Shallow-Water Messenger-Line Recovery System

Albert J. Williams 3rd and Archie T. Morrison III
Woods Hole Oceanographic Institution
Woods Hole, MA 02543 USA

Abstract - **Shelf and estuarine deployments of bottom mounted instruments generally require complete recovery of the instrument, including anchors. Subsurface instruments may have lift lines for recovery, often on acoustically commanded release of a float. The lift line and float are large for heavy instruments and this creates a flow disturbance that distorts the environment being measured. When redundancy in recovery lines is added, the volume of lines and floats may become unacceptable. Light weight messenger lines with small messenger floats are less flow disturbing and can be added to provide redundancy with less compromise to the measurement.**

A set of four messenger lines with floats was used in the Hudson River in 1995 to recover a massive quadrapod deployed on the bottom for several weeks. The messenger lines, with ample scope, were used to pull, by hand, one end of a short, strong lift line to the surface for recovery of the quadrapod. In this deployment, each messenger line went to an independent lift line, but several messenger lines could be joined to a single lift line. Redundancy is needed for the most vulnerable elements of a system and in shallow water this is the lift line itself. In deeper water, the extra complexity of connecting several messenger lines to a single lift line is offset by the substantial savings in volume by eliminating a redundant lift line. Experience in two recoveries with this recovery system shows that the burnwire used to release the messenger line float works very well but can become fatigued in shipping, line fouling can trap the float in the launch silo, and floats can rise but fail to surface in strong current because Froude drag increases near the surface. We have yet to learn if biofouling and heavy sediment deposition are a problem. The benefit of redundancy has been noted in numerous other experiments where loss occurred when lift lines were cut by propellers, bilge keels, and guard buoys, and when tangles prevented a float from coming all the way to the surface. The benefit of small, low drag messenger lines would have been substantial in deployments in deep, high current regimes where a scope of two to one made the lift line package quite large. Four independent messenger line recovery packages took less space than the single primary lift line system that it replaced.

I. INTRODUCTION

Recovery of bottom tripods in shelf and coastal waters presents a greater problem than recovery of these tripods in the deep sea. Lift lines are impractical at depths greater than several hundred meters but bottom fishing by dragging is not a problem at these depths, so we have jettisoned weighted tripod bases to recover tripods in the deep sea, leaving about 180 kg (400 lb) of iron structure on the bottom. The tripod floats to the surface with 45 kg (100 lb) of net buoyancy produced by glass balls or syntactic foam floats. In about forty tripod deployments at depths from 600 m to 5000 m, only one tripod was lost (acoustic relocation failure after a one year deployment, possibly a corrosion problem). By contrast, lift line recovery of tripods in coastal waters less than 150 m deep has failed 20% of the time. Emergency recovery efforts by divers with side scan sonar, remotely operated vehicles, and manned submersible have ultimately recovered most of these tripods and in thirty deployments lasting from two days to 11 months, only one tripod was irretrievably lost. But seven emergency recoveries were needed: four by divers, one by submarine, and two by grappling. A note about grappling is justified here: it can be attempted with simple equipment but is not very effective for point targets on the bottom like tripods. It only works well for moorings. Our experience is typical of our colleagues' experience in such programs as STRESS (Sediment TRansport Events on the Shelf and Slope), OMP (Ocean Margins Program), and GLOBEC where 20% of shallow water bottom deployments had complicated recoveries requiring ROVs five times, submarines twice, divers twice and grappling once.

II. EXISTING TECHNOLOGY.

A. Shallow Water Recovery Systems

Three recovery means are possible with complete instrument retrieval in shallow water: a surface buoy tethered to a tripod, inflatable buoyancy within the bottom package, and a float released to bring the lift line to the surface. The surface buoy technique is prone to fouling by fishing activity and the wave action on the float is transmitted to the tripod unless it is anchored to an intermediate anchor which in turn is connected to the tripod by a ground line. The simple float tethered to the tripod is adequate for short deployments or deployments where dragger fishing is prohibited. Wave motion is a problem for tripods that measure velocity. Chafe and fatigue failure make the simple float and line not very secure for deployments more than a few days. Williams' own experience has been poor with this system (one irretrievable loss in a 10 day deployment, two close calls in three other five day deployments during CODE, 1981-82). The more complicated arrangement of a float tethered to an anchor with a ground line to the tripod fared as poorly in two such deployments (one tripod recovered in small pieces by divers after a clam dredge crossed the ground line, the

---

This work was supported by the National Science Foundation and by the Office of Naval Research on Grants No. OCE-9415617 and N00014-95-1-0373. This is WHOI Contribution No. 9281.

0-7803-3519-8/96 $5.00 © 1996 IEEE

other recovered intact). We have limited experience with internal buoyancy generated recovery. Although looking good in principle, we were part of the emergency recovery diving team for the only deployment of such a system we have seen. The compressed gas valve had stuck and the plumbing leaked so the system had redundant failure modes.

B. Lift Line Recovery Systems

Since 1989, all but our shortest deployments have used acoustic command released floats to carry to the surface a line strong enough to lift the tripod. Fig. 1 shows a tripod with a float and crate of packed lift line. 1/2" Nystron 2 in 1 Braided Line is generally our choice for this line. Nystron line (Samson Ocean Systems) packs compactly, has some abrasion resistance, and provides a substantial margin of safety for strength. We pack a length of line twice the depth of the water (scope of two) which keeps the float from towing under for current less than one knot. More buoyancy is needed for longer lines and stronger currents[1]. We obtained 45 kg (100 lb) of buoyancy with 10 floats of 19cm diameter with 300 m of line in a 150 m deep deployment. Tidal currents kept this float and line submerged until the velocity dropped below 1.2 knots. In another deployment with half the buoyancy, half the length, and half the depth, the float never surfaced in a 3 knot current. (The lift line was eventually caught by towing a grapnel across the current downstream from the tripod.)

As shown in Fig. 2, the projected area of the lift line (depth x diameter of the line) and the scope determine how much buoyancy is needed to bring the float to the surface in a given current. Drag of the lift line is:

$$\mathit{Drag} = 1/2\,\rho C_D V^2 (\mathit{Depth} * \mathit{Diameter})$$

where ρ = 1027 kg/m^3, C_D = 1.8, V is the current (assumed uniform), and all the drag is assumed to come from the projected area of the line. Lift required to balance the drag (for a neutrally buoyant or short line) comes from trigonometry.

$$\mathit{Lift} = \frac{\mathit{Drag}}{\sqrt{\mathit{Scope}^2 - 1}}$$

So drag of the lift line limits the current at which this system can be used. As the buoyancy is increased, flow obstruction on the tripod by the larger float becomes an issue. Increasing the float size only helps this problem slowly: larger floats have greater drag both due to projected area and due to induced (Froude) drag close to the surface where a wave is produced. This last effect is so great that the float will be towed under until the current is half or less than that permitting the line to be brought close to the surface.

The most common failure of lift line recovery systems, in our experience, is cutting of the line. Typically, the recovery ship approaches the float from downwind. The float is hooked and brought aboard. Then the lift line is hauled by hand to remove the slack near the tripod (fouling of the lift line on instruments or sharp corners on the tripod are potential problems). The float is removed, the lift line is attached to a pre-rigged hauling line, and the lift line is hauled over a block on the A-frame or crane. Frequently the line is discovered to lead under the ship where propeller, rudder, and bilge keels can cut the line. Maneuvering to prevent this is harder than it seems, particularly in the presence of crossing winds and currents, and we have seen lift lines go suddenly slack six times in thirty or so recoveries. Lift lines have also been lost by ships cutting the line before it was hooked (twice in our own experience). Suffice it to say, the most effective remedy to cut lift lines is redundancy. Since 1994, double sets of floats and lift lines have been employed on BASS tripods[2]. In four deployments since then, the second line was needed three times, and in one of these, both lines were cut by a guard buoy mooring chain, requiring submarine recovery.

The second most common failure of the float and lift

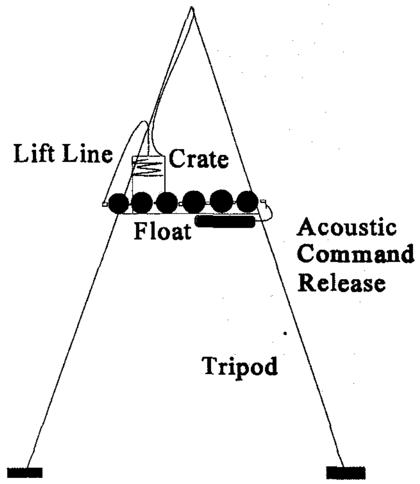

Fig.1. Bottom tripod with acoustic command released float and lift line.

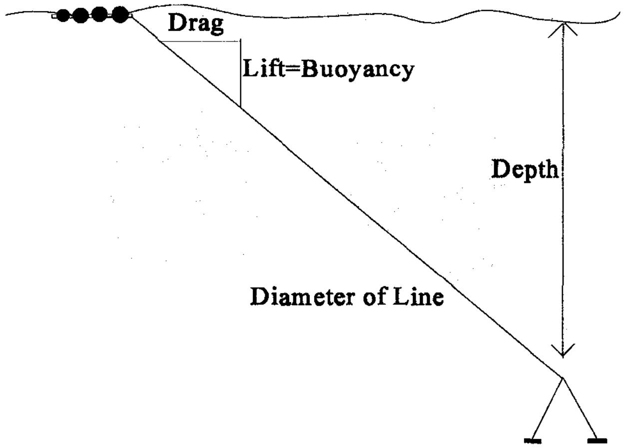

Fig. 2. Projected area of the lift line (Depth x Diameter of Line) and scope determine the buoyancy required to bring the float to the surface in a given current.

line system has been fouled lift lines, either coming out of the crate or with the float or line catching on part of the tripod. Even with great care in packing the crate, a loop of line can feed out before its turn and jam the funnel used as an exit. Strong currents can sweep the float into the upper part of the tripod.

Double lift lines are good, but quadruple lift lines might be better if they could be implemented without excess volume and cost.

III. MESSENGER LINE SYSTEM

The largest part of a float-lift line system is the float. 20 kg to 60 kg of lift (required to balance the drag of the lift line) displaces at least 20 liters to 60 liters. A light line could be buoyed with a smaller float and reduce this volume. Thus, the messenger line system was born. Redundancy of messenger lines, because they are thin and therefore have low drag, is possible without severe penalty in volume or cost.

A. Messenger Line and Float

A messenger line must be strong enough to pull the lift line to the surface. 100 kg (220 lb) is sufficient force to pull the lift line from its packing crate and is available in 1/8" nylon parachute cord. While this line does not have much chafe resistance, it will not have much tension in use so its susceptibility to breaking while rubbing on ship parts is no worse than that of the lift line. It is as vulnerable to being run over before being picked up as is the previous lift line system. However, it is possible to put more messenger lines on a tripod than lift lines with floats capable of bringing them to the surface.

Sure deployment of the messenger line is a high priority in its design. Lift lines are carefully packed in crates so they deploy without tangling. Messenger lines, being finer, can be wound on a bobbin which is in fact the axle of a dumbbell shaped float as in Fig. 3. We tested floats composed of a pair of 19 cm (7.5") diameter epoxy floatation spheres on a 2.5 cm (1") aluminum tubular shaft. The floats, designed for deeply deployed fishing gear, had a hole through the center. The shaft was pressed through this hole. 30 m of parachute cord was wound on the shaft. We watched the dynamics of this float as it rose with its tethered line from 20 meters depth with various initial orientations of the float. When the float was released with the shaft horizontal, the shaft remained horizontal and the float spun about this axis as it rose, paying out line until it reached the surface of the water. Then the float slowly drifted with the wind and current, continuing to pay out line until the bitter end was reached. The float remained stable with the shaft axis perpendicular to the current.

When we held the float with its axis vertical before release, the initial motion was a rotation about the horizontal axis to bring the shaft into the horizontal plane, after which the float spun about the axis of the shaft as it rose and paid out line. These tests were repeated and the float was given an initial angular velocity about an axis perpendicular to the shaft with the same result in every case: re-orientation to place the shaft in the horizontal plane, spin about the shaft axis to pay out line as the float rose. No oscillation of the spin axis was observed nor did the float wobble as it rose. We conclude that the messenger line float is quite stable and therefore relatively immune to fouling.

B. Messenger Line Deployments

We deployed four messenger line floats from a bottom mounted instrument (quadrapod) in the Hudson River twice in 1995. The dumbbell shaped floats were mounted in aluminum silos, cylindrical tubes 20 cm in diameter and 51 cm tall as shown in Fig. 4. Each messenger line was tied to its own 50 m lift line. An electrolytic (burnwire) release held each float in its silo. All four burnwires were activated in the first recovery, at 20 minute intervals, before a float was seen at the surface. The float was picked up, the parachute cord was hauled in by hand, the lift line was pulled from its crate on the instrument, and the quadrapod was winched to the surface. As it reached the

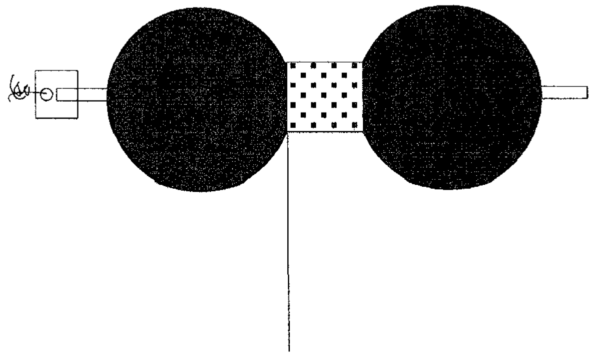

Fig. 3. Messenger float with 1/8" parachute cord. The left end of the axle shows a fiberglass block to which the parted burnwire is attached.

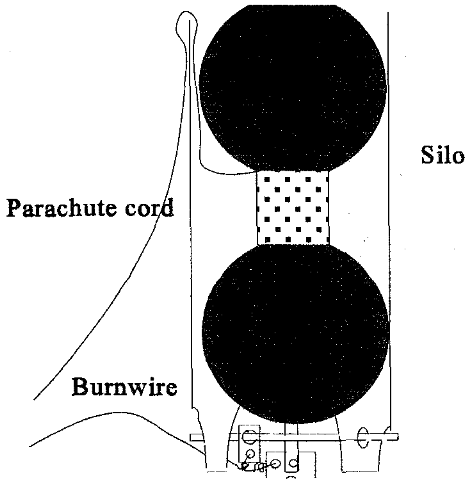

Fig. 4. Silo for messenger float with burnwire release.

surface, a second float drifted out of its silo. Its burnwire was slower to part than had been expected. A third float was part way out of its silo, the burnwire having parted, but a loop of messenger line had come adrift and, crossing the upper float, had prevented the float from rising. The fourth float had been tied in place with marlin when it left the silo on launch, having fatigued its burnwire on the truck trip from Massachusetts to New Jersey. This float was not expected to release and it did not. The burnwire had been activated however and had plated away.

Two of the messenger floats were rigged with rubber bands holding excess messenger line in place when the quadrapod was redeployed so that loops would not get free and cross the upper float. The other two were packed as previously. Only one burnwire was activated for recovery, one with a rubber band holding the messenger line excess. Nothing showed on the surface of the ebbing Hudson River until the current dropped below 2 knots. Then a standing wave appeared. At 1.5 knots, the float could be seen beneath the surface and at 1.0 knots, it had surfaced and was recovered. No tangles or defects that might affect the release capability could be seen.

The Hudson River carried a heavy load of silt and we feared the silos might fill with sediment so fast that the float could become buried. We also feared that a mussel or barnacle might grow in the annular space between the float and the silo and jam it. Another concern was that wave action and flutter from the strong tidal current would fatigue the burnwire holding the float in the silo which would break causing a premature release. Finally, we had reservations about corrosion of the aluminum silo on the stainless steel quadrapod.

Although our fears were not shown to be valid, future deployments will use a horizontal cradle of 19 cm PVC pipe, split in half. One end of the shaft through the float will be tucked under a bar and the other end will be held down by the burnwire as in Fig. 5. This geometry lowers the profile and resists fouling by marine organisms and sediment. PVC will not corrode or influence the burnwire corrosion current at release time.

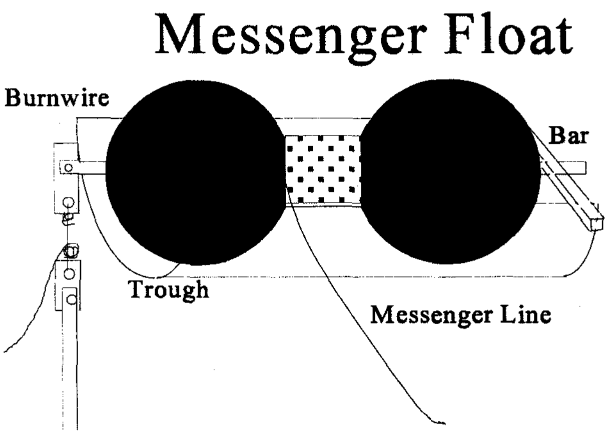

Fig. 5. Trough for messenger float with burnwire release.

C. Multiple Messenger Lines to a Single Lift Line

When the water depth is great and the lift line has a lot of volume, it is worth considering a scheme in which many messenger lines are tethered to a single long lift line. The redundancy this provides is not security against cutting a line while under load on the bottom of the ship. But is does provide security against a float being run over before being picked up. This can include premature release of a float when the recovery vessel is not there. (This is a bad thing with a single lift line on large float because the life expectancy of such a float in coastal waters is days to weeks, not months.) There will still be other floats to deploy when the ship arrives. Two ways to implement this system can be imagined: all messenger floats can be mounted on a platform attached to the lift line or a mechanism can be built that attaches the lift line to the first messenger line to apply tension and leaves the other messenger lines behind. The practical significance of this distinction is that a set of two or three messenger lines integral with the acoustic command release could be part of the platform that is raised along with the lift line and obviate the necessity of disconnects for the unused lift lines. It is simple but somewhat heavy and cumbersome. This is to be balanced against the complexity of a latch mechanism that is a mechanical equivalent to an OR gate in digital electronics.

IV. CONCLUSION

Redundancy in recovery lift lines is necessary in coastal experiments to minimize instrument loss. To reduce bulk and flow distorting drag, multiple messenger lift lines can be added in place of a float of larger size to bring a lift line to the surface. Placing the messenger floats in a horizontal cradle minimizes exposure to fouling.

ACKNOWLEDGMENT

We thank Charles J. Peters, Jr. of Woods Hole Oceanographic Institution for a stimulating discussion about an emergency recovery system in which a messenger line from an object would guide a lowered cable to hook and raise the target.

REFERENCES

[1] H.O. Berteaux, *Coastal and Oceanic Buoy Engineering*, Woods Hole, MA: Berteaux, 1991, pp. 48-57.

[2] A.J. Williams,3rd, J.S. Tochko, R.L. Koehler, W.D. Grant, T.F. Gross, and C.V.R. Dunn, "Measurement of turbulence in the oceanic bottom boundary layer with an acoustic current meter array," *J. Atmos. and Oceanic Tech.*, 4, pp. 312-327, 1987.