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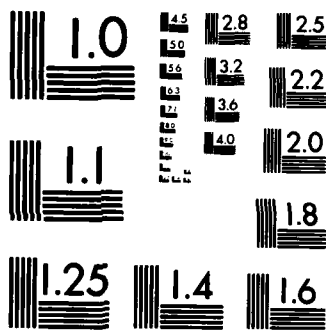
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The construction and operation of a small volume pneumatic water sampler is described. The sampler, constructed of inert materials, simultaneously collects twelve 30 ml water samples in a linear arrangement, with a spacing of 23 cm between samples. Saline waters were sampled and analyzed for salinity, silicate, and total suspended solids to demonstrate the use of the array sampler.		

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A SELF-CONTAINED POLE SYRINGE ARRAY FOR CLOSED-INTERVAL WATER SAMPLING

Introduction

Recent research concerning the dynamics of planktonic ecosystems (Harris, 1981), the recycling of nutrients (Harrison, 1980), and photochemical processes (Zafirio, 1977), as well as continued work on interfacial and frontal phenomena illustrated increasing emphasis on smaller-scale hydrographic studies. Sampling difficulties are among the greater impediments to a further understanding of fine-scale chemical and biological dynamics in limnology and oceanography. Past advances in acquiring the ability to sample water on small spatial scales has been sporadic. The evolution of fine-scale samplers has resulted in decreasing power requirements (Broenkow, 1969), increasing structural integrity and ease of operation, and specialization of materials to minimize sample perturbations during biological, or chemical sampling (Blakar, 1979). This paper describes an array sampler which can collect water samples simultaneously, i.e., within one second with fixed relative geometry. As described here, the Pole Syringe Array (PSA) sampler collects samples along a line; however, two-or three-dimensional arrays are also possible.

Description of PSA Sampler

The PSA sampler features polypropylene syringes (30 ml capacity; 3mm dia intake) as the actual collection devices, similar to those samplers of Broenkow (1969), Clasby, et al. (1972), Heaney (1974), and Blakar (1979). Unlike previous designs, the PSA sampler is nonmetallic except for two stainless steel toggle valves, is entirely self-contained, operates

independently of hydrostatic pressure so that water will not enter the sampler during descent, is armed with hand-operated vacuum and pressure pumps, is rigid and protective of the sampling syringes, and may be used at depth or on the surface in vertical or horizontal deployment. A split-pipe design allows for ease of movement through the water when deployed across hydrographic features. The distance between adjacent sampling inlets is 23 cm.

Details of construction are presented in Figs. 1 and 2 . The PSA sampler is composed of three sections: syringe array, arming and actuation valving, and pneumatic reservoir. Construction materials are split PVC piping (2.5 in., 6.36 cm diameter, Schedule 40) and PVC rod turned to fit the pipe interior diameter. Disposable polypropylene syringes are used with plunger handles removed. Pneumatic lines are also polypropylene fitted to nylon Swagelok couplings. The pneumatic reservoir is 4 in. (10 cm) Schedule 40 PVC piping capped at one end and fitted with a flange on the other end; total volume is approximately 2 liters. Standard PVC cement glue joints have proven air and water tight, and reliable. The cost of materials and support devices has been about \$300.

Access to the pneumatic system is through a cross pattern toggle valve which allows shut-off to the bottom port with uninterrupted flow through the side ports (See Fig. 1). To begin arming the sampler, both toggle valves are opened and the pneumatic reservoir is evacuated to 10KPa (0.1 atm) using a hand-operated vacuum pump (source: IPAS, Box 3360, Chapel Hill, NC,

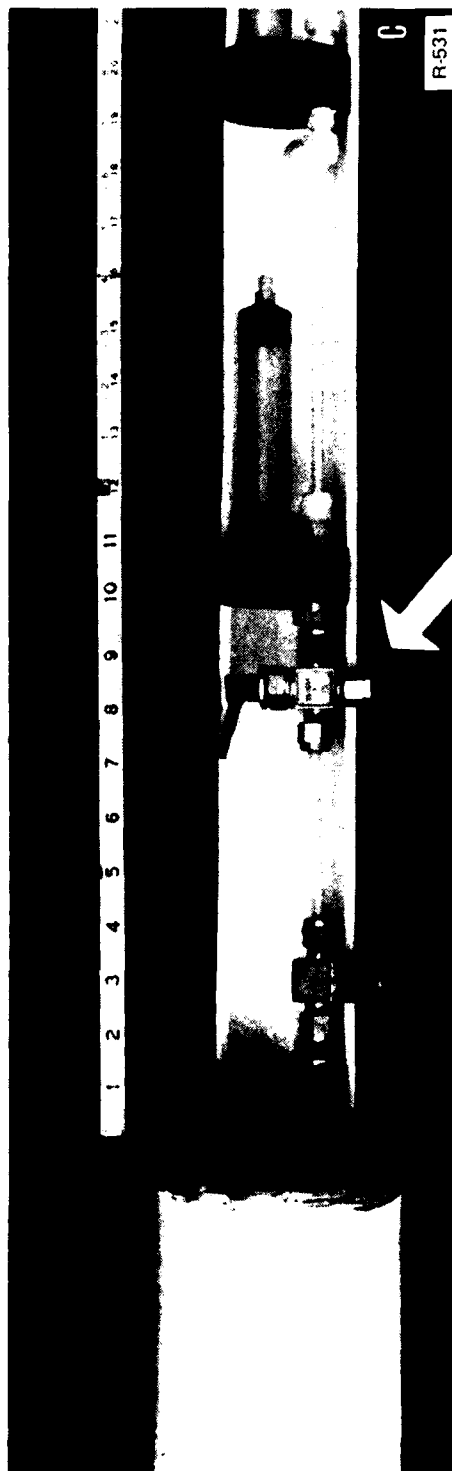
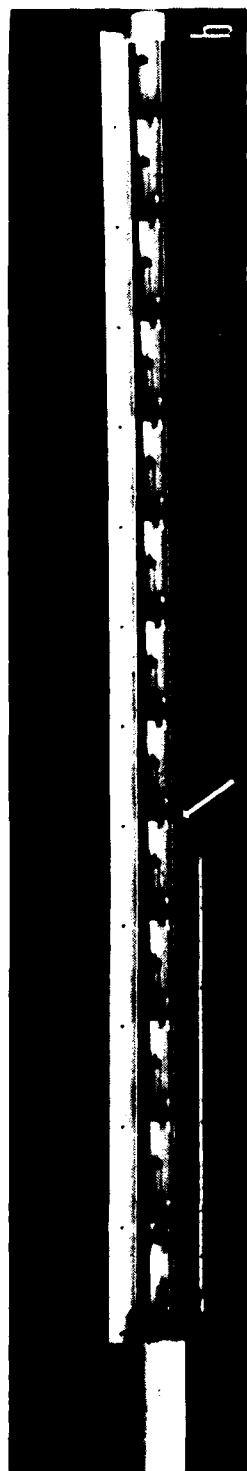


Fig. 1 — Photographic views of the PSA. (a) The PSA as deployed. The small line below the PSA is 1 meter long. (b) The internal structure of the PSA. Note syringes and pneumatic lines near arrow. Arrow indicates exit region for Teflon syringe needle. (c) Details of pneumatic system on the PSA. Pneumatic reservoir is to the left. Arrow indicates cross pattern toggle valve. Hex nut nearest arrow allows access to the pneumatic system on the PSA. Toggle valve nearest reservoir actuates sample collection sequence for the PSA, and is the only protruding valve. Note syringe, Teflon needle, plastic pneumatic lines, and stainless steel interface between toggle valves and PVC bulkheads.

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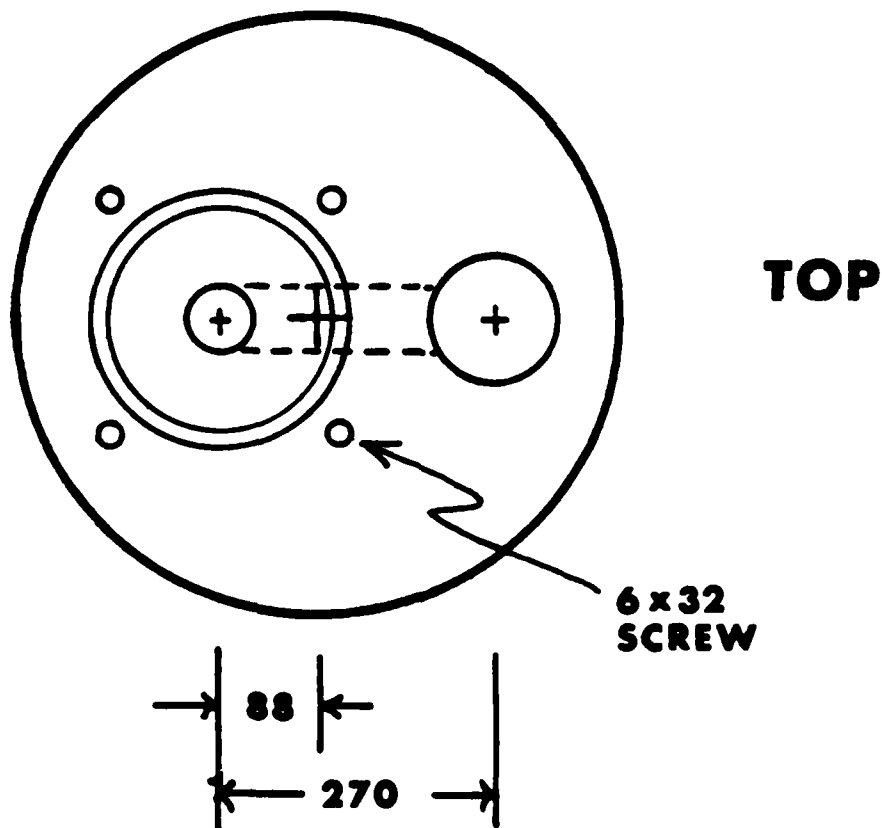
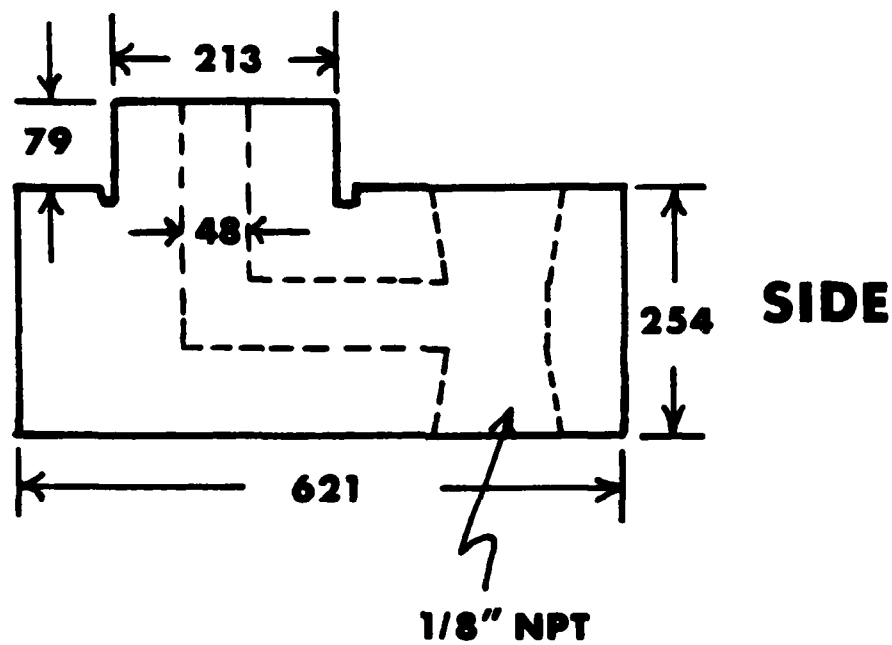


Fig. 2 - Engineering drawing for PVC bulkheads in the PSA. Unless otherwise indicated, numbers are in millimeters, and fit 30 ml syringes. NPT is National Pipe Thread. Dashed lines indicate pneumatic passages inside the bulkhead.

27514, USA). Next, the reservoir is isolated by closing the shut-off toggle valve and then the pneumatic lines and syringes are pressurized with a gauge-equipped bicycle foot pump to some positive pressure greater than the hydrostatic pressure at the depth of deployment. Thus, sampling only at the desired depth is assured. Arming of the system is completed by closing and capping the cross pattern valve. At this point the syringe plungers are seated at the delivery end of the barrel and the only dead volume in the system is that contained in the Teflon syringe needles (Hamilton, Reno, Nevada) fixed along the side of the array. This dead volume may trap air which compresses with increasing hydrostatic pressure allowing a small amount (up to 0.3 ml) of water to be added to the 30 ml sample. The amount of water potentially added to a sample is a function of depth, and would be the same for all samples collected at a given depth. The potential 1% error mentioned above is a maximum addition of water to a sample, and would occur only at depths greater than approximately 20 m. For some applications this dead volume in the present system can be minimized below the one percent contamination it represents by using needles of less length and diameter. Note, however, that small needle diameter could affect particle size distribution as collected, by potentially excluding larger seston. Alternatively, one could fill the dead space in the needles with distilled water, making allowances for the distilled water added to the collected sample.

The sampler is actuated either remotely or manually by opening the reservoir to the array, simultaneously collecting

twelve samples. The final pressure within the system has been chosen by adjusting the reservoir volume so that final internal pressure is near 6.6 kPa. After sampling, the reservoir is again isolated by closing the shut-off toggle valve. As the sampler is brought to the surface, expansion inside the pneumatic lines is insufficient to cause loss of sample, since the final pressure inside the lines is still below atmospheric pressure. The reservoir valve is the only actuating valve and it has been designed to protrude from the side of the pole array, and cannot be mistaken for the actuator.

The PSA sampler is easily operated from a small boat. Collected samples may be removed singly with suction, or expelled in unison with gentle pressure into bottles held in a rack. The sampler is adaptable to in situ filtration with Swinnex filter holders, but one would need to remove one side of the sampler's main body, somewhat weakening the device, to accommodate the filter holders and access to them.

Results and Discussion

To demonstrate the field use of the device described above, the PSA sampler was deployed to sample surface frontal systems in Delaware Bay, Delaware - New Jersey. Frontal systems, marked by accumulations of flotsam, foam, and slicked areas, can occur at the junctures of water masses of different conservative or non-conservative properties and can be persistent in Delaware Bay (Szekielda, et al., 1972). Some previous work had addressed the physical oceanography of slick frontal systems, but little has been written of the chemistry of such boundary regions (Sick, et

al., 1978). The water masses separated by the boundary can display very different, and non-homogenous, distributions of such parameters as salinity, nutrients, total suspended solids (seston), temperature, and dissolved organic matter, which can contribute to surface slick formation.

In May of 1981, horizontally spaced samples were collected at three locations approximately 2 km from the New Jersey shore in lower Delaware Bay. Sample depth was approximately 15 cm, and the PSA sampler was deployed by hand in a region marked by a linear accumulation of surface debris indicating a recent convergence within the estuary. One suite of 30 ml samples was obtained for salinity measurements, using an adapted Knudsen titration (Strickland and Parsons, 1972). One ml of sample was diluted with 20 ml distilled water, and titrated with standardized 0.22 N AgNO_3 . Blanks contained no chloride measurable by titration.

A second suite of 30 ml samples was filtered ($0.4\mu\text{m}$ Nuclepore membrane filters, 27mm dia, tared) for Total Suspended Solids and silicate analysis. The filters were rinsed with 2 ml distilled water to remove salts, and dried at 80°C , prior to reweighing for TSS retained. Silicate analyses on the filtrate (the filter rinse aliquot was discarded) was adapted from Fanning and Pilson (1973), and reagent blanks measured against distilled water showed no color development at 810 nm. All data given in Table 1 are good to approximately $\pm 0.75\%$, based on replicate analyses. Note that the non-conservative TSS and silicate varied greatly over the distance sampled. For the suite of samples

Table 1.
Selected Parameters Measured in Water Samples
Collected With the PSA Samples in Delaware Bay Fronts, May 1981

Relative Position	Series	Salinity 0/00	TSS* mg/liter	Silicate μM	Series	Salinity 0/00	TSS mg/liter	Silicate μM	Series	Salinity 0/00	TSS mg/liter	Silicate μM
1	A	-	12.7	11.1	B	21.0	64.8	8.0	C	21.2	35.8	4.3
2	A	22.9	10.3	5.9	B	21.1	22.1	5.6	C	21.2	25.2	5.2
3	A	22.9	-	-	B	21.1	27.7	6.6	C	21.2	20.0	5.2
4	A	-	9.4	5.6	B	20.9	32.4	3.5	C	21.0	25.5	5.4
5	A	-	-	-	B	21.0	44.1	5.2	C	20.9	25.4	6.1
6	A	23.2	13.1	6.6	B	21.1	43.5	6.3	C	21.0	24.2	9.8
7	A	-	10.7	8.4	B	21.3	46.1	3.5	C	20.9	30.0	6.3
8	A	22.9	11.9	7.7	B	21.2	45.3	2.1	C	21.0	29.4	4.7
9	A	-	12.2	9.7	B	20.8	54.7	8.0	C	21.3	23.7	3.5
10	A	22.8	-	-	B	21.2	46.9	7.3	C	21.1	28.3	8.4
11	A	22.8	-	-	B	21.1	56.0	7.0	C	21.0	27.6	5.2
12	A	23.1	28.4	1.4	B	21.3	59.7	2.1	C	21.3	29.2	4.3

*TSS = Total Suspended Solids captured on 0.4 μ filter

collected, which were gathered to demonstrate the PSA sampling capabilities, it appears that sampling in a visible surface accumulation region may not ensure sampling a true water mass boundary, as defined by T-S properties. Instead, note the constancy of the salinity data, which may be indicative of a homogeneous water mass.

In conclusion, a new design for evolving close-interval array sampler has been described which shows significant improvements in operation, field-worthiness, and potential for alternate sampling geometries. The sampler has proven very reliable in multiple, successive use at 20-30m (not described) and deployed from a small boat. Moderate abuse has not caused misactivation.

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