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# A Mechanically Simple and Low Cost Subaqueous Surface Sediment Sampler

by

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CONTENTS

Page



LIST OF FIGURES

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### ABSTRACT

*Over the years the author has developed a subaqueous surface sediment sampler that is simple to operate and inexpensive to construct. It is designed to be operated in water ranging from wading depths to a water depth up to 20 feet when operated from a boat. This paper describes (1) sampling rational of the sedimentation unit for which the device has been designed, (2) sample size constraints for which the sampler has been configured, (3) sampler specifications, dimensions and construction tips, and (4) sampler operation.*

### INTRODUCTION

In 2000, the author completed the design and construction of a surface sediment sampling device that can be simply operated in waist- to chest-deep wading depths or from a boat. Its origin grew from the desire of not having to dive for surf zone bottom sediments during the winter when water temperatures attain a highly uncomfortable mid-50's degrees Fahrenheit. The sampling device is currently designed to allow collection of unconsolidated sediments from wading depths or from a boat up to a water depth of 20 feet. Sampling logistics are eased from a water-depth perspective, since the device is comprised of five-foot threaded sections.

The device has specific merits. First, it can ameliorate or mitigate the water temperature problem for the sampling individual where total immersion would be required. Second, it constitutes a significantly quicker method requiring fewer personnel for obtaining a sample than using divers. Third, it allows a sample to be obtained from a boat in water not conducive to diving due to potential pollution problems. Fourth, it much more nearly samples a sedimentation unit. Fifth, it procures a sample of a size specifically suited to sieving analytical procedures.

The purpose of this paper is to describe the sampling device with the following specific goals: (1) what it is capable of sampling, (2) design details and dimensions to assist the interested researcher in its construction, and (3) how it is operated.

It is standard practice in scientific work to express length in S.I. units (International Système d'unités). However, in the United States, a great many commercially available products are specified only in British Imperial units. In fact, construction of the device described herein could not be accomplished using S.I. units. Hence, this work constitutes the rare case where mixed units are employed to insure clarity and precision. Mass (weight) is reported in grams.

### SAMPLING THE SEDIMENTATION UNIT

Central to the design of a sampling device is the question: what is to be sampled? An underlying assumption with sedimentologic studies is that the desired field sample is a *lamina* sample (Balsillie, 1995). This is the *sedimentation unit* of Otto (1938, p. 575) defined as ... *that thickness of sediment which was deposited under essentially constant physical conditions.* Apfel (1938, p. 67) used the terminology *phase sampling* in which a *phase* is defined as ... *deposition during a single fluctuation in the competency of the transporting agency* (see also the work of Jopling, 1964).

Hence, the *sedimentation unit* or *phase sample* represents a narrowly defined event. For example, it is not deposited by a flood occurring over a period of several weeks, but it might be deposited by one energy pulse occurring over-and-over during the event. Just what a sedimentation unit, lamina, phase sample, or bedding plane is in terms of physical principles, is not known. But, we do recognize them to some general extent, and regardless of the unknowns one should strive to collect sedimentation unit samples (Balsillie, 1995).

Based on observations of bedding plane characteristics, it was decided that the sampling device should be designed to collect a sample no more than 13/32 inches (one centimeter) in depth. Moreover, the design purpose of the device was to obtain a bed surface sample.

## SAMPLE SIZE AND SPLITTING

Sample size and sample splitting where necessary are other important considerations.

Upon occasion I have prevailed upon friends and co-workers to secure a sand-sized sediment sample or two from some exotic locale to which they were traveling. Even with specific instructions as to its size, I have invariably been given a quart-sized or even, upon occasion, a gallon-sized zip-lock bag filled with sand. What these individuals fail to realize is that handling of the sample bag and vibrations when transported in a vehicle will further sort a sample. Any sub-sample collected from such a large sample may well not represent the original distributive characteristics of in-place natural material. Mechanical splitting procedures can be used, but they too introduce error (*e.g.*, Wentworth, 1926; Swineford and Swineford, 1946; Sengupta and Veenstra, 1968; Sanford and Swift, 1971; Emmerling and Tanner, 1974; Socci and Tanner, 1980; Balsillie, 1995). Emmerling and Tanner (1974) found as much as 5% error per split, and recommended no more than one split where sample archiving is of importance, say, for litigation purposes.

The bullet surface sediment sampler is designed to collect a sample of a size suitable for sieving analysis. No more than 100 grams of sediment should be introduced to the sieve nest. A larger mass may result in overcrowding on one or more of the sieves (*e.g.*, Carpenter and Dietz, 1950; Daescher and others, 1958; McManus, 1965; de Vries, 1970, Jenke, 1973, Shergold, 1980; Socci and Tanner, 1980). A sample size of 45 grams is ideal, but can vary from 35 to 50 grams (Socci and Tanner, 1980; Balsillie, 1995). The bullet sampler, then, has been designed to collect a 50-gram and a 100-gram sample, bearing in mind that a certain percentage of the sample will be fluid (salt, fresh, or polluted water).

## MATERIAL SPECIFICATIONS, DIMENSIONS, AND CONSTRUCTION TIPS

The bullet sampler has five main components: (1) main barrel, (2) sliding barrel stop, (3) sliding barrel bushing, (4) sliding barrel, and (5) bullet points; see Figure 1 for basic segments, and Figure 2 for design schematics. Material specifications and dimensions and construction instructions are as follows.

### Main Barrel

The ***main barrel*** is comprised of two-inch diameter schedule PVC well casing and ***bullet points*** with ASTM F-480 threads (*i.e.*, two ¼-inch threads per inch for both male and female threaded ends and an O-ring for each male threaded end). The ***main barrel*** has an inside diameter (ID) of 1 9/16 inches, and an outside diameter of 1 29/32 inches. It is recommended that well casing segments five feet in length be used for the sampler. Well casing can be obtained from a well drilling supplier.

The first five-foot segment of the ***main barrel*** requires special design

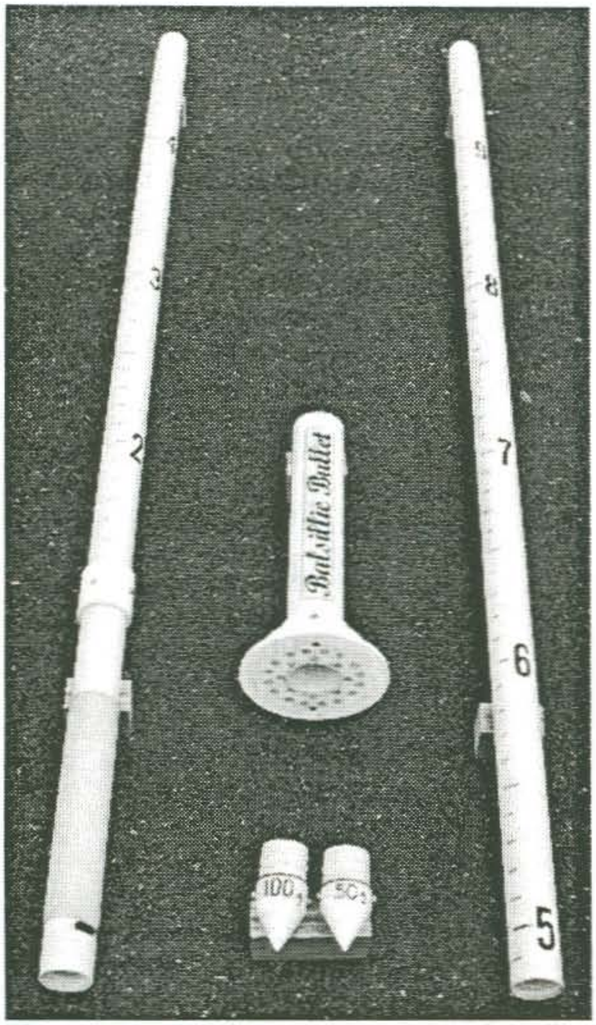


**Figure 1. Basic components of bullet surface sediment sampler showing first five-foot segment (left) with fittings, second five-foot segment main barrel segment (right) that threads onto the first segment for sampling in water depths of up to 10 feet, sliding barrel (top middle), and 50-gram and 100-gram bullet points housing the sediment collection chamber (bottom middle).**

considerations. Since the ***bullet points*** have male threads, modifications are made to the female end of the first main barrel segment. The lineal length of the threaded sections for both male and female threads is 1 ½ inches from the casing ends. Two slots approximately 1 ¼ inches length are cut across the ***main barrel*** (Figure 1), one each on opposite sides of the ***main barrel***, at a distance of from 1 ½ inches to 1 19/32 inches from the female thread end of the first casing length. This results in a slot about 13/32 inches (*i.e.*, 1.0 cm) in width. These slots are appropriately beveled to facilitate sediment sample collection when the ***main barrel*** is rotated in a clockwise direction. A rubber stopper is inserted into the main barrel flush with the top of the slots. If snug enough, friction fit will suffice. If not, it can be secured using epoxy two-part glue. This insures that upon barrel removal water draining from the ***main barrel*** will not wash out the collected sample.

All ***main barrel*** segments are perforated with ½-inch holes at 1 ½-foot distances along the ***main barrel*** length (all five-foot segments) to facilitate sampler immersion and drainage of water when the ***main barrel*** is removed from the water. The ***main barrel*** is also labeled for distances in British Imperial or S.I. units as desired beginning at the top of the sediment collection slots. Horizontal lines perpendicular to the ***main barrel*** axis are made using a fine triangular file to create shallow grooves which are then filled with indelible black ink from a fine felt tip marker. Adhesive-backed numerals can then be applied to appropriate, easily recognizable intervals so that water depths can be easily measured when the sampler is at its design collection depth.

The first length of the ***main barrel*** is also fitted with the ***sliding barrel stop*** and ***sliding barrel bushing*** whose descriptions follow.

### *Sliding Barrel Stop*

The ***sliding barrel stop*** is a piece of two-inch PVC 1120 schedule (SHD) 40, ASTM D-1785 pipe (I. D.: 2 3/64 inches; O. D.: 2 3/8 inches) that is available from any hardware retailer. A one- to two-inch piece will suffice. Cut a vertical kerf with a hack saw parallel with its length (Figure 2). This will allow one to easily slide it up the ***main barrel*** to a position where it will precisely stop the ***sliding barrel*** at the top of the sedimentation collection slots. The ***sliding barrel stop*** is attached to the ***main barrel***

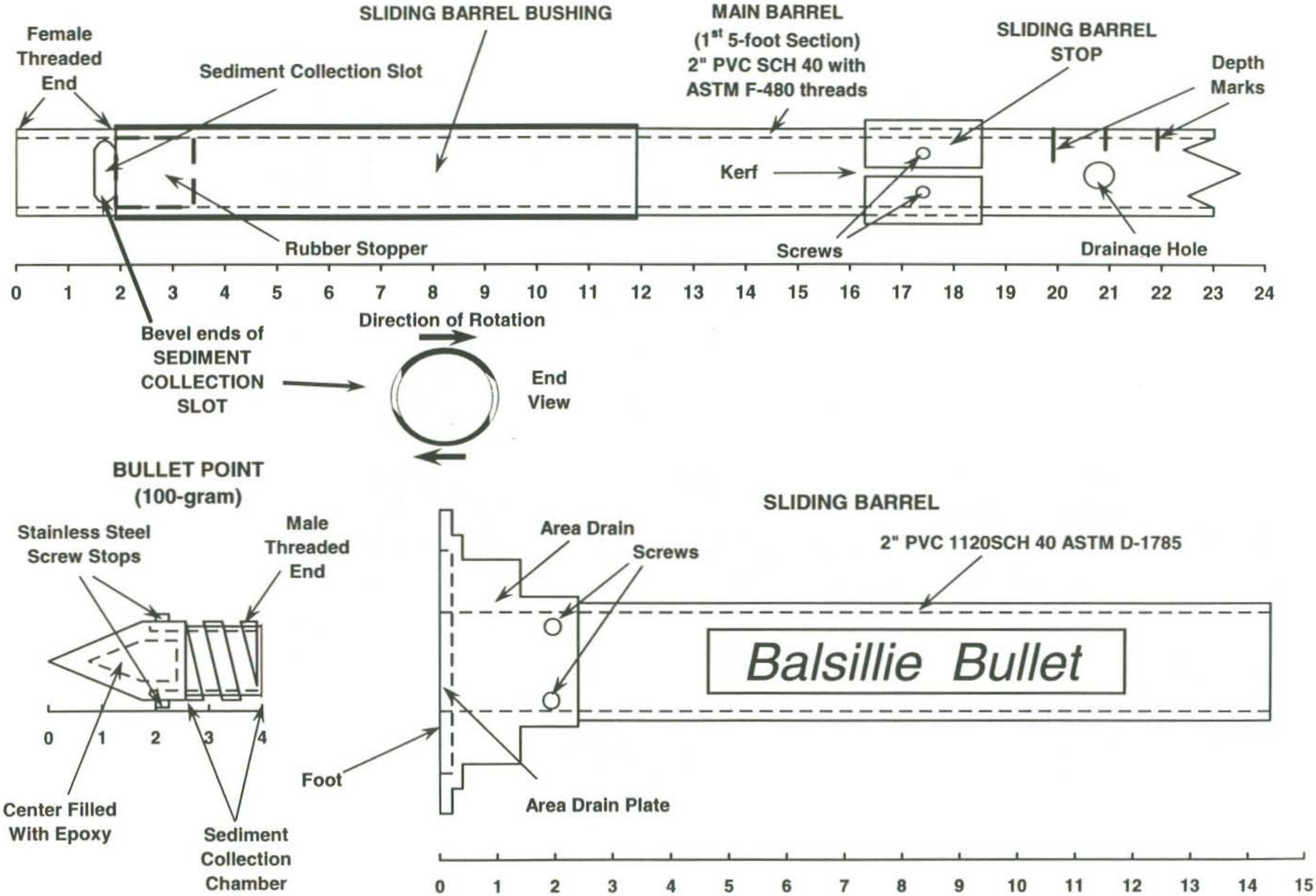


Figure 2. Schematic of dimensions of the bullet sampler; dimensions are in inches.

first segment using PVC glue and four stainless steel sheet metal screws.

### *Sliding Barrel Bushing*

***Main barrel*** well casing and two-inch PVC 1120 SCH 40 ASTM D-1785 used for the ***sliding barrel*** leaves a gap of about 1/16 inches and a sloppy fit. I fitted a piece of clear plastic tubing with an ID of 1 59/64 inches and OD of 2 1/32 inches, 10 inches in length to serve as a bushing to reduce the gap. The clear plastic tubing was found at a well drilling supplier and patiently applied by tapping it with some force into place. The fit in the bullet sampler was a friction fit. If one uses epoxy glue, only use it at the top ¼ inch of the bushing and apply it to the ***main barrel*** only (*i.e.*, not to both surfaces).

Sand-sized particles in the bullet sampler tend to sometimes get lodged between the bushing and ***sliding barrel***, reducing the effectiveness of the ***sliding barrel*** to protect the sample from being washed out of the sample container. From time-to-time the sliding barrel should be removed and both it and the bushing washed clean of any adhering sediment.

### *Sliding Barrel*

The ***sliding barrel***, 14 3/8 inches in length, is constructed of 2.0-inch PVC 1120 SCH 40 ASTM D-1785 tubing, and a 2 x 3 inch round PVC area drain with a foot diameter of close to 6 inches, both readily attainable at your local hardware retailer. The PVC tubing must extend entirely through the area drain and be flush with the 6-inch diameter surface (Figures 1 and 2). The plate of the drain can be removed and a 2 3/8- inch diameter precisely centered hole cut using a jig-saw; some sanding or filing using a rasp may be needed to "true-up" the fit. Do not use PVC glue to secure the two pieces, because it will set before the pieces can be properly aligned. Instead, position the pieces so that a flush fit is obtained and at 120° spacings secure the pieces using 5/16-inch full thread stainless steel sheet metal screws.

The ***sliding barrel*** serves two important purposes. First, it collects a surface sample by ensuring that the sampler remains at the sedimentary bed surface due to the 6-inch diameter area drain head. Second, upon extraction the barrel slides downward, to cover the sample collection slots so that sample material will not be washed out of the ***bullet point*** sediment collection chamber.

### *Bullet Points*

***Bullet points*** house the sample collection chamber. I purchased several points 6 5/8 inches in length. They are composed of two units, a point and a male threaded barrel (ASTM F-480 threads) joined by rivets. Drill out the rivets to separate the parts. Next, fill the point inside the chamber with epoxy and let it set and cure; this should take about eight hours.

Now, the ***bullet points*** can be constructed to collect specific samples sizes (*i.e.*, masses). I designed two sample sizes, a 50-gram sample and a 100-gram sample. The first is the optimal size for sieving, the second if a split is necessary for archival/litigation purposes. The depth of the sample collection chamber is made by shortening the barrel from the non-thread end. One will need to calibrate the barrel length required for sediment volumes to be collected. I use a plastic 35-mm film canister as a guide. It holds close to slightly less than 50 grams of dry medium-sized quartz sand. The researcher will have to decide, based on regional characteristics of average grain sizes to be sampled and their mineralogic content and attendant mass densities, the appropriate sediment collection chamber size. Construction of two or more chamber sizes is recommended. Also, the researcher must include in volume collection considerations, the volume of fluid that will be part of the sample collected.

When points and barrels are assembled they are joined using PVC glue and two ½ in long stainless steel round head screws. It is the screw heads which provide the lower stop for the ***sliding barrel***.

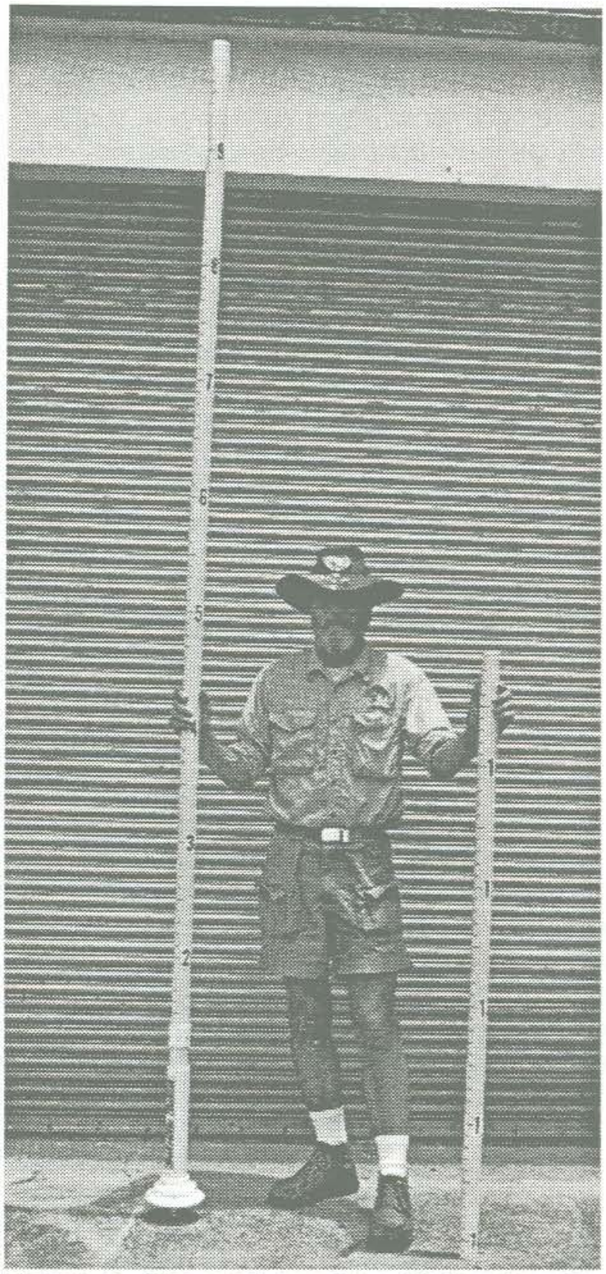

**Figure 3. The author with a 10-foot length (two five-foot segments) of the bullet surface sediment sampler (left) with an additional five-foot segment of main barrel (right) that can be threaded onto the top of the 10-foot length for sampling in a water depth of 15 feet.**

## *BULLET SAMPLER OPERATION*

The sampler is deployed in the vertical direction (Figure 3). Vertical pressure is applied until the ***sliding barrel*** is felt to make contact with the ***sliding barrel stop*** (Figure 4). For

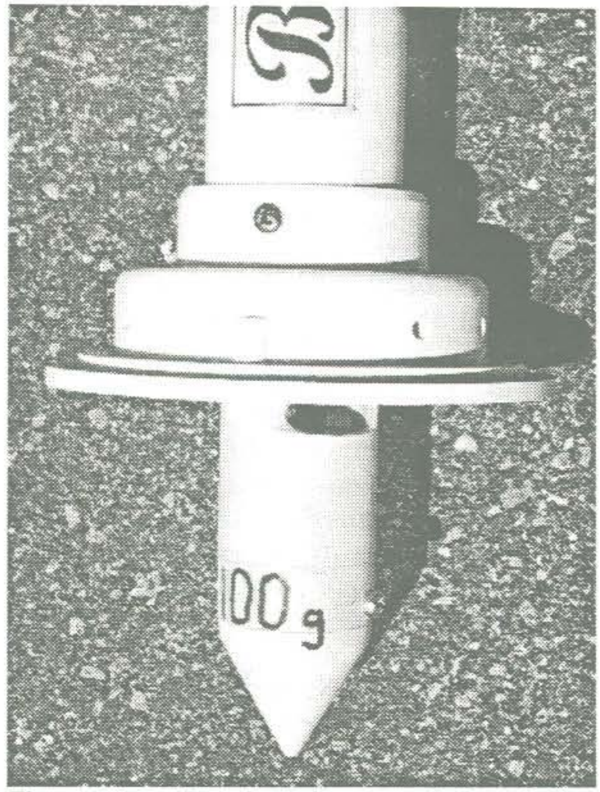


**Figure 4. Detailed image of tip of the bullet surface sediment sampler showing the sliding barrel in position for sample collection (to be rotated in a clockwise direction only), one of two sediment collection slots, and the 100-gram bullet point sediment collection chamber. Upon extraction of the sampler, the sliding barrel slips down being stopped by the screw heads in the bullet point, thereby protecting the sample from being disturbed.**

sample collection the sampler ***main barrel*** must be rotated in the clockwise direction only. If not, one risks unscrewing the ***bullet point*** sample container, thereby losing both it and the ***sliding barrel***. (Please note that PVC is neutrally buoyant).

Upon extraction, the user should feel the ***sliding barrel*** make contact with the stop screws embedded in the ***bullet point***. If contact is not felt, exert a greater vertical amount of thrust. It is possible that sand-sized material caught between the ***sliding barrel*** and ***sliding barrel bushing*** is rendering operation inefficient. In either case,

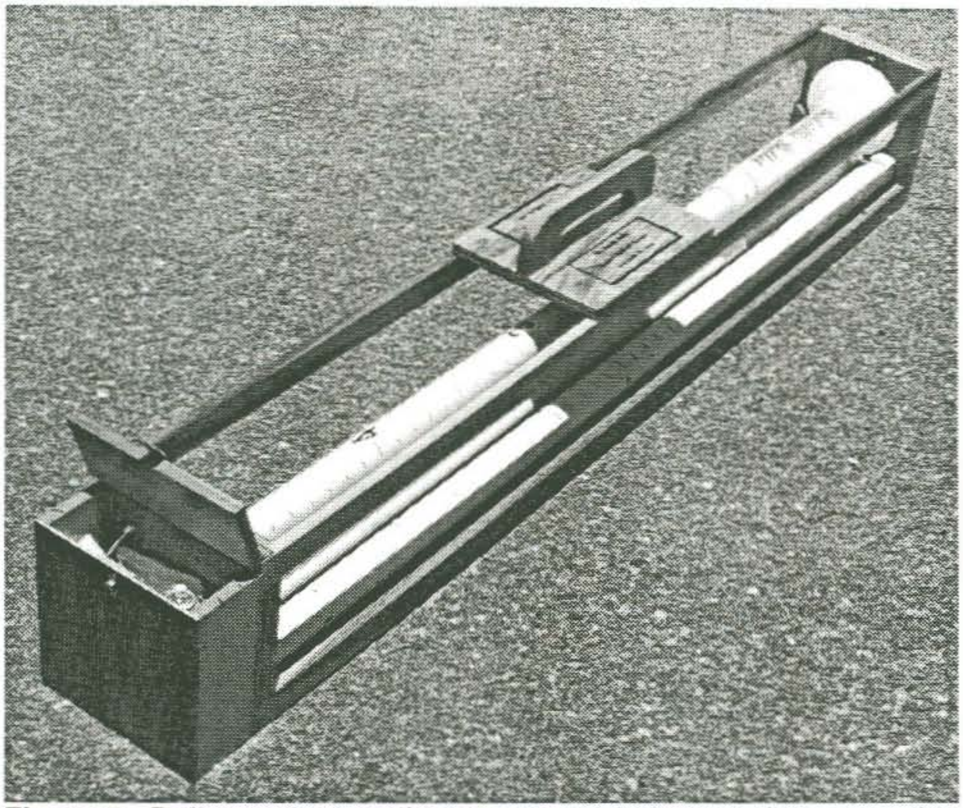

**Figure 5. Bullet surface sediment sampler in its carrying case with storage box open.**

continue to extract the sampler, keeping it vertical. In a secure posture, *i.e.*, so that the ***sliding barrel*** with not drop into the water, remove the ***bullet point*** and secure the sample in a suitable container. A narrow spatula may be required to remove the sample. Next, remove the ***sliding barrel*** and wash both it and the ***sliding barrel bushing*** clean. Feel the ***sliding barrel bushing*** from time-to-time. If burrs are felt, lightly sand it using wet-dry 180-grit or finer sand paper until smooth.

In wading depths (waist- to chest-deep water), the first five-foot length of the sampler should be sufficient for sample collection. When employed from a boat, vertically insert the first two segments (i.e., a 10-foot main barrel section comprised of two five-foot sections). Thereafter, successively thread on each additionally required five-foot sections. Following sample collection, any section greater than 10 feet in depth (or length) should be removed while the sampler is in the vertical position. Bear in mind that the PVC well casing wall is quite thin at the threads. A 10-foot section is quite substantial unless mistreated. Any length beyond that may be vulnerable to failure if handled in any but the vertical direction.

## *ECONOMIC ANALYSIS*

The author has, during the past year, donated the use of the Bullet Sampler in two Florida Geological Survey projects. To date 218 samples have been collected in one project during seven days (6 hours/day) of field work along Florida's Panhandle and Big Bend coasts. Shallow water sampling in depths of 1.5 m (5 feet) or less can be accomplished by free surface diving. However, in greater water depths, particularly where currents are moderate or strong, scuba divers are required. Even if both shallow and deeper sampling were to be anticipated in a project, one should employ scuba divers to insure continuity in the sampling effort. Local commercial dive shops were contacted for quotes on diving rates. While they can vary considerably, an equitable, competitive, and relatively low quote of $62.50 per hour was found.

Two activities sap scuba divers' strength: (1) working in a current, and (2) exiting the water and climbing back aboard the host water craft. Four such episodes constitute the diver's working day. Hence, for the work conducted 14, not seven, days of field work would have been required. In addition, two divers working together would be required to satisfy safety standards. Using divers, the 218 samples would have resulted in a commercial total value of $10,500 dollars or $48.00 per sample.

During the seven field sampling days, the author operated the Bullet Sampler. Based upon his approximate salary, the collection of 218 samples during 42 hours of field work results in a total cost of $1,050 or $4.80 per sample. For an entry level employee operating the Bullet Sampler, the cost could easily be as low as $2.40 per sample. Hence, the Bullet Sampler is far more cost effective at less than 1/10 to 1/20 of the standard cost, resulting in completing the sampling task in half the time. In one instance, three samples were extracted 15 feet from a sewage processing facility outfall in 16 feet of water, a task that divers would not have been particularly happy to perform.

## CONCLUSION

This paper describes sampling rational, sampler specifications, dimensions and construction, and sampler operation for a surface sediment sampler costing less than $70 dollars (year 2000 expenditure levels) and a modicum of tools for its construction. A carrying case is an additional concern not covered in this work (Figure 5). The case was constructed of materials left over from preceding wood working projects and extracted no other costs other than design, construction, and painting.

## ACKNOWLEDGEMENTS

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## NOTE

The sampling device described in this work was designed and constructed on the author's free time external to any time as a State of Florida employee. All material costs for its construction were incurred by the author.

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