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Deploying and Recovering Marine Instruments With a Helicopter

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PURPOSE: This Coastal Engineering Technical Note (CETN) describes the method and hardware for deploying and recovering instruments in coastal waters by means of a Chinook helicopter (CH-47).

BACKGROUND: To fulfill its mission of designing, building, and maintaining coastal projects, the U.S. Army Corps of Engineers (USACE) relies on accurate data on the dynamic ocean. Measurements of waves, currents, and other parameters enter the decision process and lead to more effective designs. Sophisticated sensors may be lowered into the water for one minute or left in place for years, and deployment techniques must be adapted to a variety of environments. The traditional platform for this work is a boat or barge, an approach that is appropriate if sea conditions are relatively mild. However, there are times and places where conditions can render this form of deployment unsafe, logistically difficult, or economically unfeasible. Installation of instruments in the surf zone and in large inlets is particularly challenging, even under calmer wave conditions. Amphibious vessels have proven useful in many situations, but for some locations, such as the Northern Pacific coast of the United States, dangerously energetic surf is normal. It is in these situations that the Corps and others have accessed the capabilities of helicopters to accomplish the data-collection mission.

Previous uses of helicopters for ocean measurements include surveying (Graig and Team 1985), deploying permanent floating and bottom-mounted gauges, laying cables through the surf zone (McGehee and Welp 1994), and taking spot measurements of the current (Pollock 1995). In each case, the over-water hover time was relatively short, on the order of a few minutes. Although many measurements can be obtained with a short-duration insertion, a wave measurement requires a sample length of about 20 to 40 minutes during which the instrument must remain stationary on the sea floor. The two options for deployments by helicopter are either to (a) remain attached to the instrument in a prolonged, near-stationary hover, or (b) drop and recapture the instrument after the measurement period. A manually controlled, 20-min hover is severely taxing on the pilot, even over land where there are visual references to the helicopter's position. It is nearly impossible offshore, where visual references are limited or distant.

A new procedure was developed under the Monitoring of Completed Navigation Projects (MCNP) Program for the Mouth of the Columbia River (MCR). The procedure permitted repeated release and recovery of the instrument package. The CH-47 was selected for this mission because of its dual, releasable cargo hooks, lift capability, multihour flight duration, and high maneuverability. General lessons learned can be applied to other helicopter platforms.

This CETN describes how to equip and operate a helicopter to deploy an instrument frame through the water column to the sea floor in shallow water. Depending on the length of the desired measurement, the frame can be immediately withdrawn and repositioned, or released and subsequently recovered with the helicopter. The advantages of the technique relative to traditional sampling from a vessel are significantly higher operational thresholds for waves and currents and much shorter transit times between stations.

The technique was demonstrated during two trials conducted in the summer of 1996 and the winter of 1997, offshore of the MCR. Confluence of the largest river entrance on the western side of North and South America, a large semidiurnal tidal range, and an unrestricted fetch across the north Pacific makes the MCR one of the roughest coastal regions in the world. Breaking waves occur at the study site under even moderate wave conditions. Dependable occurrence of breakers in the inlet prompted the U.S. Coast Guard to locate its school for motor lifeboat operators here. The winter trial successfully collected data from 10 sites, in water depths ranging from 10 to 50 m, when surface currents exceeded 6 knots and breaking waves exceeded 6 m in height. Safe navigation of a vessel and over-side operations such as deploying instruments would not have been possible under these conditions.

OVERVIEW: Figure 1 illustrates the instrument package in flight, suspended from the helicopter. The principal components of the system are: the instrument frame; a mooring line; a surface buoy; a buoyant recovery line; a stopper buoy; a triple-hook grapnel; and a lift line. To deploy the instruments, the assembly is lowered until the surface buoy is floating and the recovery line is slack. For a short (on the order of minutes) measurement, the pilot maintains a hover, without tensioning the recovery line. For a longer measurement, the frame is released by continuing downward until the stopper buoy is floating and the grappling hook disengages. Recovery is accomplished by approaching the streaming recovery line perpendicularly, with the grappling hook just below the surface (Figure 2). Continuing forward and upward slides the recovery line through the hook until the stopper ball is reached. At that point the recovery line is secure, and the load can be picked up for repositioning or return to shore.

COMPONENTS: *Instrument Frame.* The instrument frame has a 1.5-m square base, constructed of 7.5-cm (3-in.) aluminum H-beam and bolted connections. A 0.6-m-high roll cage is made from 5-cm (2-in.) square aluminum tubing to protect the instruments. The frame is also the anchor for the surface buoy, so it must be sufficiently heavy to maintain position under the expected conditions. To hold the surface buoy in high-current, surf-zone regimes, eight trapezoidal sections of 2.5-cm- (1-in.-) thick lead plates are bolted to the frame, bringing its total weight to about 1,350 kg (3,000 lb). Brackets for individual instruments are bolted to the base of the frame. Typically, several instruments (for example, wave gauge and current meter) may comprise one package, and their combined weight can exceed 100 kg (220 lb). In addition, a transponding acoustic beacon is usually included to provide a means of locating the frame in the event it becomes separated from the surface float.

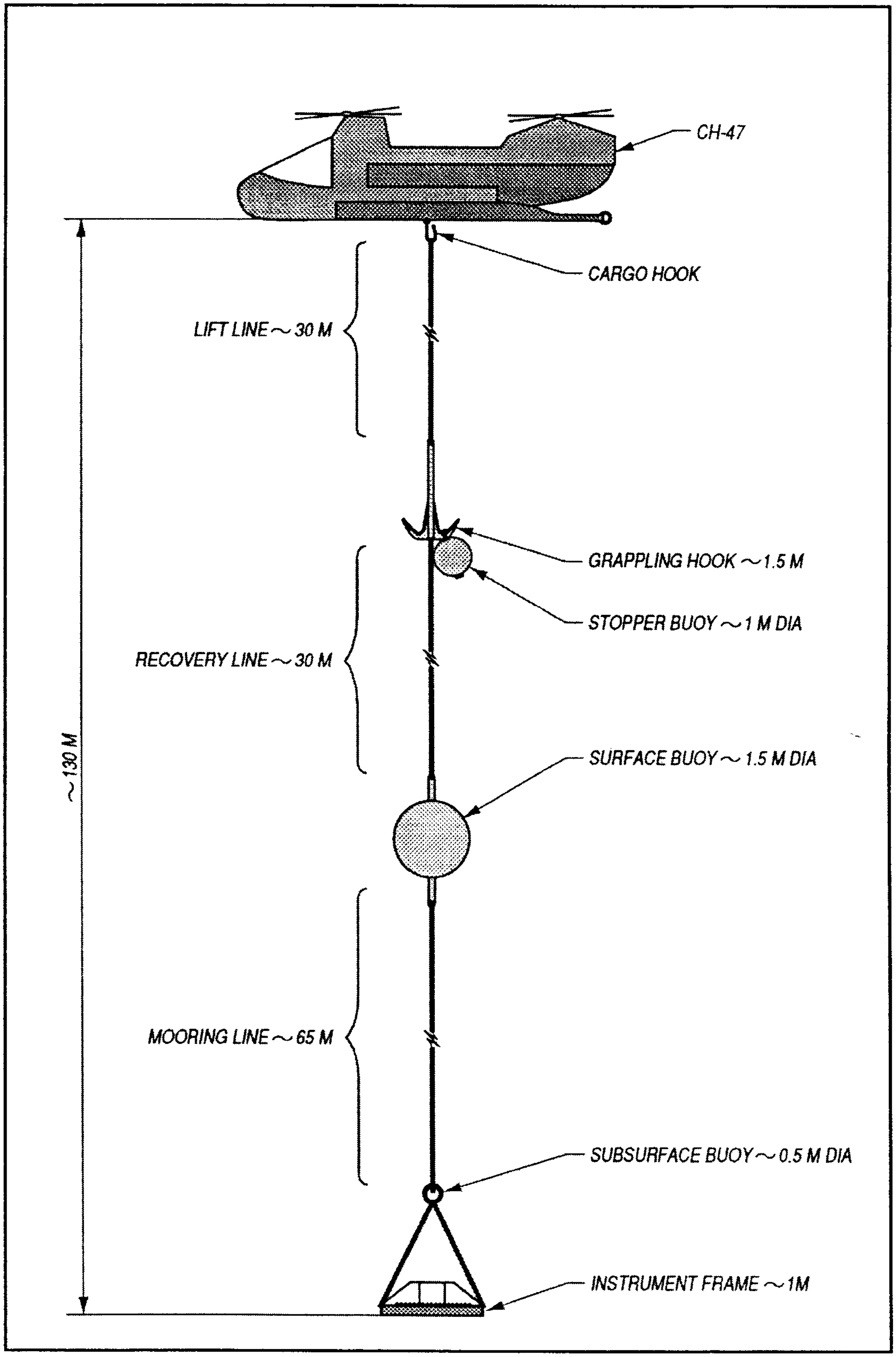

Figure 1. System suspended while in flight

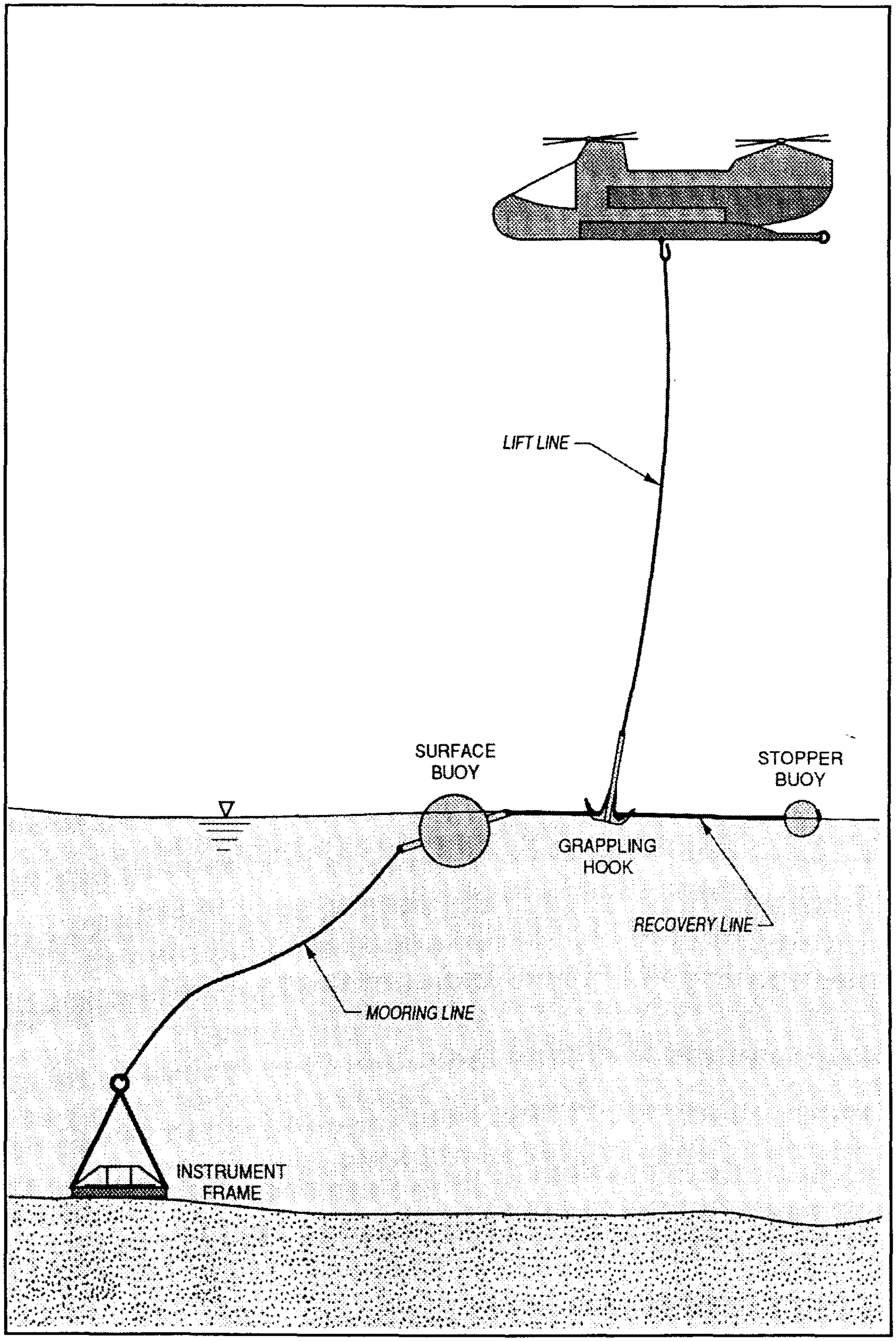

Figure 2. System recovery

A four-part lift bridle, made from 2.5-cm- (1-in.-) diam double-braided Dacron line is secured at each corner with 5-cm (2-in.) shackles. The four lift lines converge to a 2.5-cm (1-in.) section steel D-ring, approximately 1 m above the base of the frame. A float secured to the D-ring prevents the slack bridle from becoming entangled in the frame or instruments during a measurement. The float should have about 15-kg (40-lb) positive buoyancy and be rigid, so that it will maintain buoyancy at depth.

Mooring Line. The mooring line is a 2.5-cm- (1-in.-) diam synthetic line with an aramid braided core and a double braided polyester jacket for abrasion protection. This is a torque-balanced construction that combines high strength (25,900 kg or 6,000 lb breaking) with extremely low stretch (less than 1 percent at 30 percent of rated strength). The length is adjusted to be about twice the maximum water depth expected - about 65 m for the MCR experiment. Soft eyes (i.e., without thimbles) are backspliced in each end for connecting to 5-cm (2-in.) shackles.

Surface Buoy. The surface buoy is a 1.2-m- (4-ft-) diam spherical buoy made from rolled 6-mm- (¼-in.-) steel plate (Figure 3). A 1.8-m-long, 10-cm- (4-in.-) diam schedule 80 steel pipe forms a strain member through the central, vertical axis. An internal pad eye on the bottom of the pipe accepts a 5-cm (2-in.) shackle. The weight of the buoy is about 275 kg. To improve pitch/roll stability of the buoy, an additional 360 kg (880 lb) of 5-cm (2-in.) anchor chain was attached to the bottom of the pipe as external ballast, providing a metacentric height of approximately 15 cm. The attachment point for the recovery line is a welded bail of 2.5-cm- (1-in.-) steel bar at the top of the central pipe. A battery-powered light can be placed under the bail if the system is to be left at sea overnight.

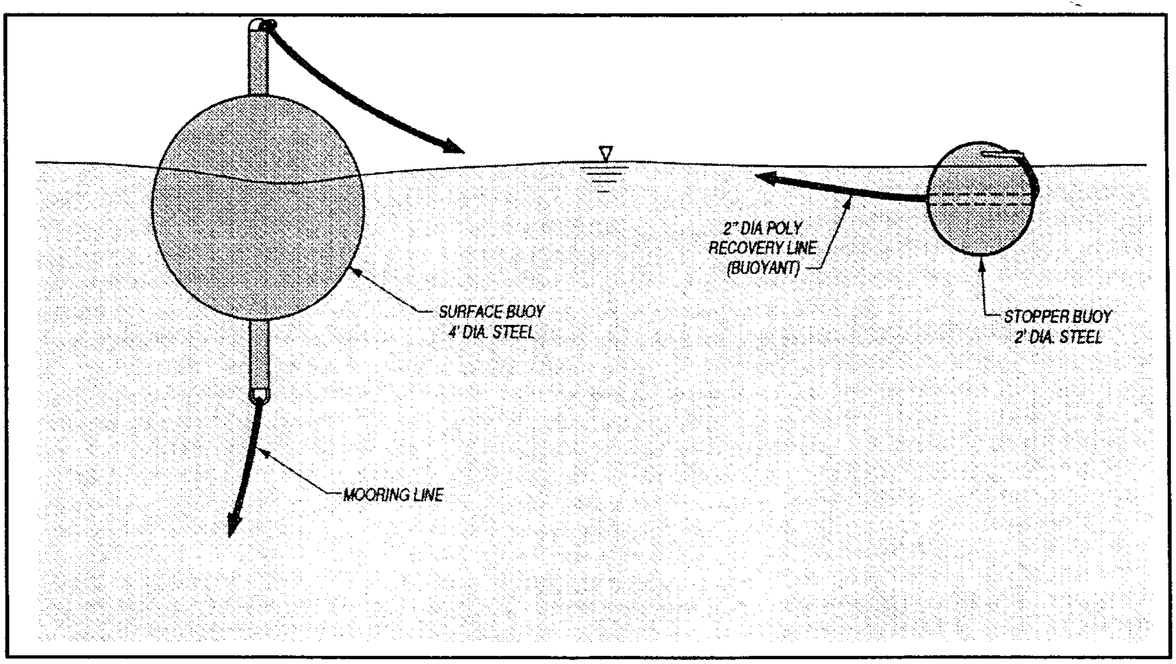

Figure 3. Surface buoy and stopper buoy (To convert inches to centimeters, multiply by 2.54)

Recovery Line. The buoyant recovery line is a 30-m length of 5-cm- (2-in.-) diam, three-strand, braided polypropylene line. The line is attached to the bail on the surface buoy with a 5-cm (2-in.) shackle and a 45,000-kg (50-ton) rated crane swivel.

Stopper Buoy. A 61-cm- (2-ft-) diam spherical buoy of 6-mm (¼-in.) steel serves as the stopper to capture the grappling hook as it slides down the recovery line (Figure 3). A 7.5-cm (3-in.) schedule 40 steel pipe is welded flush through the center, as a guide for the recovery line, and as compressive reinforcement for the impact loads from the grappling hook. At the opposite side, a 2.5-cm (1-in.) round steel bar is bent into a V-shape and welded to the buoy. The bitter end of the recovery line is pushed through the guide pipe, and a soft eye was backspliced around the V-shaped bar. This arrangement ensures the stopper buoy cannot disengage or slide freely down the recovery line. Because chafing of the line against the guide pipe is a concern, the exit hole is carefully radiused and smoothed, and the line wrapped with tape at that point.

Grappling hook. The shaft of the hook is a 1.5-m-long, 8.9-cm (3 2-in.), double-X steel pipe (Figure 4). Three hooks are cut from 1.9-cm (¾-in.) steel plate and welded to the shaft. Sections of 2.5-cm (1-in.) pipe are slotted to fit over the inside surface of the hooks as fairlead, to prevent abrasion of the recovery line. A 6-cm-diam hole in the upper end accepts the 5-cm (2-in.) shackle; next is another 45,000-kg- (50-ton-) rated crane swivel, to prevent torque transferring up the lift line to the cargo hook.

Lift Line. The lift line is a 30-m length of the same Spectra line used for the mooring line with soft eyes. At the upper end, a special hi-tensile steel shackle, a piece of standard hardware for the CH-47, makes the connection to the helicopter's cargo hook.

DISCUSSION: Several points should be considered in planning this type of operation. The ability to measure coastal waves and currents in situ at multiple sites, under extreme wave and current conditions, has been demonstrated at the MCR. However, weather restrictions prevent this from being an all-weather option. Deployment by helicopter is a VFR (visual flight rules) operation; a ceiling of at least 500 m is required. Although it can fly in strong winds, the CH-47 cannot start its engines in winds exceeding 30 knots. If the winds exceed 60 knots, the aircraft cannot remain outdoors, but must be secured in a hanger. With practice, each wave measurement should take 30 to 45 min. If a landing area is available in the vicinity, four to five sites per fueling are possible. Refueling takes about as long as one wave measurement. The process is logistically challenging. Functioning aircraft and instrumentation have to coincide with personnel schedules and operational flying conditions for a successful day of measurements. Adequate time must be allowed for crew training and aircraft maintenance on top of the expected field delays. A full week should be allowed for most data collection experiments. The expertise of the air crew is central to the success of the mission. Refinements in the hardware and procedures can reduce the reliance on crew skill, but precise hovering and positioning over rough water will always exercise piloting skills. More so than most field operations, advanced planning and design of every component are essential for success. Every nut and bolt must be examined in light of its marine, aeronautical, safety, and measurement function.

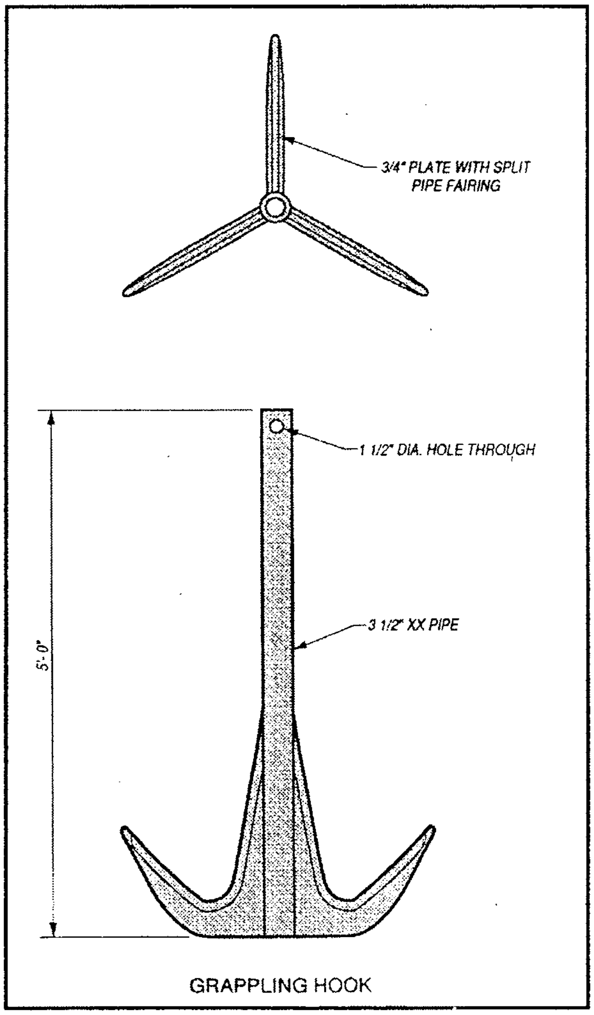

Figure 4. Grappling hook (To convert inches to centimeters, multiply by 2.54)

SUMMARY: This CETN describes a technique for deploying and recovering an instrumented frame through the water column - to the sea floor, if desired - in shallow waters with a CH-47 Chinook helicopter. Depending on the length of the desired measurement, the frame can be immediately withdrawn and repositioned or released and subsequently recovered. The advantages of the technique relative to traditional measurements from a vessel are significantly higher operational thresholds for waves and currents and much shorter transit times between stations.

ADDITIONAL INFORMATION: Questions about this CETN can be addressed to Ms. Cheryl Pollock at Cheryl.E.Pollock@usace.army.mil or to Mr. Timothy L. Welp at Timothy.L.Welp@usace.army.mil This CETN was prepared by Mr. David D. McGehee, formerly of the U.S. Army Engineer Research and Development Center and now at Emerald Ocean Engineering (http://www.emeraldoe.corn/).

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REFERENCES

Graig, R. and Team, W. (1985). "Surf zone and nearshore surveying with helicopter and a total station." *Proceedings U.S. Army Corps of Engineers Survey Conference.* U.S. Army Engineer Research and Development Center, Vicksburg, MS.

McGehee, D. D., and Welp, T. L. (1994). "Helicopter deployment of oceanographic instruments." Video file # 94039, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Pollock, C. E. (1995). "Effectiveness of spur jetties at Siuslaw River, Oregon; Report 2: localized current patterns by spur jetties; airborne current measurement system and prototype/physical model correlation." Technical Report CERC-95-14, U.S. Army Engineer Research and Development Center, Vicksburg, MS.