mesh, especially as bags break down or if the reef project fails to establish.

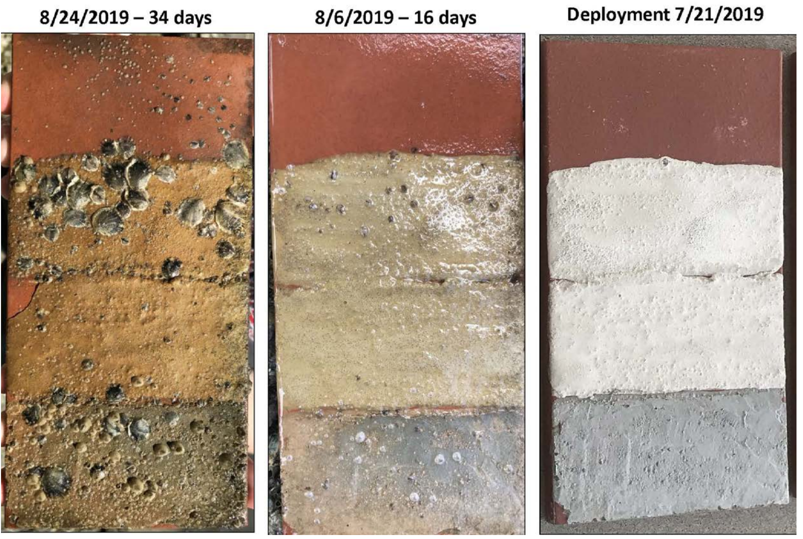
Shell bags have been widely used in shoreline restoration projects because they have advantages over other materials. Reasons for their application include:

- They are inexpensive to produce, which makes them more cost-effective when compared to some alternatives.
- The bags are easy to assemble and deploy using volunteer assistance.
- They offer a high degree of flexibility in project design (e.g., they can be stacked in any configuration).
- They have a history of proven success in many states.

Because of these benefits and the relative lack of viable plastic-free alternatives that encompass the considerations above, the living shoreline community has been slow to move away from shell bags and other plastic-based materials. The desire to continue working with local volunteers and communities to build living shorelines is an overarching reason why shell bags remain popular, but most practitioners at national conferences and meetings express a desire to eliminate plastics from living shorelines.

Practitioners searching for plastic-free alternatives to shell bags will likely encounter many proprietary options such as domes, blocks, panels, and other structures made from **portland cement.** These options often contain embedded oyster shells or various additives aimed at adjusting the pH, since the highly basic pH of portland cement is thought to hinder the recruitment of some biological communities. Newer companies entering the market offer substrates made from recycled vegetable starch or rope-like filaments embedded with portland cement and formed into various shapes. While these alternatives may work in many contexts, most of them do not retain the benefits of shell bags since they cannot be produced locally or by volunteers, can be hard to deploy using volunteer labor, usually cost more than shell bags, or are not readily available in all markets. Therefore, shell bags often prevail over these alternatives. Furthermore, many of these alternatives have their own environmental downsides, such as the high carbon footprint associated with portland cement and long-distance transport of heavy cement items from factory locations.

In response to the need for a modular, plastic-free alternative to shell bags that practitioners could build and deploy using affordable and readily available materials, a development team led by Dr. Mark Clark at the University of Florida spearheaded the creation of a material called **Jute Reinforced Calcium Sulfoaluminate (JR-CSA)** that can be formed into multiple shapes, mainly "reef prisms" and "reef panels". The material was first deployed along Florida's central west coast in 2018. As a result of this, the **P**lastic-free **R**estoration of **O**yster **S**horelines (PROS) **C**ommunity **o**f **P**ractice (CoP) was formed with support from Florida Sea Grant and the Florida Department of Environmental Protection (FDEP) with the goal of promoting living shoreline demonstration projects utilizing newly developed plastic-free materials such as JR-CSA reef prisms.




# Introduction

Initially developed as a plastic-free alternative to mesh shell bags and used as a low intertidal sill and wave break element along living shorelines, other JR-CSA configurations now include application as a high surface area substrate for oyster recruitment and habitat restoration on declining natural reefs.

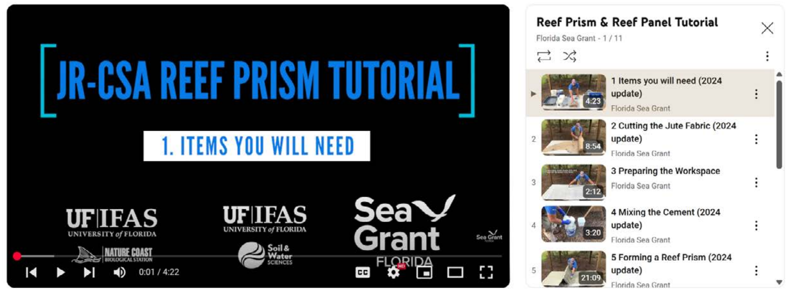
The material is a combination of readily available jute erosion control matting and calcium sulfoaluminate (CSA) as either premixed Cement-All® (CTS Rapid Set®) or a tailored mix of CSA, sand, and water reducing additive. The CSA-coated jute is then placed on a form for curing. Although the material can be arranged in almost any shape, the two principal shapes covered in this manual are triangular prisms (12 in. x 48 in.) referred to as "reef prisms," and a square-shaped, corrugated "reef panel" (2 in. x 48 in. x 48 in.). The development team selected CSA instead of portland cement due to its rapid set times (20-30 minutes), early curing strength, more neutral final pH, and reduced carbon footprint. These characteristics facilitate a more efficient use of forms during production and the potential for rapid deployment.

Another design objective of JR-CSA was a material that allowed stakeholders and/or volunteers to participate in the construction and deployment process without relying on specialized equipment. Since inception, the material has been deployed at multiple sites throughout Florida and South Carolina. When compared to other substrates, JR-CSA performs well for oyster spat colonization and growth. Depending on the mortar mix ratios and deployment site conditions (e.g., water quality, wave energy, storm impacts), JR-CSA can last between 18 months and five years, typically sufficient time for oysters to recruit and become established.

# Constructing Reef Prisms

The following section is a step-by-step guide for the construction of a reef prism. Other dimensions and shapes using Jute Reinforced Calcium Sulfoaluminate (JR-CSA) are possible, but fabric lengths and weights of cement, sand, and water will vary. **Therefore, the values in this guide are specific to a reef prism measuring 12 inches tall and 48 inches wide.**

A series of step-by-step videos is also available on Florida Sea Grant's Reef Prism and Reef Panel Tutorial playlist on YouTube. These videos supplement the information found in this construction guide and provide visual examples for many of the steps outlined below. **Appendices I-II** contain information on construction of the reef prism form and the end cap form, both of which are essential components in the construction of a reef prism.




## Materials Needed

The following materials list is discussed in Episode 1: Items You Will Need (2024 update) of the Reef Prism Tutorial available on Florida Sea Grant's YouTube channel.

- Large worktable (e.g., 4 ft x 8 ft table made of plywood)
- Work gloves
- Safety glasses
- Apron (optional, but be prepared to get concrete on uncovered clothing or shoes)
- Sturdy pair of scissors or electric circular cutting shears
- Masking tape
- Measuring tool
- Squeegees
- Mixing device, such as a cordless drill equipped with a mixing paddle
- Two 5-gallon buckets (one for mixing the concrete, one for rinsing the paddle)
- Three 2-gallon buckets with lids to separate individual components
- Medium concrete mixing tub 6 in. x 20 in. x 28 in.
- 2 sheets of 6 mil plastic, each measuring approx. 4 ft x 5 ft
- 1 reef prism form wrapped in 3-6 mil plastic (polythene/polyethylene)
- 1 piece of plywood measuring 14 in. x 48 in. (1/8-1/4 in. thickness)
- Jute fabric (cut from a larger roll of jute erosion control matting, individual piece should be cut to a length of 96 in.)
- 34 lbs of Cement-All® (premixed CSA and sand) **OR** 17 lbs of pure CSA and 18 lbs of medium-texture sand
- 8 lbs of water if using Cement-All® **OR** 8.5 lbs of water if using pure CSA and sand
- 1 (2.1 oz) packet of Rapid Set FLOW Control if using pure CSA and sand

## Techniques for Cutting Jute Fabric

The first step in the reef prism construction process is to cut appropriate lengths of jute to be coated with a calcium sulfoluminate cement (CSA) mix. The jute fabric used to make JR-CSA is traditionally used as an erosion control matting to stabilize embankments while seed and other vegetation become established. Trade names for the material include "jute erosion control matting," "erosion control matting blanket," "jute mesh blanket," and "jute soil saver." A roll of jute netting is typically 48 inches wide and 225 feet long.

Due to the size of the jute roll and length of fabric required for this process, it is best to use a large table when cutting the jute. A table made from a sheet of plywood (4 ft x 8 ft) covered with plastic (polythene/polyethylene) sheeting stapled to the plywood works well. Additional materials needed for this step are a pair of scissors and 1-inch-wide masking tape. When cutting a large quantity of jute, the authors recommend using electric circular cutting shears (pictured below) instead of scissors.

Because the jute fabric is a loose weave of warp (longitudinal) and weft (side-to-side) yarn strands, it can easily unravel when cut. **To reduce the risk of unraveling, avoid cutting weft lines whenever possible and use masking tape to hold the warp strands in place.** The best way to do this is to locate the space between two weft lines at the length you want to cut and run a length of tape between those two weft lines across the width of the fabric. Don't worry about the tape being perpendicular or square to the table or fabric, just follow the space between the two weft lines wherever it goes. When you are ready to cut, cut down the middle of the tape with shears or scissors. This technique should allow you to avoid any weft lines and will result in two pieces of tape on either side of the cut.

## Cutting Jute: Step-By-Step Instructions

The following instructions are demonstrated in Episode 2: Cutting the Jute Fabric of the Reef Prism Tutorial available on Florida Sea Grant's YouTube channel.

1. Roll out jute fabric to a length of 96 inches.
2. Using the masking tape, place a piece of tape between two weft lines and run the tape from one edge of the fabric across to the other edge. Cut the tape about 1-2 inches longer than the edge of the fabric and tuck it around the edge and under the fabric.
3. Run your finger down the tape line so that the tape adheres to the fibers.
4. Cut down the middle of the tape.
5. Fold cut fabric in half longitudinally and then half again. This should leave you with a 1-foot-wide piece of fabric four layers deep and 96 inches long.
6. Roll the fabric up and place in a bag or box until you are ready to use. **NOTE:** Jute can be stored in a plastic bag for short periods, but condensation build up can cause rot. Long-term storage should be in breathable containers.

## Preparing Your Workspace

Watch Episode 3: Preparing the Workspace to ensure you have the correct supplies and an appropriate surface for construction.

## Wetting the Jute

To minimize the effects of variation in jute quality, we recommend you saturate the jute fabric with water before coating with the concrete mix.

1. To saturate the jute, leave the jute folded/rolled and immerse in water for at least 10 minutes.
2. Next, place the saturated jute on a pervious surface and let drain until the outflow shifts from a steady stream to a steady drip.

**NOTE:** Using the jute without allowing for adequate drainage will result in excess water being added to the mix, lowering strength and durability of constructed reef prisms.

## Weighing and Mixing CSA Cement

If you are working in warmer conditions, please refer to the "Mix Ratio Guidance and Troubleshooting" section on page 11 for tips on how to prevent concrete from hardening too quickly. You may need to add ice to your mix.

**SAFETY TIP #1:** Dust from CSA and sand that becomes airborne during weighing and mixing can be hazardous if inhaled. It is highly recommended to wear a N-95 face mask and safety glasses during this process.

**SAFETY TIP #2:** Liquid concrete is alkaline, and the CSA concrete will have a pH of 10-11. This can result in skin irritation. Wear gloves to protect your skin and safety glasses for eye protection when handling wet concrete and coated jute during mixing, construction, and curing.



## Weighing and Mixing CSA: Step-By-Step Instructions

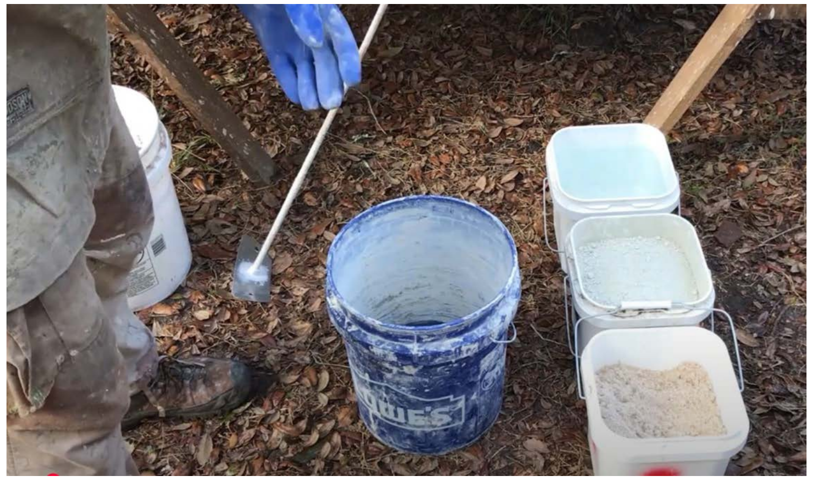
For a demonstration of the mixing process detailed below, view Episode 4: Mixing the Cement (2024 update) of the Reef Prism Tutorial available on Florida Sea Grant's YouTube channel.


**If using Cement-All ®:**

1. Weigh ingredients as follows into separate buckets:
   a. 34 lbs Cement-All ®
   b. 8.0 lbs water
2. If materials are weighed out in advance, place lids on the tops of the buckets.
3. When you are ready to mix, add Cement-All ® by shaking the bucket slowly into the 5-gallon mixing bucket. Then, slowly pour the water on top of the cement mix. Mix using a handheld drill equipped with a mixing paddle.
4. Mix ingredients for 1-2 minutes, making sure to scrape the sides and bottom of the bucket so that all ingredients are fully incorporated.
5. Remove mixer and clean paddle by running it in a separate bucket filled with water. **Don't leave tools with concrete on them for long as the CSA cures quickly.**
6. The bucket of mixed Cement-All ® is now ready to add to the jute.

**If using bulk (pure) CSA:**

1. Weigh the three ingredients as follows into three separate buckets:
   a. 17 lbs CSA
   b. 18 lbs sand
   c. 8.5 lbs water



2. If materials are weighed out in advance, place lids on the tops of the buckets. If you have a limited supply of lids, cover the CSA and water buckets and make sure the sand buckets are stored somewhere protected from rain.
3. When you are ready to mix, pour sand first into a 5-gallon plastic bucket, then add CSA by shaking the CSA bucket slowly into the 5-gallon mixing bucket. Add the water to the sand and CSA mixture. Mix using a handheld drill equipped with a mixing paddle.

4. Mix ingredients for 1-2 minutes making sure to scrape the sides and bottom of the bucket so that all ingredients are fully incorporated.
5. Add one packet (2.1 oz) of Rapid Set ® FLOW Control. This is a water reducing additive that will increase the flowability of the concrete mix without increasing the water content.
6. Remove mixer and clean paddle by running it in a separate bucket filled with water. **Don't leave tools with concrete on them for long as the CSA cures quickly.**
7. The bucket of mixed CSA is now ready to add to the jute.

## Forming a Reef Prism

**You will need the following items:**

- 1 prism form
- 2 pieces of 6 mil plastic (4 ft x 5 ft)
- 1 plastic sleeve for the prism form
- 1 14-inch x 48-inch piece of plywood (1/8-¼ inch thick) covered with a sheet of plastic. This will be referred to as "the board" in the instructions below.
- 1 mixing tub
- 1 6-inch squeegee
- 1 12–18-inch squeegee

To see how a prism is formed, watch Episode 5: Forming a Reef Prism (2024 update) of the Reef Prism Tutorial available on Florida Sea Grant's YouTube channel and refer to the step-by-step instructions below.

Like the table used to cut the jute, a sheet of plywood covered with plastic is what you will use to form the prism on. When forming the reef prism, keep in mind that you will need to move quickly to mold the structure before the concrete hardens. Once the coated jute is placed on the form, continuously pull the jute fabric on the form out toward the edges of the form so that the width of the prism is as close to 48 inches as possible. Typically, prisms end up being about 46 inches wide, but stretching the fabric helps make the final product as wide as possible.

**While forming, make sure the coated jute still looks wet and does not show signs of drying.** If the concrete coating has already begun to cure before the reef prism is fully formed, it is best to start over with a new batch of concrete and jute as not much can be done to reverse curing. You may need to add ice water to the next mix to ensure this does not happen again.

## Forming a Reef Prism: Step-By-Step Instructions

1. Decide which end of the table will be the starting point to form the prism. We'll refer to this as the baseline.
2. Take one of the 4 ft x 5 ft pieces of plastic and align it with the baseline end of the table so that the 4 ft width of plastic aligns with the 4 ft width of the table. Using a staple gun or stapler, staple the plastic to the table at three spots along the edge of the plastic in the middle of the table only.

3. Place the other 4 x 5 ft piece of plastic and align it with the other end of the table, letting the plastic overlap the first sheet in the middle of the table.
4. Place the board under the first sheet of plastic and let it hang over the baseline edge of the table about ¼ inch.
5. Place the mixing tub on the table and partially unroll a section of pre-wetted jute (refer to the information in "Wetting the Jute" on page 4) so that part of the jute is in the tub and the rest of the jute remains on the table. Don't unfold the jute, just unroll it so that there is a 1 ft wide, 4-layer deep section in the tub.

6. Pour contents of the concrete mixture over jute fabric in the mixing tub. Using the small squeegee, scrape out any remaining concrete from inside the mixing bucket.
7. Start working the CSA concrete into the jute by pressing the jute into the concrete mix and pulling the jute toward you while keeping the fabric submerged. Keep doing this until all the jute is in the mixing tub. Proceed to roll and unroll the jute two times in the concrete mix so that the CSA is worked into and in between the jute fibers, making sure that all areas of the jute are well coated. Don't squeeze the jute or roll it tight. Instead, try and create a loose roll of jute coated by the concrete mix and "fluff" rather than squeeze the jute in the mortar.

8. Once thoroughly coated, remove the jute from the mixing tub and place on the table. There should still be some concrete left in the mixing tub, which you should set aside for later use.
9. Before spreading out the fabric, find the "hinge." This is the bend in the fabric when it was first folded from 4 ft wide down to 2 ft wide. Once you find the hinge, orient it down the middle of the table and then open the jute fabric so that the two side edges are near the sides of the table and one edge of the jute is aligned with the baseline end of the table.

10. Start spreading the jute out by pulling the fabric toward the baseline edge so that the edge of the fabric is at or slightly overhangs the end of the table. **When pulling on the ends of the fabric, make sure you are pulling on the warp lines and not the weft lines so that you do not unravel the fabric.**
11. Next, work along the two sides of the table and pull the fabric toward the edges to maximize its width.
12. Pull warp lines at the other end of the fabric from the baseline, pulling until the fabric just starts to move off the baseline.

13. Go back down the two sides and pull the fabric out as much as possible toward the edges of the table. This process will maximize the length and width of the fabric before you wrap it around the form.
14. Place the prism form on the baseline end of the table about 2-3 inches from the edge and center the prism form right to left on the table.

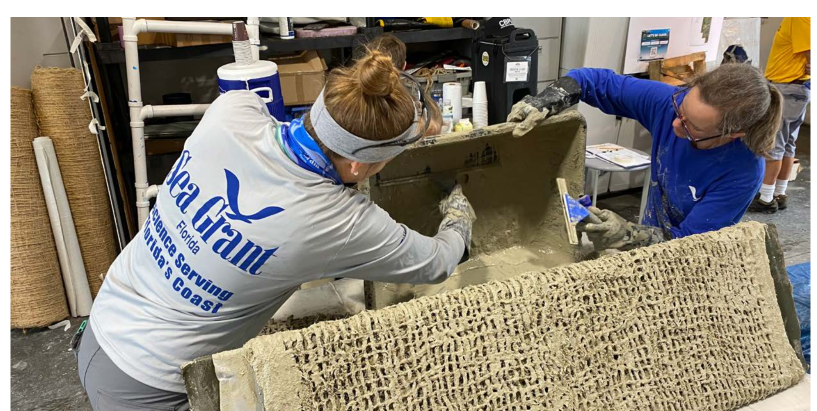
15. Pushing down on the top of the prism form and pulling up on the board, pinch the CSA-coated jute between the two and rotate the form toward the other end of the table.
16. Don't let go until you have rolled the prism over two sides. If for some reason the jute slides out, reset everything and try again.
17. After two rolls, take the board off the form and place it under the plastic sheet at the other end of the table and pull back the sheet of plastic that stuck to the side of the prism when turning the form.

18. Gently push the bottom of the form back toward the baseline. This will help to tighten the fabric on the form. You should repeat this step occasionally after subsequent rolls to keep the fabric taut on the form.
19. Tip the form back slightly and tuck the ends of the fabric that are sticking out at the base of the form back under the form so that they are now under the edge.

20. Pull the ends of the fabric toward the outer edge of the form and try and align the edge of the fabric on the form with the fabric on the table.
21. Roll the form again by placing your hand along the bottom edge of the form opposite the baseline and pushing on the top of the form away from the baseline end.

22. Repeat previous step (#21) until there are two layers of jute on all sides of the form.
23. Lay any plastic attached to the form back on the table and using the large squeegee, scrape any residual concrete that is on the table into the mixing tub.

24. After the table is cleaned off, place the mixing tub near the prism form and scoop up some concrete and place it along the outer 2 inches of the form along both sides. Also add concrete between the two layers to help glue these two layers together.
25. Pull the fabric one last time toward the outer edges of the form to maximize the width and align the two layers of fabric.
26. Rotate the prism form back one turn toward the baseline end of the table.
27. Push the board that is under the layer of sheet plastic toward the baseline end of the table until it bumps into the base of the prism form.
28. Using the outer edge of the board as a guide make sure all fabric that is on the table is up on top of the board and any folds of fabric are flattened as much as possible and the jute is equally distributed.
29. Pour the remaining contents that are in the mixing bucket on the board area. Using the 6-inch squeegee scrape out any remaining concrete in the mixing tub and spread it evenly over the board and jute.



30. Rotate the prism form back to its previous position so that it is now over the top of the board
31. Make sure the prism form is aligned directly above the board both front to back and side to side.
32. Fold the layer of plastic on the table opposite the baseline up onto the prism form.
33. Fold the other end of that piece of plastic up and over the top of the prism form and eventually tuck it under the board.
34. Making sure your fingers are under the board, lift the board and prism and place it in the curing area and tuck the loose piece of plastic under the board to minimize moisture loss
35. Wait for the JR-CSA to cure.

## Curing JR-CSA

Once the coated jute fabric is wrapped around the form, a quick curing time will allow you to recover the forms and reuse the materials to construct additional reef prisms. The curing process generates heat, thereby reducing the setting time. If the ambient air temperature is below 70°F, it may be beneficial to insulate the curing prisms using blankets and minimize the air movement around the forms. However, the best option is simply to place the curing forms in a sunny location.

You can monitor the curing process by tapping the side of the prism form. At first, the sides will flex if the concrete has not yet begun to set, but after 15-20 minutes the sides will begin to stiffen. After approximately 30 minutes, the sides should feel firm. As soon as the concrete has cured, the form can be collapsed, removed, and used again. If you are not assembling multiple reef prisms, forms can be removed at your convenience as leaving the form in place for longer will not impact the prism. To see how the prism form can be collapsed and removed, view **Episode 6: Releasing Prism from Form** of the Reef Prism Tutorial available on Florida Sea Grant's YouTube channel.

The authors recommend leaving the plastic sleeve inside the curing JR-CSA and the outer plastic covering for as long as possible. Keeping moisture trapped close to the curing concrete prevents it from drying out too quickly. If the plastic must be removed, occasionally spraying the JR-CSA with water will help to complete the curing process. When handling the prisms during this initial hardening phase, pick them up and move them by holding the corners, not the fabric between the corners.

## Curing JR-CSA: Step-By-Step Instructions

1. Monitor sides of curing prism form until firm to touch.
2. Collapse the prism form by pushing the hub in toward the center of the form from both ends. This may take some force and is best done using a quick blow of a 2x2 directed at the center of the hub.
3. Remove prism form and reuse but leave inner plastic sleeve and wrap surrounding prism for up to 6-12 hours.
4. If plastic needs to be removed, occasionally spray Reef Prism for the first 2-3 hours to prevent it from drying out too quickly.

# Forming Prism End Caps

Reef prisms are typically deployed with oyster shell inside, so both ends must be sealed or "capped." This is done using the same CSA-coated jute as the main form; however, caps are smaller pieces of jute that are either placed on the end cap form or on top of the shell once filled. The jute pieces used for end caps are 14 in. x 16 in. and cut using masking taped edges like the main swatch of fabric used for the reef prism. **Each end cap requires 0.75 lbs of CSA, 0.75 lbs of sand and 0.65 lbs, of water or 1.6 lbs of Cement-All® and 0.6 lbs of water.** Typically, multiple end caps are placed at the same time and a scalable batch of concrete based on these mix proportions can be created. To see how prisms are capped, watch Episode 7: Placing End Caps on Prism (2024 update) of the Reef Prism Tutorial available on Florida Sea Grant's YouTube channel and refer to the step-by-step instructions below.

# Forming End Caps: Step-By-Step Instructions

1. Place cured prism on end, preferably on a soil surface, and insert prism end form inside the prism with the triangular end up. Adjust triangle so that it is relatively flat (parallel to end of the prism).

2. The top of the end form should be recessed at least 2 to 3.5 inches below the top of the prism. If it is not, tap the top of the end form down into the soil or raise the prism up using shims until the end cap is sufficiently recessed.
3. Spray the inside edge of the prism to wet the surface of the JR-CSA to improve the bond of end cap fabric.
4. Mix a batch of the CSA in a 5-gallon bucket and either immerse the end caps into the bucket if making 8 caps or less or pour CSA into the mixing tub and coat jute end caps there.

5. Place one jute piece on top of the end form and spread the jute out so that the jute lays flat across the form and the sides of the jute go up the side of the prism. Using your fingertips, push the jute down around the edge between the side wall of the prism and the top of the end cap form.
6. Using any residual concrete in the tub and adding some water, pour the liquid around the inside edge of the end cap so that there is a wet bond between the end cap jute and the prism jute. If there is a visual gap between the two, add more liquid and press down on the CSA-coated jute so that there is a good bond.

7. After the end cap has cured for several hours, turn the prim over and remove the end cap form. **NOTE:** This might require moving the post back and forth or to one side so that the triangle end is tilted as it is removed from the prism so that it clears the sides. This may be difficult if the sides of the prism are bowed.
8. Fill the inside of the prism with oyster shell and vigorously shake the form after every foot of shell added so that the shell settles. Keep filling the shell until it is within 3 inches of the top end of the prism.
9. Arrange shells at the surface in a way that the surface is relatively flat and there are no large gaps or holes around the edges.

10. Make another batch of CSA and coat more jute end cap fabric.
11. Place these end caps directly on top of the shell layer and press the fabric along the edges and add additional CSA cement if necessary to get a wet seal along the edge.
12. After several hours of end cap curing, these prisms are ready to deploy!

# Mix Ratio Guidance and Troubleshooting

The following information is the latest guidance for establishing a mix ratio when using Cement-All ® or bulk calcium sulfoaluminate (CSA) to coat jute erosion control mats for the construction of Reef Prisms or Reef Panels. Please refer to the "Glossary of Terms" on page 17 for clarification on terminology. **NOTE:** All values described in this guidance document are based on mass or area, not volume. All values for sand are based on dry sand. If you are using damp sand, the sand weight will be about 3% greater than dry sand. Thus, sand weights will need to be revised accordingly when sand is damp.

# Discussion of Variables

Significant variability exists in the quality of jute erosion control matting, texture of sand when purchased in bulk or bags, and environmental conditions such as temperature at assembly sites. Variations in materials or conditions during construction can impact a user's ability to properly coat the jute fabric with wet concrete, thereby affecting the final product's durability. Over the last five years, the authors have increased their understanding of these variables and have refined mix ratios to improve the quality of final products. However, minor adjustments may be required to ensure desired results. In addition to the general mix ratio guidance below, potential adjustments are addressed at the end of this section to help guide necessary modifications during construction.

# Jute Quality

When trying to achieve a consistent mix, jute quality/weave density is the largest variable. As shown in **Figure C.1,** weave density varies considerably and influences the overall surface area that the concrete must cover. The material's main differences are the number of weft (side-to-side) lines, ranging from 10-14 strands/foot, and the thread diameter of warp (longitudinal) lines, ranging from 3.6 to 6.7 mm. As the number of weft lines per foot increases and/or the thread diameter of warp lines increases, the amount of concrete per fabric area must also increase to achieve a desirable coating.

The most common jute erosion control mat encountered had an average warp count of 21.5 threads ft-1 and a weft count of 10.2 threads ft-1 with a diameter of 4.4 and 3.9 mm respectively. The authors have also found that the outer part of a 225-ft roll of jute typically has a lower density weave, and the inner part of the roll (inner 20-30 feet) can have a very high weave density.

**Figure C.1.** *Range in quality of jute erosion control mat. The matting pictured on the left side has a warp thread count of 21.3 threads ft-1 and a weft thread count of 9.7 threads ft-1 with a diameter of 3.6 and 4 mm respectively. On the right, matting shown has a warp thread count of 21.6 threads ft-1 and weft thread count of 14.0 threads ft-1 with thread diameters of 6.7 and 3.6 mm respectively.*

## Wet vs. Dry Jute

Using wet jute matting instead of dry jute appears to reduce the effect of variations in jute quality on the final product. However, it is important to note that wetting jute in advance significantly decreases the amount of water needed in the mix. If dry jute is used, weight of water added must be increased and will differ from the measurements provided in this guide.

## Controlling Temperature

Calcium sulfoaluminate (CSA) cement's rapid curing time allows for quick construction, reuse of forms and other materials, and swift deployment of structures. However, this also limits the period of workability before the mixture begins to harden, especially when working in warmer conditions. When air temperatures rise above 80-85° F, the concrete can sometimes begin to harden before the JR-CSA is placed on the form. **Curing time is directly related to temperature, so the key to managing the rate of curing is to keep things cool from the beginning.** This may involve storing ingredients and constructing reef prisms out of direct sunlight or adding ice during the weighing and mixing process. Guidance on mix modifications related to temperature is provided in the "Troubleshooting FAQ" section on page 13.

## Mix Ratio Using Cement-All ®

If using premixed Cement-All®, the established CSA to sand ratio ranges from 40-60% cement to sand according to the manufacturer's material specifications. Therefore, you only need to know how much water to add per unit of Cement-All®. This ratio should be around 1:0.235 (Cement-All ®: water) by weight. Thus, **every pound of Cement-All® should be mixed with 0.235 lbs of water.**

## Mix Ratio Using Pure CSA

If using pure CSA, it will need to be mixed with sand, water, and a water reducing additive (also called a water reducing admixture or plasticizer). Through extensive experimentation, the authors determined the best ratio is **one part CSA to 1.06 parts sand to 0.5 parts water (1:1.06:0.5, c/s/w).**

## Adding Sand to CSA

When adding your own sand to pure CSA, we recommend using a **medium texture sand.** If you buy sand in bulk and can specify a texture, something with a particle size range of 0.13-0.25 mm (#120–#60 sieve) is preferred. This texture is often called "masonry sand" or "beach sand" and is similar to what is used for beach nourishment projects in Florida. Finer sand, with a median texture less than 0.13 mm can be used to construct reef prisms but will require a higher water ratio in the mortar mix. Purchasing bags of sand from home improvement stores such as Lowe's or Home Depot is also an option but remember to check the contents carefully and select the sand with a coarser grain size.

## Water Reducing Additive


As indicated in **Table C.1,** one packet of Rapid Set® FLOW Control (2.1 oz) is recommended when making a batch of cement with pure CSA. Less than one packet may be sufficient if you are making a smaller batch of concrete, but the authors have not investigated a specific ratio of FLOW Control to CSA. Add the Rapid Set® FLOW Control to the mixing bucket after an initial mixing of CSA, sand, and water then slowly pour the contents of the FLOW Control packet into the bucket while actively mixing. This will prevent the FLOW Control powder from clumping together.

## Ratio of Concrete Mix to Jute Fabric

While a uniform ratio of concrete to jute fabric area is ideal, variability in jute quality makes the ratio a "rule of thumb" rather than an absolute value. The weights provided in **Table C.1** err on the side of having excess wet concrete to coat the jute vs. not enough. If you consistently have excess concrete left over due to jute quality, reduce the total mix yield while keeping a consistent ratio of cement to water. Both reef prisms and reef panels use the same amount of jute matting (4' wide x 8' long) and require the same amount of cement mix.

The amounts of cement, sand, water, and additives recommended in **Table C.1** are based on this "typical" jute quality with a slight buffer and should be adequate for most jute fabric. If, however, you note an unusually dense or loose weave, you can adjust the amounts as needed while maintaining the overall ratios.

| Mix type | Cement-All® / CSA | Sand | Water | Additive |
|---|---|---|---|---|
| | lbs. | | | |
| Cement-All® | 34 | | 8 | |
| Bulk (Pure) CSA | 17 | 18 | 8.5 | 1 pkt* |

*One 2.1 oz packet of Rapid Set® FLOW Control

**Table C.1.** *Recommended concrete mix for both reef prisms and reef panels.*

## Troubleshooting FAQ

**Q: I am working outside in warmer conditions. How can I prolong the workability of my concrete mix?**

A: The curing time for Cement-All ® is slower than bulk CSA, but if any concrete mix is setting too quickly, consider the following:

- Set up construction area in the shade. Do not construct in direct sunlight.
- Keep dry mix of CSA and sand out of the sun and preferably in a cool place prior to mixing.
- If using water from a hose, keep the hose in the shade or flush the hot water from the hose before using the water for the mix.

You may also benefit from adding ice to the water in the mix to cool it down. A wet cement mix of ~60° F performs well even at an ambient air temperature of 90° F and can be obtained with 1.5-2 lbs of ice used as part of the water weight, assuming other ingredients are not too hot. Remember to add the ice when weighing as frozen and liquid water weigh the same. Wait until the ice is melted before mixing with cement.

**Q: Why am I having trouble coating the jute fabric completely?**

A: When folding the jute fabric into the concrete mix, fabric should be totally coated. There should also be some excess concrete leftover in the mixing tub. If you struggle to sop up every bit of concrete to properly coat the jute, the amount of concrete being used is not sufficient. This happens when the jute weave is dense and often occurs when the jute comes from the center of the roll (see **Figure C.1**). To salvage the mix you are working on, you can add water and continue folding the jute into the mix until everything is coated. To minimize issues with the next batch, increase the amount of concrete being used. Excess concrete can always be used to reinforce the fabric's edges or create a solid bottom for a reef prism. If your jute has a lower weave density and you consistently encounter excess concrete even after using leftovers to reinforce the edges, you can choose to reduce the total weight of ingredients.

**Q: Why does the coated jute appear "cakey?"**

A: While coating the jute fabric, the wet concrete should be fluid enough so that gravity allows it to seep between the individual strands of fabric. The concrete should also easily penetrate the spaces between each strand's fibers, almost as if the individual strands are soaking up the concrete. If concrete does not penetrate jute fibers or the outside of the fibers appear dry or "cakey," then the mix is too dry. If that happens, add more water to the mix in small increments (keeping track of the volume/mass added) until you get the right consistency. Adjust the water to dry mix ratio accordingly for future batches. Keep in mind that the mix should not be too watery, as this will lower the strength and durability of the final product.

# Cost Breakdowns

Cost breakdowns for materials needed to construct JR-CSA Reef Prisms and Reef Panels are listed below. Costs are current as of April 2025 but may be subject to change. All calculations reflect the use of premixed Cement-All® acquired from Home Depot with a bulk discount (25 bags or more) and the midrange cost of a roll of jute fabric from multiple sources.

**Raw materials**
Cement-All® = $0.473/lb based on $26/55lb bag
Jute = 0.167/sq ft based on $150/900 sq ft roll (White Cap)

**Batch cost for materials**
34 lbs Cement-All® = $16.07
32 cu ft Jute = $5.33

**Cost per sq ft JR-CSA**
Single layer JR-CSA = $0.75/sq ft
Double layer JR-CSA = $1.34/sq ft

**Cost per Reef Prism**
Total cost of one prism including two end caps = $23.33
Cost per prism footprint = $5.01/sq ft
Cost per prism surface area (two outer sides) = $2.50/sq ft

**Cost per Reef Panel**
Cost of one panel (no skids) = $21.25
Cost per panel footprint =$1.33/sq ft

# Monitoring and Assessment

As organizations throughout Florida implement reef and shoreline restoration projects with similar designs and over similar timeframes, there are opportunities to collect data that will help evaluate the efficacy and durability of these new technologies in different environments. Standardized monitoring techniques are essential for these broad comparisons, and the goal of this section is to provide users with monitoring protocols. These methods are targeted at monitoring of Reef Prisms but can easily be adapted to other deployment structures.

## Nomenclature

**For data to be useful and interpretable, it is essential to use the same terms across all projects.** Each project contains multiple reefs made of rows of prisms. Reefs at the project site are numbered from left to right while facing the water. We refer to the **waterward** side as the front of the reef and the **landward** side as the back of the reef. Left side vs right side is relative to the direction you are facing; therefore, include a reference when using these terms—for example, left side from front, or right side from back.

Within a reef array, prisms, or other PROS elements should be labeled with a numeric-numeric-alphabetic code. The first number references the reef. The second number refers to the row within the reef, with 1 being the front most row. Letters are used to designate the prism or other PROS element within each row starting from left side from the back to right side from the back. **Figure M.1** provides an example of this numeric-numeric-alphabetic labeling code below.

## Parameters of Interest and General Guidance

Oysters and oyster reefs modify their environments in several important and valuable ways, so there are many parameters that can be measured and are expected to change with the introduction of oyster reefs. Here we are focusing only on a few parameters – those that can be easily measured multiple times per year with trained volunteers and inexpensive equipment. Equipment and data sheets for these measurements will be provided to PROS partners; however, all supplies are relatively inexpensive and can be purchased online or at a local hardware store.

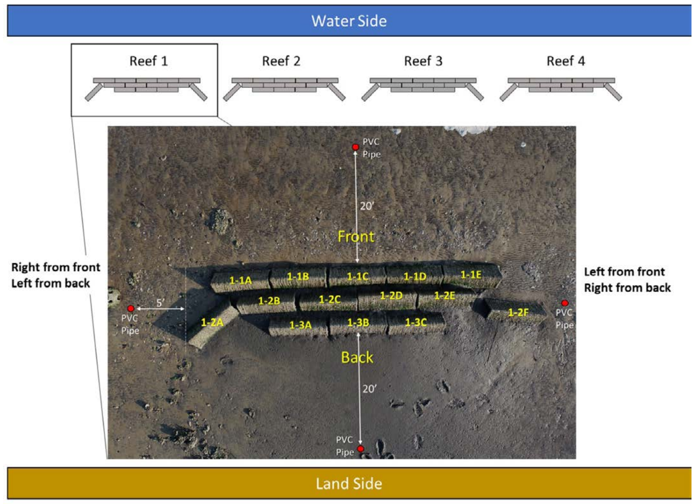



**Figure M.1.** *Example nomenclature of reefs and prisms within reefs at pilot site. Diagram also illustrates location of four PVC poles used to identify photo stations and measure sediment accretion/erosion.*

Additional intensive monitoring parameters can be collected and will likely be investigated at specific project sites by PROS personnel. All proposed monitoring parameters and proposed sampling frequencies for PROS project sites are outlined in **Table M.1.**

During installation of PROS reefs, one reef will be designated as the "focal reef". On that reef, four 1-in. diameter 60 in. long PVC poles will be installed to a depth of 36 in. or point of refusal. One pole will be in front and centered on the reef array, one will be centered at the back, and there will be one on each side in line with the middle row of prisms. Poles in front and back of the reef will be placed approximately 20 feet away from the reef and poles on each side will be placed five feet away from the closest prism. These locations should allow for a photo that encompasses the entire array by adjusting the zoom feature on camera to maximize the reef array in the image.

In most instances, installation of PROS reefs will be intertidal and therefore sampling should be conducted at low tide when the structures are fully exposed. If the deployment site is subtidal, sampling must be conducted using mask and snorkel and/or photos collected with an underwater camera. It may also be possible to conduct the sampling from a vessel using an underwater viewing device such as a clear-bottom bucket or box if the water is clear and the site is relatively shallow. All parameters of interest identified for measurement in this guide can be collected subsurface; however, some parameters will be more difficult to assess such as movement of prisms due to the limited sightlines and any photographs will need to be taken closer to the face of the prism especially if water clarity is poor. When it comes to assessing habitat, photos of prisms may require multiple closeup photos of the face of the prism instead of capturing the whole prism in a single image. For the quadrat assessment of oyster size and percent cover, a single photo of the quadrat on the face of the prism may be better than attempting to count individual oysters within the quadrat from the surface or while snorkeling.

To optimize visibility underwater, sampling should be conducted on a clear day when the sun is overhead and when wind driven waves and boat traffic are minimal to reduce sediment resuspension. In some instances, seasonal variations in water clarity may prevent even these subsurface observations from being collected and a quarterly sampling may not be possible until water clarity improves. In those instances, a datasheet should still be submitted with whatever parameters can be measured and notation made of conditions where parameters could not be measured.

## Data Collection

All data collected by site partners and volunteers will be guided by a datasheet. The datasheet is broken into four sections, 1) Prism Physical Integrity, 2) Prism Movement 3) Habitat and 4) Sediment Accretion/Erosion. A sample datasheet can be found at the end of this document in **Appendix III.** A description of methods for each section follows.

| | Parameter | Quarterly | Annually | Opportunistically (event related) |
|---|---|---|---|---|
| **Prism Structure** | Physical Integrity | X | | X |
| | Movement | X | | X |
| **Ecosystem Functions** | Habitat | | | |
| | *Photo* | X | | |
| | *Quad* | X | | |
| | Wave Attenuation | | X | X |
| | Water Quality | | X | |
| | Sediment Accretion | | | |
| | *PVC* | X | | |
| | *Drone* | | X | X |

**Table M.1.** *Monitoring parameters and suggested frequencies. The blue shaded cells are those parameters that are considered baseline, required, and to be conducted by site partners or volunteers supervised by site partners. The unfilled boxes represent additional parameters that may be added, and that the PROS team may be able to measure.*

## Prism Structure

We expect that the prism material will break down over time, hopefully to be replaced by oysters. However, we do not know how quickly that might occur and whether certain parts of the prisms or areas on the reef will degrade faster than others. We also don't know how significant individual prism movement within the reef might be. To assess these changes, we need to monitor two aspects of prism structure; physical integrity and movement.

## Physical Integrity

The first section of the datasheet assesses prism physical integrity. Visually inspect prisms within a reef array and note if any damage or degradation has occurred. If so, place an "x" in the appropriate prism on the reef array diagram and in the approximate location on the prism. Make sure to note which reef number you are assessing and briefly describe the overall type(s) of damage observed and add any notes you feel are pertinent. Photos of damage are also encouraged, just make note that photos were taken and submit them along with the datasheet.

## Movement

Some movement of prisms within the reef array is expected. To determine how much movement occurs, four PVC poles were set up around one of the reef arrays (focal reef). Each PVC pole is used to measure changes in elevation and as a photo station to assess movement. **Since we don't want to disturb the elevation around the base of the PVC pipes, stay at least 1-2 feet away from the PVC pipe when taking photos.** At each PVC pole, face the reef and hold your camera approximately five feet above the ground. Using a landscape orientation and centering your camera horizontally and vertically on the reef, zoom the image in or out so that all portions of the reef fit within it. Confirm all four photos were taken by answering the question on the data sheet. Remember to note any visual movement of prisms apparent at this reef or other reefs at the site.

## Habitat

The third section of the datasheet looks at habitat, specifically to evaluate whether oysters and other sessile organisms might be colonizing the prism substrate. We will document this through photos and by counting the organisms with a quadrat. These measurements will be taken at three specific prisms within the focal reef. If findings at these prisms or at the focal reef in general look different than other reefs at the site, please note the differences on the datasheet.

At the focal reef, measurements will be taken on three prisms—prisms 1C, 2A, and 3B. Habitat function is likely to vary based on exposure, and these representative locations will help us draw large scale inferences.

## Photo Assessment

Participants should use the included dive slate to identify which prism is being imaged. On the dive slate, they should indicate the site name, reef number, prism location and whether the image is of the front or the back of the prism (**Figure M.2**). The slate and quadrat should be placed adjacent to the target prism so it can be seen in the photo but does not block any view of the face of the prism. When taking a photo, set your camera zoom to 1x (no zoom) and get as close to the prism as possible to capture the full face of the prism within the image as well as the dive slate. Orient the camera so that it is perpendicular to the angle of the prism face being photographed.

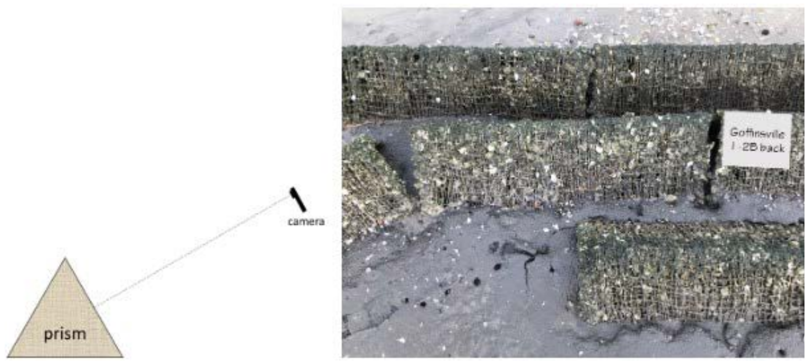



**Figure M.2.** *Example orientation of camera relative to face of prism being photographed (left) and habitat photo of prism showing orientation of prism and placement of dive slate(right).*

## Quadrat Assessment

Using the quadrat provided, center the quadrat both horizontally and vertically on the front face of the designated prism. Without moving the quadrat, count the number of live oysters that are smaller than your thumbnail and those that are larger than your thumbnail. Write those values on the datasheet. After assessing individual oysters, estimate the percentage of the area within the quadrat that is covered by live oysters. Write that value in the appropriate place on the data sheet. After completing the front face of the designated prism, repeat the process on the back face and then move to the next designated prism and repeat until all three prisms and six quadrat assessments are complete. While conducting the assessment, make note of other organisms that might be visible (e.g., barnacles, crabs, macroalgae) and indicate if there are dead oysters present.

## Sediment Accretion

Sediment accretion or erosion will be measured at each of the four PVC poles placed around the focal reef. **Stay at least 1-2 feet away from the PVC pole while making your measurement so as not to disturb the sediment around the pole.** At each pole, measure the distance from the sediment surface to the top of the pole and write the value down in the appropriate place on the datasheet. Make note of any apparent disturbance or localized depression(s) around each of the PVC poles.

## Data Management

All datasheets will be converted to a digital format by photograph or scan. Electronic datasheet files will be labeled by location and date (mmddyyyy) e.g., Cedar_Key_03222020.

Electronic datasheets and all photos associated with that sampling event will be uploaded to the Microsoft Teams PROS channel under the appropriate Pilot Site name and placed in the Post Assessment folder. A new folder will be created for each sampling event and labeled with the sampling date and all electronic files for that sampling date will be placed within that folder.

Hard copies of datasheets will be compiled in a notebook and kept by the pilot project coordinator.

## Glossary of Terms

**Cement** is the term used for dry cement whether it is ordinary portland cement or calcium sulfoaluminate (CSA). Cement powder acts as a binding agent when mixed with water and other materials to make concrete or mortar.

**Cement-All®** is a commercially available premixed CSA and sand mix that is available at Home Depot and other retailers/wholesalers.

**Concrete** refers to a mix of wet or hardened cement consisting of cement, water, and coarser aggregates, such as sand or gravel.

**CSA** is the abbreviation for calcium sulfoaluminate. When used in this document, it will refer to pure CSA with no sand in the mix.

**JR-CSA** is the abbreviation for Jute Reinforced Calcium Sulfoaluminate.

**Jute** is a rough fiber that can be spun into coarse threads used to make twine, rope, or woven matting. The fiber is harvested from the stems of *Corchorus* plants from Southeast Asia and the Indian subcontinent.

**Mortar** is the term used for mixed wet or hardened cement consisting of cement, sand, and water. In practice, the same basic components used to make concrete are also used to mix mortar. However, finer-textured sand is typically used to make mortar and additional lime may also be added.

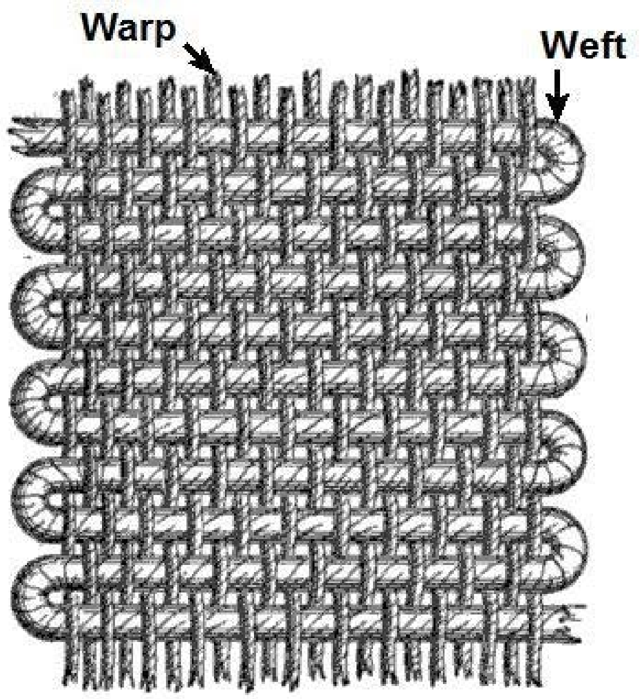
**Portland cement** is a common, general-use cement that hardens under water. It is produced by heating limestone and clay minerals to form clinker (a solid intermediary product), which is then ground into a fine powder with the addition of gypsum.

**Reef panel** is the term for another application of JR-CSA material in in the form of a square, corrugated panel. For instructions on making reef panels, refer to Making a Reef Panel, an instructional video on Florida Sea Grant's Youtube channel.

**Reef prism** is the term used to describe a modular, plastic-free restoration material made from JR-CSA formed into a triangular prism shape.

**Warp** is the term used for individual threads running lengthwise to the run of fabric.

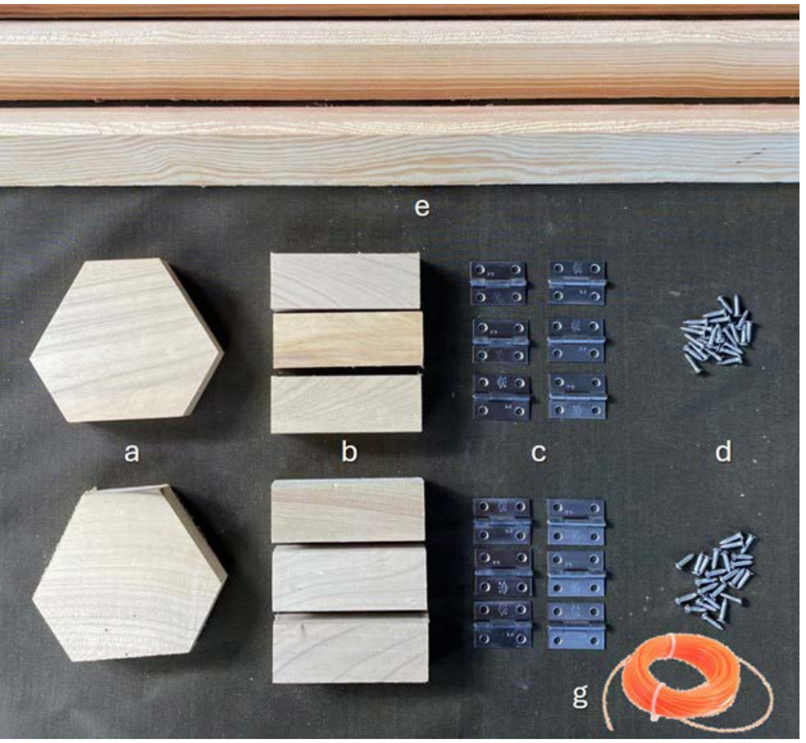
**Weft** is the term used for individual threads running perpendicular to the run of fabric that double back and forth across the warp lines (see image below).



# Appendix I: Materials List and Construction Guide for Reef Prism Form

## Materials Needed:

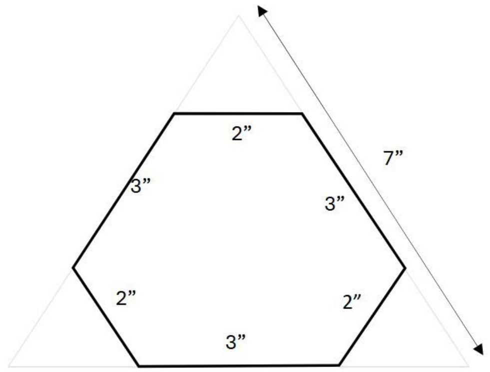
a. 2 hubs (made from ¾-1 in. thick lumber, preferably hardwood)
b. 6 spokes (made from ¾-1 in. thick lumber, preferably hardwood)
c. 12 hinges – 1.5 in. x 1.2 in. butt hinge, 0.04" (1 mm) thick metal; **https://www.amazon.com/Adiyer-Stainless-1-5-inch-Furniture-Hardware/dp/B08V5L41QH?th=1**
d. 48 screws – ½ in. long wood screws (these should come with hinge order)
e. 3 rails – 50 in. long, 1.75 in. tall equilateral triangles cut from 1.75-2.0 in. thick lumber
f. 1 wrap – 50 in. wide x 34.5 in. long 3.0mm neoprene scuba fabric (not shown in image below); **https://fabricwholesaledirect.com/products/neoprene-scuba-3mm-fabric**
g. 2 splines – 52 in. long pieces of 0.095 in. nylon grass trimmer string with angled edges
h. Staple gun with 3/8 in. staples (not shown in image below)




## Making a hub for a reef prism form

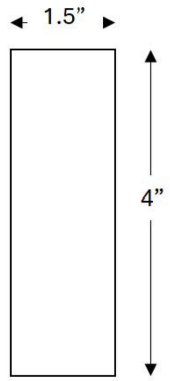
Use the template provided or make your own. To make your own hub template, draw an equilateral triangle with 7 in. long sides. Next overlay an equilateral triangle with 2 in. sides in each corner and draw a line on the side that is toward the center. Now cut around the sides of the 7 in. equilateral triangle and cut off the ends at the line drawn by the 2 in. equilateral triangle overly. You should end up with a hexagon that looks like the diagram below.

Using ¾ in. or preferably 1 in. hardwood lumber, trace the outline of the hexagon template and cut out. This process can be made more precise by realizing each side is parallel to the opposing side and all sides are the same distance apart. Once one side is cut, the opposite cut can be made using a table saw with the fence set to 4.25 in. to cut a parallel edge on the opposite side.



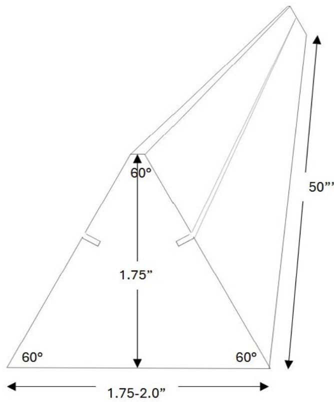

## Making a spoke for a reef prism form

Spokes are made from the same thickness and type of material that the hub is made. Cut spokes to a width of 1.5 in. and a length of 4 in. make sure end cuts are perpendicular to the long axis.




## Making a rail for a reef prism form

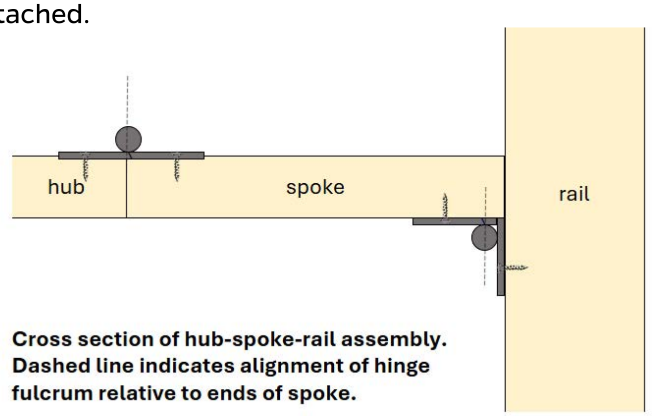
Rails can be cut from store-bought 2 in. dimension stock lumber or from a 2 in. thick rough-cut board. These can be cut from hardwood or softwood. Cut the rails with a 60° angle on all sides so that the cross section is an equilateral triangle 1.75 in. tall. If you use a store-bought 2 in. board the resulting height of the triangle will be 1.75 in., if you use 2 in. thick material, cut ¼ in. off one edge of the triangle so that the final height is 1.75 in. The flattened edge will be the outer edge when assembled. The flattened edge provides a little more rounding of the outer edges of the final prism and a place to staple fabric to rail but is not required. Cut the rail to a length of 50 in. On one of the three rails, approximately 1 in. or halfway down from what will be the outer angle, cut a 3/32 in. wide x 3/8 in. deep groove along two sides of the rails as seen in image/photo. This will hold the fabric in place along with the spine.




## Assembling the hub and spokes

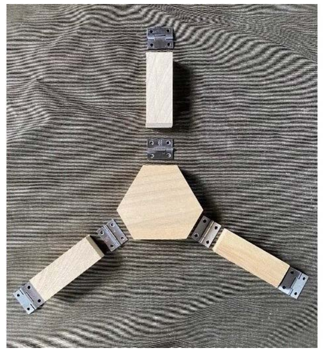
Using the acrylic template provided, pre-drill 3/32 pilot holes in the hub and spoke pieces. Note that there is a hub end marked "H" and a rail end marked "R" on the spoke template. These holes are drilled on opposite ends and opposite sides of the spoke. Make sure to keep track of which end is hub and which is rail as the spacing of holes is different.

Attach one leaf of the hinge to the hub side and the other to the spoke. The pin barrel (fulcrum) of the hinge should be centered where the two pieces of wood come together (see diagram). After the three hinges have been attached, flip the hub and spokes over and attach another set of hinges to the outer end of each spoke. Alignment of these hinges is different than the hub side. Here the pin barrel is flush with the outer edge of the spoke instead of centered (see diagram). Predrilled holes should put the hinge in the correct location, but visually check placement once attached.



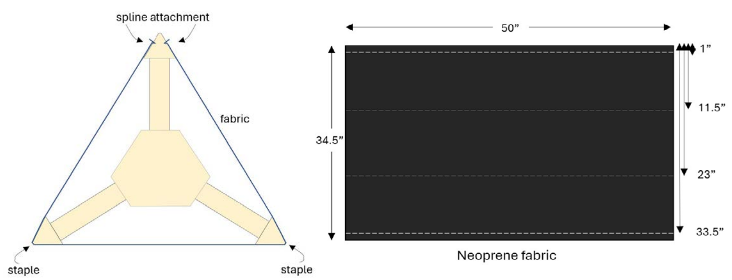

**Cross section of hub-spoke-rail assembly. Dashed line indicates alignment of hinge fulcrum relative to ends of spoke.**

To attach hub and spokes to the rail, measure 8 in. in from each end of the rail and draw a line perpendicular to the long axis of the rail. Pre-drill pilot holes by using the acrylic spoke template. Align the sides of the template parallel with the sides of the rail and the end of the template with the line drawn perpendicular to the rail. Make sure you are consistent with the end of the template used (H or R) and placement of the template relative to the line. Attach the rail leaf of the hinge to the rail while making sure the hinge stays square to the rail. This can be a bit tricky and is facilitated by having a long extension on the drill bit so that the drill is not running into the hub, and by not tightening all screws at first and instead only partially tightening all screws (on both ends), then expand the form and tighten all screws. Make sure to orient hub and spoke correctly when attaching to rail. The hub to spoke hinges should face out and the spoke to rail hinges should face in (see photo).



## Attaching fabric to the prism form

Cut fabric to 50 in. wide and 34.5 in. long. When laying fabric out make sure it is on a nonbinding surface so that the elastic fabric doesn't hold a stretch point and is allowed to contract to its unstretched condition. Using a light-colored crayon or wax pencil, draw lines across the width of the fabric at 1 in., 11.5 in., 23 in. and 33.5 in. from one end (see figure below). With the wooden form collapsed, attach one end of the fabric to the rail by pushing the tripper string (spine) into the fabric along the groove line. Let the spline overhang the end of the rail by approximately ¼ in. so that it can be more easily removed if necessary. Then follow the crayon line down to the other end pressing the spline into the groove as you go. After one side is complete do the same to the other side with the wooden form still collapsed. Once fabric is attached on both sides, expand the form and adjust the fabric on the rails so that the crayon line lines up with the outer angle of the other two rails. Stretch the fabric slightly pulling along the long axis of the form so that it extends ½ in. beyond the end of the rail and has equal tension throughout. Using the staple gun, staple the fabric to the rail either on the side of the rail or along the flat outer edge.




If the fabric is not tight enough or begins to sag along the sides over time so that the final prism has sides that are bowed in, you can take out staples and remove one of the splines and shorten the overall spline attachment point to less than 33.5 in.

Pressing the spline into the fabric along the groove line (left) and stapling fabric to outer edge of rail (right).

## Using the triangular prism form

When expanding the form, reach inside the form and pull the hub toward you until hinges lock in place. Due to the stretch of the neoprene fabric this can be tricky since the rails will also tend to try and move out of alignment. Try holding all three rails in place while pulling back on the hub or have two people pull on the hubs on either end of the form at the same time. Wear gloves and make sure to avoid the hinges as they lock in place. To collapse the form, push inward on the center of the hub until hinges unlock. Sometimes this requires a quick poke in the center of the hub with a 2x2 or 2x4 piece of lumber, or some sort of handle if the JR-CSA has cured tightly around the form.

Whenever forms are not in use, the form should be collapsed to reduce permanent stretching of the fabric.

Image of expanded triangular prism form from side and end

# Appendix II: Construction Guide for Reef Prism End Cap Form

## Constructing a reef prism end cap form

1. Using 3/8 in.-1/2 in. plywood, cut equilateral triangles with sides 12.5 in. long. You may want one or two forms with side lengths of 12 in. or 11.75 in. if some prisms have sides bowed in.
2. Cut ¾ in. off each tip.
3. Find the middle of the triangle by drawing lines on the triangle end piece from each tip to the center of the opposite side.
4. Cut a 2 x 4 ft piece of lumber in half lengthwise to create a 1.5 in. x 1.75 in. dimension board or purchase a 2x2 ft piece of lumber. Cut to length of 44 in.
5. Center the triangle over the end of the 2x2 ft and attach with three 2 in. wood screws.
6. Place a layer of 6-mil plastic (polythene/polyethylene) over the end of the triangle and wrap the ends around the edge of the triangle and attach to the back with a staple gun.



# Appendix III: Sample Data Sheet for Site Assessments

## PROS Site Assessment Data Sheet

**Site Name:**

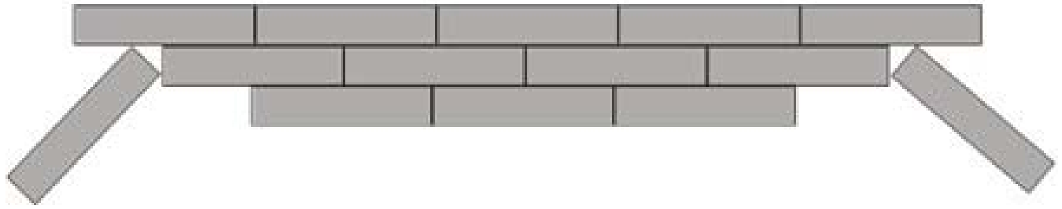
**Date Sampled:**

**Surveyors:**

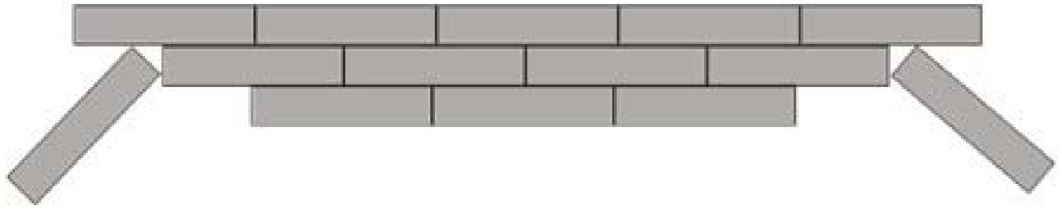
## Prism Physical Integrity

Visually inspect prisms within reef array and note any damage or degradation by placing an "x" in the appropriate prism.

**Reef #**



**Reef #**



**Notes about damage found:**

## Prism Movement

**Have photos at all four PVC poles been taken?** Yes No

**Notes about prism movement:**

# Habitat

**Photo Assessment**

**Have 6 photos been taken (front and back of prisms 1C, 2A and 3B? Yes No**

**Does the focal reef look representative of all reefs? Yes No**

**If the reef is different, please explain:**

# Quadrat Assessment

| | Prism 1C | | Prism 2A | | Prism 3B | |
|---|---|---|---|---|---|---|
| | Front | Back | Front | Back | Front | Back |
| Oysters (smaller than thumbnail) | | | | | | |
| Oysters (bigger than thumbnail) | | | | | | |
| Oyster % Cover | | | | | | |

**What other organisms do you observe?**

# Sediment Accretion/Erosion

| Location | Distance | Comment |
|---|---|---|
| Front pole | | |
| Back pole | | |
| Right pole from front | | |
| Left pole from front | | |

**Were measurements taken in centimeters or inches? (please circle)**

**Additional notes and comments:**



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## April 2025