**FINAL REPORT**

# DESIGN, TESTING AND EVALUATION OF AN ACOUSTIC RELEASE SYSTEM FOR OFFSHORE LOBSTER POT BUOY LINES

Project No. 40EANF800065

Submitted to:

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30 April 1999

## INTRODUCTION

On 29 September 1998, the National Marine Fisheries Service issued a contract to DeAlteris Associates, Inc. to "design, develop and evaluate, in consultation with the offshore lobster industry, a cost effective prototype acoustic release system for the buoy end line of offshore lobster trap gear." Additionally, "the system must be compatible with existing lobster gear and equipment" used in the offshore fishery, and the acoustic release must be "capable of distinctive activation codes." The proposal from DeAlteris Associates Inc. dated 22 September 1998 identified a two phase project designed to meet the requirements of the "Request for Quotation" and the goals of the project.

## BACKGROUND

The Northern Right Whale (*Eubalanea glacialis*) and other large whales inhabiting New England waters have an interaction problem with the buoy line of lobster pots. It is believed that as the whales encounter the lines, they slide along the whale until a knot or buoy is caught in the baleen or joint between body and an appendage. At that point the whale senses the resistance of the gear, thrashes, and becomes entangled. While disentanglement has been successful in some cases, the optimum solution is to minimize the probability of entanglement. This can only be achieved by prohibiting the lobster fishery when the whales are present, or by removing the buoy lines in the water column that can entangle the whales. Unfortunately, buoy lines are required to mark the locations of the gear so lobstermen do not set trawls of traps over each other, and mobile gear fishermen are aware of the presence of fixed gear. Therefore, it has been suggested to use low-strength buoy lines that can be easily broken by entangled whales to mark the end of trawls of traps, and a remote, acoustically triggered system to release a "pop-up" buoy and hauling line from a canister at the end of the trawl of traps.

Acoustic releases have been used for more than two decades in the moorings of oceanographic instruments in the deep ocean. Typically the equipment includes an acoustically triggered sub sea unit with a motor actuated release jaw that opens and releases a buoyed instrument package from a bottom anchor, and a vessel deck unit that is used to transmit a coded acoustic signal to the sub sea unit. These units are commercially available, off-the shelf, from regionally located manufacturers in both expensive deep ocean models, and low-cost shallow water, continental shelf models.

## METHODS

The objective of the first phase of the project was to design and develop the prototype acoustic release. The tasks involved in this first phase were:

(1) Meet with manufacturers of acoustic release instruments and acquire a subsurface release and deck unit for incorporation in the acoustic release system.

(2) Meet with members of the offshore lobster industry, discuss the objective of the project, and identify operational requirements/constraints for the acoustic release system to be successfully incorporated into their operations.

(3) Determine design requirements/limitations for the acoustic release system based on hydrodynamic principles.

(4) Design and construct a prototype system.

(5) Test this prototype system in relatively shallow water (less than 200 feet) in Narragansett Bay and the adjacent coastal waters.

The second phase of the project evaluated the prototype acoustic release system in the offshore lobster fishery on vessels operating from southern New England and New Hampshire.

This final report presents the results of the both phases of the project.

## RESULTS

Phase 1 - Task 1. Acquisition of an Acoustic Release Unit

In early October, we met with Bob Catalano of Benthos and Greg MacEachern of EdgeTech. Both firms manufacture shallow water acoustic release devices (Benthos, Model 875; EdgeTech, Model AMD 200). In traditional oceanographic applications, these devices are used to release an instrument package including the subsurface buoy from the mooring anchor, on command. The units are designed to be placed directly in the mooring line with the acoustic sensor (hydrophone) oriented upward, and the release lever oriented downward. Dimensionally, both units are cylindrical (about 18 inches in length and 3 inches diameter) and are mounted in a synthetic strongback. The Benthos unit uses a motor driven actuator that rotates and releases the retaining lever. The EdgeTech unit uses a spring loaded solenoid to release the retaining lever. The subsurface units have an operating depth rating of 1000 feet, a 200 pound load rating, and 6-12 month operating life on conventional dry-cell batteries. Both units operate in the 7-15 kHz range in 0.5 kHz increments, and have programmable digital codes. The operating slant range of the units is about 5 nm (30,000 feet). The cost of the subsurface units is $2,000 each. The Benthos deck unit (DS-8750) includes permanent internal batteries, a battery charger, a transducer with a 30 ft cable, and is programmable for a wide range of frequencies and digital codes. This unit costs $5,000. The EdgeTech unit (AMD 200) also includes a transducer with but operates on 9 volt alkaline batteries. The unit is programmable for a wide range of frequencies and digital codes and costs $3,000.

Both manufacturers indicate that if demand is appropriate (greater than 1000 subsurface units), they would redesign their shallow water acoustic release device for the needs of the lobster industry, and the resulting subsurface products would be substantially reduced in cost, estimate to be less than $1000 each. In particular, we discussed the benefits in increasing the operating frequency to 20 to 30 kHz, resulting in a reduced operating range, but gaining a substantial cost savings and reduced power requirement. Additionally, the deck unit would be modified for external power, interior placement in the pilothouse, and a hull-mounted transducer. Again, these modifications would result in substantial cost savings, reducing the deck unit cost to approximately $2500.

In mid-October, we purchased a Benthos subsurface unit and received on-loan a deck unit. EdgeTech also provided a subsurface unit and surface deck unit, on-loan for testing in the second phase of the project. We evaluated the equipment of both manufacturers in the second phase of the project. We also reviewed acoustic release units/designs from Inter Oceans and Dukane, but neither was appropriate for this application.

Phase 1 - Task 2. Determination of Fishery Dependent Operational Parameters

To determine the fishery dependent operational parameters, we interviewed lobster fishermen at Fish Expo, and met with lobstermen from Southern New England and New Hampshire. At Fish Expo, in Boston, October 15-17 1998, we set-up a display of the acoustic release at the information booth operated by the University of Rhode Island, Department of Fisheries. We queried lobster fishermen as to their concerns and operational constraints. In early

November, we met with Nick Jenkins and Will Bland of Little Bay Lobster Co. (Shafmaster boats). We discussed the fishery dependent operational parameters including on-deck operations, gear design considerations, etc. We have also discussed southern New England operational requirements with Capts. Dick Allen, Paul Bennett and Dave Spencer. In general, the offshore fishery operates year-round, in water depths from 50 to 100+ fathoms (300 to 600+ feet). Lobster traps are constructed of either wood or vinyl-coated wire, with wet weights on deck of 40 to 100+ lbs. The traps are attached to a mainline up to 6000 feet in length, and at spacings up to 300 feet. A typical offshore trawl of traps (6000 feet) includes a maximum of 40 traps at a spacing of up to 150 feet. At each end of the bottom mainline is a hauling line to the surface attached to a marker buoy (60 inch circumference soft plastic float). A weight (100+ lbs) is placed at the junction of the buoy line and bottom mainline to anchor the trawl of traps in place and resist the drag and lift forces due to the buoy line. The hauling line can be as long as 250 fathoms (1500 ft) when working in the deepest water, is usually made of polypropylene, and ranges in diameter from 1/2 to 5/8 inches. During fishing operations, the vessel approaches the float, and places the hauling line into the hydraulic pot hauler. At this point the hauling line becomes an anchor line connecting the vessel to the trawl of traps on the seabed.

Based on our discussions with the offshore lobstermen, we developed the following minimum requirements for the prototype acoustic release system.

(1) The system must carry at a minimum 1000 feet of hauling line to operationally test the concept.

(2) The system must be sufficiently rugged to withstand deck operations, but must weigh less than 200 lbs to be effectively handled by the deck crew.

(3) The hauling line must be of adequate strength to handle the loads of the vessel against the trawl of traps on the seabed (greater than 4000 pounds breaking strength). This precluded the use of a light line, pop-up buoy.

(4) The hauling line must be of sufficient diameter (greater than 3/8 inch) to work on a pot hauler, set for the larger diameter bottom line and traditional hauling line (1/2 to 5/8 inches).

(5) Because of the heavy loads on the hauling line, the line will have to be completely removed from the acoustic release system after being deployed. That is the hauling line is not connected to the release system structure, but directly connected to the mainline near the anchor weight.

The acoustic release system, if implemented by regulation, will release a strong hauling line. However, each trawl of traps will have to be marked with at least one buoy at one end to identify the presence of gear, so as to avoid lobstermen setting gear over each other, and interactions with mobile gear fishermen. Therefore, it is proposed to mark the gear with buoy attached to a line with a weak link at the bottom where the buoy line attaches to the anchor weight. In the case of a large whale entanglement, the weak link would break allowing the whale to be entangled only in the line but to be free of the lobster gear. The acoustically released hauling line would be at the other end of the trawl of traps.

<u>Phase 1 - Task 3</u>. Design Requirements Based on Hydrodynamic Principles.

There are several hydrodynamic issues that must be considered if this proposed acoustic release system is to be successful. The system must be capable of carrying to the seabed and deploying at least 1000 feet of hauling line. The buoy must be capable of withstanding pressure at water depths up to 150 fathoms (900 feet), must have sufficient buoyancy to drag up to 1000 feet of line to the surface. The larger the buoy, the greater the buoyancy, but then the system will require more ballast, so that the entire system is negatively buoyant and behaves similar to a lobster trap as it settles to the seabed. Finally, the system must be very stable in the upright position; so that it always lands on the seabed upright, and remains that way. Otherwise, the acoustic release will not function properly, nor will the hauling line deploy properly.

The stability of the system in the water column and on the bottom can be assured by separating the centers of buoyancy and gravity. That is, by placing any required ballast on the bottom of the system, and the buoy at or near the top of the system, and separating vertically the centers of these forces, the system will always return to the upright position when disturbed.

The buoyant force of the buoy must overcome the drag of the line in the water column. The magnitude of this line drag is proportional to the length of the line, the diameter of the line, and the velocity of the line through the water squared. Thus a 1/2 reduction in line diameter results in 1/2 reduction in line drag, and a 1/2 reduction in buoyancy required by the float.

Given these two important reasons to reduce the hauling line diameter (a smaller diameter line has less bulk and less drag), we determined the breaking strength of existing polypropylene line used in the fishery to be about 5000 pounds (1/2 inch is 4200 pounds and 5/8 inch is 5100 pounds). We identified a "soft lay", 3/8 inch polyester/nylon double braid with a breaking strength of 5600 lbs, and a relatively low cost of $225 for 1000 feet. This line random packs into a canister (plastic tub) 19 inches in diameter and 18 inches in height. We also found a relatively economical ($64), large diameter (14 inch) rigid buoy that provides 38 pounds of buoyancy and has a working depth of 400 fathoms (2400 feet). At the request of lobstermen, we have also attached an 8 inch diameter, deep-water float about 2 feet from the large bnoy to aid in the retrieval of the gear. The combined buoyancy of these buoys is about 45 pounds.

In shallow water, discounting line drag, the terminal ascent velocity of the buoys is calculated by equating the buoyant force (B.F.) of the buoys to the drag (D.F.) of the buoys, and solving for the velocity (V).

$$\text{B.F.} = \text{D.F.} = 1/2\ \rho\ V^2\ Cd\ A$$

The drag coefficient of a sphere is assumed to be 0.5, and the projected areas of the two buoys are (0.050 $m^2$). Using the density of seawater at 102 $kg/m^3$, the predicted terminal velocity is 10.7 ft/sec (3.5 m/sec).

Using the same rationale, but including the drag of the line, it is clear that as the length of the line in the water increases with water depth, the float ascent velocity decreases. For example, in 100 ft of (30 m) of water, terminal ascent rate is 6.9 feet/sec (2.24 m/sec); and in 600 ft (200 m) the terminal ascent rate is 3.3 feet/sec (1.08 m/sec). Thus, line drag results in a significant reduction in the buoy ascent rate. In 100 feet (30 m) of water, the ascent time is estimated to be 11 seconds; and in 600 feet (200 m) of water the ascent time is estimated at nearly 120 seconds (2 minutes). Deeper depths requiring longer lines may require 2 large buoys, rather than large and small buoys.

Phase 1 - Task 4. Design and Construction of a Prototype Acoustic Release System

The results of the previous tasks provided the essential elements of the system that had to be incorporated into a functional design.

(1) The acoustic release must be vertically oriented with the hydrophone upward.

(2) The large and small, hard plastic buoys must be retained in the upper portion of the system until deployed, and separated by a vertical distance from the ballast which should be placed as low as possible in the system. Additionally because the buoys provide about 40 pounds of buoyancy, the ballast must provide at least 50 pounds of negative buoyancy.

(3) The device must be of sufficient size to carry the hauling line canister (19 inch diameter and 18 inches in height), and the canister must be easily removable and reloadable during regular vessel operations. The hauling line has eyes at each end, that are fastened to the release buoys and the junction of the system bridle and the lobster pot trawl groundline, respectively. After each deployment, a spare empty canister is placed under the pot hauler, and as the line is taken aboard, it is directly reloaded into the canister. This results in an end for end rotation of the hauling line after each use, and an exchange of canisters.

We constructed the device using 12 gauge, 2 inch square, vinyl-coated lobster trap wire. The initial design had a high-aspect ratio (height is about two times greater than the base) and is shown in Figure 1. The base is 22 x 26 inches, and the height is 56 inches. The device is divided vertically into three sections, the lowest section retains the four ballast bars of 25 pounds each, the mid-section retains the hauling line canister, and the upper section carries the acoustic release unit, the hard-plastic buoys, and the feeder line tube from the hauling line canister to the top of the device. The upper section is sub-divided into compartments with wire mesh partitions. Overall, the dry weight of the system is about 180 pounds (40 pounds of line, 100 pounds of ballast, 25 pounds of buoys, and 15 pounds of wire, plastic, etc.). The final design had a low-aspect ratio so as to more closely resemble a lobster trap and is shown in Figure 2. The revised design has a base 46 x 24 inches, and a height of 32 inches. The device is divided into several compartments with four ballast bars at the base, the hard plastic buoys are in the mid section, the hauling line canister is at one end and the acoustic release is at the other end. Again, the dry weight of the system is about 180 pounds.

Several methods for storing the hauling line in the canister were evaluated. The simplest was the random pack. Other methods included a hollow central core and a spool. The random pack method proved to be not only the simplest, but also the least likely to snag. However, even with this method, some care must be exercised in the reloading/repacking process.

Phase 1 - Task 5. Initial Design Prototype Testing

The initial design, high-aspect, prototype system was tested on several occasions in late December 1998. On the first day, the shackle and line from the acoustic release device to the buoys snagged when the lever was released. This required some redesign and reconstruction of the upper portion of the device, so as to ensure that the tension and travel of the release shackle was directly downward, until the shackle passed around a bar and then moved upward with the buoys. Additionally, the shackle was replaced with a ring, so as to further reduce snags.

On the second day of testing, a diver checked the stability of the system on the seabed. Essentially the system could be rolled over, and it returned to the upright position. It was deployed from the vessel sideways, and always landed on the seabed in the upright position. The system also successfully released the buoys and hauling line in shallow water (20 feet). The ascent rate of the buoys in shallow water was timed at 10 feet/sec.

On the third day of field evaluation, the system was tested once in shallow water (30 feet) and twice in relatively deep water (90 feet). On all of these occasions, the buoys were released, and rose to the surface. The ascent rates were 10 ft/sec in shallow water and 8 ft/sec in deep water. The final day of Phase I field testing was conducted on 28 December 1998 in 120 feet of water in a deep channel in the East Passage of Narragansett Bay. The system was tested twice. On the first trial, the buoys released, but the hauling line reached a snag in the tube after 60 feet of line deployed. The device was retrieved, reloaded, redeployed, and operated successfully on the second attempt. Again, the mean buoy and line ascent rate was timed at 8 feet/sec.

Phase 2. Design Revision and Offshore Testing and Evaluation

The final design, low-aspect, prototype was constructed in January 1999. The purpose of the revised design was to reduce the potential for snags in the hauling line as it passed from the canister, through the conduit and out of the device. The canister was further modified with a cross pattern of elastic-shock cord to retain the random pack hauling line. As the 1000 foot line only required 60% of the canister, the shock-cord was placed at the 60% level. The shock-cord retainer can be lowered or raised as the quantity of hauling line is changed.

In mid-February 1999, the low-aspect prototype was tested from the F/V Ocean Pearl in 150 feet of water in Rhode Island Sound. The EdgeTech release was used initially, but had several occasions when the release did not function. The Benthos acoustic release was then installed and 8 of 10 sets were successfully completed. On the last two sets, the hauling line snagged on deployment, after the acoustic release triggered. In each case, the problem was related to slack in the shock-cord line retainer. The EdgeTech acoustic release was returned to the factory and apparently had failed due to an electronic malfunction.

In mid-March 1999, the F/V Ocean Pearl was again chartered to further evaluate the low-aspect prototype design. The shock-cord line retainer was replaced prior to the testing. The unit was successfully set, released, and hauled 20 out of 20 attempts. The modified shock-cord line retainer was deemed a success at preventing snags in the hauling line deployment.

In early April 1999, the low-aspect prototype was tested aboard the F/V Eulah McGrath in the Gulf of Maine. The water depth was approximately 300 feet. Our acoustic release unit was installed in a short trawl of traps, and was successfully set, released, and hauled 19 out of 20 attempts. On the last set, the hauling line was incorrectly attached to the acoustic release, so although the release functioned properly, the buoy did not deploy. The first 10 sets were accomplished using the Benthos release, and second ten sets were accomplished using the EdgeTech release.

## SUMMARY AND CONCLUSIONS

The purpose of the project was to design, test, and evaluate an acoustic release system for offshore lobster buoy lines. Over a six month period in 1998-1999. We accomplished the following:

(1) Interviewed lobster fishermen as to their operational requirements for the system.

(2) Researched shallow water acoustic release equipment available from manufacturers.

(3) Analyzed and identified system constraints and developed a conceptual design.

(4) Developed, constructed, and tested an initial, high-aspect, prototype design.

(5) Revised the initial design to a low-aspect design, and constructed and tested that unit.

The final product is a system that carries 1000 feet of hauling line, and will operate up to water depths of 600 feet. The final design was successfully tested 39 out of 40 attempts. The only failure was an operator error. The system was successfully tested at sea aboard lobster fishing vessels in the Gulf of Maine and Southern New England.

The objective of the project was to demonstrate a "proof of concept." We have developed a system that will provide lobster fishermen an alternative if the regulations are enacted that prohibit buoy lines in the water column. The solution is not inexpensive; but given the alternative of not being able to set and haul gear or having to grapple for gear with no buoy lines, this solution may be attractive. We have only demonstrated the concept. We expect that individual fishermen will improve the design of the system as they work with it, if and when that time comes.

## ACKNOWLEDGEMENTS

The project could not have been accomplished without the assistance of the lobster fishermen, and in particular Capts. Nick Jenkins of Little Bay Lobster and Dick Allen of the F/V Ocean Pearl. Neil Thompson was invaluable in the implementation of the field studies, Dave Beutel assisted with the gear construction, and Laura Skrobe assisted with reports.

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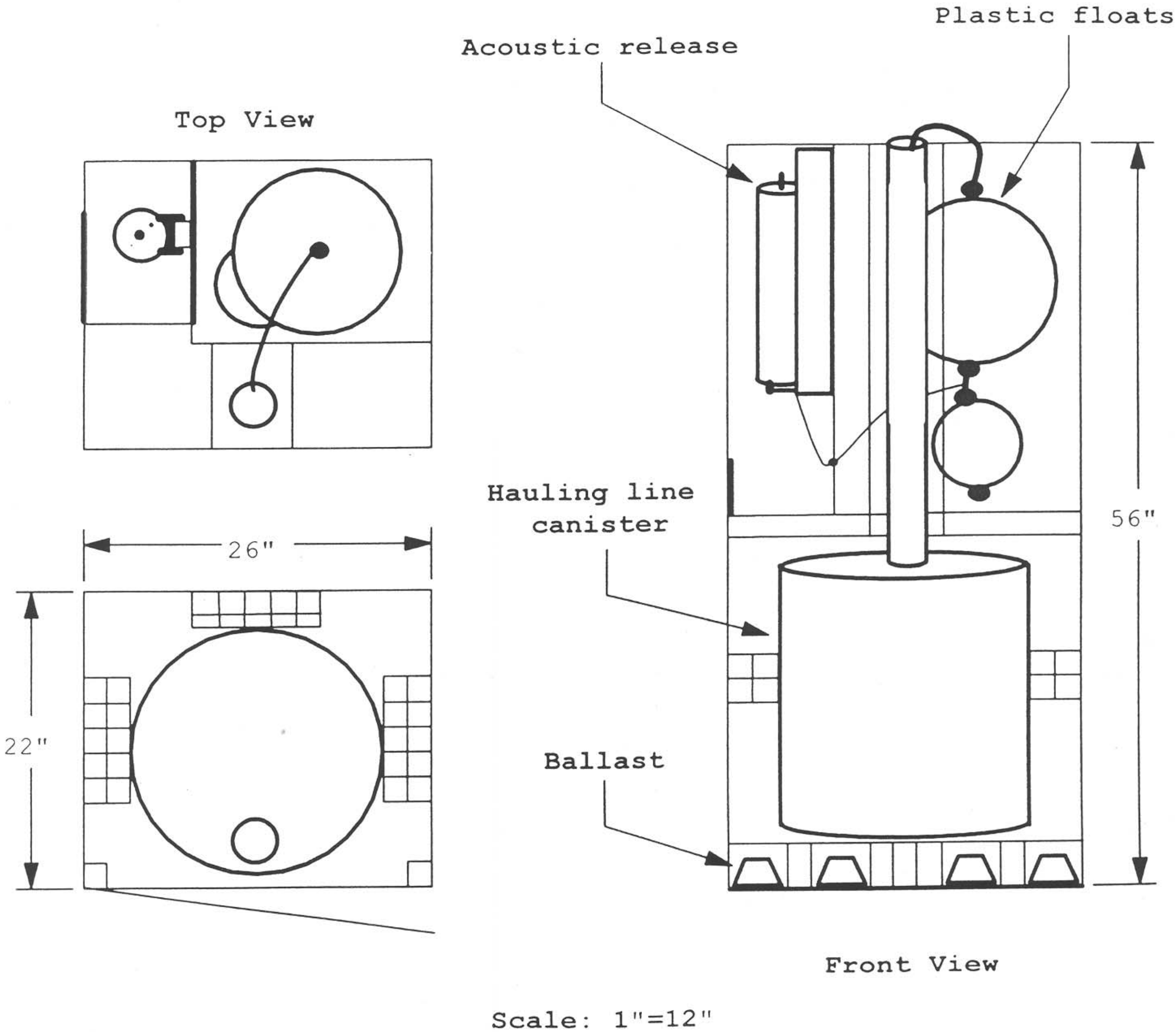


Figure 1. High aspect, initial design, for hydroacoustic release system.

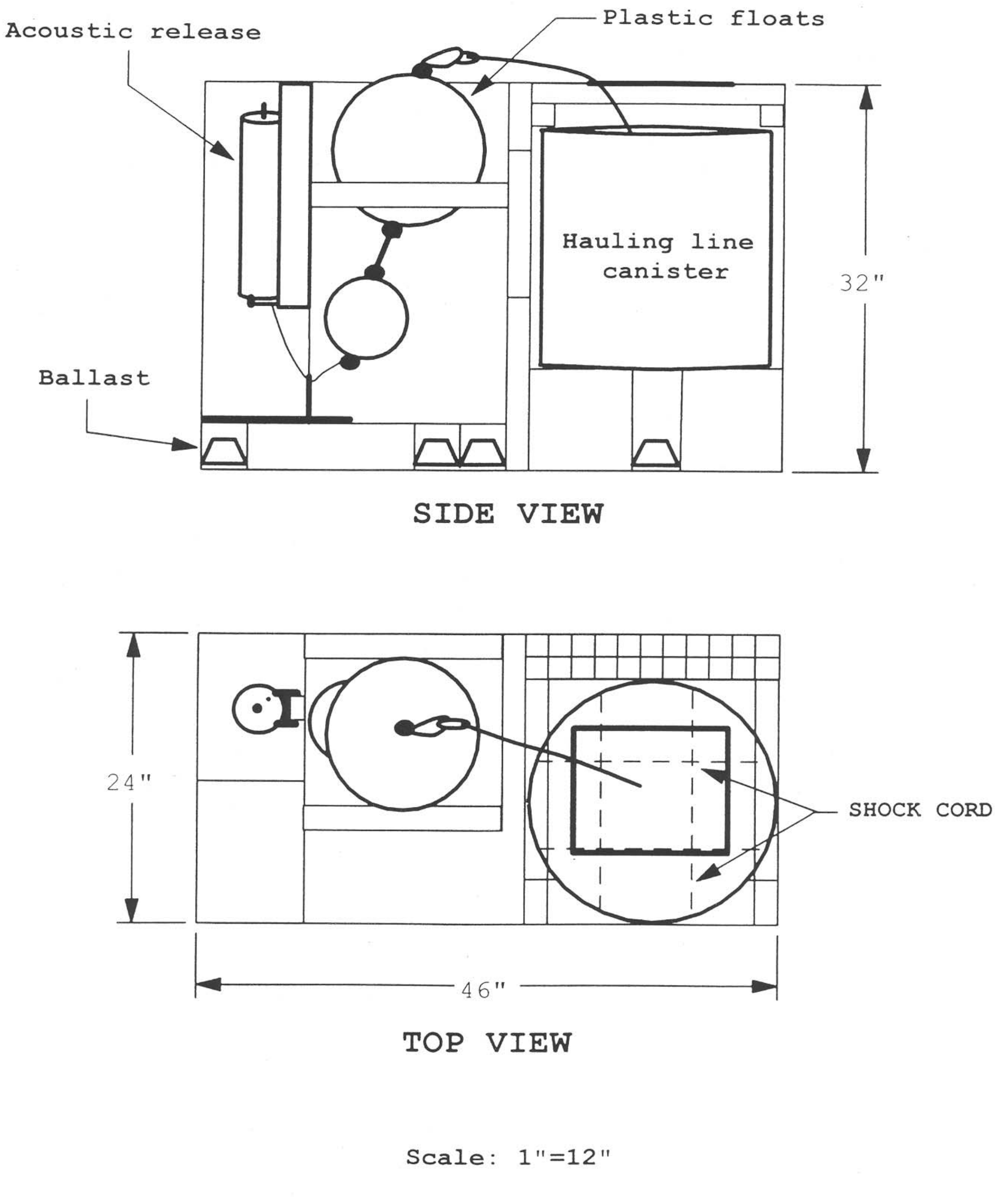


Figure 2. Low aspect, final design, for hydroacoustic release system.