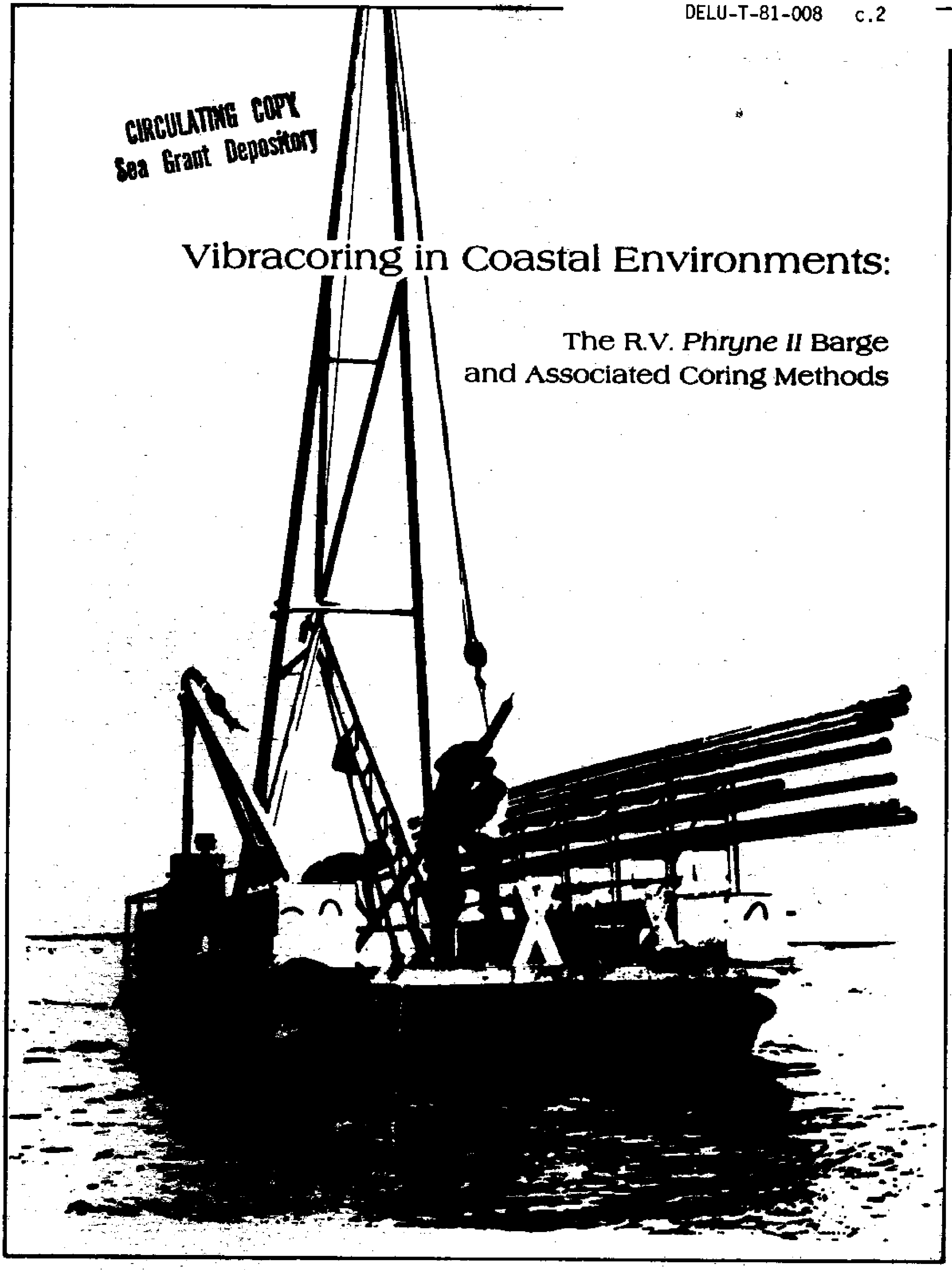
Vibracoring in Coastal Environments:

The R.V. *Phryne II* Barge and Associated Coring Methods



Vibracoring in Coastal Environments:

The R.V. *Phryne II* Barge and Associated Coring Methods

Edited by

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CONTENTS

Foreword

Over the past decade, major advances in technology of the vibracore technique for obtaining continuous cores of coastal and shallow marine environments have been attained. Many of the researchers in the coastal zone are using these techniques with many variants in types of equipment and methodology. Further, I have noted that a large number of workers in the coastal zone do not use these more advanced techniques. Therefore, we decided to share our experiences and techniques with other potential users.

Great difficulties in vibracoring can be encountered if a proper boat or platform is not available. Over the past ten years at Delaware, we have had a twin-hull barge for use in shallow waters. Recently, it became necessary to replace this barge. As a result, we completely redesigned the barge and the equipment used in the vibracoring technique. In this publication, we publish a design plan and maintenance manual for use of this new barge. With electrical and multiple winch systems, we have been able to increase our productivity or rate of extraction of cores three to five times that of our previous technique and to greater depths. We hope that the reader will benefit from our experiences and from the technology that has gone into the development of this new system.

We have further extended our uses of the vibracore technique into many types of environments and extremes of sediment compaction — many from which we could not obtain vibracores ten years ago. Accordingly, part of this report includes a description of vibracoring equipment and procedures now used in the coastal geology program at the University of Delaware. Here again, we hope that the reader will benefit from a knowledge of our techniques and be able to increase quality and productivity of cores recovered. We feel that we have achieved greater capabilities in vibracoring techniques in the many varied coastal and shallow marine environments and in the adjacent Pleistocene sediments, which contain many analogs of the recent sedimentary environments. From this point of view, we submit this report with the hope that our colleagues elsewhere will benefit from our past difficulties, blunders, and successes.

John C. Kraft
Chairperson and
H. Fletcher Brown
Professor of Geology

I. A Versatile Twin-Hull Barge for Shallow-Water Vibracoring

James M. Demarest II and William H. Hoyt

Introduction

The difficult logistics and great expense of taking shallow-water cores in rivers, bays, lakes, and nearshore oceanic environments have prevented many researchers from investigating the sedimentology of these interesting areas. Geological and engineering consulting firms traditionally have provided vessels on a *per diem* or contract basis; often, however, the costs are prohibitive or the rented vessels are inflexible to the demands of the project. At the University of Delaware, the Geology Department has evolved a satisfactory solution to this problem over the last decade. Completed in 1980, a second-generation coring barge, the R.V. *Phryne II*, was designed specifically for estuarine and marine vibracoring, with many diverse, ancillary capabilities.

Mobility

The barge and trailer were constructed so that the vessel could be transported in either of two ways: fully assembled at a 3.6-m (12-ft) width, which constitutes a "wide load" on the highway; or dismantled at a 2.4-m (8-ft) width, the legal width in the United States. This capability allows the barge to be taken virtually anywhere a road goes, be it to a remote lake across the country or to a site just a couple hundred kilometers down the coast. The trailer has a 6-m (20-ft) tongue extension to facilitate launching and retrieval in a wide variety of situations. The vessel can be adequately trailered with a standard carryall vehicle equipped with a heavy-duty hitch. The vessel is capable of obtaining sustained speeds of 10 knots with twin 35-hp motors, or higher speeds with larger engines (up to twin 150 hp). It also can be used under most conditions in inland waters, and can handle storm conditions safely, although coring may be impossible during heavy seas.

Barge Construction

Twin-hull construction provides several advantages, including an area for a center deck hole, convenient sites to mount twin outboards, relatively high hull speeds, the combination of great stability with shallow draft, and the ability to dismantle the boat quickly and easily. Several domestic manufacturers of pontoon barges exist in the United States for plastic foam pontoons (Rotocast Plastic Products, Inc., Miami, Florida) or fiberglass pontoons (Bristol Bluewater Boat Co., Bridgeport, Connecticut). We chose the latter because the patented deck design consists of transverse aluminum box beams covered with a 1.9-cm (¾-in.) malamine resin-impregnated, painted, non-skid plywood deck. The strong, light-weight aluminum box beams are useful in welding and bolting down all aluminum hoists, racks, and railings in the superstructure. The aluminum box beams and deck segments can be replaced with minor expense and delay as needed. The use of marine-grade aluminum (6061 T-6) allows the vessel to be light-weight (approx. 3,000 lb) but durable in the marine environment. The load capacity of the vessel (over 4,000 lb) is quite adequate and the vessel has a deck area of 27 sq m (288 sq ft).

Vibracoring at Sea

The general principles of vibracoring are reviewed by Foster and others (1974), and the specific operation of our cement vibrator power source is reviewed by Lanesky and others (1979). On the water, the vessel must be anchored securely over the coring site, preferably with a three-point, self-centering system. Once the core is hoisted upright by the main-hoist block and tackle (see section II), vibracoring is very similar to the operation on land, except for the motion of the deck.

We designed a 3-m (10-ft) side hoist to pull the core out of the bottom; the hoist is located on the starboard side of the vessel and is capable of lifting more than 5,000 lb by electric winch. Once the core is free from the bottom, a 5:1 block and tackle from the top of the 9-m (30-ft) main hoist is attached to the core; the core can then be raised above the deck, capped, and lowered in a controlled descent to the deck as shown in section II. The high-quality cores obtained by this barge (Figure I-1) have greatly enhanced the research program in coastal and estuarine geology at the University of Delaware.

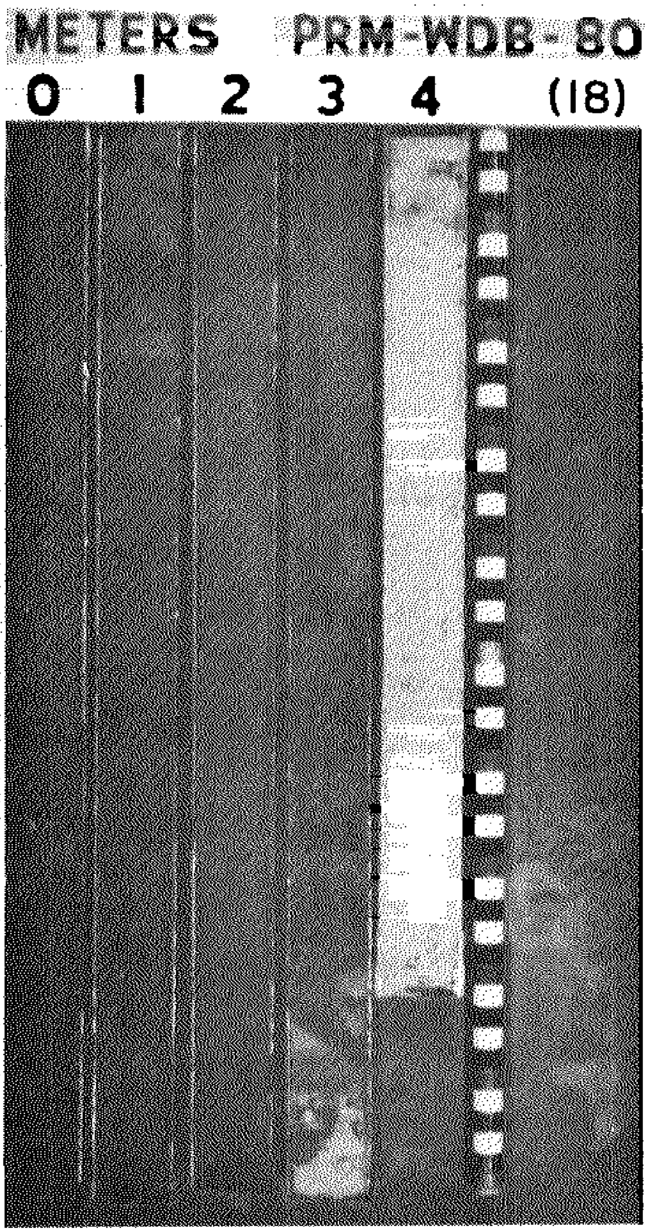


Figure I-1. Vibracore from western Delaware Bay taken with the R.V. Phryne II. Core is taken from 7 km offshore in 1.6 m of water. From 0 to 3.5 m depth, estuarine muds were penetrated; from 3.5 to 3.8 m, a basal "peat" was cored. The pre-Holocene sands stopped penetration at 4.8 m.

Capabilities of the System

The R.V. *Phryne II* was built to handle safely core pipes as long as 12 m (40 ft). It normally takes about an hour and a half to take a core from the barge. We have taken cores in water depths of 9 m (30 ft). However, with the use of SCUBA and shaft extensions on the power source as described by Lanesky and others (1979), depths of sampling could be extended to 25 m (80 ft). Even deeper sampling, to the limits of SCUBA, could be performed with this vessel by using an electric, self-contained vibrator run by the 120-volt, 2600-watt generator on the deck.

The vibracoring system described here is capable of penetrating unconsolidated and semiconsolidated sediments. The depth of penetration is dependent on grain size, sorting, and various other mechanical properties of the sediment. For example, the estuarine muds of Figure I-1 were easily penetrated to 3.8 m, while the pre-Holocene semiconsolidated sands (3.8 to 4.8 m) stopped penetration at 4.8 m. Pre-Holocene semiconsolidated sands have been penetrated up to 9 m and Holocene estuarine muds and sandy muds have been penetrated to 11.4 m.

This vessel also has been used for other kinds of research in shallow water environments such as seismic surveying, biological sampling, bottom sampling, current meter deployment and retrieval, and others. The combination of lifting capacity, stability, 120-volt and 12-volt power supplies, and precise navigational instruments makes it a versatile vessel for nearshore and inland water research.

Cost of the System

Total cost of the marine vibracoring system was under $25,000 in 1980. This amount includes the entire barge with superstructure, two 35-hp outboards, trailer, vibracore system, LORAN-C navigation with steering guidance, VHF radiotelephone, fathometer, and miscellaneous equipment in support of the operation.

The daily operating expenses of the complete system at sea are extremely low; for example, in order to traverse 80 km (50 mi) and take five 6-9-m (20-30-ft) cores, the total core pipe and fuel cost (1980 prices) would be a few hundred dollars. For the high-quality, undisturbed cores obtained by this method, the costs are low, within the financial constraints of most research institutions.

II. Maintenance and Operation Manual for a Twin-Hull Vibracoring Barge, R.V. *Phryne II*

William H. Hoyt, James M. Demarest II, Lester D. Fitler, John C. Kraft, and David F. Butters

Introduction

In 1971, the R.V. *Phryne*, a twin-pontoon coring platform 26 ft long and 14 ft wide was built by geology graduate students R. Strom and G. Elliot, along with maintenance department personnel in the College of Marine Studies (CMS), for purposes of supporting a large-scale jet-wash boring rig. After discovering that the jet-wash system was inadequate, the Department of Geology ceased using this vessel. For a period of about 6-8 years, the vessel was kept mostly in dry dock, but incurred damage to the pontoons through freeze-thaw cycles. In 1978, geology graduate student W.H. Hoyt convinced Chairman J.C. Kraft that the R.V. *Phryne* was well-suited to support a marine vibracoring operation for Sea Grant contracts, which would greatly enhance research opportunities in the offshore zone. The vessel was outfitted with a new derrick and miscellaneous gear to allow vibracoring in Delaware Bay. In the first season, some 50 vibracores were obtained from Breakwater Harbor, Rehoboth and Indian River Bays, and Delaware Bay by graduate students in the Department of Geology (College of Arts and Science) and CMS. Much was learned about better ways to design a coring barge.

In the R.V. *Phryne's* second vibracoring season (1979), it became weaker structurally and, by the end of the summer, was condemned by the university's marine safety officer. All agreed that it had served its purpose well, but had grown too weak in its dilapidated condition.

The decision not to reinforce the old vessel and pontoons led to disposal of the R.V. *Phryne* and replacement with an entirely new vessel, the R.V. *Phryne II*. As part of continuing Sea Grant contracts, W.H. Hoyt was asked to coordinate plans to design, purchase, and complete the R.V. *Phryne II* for the 1980 season. The task was finally completed by July 1980 with the help of some 20 people, some of whom were reimbursed for their services. Graduate student J.M. Demarest, in particular, provided ideas, encouragement, and electrical engineering expertise, much of it in concert with his father, D.M. Demarest, PE. Other geology graduate students instrumental in design or construction were P. Marx and K. Maley. Geology Department technician, David Butters, put in many long days fabricating aluminum parts in the CMS shop at Lewes with research machinists J. Stuart and M. Mitchell. In addition, many other hired or volunteer workers provided labor in various phases of the work. Marine Operations personnel at CMS in Lewes provided necessary expertise and logistical support during various phases of the project. Facilities Engineer L.D. Fitler, PE, in particular, designed safety into the superstructure. Finally, none of this would have been possible without the financial wizardry and herculean support of Dr. John C. Kraft; the vessel is a testament to his determination.

After examining all options, it was agreed that we should buy, ready-made, a 26-ft long by 12-ft wide twin-pontoon Seadeck Catamaran Utility Boat built and patented by Bristol Bluewater Boat Company, Bridgeport, Connecticut. This vessel was built so that it could be disassembled and trailered on the highway at the legal 8-ft width. When assembled, deck area is 288 sq ft and weight capacity is 4,160 lb, although total pontoon displacement is three times this. The pontoons are hand-laid-up fiberglass hulls 36 in. deep. The flanges are ⅜ in. thick and radiused for extra strength. The flotation is a system of encapsulated, poured-in-place urethane foam, and bulkheaded, pumpable air chambers for positive flotation far in excess of rated loads. The hulls are Coast Guard-certified for safety. The deck structure consists of transverse aluminum box beams below a ¾-in., melamine-impregnated and painted plywood top skin. This construction forms a series of 4-ft stressed-skin torsion boxes. The outside edges of these boxes are combined with the hull flanges and encased in a 4-in. x 2½-in. extruded aluminum channel rubstrake, which encircles the whole deck. The deck and flanges are then through-bolted through the rubstrake encasement with 5/16-in. stainless-steel bolts and stainless-steel nylon-insert lock nuts. The holes for these bolts are drilled large enough to allow assembly and disassembly of the above components. The rail system is a 1¼-in.-diameter aluminum tube, the bases of which are through-bolted onto the deck with stainless-steel nuts and bolts. The resultant boat is an extremely strong, light vessel capable of carrying large loads at high speeds (in excess of 40 mph) with relatively low horsepower. One of the company's recent boats, powered by twin 175-hp outboards, was clocked at 52 mph carrying a payload of 8,000 lb. These catamarans are designed for open-water use. The new 36-in.-deep hulls are ocean-proven and give extra freeboard to handle big payloads.

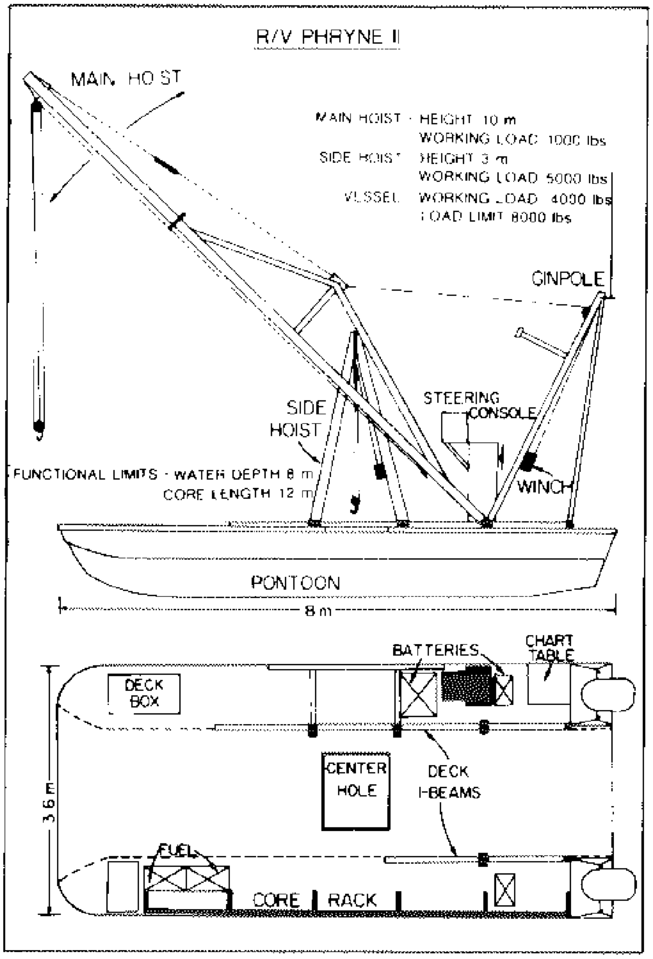


Figure II-1. Simplified engineering sketches of R.V. Phryne II. Side elevation view and plan view are included along with pertinent specifications of the vessel.

All aluminum materials in the frame are 6061 T-6 marine-grade aluminum, which has welding compatibility with all the superstructure elements (the same grade aluminum). The CMS shop in Lewes has in-house capability to fabricate and weld this type of aluminum.

Considering all of the design alternatives discussed for systems to anchor the barge and handle the cores, it might be considered miraculous that we ended up with such an efficient and safe marine vibracoring system. The capabilities of this vessel are remarkable for its size and operating costs. Safety features include 100% flotation up to 4000 lb. (The manufacturer says that when the pontoons are blown apart, all the pieces float because of the urethane foam.) Communications, safety, and navigational aids include marine VHF radiotelephone, LORAN-C, compass, chart-plotting instruments, radar reflector, flares, fog bell, horn, spotlight, depth sounder, life jackets, ring buoy, international running lights, low-maneuverability indicators, fire extinguishers, lightning protection, and flotable aluminum pipes on all superstructure elements. The barge is self-propelled with twin outboards controlled from the console; maneuverability is excellent because the twin propellers, and its shallow draft (2 ft), allows cores to be taken in areas inaccessible to larger boats or from land. Two electric 12-volt winches power the majority of hoisting required on board. The maximum lengths of cores obtained to date have been 36 ft (10.8 m).

A crew of three can take a core in about an hour under normal conditions, but it may take longer in rough water (2-ft waves) or in swift currents (2 knots). Obviously, one should not take cores in truly rough water (small craft warnings) or in very swift currents (faster than 2 knots), although the vessel can handle such conditions in an emergency. Vibracoring is a fair-weather operation, exclusively. Training of the crew is not a complicated, lengthy process — usually a few days of observation and participation is sufficient. Also, specialized permits for marine vibracoring normally are not required with this type of minimal-disturbance system. Caution in this regard, however, is advised, especially when working in wildlife refuges, protected oyster beds, and the like.

Routine Safety and Maintenance

Engineering sketches of the R.V. *Phryne II* are shown in Figure II-1 with a side-elevation view and a plain view. Important specifications are also listed here.

Pontoons. Maintenance and upkeep of the pontoons is of paramount importance, for without their structural integrity, the entire vessel is useless. Figure II-2 shows that the bottom two-thirds of the hulls are painted with antifouling paint. This paint should be touched up annually, but more important, any damage to the underlying hull should be repaired. Several such spots on the hulls are visible in Figure II-2. *Before* launching the vessel in the spring, these areas should be patched with Marine Tex Epoxy (or equivalent) and painted with copper-based antifouling paint. A trouble area exists where the sterns begin to ramp up (see Figure II-2).

The airtight compartments in the upper part of each pontoon are accessible from above through plastic, water-tight hatches (Figure II-3). These hatches should be checked frequently to insure that no water is accumulating in the pontoons. The rubber "O-rings" on the plastic caps should be replaced as necessary, should they become damaged.

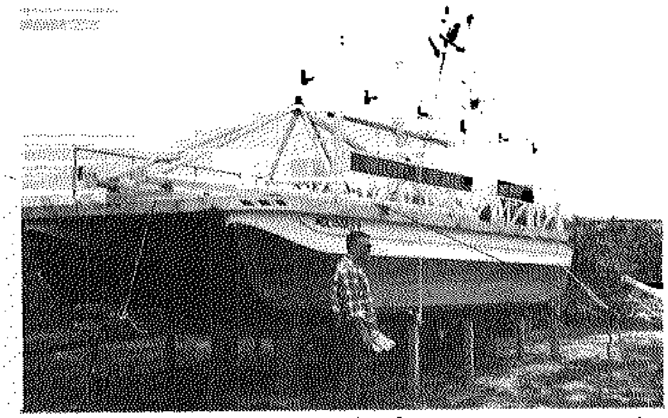


Figure II-2. Damaged areas in the pontoons below the water line are visible here as white spots. Also shown here is the winter storage tie-down procedure.

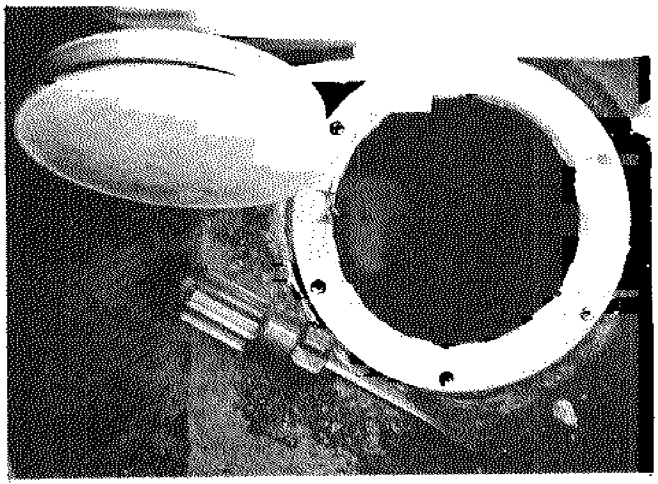


Figure II-3. The air chamber in the top of each pontoon is accessible from above through a single plastic, water-tight hatch. The hatches are located below the engine battery compartments in the aft of each pontoon; they should be carefully pried open with a screwdriver, and any water pumped out. If water continues to accumulate, there is a leak somewhere which should be sealed and rétested.

Electric. A bank of three 12-volt batteries (Figure II-4) power the electric winches. Maintenance of these batteries, and those for the two outboards, includes checking electrolyte level (add clean water, if necessary), cleaning the terminals, and maintaining solid electrical connections. In the first season of use, salt-spray caused corrosion of battery terminals, so there is a design plan to prevent this problem in the future.

Should maintenance of electrical-system components become necessary, refer to the wiring diagram (Figure II-5). Should electrical problems persist, contact designer Jim Demarest or Marine Operations electrician, Art Sundberg. All circuits are fused, and the fuses are found on the front of the switch panel described later (Figure II-21). The battery charger (Figure II-20) is also fused. When leaving the vessel, always cover the switch-panel area with the canvas provided.

Outboards. Maintenance of the outboards should follow standard procedures: always flush with fresh water, keep spark plugs clean and the threads greased, and follow winter-storage guidelines suggested by the manufacturer. The gasoline/oil mixture hose should be disconnected and the outboards run in fresh water until they run out of gas. Spray the cylinders with an anti-corrosion agent and store them on the engine racks in the Marine Operations Building shop.

Other Maintenance Steps. Nuts and bolts will come on and off easier if an anti-seize compound is applied to them. Likewise, the winch cables and other moving parts in the barge superstructure and steering will last longer if cleaned and lubricated thoroughly each year. Tools used in salt water should be thoroughly rinsed and soaked in oil after each day's use. Tools should never be stored below decks in salt water.

Painting the deck and covering bare-wood surfaces will lengthen the life of wooden components. It is envisioned that a new deck will be needed after about ten years if the present one is

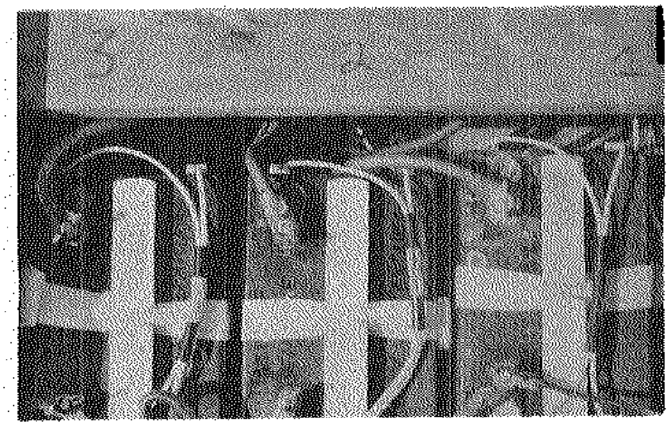


Figure II-4. Bank of three 12-volt batteries that power the electric winches. The compartment is located below decks just forward of the steering/control console.

properly maintained. If it is not taken care of, the deck will last only a fraction of this time. It also should be noted that trailer and boat license permits need to be renewed each year. Geology Department personnel have been ticketed and fined in the past for failure to renew.

The 2-ft x 2-ft bronze plate permanently mounted off the starboard midship serves as a grounding plate for lightning protection and as a mounting bracket for the fathometer transducer. These items should be checked periodically for structural integrity and cleanliness (Figure II-6).

Winter Storage of Vessel

The single most important maintenance item is this: always store the vessel for the winter with the bow considerably higher than the stern so that water will drain out. This cannot be overemphasized. Ice damage to the hulls can render the vessel useless. The winches should be taken in or covered with canvas. All instruments on the control console (except the horn) can be disconnected and should be stored in a protected, dry place. The same applies to the 12-volt batteries, the fire extinguishers, the life vests and ring buoy, storage boxes, all lines, the block and tackle, and all vibracoring equipment.

Figure II-2 shows the vessel with 4-in. x 4-in. wooden blocks under its trailer. These blocks prevent the trailer cross-beams from bowing under the weight of the barge. The blocks also keep the rubber trailer wheels off the ground to lengthen tire life. Screw-type anchoring stakes

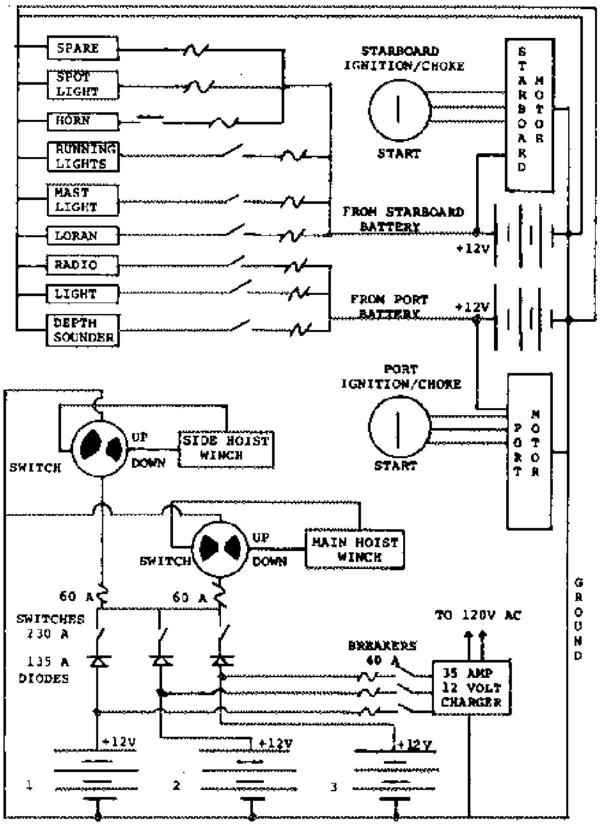


Figure II-5. Electrical wiring diagram of the R.V. Phryne II. A total of five 12-volt DC batteries are installed on board to power all units on the vessel. An automatic 35-ampere charger, which runs off of 120-volt AC current from shore power or a generator, recharges the three 12-volt batteries designated to power the winches. In addition, each outboard has its own battery with a built-in 5-ampere charger (these batteries may need to be charged supplementally — check them).

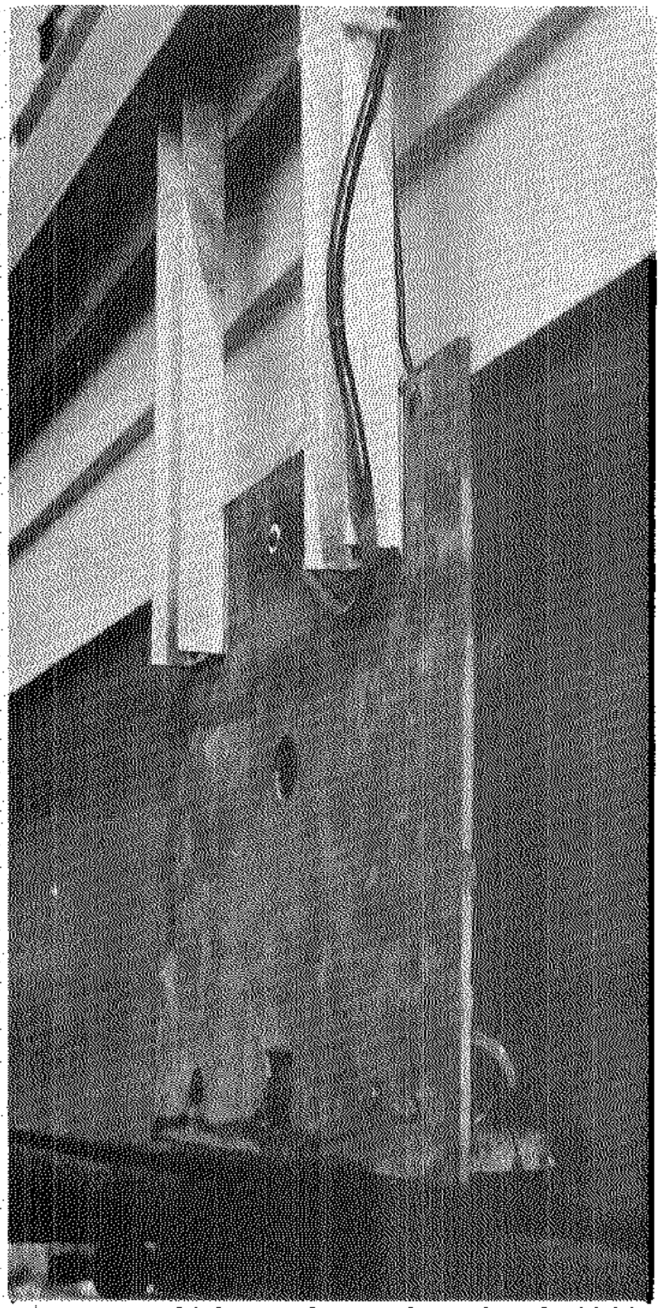


Figure II-6. This bronze sheet off the starboard midship serves as a grounding plate for lightening protection and a mounting bracket for the fathometer transducer. The aluminum support arms will need to be replaced every few years because electrolysis between the bronze and the aluminum will weaken the aluminum even though electrical insulation has been installed.

should be used to firmly anchor the vessel to the ground with lines from the bow, stern, and two sides. The vessel should be checked periodically in dry-dock and repairs attended to as needed.

Launching and Trailering Procedures

Assembled, the R.V. *Phryne II* is 12-ft wide, and the trailer can carry it at this width providing all superstructure is in a lowered position to clear utility wires. State and federal laws, however, require that a permit be acquired for trailering loads wider than 8 ft. These permits can be obtained, but for long-distance interstate trailering, a wide load could become a problem. Therefore, all aspects were built so that the vessel could be dismantled, the pontoons moved side-to-side, and gear stacked between and on top of them. Likewise, all electrical connectors and mechanical connectors are of the quick-release type, as shown

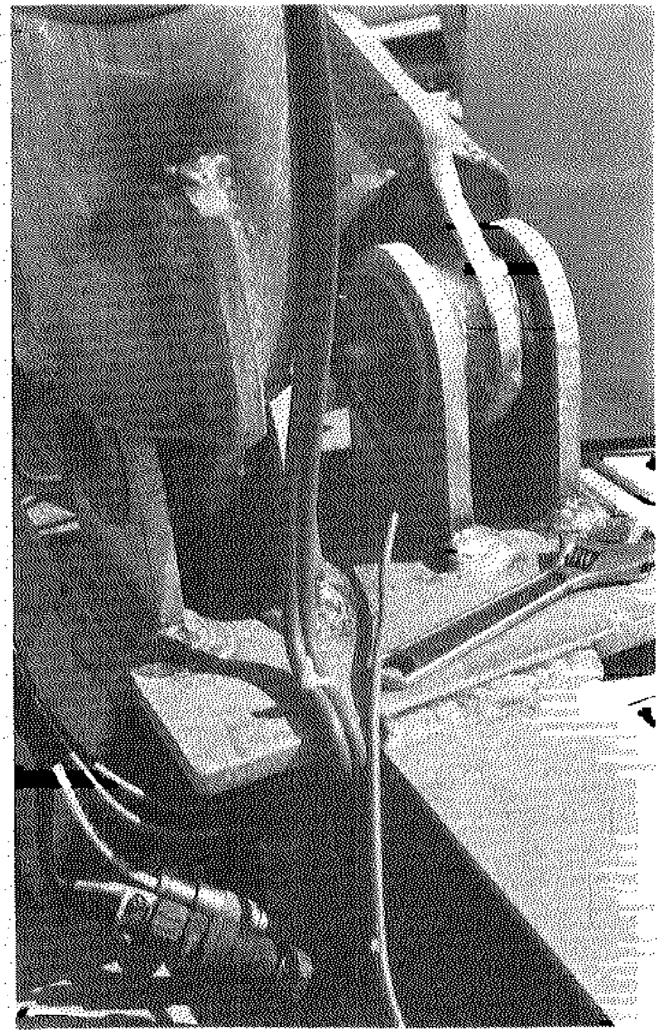


Figure II-7. Detail of the main hoist/gin pole pad-eye supports showing pivoting capability around stainless pins. Also shown are various wires for LORAN-C, radio, powerwinch, anchor lights, and grounding strap. All wires can be disconnected quickly if the vessel is ever taken apart for trailering at the 8-ft width instead of the assembled 12-ft width.

in Figure II-7. It is estimated that breakdown and reassembly would take two experienced workers about four days, in total. Also, it can be expected that about 10% of the stainless steel fasteners and 100% of the plastic fasteners used would need to be replaced on reassembly. It is not recommended that the vessel be dismantled unless it is absolutely necessary.

Figure II-8 shows the trailer alone, with the 20-ft-long launching tongue attached. The extra length of this tongue allows the vessel to be launched without getting the truck or personnel wet. The road-trailering tongue is sitting on top of the trailer. The four aluminum witness poles are to be used in guiding the ship on and off the trailer — these poles are not strong enough to take much abuse so caution must be exercised.

Figure II-9 shows detail of the front part of the trailer, including the rotating support wheel, which locks in the up or down position. It *is not* a good idea to roll the loaded trailer on either support wheel because neither wheel is designed to support that much weight. The integrity of the

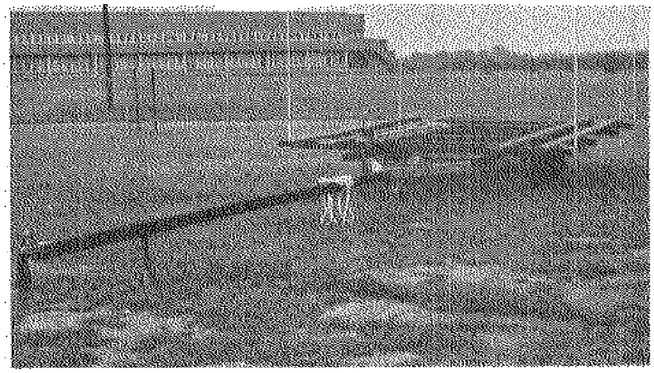


Figure II-8. Empty trailer with 20-ft launching tongue attached. The extra length allows the vessel to be launched without getting the truck wet. The four vertical aluminum "witness poles" guide the ship on and off the trailer during launching.

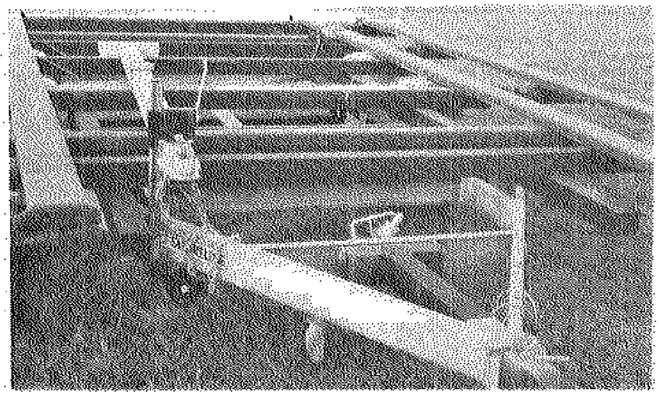


Figure II-9. Detail of trailer front showing trailering tongue (left), rotating support wheel (center), and wiring for lights (right). Note safety chain and tilt lock (the trailer can tilt, but should not for this barge). The carpet-covered boards running the length of the trailer support the pontoon evenly.

trailer wiring, and the bolts connecting the beams to the metal trailer frame should be checked periodically. With our present vessel, the trailer-tilting mechanism should never be needed.

A close-up of the trailer axles, with the wooden blocks permanently attached, is shown in Figure II-10. Lubrication of the trailer wheel bearing should be checked periodically (pump grease into the "buddy hubs"); the entire trailer and barge should be sprayed thoroughly with fresh water each time they are removed from salt water.

Check-out for launch readiness includes tilting outboards up, securing all items on deck

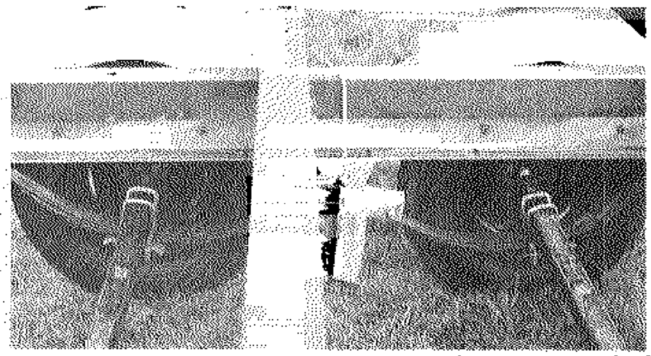


Figure II-10. Detail of trailer axles showing attached blocks for wheels and the fore/aft mobility of the axles under the trailer, should a redistribution of weight ever be needed.

(the more you load later, the easier this will be), raising the main hoist to full up position, installing launching tongue, and preparing lines and gunwhales for moving past the witness poles (Figures II-8, II-11). Always make sure someone watches you back down the ramp because you can't possibly see 60 ft behind you!

A vehicle that has a two-in.-diameter trailer hitch ball that is rated for at least 3,000 lb gross weight is needed to trailer and launch the R.V. *Phryne II.* The Department of Geology truck has a hitch built specifically for trailering the vessel. The CMS diesel tractor or fork lift can be used for launching, but it is not as safe as using the truck (Figure II-12). Launching on the CMS ramp before the christening is shown in this photograph. We quickly learned that a long trailer tongue was needed, and that the more stern-heavy the vessel was, the easier launching became. Therefore, the main hoist should be all the way up for launching.

When retrieving the vessel from the water with the trailer, the launching tongue again should be used. Because of all the wood on the trailer, it will float, but as the boat is drawn onto the trailer, the trailer will sink. Again, it is best to remove all heavy gear from the deck and put the main hoist in the full up position. Carefully guide the boat onto the trailer, making sure the pontoons are resting properly on the boards and

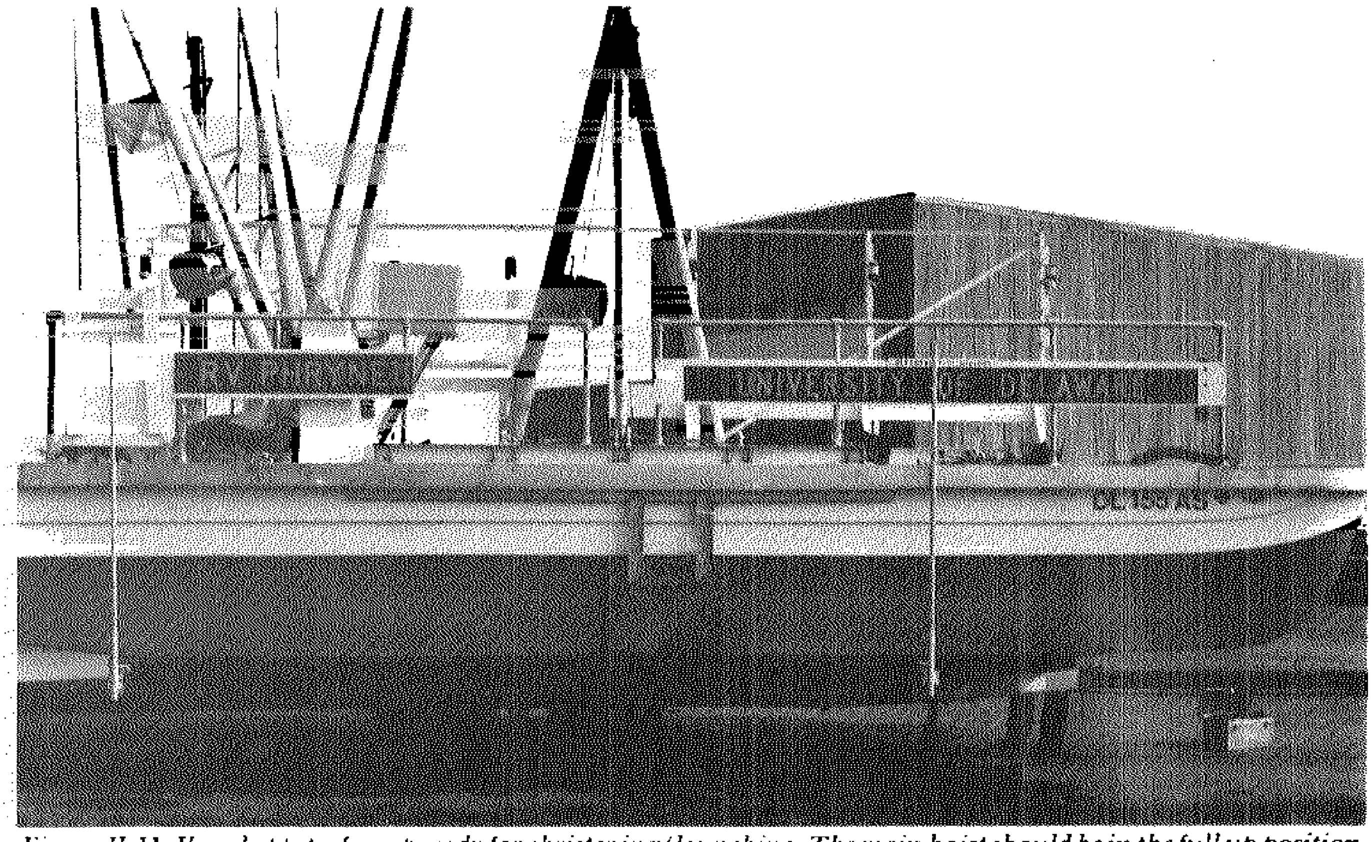


Figure II-11. Vessel at top of ramp ready for christening/launching. The main hoist should be in the full up position to bring weight aft for ease of launching.

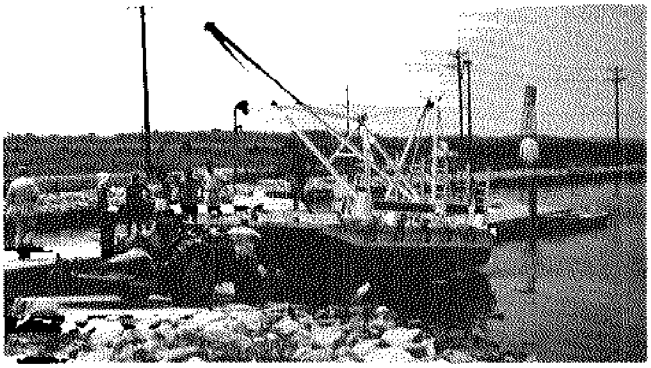


Figure II-12. Christening ceremonies, July 16, 1980. This first launch shows what ***not*** *to do! The 20-ft launching tongue should be used, and the main boom should be in full up position.*

that the witness poles come to the proper place along the deck. Throughout the operation move slowly and use common sense.

Operation of Vibracore System on Board

General Precautions. *Always* keep hands and other appendages away from the "bite" of lines and cables. Even in light seas, enormous stress can be produced by the inertia of the vessel and equipment by a small roll of the boat — enough to remove an arm instantaneously. Keep hands, hair, and loose clothing clear of cables and winches!

When working on water it is best to prevent objects from moving in the first place rather than to try to stop movement once it begins. This means keeping all equipment and core pipe securely tied down and using lines to hold core pipe when it is being raised or lowered. This is particularly important when lowering the full core pipe. If it begins to swing across the deck with a roll of the vessel, it can easily knock equipment and people off the deck. In severe wave conditions or with inexperienced crew, it is best to lower the full core pipe by lowering the entire main hoist. This will prevent the pipe from swinging across the deck.

Never operate outboard motors when people are in the water or when lines are trailing over the stern.

Equipment or tools left loose on deck will roll or be knocked overboard. *Always* secure equipment and stow tools when not in use, particularly when underway.

This vessel has been carefully designed to make coring as safe and effortless as possible. If great human strength is being used during any part of the operation, the coring is not being done properly. *Always* use ropes, winches, and pulleys to maximize mechanical advantage and to prevent injury and equipment damage. Shortcuts and laziness can carry a high price in wasted time and personal injury.

The safe operation and maintenance of this vessel are primary responsibilities of the chief scientist. Maintenance and safe operation go hand-in-hand: they are very closely related and you cannot have one without the other. This means that all equipment, including safety equipment, should be checked before leaving the dock. Proper use of the radiotelephone should be known by at least two crew members, and it should be checked by calling the College of Marine Studies or the Coast Guard for a radio check. The structural integrity of the entire vessel should be checked before launching. This responsibility should be taken very seriously as the lives of the crew and the utility of the equipment are dependent upon the caution and common sense of the chief scientist. A sense of this responsibility should be felt by all aboard as well.

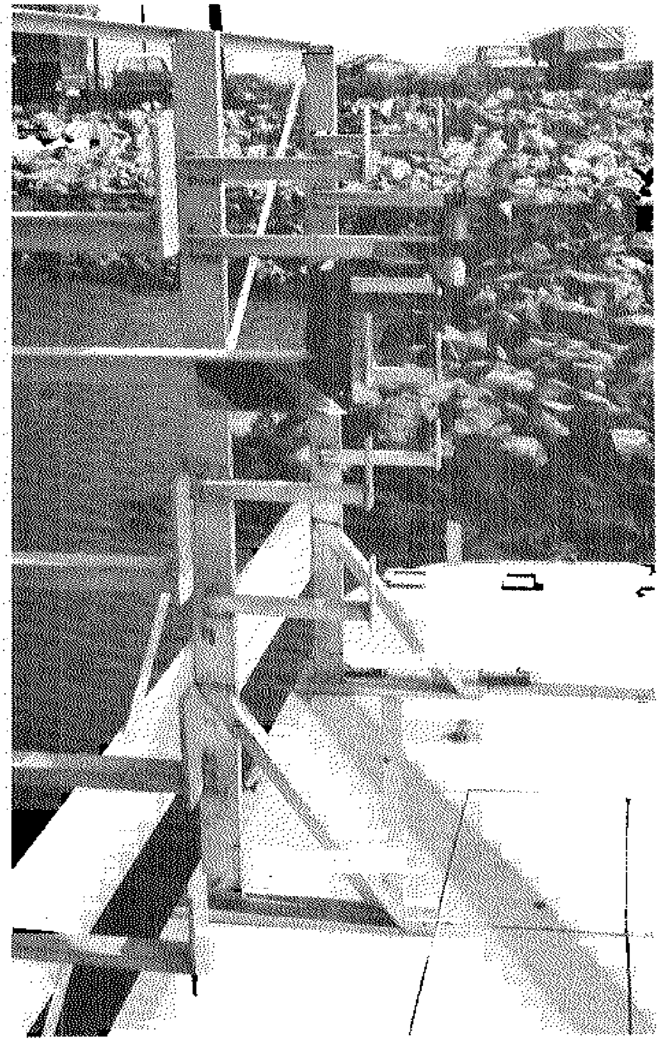


Figure II-13. Close-up of empty core rack on port side of vessel. The bottom of the rack is designed to hold full cores and the top is designed to hold empty cores. The set-up rack (with tape and rubber protectors) is to be used while attaching vibracoring head to pipe. The blocks attached to the port bow deck are to secure the small storage box in heavy seas. The starboard bow has similar blocks for the large storage box.

All crew members should read this entire manual, as wêll as the manuals for operation of instruments and equipment onboard.

One last word of caution. The weather is the most unpredictable and, potentially, the most dangerous part of the operation. This vessel can handle almost any weather condition that might appear unexpectedly while on the water in nearshore and estuarine environments. Use common sense and if rough weather does suddenly come upon you, it is best to head for the dock slowly under control, rather than make a mad dash for the nearest landfall. Keep track of the weather conditions by listening to the NOAA weather radio stations. If things get serious, you can contact the Coast Guard, but remember that the Coast Guard is only going to respond to life-threatening situations. It is your responsibility to handle the vessel (this includes going aground) and to take care of equipment failure.

Elements of Vessel's Vibracoring Operation. Familiarity with the vessel and all of its components will make vibracoring much easier and more productive. The core rack on the port side of the vessel is one such example (Figure II-13). The lower sections of this rack are designed to carry heavy cores full of sediment, while the upper sections are designed to carry empty, 40-ft cores. The set-up rack is longer than other sections of the rack and is shown in the photograph with warning tape and rubber bumpers. The vibracore head can easily be attached to the core when the set-up rack is used. *It is not recommended* that heavy cores be stored on the top of the rack; the rack may not be strong enough for this. Likewise, it is not suggested that empty, 40-ft cores be stored on the bottom of the rack; the open ends of the cores may then catch the water surface and subsequently damage more than just the pipe. The empty pipes on the rack should be capped on each end during loading to prevent sinking, should they fall overboard. Also, a buoyant pipe will facilitate core set up procedures on the rack. Methods to obtain maximum core penetration are outlined in section III. A mechanical understanding of the 2600-watt, 120-volt electric generator is recommended. In addition, proficient and safe operation of the anchor winch takes practice and the knowledge that the handle is detachable.

The deck storage compartments below the core rack are shown closed in Figure II-13 and open in Figure II-14. These compartments are designed to store four six-gallon fuel tanks and miscellaneous gear. The more gear that can be stored in these compartments and storage boxes, the more free deck space will be available for the coring operation. It is very easy to kick gear and tools overboard by mistake; therefore, it is suggested that every item have a designated, secure place. Tools used frequently can be stored securely in the boxed-in area adjacent to the starboard hoist.

The vessel underway on a coring operation is shown in Figure II-15. Note the positions of the main hoist and its support structure on the stern (called the ginpole). On the far side of the vessel is the starboard hoist for pulling cores free from the bottom; on the near side (port) is the core rack.

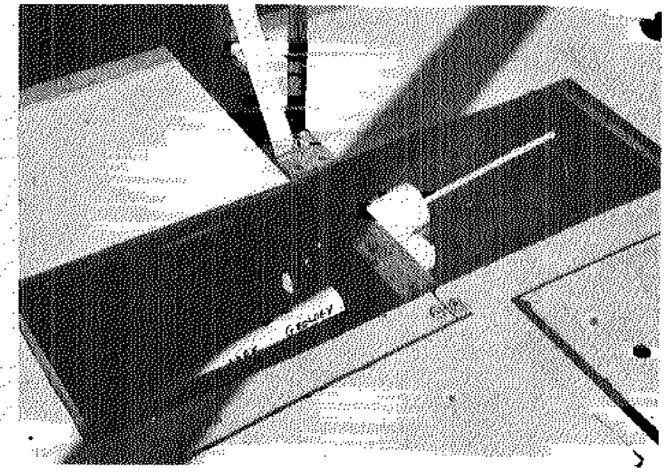


Figure II-14. Detail of port bow storage compartments for plastic gas tanks (metal ones are too tall), life vests, and miscellaneous supplies. Thumb holes on all deck covers should be aft, not forward.

A photograph of the starboard hoist pinned in the outboard position is shown in Figure II-16. It should be in this position while underway or while using the main hoist. Figure II-17 shows the same hoist in the inboard or working position. It will take two people some practice to become proficient at raising and lowering the side hoist. If one of the stainless steel pins is lost while adjusting the hoist, spares can be found in a white storage box on deck. Don't lose these as they are hand-made and expensive. All electrical equipment except the hoists can be operated from the steering/control console area (Figures II-18, II-19). Separate operation manuals for the fathometer, LORAN-C, and radiotelephone are located in the Marine Operations Building shop in Lewes and may be obtained from Dave Butters. The LORAN-C coordinates and the water depth can be read easily by the helmsman or the individual working on the chart table. Electronics engineer Art Sundberg at the Marine Operations Building in Lewes can help with any problems with the electronic gear. The fathometer, LORAN-C, radiotelephone, and compass can all be disconnected quickly and removed from the vessel at night — don't invite the theft of over $3,000 worth of marine electronics!

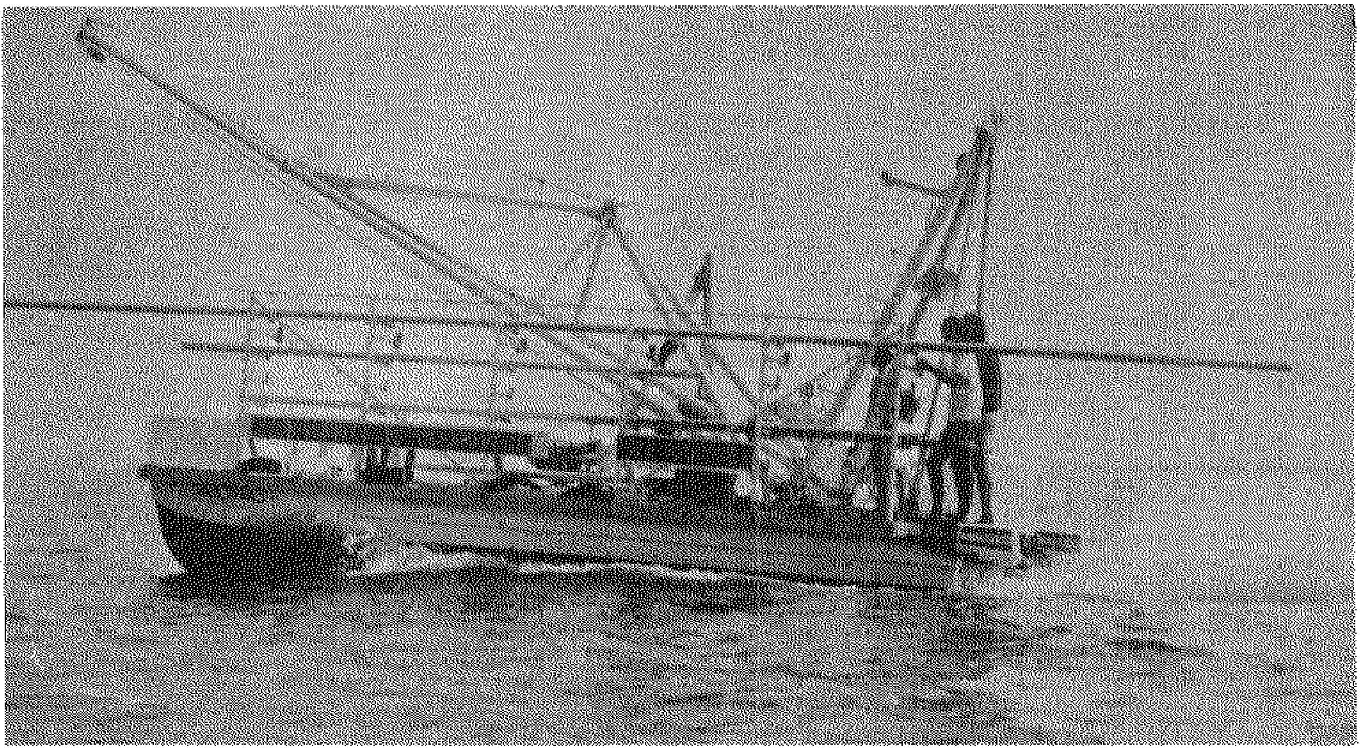


Figure II-15. Vessel underway showing the tall, main hoist and the short, side hoist on the starboard midships. The support structure for the main hoist (called the gin pole) has a ladder built onto the front to provide access to antennas, lights, and radar reflector.

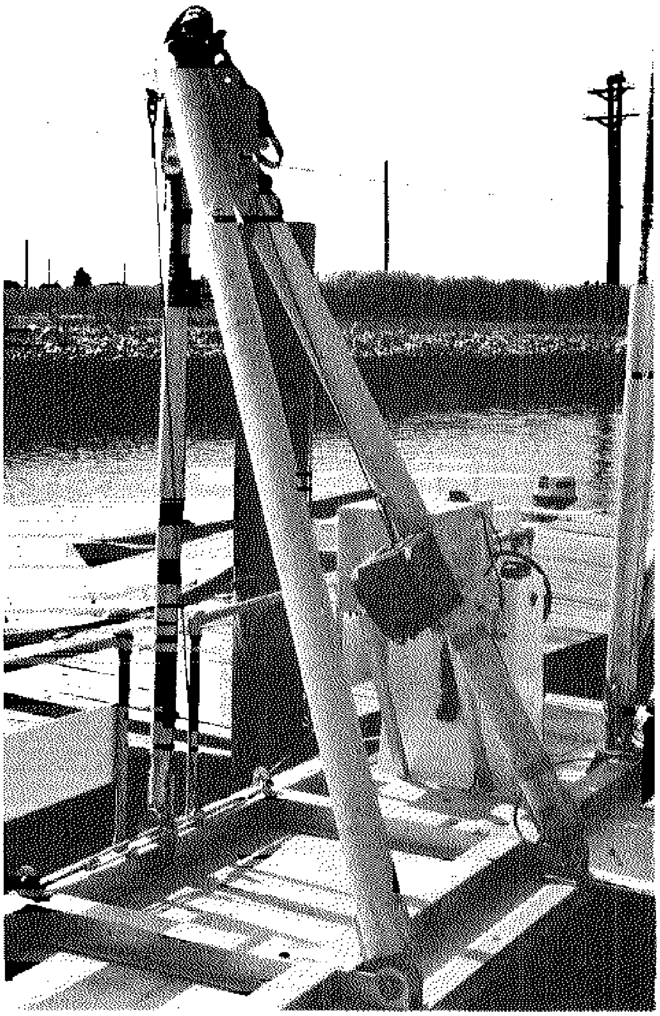


Figure II-16. For cruising applications and while using the main hoist, the starboard hoist should be pinned in this up position. Note the location of the fire extinguisher on the front of the console — another one is on the starboard bow railing. On the inboard side of the console, a plug for the spot light is visible.

The 35-ampere, 12-volt battery charger (Figure II-20) is designed to charge simultaneously and automatically the three batteries used to power the winches. The ammeter needle is not doubly-damped, so it "bounces" a lot. The manufacturer says this behavior is normal for this unit. The charger is permanently mounted under the console and also has a manual.

The electrical switch panel (Figure II-21) consists of three components. The charging switches in the upper left are three circuit breakers to the batteries, labeled 1, 2, and 3 in Figure II-4. The switch panel in the upper right powers units as marked, and the round switches at the bottom of the panel supply power from battery 1 and/or 2 and/or 3 to both of the power winches. All electrical systems are fused and protected from leaking charge. It is more efficient to run the winches from one battery until it is worn down; then switch it off and switch on the next battery. Each is isolated with diodes so that one dead battery will not draw down the other two, even if all are on simultaneously.

Operation and safety of the winches are outlined in Figures II-22 and II-23. Always be sure

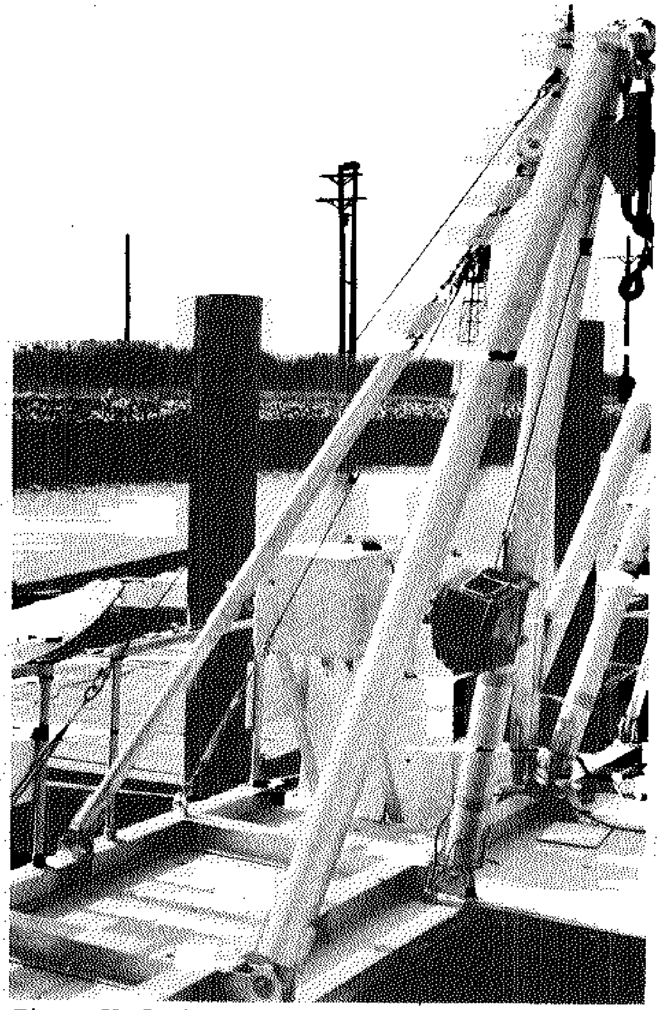


*Figure II-17. For breaking core free from the bottom and lifting heavy loads, use starboard hoist in down position; adjust tension with turnbuckles so that cables take most of the strain. Also, to prevent losing stainless locking pin overboard, install with the larger end on **the inboard** side of the sliding posts.*

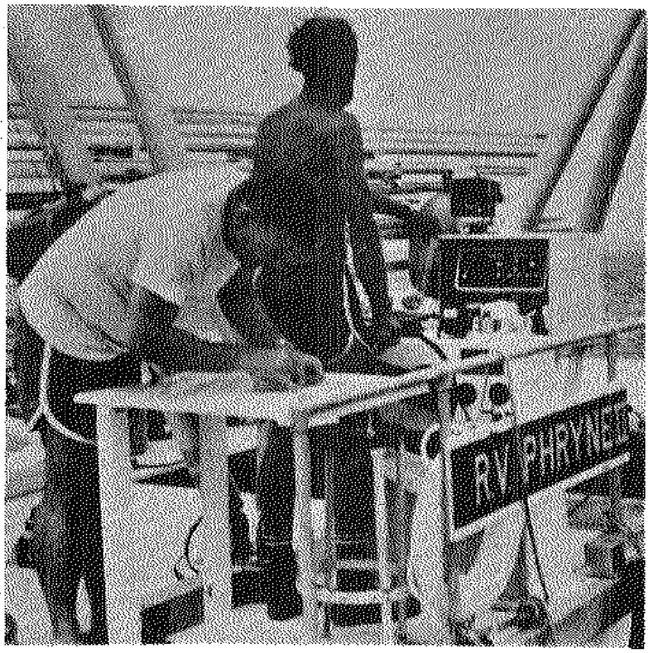


Figure II-18. View of chart table and control area. Chart table is covered with plexiglass for weather protection and folds down against guard rail for storage. The electrical switch panel shown in Figure II-20 is located just below the steering wheel behind a canvas cover. Note the ring-buoy location.

to keep the brake-adjustment wrenches stored on the clips above the winches as shown. Since this brake is the only mechanism holding up the main hoist, it is essential that it be maintained carefully and faithfully. The support mechanisms of the main hoist are shown in Figure II-24. The contoured cradle arms shown are designed to firmly affix the main hoist in the up position; it is not necessary to pull the main hoist into these supports with a lot of force (this may cause failure of the cable or winch). A safety rope may be used in case of cable failure.

The vibracoring operation itself is relatively straightforward. Background information on vibracoring can be obtained by consulting section III in this report. The marine vibracoring operation on the R.V. *Phryne II* is displayed, step-by-step, in Figures II-25 to II-35. Please read through those figures, which discuss standard coring operations. The text will discuss abnormal difficulties involved in particular situations.

When approaching the coring site, the LORAN-C steering guidance system can be used to reach prearranged coordinates. The barge should be anchored with the bow into the current or the wind, whichever is stronger. Allow at least five times as much anchor line as the depth of water (e.g. 50 ft of anchor line in 10 ft of water). It is easiest to anchor the two bow anchors at an angle of 120° first (100 ft apart in 10 ft of water), and then have a second boat take the single stern anchor straight back. It takes considerable practice and common sense to master the anchoring operation with the anchor-tending boat. Run the procedure in reverse to retrieve the anchors. Obviously, tight anchor lines are essential to the success of the coring operation; if the boat drifts over the core site, adjust one of the anchor lines accordingly. Proper anchor geometry will save time and increase the safety of the operation, so take the time to get it right.

Any type of motorized vessel can be used as an anchor-tending boat, but if it is light enough (less than 500 lb) it can be brought on deck by the main hoist and stored there while cruising from one core site to the next. This keeps all crew members on board the large vessel during most of the coring operation and also saves fuel. We used a 16-ft aluminum "John Boat" with a 7.5-hp outboard as an anchor-tending boat, which could be hoisted easily on deck. However, in open-ocean situations, it is wiser to use an anchor-tending

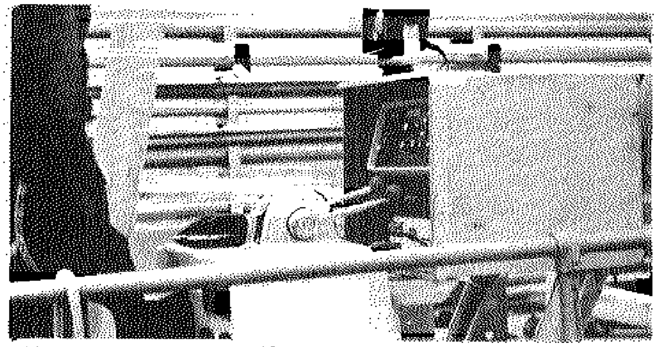


Figure II-19. Detail of steering/control console showing twin outboard controls, horn, ignition switches, and steering wheel. Water-tight box in front of console houses fathometer (mounted on top), LORAN-C system (in upper part of box), and marine radiotelephone/weather radio (in lower part of box). A plexiglass sliding door provides rough-weather protection. The plaque on the steering console reads, "Don't Start Vast Projects With Half Vast Ideas".

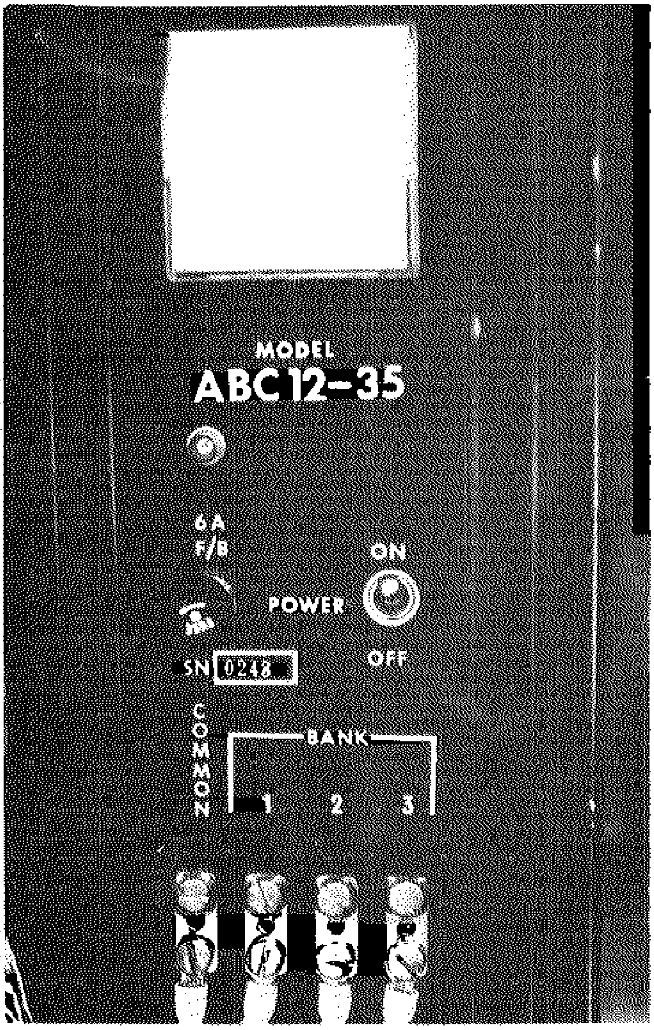


Figure II-20. Thirty-five-ampere battery charger is wired to bank of three 12-volt batteries for running winches. The charger automatically trickle charges the batteries so the unit can be left on overnight, if necessary. However, in the first year of operation, we found that the battery bank would power the winches for 3-5 days of coring without needing to be recharged.

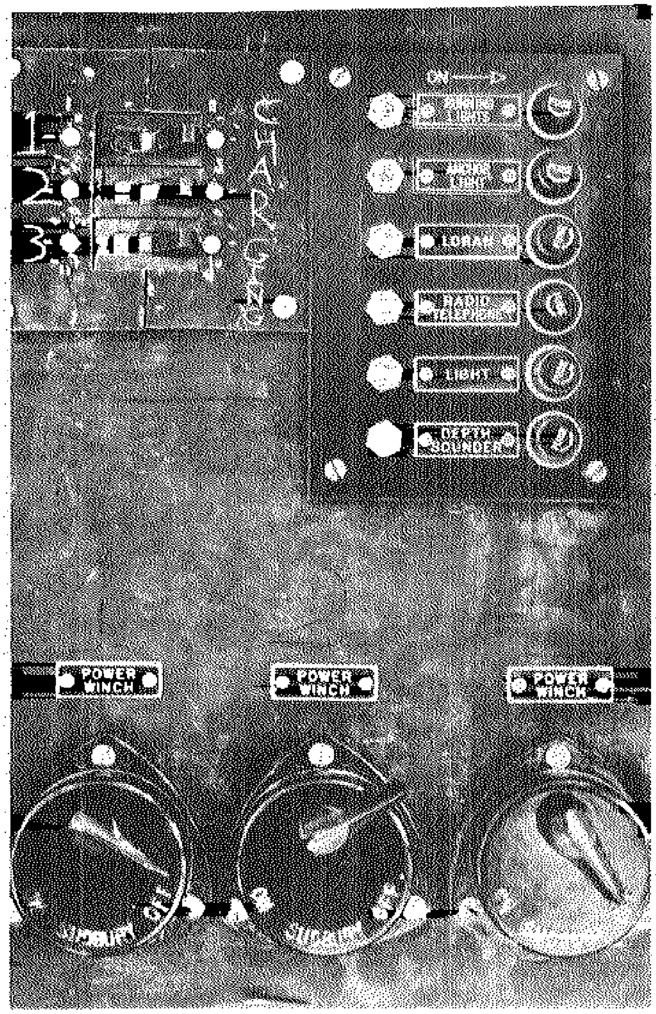


Figure II-21. The electrical switch panel, located below the steering wheel, consists of battery-charging switches in the upper left, a set of power winch switches in the lower area, and miscellaneous switches in the upper right. The charging and power winch switches can be engaged so that any one, two, or three batteries are involved.

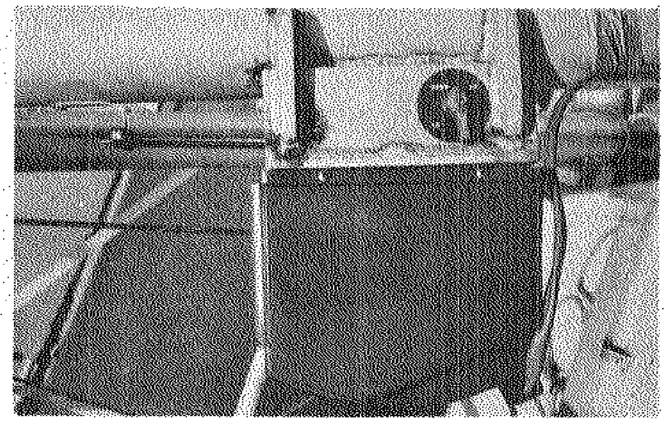


Figure II-22. The power winch for the main hoist has switch for power up and power down only — no free-wheeling is allowed by the winch unless overload occurrs. In that case, the mechanical brake can be adjusted using the wrench permanently stored above the winch. Figure II-23 shows how to tighten the brake with the wrench provided.

boat that is more seaworthy and faster; in case of emergency, you have the option to get back to shore quickly, or you can use the fast boat to obtain equipment or change personnel.

When a swift current is running, it is difficult to start the core in a perfectly vertical position; again, practice and common sense will help you. Use the hoist and leverage to your advantage, but be careful not to bend the aluminum core pipe.

Once the vibracore head passes down underneath the deck, it becomes risky to remove it from the core because it is easy to loose nuts and U-bolts; it is easier to remove it before the head gets near the deck, or, just let it go below water level. The large storage box may be used as a ladder to move the vibracore head up the pipe, if necessary. Be careful not to drive the vibrator head down

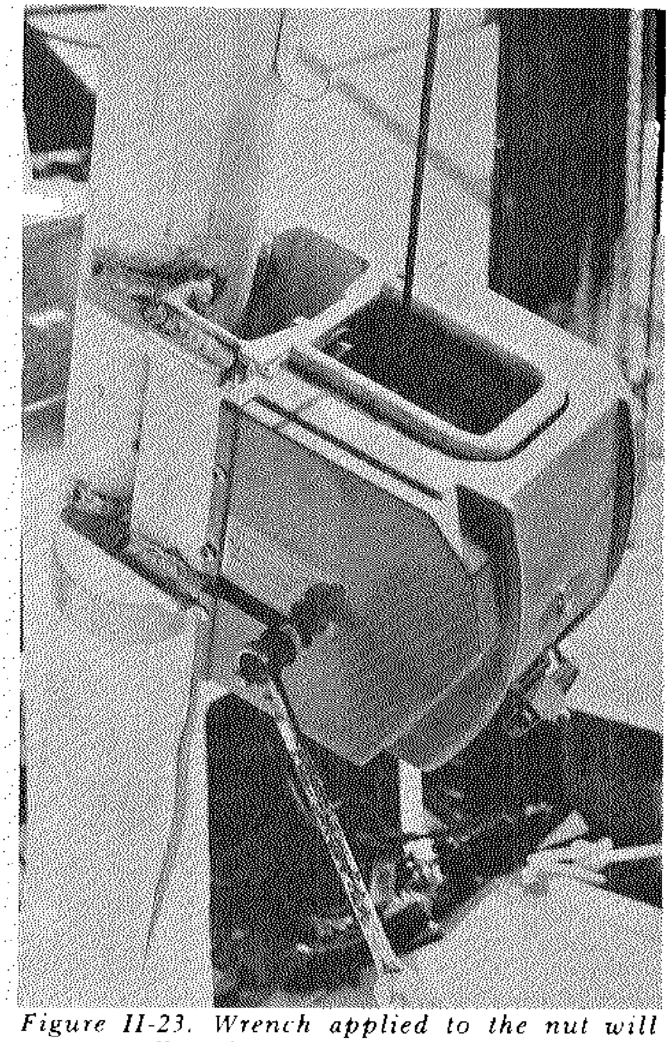


Figure II-23. Wrench applied to the nut will automatically tighten the brake if the load is pulling the cable out. The load can also be stopped by turning the power switch to "up". The power can be disconnected at lower right for winter storage. The winch itself can be removed from the bracket for storage, cleaning, and replacement of cable (if it gets frayed). The cable and winch should be tested periodically for safety and frequently checked visually.

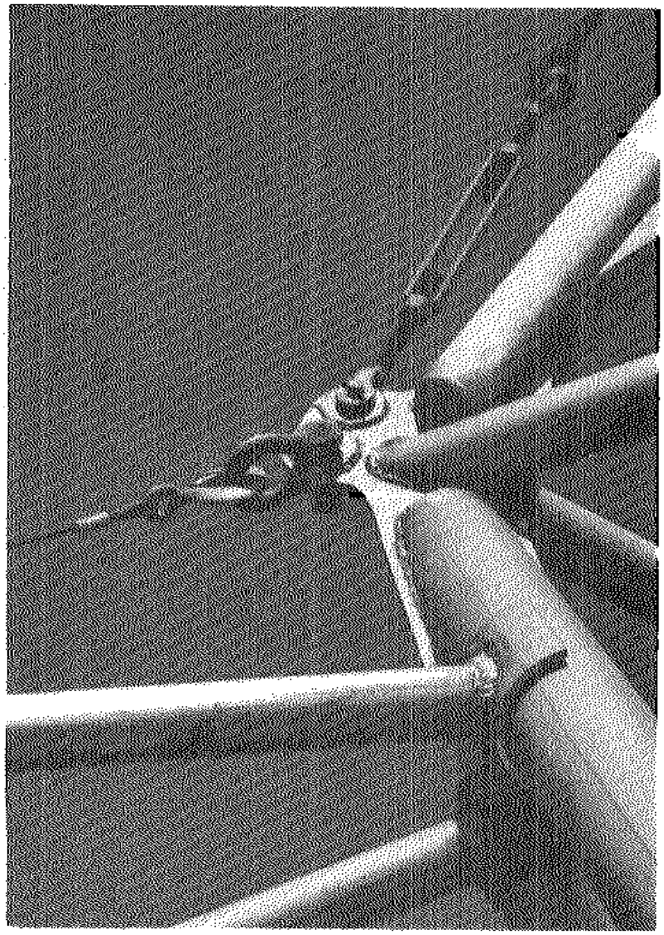


Figure II-24. Detail of main hoist guidance support system. Be careful not to pull the cable up too tightly into the horizontal support arms. The turnbuckle is used to adjust proper tension on top section of main hoist (see Figure II-25). A safety rope can be added in case of cable failure, but the rope would need to be removed each time the main hoist is lowered.

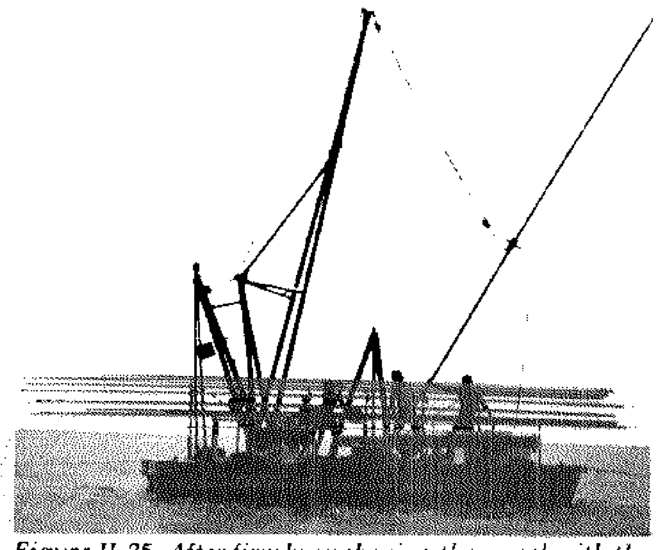


Figure II-25. After firmly anchoring the vessel with the three-point system and attaching the vibracore head to the pipe, use the hand pulley hoist to raise the 40-ft (12.2-m) pipe to vertical. Attach the head about halfway up the core pipe.

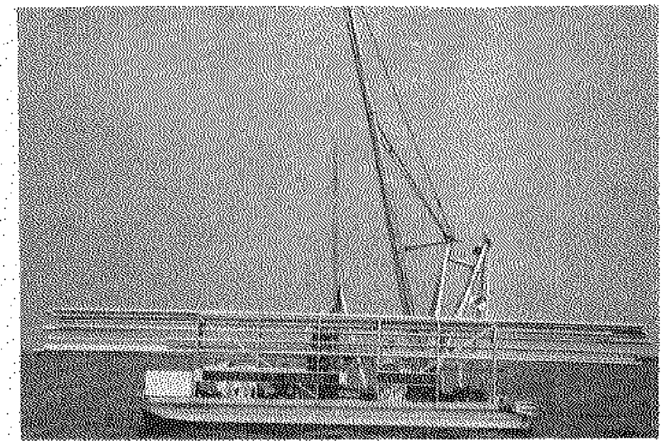


Figure II-26. As the core enters the sediment under the influence of the vibration, the hand hoist can be removed completely.

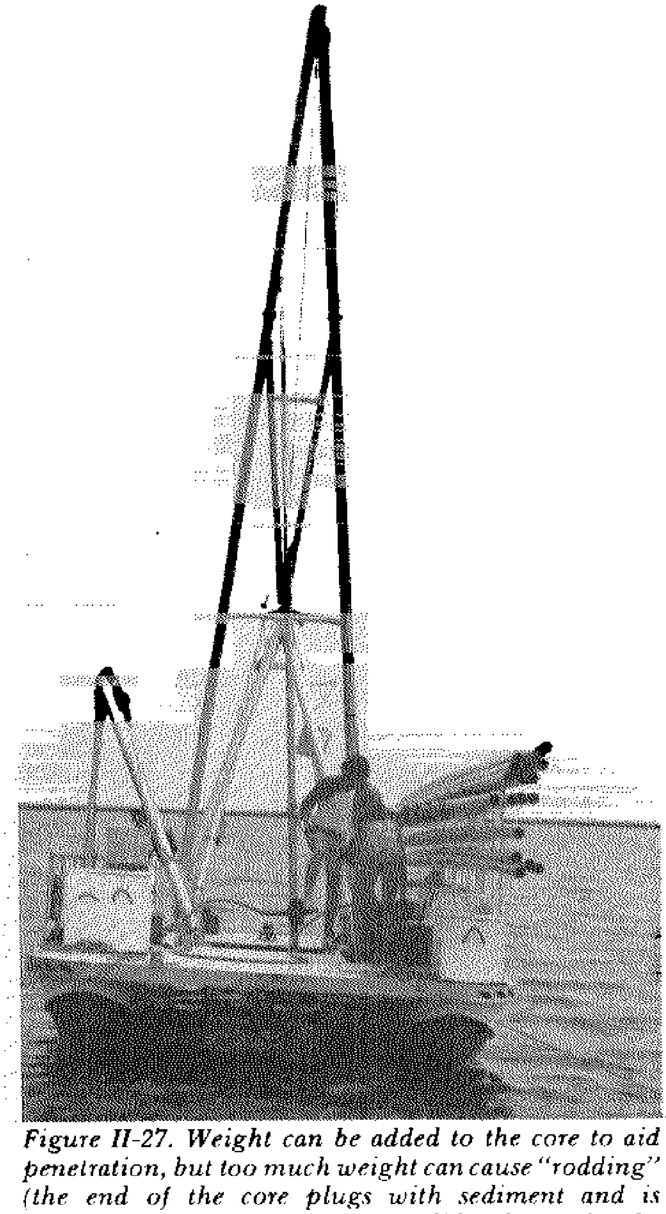


Figure II-27. Weight can be added to the core to aid penetration, but too much weight can cause "rodding" (the end of the core plugs with sediment and is subsequently driven down as a solid rod). Notice the tremendous capability to store core pipe on the rack and the 120° spacing of the three anchor lines.

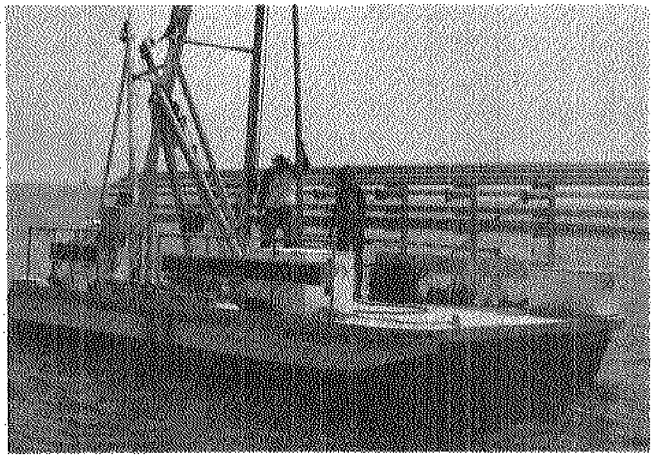


Figure II-28. The chief scientist must determine the point of refusal and be careful of the position of the head in relation to the bobbing deck. Usually, it is safer to remove the head from the pipe before pulling core out (see text for explanation of problems involved).

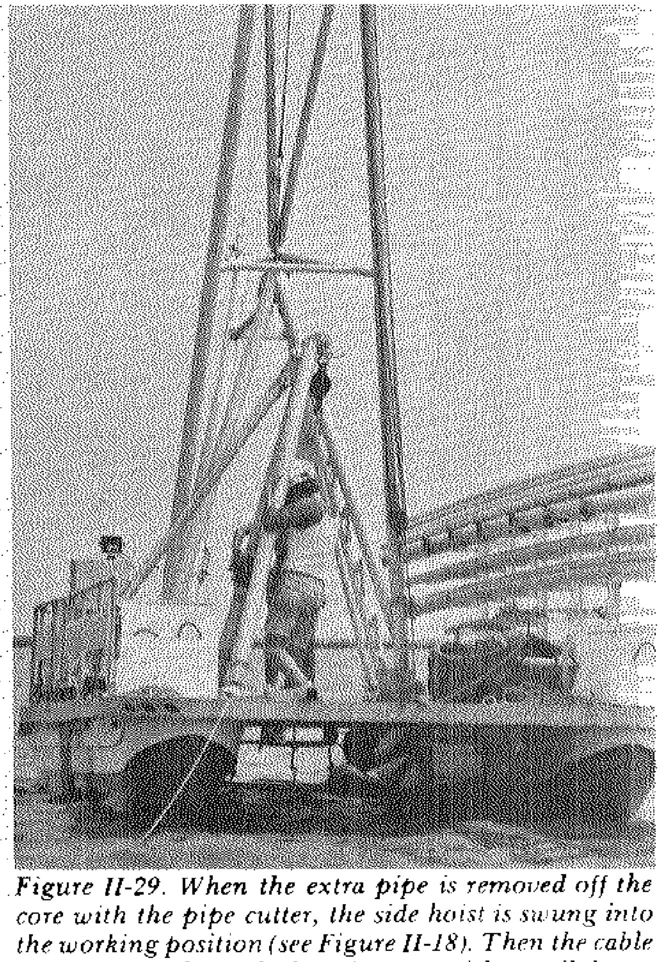


Figure II-29. When the extra pipe is removed off the core with the pipe cutter, the side hoist is swung into the working position (see Figure II-18). Then the cable is lowered and attached to the core with prusik knots (see ***Webster's Third New International Dictionary*** *(Unabridged) for a picture of this knot). The core must be filled with water and plugged with the gas main sealer. Caution must be exercised to prevent the boat from drifting over the top of the core. Adjust the anchor lines as necessary. Knotted safety ropes are strung from the center deck hole into the water so that individuals in the water have something to hold onto.*

below the sediment-water interface. Also, be careful not to allow the vibrator head to hook under or above the deck as the deck rises and falls with the seas.

After refusal has been reached, the pipe must be trimmed to allow it to be filled with water and plugged with a gas-main sealer. The head may or may not be removed. If it is not removed, there is a chance that is could be damaged by ropes. Also, the prusik-knot ropes may be damaged by the sharp edges of the head (refer to *Webster's Third New International Dictionary* for an illustration of the knot). To help prevent slipping of the ropes, one prusik knot can be wrapped on the top of the other. *Don't forget* to label the map orientation of the core before removing it from the bottom.

Careful measurements of core length should be taken before removing the core from the bottom. This will allow accurate determination of total depth of sample obtained, a vital statistic for radiocarbon dating and correlation.

Figure II-30. The cable from the side hoist can be doubled for maximum pull to break the core free from the bottom. Once the core has started out, a single line pull of the cable is sufficient to remove the core (and is twice as fast). Notice the hand hoist block and tackle are tethered to the main hoist cleat.

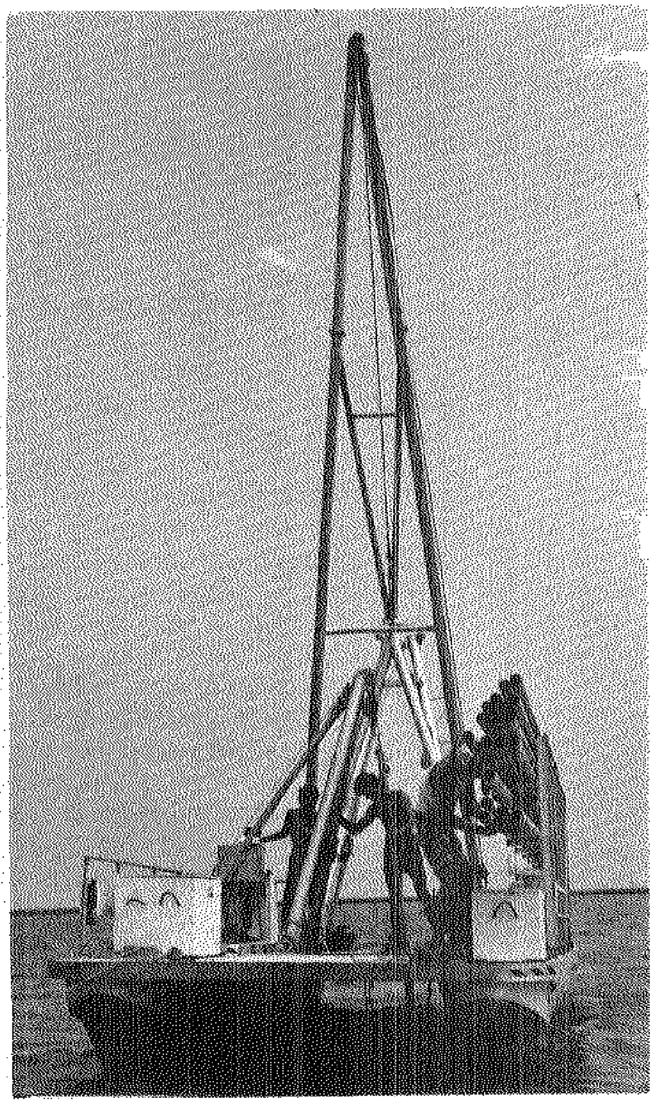


Figure II-31. Pulling the core out with the starboard hoist. The core pipes on the rack are secured with plastic shock cords. Note: whenever wrapping cable onto the winch drums, be careful to keep tension on the cable to insure even wrapping of the cable.

Once the pipe has been pulled out most of the way, it can be hoisted quickly using the main hoist block and tackle. The main hoist should be in full up position and the side hoist should be positioned outboard. For safety's sake, keep a wrap of the rope around the cleat at thigh-level on the main hoist. Once free of the water, the bottom of the core can be capped and moved into the rotating boot for lowering. Remember that you only have about 28 ft of length to pull from the deck to the top of the main hoist. For cores 30 ft or longer, it is suggested that two ropes be used to support the core, as described in Figure II-34. In rough water, the main hoist can be lowered all the way to the deck. In other cases it may help to partially lower the main hoist. Once the core is on the cross-brace horses, it can be cleaned, labeled, and sealed.

Trimming the vessel for seaworthiness is a tricky business (Figure II-35). Bringing the main hoist into the full upright position brings the bow up out of the waves, but also slows the vessel. Whatever trim you select, be careful not to have too much weight forward. This may happen when the anchor-tending boat is hoisted onto the bow deck. In the early days of the original R.V. *Phryne*, oysters piled high on the bow caused temporary sinking of the vessel when it plunged beneath a wave and didn't come up. A repeat of this would be easy if the bow is loaded too heavily.

The CMS harbor at Lewes includes a mushroom anchor and mooring designated for the R.V. *Phryne II*. However, at low tide, even with the shallow draft of less than 2 ft the outboards grounded. The starboard side of the vessel can be tied alongside the floating dock in the harbor until dredging clears the area where the vessel is moored. This will prevent further sediment damage to the outboards.

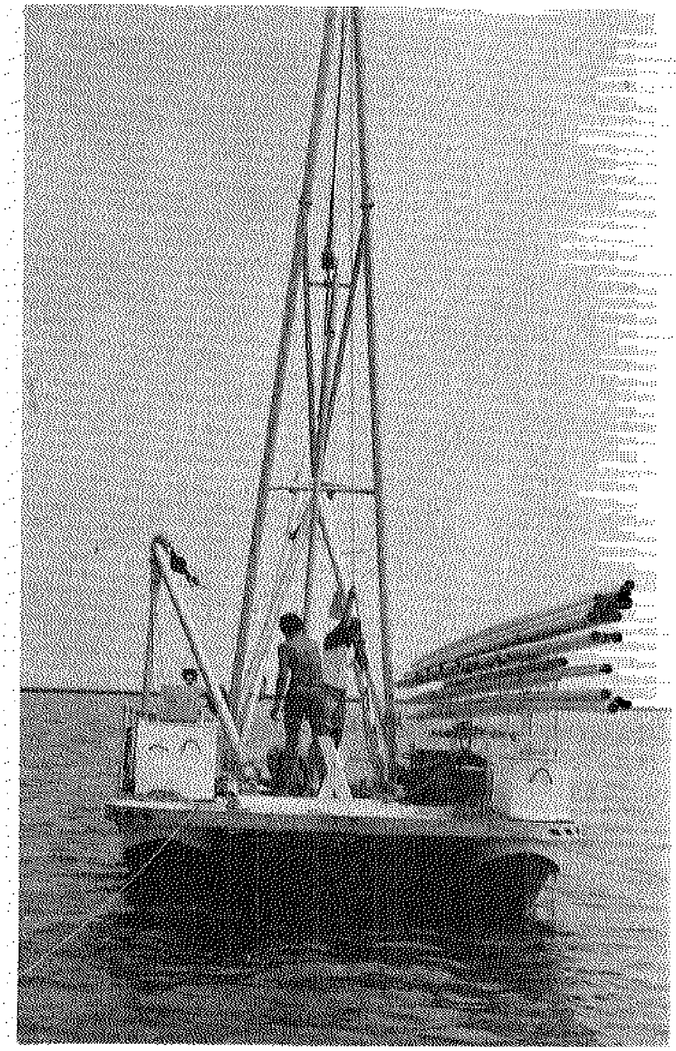


Figure II-32. Once the core pipe is out of the bottom (or nearly so), the main hoist block and tackle can be used to raise the core out of the center deck hole. The rope should be taken around the cleat for safety, but is improperly done here. An end cap is being placed on the bottom of the core to prevent loss of sample out the bottom of the core.

Use of the Barge for other Purposes

This boat is quite versatile and already has been used in marine seismic surveys and regional sediment sampling of Delaware Bay. The vessel can be used as is, with all the hoists attached, or the main and/or starboard hoists can be removed if they are in the way. The outboards (35 hp each) can move the barge at about 10 knots; therefore considerable distance (100 mi.) can be covered in a full summer work day. Potential uses of the barge are several, but it performs its designed function best of all.

Several modifications of the vessel could be made to equip it for other purposes. A wooden plywood cover could be placed over the center deck hole to eliminate the danger of falling into the water or losing equipment into the hole. Other additions could be made as necessary.

Conclusions and Future Improvements

The present capabilities of the marine vibracoring system are to obtain 3-in. diameter cores up to 40-ft long in water depth to about 60 ft. By using SCUBA gear and adding extensions onto the flexible shaft, this could be extended to about 75 ft. Furthermore, by using an electric motor-in-head vibrator (which the Department of Geology owns), this depth could be extended to the safe limit of SCUBA, well over 100 ft. Dangers associated with diving in murky waters with swift currents would have to be taken into account.

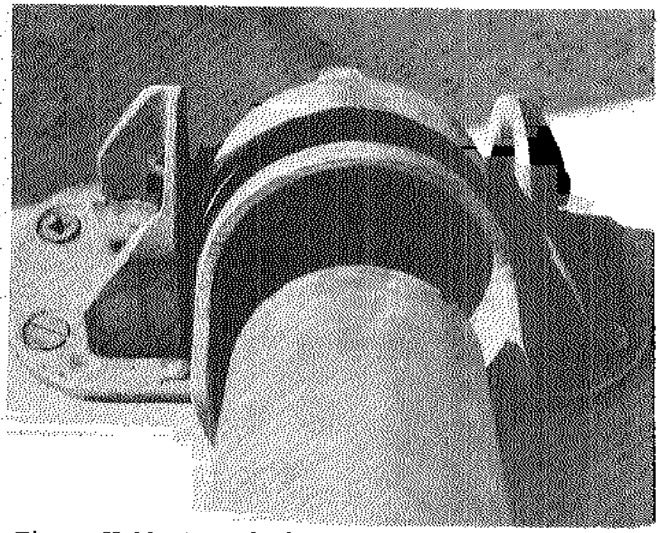


Figure II-33. After the bottom of the core is free of the deck, it is walked back into the core boot on the deck, which holds the base of the core while it is lowered onto the cross-brace horses. While the pipe is being lowered, someone should steady it to insure that it stays in the boot.

This next step, however, could be taken with minimal expense.

The present outboards provide a thrust of 70 hp, which is insufficient to bring the barge up on a plane. When these engines are traded in, it is recommended that larger outboards be obtained, perhaps twin 60-hp engines for a total thrust of 120 hp. Other barges of this type have been powered with 350 hp. Now, the barge is underpowered, but that is not all bad — it can be argued that a boat of this size should not go too fast. On the other hand, the barge is quite slow and uses a lot more gas by plowing through the water instead of planing off the top. Also, by being so low in the water, the barge deck, and the equipment on it, are continually getting wet (Figure II-35).

Other desirable improvements include installation of low maneuverability lights and day markers on the main hoist. Also, all-aluminum superstructures can be preserved better by painting them using the "Nupon System". Finally, touch-up painting of bare wood and bare metal surfaces (e.g. the steel trailer tongue extension) would lengthen the life of these components.

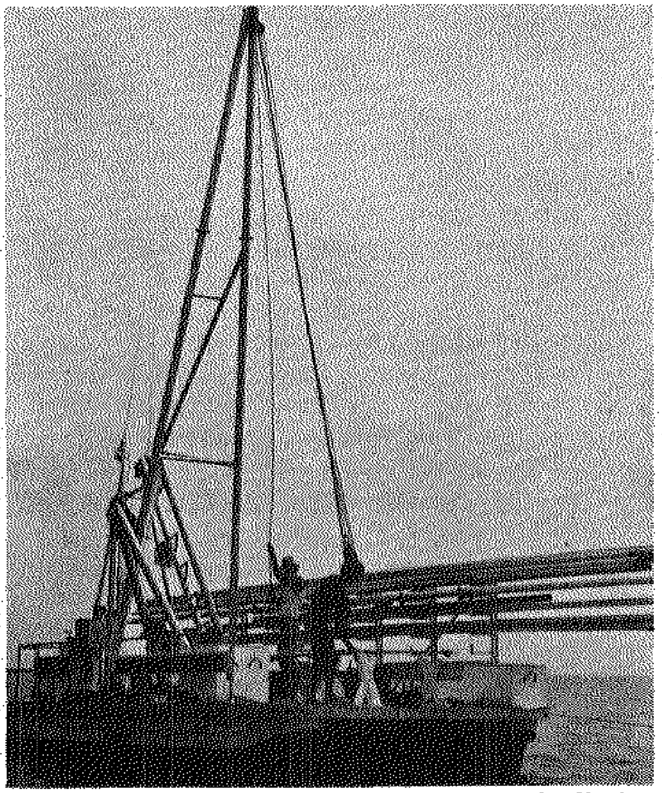


Figure II-34. The core can be lowered gradually by hand or by electric winch (if the weather is rough) onto the cross-braces shown. These supports keep the core off the deck and allow it to be worked on easily. If the core is over 30 ft, two ropes should be used to tie onto the core, one about 10 ft down from the top and another about 10 ft down from there. This will prevent bending of the pipe.

The present marine vibracoring system aboard the R.V. *Phryne II* could easily accommodate improvements as described above. This vessel, if properly maintained, should see service for the University of Delaware past the year 2000.

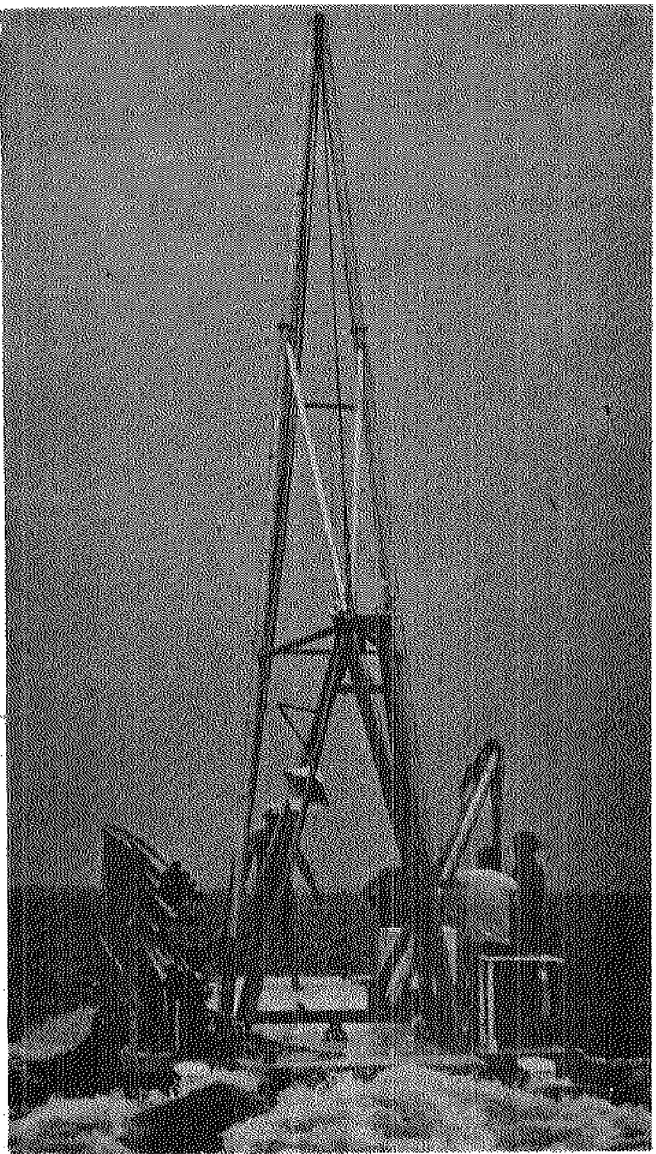


Figure II-35. People, gear, and the main hoist can be used to trim the vessel fore to aft and port to starboard. In heavy seas, it is better to have the bow up so that water will not flood the top of the pontoons and soak the deck.

III. Vibracoring in Coastal Environments: A Description of Equipment and Procedures

William H. Hoyt and James M. Demarest II

Introduction

Following the lead of other coastal research groups worldwide, the Department of Geology acquired the necessary equipment to obtain our own vibracores. Our system is modeled after the cement vibrator system described by Lanesky and others (1979). We have developed, however, specialized equipment and procedures that have greatly enhanced the ease with which cores are obtained. This is a description of the procedures used for vibracoring on land and in shallow water (less than 4 ft).

Vibrating a thin-walled pipe allows the pipe to slide into the ground because the sediment adjacent to the pipe becomes thixotropic. This sediment acts as a lubricant, allowing the core pipe to penetrate. Eventually, enough friction builds up to stop further penetration. The depth at which this occurs is variable depending on water content, lithologic sequence, weight on the pipe, and degree of consolidation. We have reached depths of 11 m (36 ft) in both Holocene and semiconsolidated Pleistocene sediments. Normal penetration is 5 to 8 m.

The advantages of this system over most other coring systems used in similar environments are as follows:

- Except for a zone of 1-2 mm adjacent to the core pipe, the sediment cored is virtually undisturbed. Few other techniques can obtain both continuous and undisturbed cores with excellent preservation of sedimentary structures.
- The cost of purchasing all the necessary coring equipment is relatively low (about $1,200 in 1978) and the cost for recovered core is one to two dollars per foot, depending on the amount of wasted pipe.
- The coring operation is relatively simple and uses all hand-operated equipment. All equipment can be transported easily in a truck or travelall and even has been carried in a station wagon. Because no heavy machinery is used, the operation is relatively safe and handled easily by two or more people.
- Due to the minimal disturbance to the ground or aquifers, no licenses or permits are generally required and landowners usually don't mind giving access to their property.
- Since all the equipment is hand carried from the vehicle to the core site (usually less than 100 m), cores can be taken virtually anywhere on land. Also, cores can be taken in shallow water when a small boat (generally not less than 16 ft long) or coring barge (see section II) is used for transportation.

There are a few disadvantages that should be kept in mind when designing a research program around this equipment.

- The depth of penetration is limited and controlled by the lithology. Sometimes, critical horizons will be just out of reach with this technique. Also, important lithologic breaks or unconformities usually represent planes of weakness and are therefore more susceptible to detaching and falling out the open end of the pipe during core retrieval.
- Core sites are limited to where access to water-saturated sediment is available. This usually means water table on land. In some areas, this will not be a serious problem, but think twice before packing for dry climates.
- The vibracoring technique will not, as a general rule, penetrate consolidated sediments. Areas that contain carbonate reefs or iron-cemented sandstones may need to be drilled by some other technique.
- Even if the sediment is unconsolidated or semiconsolidated, the vibracorer may have trouble penetrating more than a few meters. Experience has shown that medium to coarse, well-sorted sands, even when water saturated,

are difficult to penetrate. The pipe refuses to penetrate these materials and sediment clogs in the pipe, causing it to rod. Unfortunately, many beaches are unsuitable core sites for this reason. Where thin, well-sorted sands overlie soft muds, extensive rodding can also occur. Some of these problems can be overcome by reentering the hole with new pipe, as discussed later.

Required Equipment

Below is a list of the equipment that we use during vibracoring on land or in shallow water. The manufacturers and suppliers are listed for major items. This is for the reader's convenience but does not represent any actual or implied endorsement by the University of Delaware. In fact, it is our experience that substitutes are readily available and equally functional.

Power Source and Vibrator Head. We have successfully used two different systems for generating the necessary vibrations for coring (about 10,000 vibrations per minute). The most-used and older of the two methods is a 5-hp gasoline engine attached to the vibrator head with a flexible shaft (Figure III-1). The second method is an electric motor-in-head vibrator, which plugs into a portable 120-volt, 2600-watt generator. These are available from the sources below. If applicable, always ask about educational discounts.

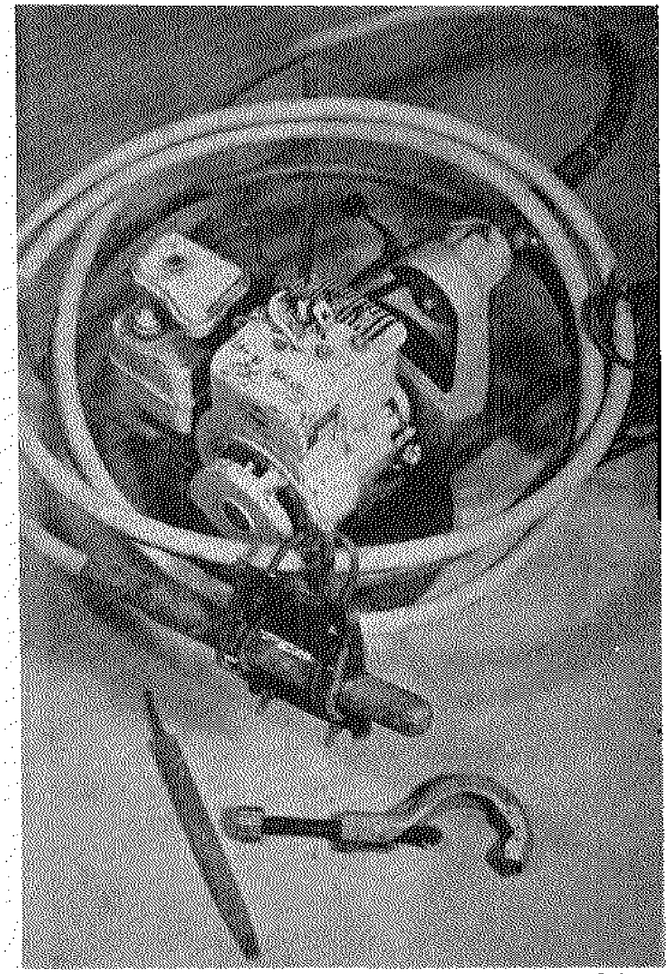


Figure III-1. Gasoline engine power source drives flexible shaft, which in turn rotates eccentric weight in vibracore head at about 10,000 vibrations per minute. Attachment devices shown along with tube cutter and hasp file.

Flexible shaft system:
Stow Manufacturing Co.
Brandywine Highway
P.O. Box 490
Binghamton, NY 13901
or
1630 Evans Ave.
San Francisco, CA 94124
Phone: (607) 723-6411 Telex: 932420

Description:
- 5-hp Briggs & Stratten clutch — two belt power transfer
- 21-ft flexible shaft
- 6½-lb vibrating head
- Cost: $800 (1978)

Electric System:
Stow Manufacturing Co.
Brandywine Highway
P.O. Box 490
Binghamton, NY 13901
or
Remington Manufacturing Co.

Description:
- Model YUB-21
- Motor-in-head vibrator
- 21-ft waterproof case
- On-off switch
- Weight: 40 lb.
- Cost: $900 (1978)

The Flexible Shaft system has been our workhorse since 1978. In an attempt to improve on this system in terms of ease of operation, the electric system was set up. Two problems developed, which have not allowed us to evaluate this system fully. First, due to a manufacturer's defect in the electric generator, the motor in the vibrator burned out after only a few hours use. The generator also burned out due to the defect. Second, cooling problems in the motor-in-head vibrator were more severe than anticipated, but, due to long delays in repairs to the equipment, this has not been fully evaluated.

The Flexible Shaft system is quite functional under most conditions, but it was hoped that the electric system would allow deeper penetration because it would remove the need to stop the vibrator to move the point of attachment up the pipe after about six meters. However, approximately equal penetration was achieved with both systems. The electric system also removes the need to carry the motor to the core site as extension cords can be used up to about 100 meters. A third type of system could be used, which combines advantages of the flexible shaft system with an electric motor instead of the gas motor described above. However, the gasoline-powered electric generator would still be needed.

Tripod. We use an aluminum, five-ton capacity tripod, 13 ft high, with three-in.-diameter, half-in.-wall, aluminum pipe for legs (Figure III-2). Ours was made in-house, but they can be obtained from

Acker Drill Co., Inc.
P.O. Box 830
Scranton, PA 18501
Phone (717) 586-2061 Telex: 837-415
Cost: At least $200

Check with the U.S. Army, Corp of Engineers, Coastal Engineering Research Center (Ken Finkelstein and Leita Hulmes) before making a purchase or settling on a design. They have recently developed a similar, but more advanced tripod.

Core Pipe. We obtained 3-in. O.D., .05-in.-wall-thickness aluminum irrigation pipe in lengths up to 12.2 m (40 ft). By ordering from our supplier in bulk quantities, we got the price down to $.70/ft. This item was difficult to locate, so get an early start and shop around. We suggest that you check with major aluminum manufacturers such as Reynolds or Alcoa, since the pipe probably will be made by them. Find out the name of a local supplier or try to buy direct at reduced rates. Note: aluminum pipe can be recycled at about $.25/lb. It is well worth the effort since about 20% of the original cost of the pipe can be recovered.

Comealongs, Cable Pullers, Power Winches. Several varieties of cable pullers are on the market and are of variable quality. We have found useful the kind with the option of a pulley (Figure III-2). In any case, we suggest two, one-ton-capacity models. These can be obtained at hardware and department stores, but make sure there is at least 12 ft of cable. Cost: $30-40 each.

If power winches are used on a barge or on land, we recommend one that has power-in and power-out capacity. This safety feature will prevent the possibility of dangerous free-wheeling.

Prusik Knot Line. We use ⅜-in. polypropylene line (ski rope), which has a tensile strength less than the cables on the comealongs. If something is going to break, you want to be sure that it is the rope. We have found that the

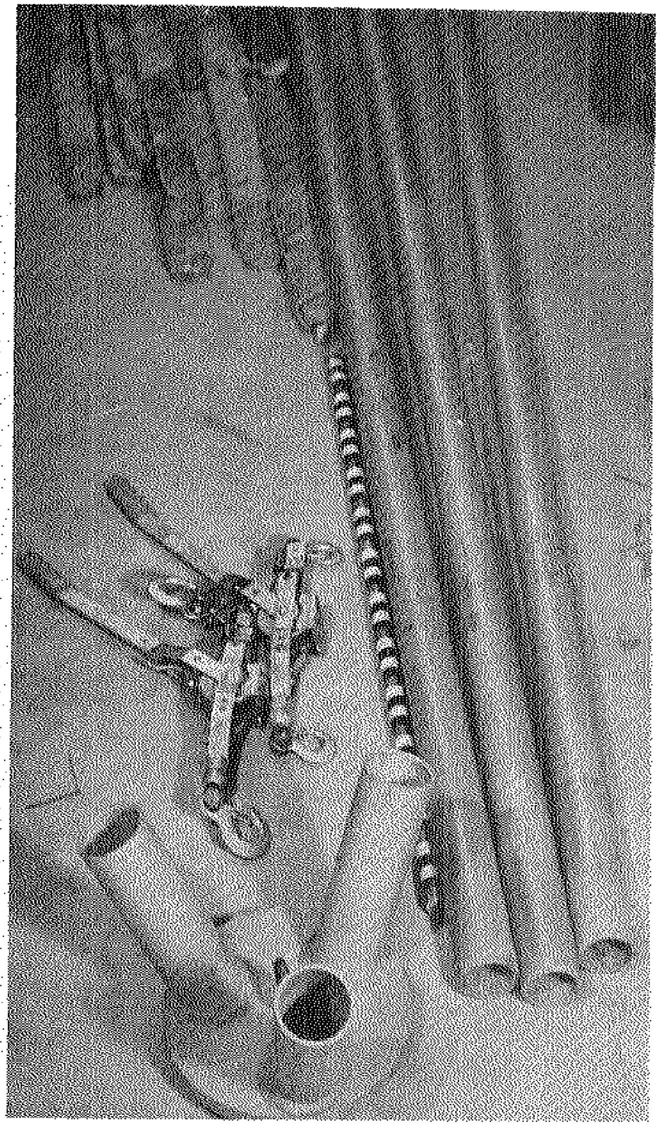


Figure III-2. Comealongs and tripod for removing cores.

polypropylene is best because it does not stretch much, and it is easier to handle when wet and dirty than nylon line. The stretchiness of nylon is dangerous if it breaks. Cut about a 6-ft length of line, tie the ends together, and tape the bitter ends. You now are ready to tie a prusik knot around the aluminum pipe for extraction.

Other Equipment. *Gas main sealer*. This is used to seal the end of the pipe before extraction. We use a "Type A" expandable plug, 2¾ to 3¼ in. Write to Safety Gas Main Stopper Co., 525 Atlantic Ave., Brooklyn, NY 11217. Phone: (212) 875-4421. Cost: $8

Tube cutter. Any tube cutter for three-in. pipe will work. Available at most plumbing supply stores (Figure III-1).

Core to vibrator attachment device. We make ours from six-in. I-beam with flanges cut off on one side, and flanges trimmed on the other. The attachment is about eight in. long and is fastened to the vibrator head with U-bolts on the flat side (Figure III-3). A piece of three-in. I.D. steel pipe is welded to the inside of the other side (Figure III-4). Muffler-type U-bolts (three-in.) are used to hold the core pipe to the vibrator. Note that the vibrator is mounted perpendicular to the core pipe (Figure III-3).

Roof core rack for truck. Full cores can be carried from the field in two ways:

1. Cores can be cut into one- to three-m lengths for transportation inside the vehicle, or

2. Full-length cores can be carried on a specially designed roof rack.

The latter method preserves full, undisturbed cores and takes less time in the field. A core rack on the roof is necessary, in any event, to carry empty core pipes to the core site. We made ours by drilling three-in.-diameter holes in the middle of two 2 x 4-in. boards, six feet long. Each board is notched to create three-in.-diameter half circles, into which the core pipes can fit securely. A flat board can be tied across the top of the rack to secure the pipes. These core racks can be tailor-made for a specific vehicle.

Carbide-tipped saw blades. We use a standard two-hp hand circular saw with carbide-tipped

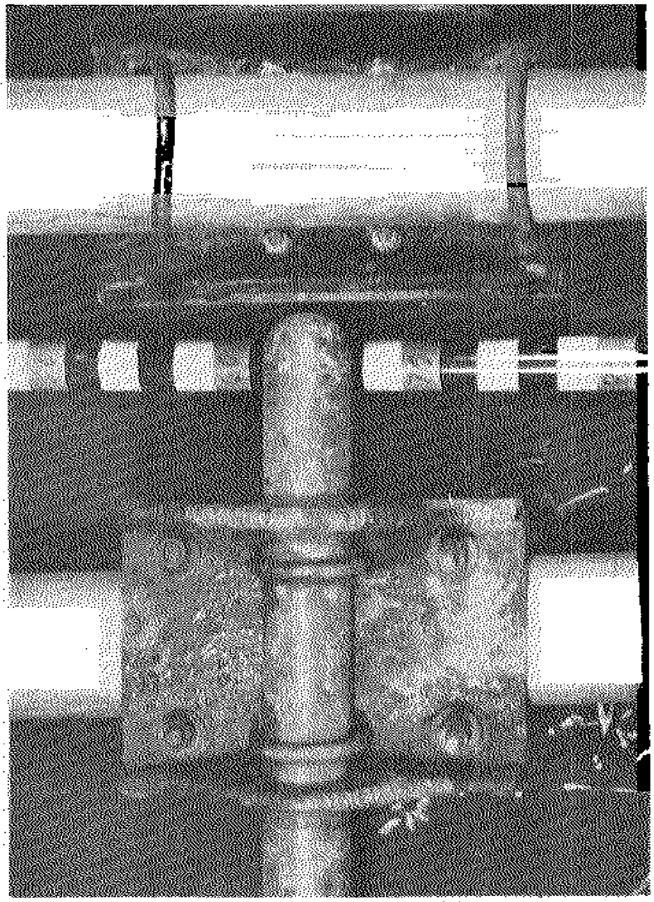


Figure III-3. Detail of vibracore head bracket showing method of attachment (bottom) and bolting aluminum core pipe to bracket (top). Scale is in 2-cm increments.

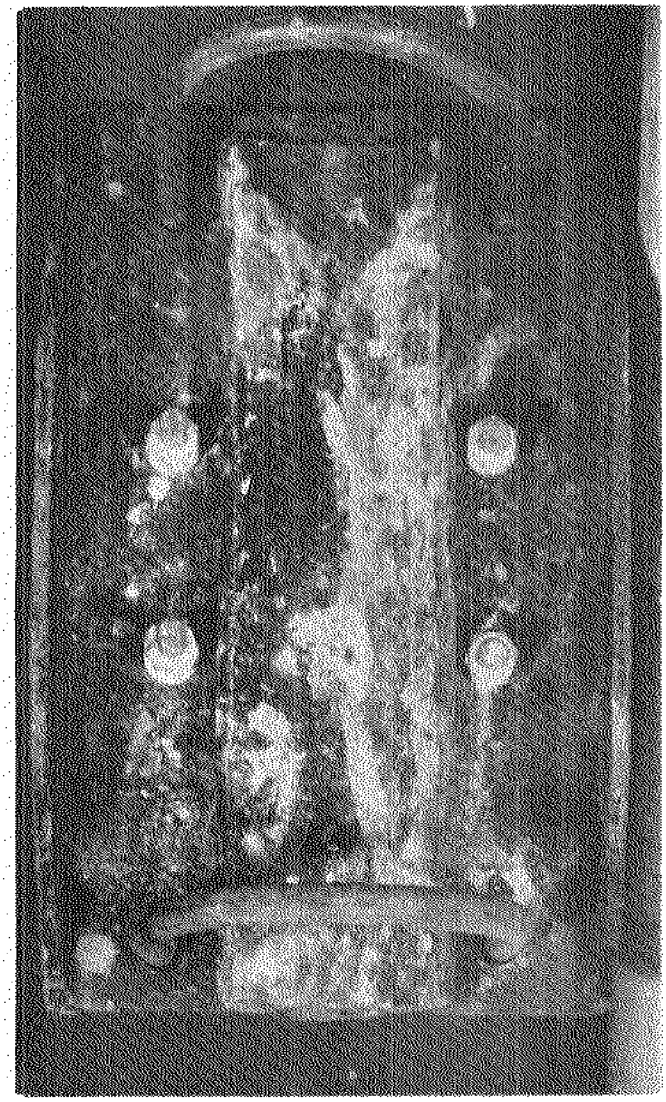


Figure III-4. Detail of aluminum-pipe mating sleeve on vibracore head. This curved sleeve prevents flattening of the aluminum core pipe when the "U" bolts are tightened.

metal cutting blades to open the cores (try Black and Decker no. 73-247130247. Cost: $9 each).

Plastic end caps. These caps fit over the ends of the core pipe and are taped on in the field. Ours are made to order by Franklin Fibre-Laminex Co., 902 E. 13th St., Wilmington, DE 19899. Cost: $125/1000.

Polyethelyne core wrapper. This is a clear tube of plastic that slides over the opened core sections. Ours are from Cadillac Plastics, Airport Industrial Parkway, Pensauken, NJ 08109. Cost: $50/1000 ft.

Miscellaneous items. Ratchet wrench, hacksaw, hasp file, sample bags, aluminum foil, black electrician's tape, magic markers, pocket knife, Brunton compass, twist bag ties, tool kit, first-aid kit, bucket, etc. We have had limited success with a piston to prevent rodding during the coring operation. Lanesky and others (1979) report they have had success with the piston, but our experiences suggest otherwise. A thin spring steel core catcher mounted in the bottom of the pipe reportedly prevents loss of sediment out the bottom of the core (personal communication, R.N. Ginsburg).

Coring Procedure

The first task in coring is to decide on the coring site. Remember that it is generally best to try to minimize the distance that the coring equipment must be carried. Also, remember that you must have access to water-saturated sediment. Once the coring equipment has been transported to the site, set up the tripod to make sure that it will be stable during extraction (Figure III-5). On land or in shallow water, it is best to plan on reentering the hole at frequent intervals (two m or less) to prevent rodding and to increase the total depth of penetration.

Attach the vibrator to the core pipe as near to the top as possible (no more than about six m from the bottom end). Don't attach it any closer than about 30 cm from the top so that the end of the pipe is not deformed. This will make it much easier to insert the gas main sealer later. If you plan to reenter the hole, use a short piece of pipe to start (2 m) and set up progressively longer sections for later use. Sharpen the end of each section of pipe using the rasp file. It seems to help if the end is notched with the file as well. You are now ready to begin coring.

Carefully raise the pipe to a vertical position over the spot to be cored. This is generally about one ft away from the point directly beneath the tripod. Make sure there is plenty of room to lower a full 12-m section of pipe on the side of the tripod that you begin on. Also make certain that there are no power lines or other obstructions to the raised pipe. It is also a good idea to walk along the side of the road or around the field to check for underground pipe or cable markers. Gas mains and telephone cables are generally well marked, but storm sewers and water mains are not.

With the core standing upright, start the vibrator motor and allow the core to enter the ground under its own weight (Figure III-5). Once a meter or so has been penetrated, it is no longer necessary to hold the pipe. Allow the pipe to penetrate under it's own weight for as long as it continues to do so. If you are a meter or so above the water table to start with, it may help to pour water around the core pipe to help lubricate the outside. It also helps to dig a small hole and fill it with water before standing the core pipe. This wets the inside of the pipe as you core.

As the rate of penetration slows, first try varying the speed of the motor (if it has this

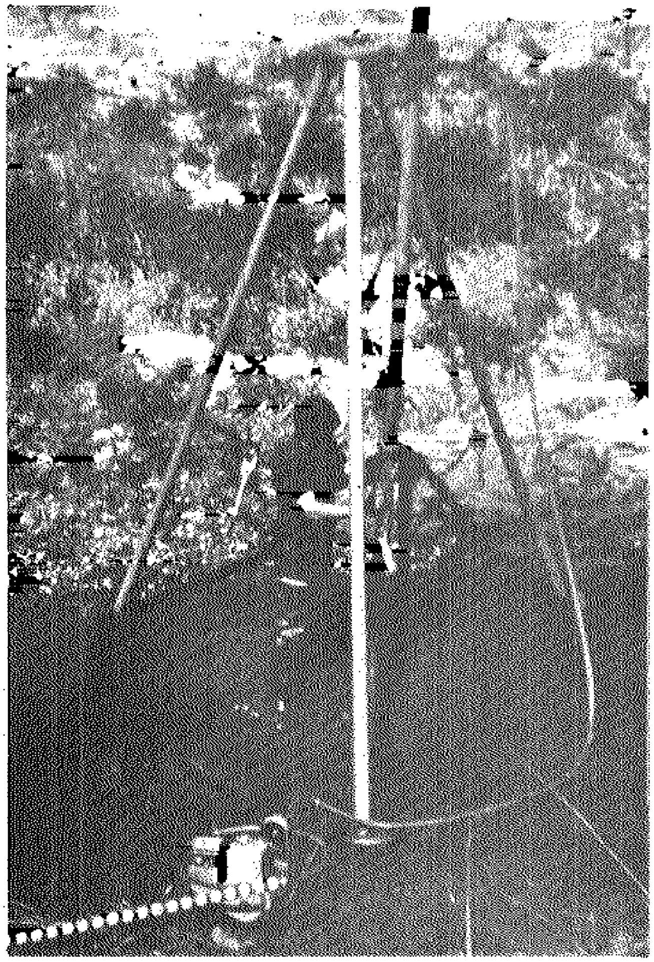


Figure III-5. Tripod set up in southern Delaware at Dirickson Creek Agricultural Ditch. Vibracore is entering sediment under its own weight.

capacity). In some cases, certain vibration frequencies work better than others. Constructive interference can be set up to create what we have termed the "jackhammer mode". If penetration stops under its own weight, or becomes extremely slow, try pulling down on the core pipe with the prusik ropes, or standing in the prusik rope loop (Figure III-6). We have found it much more comfortable to stand in a large rubber strap attached to the prusik rope (we use standard mooring shock straps, which are available at most marine supply stores). This prevents early arthritis in the joints and keeps graduate students at normal intelligence levels. We have stood as many as three people on the pipe for extra weight (about 500 lb). This can be counterproductive when you have the capacity to reenter the hole because it can increase rodding (causing gaps in the core recovered) and it can be time-consuming as well as hard on the "weights". Experience will allow one to judge when to quit. During the entire coring procedure, check the vibrator *frequently* to make sure it is not overheating. This will damage the vibrator, since it was made to be used submersed in water or concrete. It can be cooled effectively by pouring water on it while it is running. This is particularly important if the motor-in-head electric system is being used, since the electric motor is easily damaged by excess heat.

Caution must also be exercised during coring for personal safety and to protect the equipment. For example, never attach the prusik knots onto rough edges of the pipe or the attachment device — the vibration will cut through polypropylene like butter. Also, the top of the core can cut easily into shoe soles if one stands on top. Finally, do not allow the vibrator head or flexible shaft to get hung up on the tripod or derrick.

When the end of the pipe or refusal is reached, turn the vibrator off and prepare to extract the core. Remove the vibrator head from the core pipe. Before going any further you must mark north on the pipe (use a pocket knife), measure the amount of the pipe above ground level, and measure the depth to the sediment inside the pipe. The two measurements are essential to reconstruct the depths of the cored sections. It is best to have the chief scientist or his appointee responsible for making sure these measurements are taken every time since they are easily forgotten in the excitement.

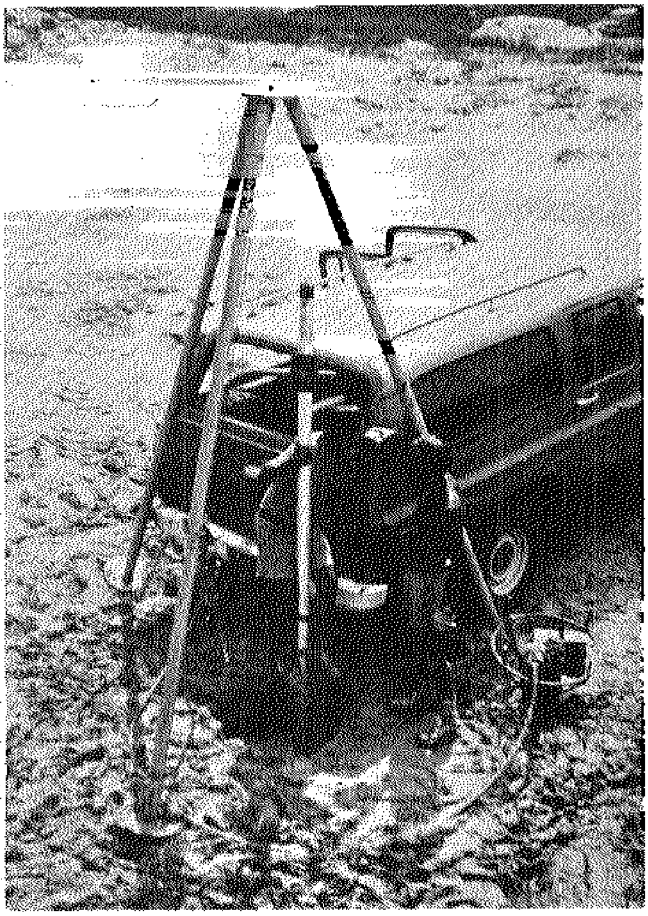


Figure III-6. Vibracoring in southern Delaware at the Harvey Justice gravel pit. Weight is added to the core by standing on prusik ropes.

Next, attach the vibrator to the next section of pipe to be inserted in the hole and ready the next pipe for insertion immediately after the first section is extracted. Fill the core pipe above the core sediment with water, seal the end with the gas main sealer, use prusik knots to attach the comealongs to the core pipe, and begin raising the core. It usually takes both comealongs and considerable effort to begin moving the core out of the ground. Once the core is "broken loose," a single comealong can continue to raise the core pipe while the other is attached to the pipe near the ground to take over when the one pulling runs out of travel. In a few minutes, the core pipe will be nearly out of the ground, and it will have to be lowered as discussed later. Once it is lowered, the second section can be inserted quickly in the same hole and pushed down as far as possible without vibration. In very soft muds, it may be best to start the vibrator before the core pipe is pushed past the depth of penetration of the previous core section. Continue coring as with the first section.

As each section of core comes from the ground, the end must be plugged, the north arrow must be transfered to the lower part of the core, the section must be labeled with a numbering system, and the length of pipe must be measured. Cut off the upper end at the top of the sediment inside the pipe (at the inside measurement taken before extracting) and cap the end. The difference between the inside and outside measurements before extraction is the amount of rodding, and the total length of pipe, minus the amount above ground before extraction, is the total depth of penetration. This is the depth that must be reached with the second section before new sediment is sampled.

This procedure can be continued indefinitely (up to 40 ft), with each successively longer section of pipe. The inside measurement after the first section is meaningless except as a measurement for how much pipe must be cut off before the top end is capped. Sediment is scraped off the side of the hole as each new section is pushed down the hole, so that the inside measurement is not a measurement of rodding (after the first section). It is of paramount importance that the outside measurement be taken each time so that the total depth of penetration can be calculated by subtracting this measurement from the total length of pipe. Cut off each section at about one to two m above the depth of penetration of the previous section or at the top of the sediment inside the pipe, whichever is lower. There is no point in carrying back to the lab and opening three m of scraped sediment from depths already sampled when only the bottom meter is new core. The depth of the bottom of each section of core is easily calculated in the field and is essential for determining the depth of various lithologies cored. Upon opening in the lab, the amount of rodding can be determined for each section. This will be discussed later. Also note that as the coring becomes deeper, substantial amounts of water will be required to fill the core before sealing the end before extraction, so plan to have access to plenty of water.

Lowering the full sections of core after extraction is the most dangerous part of the operation. As each section becomes longer, this problem becomes greater. Full core pipe weighs about 10 lb/ft. Therefore, a full section of pipe, 40 ft (12 m) long weighs between 300 and 400 lb, depending on how much water is in the top. This pipe must be held vertical until the bottom comes out of the ground and then the whole pipe is lowered, ideally at rates below those produced by gravitational acceleration. This is generally not a problem for sections shorter than about six m (20 ft), since the tripod is stable enough and the personnel strong enough to keep things under control. We usually tie a lasso around the tripod and core pipe and slide it to the top of the tripod to keep the core vertical until everyone is in position. Once the bottom of the core leaves the ground, the vertical pipe becomes unstable as the bottom can swing out from under the pipe. One person must be assigned to keep the end of the pipe in place. All comealongs should then be detached and fastened out of the way. The pipe can then be lowered by walking away from the tripod in reverse "Iwo Jima" fashion. One person on the bottom end and two people walking toward the top usually is sufficient.

For core pipe longer than six m (20 ft), lowering becomes much more difficult. With two people on the bottom end and four people lowering, we have handled up to 9 m (30 ft) without undue strain. For pipe longer, we usually clear everyone out of the way, attach a comealong to the base of the core, and let the pipe fall. The rope used to hold the pipe at the top of the tripod is used to slow the rate of descent as much as possible. Remember that it is better to damage the pipe a little than to damage the coring crew. Also be careful not to tip the tripod; this can be both damaging and dangerous. In standing water, the core can be felled and it will come through it all unscathed because the water cushions the fall.

Opening, Photographing, and Describing Cores

It is generally agreed that the best way to transport core sections to the lab is in meter

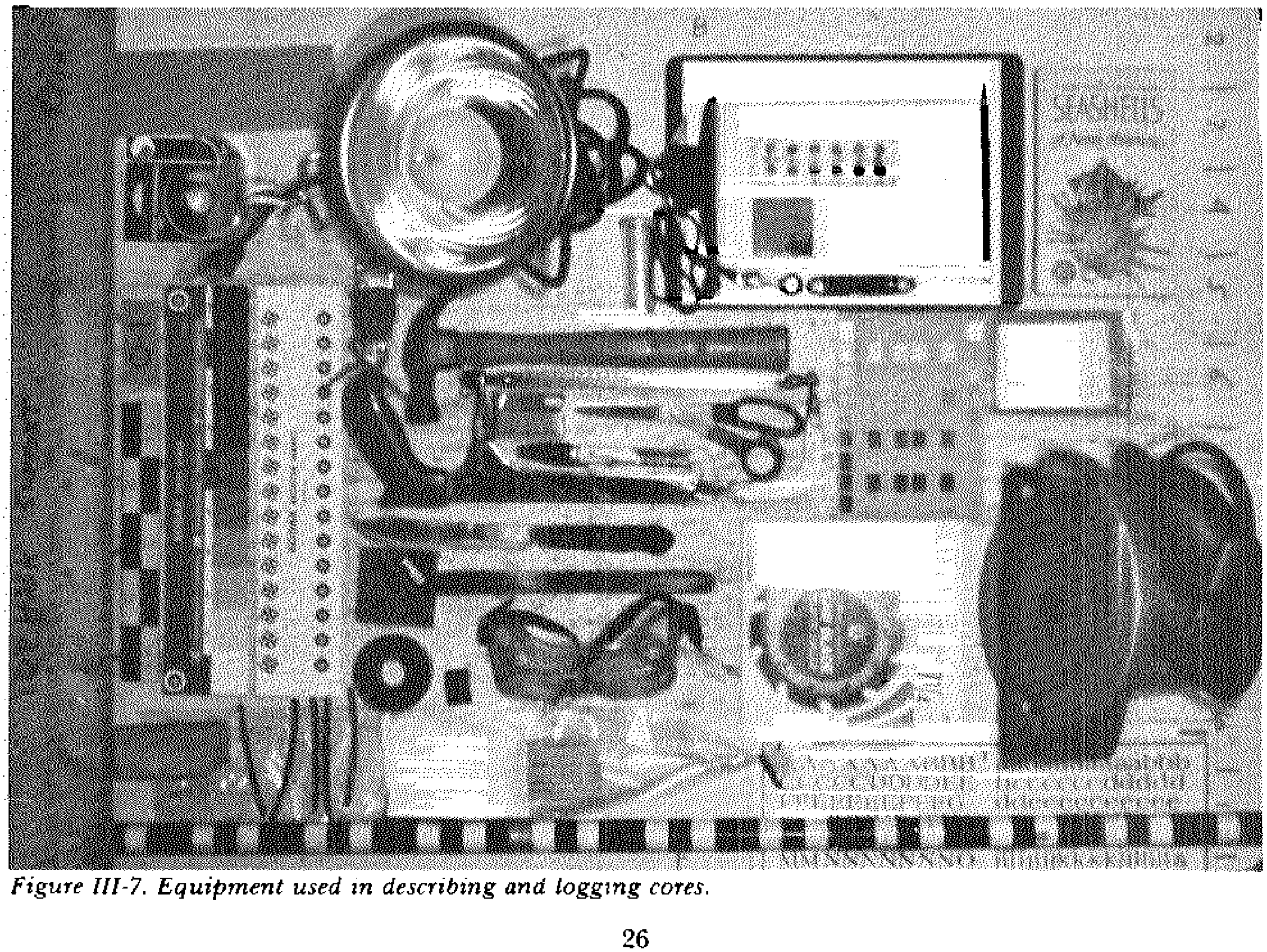


Figure III-7. Equipment used in describing and logging cores.

sections standing vertically. This is often difficult in most vehicles. We have found that they can be transported horizontally in longer sections if they are well supported. Vibration, rolling, and bumping can cause substantial disturbance to the sediments if they are not well packed to start with.

We have experimented with opening cores in the field or at the field base. Scientifically, this is very useful because the next day's cores can be taken based on an evolving model of the geologic history or stratigraphy. This must be weighed against the importance of laboratory analysis of the data, since it is difficult to transport opened cores without destroying or disturbing the sediment. If they are cut into meter sections and laid horizontally with plywood between layers, they can be transported effectively. However, all this is time-consuming and must be weighed against the need for many cores in a given amount of field time. The procedures for opening and describing the cores are the same whether in the field or in the laboratory. Equipment and materials commonly used in describing and

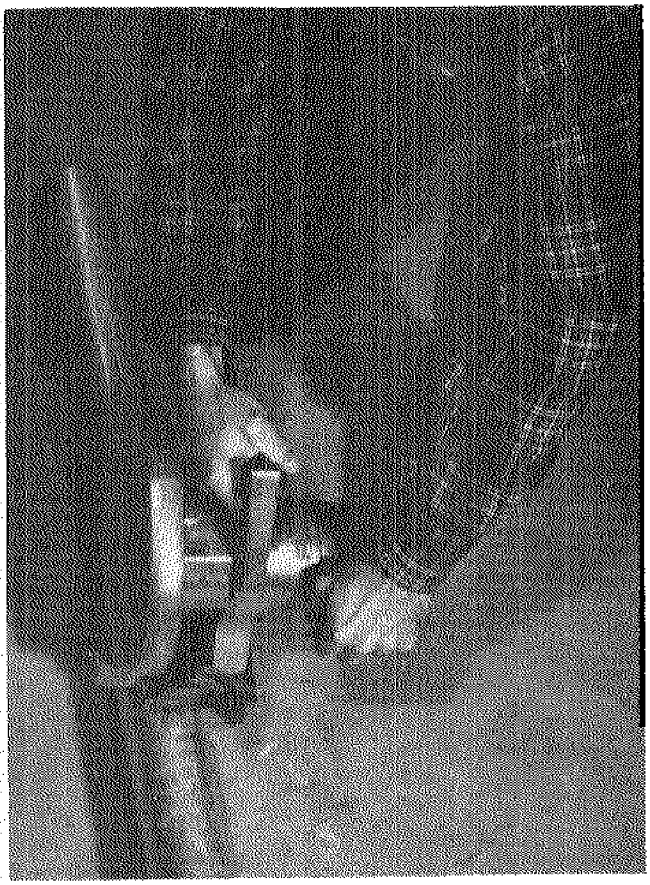
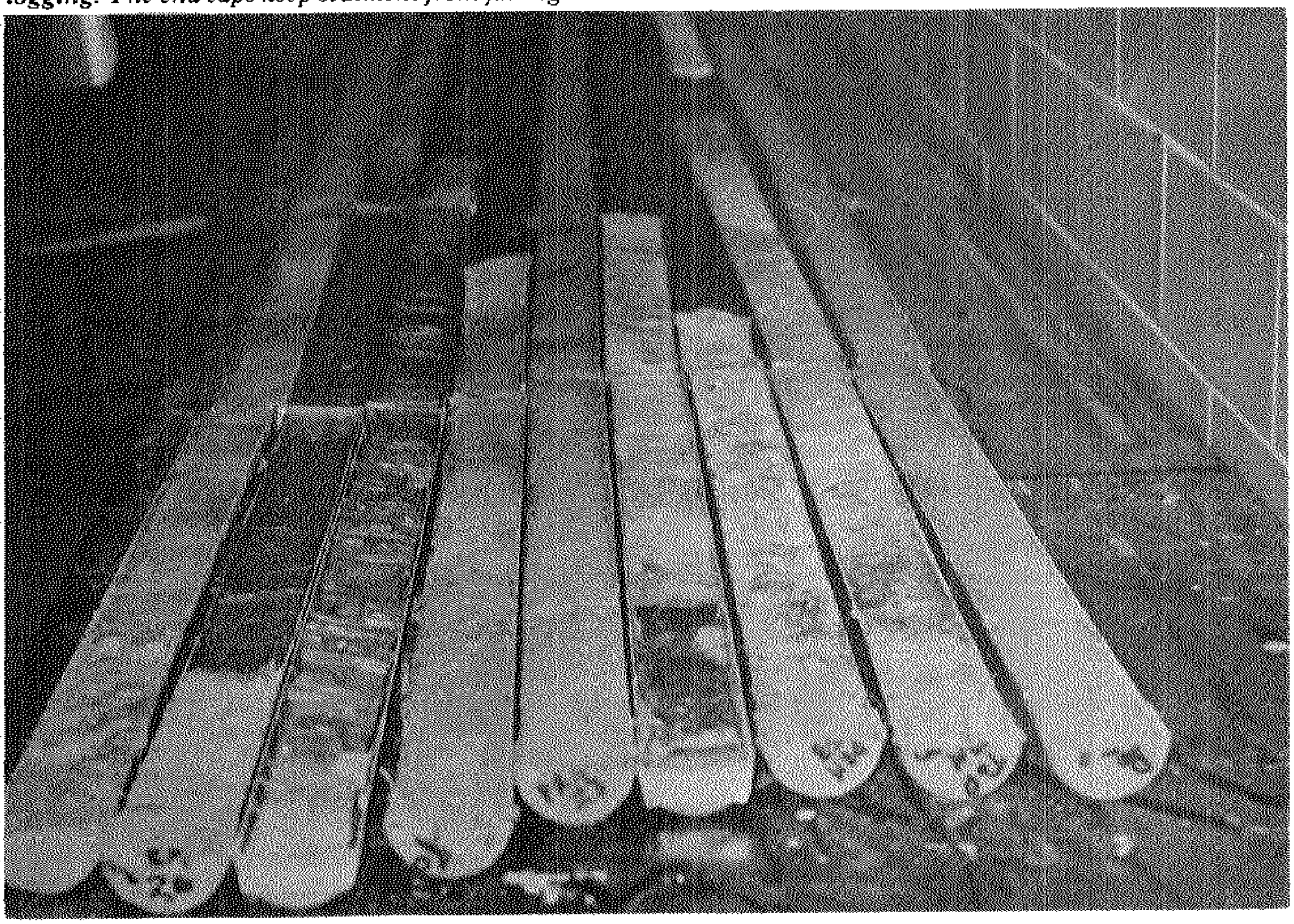


Figure III-8. A circular saw equipped with a carbide-tipped blade is used to open the oriented core pipe.

Figure III-9. Vibracores split open and displayed for logging. The end caps keep sediment from falling out.



logging cores is displayed in Figure III-7. Appendix A shows a standard core description form described in detail later.

Lay out all the sections of a single hole with the "up" end in one direction. This is made easier if the end caps were labeled with the core number, section number, and top or bottom when the core was taken. The cores are opened with a 7-or 7¼-in. circular saw with a carbide-tiped metal cutting blade (Figure III-8). A cut is made down each side of the core, with the depth of cut set at just enough to penetrate the thickness of the pipe wall. We use a carpenters chalk line to mark the line of cut. Decide which orientation of the core you want to look at and cut appropriately (e.g. the east-west section must be cut on the east and west sides of the core). While cutting, *always wear safety goggles and ear protectors* as sharp metal cuttings fly and the noise is deafening. After both sides have been cut, take a knife or wire and slice the sediment in the core. We prefer a length of fine piano wire tied to handles because it is thin and strong. We have tried an electro-osmotic knife, but found that the shards of aluminum continually shorted out the knife.

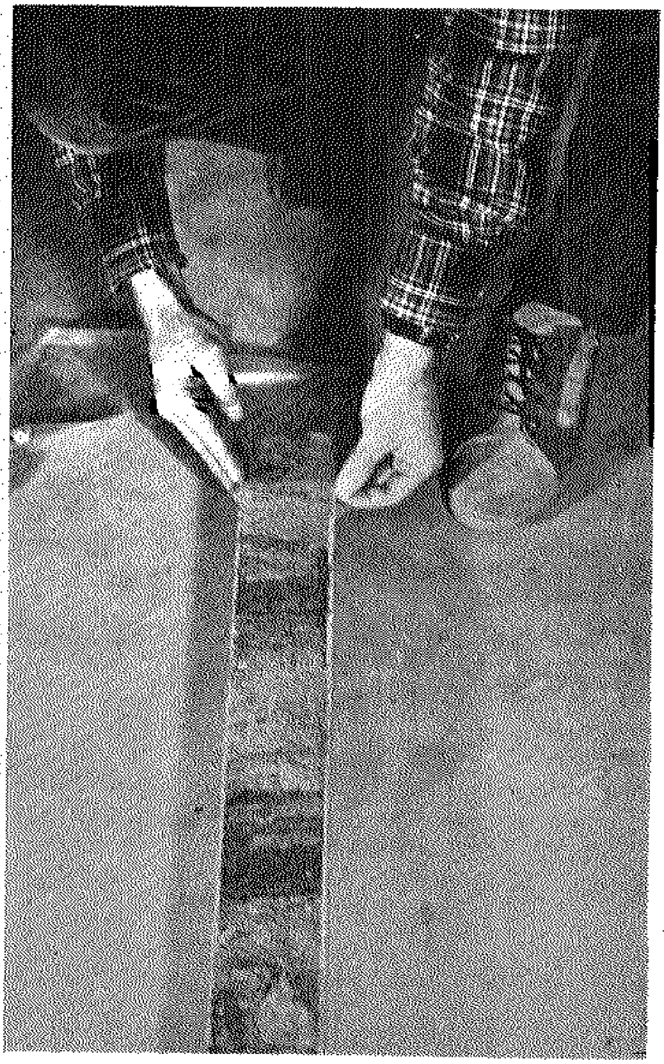


Figure III-10. Clear polyethelyne sleeves can be slipped over cores to protect them. A 12-oz soda can and a core end cap will facilitate puting the plastic over the cores.

Separate the two halves of the core and lay it out on the bench or ground. Repeat the procedure until all sections of a single core are opened (Figure III-9). Some people prefer to open a number of cores and then describe them all. Others prefer to open them one at a time and describe and photograph them one at a time. Both methods have merit so it's your choice.

When more than one section for each core exists (the hole was reentered) the depth relationship of each section to the entire core must be reconstructed. With the field measurements in hand, lay out each section with the bottom of the section at the depth of penetration measured for that section (i.e. total length of pipe minus the amount aboveground before extraction). The depth difference between the bottom of one section and the bottom of the section above it is the maximum possible core length for that section. However, if rodding has occurred, the actual new core will be less than this maximum by the amount of rodding. In most cases, it is easy to distinguish new core section from the sediment

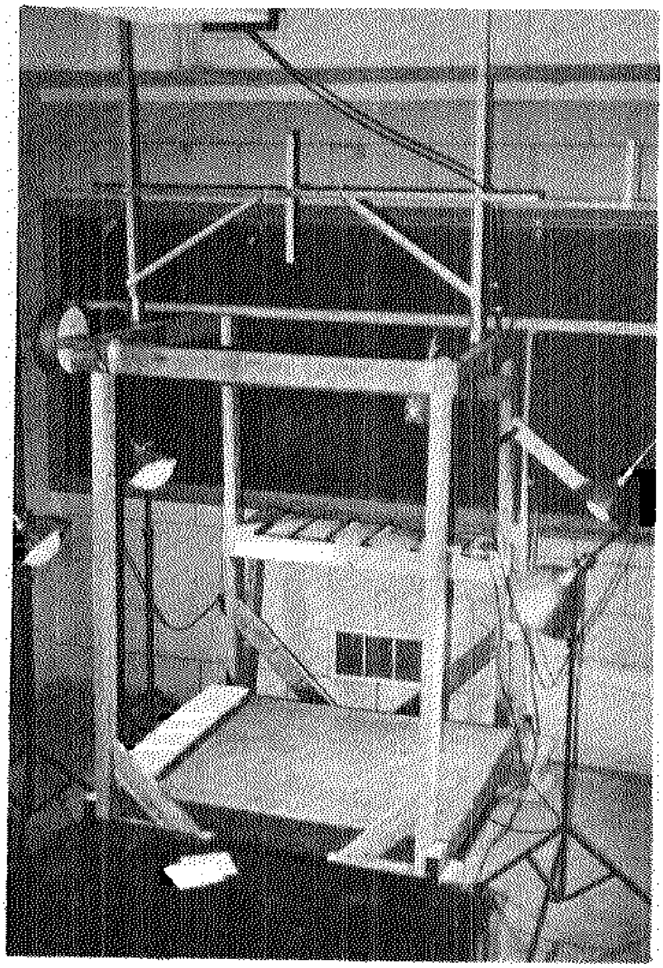


Figure III-11. Stand for photographing vibracores. Note camera stand and lighting method.

that scraped off the side of the hole during reentry. The amount of rodding (i.e. the difference between the theoretical core length and the actual sediment recovered) should be left as a gap at the bottom of the section, since presumably this is where the rodding occurred. Alternatively, the section should be expanded to make up the difference if the rodding is thought to have occurred continuously during penetration. We prefer to use the former, and, as long as the amount of rodding is small as a percentage of core recovered, it does not make much difference either way. The next lower section begins at the depth of maximum penetration of the section above it.

In some cases, portions of the section have been repeated in two core sections. This occurs because the hole is not reentered straight. This is duplicated work and should be avoided if possible; if it does occur, however, it makes reconstructing the core sections easier.

Once the sections have been lined up in depth in a satisfactory manner, cut one-half into meter sections starting with zero (the surface) at the top. Leave gaps where rodding has occurred and remove any overlaps due to repeated sequences. These meter sections can be photographed, described, and stored for later use or observation. It is often useful to describe and photograph the cores again after they have dried somewhat, since many structures are more visible when the sediment is dry. The uncut sections can be sampled, stored, or disposed of as appropriate. We like to cut the end caps in half and tape them to each meter section end to help hold the sediment together (Figure III-9). The meter sections usually are labeled and inserted into the plastic liners to stop drying and to protect them (Figure III-10).

Special copy stands for photographing the cores were designed and built by several geology graduate students (Figure III-11). The cores are laid out on the stand with appropriate labeling at the top. Four 300-watt photofloods are used to illuminate the cores and set at about 45° angles from each of the four corners of the stand. About two m above the core table is a camera mount for standard 35-mm SLR cameras. The distance is set up for a 50-mm lens. It is essential that the line of sight of the camera be perpendicular to the core table to avoid distortion of the core in the photograph. This can be accomplished by using a carpenter's plumb (or equivalent). Hold the string in the center of the camera lens and mark the spot on the table that is directly below the camera center. Looking through the camera put the center of the field of view on this spot. The camera is exactly perpendicular to the table if the table is level. Adjust the position of the core or move the camera and repeat the center procedure to frame the core properly.

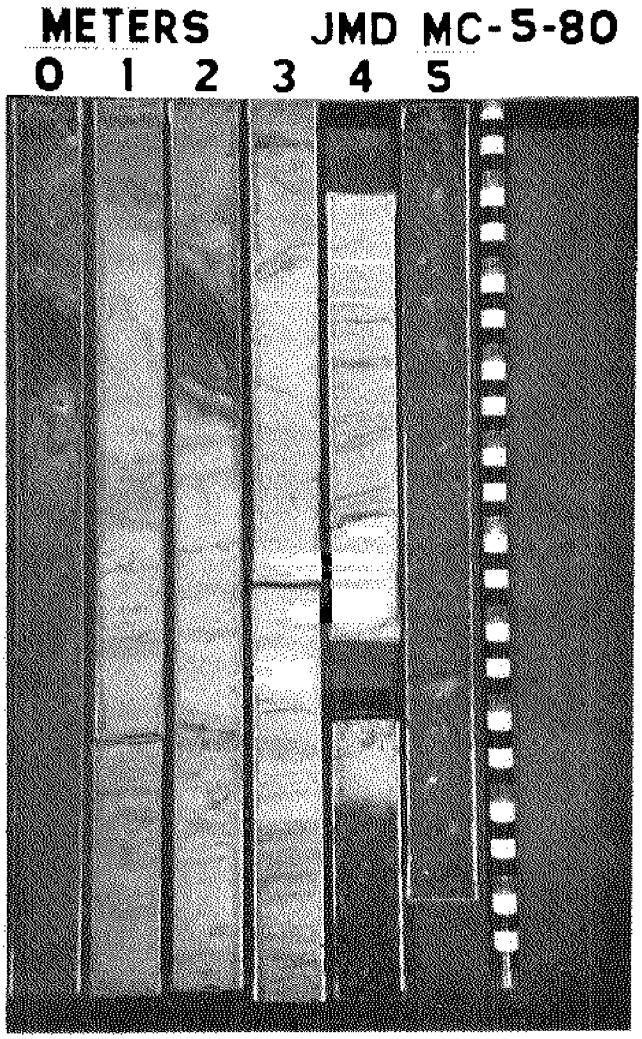


Figure III-12a. Photograph of vibracore.

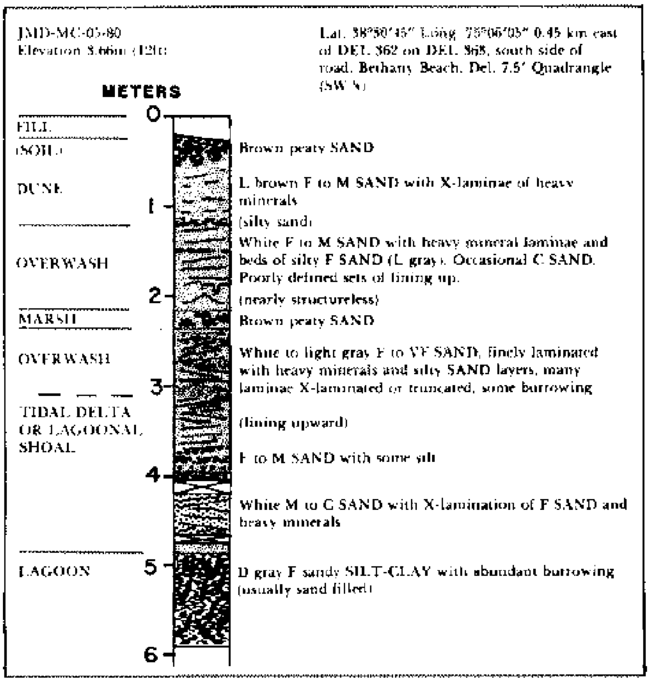


Figure III-12b. Associated lithologic section.

We generally take several photographs at ½ F-stop intervals either side of the light meter reading to assure proper exposure. The best film to use is Kodak Ektachrome 160-tungsten color slide film. This is color balanced for the 3200 K flood lights (GE-EBV or equivalent). We have also had satisfactory results with Kodachrome 64 and an 80B filter. Black and white negatives and prints (Figure III-12) then can be made from the best of the slides, or color prints can be made from the slides. The slides also can be used in technical presentations. We also have used a Polaroid Land camera (The Reporter) and black and white negative and print Polaroid film to get an immediate print and a negative for later use. The photograph can be put in the notebook with the lithologic description.

We have developed a standard core description form (see Appendix) to assist in describing the cores. This, or your own system, can be used. Most of the usual kinds of information needed in the lithologic description are on this form, so it can be very useful to the beginner. The usual presentation in publications theses or professional papers is the photograph in conjunction with the lithologic discription. One way of doing this is shown in Figure III-12. The lithologic column was constructed using Formatt sheets purchased from graphic arts suppliers. The photograph was made from a color slide original.

IV. References

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Hoyt, W.H. and Demarest, J.M. II. 1981. "A versatile twin-hull barge for shallow-water vibracoring," *Journal of Sedimentary Petrology*, 51 (2): 656-657.

Lanesky, D.E., Logan, B.W., Brown, R.G., and Hine, A.C. 1979. "A new approach to portable vibracoring underwater and on land," *Journal of Sedimentary Petrology*, 49: 654-657.

Appendix

UNIVERSITY OF DELAWARE DEPARTMENT OF GEOLOGY

STANDARD CORE DESCRIPTION FORM

CORE DESIGNATION: Init. Loc. Yr. Seq. I.D. #	OPERATOR(S):	METHOD:	DATE: Taken: Described: Photographed:

LOCATION:	PROJECT:
Landmarks:	
Descr. of Land Surf.:	Described By:
Quadrangle/Navigational Map:	PURPOSE OF CORE:
Latitude, Longitude:	
Formation Name:	
Elevation of Core Top:	
Elevation of Core Bottom:	
Datum Used:	

TOTAL PENETRATION:	RECOVERED CORE:	%RECOVERY:

CORE SECTION DATA (If Hole Was Reentered):

\# Of Sections:

Section Descriptions:

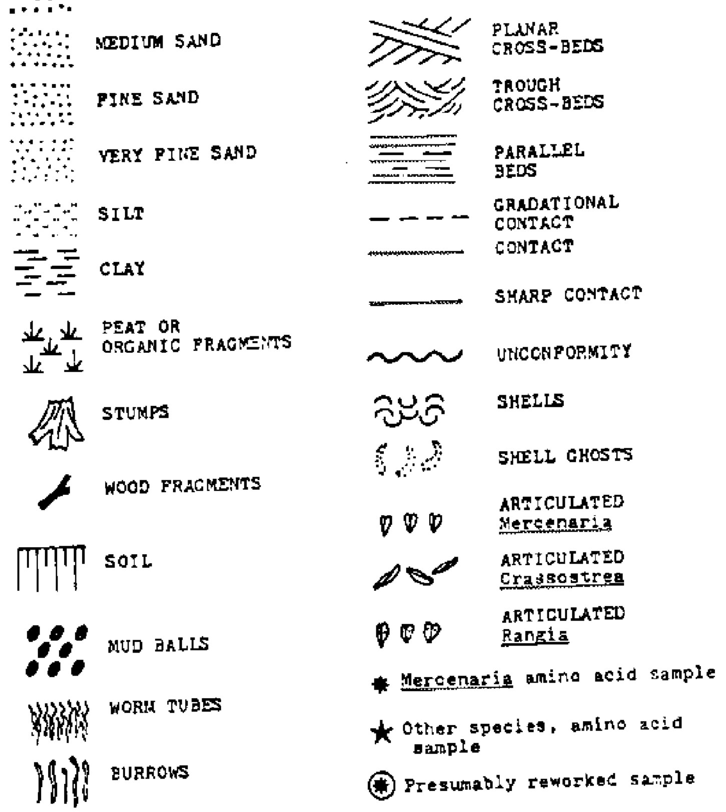
REMARKS:

MAP/SKETCH OF CORE SITE VICINITY:

LEGEND

Applies to all descriptive logs presented in this paper.

ADDITIONAL LITHOLOGIC SYMBOLS USED:



CORE PHOTO(S):

CORE LOG FOR: ______________________________

DEPTH (M)	GRAPHIC LOG	VERBAL LITHOLOGY	SED. STR. MAP DIR.	COLOR (MUNSELL)	ORGANICS FOSSILS	SAMPLE TAKEN	AGE YR.	ENV. OF DEPOSI.	NOTES ETC.