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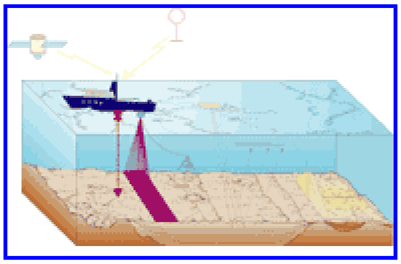


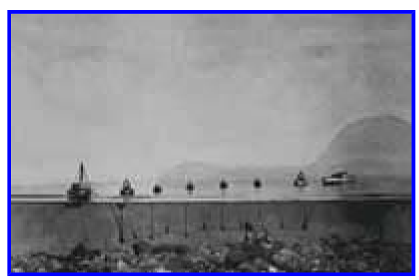
Bathymetry systems

History and Methodology

Bathymetry

Early bathymetric measurements, or "soundings" were made by lowering a weighted line over the side of a boat and measuring the length of line output when the weight hit bottom. The lead weight was usually conical in shape, sometimes with a touch of wax or lard on the base to collect a small sample of the surficial sediment. Similarly, sounding poles were used in shallow water environments. The importance of these sounding measurements was noted in the logs of the H.M.S. Challenger expedition: "The ordinary deep-sea sounding lead, from 12-14 lbs. in weight, armed with lard, often gives valuable and reliable information concerning the deposits in all depths under 100 fathoms." (H.M.S. Challenger Report on Deep-Sea Deposits, p.1) Locations of these soundings were made by celestial navigation methods, using a sextant or earlier instruments such as astrolabes and quadrants to convert their observations to a position on a chart (Fairbridge,ed.,1966).

Tanner Sounding Machine. Designed by Zera Luther Tanner, first captain of the ALBATROSS I



Wiredrag diagram. The basic principle is to drag a wire attached to two vessels. If the wire encounters an obstruction it will come taut and form a "V"

Both images courtesy of NOAA (NOAA Central Library, Historic C&GS Collection).

Ingenious sounding machines using reels to deploy wire and to measure output were created to increase accuracy and speed of deeper water soundings.

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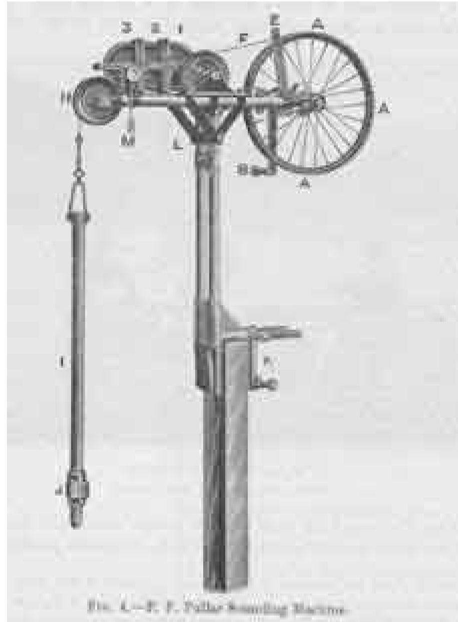
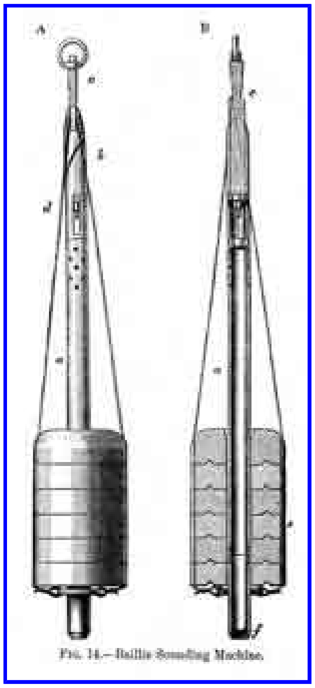
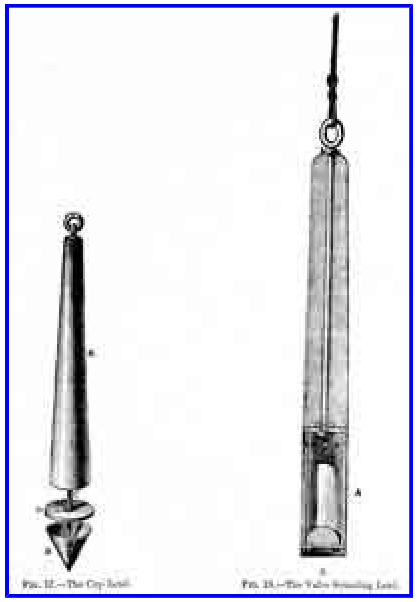
Sounding machine developed circa 1895, consisting of a take-up reel and handle. The sounding weight is suspended from the reel. (Murray and Pullar, 1910, Fig. 6, p. 13). Courtesy of the National Library of Scotland - www.nls.uk.



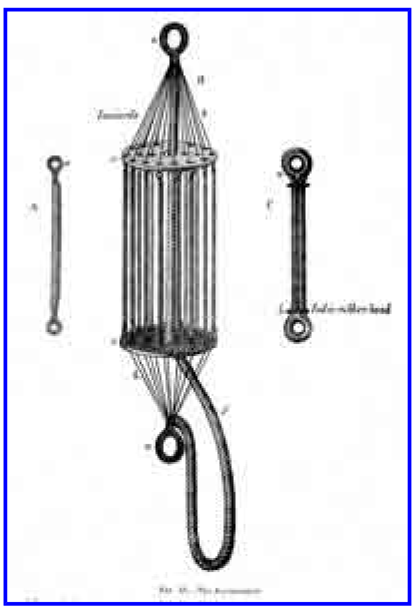
Sounding device designed by Fred Pullar, based on bicycle tubing with a drum. 1000 feet of wire could be reeled out, the ouput measured by three dials for feet, tens of feet, and hundreds of feet. Deposits were collected in brass tubes attached to the base. (Murray and Pullar, 1910, Fig. 4, p. 11). Courtesy of the National Library of Scotland - www.nls.uk

The H.M.S. Challenger expedition made depth measurements and sampled or “sounded” the sea floor using a variety of sounding devices. The heave effects on the sounding line were compensated by devices named “accumulators” (Sverdrup, Johnson, and Fleming, 1970). They were attached at intervals along the length of the sounding line and could stretch up to 17 feet and exert 70 pounds force in order to somewhat equalize the strain on the line due to vessel roll, bottom snags, or other sudden motions (H.M.S. Challenger Results, Narrative, vol.I, p.62).

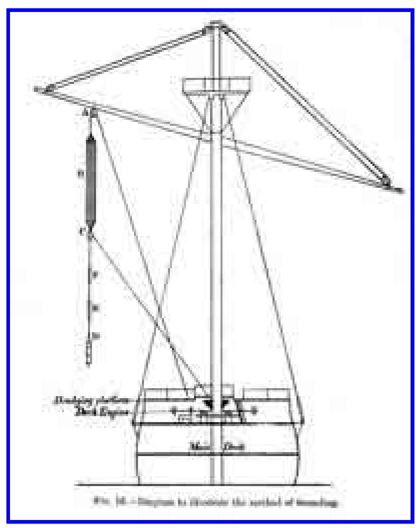




Three types of sounding devices used by the H.M.S. Challenger using a variety of weighting and sampling mechanisms. The Baille sounder/sampler could bring up two feet of sediment. The cup lead was an iron spike(C) with a hollow core (B), and a sliding iron disk that would cover the cup once the sample was taken (D). The valve lead had an iron cylinder (A) with a butterfly valve (B) at the base (Baille: H.M.S. Challenger Narrative, vol. I., p. 60; Sounding leads, p. 69;) Courtesy of The Royal Society.

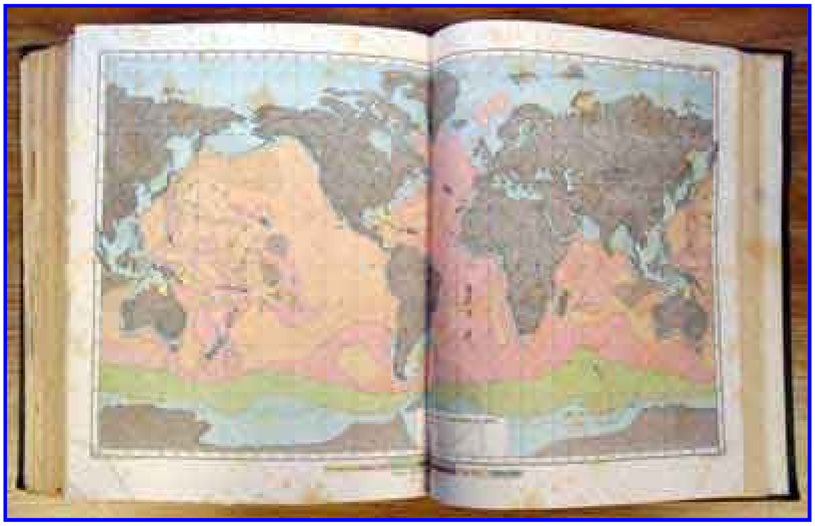


Accumulator used to prevent heave effects on the sounding line.



H.M.S. Challenger method of sounding. A: block, B: set of accumulators, C: gin block, 9", D: sounding rod and sinkers, E: water bottle, F: 2 or 3 thermometers and pressure gauge. H.M.S. Challenger Results, Narrative vol.I, p. 64. Courtesy of The Royal Society.

The soundings collected by the H.M.S. Challenger were sparse by today's standards, but were sufficient to establish "The bottom of the ocean it appears is as varied as the land for there are valleys & mountains, hills & plains all across the Atlantic". (Rehbock,1992) A bathymetric contour map of the world's oceans was produced from the expedition.



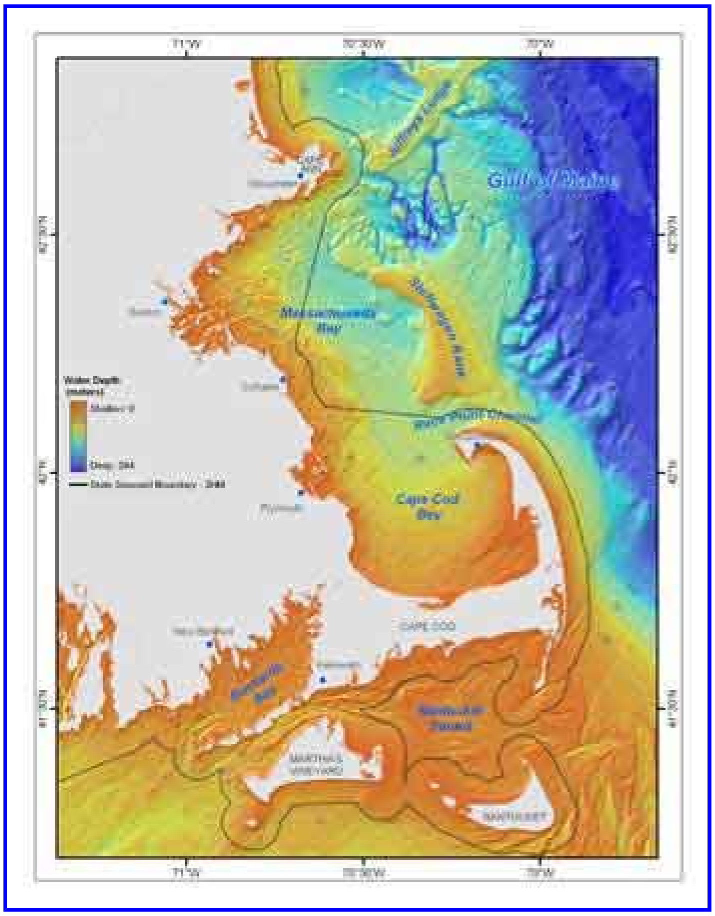
An inspection of Chart 1 (this map), showing the horizontal distribution of deposits, and an examination of accompanying descriptions, will show that the various types of deposits pass insensibly the one into the other and that a slight alteration in the depth is frequently sufficient to produce a marked difference in the character of the deposit, the other conditions remaining unchanged. (H.M.S. Challenger Results, Report on Deep-Sea Deposits, Appendices and Charts, Courtesy of The Royal Society)

With the advent of the First and Second World Wars and the determination of the speed of sound in water, the use of underwater sound was developed to replace the mechanical measurements. The depth of water under the ship could be determined by measuring the two-way travel time (from the ship, to the bottom, and back) of a pulse of acoustic energy (sound) sent by a transducer directly below the ship. This is the basis of the single-beam echosounders. The sea floor is repeatedly'pinged' with this narrow (less than about 5 degrees) cone of acoustic energy as the ship moves along the track. So, researchers obtain a recording of the two-way travel time of sound energy directly below the ship, along the ship's path. These time values are converted to depth by multiplying by the speed of sound in the water, commonly assumed to be 1500 m/sec, and dividing by two to account for the two-way travel time. Today, a sound velocity profiler is able to provide precise speed of sound measurements throughout the water column.

A single-beam echosounder uses one transducer to transmit and receive sound energy. Low frequency echosounders, operating at 3.5kHz, actually penetrate the sea floor, so some information about the subsurface, dependent on sediment type, is acquired. Higher frequency instruments generally only provide water depths. Echosounders are limiting, though, because data are only gathered directly beneath the vessel; no data are acquired to either side of the ship track.

With the ever-increasing need for accuracy and coverage, the technology advanced to swath bathymetric systems, introduced in the 1970's, so that multiple points or swaths of the ocean floor could be ensonified with each transmission of acoustic energy. Thus, multiple contiguous points of the sea floor are mapped with each ping. Additionally, motion sensors are used to record pitch, heave, and roll of the vessel in order to correctly place soundings.

Interferometry is used to describe a technique that uses the phase content of the sonar signal to measure the angle of a wave front returned from the sea floor (sonar target). Interferometric systems, such as those used by the WHSC, measure the range and angle to a series of points on the seabed, producing high-resolution depth and backscatter measurements of a survey area.



Example of modern high-resolution mapping of the sea floor offshore Massachusetts. The WHSC has been involved in cooperative studies to produce high-resolution bathymetric and geologic maps and a geographic information system (GIS) for the area. http://woodshole.er.usgs.gov/project-pages/coastal_mass/index.htm

This brief history is not intended to be a complete one. It is an overview from which readers may further explore the topic in libraries or on the web, using the topics presented above as starting points.

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