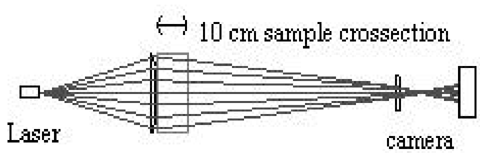
Lesson II. Oceanographic Instruments

Shadowed Image Particle Profiling Evaluation Recorder, SIPPER

The Shadowed Image Particle Profiling System (SIPPER) is an optical imaging system designed to produce high resolution images of very small sea life. SIPPER's sampling tube has a cross section of 100mm by 100mm, and it has been optimized to yield very good images of very small specimens within the entire sampling tube. Below is a schematic of the SIPPER instrument.



A laser with line generator optics creates a fan beam of light, which is brought back together by a first lens. The resulting beam is 100mm wide by 1mm high and passes through a clear opening in the sides of a square sampling tube. The imaging lens produces an unchanged and demagnified image of the particles onto a line scan camera. The digital output from the camera is sent to an image processing board (not shown in the schematic), which acquires the data and displays and saves the sequential lines on a computer. Shown on page 12 is a picture of a light bulb filament taken by the SIPPER.

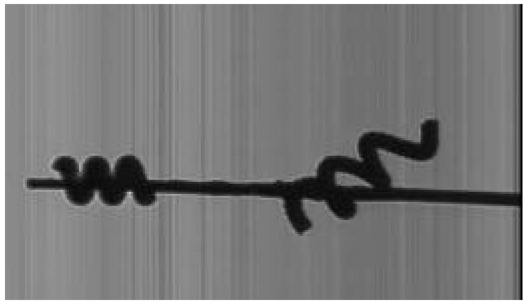
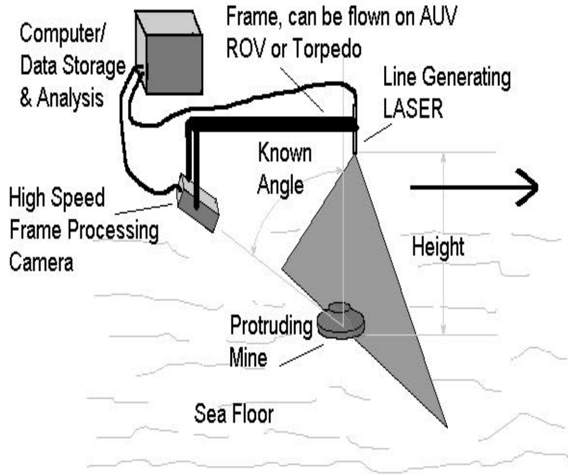


Image of a 1.5mm diameter light bulb filament and a 250 micron optical fiber at the center of the sampling tube, moving at 0.25 m/sec through the light sheet. The camera scan rate is 6000 lines/sec. The figure shows a 3.62 mm portion of the 100 mm sample cross section.

Real-time Ocean Bottom Topography System, ROBOT

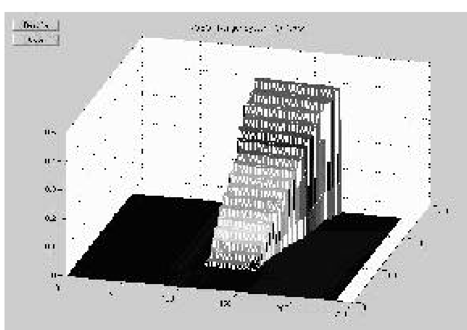
Range scanning, illustrated in the figures below, can provide real-time range information along with shape, orientation, texture, and volume of a target. Laser light, generated in a fan pattern as illustrated in the first figure, illuminates the bottom surface as the host platform moves across the sea bed. A high speed (700fps) 256 by 256 pixel camera views the illuminated scene, captures and analyzes data in real time, and transmits it to a display computer.

AUVs typically have sophisticated control systems that allow for optimization of mission parameters. Parameters such as uniform mean altitude, constant velocity (either with respect to ground or water) and accurate positioning make AUVs ideal as a platform to carry the Real-time Ocean Bottom Topography (or ROBOT) system.



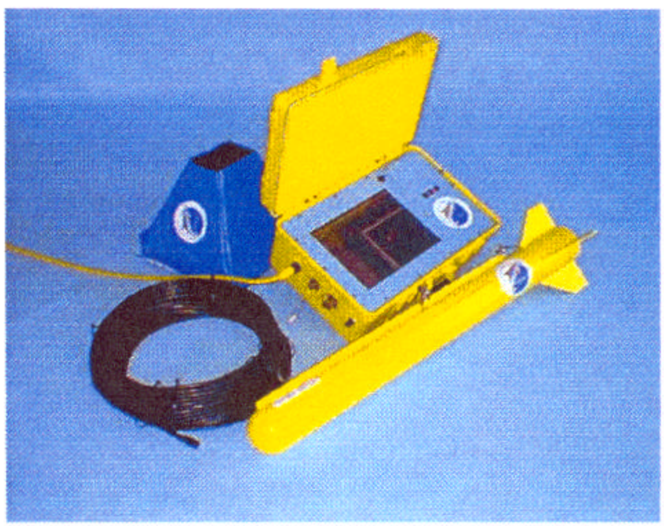
The figure above shows range scanning with a low power laser and a high speed CCD camera. Data are stored in line scan form, 256 bytes at a time in the host computer. Initial processing of "brightest pixel" information, using a threshold process, as well as the option of more sophisticated processing (successive approximation) is performed in the camera itself.

The figure below shows a scanned image of a calibration "stair step" platform examined at a speed of 1 m/sec in air.

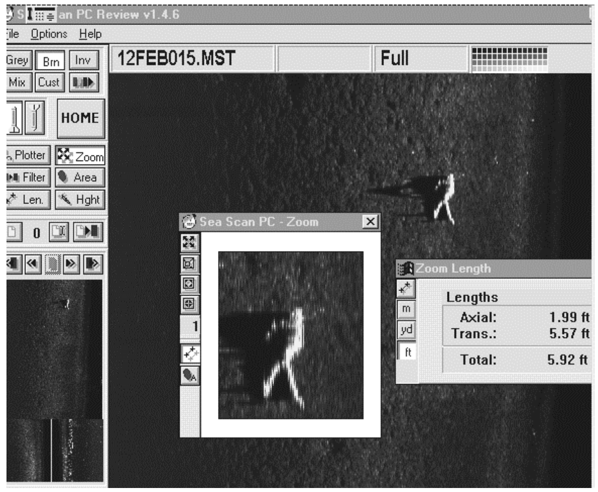


Side Scan Sonar

Once only of interest to the military, side scan sonar offers a unique ability to locate objects underwater with near photographic quality. Sonar uses sound waves instead of light, and can “see” much farther in water. Until the advent of imaging type sonars, objects lost overboard and even ship wrecks virtually disappeared until located by underwater divers, sometimes many years later. Imaging sonar has opened the door to an entirely new capability for ocean scientists, enforcement law enforcement personnel (who use it for evidence retrieval and recovery of drowned victims), treasure hunters and amateur divers (who can more quickly locate shipwrecks and debris from wrecks). The side scan sonar makes all underwater searches more efficient. The photo below shows the side scan sonar as it is encapsulated in the torpedo-shaped towfish. Also included in the picture are the additional parts to the side scan sonar system: the computer (in the yellow case), cable and sun hood (to better focus on the computerized pictures).



The side scan sonar plots the ship's position, the position of the object, and tracks swath coverage. The operator of the side scan sonar is able to see the big picture and is also able to zoom in on objects of interest. Below is a side scan sonar picture of a body at the bottom of a lake.

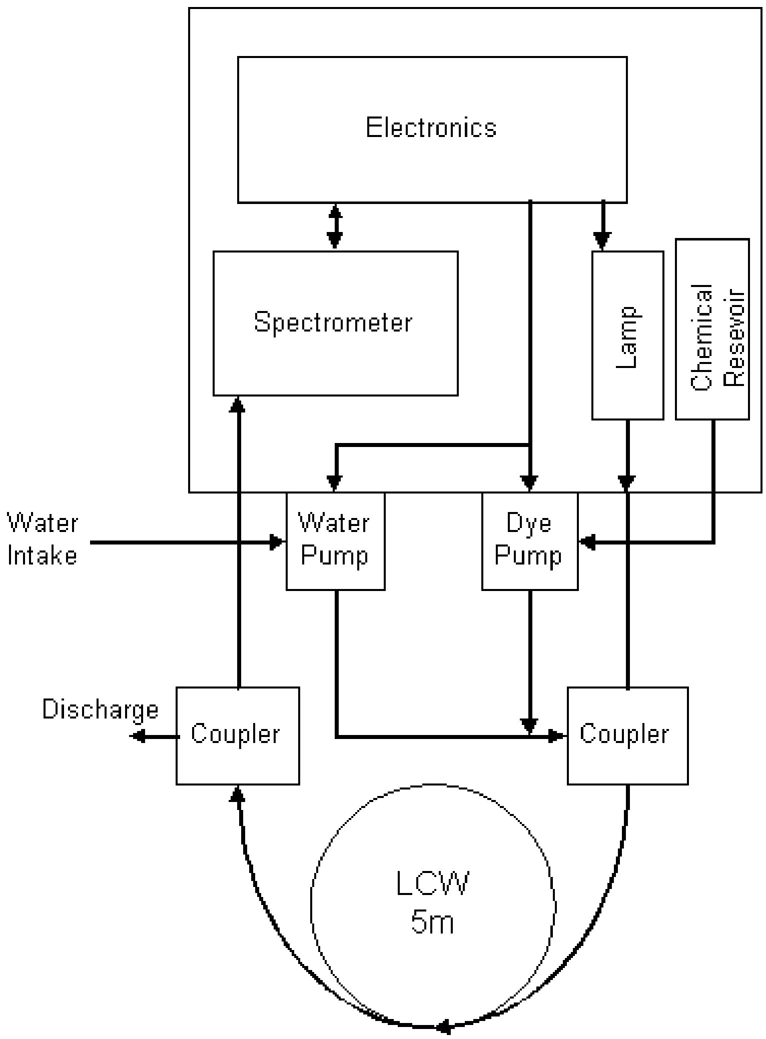


Spectrophotometric Elemental Analysis System, SEAS

The purpose of this instrument is to allow *in situ* measurement, with greatly extended detection limits, of essential oceanic trace metals and nutrient ions. The instrument as developed contains a 4.5 meter optical path length. Using the long optical path length and colorimetric procedures for seawater analysis developed by many investigators over more than fifty years, the chemistry of the upper ocean can be studied in a manner heretofore impossible. With a single type of measurement (long path length spectroscopy) simultaneous *in situ* analysis of a variety of solutes can be obtained rapidly and without preconcentration.

This **spectrophotometric** approach is versatile in that multichannel spectrophotometric systems are capable of performing analyses for iron, manganese, copper, phosphate, ammonia, nitrate, nitrite, pH, alkalinity and others. This capability is important in learning more about the chemistry of the ocean. Closer to home, this instrument could be used in all types of water control systems to determine whether or not the water is fit to drink.

The instrument's long optical path length is obtained with a liquid core waveguide (LCW). The liquid medium inside the waveguide has a refractive index that is greater than the surrounding medium; therefore, light is constrained within the waveguide. The outstanding features of this approach to measuring oceanic trace metals and nutrient ions is that because it uses a very small sample volume, the size of the total instrument is also small. The typical sample volume needed for a five-meter path length is on the order of $1cm^3$. The LCW itself can be coiled into a volume on the order of 25 cm^3 or smaller. Shown below is a schematic of the LCW.

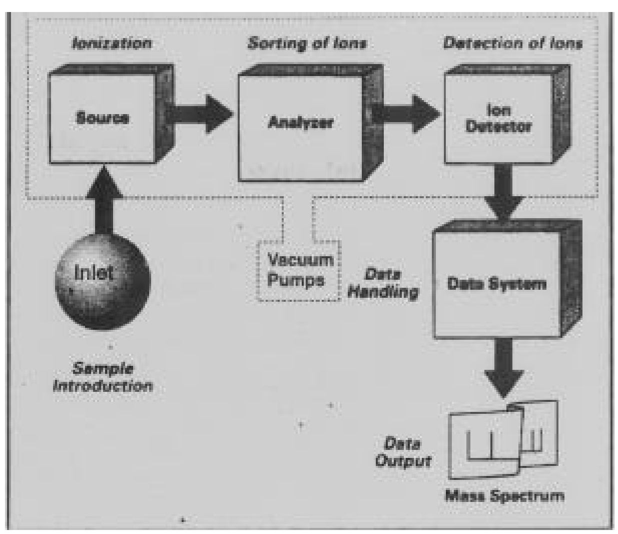


The water enters the water pump and is mixed with a dye that will determine the presence or absence of the chemical of interest. The mixed fluid is sent through the LCW, and is ejected.

The light from the LCW is measured and interpreted by the spectrometer, which determines the amount and intensity of the chemical of interest.

Underwater Mass Spectrometer

Numerous scientific groups have made progress in identifying chemicals, measuring their concentrations and understanding their interactions within the water column. What is missing from this work is a comprehensive sensor that would provide a complete picture. For this reason, the Center for Ocean Technology is working to develop an *in situ* mass spectrometer that can be deployed on an AUV. The mass spectrometer will fill the need for a comprehensive sensor because of its versatility and power. Mass spectrometry provides high resolution molecular fingerprinting; that is; it yields unambiguous information about molecular structure and identity. In addition, mass spectrometry has the potential to detect all elements in the periodic table. The following schematic depicts how mass spectrometers do their work.



Microelectromechanical Systems, MEMS Devices

The miniaturization revolution in instrumentation has emerged as the driving force in the development of electronic, biomedical, analytical and electromechanical systems. The present trend indicates that microsystems technology will influence a vast number of products and services over a wide range of industries around the world. Current emphasis on **microinstrumentation** development focuses primarily on biomedical, chemical and automotive applications. To date oceanographic microsystems have been neglected, yet they offer an opportunity to develop relevant sensor systems for coastal surveillance and defense, sea exploration, management of emerging economic zones (EEZs) worldwide and deployment of unattended ground sensors (UGS) for military surveillance, meteorology and global climate measurements.

Microsystems technology, commonly called MEMS (microelectromechanical systems), is made up of miniature electrical and mechanical devices using structures about the width of a human hair. They are an offshoot of the technology associated with fabricating integrated silicon devices. This is a large field that incorporates all existing "micro structure" technologies, but is simply machinery at a smaller scale. Some everyday examples of microsystems are airbag sensors, blood pressure monitors, computer disk drives and ink-jet printer heads.

The University of South Florida's Department of Marine Science is undertaking a project to develop marine sensors using MEMS technology. The approach capitalizes on industry development efforts that have created **micro pumps**, sophisticated optical devices, accelerometers, motors/geared devices and pressure transducers. The successful creation and implementation of such sensors will open the door to vast, practical and inexpensive networks for monitoring and studying the world's aquatic environments.

Student Information Sheet Lesson 2

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Activity I: Research and Learn

Research the AUV (Autonomous Underwater Vehicle). Use various sources such as web sites, online encyclopedias, library books, magazines and journals.

Write a two-page paper about how they work, when they were created, what they are used for and what instrumentation they carry.