TECHNIQUES FOR NEARSHORE OCEANOGRAPHIC INSTRUMENT INSTALLATIONS

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A number of tools and techniques used in the installation of oceanographic instrumentation in the nearshore zone are presented. The diver is central in all of these techniques. In water less than 100 feet deep (which is the primary depth range associated with the author's work) the diver has proven to be effective. The use of diver-deployed wave gage mounts, subsurface tide gages mounted on galvanized pipe, pressure sensor arrays, relocation and search techniques, as well as a look at future deployment hardware and techniques are discussed. Tripods that can be assembled on the bottom have been used in high surge areas for four years with good results. Pipes used to hold various instruments are routinely installed in sediments by fluidization. Relocation and search techniques using precision navigation equipment are increasingly used to relocate sites that are inappropriate to be marked by surface expression and to find lost instruments.

INTRODUCTION

The use of underwater tools and techniques date back, at least, to the time of Alexander The Great, when in 332 BC Alexander had himself lowered into the sea to observe marine life. If one considers people trying to do simple tasks such as recovering items dropped into the water and harvesting sponges and other life from the sea, the use of underwater tools and techniques extend beyond recorded history. More recently man has found many reasons to use an assortment of tools and techniques to accomplish work in the underwater environment.

The author's underwater work experience started in 1972 at the Scripps Institution of Oceanography in Jimmy Stewart's diving class. Jimmy's class showed the beginning diver how to use simple tools and techniques to accomplish tasks underwater. The author has applied these and other techniques to accomplish various tasks necessary for installing and maintaining underwater instrumentation.

Tools and procedures that the author has used and is using in oceanographic research will be discussed (Table 1 and 2). Table 1 includes some tools not discussed here to simply add information to the table while keeping the paper length to a minimum. If there is an interest in some undiscussed item, please contact the author. The importance of using the right tool or technique will be stressed. Available funds, portability, ruggedness, expected life, appropriate approach (there are many ways to accomplish all tasks), ease of implementation, personal preference of the user, work environment, ramifications if tools are lost, likelihood of tools being lost, skill of people using the tools, and importance of task are some factors to be considered in selecting the proper tool or technique. Only those techniques and tools that are relevant to the installation of oceanographic instrumentation will be discussed. The intent is to document installation techniques and hardware with an

emphasis on choosing the tool or technique in such a way as to optimize the use of available resources.

Tool	Description	Date used
Battery Box	Oil filled box for use in shallow water	1973 - 1980
Spar Scraper	Scraper to clean Tilting Spar Buoy	~ 1975
Mechanical Joint	Hard shell seal around an electrical cable spice	1978 - 1980
Cable hand winch	Hand winch to allow divers to spool cable onto a reel and to count turns of reel	1977
Diver operated pipe puller	Device used to pry mounting pipe out of sand	~ 1979
Diver adjustable probe clamp	A device to hold steady a sensor after the divers have adjusted its orientation	1983
Shallow water marker buoy	A lighted buoy that can be deployed from small boats	1985
Electrical winch	An over-the-side winch for a 17' Boston Whaler	~ 1975 - 1980
Diver held water pump	An internally powered diver held pump	1978
Current sensor orienting device	A compass and bubble level mounted on an aluminum arm	~ 1975 - 1989
"Spider Tripod"	A stable instrument mounting tripod that can be deployed from a small boat and assembled on the bottom by divers	1983 - 1989
"LDV platform"	A mounting platform for the Laser Doppler Velocimeter to allow vertical and horizontal rotational adjustment	1987 - 1989
Surface drifters	A drifter having low wind drag and high visibility for photographing from a model airplane (Hess and Aubrey 1985).	

Table 1. Some Underwater Instrument Support Tools

SPIDER TRIPOD

In 1983 a mounting platform was needed for a Sea Data model 635-9 wave gauge to be used in the Canadian Coastal Sediment Study (Aubrey and Spencer, 1984). The tripod had to be launched from a small boat so we designed it to be modular. With tripod components made of readily available galvanized pipe, not only could the tripod be assembled underwater by divers but damaged parts could be easily replaced. The experiment site could present high wave energy so it was important to have a tripod with low drag and low center of gravity (Fig. 1). The total cost in 1989 U.S. dollars is approximately $1500 which includes all labor and materials (with 530 pounds of lead for the 4 weights). The tripod has since been used for the mounting of various instrumentation thus providing a general use platform. Long service life (we are still using the tripod that

was built in 1983), portability, and the ability to deploy from a small boat are the primary advantages of this design. The tripod is rugged, it is portable in that it can be installed from a small boat (it was installed from a 16 foot inflatable boat in Canada), and it meets the low cost criteria of the project.

Technique	Description	Date used
Fluidization	Insertion of galvanized steel pipe into sediment for bottom-mounted instrumentation	1973-1989
Circular search	A search pattern used to locate instruments near an installation site	1972-1989
Laser positioning	The use of a laser surveyor's total station to document the location of an instrument	1988-1989
Microwave positioning	The use of micro-wavelength distance measuring equipment to establish an instrument position	1980-1989
Automated positioning	The use of an integrated navigation and data acquisition system to position instrumentation	1988-1989

Table 2. Instrumentation Techniques

BATTERY BOX

An example of low cost, portable, and rugged design is given by a waterproof battery box. The box (made of polyvinylchloride) was designed and fabricated in 1973 to protect power supply batteries of a tilting spar shelf and shore station (Lowe *et al.*, 1972). Figure 2 shows the concept view. It is recommended that the box be used in depths less than 100 feet and that an electrically insulating oil (transformer oil manufactured by Shell oil company) be used to insure that the box is adequately pressure compensated. This box was used from 1973 to 1980 with excellent results.

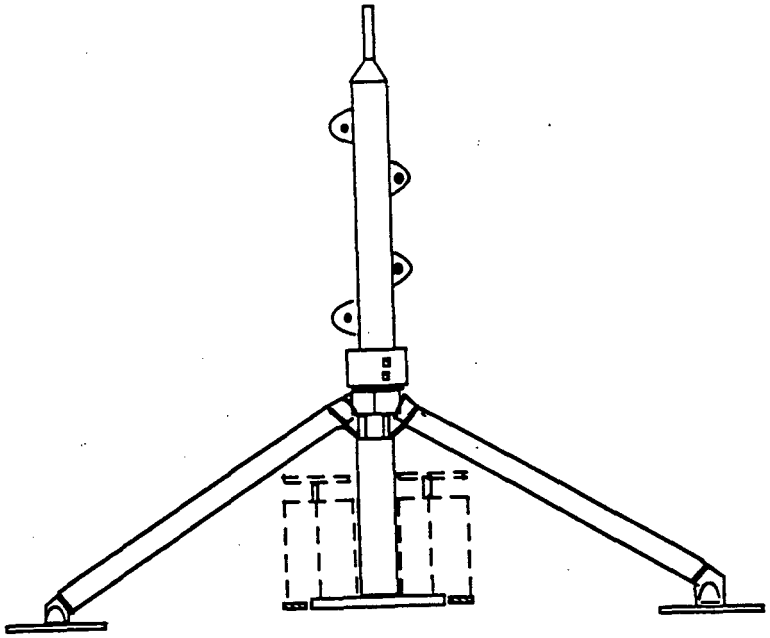
The box can be fabricated with commercially available components using common tools. Each battery box is light weight thus making it portable and easily installed from a small boat by two divers. The design is rugged in that it withstands banging around which sometimes happens during use.

HAND-POWERED CABLE SPOOLER

A diver-held, hand-powered cable spooler was designed and fabricated in 1977 as a component of a prototype diver-held beach profiler (Fig. 3). The purpose of the spooler was to allow the diver to control the retrieval of a profiling pressure sensor. The divers would swim the profiler to the beach where the pressure sensor was left. The connecting cable was played out as the divers swam the profiler back offshore. Once offshore the divers would reel the pressure sensor in. An internally powered and internally recording system located inside the axis of the profiler would record spool rotations and pressure, yielding a record of estimated distance offshore versus depth. This instrument was not rugged in that the electronics were fragile. The spooler itself was rugged and portable

allowing the diver the freedom to swim with it held in one arm. The instrument was fabricated with parts and supplies owned by the laboratory so the costs were low. If all components were bought new today a 1989 dollar estimate would be near $1000 in parts and 2 months development time for the first unit.

Figure 1. Spider tripod



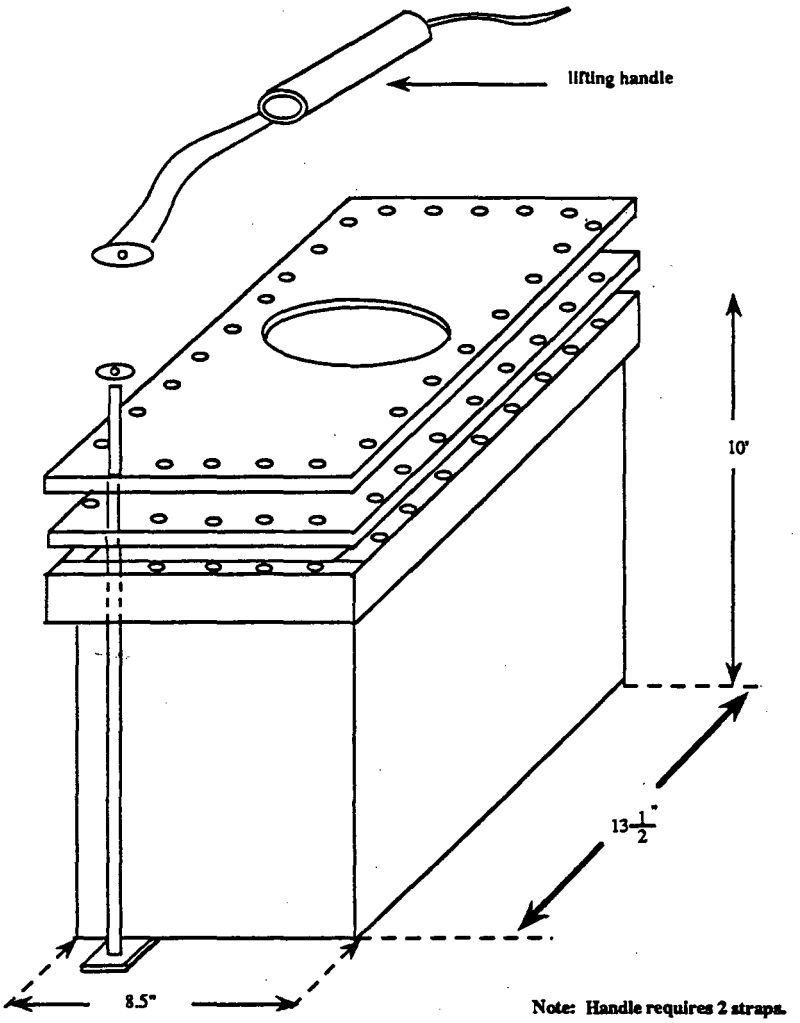
MECHANICAL JOINT

A mechanical joint (Spencer and Aubrey, 1981) was designed and fabricated by the author in 1980 to seal the electrical splice between a neoprene-jacketed pigtail connector and a polyethylene-insulated cable (Fig. 4). The joint was used with success in the field. When the joint was removed from the water a short shelf life was noticed. This poor shelf life was thought to be the result of the deformation of the sealing parts during storage. A simple spring washer to compensate for the deformation of the sealing washer is suggested as a solution to the short shelf life problem. This design can be rugged and low cost depending on the materials used. It is portable in that it can be installed in the field and is small in size.

DIVER-OPERATED PIPE PULLER

The use of galvanized steel pipe to bottom mount instrumentation created a need for retrieval (pull the pipe out of the sand). Once a pipe was installed to a depth of 6-10 feet into the sediment it became hard for the divers to pull out. A simple lever arm having a pipe holding jaw was designed in 1979 to accomplish this pull. As seen in Figure 5, the jaw and attached foot make it easy for divers to position the puller. Although this puller is a one-piece unit thereby having a distinct advantage, a simple pry bar and a flat plate have been used to accomplish pulls underwater by tying the pry bar to the pipe and lifting (lifting up is much easier for divers to accomplish than pushing down) on one end of the pry bar. The puller also comes in handy when a number of pipes have to be pulled in one dive. The puller is rugged, portable, and low cost.

Figure 2. Battery box for underwater power source



CURRENT SENSOR ORIENTING DEVICE

In 1975 there was a need for divers to adjust the orientation of an electro-magnetic current sensor. Bob Lowe, Paul Cunningham, and the author decided that the low cost portable orienting device in Figure 6 was suitable for the task and environment . The compass is held 18 inches from the mounting device to reduce errors induced by residual magnetic fields of the mounting hardware. The compass indicates the magnetic heading of one axis of the current sensor. A bubble level is used to insure that the sensor mounting hardware is adjusted to hold the sensor vertical. The orienting device has been used extensively by the author since 1975; it is portable, rugged, and low cost.

Figure 3. Diver-held hand cable winch

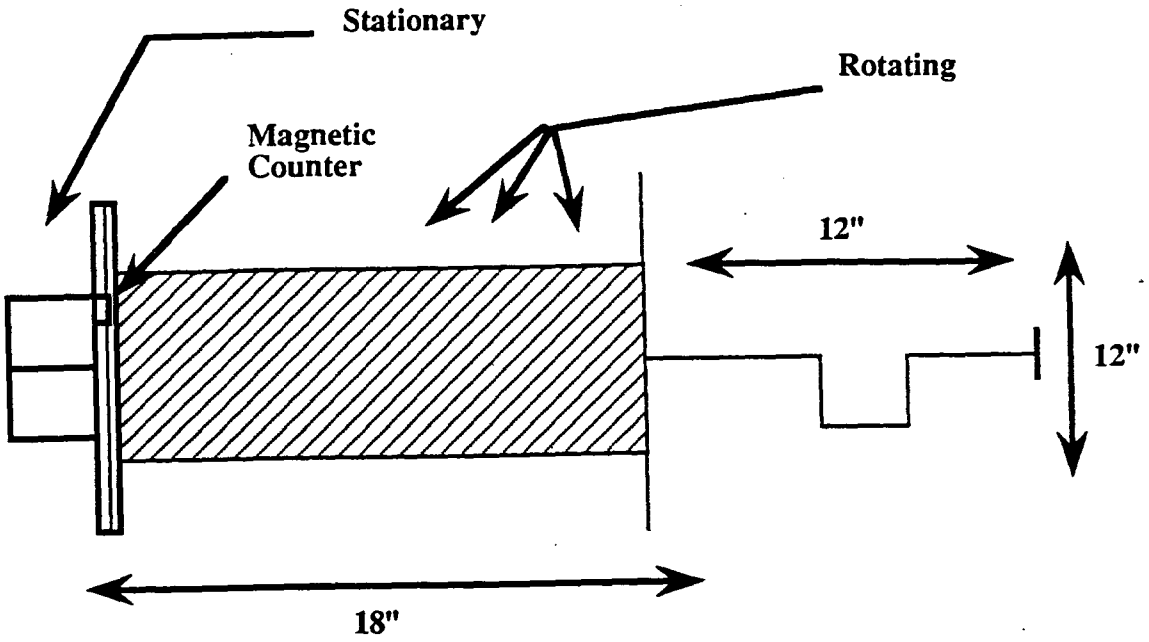


Figure 4. Mechanical seal around an electric splice.

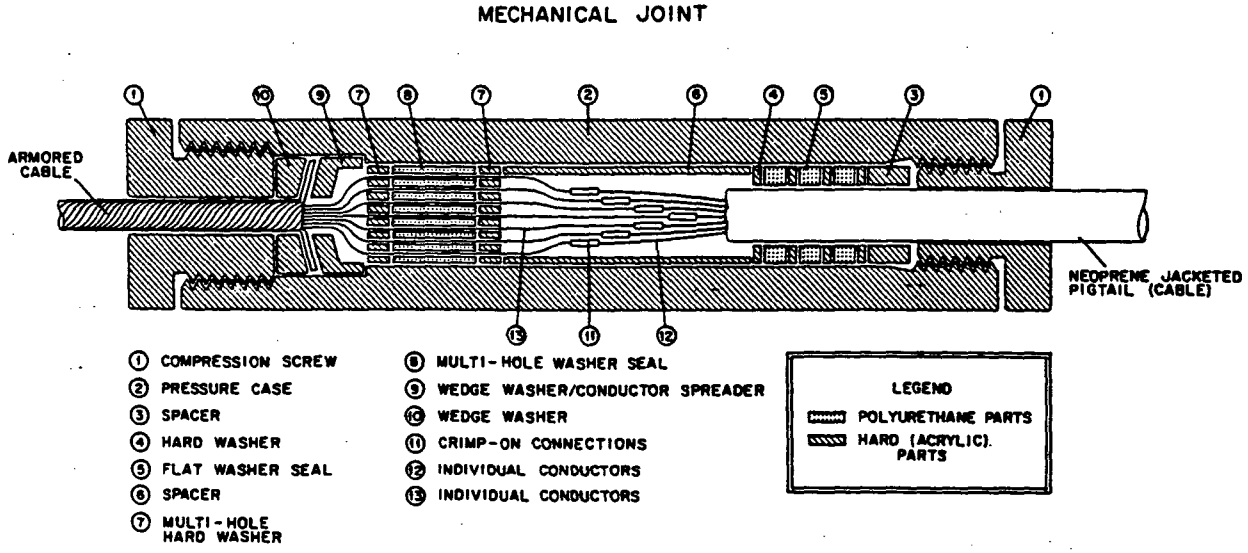


Figure 5. Diver operated pipe puller

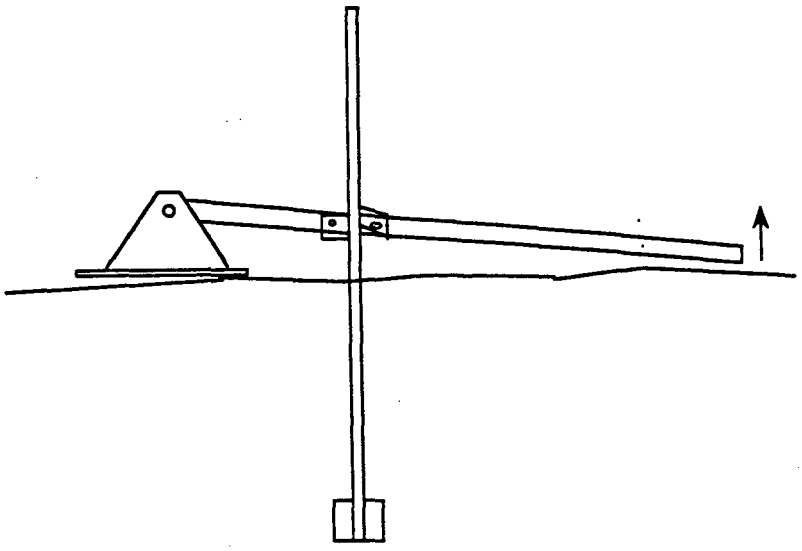
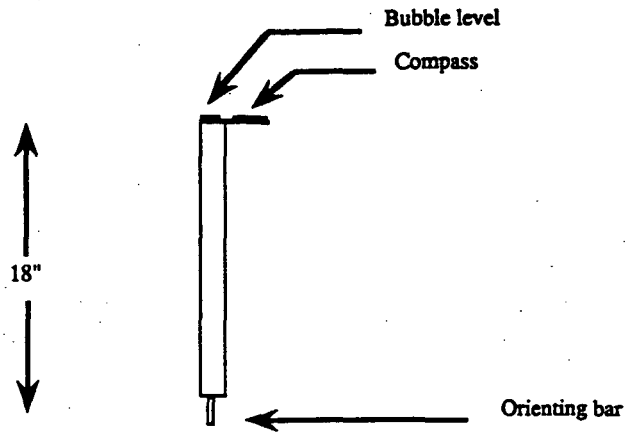


Figure 6. Current sensor orienting device

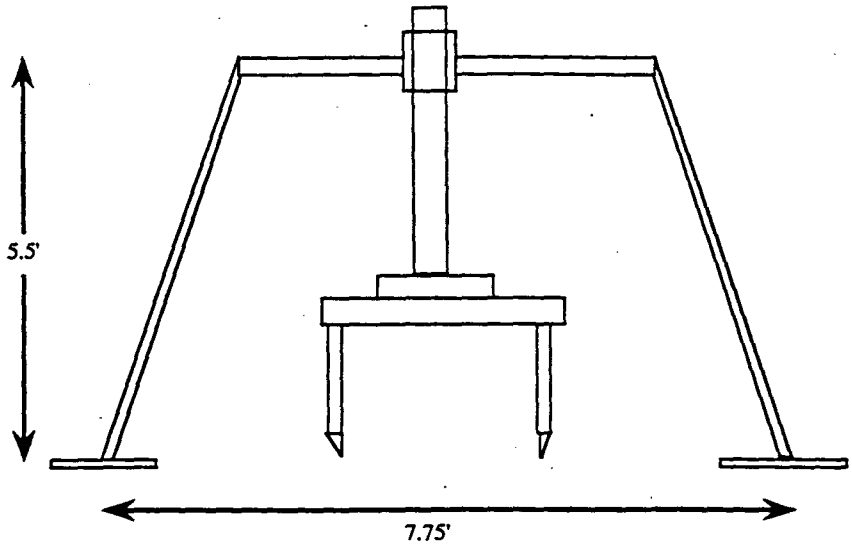


"LDV MOUNTING PLATFORM"

In 1987 and 1989 a Laser Doppler Velocimeter (LDV) was used to measure near bottom flow induced by surface waves (Agrawal and Aubrey, 1988). A new platform was designed to permit vertical movement and horizontal rotation of the LDV. The platform had to be low cost, low drag, high stability, and deployable from a 46-foot overall length boat (R/V Asterias). The design in Figure 7 shows the LDV platform in side view. A more automated and portable design is planned for future deployments to accommodate different experiment criteria. While using the LDV platform, divers are needed to make rotational and vertical adjustments to the LDV. A simple clamping arrangement holds the LDV steady while current measurements are being made. This unit is not very portable in that it requires a larger boat (~50 foot length with a lifting boom). Ruggedness is not a strong point

because of the long and thin frame members. The unit was low cost which happened to be important at the time. Although the unit did not meet two major criteria, it is important to note that the platform accomplished the stated task successfully which tends to overcome the lack of other criteria.

Figure 7. LDV platform showing the LDV mounted.



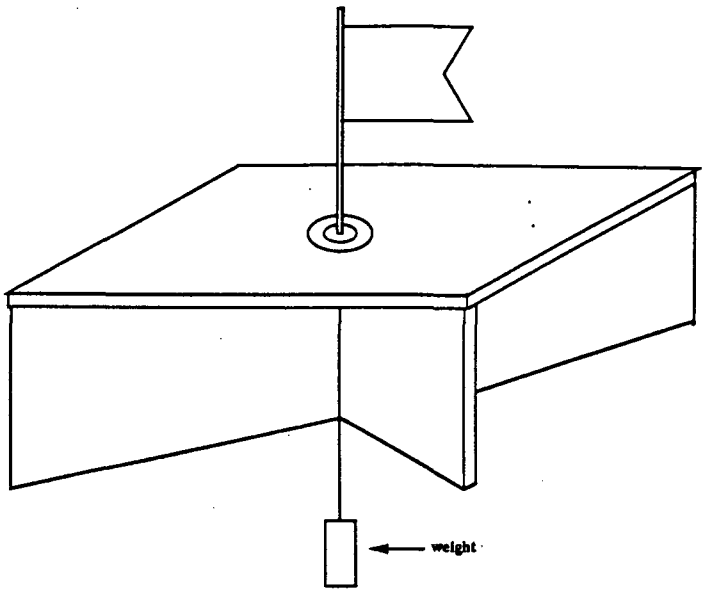
SURFACE DRIFTERS

A major task during the 1984 Nauset, Massachusetts field experiment was to document the surface Lagrangian flow through Nauset inlet (Hess and Aubrey, 1985). To accomplish this task we decided to use surface drifters that would be photographed from radio-controlled model airplanes. The surface drifter (Fig. 8) was designed to meet the requirements of low wind drag, high water current drag, high visibility (both from the air and surface), and low cost. Nautical flag markings were painted on the numerous drifters making each drifter unique when photographed from the air. When drifters were to be tracked from the surface only, one drifter at a time was deployed with a highly visibly orange flag installed on the pipe mount. The drifter was easy to track, low cost, and seemed to follow the surface flow well. They were not very rugged but only one drifter was destroyed during the experiment.

TILTING SPAR SCRAPERS

The tilting spar scraper was designed and fabricated to clean biological fouling from the "Tilting Spar" (Lowe *et al.*, 1972). It is mentioned here to demonstrate the principle of "the right tool". Although the scraper was a simple device (a half cylindrical blade made of stainless steel on a handle), it accomplished a much-needed cleaning of the Tilting Spar *in situ*, with minimum diver time, and at a small cost. If the divers had simply picked up a conventional scraper and gone to work they would have spent much more time in the water than with the scraper to accomplish a comparable cleaning. The time spent in preparing well for underwater tasks is almost always rewarded in better performance and lower costs.

Figure 8. Surface drifter.



FLUIDIZATION

Since 1972 galvanized steel pipe has been used as a support to mount instrumentation on the ocean floor in shallow water (less than 100 ft. deep). Before 1973 pipes were inserted into the bottom using a 50-pound slide hammer. In 1973 a technique of pumping water through the pipe while pushing the pipe into the bottom sediment (fluidization) was used. This technique has been used since 1973 by the author for a wide variety of instrumentation and has been a valuable technique. A small water pump (a common trash pump that can be carried by one person), 50-100 feet of hose, and the pipe (Fig. 9) are all divers need to install a stable bottom structure to mount virtually any instrument. The pump and pipe are both rugged and low cost.

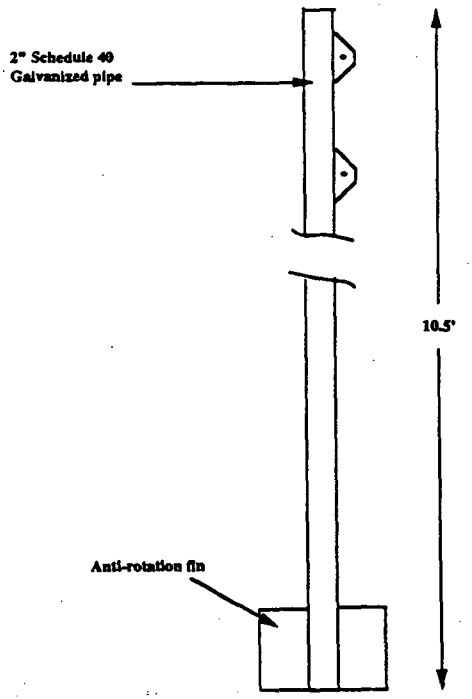
SEARCH AND POSITIONING

A. Circular Search

If a surface expression marking the position of an instrument has been lost there is a need for a search and retrieval crew. The divers' first order of business is to find the instrument, then to either hook a lifting line to the instrument, trip a release or swim the instrument back to the boat. In searching for the instrument the divers need to plan a search pattern. One search pattern that has been used successfully is the circular search pattern. In this pattern the divers swim around a point to which one end of a line is anchored. As the divers swim they hold the line tight and close to the bottom. When the line starts to wrap around the lost instrument, the divers can swim along the line until the instrument is found.

Simplicity of underwater activity (the divers don't have to move their pattern or use complicated patterns), and coverage around a point (often the rough position of the instrument is known) are advantages of this search technique. If there is a high current in the area a disadvantage of the circular search is that the divers will have to swim against the current through half of the circle (in which case the divers may want to swim a line search starting up current and drifting down past the instrument).

Figure 9. Pipe used in fluidization technique.



B. Laser Positioning of Instrumentation

As lasers for land surveying become more available, it is practical to use these instruments to document the location of nearshore instrumentation. The installation becomes more complicated (one additional person is required as are survey markers and/or local landmarks), but this is more than compensated for by knowing the exact location of the instrument (within a few inches is typical). Knowing the exact location of the instrument is useful for data analysis or if the instrument is lost.

C. Microwave Positioning

In 1979 a "Trisponder" system manufactured by Del Norte (loçated at Euless, Texas) was purchased by the Woods Hole Oceanographic Institution. This system provides the user line of sight ranges measured electronically (accuracy of ± 1 meter is available) from transponders on shore (remotes) to calculate position. The task of establishing horizontal control positions for the remotes and installing all necessary shore hardware are

some disadvantages of the technique, but when the project warrants the extra effort to install the "Trisponder" system the user has a fine way of locating all installation sites. This system has been extremely reliable since it's purchase.

D. Integrated Navigation and Data Acquisition System (INDAS)

An extension of the Del Norte "Trisponder" system is INDAS (software copyright to Science Applications International Corporation, SAIC). INDAS uses navigation data provided by "Trisponder" (and other navigation systems) to calculate position automatically. INDAS also can record to 3.5 inch floppy disks data such as fathometer output. When in the data acquisition mode, INDAS offers real time guidance to the helmsman with a number of positional options (position location and coordinate transformations, for example). The person on the boat can conduct a complete bathymetric survey while ascertaining the position of an unlimited number of installation sites. The system does need a weathertight cabin and is relatively expensive. It can take 1 to 3 days for a crew to get the INDAS system set up in a new area. With the use of INDAS, the diver's task becomes easier.

CONCLUSIONS

The emphasis in any tool or technique selection should be the suitability of that particular tool or technique for the task. This suitability, as stated earlier, has many components. In selecting a tool or technique one must stay within the financial budget. For shallow water research, budget constraints generally are significant. The person designing or selecting the tool or technique must take into account factors such as portability, ruggedness, expected life, appropriate approach, ease of implementation, and personal preference. In most of the above discussed tools and techniques budget has been a primary concern. In numerous cases the budget is "as inexpensive as you can" because the need for the tool or technique has been realized after the funding has been established.

When a tool or technique is to be used only once, different considerations arise. Such things as the tool being hard to use or requiring a lot of maintenance after each use or lack of ruggedness are less significant if the tool is used once a year than if it is used 50 times a year. A frequently-used tool or technique might require more time and money for development.

Portability is often a big factor in design. In most cases smaller is more expensive so the designer must be sure that portability is essential before spending resources on miniaturization.

Ease of implementation is sometimes related to compactness in that small tools are often easier to use. There is no need to take extra time and money in procuring a tool that feels like an old glove (it is comfortable to use) if it is going to be used only once a year on a relatively unimportant task. Similarly, it makes no sense to design a technique that requires the help of 20 people when the greatest number of people you can get together at any one time is ten.

Sometimes appropriateness of approach is important. It certainly does not make much sense to drive heavy trucks across a wetland area that is the subject of an environmental impact study. Often personal performance is significant in deciding what is appropriate. If you are good at swimming it may be more to your preference and thus more appropriate to swim out to your instrument site than to go to a lot of trouble getting a boat to the installation site.

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