Keith Bradley

Honjo's early sediment traps were large, gray cones, often deployed in pairs.

Catching the Rain

Sediment Trap Technology

WHOI Senior Engineer Ken Doherty developed the first sediment trap in the late 1970s for what has come to be known as the WHOI PARFLUX (for "particle flux") group. Working closely with the scientific community, Doherty has continued to improve sediment traps for two decades, and these WHOI-developed instruments are widely used both nationally and internationally in the particle flux research community. Because ocean particle flux research encompasses nearly all areas of biogeochemistry, the trapped samples are shared by many programs to take advantage of interdisciplinary cooperative research. This is one reason why the trap opening must be relatively large, to collect enough samples to share with many programs. Many time-series sediment traps have openings at least half a meter square, which results in an instrument about one meter in diameter—time-series traps may be the largest instruments routinely deployed along moorings. However, we do expect that improved analytical methods will allow future reduction in the size of time-series traps used for multidisciplinary research.

Sediment traps require great mechanical strength, as they are often deployed for as long as a year or more, and then redeployed immediately after recovery of samples. Titanium is used extensively where strength is a critical requirement, such as in the structural frame and in the chamber that houses electronics under great pressure. Titanium is light yet as strong as steel and has virtually no reaction to seawater. Various industrial plastics that are very stable in the deep ocean are also used. The opening and closing of a trap requires a reliable mechanism

Courtesy Susumu Honjo

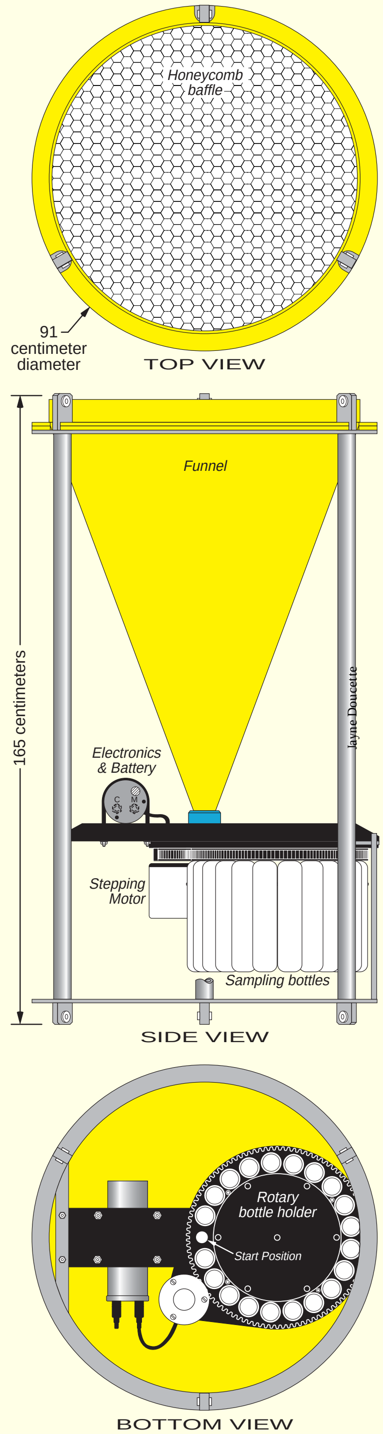
These smaller, yellow cones show the current design. Research Specialist Steve Manganini, who has been involved in some 32 sediment trap deployments in several oceans, is at center.

with many moving parts. The shorter the open period, the better the temporal resolution. However, a shorter collection period requires more collection cups, and there is a limit to the number of cups a trap can accommodate. For a given trap diameter, a short open duration catches less volume of sample. Balancing the need for high temporal resolution with the engineering limitations, many scientists have set a unit duration of about two weeks, and cover a year with some 20 open periods. Sampling cups are opened sequentially: As one cup completes its open period, it rotates away from the base of the funnel opening and a new cup moves to the position, allowing no break in the collection of raining particles. Other than the one that is open, cups are sealed from the ambient water until recovery. In an effort to find a method to keep organic-matter samples in the trap in the best possible condition until they can be retrieved, scientists have tested many preservatives, and a formalin solution is now considered best for general purposes.

Through control technology, Doherty's design allows a scientist to program the entire open/close schedule into a trap's microcomputer from a laboratory PC before deployment. This enables the scientist to use, for example, periods of exactly equal duration throughout the experiment, to open/close frequently during an expected bloom season, or to sample for longer periods in winter when the ocean is less active. Another option might be to open and close in response to signals from various sensors such as turbidity, currents, etc.

There are still questions, however, about whether a trap (of any design) collects all of the particles settling through the water column. Experimental and modeling research on the behavior of settling particles is in progress, and the questions are also being addressed by an ingenious method using isotopes that are absorbed by particles that remain in the water column (see article on page 29).

The sediment trap must be kept stable, maintaining its upright position at all times during its deployment, and



The sampling bottles rotate on a schedule programmed before the instrument is deployed, each collecting about 5 day's to a month's worth of "rain" before being sealed for analysis upon recovery of the sediment trap. At right is a diagram of an Arabian Sea mooring that included PARFLUX traps (yellow cones) for WHOI–Oregon State University joint research and traps specially designed for biochemical studies (red squares) by researchers from the State University of New York–Stony Brook, Skidaway Institute of Oceanography, and the University of Washington.

it must also be retrieved intact. WHOI Research Specialist Steve Manganini, with the cooperation of other Institution buoy engineers, has made continuous improvements to the deep water sediment trap mooring system. Since 1979, Steve's team has achieved 100 percent recovery of PARFLUX sediment traps. They study computer models of mooring behavior and buoyancy and then adjust mooring component designs to reduce the tilting and lateral motion of traps located along the taut line. The mooring line is usually composed of galvanized steel wire jacketed with plastic sheathing. A time-series sediment trap mooring is made up of hundreds of parts, including a large quantity of line, wire rope, and other hardware that are all carefully loaded onto the research vessel.

A deep-ocean time-series mooring is typically set, say, 3 to 5 kilometers deep. In order to avoid collecting particles resuspended by boundary conditions just above the seafloor, the deepest trap is generally deployed about 0.5 kilometers above the bottom. Traps are also often deployed at depths of 1 kilometer and 2 kilometers. Our PARFLUX group pioneered synchronization of the open/close timing of multiple traps to trace particles in time and space. We have extended this from a single mooring to synchronization of many moorings.

Areas where cross-basin arrays have been deployed by JGOFS (the Joint Global Ocean Flux Study) and other programs include several locations in the Pacific and Atlantic Oceans, the Arabian Sea, the East (Japan) Sea, and the southern ocean around Antarctica. These arrays enable scientists to study the multidimensional processing of particles in a large oceanic basin over long periods of time. Currently, an international group of scientists is synchronizing traps that are or will be deployed in the Arabian Sea, Sea of Bengal, South China Sea, East/Japan Sea, and the northwestern Pacific. This giant time-space network will provide important information on how Asian monsoons affect biological pump removal of carbon dioxide carbon from the atmosphere to the ocean's interior.

—Sus Honjo