The Multiple Unit Large Volume in-situ Filtration System (MULVFS) was first described (Bishop et al., 1985). MULVFS consists of 12 ship-electricity powered pump units deployed simultaneously to kilometer depths using a dedicated (unified) 1000 m long electromechanical cable and winch system (Fig. 1). Details of filtration units are described below and in Fig. 2)

Fig. 1. MULVFS shown deployed from the starboard side of R/V Revelle. Shown are the drum winch and associated hydraulic power system, level wind, electromechanical and wire handling system. Photo from 2002 during the Southern Ocean Iron Experiment. Setup during VERTIGO was identical.

MULVFS sample depths were 30, 55, 80, 105, 155, 205, 255, 330, 480, 575, 680, 770, and 880 m at ALOHA, and 10, 35, 60, 85, 135, 185, 235, 310, 460, 560, 660, 760, and 810 m at K2. The shallowest sample was always within the surface mixed layer. VERTIGO casts were timed to capture particles near local noon and midnight to investigate the effects of diurnal zooplankton migrations on particle distributions. At ALOHA, 3 day and 2 night casts were obtained; at K2, 2 day/night pairs were obtained.

Each pump unit can collect samples of particulate and dissolved species using three flow paths (Fig. 2A and 2B). Check and gas release (de bubbler) valves (Fig 2B) protect filter samples from the effects of back flow, contamination, and disruption due to trapped air on deployment and degassed air expansion on recovery. The later is a problem in shallow samples.

Depending on depth and particle concentration, 2000–16 000 L volumes of seawater are filtered under a suction of ~0.8 atmospheres over 4–5 h through the main multi-stage (3 anti-washout baffles and two filter stages) filter holder (Fig 2C). The first anti-washout baffle (Fig. 2C) is a heavy polyethylene plastic cover with incised 1 cm scale triangular flaps centered over each of the 52 tubes of the second baffle stage (Fig. 2C) and was added to ensure particle retention under strong current shears.

The main filter series (with an effective filtration diameter of 24.5 cm) consists of a 51 µm polyester weave mesh prefilter supported by 149 µm polyester mesh and 1.2 cm spaced 1.2 cm thick plastic grid in the prefilter stage, followed by two identical Whatman QMA quartz fiber filters supported by 149 µm polyester mesh and 149 µm porous polyethylene frit. All filters and components are acid cleaned. The three particle size fractions represented by prefilter and QMA filters are >51, 1–51, and <1 µm. Fiber filters are 'depth' filters and particles are captured from the flow by the fibers, not pores. Thus a second filter captures additional small particles that pass through the first (Bishop and Edmond, 1976). The "<1 µm" fraction, thus represents some of particles in the larger submicron particle class (Bishop et al., 1977, 1985).

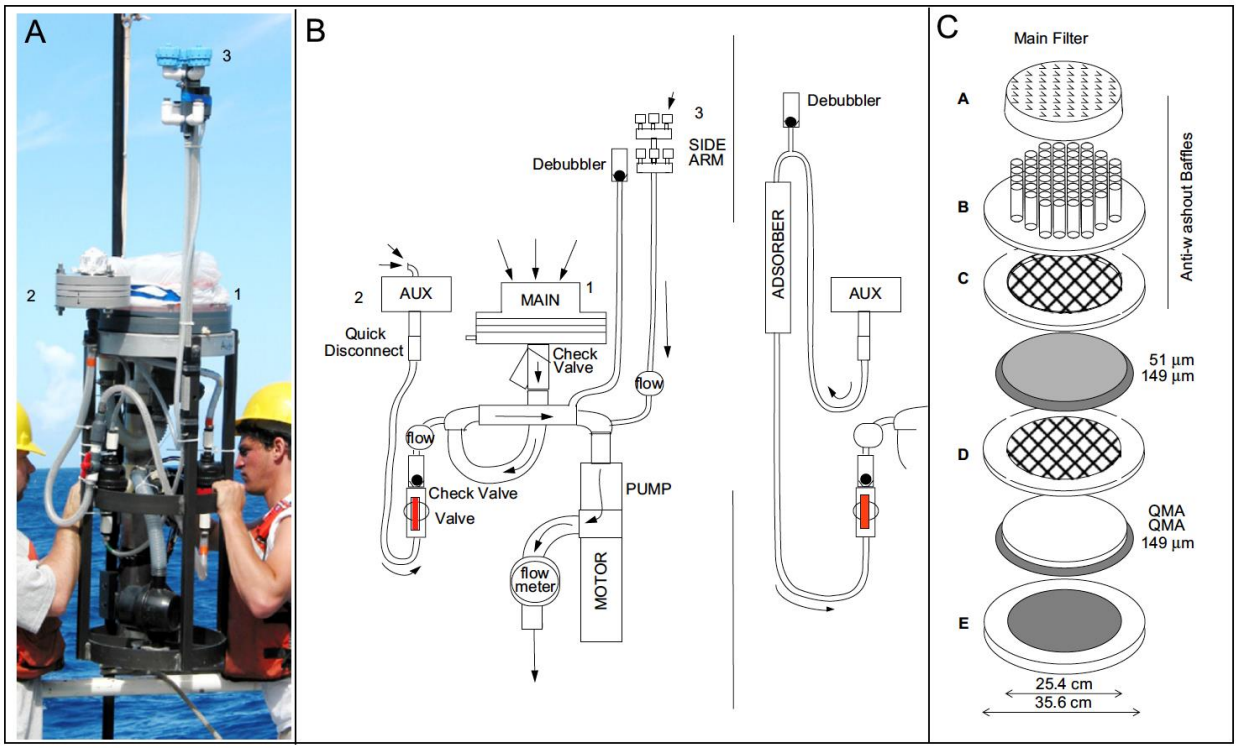


Fig. 2. (A) MULVFS pump shown attached to the polyurethane coated electromechanical cable. Filter holders are protected with plastic until seconds prior to deployment. (B) Flow logic and configuration of three separately metered flow paths: (1) Main filter holder. (2) Auxillary flow path shown occupied by a filter holder assembly provided by T. Trull. Absorber cartridges were also added in-line as illustrated. (3) 'Side Arm' flow path. Used for up to six 47 mm filter holders. (C) Exploded view of main filter holder indicating filters and baffle assemblies

The second flow path (Fig. 2A-2 and 2B-2), with 500–2000 L water flow capacity was used for separate multi-stage filter assemblies and in-line Mn radionuclide adsorption cartridges (Charette et al., 1999). The filter assembly used by T. Trull (University of Tasmania, UTAS) is shown in 1A-2. The third ('side arm') flow path (Fig. 2A-3 and 2B-3) was used for simultaneous attachment of up to six 47 mm filter holders or smaller absorbers. We used two for separate quantification of >0.4 µm Si and for >0.4 µm Ba and Mn (Poretics Polycarbonate, 0.4 µm, Osmonics, Inc.); About 30% of the time all side arm filter holders had a common 0.4 µm filter and the volume was apportioned by number of samples collected. When different filters/adsorbers were used we estimated flow through each type apportioned by flows measured under suction aboard ship.

Bishop, J.K.B., Edmond, J.M., 1976. A new large volume filtration system for the sampling of oceanic particulate matter. Journal of Marine Research 34, 181–198.

Bishop, J.K.B., Edmond, J.M., Ketten, D.R., Bacon, M.P., Silker, W.B., 1977. The chemistry, biology, and vertical flux of particulate matter from the upper 400 m of the equatorial Atlantic Ocean. Deep-Sea Research 24, 511–548.

Bishop, J.K.B., Schupack, D., Sherrell, R.M., Conte, M., 1985. A multiple unit large volume in situ filtration system (MULVFS) for sampling oceanic particulate matter in mesoscale environments. In: Zirino, A. (Ed.), Mapping Strategies in Chemical Oceanography, Advances in Chemistry Series, Vol. 209. American Chemical Society, Washington, DC, pp. 155–175.

Charette, M.A., Moran, S.B., Bishop, J.K.B., 1999. 234Th as a tracer of particulate organic carbon export in the subarctic Northeast Pacific Ocean. Deep-Sea Research II 46 (11–12), 2833–2862.