Summary of Lionfish Non-Containment Trap Designs 2021

As part of the Saltonstall-Kennedy project, Lead PI Candelmo has been collaborating with a team of project partners and seeking advice from local experts to determine best design modifications for reducing sea turtle entanglement risk. Project partners include Tom Matthews, Emily Hutchinson and Sam Hagedorn (Florida Fish and Wildlife Conservation Commission), Steve Gittings (NOAA Marine Sanctuaries), Alex Fogg (Coast Watch Alliance), Holden Harris (University of Florida), ReefSave and Lionfish University, Rachel Lynn Bowman and Peter Angelotti

During June 14-19, 2021, we met with local Florida Keys lobster fishermen, Gary Nicols, Butch Hewlett and Bruce Irwin for their advice on trap design and deployment strategies and with Bette Zirkelbach, manager of The Turtle Hospital to discuss turtle behavior and gear risks.

On a conference call on September 29, 2021 with project partners and NOAA scientists Daniel Foster, Jeff Gearhart, Bret Hataway and Eric Hoffmayer, we discussed existing and potential designs. It was determined that a design similar to Design 8 would be the best method for eliminating sea turtle entanglement. We will be shipping a trap next week to the NMFS, SEFSC, FATES Division, Gear Research Branch in Pascagoula, Mississippi so they can work with the trap in person and brainstorm other modification so we can further benefit from their expertise.

In conjunction with multiple virtual and in-person meetings with project partners and experts in gear design and turtle risks, we conducted a series of field tests to identify the most effective design for eliminating the risk of sea turtle bycatch.

The observed turtle entanglement occurred with a large green turtle wedged itself under an open trap, then tried to ascend through the soft netting of the trap and was unable to find its way back out past the rebar. The turtle continued to push up into the loose netting instead of moving back down and under the rebar.

<u>Designs that have been discussed, created and tested in some format include</u>

1. **Open Hole in mesh on both sides of trap, each held closed with breakaway line** – The trap operates well and the hole remains closed in normal operation. Consultation with NMFS, however, suggests that no scientific information exists on the breakaway strength of turtles, which would otherwise inform the required tensile strength for the breakaway line. Anecdotal evidence suggests that the power generated by a turtle is insufficient to break virtually any practical line, so this design is likely to be unsuccessful in protecting turtles from entanglement.

2. **Breakaway line along edge, where net attaches to rebar –** The trap works well, and functions like the unmodified original design, but the same problem exists – the lack of data on a turtle's breakaway power. Also, assuming the line would have to be quite weak to allow turtles to break through, it is likely to fail quickly, or even during normal operation, and it would need to be replaced often. Anecdotal evidence of the limited breakaway power of turtles suggests that this design is likely to be unsuccessful in protecting turtles from entanglement.

3. Open hole in net on both sides of trap with flaps that open – Multiple approaches to this design idea were created and tested, but at full size, the netting sags too much. The hole expands as the trap is deployed and retrieved. The flap cover sometimes works, covering the hole during retrieval, but often floats up, exposing the hole in the net, or ends up outside the hole, which could allow lionfish escapement. We added weighted line to the flap edge to keep it closed and had some success. We also added a bungee across the frame to tighten the bottom edge of the hole. That helped, but didn't prevent the flap from falling irregularly across the open hole. It also raised a concern that a turtle would find it more difficult to find the hole, or become trapped by what is effectively yet another type of "frame" attached to the net. The design also does not prevent a turtle from finding its way to a "corner" of the frame (away from the opening in the mesh) and getting caught by the loose netting (which is what happened in the mortality event).

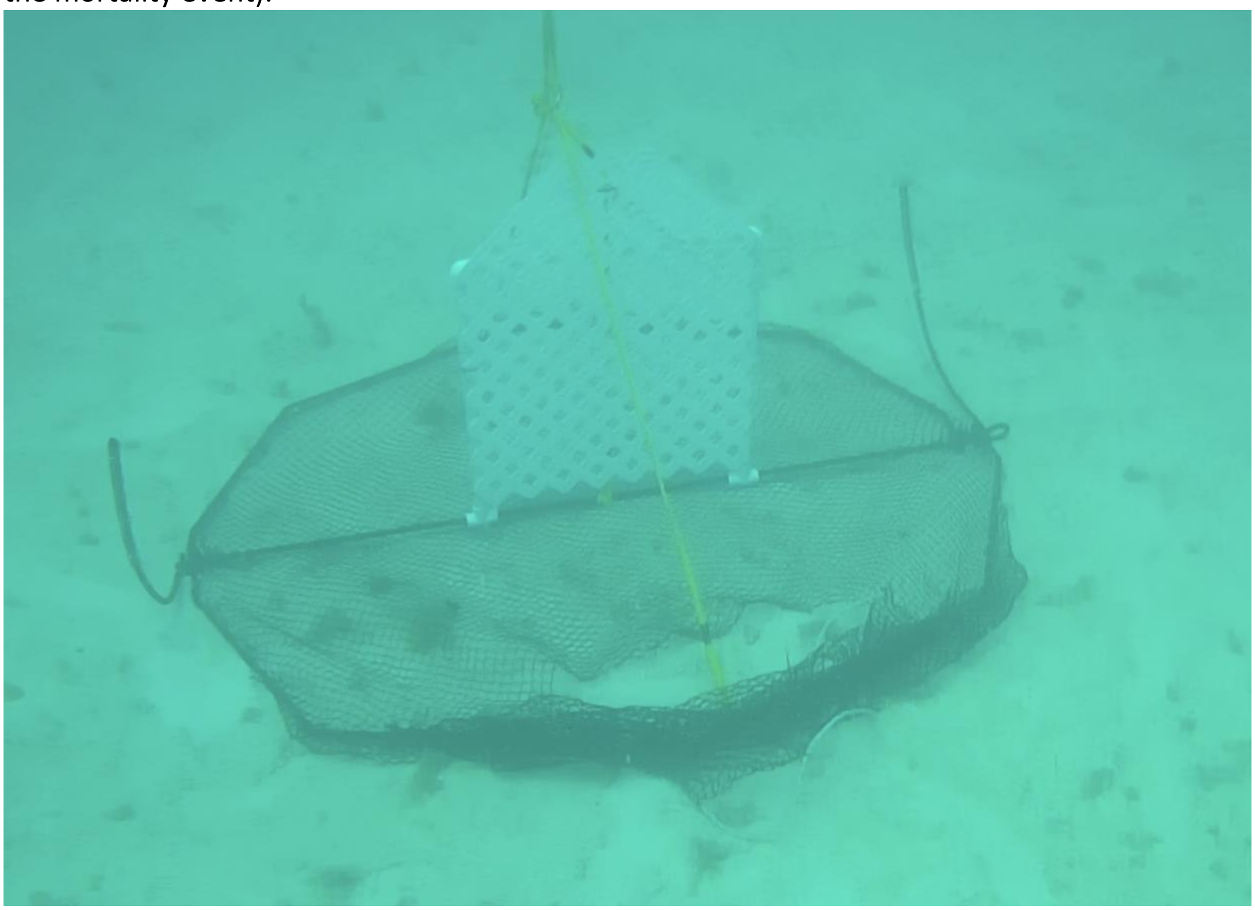

Figure 1. Design 3, Hole in netting. Lands open as flap floats up during deployment and often lands outside of net.

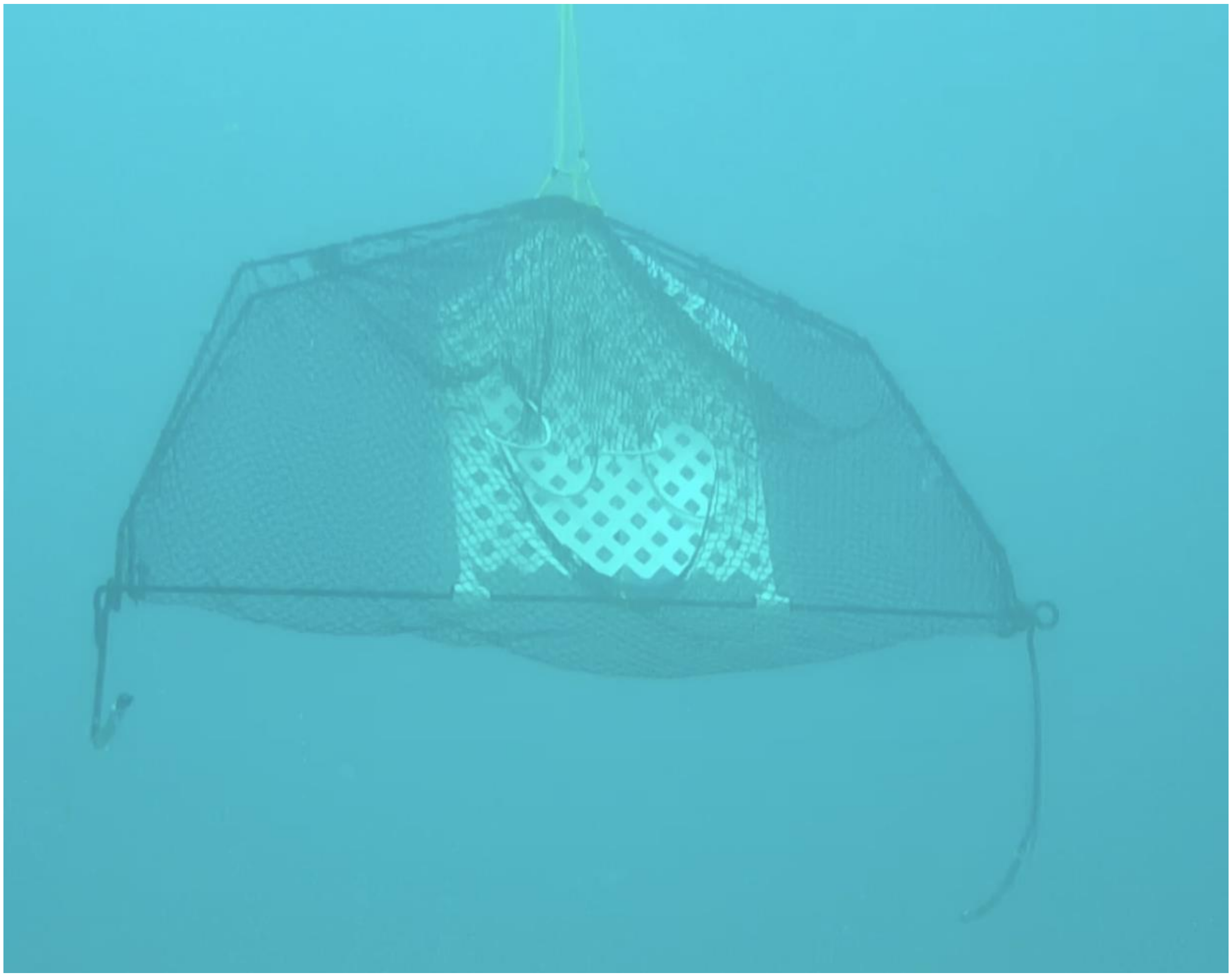

Figure 2. Design 3, Trap hole opens up from water drag during retrieval

4. Open hole with bungee or batten to hold all or some of it closed

This option keeps the hole closed, so there is less risk of losing lionfish from the trap, but it would probably make it more difficult for a turtle to find its way out of the trap, particularly if the stiffeners are too taught. The risk of entanglement in trap is likely similar to original design.

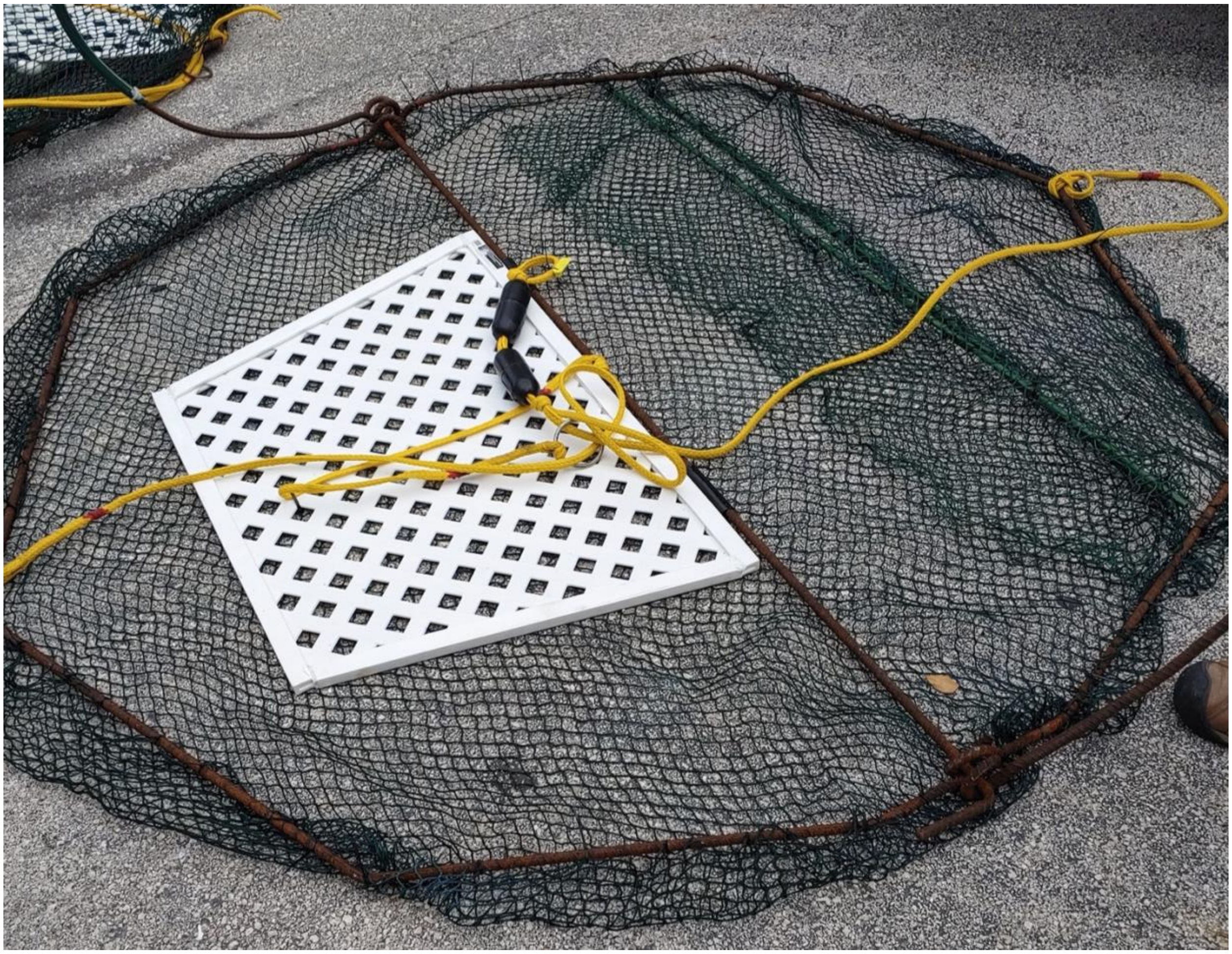

Figure 3. Design 4, example of two stiff batons holding gap closed, with flap of netting draped inside

5. Combination of stiff mesh and netting with escape gap

Goal is to allow turtle to push through but keep the gap closed during deployment and retrieval**.** Problems: In order to keep the hole closed, probably make it more difficult for a turtle to find its way out of the trap, particularly if the stiffeners are too taught. The risk of entanglement in trap is likely similar to original design.

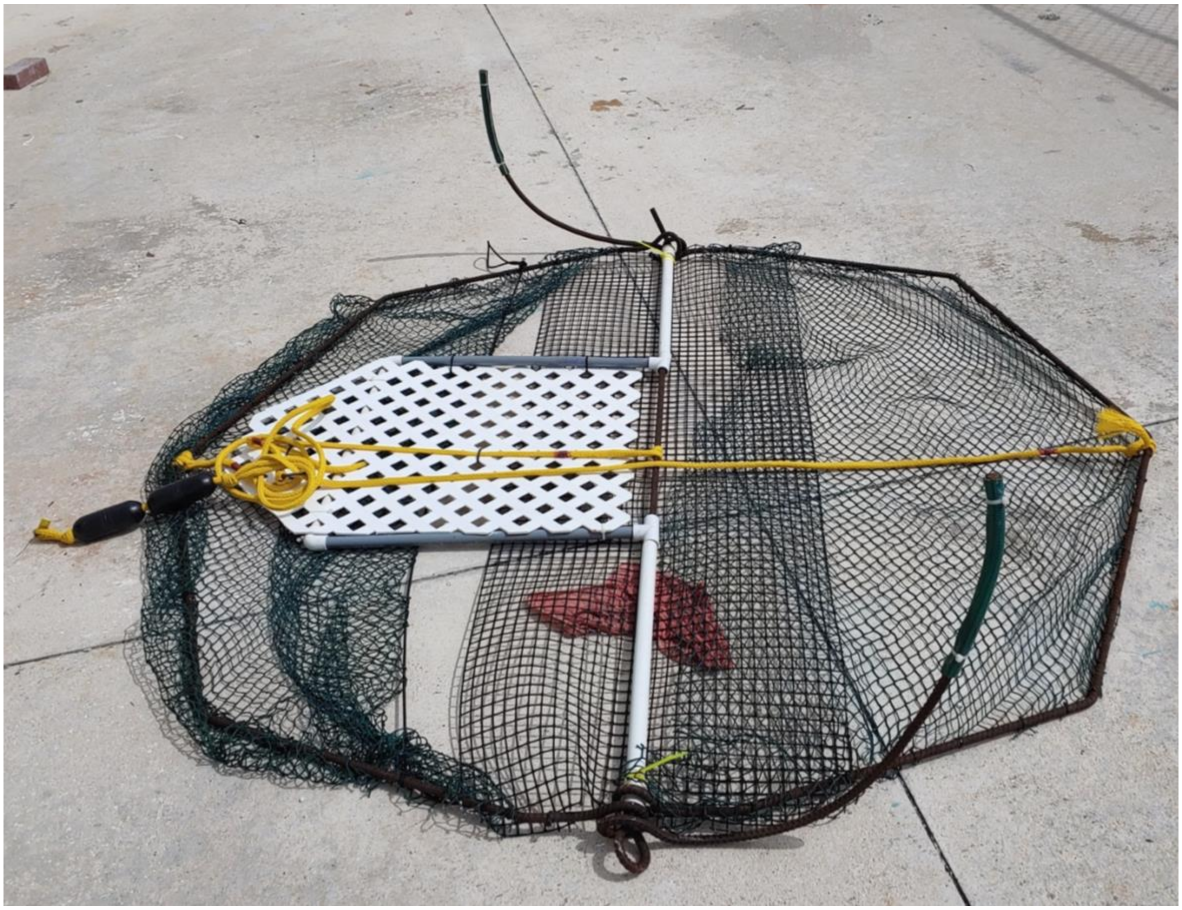

Figure 4. Design 5, Stiff black netting and loose green netting combined to allow for a gap in the net for sea turtle escapement but eliminate gaping.

6. Stiff mesh as an entire panel, attached loosely so it will billow; with no loose netting

This design has only plastic mesh, and eliminates the risk of the loose netting, but it did not operate well as a trap. The material, which is loosely attached to the frame in order to allow it to billow while closing, was difficult to shape and actually did not billow well, nor did it flatten well when not in use, making storage difficult. This idea would be an attractive option if a permanent billow could be built into the plastic mesh, but that could cause other issues, such as orientation and stability on the bottom, and deck storage.

Figure 5. Design 6, Sewn layers of stiff black mesh designed to allow for billow

7. Normal netting with multiple horizontal bars on inside;

This design will allow the net to billow, but contain bars that would act like a ceiling for any turtle underneath. The bars would force the turtle out the side rather than allowing it to try to exit through the net. Discussions with TED experts suggested the bars would probably need to be as close four inches apart to ensure turtles would not instead get caught between the bars. This would require 5-6 bars per side of trap, and there would still be a risk of entanglement for small turtles, which could get their heads between the bars while under the trap. We are also concerned that a large number of bars might scare lionfish out of the trap as it closed and make the trap less effective.

Figure 6. Design 7 Horizontal bars are placed across the netting on the inside to create a ceiling to prevent turtle from getting traps or disorientated by netting. Demonstration that the gaps would need to be narrow enough to prevent small turtles from going between the bars.

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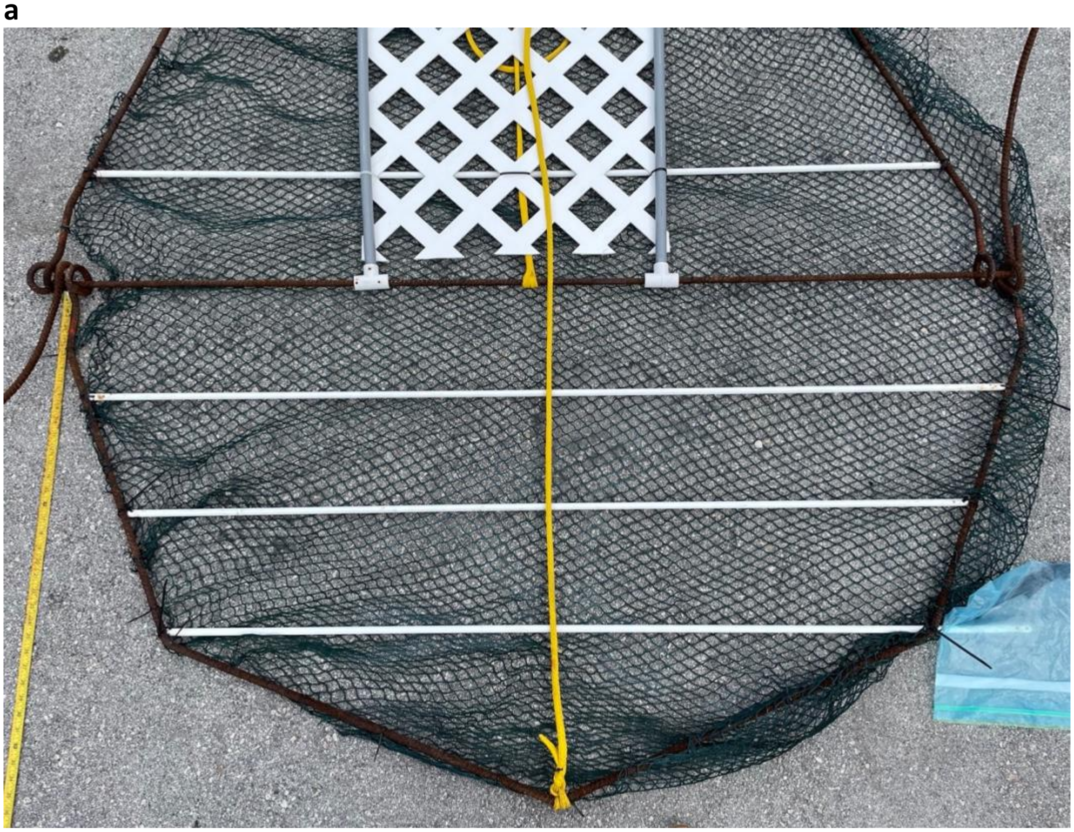

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Figure 7. Design 7, Three horizontal bars on each side leave 8 inches of space between them which could be too large to prevent turtles from going through. Experts suggested we should reduce this to 4 inches which would require 5-6 bars.

8. Stiff plastic netting used as bottom panel. Attached with about 12 inches of netting to allow it to billow.

This design allows the trap to billow upon retrieval, yet it provides a rigid ceiling for any turtle crawling under the trap, preventing it from getting stuck in the netting. The stiff plastic extends beyond the rebar frame of the trap so it cannot invert through the trap and cause confusion for the turtle. There is only a small amount of netting in this design, further reducing entanglement risk, and the stiff plastic is also less likely to snag on the bottom.

Fishing Issues – The trap is more cumbersome to handle due to the extended plastic mesh. We would also like to add a semi-rigid frame around the plastic mesh to cover the sharp edges and reduce snag points for lines. That will require additional engineering. At the moment we are using battens to prevent inversion. These are easy to install but can get tangled in the netting of the trap.

The additional rigid plastic material increases the surface area of the trap and increases drag; the rate of descent is slightly slower with rigid plastic versus soft netting. This could be countered with weights. The current design also remains slightly expanded during retrieval, which may increase resistance, as well as stress on the mesh and netting.

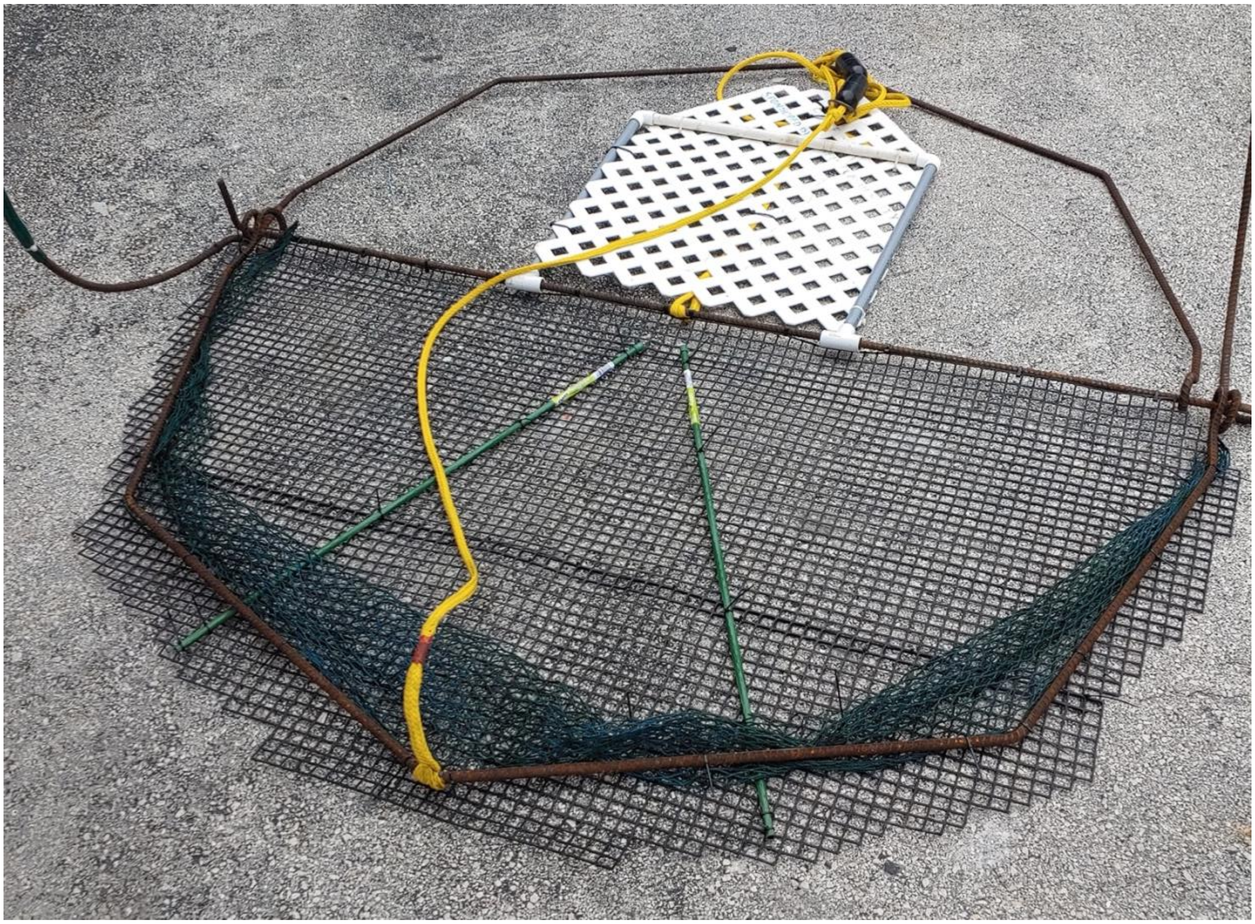

Figure 8. Design 8, Rigid plastic netting will be outside the rebar frame with either bars or an additional frame to prevent it from being able to be inverted through the rebar frame from below.

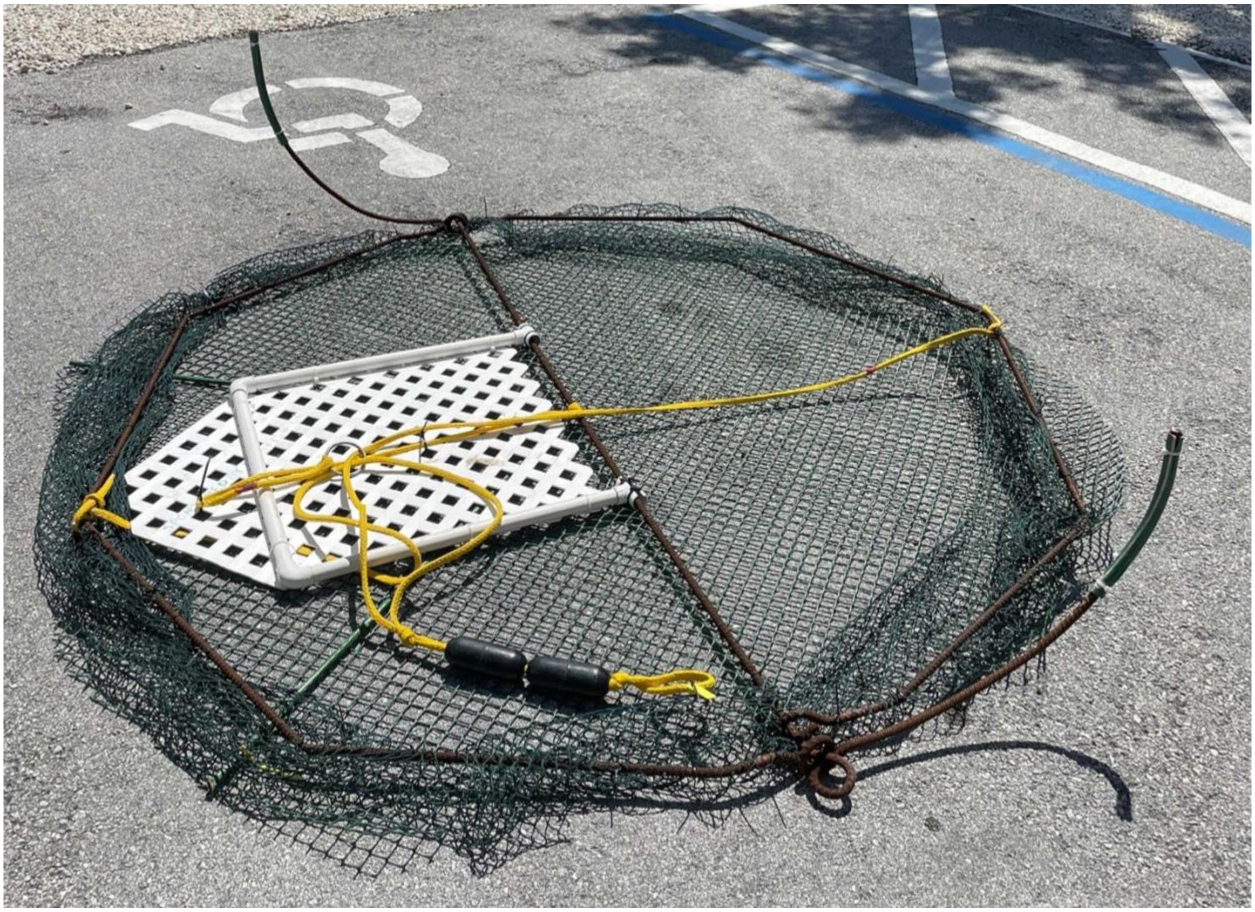

Figure 9. Design 8, Rigid plastic netting will be outside the rebar frame with either bars or an additional frame to prevent it from inverting through the rebar frame from below. The green plastic netting shown here and in the remaining figures is stronger than the black plastic netting in the figure above and will likely be the material of choice.

Figure 10. Design 8, “Baffle Design” about 12 inches of netting is attached to rigid plastic mesh, creating an accordion-like design.

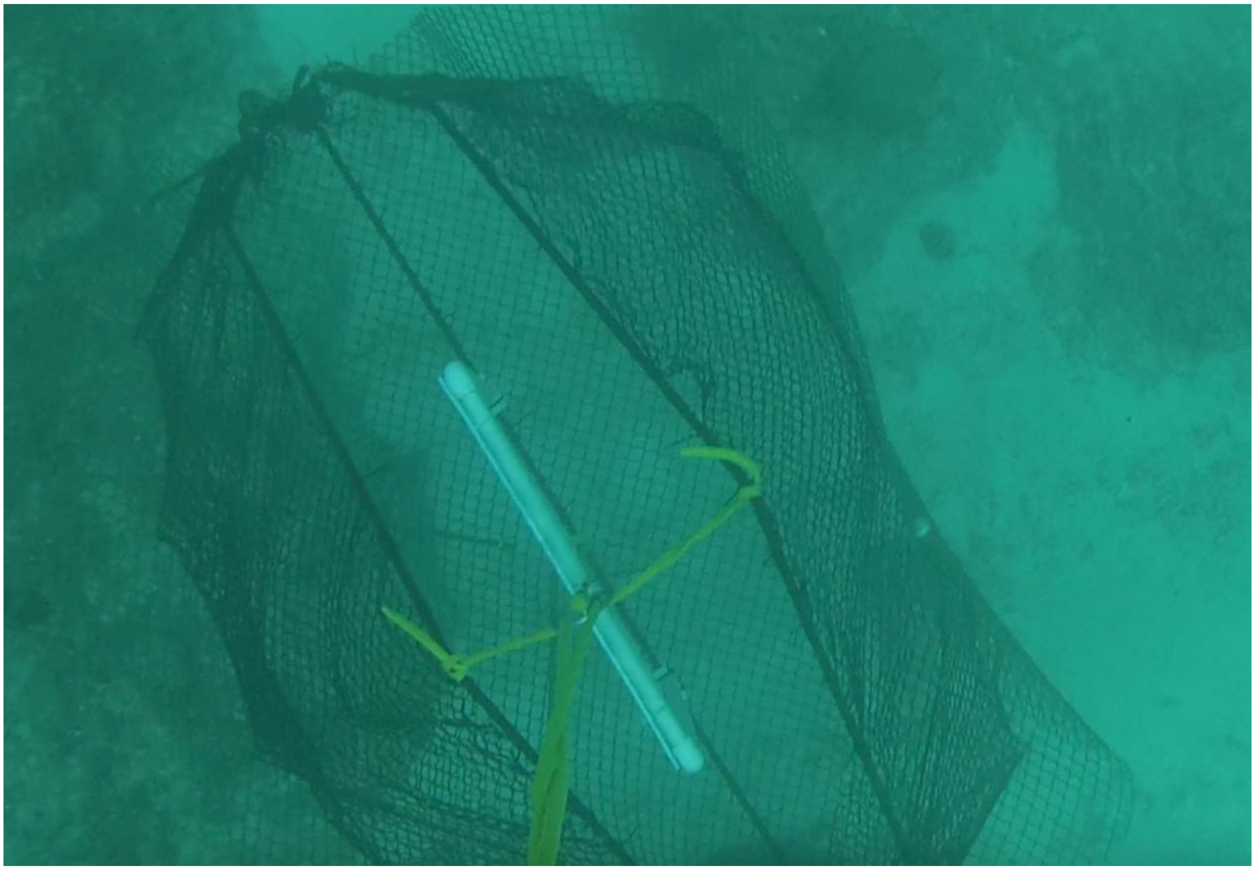

Figure 11. Design 8, The “baffle design” allows for a adequate billowing, and the billow may not be affected by a cross current as much as a frame with soft netting alone.

Photos of models that Dr. Steve Gittings created of the last three designs can be found at this link
https://drive.google.com/drive/folders/1_reqby4ssh0qMxlPX4nuveHlJNzQiFG3?usp=sharing

Summary of Lionfish Non-Containment Trap Designs 2022

Designs that have been created and tested

1. Rolling edges of stiff plastic netting used as bottom panel, with about 12 inches of netting to allow it to billow – The "baffle design" allows the trap to billow upon retrieval, yet the rigid ceiling reduces the risk of entanglement for turtles crawling under the trap. The stiff plastic extends beyond the rebar frame of the trap, so it cannot invert the trap and cause confusion for the turtle. Rolling the stiff plastic reduces the amount of sharp edges and snag points. The rolling also creates a clean edge to frame the trap. Creating a template for where to cut in order to roll the plastic, allows for traps to be framed out quicker and to reduce variability in replicates. The corners of the plastic netting are rolled into each other to create an angle similar to that of the rebar frame. The bottom panel is flipped over before being attached to the frame of the trap, so not to interfere with the harness or closing.

The additional rigid plastic material increases the surface area of the trap and increases drag. When being retrieved from deployment, generally one side of the rigid plastic will be closed and the other will be open due to current and wave conditions; does not interfere with billowing of trap during retrieval.

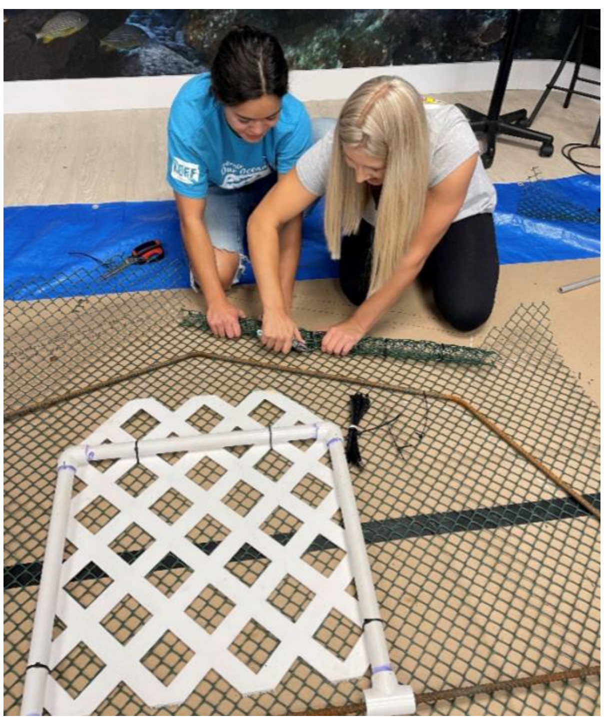

Figure 1. Stiff plastic netting being rolled to create bottom panel for trap. Plastic is rolled and zip tied into place to hold the shape.

Figure 2. Plastic frame rolls completed and panel is flipped over for final positioning. The trap is still on the template made at REEF.

Figure 3. GoPro footage of trap retrieval with "baffle design". Once closed and being brought up from the bottom, depending on waves and current, one side of the design pushes up again the frame.

Figure 4. Trap lacing to attach netting to rebar frame and rigid plastic netting is less than an inch apart, closer than previous trap designs. Added drag from the rigid plastic netting was counteracted with closer lacing to increase the surface area being pulled on.

Photo Sequence of "Baffle Design" – moving from being open to closed

Figure 5. (1) Trap open on the ground. Rigid plastic netting and mesh lay flat on the ground. FAD is taught.

Figure 6. (2) Trap is starting to close. Mesh is pulled up first to create space for billowing. The rigid plastic follows.

Figure 2. (3) Trap is fully closed and off the ground. Mesh is billowing. Rigid plastic is sitting off trap frame.

Figure 8.

2. Adding additional rebar to the outer frame and axle of the trap – This design counter balances weight from the top of the frame and the axle to assist in proper opening of the trap. The weight is added through additional pieces of #6 rebar cut to certain lengths to fit different areas on the rebar frame. On both sides of the frame, two pieces of rebar were added at the topmost angle, on each side of where the harness is attached to. The additional weight on the top of the frame required weight on the bottom of the frame to make sure the trap did not fall sideways and not open. Four to five pieces of rebar on each side of the FAD were the optimal amount of weight to make sure the trap deployed properly.

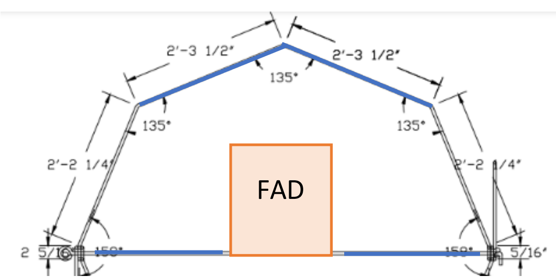

Figure 8. Diagram of the trap frame. The blue lines mark the area where rebar was added for additional weight.

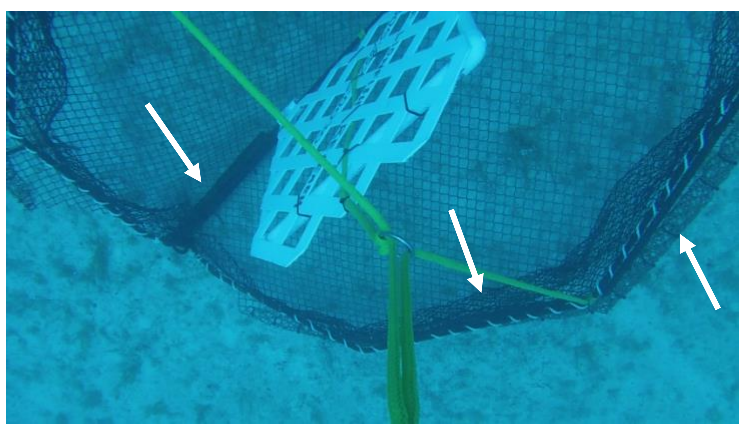

Figure 9. Counter balance weight system at 150 ft. Additional rebar weight is added on the axle and on the frame (shown with arrows). Weight is zip tied to rebar frame.

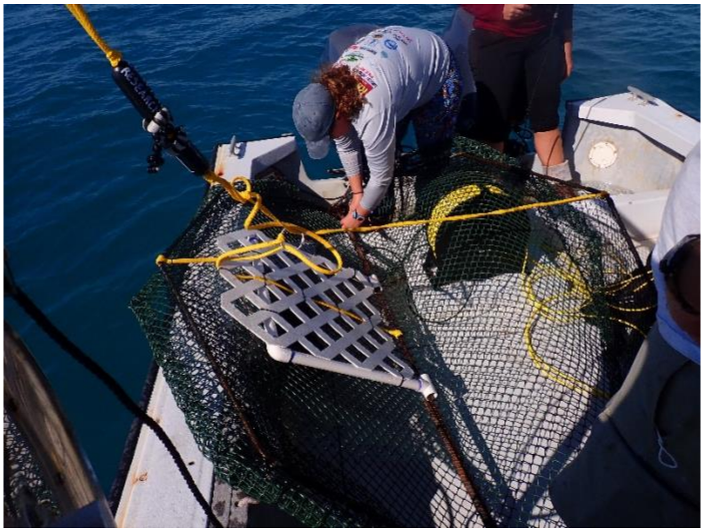

Figure 10. Project Coordinator Alexa Bryant adding weight with rebar to the frame of the trap using zip ties on FWC research vessel. Testing counter balance trap weighting.

3. **Singular trap trawl design tests** – Deployment testing was conducted in shallow water (less than 30ft) with a single trap and a 40 lb block of concrete. The trap and the surface float were both attached to the concrete block. This design allowed for surface float movement to not effect the trap on the bottom; no lifting of the trap frame in rough conditions or movement of entire trap. The line pulled the harness of the trap to the side, when concrete block was dropped, causing some motion in the frame arms. Using a neutrally buoyant line would be an option to test to not cause an arch between the harness and the concrete block.

Figure 11. Line at the bottom of the photo is coming from the trap to the concrete block with the line at the top of the photo going to the surface float from the concrete block.

4. **Smaller ring on harness to make trap close tighter and zip ties to close trap near hinge**– The original testing was conducted with a 3-inch ring attached to the FAD. When the trap closed to be retrieved, the frame arms were separated about 2 ½-inches. A 1-inch and 1 ½-inch ring were both tested to replace the 3-inch ring. The traps closed tighter around the harness and provided less of an opportunity for escape when retrieving the trap. The mesh netting around the hinge was attached to the frame of the trap to not impair the hinge movement. Zip ties were used to close the area, but in the future, that area could be tied with line.

Figure 12. Trap harness with original 3-inch ring. Finger used to show distance between the top frame arms of closed trap.

Figure 13. Trap harness with 1-inch ring. Finger used to show distance. Trap is closes tighter with smaller ring.

Figure 14. Area of trap near hinges. Zip ties used to close the edges of trap and not impair hinges. Hinges are visibly clear of mesh and rigid plastic netting. Axle eye loop is closed directly around door eye loops to keep doors closed tightly and prevent them from sliding side to side.

Non-Containment Gittings Lionfish Trap Building Photos from December 2021

Figure 15. Dr. Steve Gittings of NOAA, checking newly bent lionfish trap frames to make sure hinges are not binding with newly bent axle.

Figure 16. Alexa Bryant cutting out rigid plastic with rigid dowels instead of rolled edges. Hinges of trap doors were originally design to be placed inside eye loop and 90 degree angle of axle. Current design (Figure 14) shows axel eye loop wraps around door eye loops to stop the doors from shifting side to side and keep a tighter closure.

Figure 17. Dr. Steve Gittings and Peter Angeloti, bending rebar for frame. Angle and distance of each rebar bend was adjusted and finalized during the building process to create a final design template for future replication.