Lionfish Trap Design

Final Report D-LAB II

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1.0 Design Brief

The Caribbean region is facing an environmental challenge regarding the invasion of lionfish (Pterois volitans). A lionfish trap is necessary for the market based approach to tackle this environmental concern. Lionfish fishing targeted for human consumption is a potential cost-effective management solution and has been adopted in countries like the Bahamas, Jamaica, Belize and Bermuda. This approach is dependent on building a supply of lionfish meat to consumers. However, the ability to catch lionfish in large numbers is yet to be developed in T&T. The most common method for catching lionfish is via spearfishing, which makes the lionfish market dependent on highly skilled and well-trained few individuals. Therefore, we propose to develop prototypes of lionfish traps in D-LAB II to be tested by our partner organization in Trinidad and Tobago, the Institute of Marine Affairs. The proposed lionfish trap is an adaptation of a trap developed by NOAA, and it will be further discussed in this report.

The client is a research institute that develops and implements programs that translate the marine and related policies of the Government into activities that contribute to national development, among other responsibilities.Kahlil Hassanali, the Institute of Marine Affairs, Trinidad and Tobago is the main point of contact for the project. This project aims to design a low-cost lionfish trap prototype to be tested in the field by our client in Trinidad and Tobago. The goal is to adapt the “Dome Trap” prototype of lionfish traps designed by the Office of National Marine Sanctuaries/NOAA to our client’s needs and budget and share the lessons learned from the building process to advise our client before they decide to upscale the lionfish trap production. The target market for the project are scientist, environmental managers and overall fishermen. NOAA provided benchmarks for their design that will be compared to other fish trap designs like lobster traps and Antillean fish traps. The prototype budget was estimated at $80.

2.0 Design Specifications

Before beginning to identify and design a solution, the needs of the stakeholders had to be identified. From these, specifications were developed for the design. Finally, once the design was underway, industry standards had to be considered in order to develop a viable solution. The needs, specifications, and standards will be discussed next.

2.1 Considerations

Technical

The technical considerations for the project were selected based on the main needs for the trap. The mechanics of the trap allowed for many properties to consider but the most important considerations were collapsible, plastic bait or aggregation devices, lightweight, resistant to flow, stable, negative buoyancy. Lightweight and negative buoyancy are contradictory in some respects therefore these were targeted separately. The weight of the trap was the initial focus with the intent to produce negative buoyancy as needed using diving weights.

Social

The trap also needed to be easy to use for fisherman and scientist to adopt. The important considerations for the target consumers were easy to handle. The traps are different in design to common traps but it uses well established fishing practices. A buoy is used as a marker for the traps and they are pulled up after similar to lobster trap setup. The main introduction of new knowledge is the required lionfish handling training, but this is an additional consideration for implementation of the project. This consideration helped in the selection of the material for the trap and the design of the hinges for the trap. In addition, the skill level for building the trap were also taken into consideration for manufacturing.

Environmental

Although there are currently no restrictions in Trinidad and Tobago towards the us of fishing traps/pot, materials or bycatch it was important for the team to use ethical practices and make environmental impact a consideration. The use of a fish aggregation device or plastic bait was preferred to real bait to limit bycatch and limit the environmental impact.

Financial

In order to make the fish trap design more attractive to fisherman and accomplish the overall goal of introducing a market based approach to lionfish management the trap needed to be low cost, easy to repair and easy to reproduce. The need for limited investment provides for a minimal risk for fisherman which is an incentive for them.

2.2 Design Ideas for FAD

The lionfish trap consist of two main components. The main component is the trap itself with its main body. The other component is the method for attracting lionfish. The behavior of the lionfish aided the design of NOAA’s fish aggregation system (FAD). The team therefore decided to evaluate multiple ideas for the fish aggregation devices (FAD). The top ideas were put into an evaluative matrix, shown in Table 1 below, which was created to determine which FAD should be used. Plastic bait was shown to be the best method. Given that plastic bait is easy to order online the team combined the design selected for NOAA of buckets and add plastic bait hanging from the overhang.

Table 1. Evaluative Matrix

Idea	**Effectiveness**	**Weight**	**Cost**	**Weight**	**Environmental Impact**	**Weight**	**Total**
Aggregation Device with buckets	3	3	3	2	3	3	24
Aggregation device with shelves	3	3	4	2	3	3	26
Plastic bait	4	3	2	2	4	3	28
Real bait	2	3	5	2	1	3	19

Table 2. Pros and cons of ideas

Idea	**Pros**	**Cons**
Plastic Bait	● Smaller amount of plastic= smaller environmental impact	● Expensive to buy in T&T
Aggregation device with shelves	● Collapsible	● More expensive to build a prototype
Aggregation device with buckets	● Relatively inexpensive ● Easy to build ● Easy access to material	● Inefficient use of space ● Limits volume ● Size constraint
Real Bait	● Accessible to fisherman ● Require less training for use ● Known fishing practice	● Large negative environmental impact ● Higher bycatch ● Gone after one fish eats it

2.3 Criteria, Metrics, and Target Values

The criteria for evaluating the design are described in this section. The NOAA design we chose was selected from a wide selection of lionfish traps founding during market research. The NOAA trap was advantages based on the data provided by the initial report from NOAA researchers. After the initial selection of the design, it was important to select parameters for evaluating the lionfish trap. The effectivements was the main consideration. The ability for the trap to sink, attract/catch lionfish, and be cost effective were the main criteria for the trap. The target values for the criteria are provided in table 3.

Table 3. Table of criteria and metrics

Criteria	Qualitative/ Quantitative	Testing	Target Value	Metric
Effectiveness	Quantitative	Field testing	14% minimum	% of fish in the area/trap/day
Cost ● D-lab ● Trinidad and Tobago	Quantitative	Calculate using the budget	**D-lab**: $30 max **Trinidad and Tobago**: $10 max	$
Environmental Impact ● By catch ● Non-toxic ● Recyclable	Both	Field testing	**By catch:** 50% max **Ocean:** Materials are non-toxic in the ocean **Recyclable:** Materials can be used for other purposes after lifetime	**Bycatch**: % of other species caught **Ocean:**Toxicity of materials used (qualitative) **Recyclable**:Qualitative
Life-cycle ● Material availability ● Durability	Qualitative	Lab testing (hydraulics lab)	**Material availability:** All materials can be found on the island of T&T **Durability:** Materials last for 1 year max (of being in the ocean)	**Material availability:** Distance (mi) from T&T that the material can be found **Durability:** Amount of time in the ocean (days) until end of material lifetime
Transportable ● Weight ● Collapsible	Quantitative	Using scale	**Weight:** 15 lbs max (before adding weights) **Collapsible:** Can collapse to 22 cm x 35 cm x 56 cm max	**Weight:** lbs **Collapsible:** Qualitative

In addition to low manufacturing cost, the cost of the trap should be compared in relationship to profit margins and the time it takes to recover the initial investment. Based on the calculations provided in the appendix, assuming the maximum catch of 7 fish the profit for the whole fish would be $28 meaning that with the initial investment of $80 after three catches the investment would start giving a profit. Assuming that fisherman will use more than one trap at a time this is a profitable solution for lionfish management.

Table 4. This table includes the estimated values for the lionfish size, weight and volume.

Parameters	Size	Weight	Estimated Volume	Fillet Weight
Values	25-30 [cm]	250-300 [g]	15,625-27,000 [cm]	7.5-9 [g]

Table 5. This table includes typical market values for retail price of lionfish.

Retail Price	Whole	Fillet

NY	$10.95 - 12.95/lb	$24.99 - 29.99/lb
T&T	$6.00 - 8.50/lb	$13.70 - 19.7/lb

3.0 Methodology

3.1 Materials

This design was adopted from the National Oceanic and Atmospheric Administration. This trap is named for its shape when closed. The trap consist of a main body made of stainless steel circular base, and an aggregated attraction device in the center.

Table 6: Projected cost based on local materials and design modification.

Part/ Feature	Material	Design Dimensions	Material/Part Provider	Cost	Total Cost
Circular base	Steel	6ft (1.8 m)	Home Depot	$3.00	$6.00
Two hinged half hoops “jaws”	Steel	6ft (1.8 m)	Home Depot	$3.00	$6.00
Two cross bars for strength	Steel	1.9ft (0.58m)	Home Depot	$3.00	$3.00
Polyethylene mesh and net curtain	7 ft. x 20 ft. Protective Polypropylene Mesh Covering Bird Netting	⅞ in sq mesh	Home Depot	$6.67	$6.67
Two line Harness	Everbilt 3/16 in. x 100 ft. White Diamond Braid Nylon Rope	at least 30 ft	Home Depot	$10.98	$10.98
Two Hinges	Custom	fit frame size	Recycled material		
Two Buckets		5 gallon (18.9 L)	ACE	$ 5.50	$5.50
Gardening Edge		30 in (0.76 m)	Home Depot	$ 6.98	$6.98
Zip ties			ACE		$3.50
Fasteners			ACE		$2.50
Total					$50.13

3.2 Design Process

Step 1: Acquire materials
The materials shown in the tables in section 3.1 were purchased.

Step 2: Bend steel to circle
A wooden frame was used to bend the steel tubing into the 3' diameter circle. Four pieces of tubing were bent into semicircles (2 pieces for the base of the trap and 2 pieces for the doors).

Step 3: Connect circular steel base
A steel pipe with an interior diameter larger than the ½ steel frame member was cut to about 3" pieces and used a as a connector for the steel base. The material we used for this connector came from the handlebars of an old bicycle.

Step 4: Construct hinges
Holes were drilled into small metal plates to use as hinges. Holes were also drilled into the edges of the steel tubing that was used as the door.

Step 5: Weld hinges to circular base
The metal plate with holes was welded onto the steel tubing connector. This can be seen in Figure 1 below.

Step 6: Connect the doors to hinges using lock nuts
Lock nuts were used to complete the hinges. They screw through the metal plate and the door.

Figure 1. Hinges welded onto connector

Step 7: Add mesh net and rope
Mesh net was added to the entire trap. The netting was connected to the steel tubing with zip ties. A rope was then died to the doors of the trap.

Figure 2. Trap with mesh net and rope added

4.0 Results and Discussion

Preceding the design process, the evaluation criteria were discussed in section 2. The lionfish trap is a working progress, and further modifications need to be made be for field testing can take place. In the recommendations the next steps will be outlined to prepare for field testing. In this section we will discuss the lessons learned from the manufacturing process, and preliminary results from the trap usability.
As discussed previously the total cost for the lionfish trap was approximately $50. Taking into account the traps volume and that of the lionfish a total profit of $28 can be expected for a full trap. Table 7 also shows the expected profit for the NOAA trap built by researchers. The final design was 3 feet in diameter due to restrictions in materials available locally and transportation considerations. It is important to note that a significant increase in volume and fish catch are visible with a two-fold increase in size nevertheless it requires more skills potentially two or three-fold investment. All in all, evaluating the lionfish trap based on cost the specific cost goal was met. This design is viable in terms of cost.

Another specific target that can be determined from the current state of the design is the life-cycle of each trap. The material used for the trap was steel. The type of steel in terms of percentage of metals used has an impact on the corrosion resistance. In general galvanized steel is the least corrosive resistant material even then it is 50 years of resistance in salt water environments (dahlstrom roll form). In addition steel is recyclable and generally not toxic to humans or animals.

Table 7. Size and profit for each trap based on trap radius. R = 1.5 is the radius of the fish trap made by the team and R = 3 is the radius of the fish trap made by NOAA. This is used as a comparison, and the parameters can be found for all sizes using the calculations in the appendix.

Trap Radius	Trap Volume	Max Catch	Revenue of Whole Fish	Revenue of Fillet
R = 1.5	7.07 inch3	7 fish	$28	$18
R = 3	56.55 inch3	59 fish	$234	154

Figure 3. Finished trap (without FAD)

Finally, evaluating the trap design (Figure 3) the manufacturability is a key factor. The team building the trap had limited experience in manufacturing traps. The design process was better detailed in section 3, but here the lessons learned will be described. The main learning was that in order to up scale the design a fixture for bending tube to correct diameter must be built. There are two main designs used to bend metal tubing. The method used by the team was forming the tube around a wooden die, but the other method might be best for upscale production. The other method is to slide the pipe through a set of circular rollers. This method requires more technical knowledge in the design of the device for bending. The method used by the team requires intuition but it is easy to pick up after a few practice runs. Another consideration for the design is the material yield strength. The steel used for the frame construction was very “soft” this translated to a very bumpy surface on the trap. The field testing for the trap is still to be determined. The aggregated device needs to be finalized. The trap itself is ready for further evaluation. The main objective for the project shifted for the team to build a trap using materials and equipment available to students. This objective was accomplished.

5.0 Conclusions

The chosen design from this project was modeled after a design recommended by NOAA. This design can be seen in the report in Appendix 1. The size of the trap was scaled down due to limited material availability, however shown in Table 7 are calculations for max catch and revenue. The trap made by the team has a 1.5 foot radius and cost about $50 to construct. The max catch for the trap is 7 fish which would yield a revenue of $28. If the trap is scaled up to have a 3 foot radius, the max catch would increase to 59 fish with a $234 revenue.

The trap is stable and closes when pulled up. The size should be chosen based on material availability and needs of the fishermen in Trinidad and Tobago. If possible, stainless steel or another non-corrosive material should be used for the tubing. The FAD should be built or added using materials that are easily accessible in Trinidad and Tobago to increase the efficiency of reproducing the trap on a larger scale. The team found that plastic baits are also available to order and would help attract fish.

6.0 Recommendations

The Bermuda lionfish trap project found that plastic baits are as effective as real bait to attract lionfish, but they have a lower environmental impact because they reduce bycatch of non-target species. Also, the ideal soak time for a modified lobster trap (box with funil) with a plastic bait was around 10 days, which is a reasonable time. The NOAA lionfish traps (dome and purse traps) attract lionfish using FADs (fish attractant devices) that can have either a bucket or a shelf design. The large amount of plastic and the time to build the FADs are the two major environmental issues of these devices. Future directions suggested by our group is to analyze the relationship between the volume, capacity and other parameters of the FADs in relation to the trap size to calculate the optimal FAD design. Also, it is key to investigate the parameters that potentially attract fish to the fake bait (shape, color, size) and look for the ideal fake bait design and whether it can be manufactured in Trinidad and Tobago.

The next steps for the trap include calculating the target volume for maximum lionfish catch, include combined lionfish behavior and evaluate the fake bait and FAD design and optimize FAD design as well as look into more effective designs. Ultimately it is important to note that the effectiveness of traps lie on their ability to attract and catch fish.

7.0 Bibliography

Gittings, S.R., A.Q. Fogg, S. Frank, J.V. Hart, A. Clark, B. Clark. S.E. Noakes, and R.L. Fortner. 2017. Going deep for lionfish: designs for two new traps for capturing lionfish in deep water. Marine Sanctuaries Conservation Series ONMS-17-05. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries, Silver Spring, MD. 9 pp.

8.0 Appendix

Appendix 1. NOAA Report - Going Deep for Lionfish

Appendix 2. Ideas, sketches, and calculations