WHOI-83-36

**Tripod Modification of Sphincter Corer:
Construction, Operation, Core Extrusion and Sampling Efficiency**

by

John C. Burke
Woods Hole Oceanographic Institution
Woods Hole, Massachusetts 02543

Robert E. Hamblin
Oceanic Industries
Monument Beach, Massachusetts 02553

and

Susan A. Casso
Woods Hole Oceanographic Institution
Woods Hole, Massachusetts 02543

September 1983

Technical Report

Funding was provided by the U.S. Department of Energy under Contract EY-76-C-3563, Sandia National Laboratory under Contract 37/3164 and the U.S. Nuclear Regulatory Commission under Contract NRC-04-76-349.

Reproduction in whole or in part is permitted for any purpose of the United States Government. This report should be cited as: Woods Hole Oceanog. Inst. Tech. Rept. WHOI-83-36.

Approved for Distribution

Werner G. Deuser, Acting Department Chairman
Department of Chemistry

ABSTRACT

A 21-cm diameter sphincter corer (Burke, 1968) has been modified by mounting it in a tripod frame. This modification results in more dependable recovery of undisturbed surficial sediment and greater penetration into firm sediment. The device is useful in water depths from 2-6000 m, is adaptable for use on small boats, is very easily employed on large research vessels, and can be readily disassembled for more convenient transporting and storing.

Since 1967 we have been using a 21 cm diameter corer with sphincter valve closure (Burke, 1968) to obtain sediment samples for radionuclide fallout analyses. Over the years this has proven to be a very useful device, penetrating to depths of pre-fallout levels and giving us large volumes of sediments so that usually 1 cm-thick sections of the core suffice for analysis of Pu or other fallout nuclides. In most cases visual examination of the sediment surfaces showed that the top sections of the cores were undisturbed. When the corer was driven into the sediment too fast, however, cone-shaped top sections showed that impact had resulted in displaced sediment. In other cases, when the speed of penetration was too slow, or when sediments were too firm, the corer was tipped over by lateral movement of the ship; this was particularly a problem in bad weather. Furthermore, in very soft sediment the corer sometimes overpenetrated, actually forcing the sediment column out through the top valve. A device was needed which could ensure a controlled speed of penetration and provide maximum vertical stability during penetration, and thus be less susceptible to operator errors or weather variables.

Using a Soutar-type box corer (Soutar, personal communication; Hessler and Jumars, 1974) was a possible solution, but one we wished to avoid since a good deal of our work requires use of small boats (the first sphincter cores were taken in Crater Lake, Oregon (Volchok et al., 1980) from a 17 foot (5.2 m) Boston Whaler-type boat) equipped with low-powered winches and light-weight wire. The device that we developed uses the barrel and nose-cone of the original 21-cm sphincter corer but is mounted in a tripod as shown in Figure 1. The operation of the sphincter corer is not changed by this design; the tripod frame only provides stability to keep the corer in a vertical position while it penetrates. This design also allows the corer to be placed on the bottom very slowly with minimal sediment disturbance. The core barrel is driven into the sediment only by the force of weights mounted on the weight stand. Varying the amount of this weight gives control over penetration in various sediment types. The tripod corer is manageable on small boats and is easily disassembled for transporting or shipping. It has been used with a variety of winches, from Markey hydrowinches on large oceanographic ships to a 3-hp gasoline winch (Hydro-products, P.O. Box 2528, San Diego, California 92112). Wire as small as 0.32 cm can be safely used in shallow water. Hydrographic wire (0.48 cm,

3 x 19 torque-balanced, galvanized) has been used successfully and safely to depths over 6000 m. We are grateful for the encouragement and constructive comments of V. T. Bowen and H. D. Livingston and for the editorial assistance of B. L. Olson.

Tripod Corer Design and Construction

The tripod corer consists of the three basic sections (Figure 1) described below.

1. Weight Stand:

The weight stand is constructed of mild steel tubing and plate (galvanized after welding) to form two concentric cylinders. The inner tube is 12 inches (30.4 cm) long with an 8.75-inch (22 cm) I.D. and a 3/8-inch (0.95 cm) wall. A steel ring 1/8-inch (0.3 cm) thick by 1/4-inch (0.65 cm) deep is welded to the inside of the tube 2 inches (5 cm) from the bottom to act as a core barrel stop. A steel flange 3/8-inch (0.95 cm) thick, 16.5 inch (41.8 cm) O.D. and 9.5 inch (24.1 cm) I.D. is welded to the outside of the tube 2 inches (5 cm) from the bottom. To this flange is welded the outer cylinder, which is 1/8 inch (0.3 cm) thick, 10 inches (25.4 cm) long by 16-1/4 inches (41.2 cm) O.D., and provides housing for the lead weights. A length of 3/4 inch (1.9 cm) stainless steel tubing welded to the flange and inner barrel provides a protected pathway (the wire guide) for the core-catcher closure wire.

Fourteen 30-pound (13.6 kg) lead weights are cast to fit tightly into the weight stand. An eye in the top of each aids removal, allowing for weight adjustment from 30 to 420 pounds (13.6-190 kg). (As little as one weight has been used without affecting the trim.) Additional weight can be added to the outside of the outer cylinder in the form of contoured lead castings 1 inch (2.54 cm) thick by 4 inches (10.1 cm) wide by 8-1/2 inches (21.5 cm) long which fit inside a 1-1/4 inch (3.1 cm) wide by 18-1/4 inch (46.3 cm) diameter ring with standoffs. For clarity the additional weights are not shown in Figure 1. Two hose clamps secure these saddle weights firmly to the shroud to add as much as another 200 pounds (90.7 kg) to the total useful force.

A three-legged bail of 3/4 inch (1.9 cm) steel bar is welded to the outside of the outer cylinder, projecting above the weight stand. This bail supports the release mechanism (Burke, 1968) and the weight stand during assembly and disassembly and helps keep the barrel and weight stand in

place during lowering.

Three rod stops of 3/4 inch (1.9 cm) steel round stock 2 inches (5 cm) long are welded to the bottom of the flange so as to contact the guide ring when the weight stand is in its lowest position. When short cores are desired or when sediment is extremely soft, sections of pipe can be fitted over these stops and pinned through drilled holes to keep the weight stand and core barrel from completing their full travel. This procedure allows us to use sufficient weights to prevent pretripping and still avoid over-penetration in soft, fluffy sediments.

2. Frame:

The tripod is made entirely of 6061T6 aluminum. The legs are 1-1/2 inch (3.4 cm) schedule 40 pipe. Leg flanges are bolted to a triangular-shaped top of 3/8 inch (0.95 cm) plate. Horizontal supports extend from each leg to the core barrel guide ring, to which they are connected by flanges. The guide ring is pipe or rolled and welded stock 2-3/4 inches (7 cm) long with a 10-1/2 inch (26.6 cm) I.D. and an 11-1/2 inch (29.2 cm) O.D. Vertical supports from the legs to the horizontal supports act as guides for the weight stand. Three polyvinylchloride guide blocks with indentations toward the vertical supports are bolted to the underside of the weight stand. These can be adjusted to fit loosely around the vertical supports so that the weight stand slides up and down easily but cannot topple out of the tripod frame. A step is made by welding an additional member between one vertical support and one leg to make the release mechanism more accessible and wire attachment easier. With the removal of the fifteen 3/8 inch (0.95 cm) stainless steel bolts which hold the flanges together, the tripod disassembles to an easily manageable package for shipping or storing.

Bail guides attached to the underside of the top plate consist of three 8-inch (20.3 cm) forks of 1 inch (2.54 cm) by 3 inch (7.62 cm) aluminum stock with 1 inch center slots. Sets of 3/8 inch (0.95 cm) holes for quick release stop pins are drilled near the top and the bottom of each fork. These forks are positioned on the plate so that the bail slides up into the slots when the weight stand is lifted. When the pins are in the top set of holes with the bail on the top of the pins, the weight stand is supported, so the core barrel with core catcher can be installed or removed. For the coring operation the pins are placed in the lower holes

with the bail under the pins (as in Figure 1). This brings the core catcher down inside the guide ring.

The four inch (10.1 cm) center hole in the top plate is lined on the top and bottom by hard coated (an electrochemical process producing a file-hard coating) aluminum half rings which guide the release eye and shackle through without hangups.

Tripod feet are 12 inch diameter (30.4 cm), 3/8 inch thick (0.95 cm) plates. Hemispheres of aluminum or fiberglass, attached below the plates, streamline the descent of the instrument. It is sometimes necessary to remove the hemispheres for work on a small boat with limited clearance for tall packages.

3. Core Barrels and Attachments:

The core barrels are 8.3 inch (21.3 cm) I.D., 8.6 inch (21.9 cm) O.D. fiberglass pipe with a wall thickness of 1/8 inch (0.3 cm). Our standard length is 35 inches (88.9 cm) although we have used 54 inch (137.1 cm) long barrels successfully.

The core catcher has a sphincter-type closing mechanism. A dacron sleeve is used, one end of which is held firmly in a ring just above the cutting edge of the nose cone, the other end being held in a second, rotatable ring just above this. Rotation of the upper ring closes the diaphragm in an iris-type seal. The mechanism for rotating the ring to close the sleeve is a wire with one end attached to the ring and leading, through a groove in the ring, out through the mainpiece of the core catcher. The wire then passes through a fair-lead fixed to the outside of the core catcher and up to the release eye.

The release mechanism is tripped after bottom contact when the weight of the core rig is transferred to the sediment. The winch stops paying out wire and the corer is allowed to penetrate for about 1 min. Then the winch starts hauling back, first pulling the release shaft through the release mechanism; this simultaneously pulls the wires from the core catcher and valve closing the two sphincter sleeves. At the end of the wire travel of the valve and core catcher, a stop engages against the release mechanism so that the weight of the complete corer is on the stop. This closure method, described in detail by Burke (1968), has been used on our 21-cm diameter corers for over ten years and has proven to be very reliable.

Both the top valve and nose cone are made from 8.250 inch I.D. (20.9

cm) by 9.250 inch (23.5 cm) O.D. stainless steel tubing. The valve (a new design from that described by Burke, 1968) differs from the nose cone in the following ways. The bottom 2 inches (5 cm) of the valve are reduced to fit inside the weight stand and are held in place by six set screws. Rather than the inside groove in the rotating ring of the nose cone, the valve has a 190° slot machined in its outer shell. The rotating ring, which closes the diaphragm in an iris-type seal, is exposed by the slot in the valve. A stud with a drilled hole is screwed into the rotating ring through the slot. The closure wire is attached to the stud and led through a fair-lead to the release eye. When the release shaft is pulled through the release mechanism, the valve and core catcher are closed at the same time.

In 1967 the stainless steel tubing used for the core catcher was listed as a stock item. It is no longer available as stock but may be specially ordered from Tube Sales, Co., 124 Hebron Avenue, Glastonbury, Connecticut 06033. The fiberglass barrels have been obtained from three different suppliers and are still available as stock 8 inch pipe with 1/8 inch thick wall from Naiad Associates, 150 Kennedy Drive, South Burlington, Vermont 05401.

ASSEMBLY AND OPERATION

The core catcher is first taped (2 inch wide heavy duty cotton duct tape with a fused vinyl coating used for heating and air conditioning ducts) to the core barrel, then three stainless steel straps 1 inch (2.54 cm) by 1/8 inch (0.3 cm) thick are attached to the core catcher with 10-32 screws. The weight stand bail has been pinned above the top stop holes in the forks. The barrel is inserted into the weight stand and the straps are attached to the weight stand. The wires from the catcher and valve are attached to the release eye and the release pin is engaged and secured. Next the weight stand is lowered so that the pins are placed in the bottom set of holes in the forks and the bail is under the pins (as in Figure 1). The tripod is now ready for lowering.

The corer is lowered at 100 m per minute (75 m per minute in fairly active weather) until it is 50 to 100 m from the bottom. It is then slowed to 10 m per minute, or as slow as the winch will operate, for placement on the bottom. The feet of the tripod contact the sediment first. The barrel continues to descend penetrating the sediment by the force of the weights

contained in the weight stand. The core barrel stops its downward travel when the weight stand comes in contact with the guide ring or when the resistance of the sediment is sufficient to stop downward penetration. When the weight stand comes to a stop the weight is taken off the spring-loaded release pin and the pin retracts. This should be completed within 60 seconds after the corer reaches the bottom. The pull on the wire to retrieve the corer begins immediately and closes the diaphragms of the core catcher and the top valve. Stress is taken off the closure wires by a stop which engages the bottom of the release mechanism where force is exerted during retrieval.

The corer is pulled out of the mud at the slowest winch speed or about 10 m per minute. Pullout forces have not exceeded 1000 pounds and are generally somewhat lower. After pullout it can be retrieved at 100 m per minute.

The removal of the full core barrel is the opposite of the assembly except that we use a tray under the core catcher and barrel to help lift the extra weight clear of the tripod. Before the core barrel is moved, water retained above the core is usually siphoned off and reserved for analysis.

CORE EXTRUDER

The method we have used to extrude cores for the last six years involves inverting the core and extruding from the bottom. The analyses of these cores indicate no displacement or significant loss of sample. Nevertheless, we have spent time and effort to develop a method to extrude without inverting the core, so far unsuccessfully.

The extruder (Figure 2) consists of six main pieces. The aluminum base plate is 16 inches (40.6 cm) square by 1/4 inch (.64 cm) thick with two 2-inch (5 cm) long, 1 inch (2.54 cm) diameter studs welded to the center and to one side. A combination handle clamp and guide fits around the core barrel. The main body of the handle clamp is the same I.D. as the O.D. of the fiberglass core barrel. It is made of mild steel 3 inches (7.6 cm) wide by 1/8 inch (.32 cm) thick cut in half vertically and joined by a hinge on one side and by two flanges with bolt holes on the other. Two handles of 5 inch (12.7 cm), 3/4 inch (1.9 cm) diameter steel rod are welded 90° from the hinge on each side. Welded vertically to the clamp on one side, 120° from the hinge, is a 5 inch (12.7 cm), 1-1/4 inch (3.17 cm)

diameter pipe. This fits over the guide pipe, 3 feet long (91.4 cm) by 1 inch (2.54 cm) diameter, which is used to guide the core barrel during extrusion and which fits over the off-center stud on the base plate. The guide pipe has drilled holes at 0.5 cm intervals along its length as shown. Removable T-shaped stops are used to adjust the thickness of core slices.

An 8-inch diameter (20.3 cm) by 8 inch long (20.3 cm) aluminum piston, equipped with a rubber gasket on top, fits snugly into the core barrel. An 8 inch (20.3 cm) length of 1 inch (2.54 cm) aluminum rod projects from the bottom of the piston and fits into the piston pipe, a 1 inch (5 cm) aluminum pipe 30 inches (76.2 cm) long, which fits over the center stud on the base plate. Two stainless steel wires from the core catcher to a collar on the piston pipe hold the core in place while it is being inverted. The collar is held firmly on the piston pipe by two set screws; two eyes are welded on to hold the nicopressed wires. The wires have fittings on the other end which screw into the strap attachment holes in the core catcher.

EXTRUSION PROCEDURE

To prepare the core for extrusion the core barrel is removed from the tripod using the straps as handles. The straps are removed and the handle clamp is secured to the barrel. After removal of the water overlying the sediment top, the top few centimeters may be scooped in 1-cm increments when the sediment is soft. The piston is then inserted into the barrel on top of the core and the piston pipe attached. Next, the collar is slid over the pipe and the wire fittings are screwed into the core catcher. The slack is taken out of the wires by pushing down on the piston rod and up on the collar. Finally, the set screws are tightened to hold everything taut. These actions contain the core in the core barrel by the force of the piston holding the core against the still closed core catcher.

The guide pipe is placed into the 5 inch (12.7 cm) pipe on the handle clamp so that the end is even with the top of the piston pipe and is held in place with hose clamps secured on both sides of the 5-inch (12.7 cm) pipe. This whole assembly is now inverted and placed on the base plate with the piston pipe mounted on the middle stud and the guide pipe on the outer stud. After the wires are removed from the core catcher and the core catcher removed, the core is ready to be extruded and sliced.

To expose layers of core, the bottom hose clamp on the guide pipe is

removed and the stop is placed at the appropriate distance. The barrel slides down past the piston exposing the prescribed thickness of core; its circumference is next trimmed to a depth of 1 cm. The bottom of the core, which has been in contact with the sphincter diaphragm, should be trimmed at least 3 cm. There is evidence (IAEA, 1975) that surface sediment is often found in this section.

DISCUSSION

Our first coring attempts with the tripod corer were made in Buzzards Bay and Cape Cod Bay where the sediment varies from very soft mud to hard packed sand. The stability of the corer, especially when penetrating harder sediment, is greatly increased so that falling over has been eliminated. In the soft sediment no cone-shaped core tops were seen. This is certainly due to the slow entry speed ensured by the tripod. We also found that the corer could penetrate deeper in harder sediment (mud and sand mix), probably because of both the extra weight and longer time for penetration. We have now used the corer on our 22-foot (6.7 m) catamaran, our 42-foot (12.8 m) ASTERIAS, a 65-foot (19.8 m) T-boat in the Great Lakes, on four legs of our 245-foot (74.6 m) R/V KNORR, and on the R/V THOMAS WASHINGTON, a 209-foot (673.7 m) vessel operated by Scripps Institution of Oceanography. It has proven to be a useful and dependable tool in water depths from 2 to 6000 m. Both in Lake Erie and in some parts of the Gulf of Saint Lawrence, we succeeded in obtaining good tripod cores in places where, on previous cruises, we had been unsuccessful with the old-style sphincter corer. A pleasant, but not really expected, bonus appeared in the cost of the new device, which was about \$4,000 for a complete unit in 1978 compared to the quotations of \$12,000 we have recently had for Soutar-type box corers.

Convincing evidence of the improvement achievable with the tripod corer in the recovery of sediment from the sediment water interface comes from a comparison of radionuclide data from two series of paired cores, each pair being collected at the same location and time. The first series consists of cores collected using our older sphincter corer (Burke, 1968) and a box corer (Soutar, personal communication; Hessler and Jumars, 1974), whereas the second series contains cores collected with the tripod version of the sphincter corer and a box corer.

The first series was from several stations on or near the European

continental shelf, collected on R/V KNORR, Cruise 54, Leg 6. Analyses of these cores show $^{239,240}\text{Pu}$ and ^{137}Cs concentration profiles which clearly demonstrate there was incomplete recovery of surficial sediment in the cores collected by the sphincter corer. Table 1 shows the total inventories of both $^{239,240}\text{Pu}$ and ^{137}Cs in the sphincter cores are lower by a factor of at least 1.7 when compared to the inventories in the corresponding box cores. These lower inventories are believed to indicate less efficient recovery of surficial sediment by the sphincter corer.

We believe that the coring results from this cruise do not indicate that all of the cores taken with this corer were deficient in total inventory. Rather, the type of sediment and the actual handling of the corer controlled its sampling efficiency.

On R/V KNORR, Cruise 69, Leg 2 a series of paired cores was collected with a box corer and the newly modified tripod corer. $^{239,240}\text{Pu}$, ^{137}Cs and ^{55}Fe profiles and inventories measured in these cores failed to reveal any systematic pattern of loss or distortion of sediment during sampling. At none of the KNORR-69 stations is the difference shown between tripod and box core inventories of the magnitude that characterized the KNORR-54 stations. The differences that are shown at the KNORR-69 stations, besides being less, are not uniformly in favor of one device over the other. We believe they are reflecting a real local variability in nuclide distribution patterns and inventories of these sediments. These data convince us that the sampling efficiencies of the box corer and the tripod corer are about equal.

REFERENCES

- BURKE, J. C., 1968. A sediment coring device of 21-cm diameter with sphincter core retainer. *Limnol. Oceanogr.* 13: 714-718.
- HESSLER, R. R., and P. A. JUMARS, 1974. Abyssal community analysis from replicate box cores in the central North Pacific. *Deep-Sea Res.* 21: 185-209.
- INTERNATIONAL ATOMIC ENERGY AGENCY, VIENNA, 1975. Transuranic elements, sample collection. In: Reference Methods for Marine Radioactivity Studies II, I.A.E.A. Tech. Ser. 169: 6-9.
- VOLCHOK, H. L., M. FEINER, H. J. SIMPSON, W. S. BROECKER, V. E. NOSHKIN, V. T. BOWEN and E. WILLIS, 1970. Ocean fallout -- the Crater Lake experiment. *J. Geophys. Res.* 75(6): 1084-1091.

Table 1

Sphincter core/box core -- nuclide inventory comparison

	Type of Core	-----mCi/km ² -----		
		239,240 Pu	137 Cs	55 Fe *
<u>R/V KNORR-54, May 1976</u>				
Station 22	Sphincter	0.74	3.62	
58°6.8'N, 01°00.8'E				
Depth: 137 m	Box	1.84	9.17	
Station 70	Sphincter	0.22	0.53	
63°50.0'N, 00°54.0'E				
Depth: 2197 m	Box	0.57	1.22	
Station 92	Sphincter	0.22	0.76	
50°12.3'N, 8°52.9'W				
Depth: 1492 m	Box	0.46	1.33	
<u>R/V KNORR-69, September 1977</u>				
Station 5	Tripod	2.06	6.45	
43°21.1'N, 67°45.2'W				
Depth: 272 m	Box	1.42	5.44	
Station 7	Tripod	0.79	2.40	18
42°03.5'N, 68°10.0'W				
Depth: 225 m	Box	0.86	3.01	33
Station 13	Tripod	0.61	2.41	44
42°40.0'N, 64°01.3'W				
Depth: 890 m	Box	0.82	4.11	54
Station 10	Tripod	0.18	2.15	23
40°49.7'N, 64°10.5'W				
Depth: 4160 m	Box	0.19	2.02	21

*Decay corrected to 1/1/75.

FIGURE CAPTIONS

Figure 1. Detailed schematic of tripod corer.

Figure 2. Detailed schematic of extrusion rig.

FIG. 1

FIG. 2

REPORT DOCUMENTATION PAGE		1. REPORT NO. WHOI-83-36	2.	3. Recipient's Accession No.	
4. Title and Subtitle Tripod Modification of Sphincter Corer: Construction, Operation, Core Extrusion and Sampling Efficiency				5. Report Date September 1983	
				6.	
7. Author(s) John C. Burke, Robert E. Hamblin and Susan A. Casso				8. Performing Organization Rept. No. WHOI-83-36	
9. Performing Organization Name and Address Woods Hole Oceanographic Institution Woods Hole, Massachusetts and Oceanic Industries Monument Beach, Massachusetts				10. Project/Task/Work Unit No.	
				11. Contract(C) or Grant(G) No. (C) EY-76-C-3563 37/3164 (G) NRC-04-76-349	
				13. Type of Report & Period Covered Technical	
12. Sponsoring Organization Name and Address U.S. Department of Energy, Sandia National Laboratory and the U.S. Nuclear Regulatory Commission				14.	
15. Supplementary Notes This report should be cited as: Woods Hole Oceanog. Inst. Tech. Rept. WHOI-83-36.					
16. Abstract (Limit: 200 words) <p>A 21-cm diameter sphincter corer (Burke, 1968) has been modified by mounting it in a tripod frame. This modification results in more dependable recovery of undisturbed surficial sediment and greater penetration into firm sediment. The device is useful in water depths from 2-6000 m, is adaptable for use on small boats, is very easily employed on large research vessels, and can be readily disassembled for more convenient transporting and storing.</p>					
17. Document Analysis a. Descriptors					
b. Identifiers/Open-Ended Terms					
c. COSATI Field/Group					
18. Availability Statement: Release unlimited		19. Security Class (This Report) Unclassified		21. No. of Pages 13	
		20. Security Class (This Page)		22. Price	