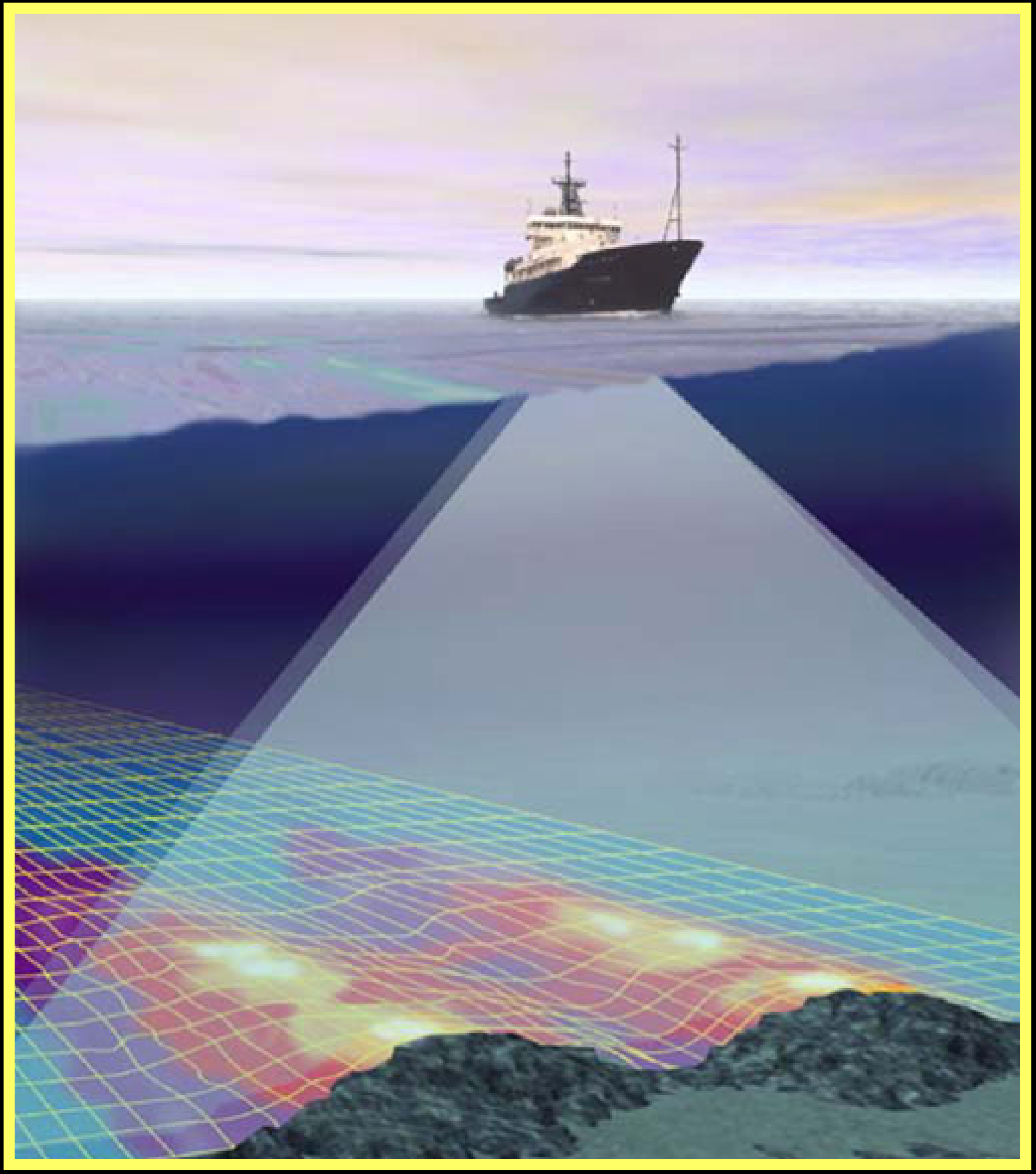


The History (short) and Fundamentals (shorter) of Sea Floor Mapping Techniques

Mark Holmes

Univ. of Washington

Mimi D'Iorio

NOAA Monterey

The sounding device of Robert Hooke, ca 1693

The weight was released on impact with the bottom, allowing the float to return to the surface

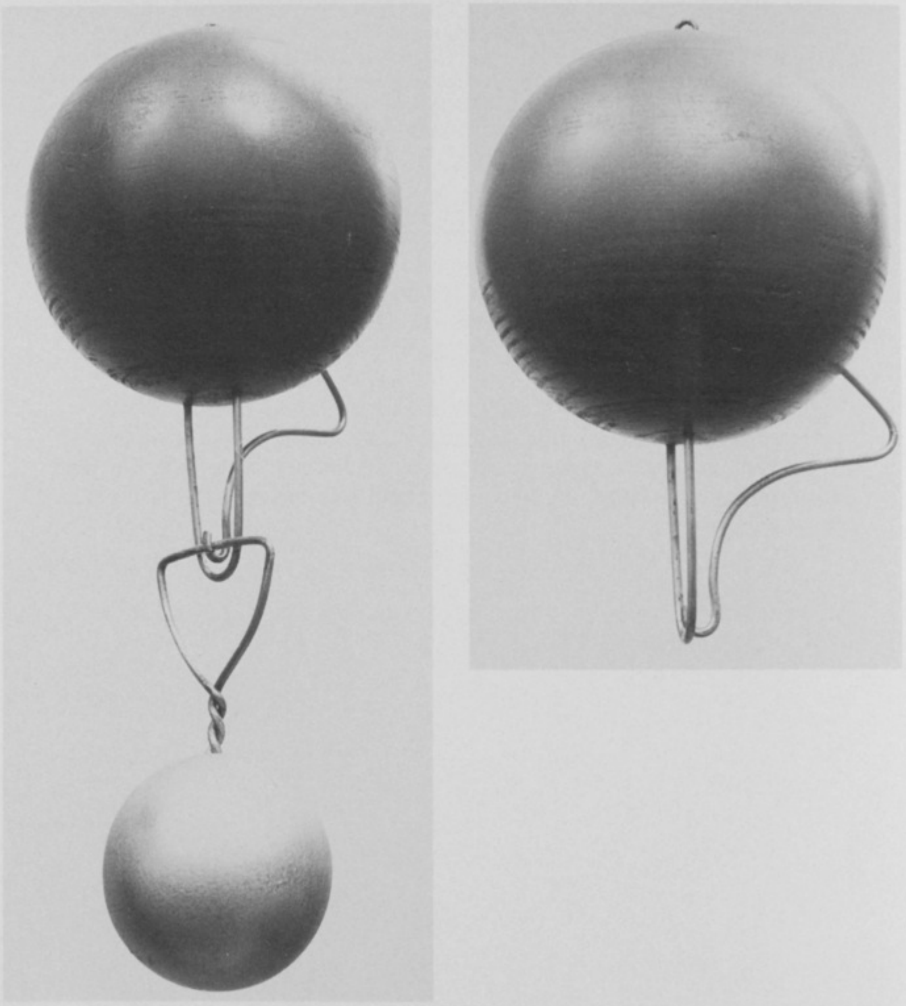


Figure 59. – Sondeur de HOOKE.
A gauche : à la descente ; *à droite* : à la remontée.

(photos Y. Berard)

The wireline sounding machine of Belloc, ca 1891

Similar - and much larger - versions were used aboard *Challenger*

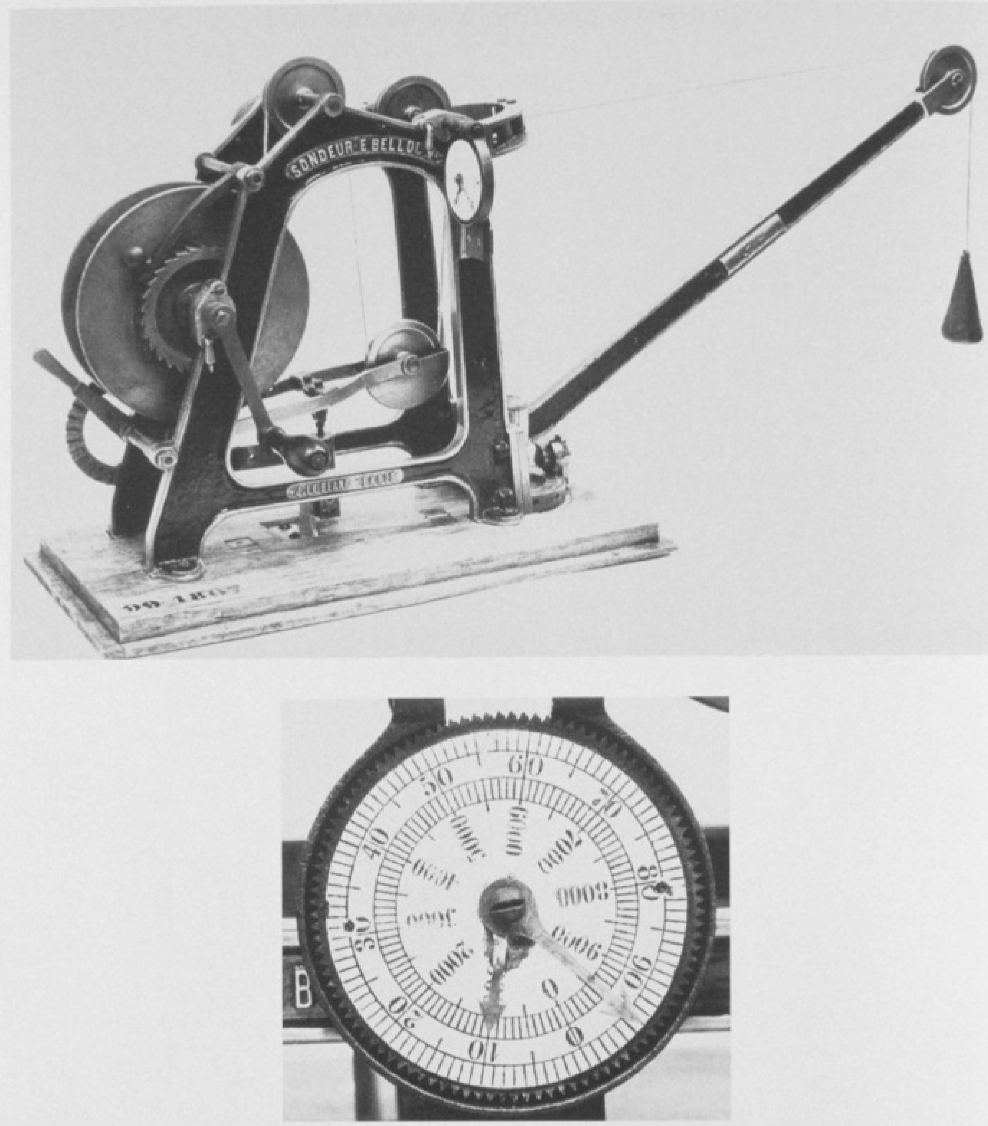
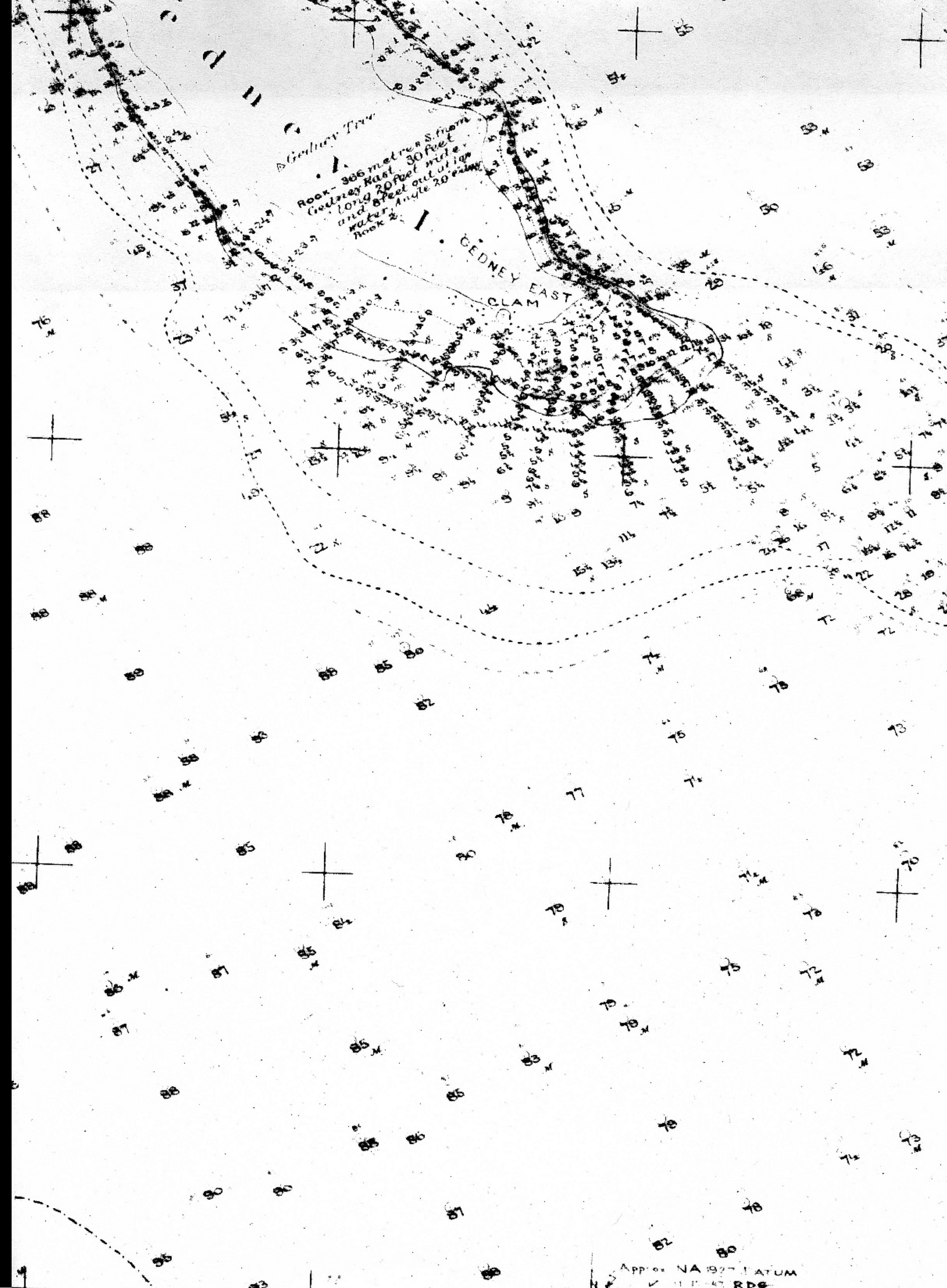


Figure 50. – Machine à sonder de BELLOC.
En haut : vue d'ensemble ; *en bas* : détail du cadran.

(photos Y. Berard)

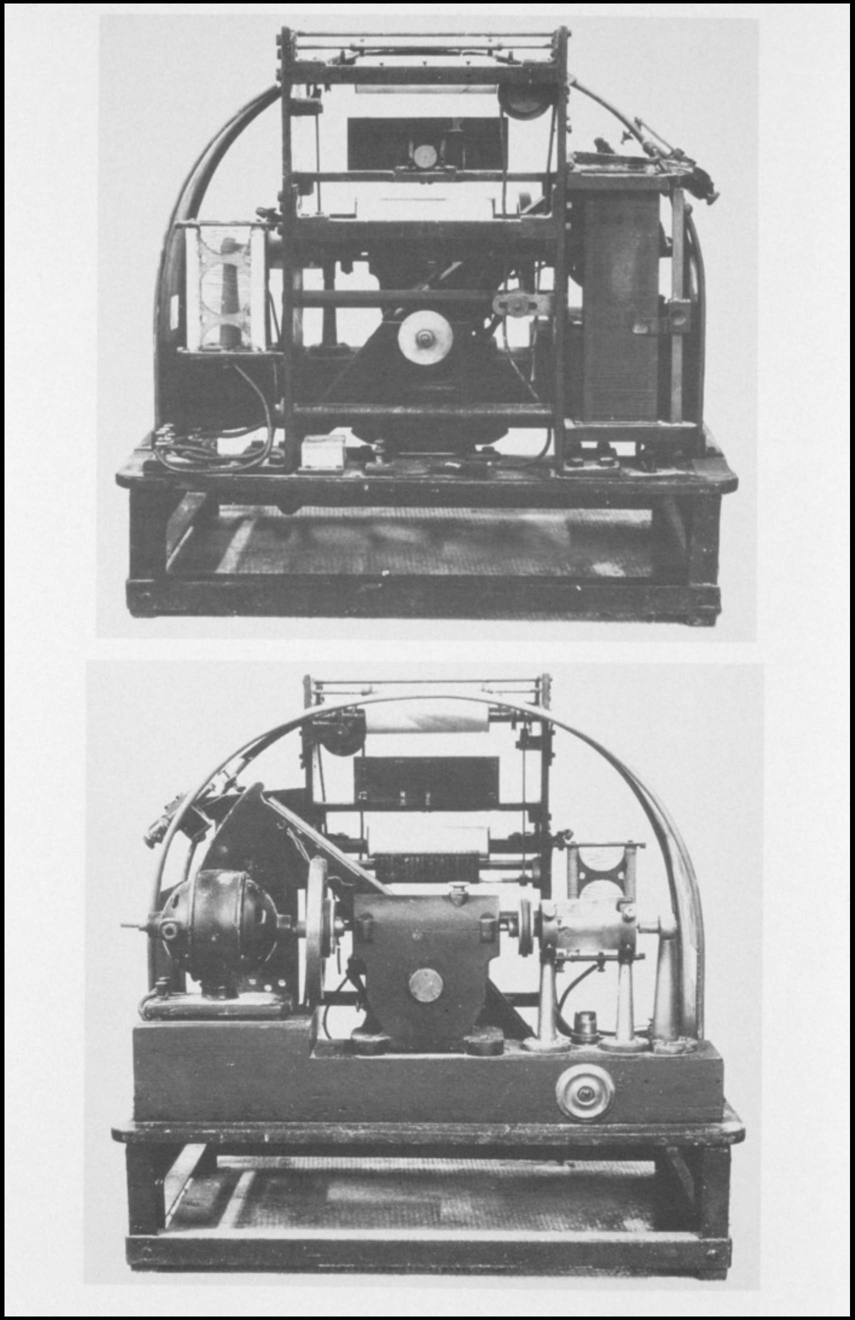
U.S.Coast and Geodetic Survey chart of the Gedney Island area, Port Gardner, 1886



One of the first acoustic sounding devices, built by Marti in 1919

The sinking of Titanic spurred development of new technologies for detecting icebergs.

And of course WWI did the same for finding Submarines.



Data from Marti's acoustic sounder

Peaks on the left denote time of outgoing pulse; those on the right the echo arrival

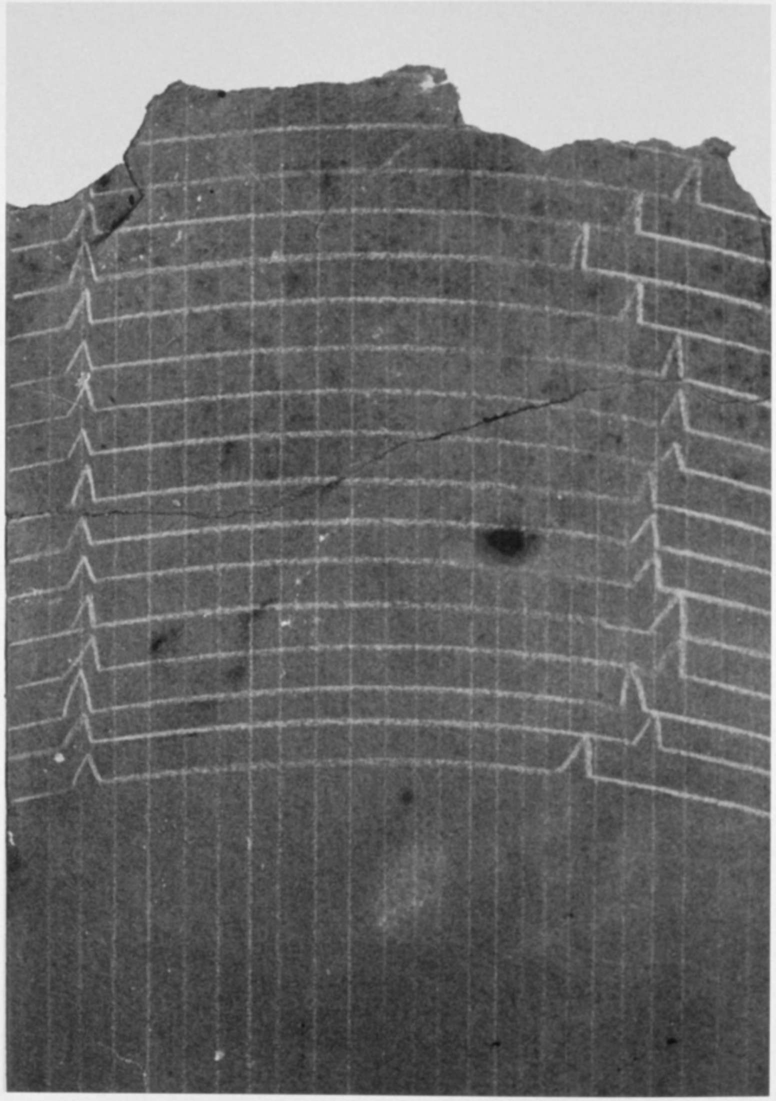
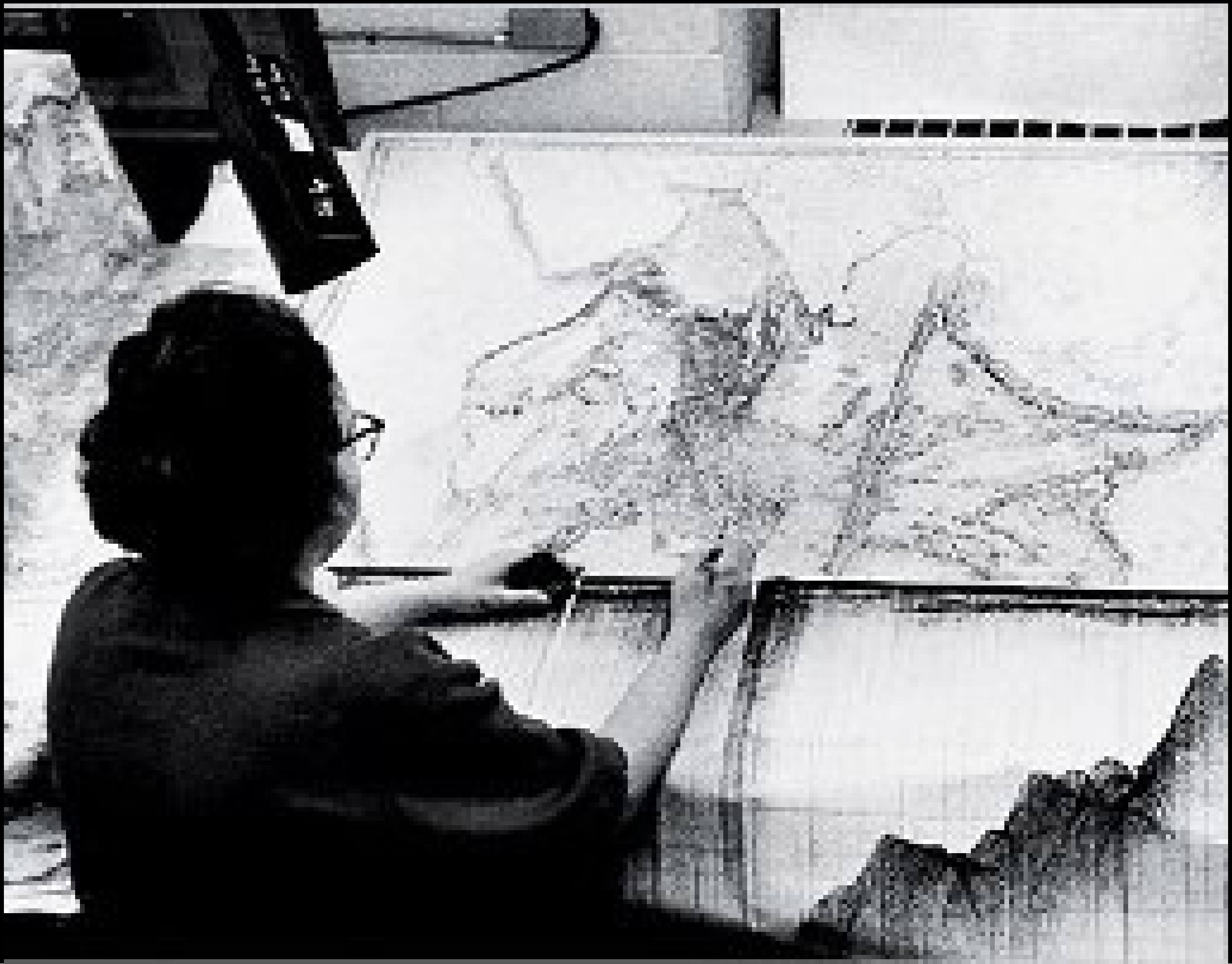


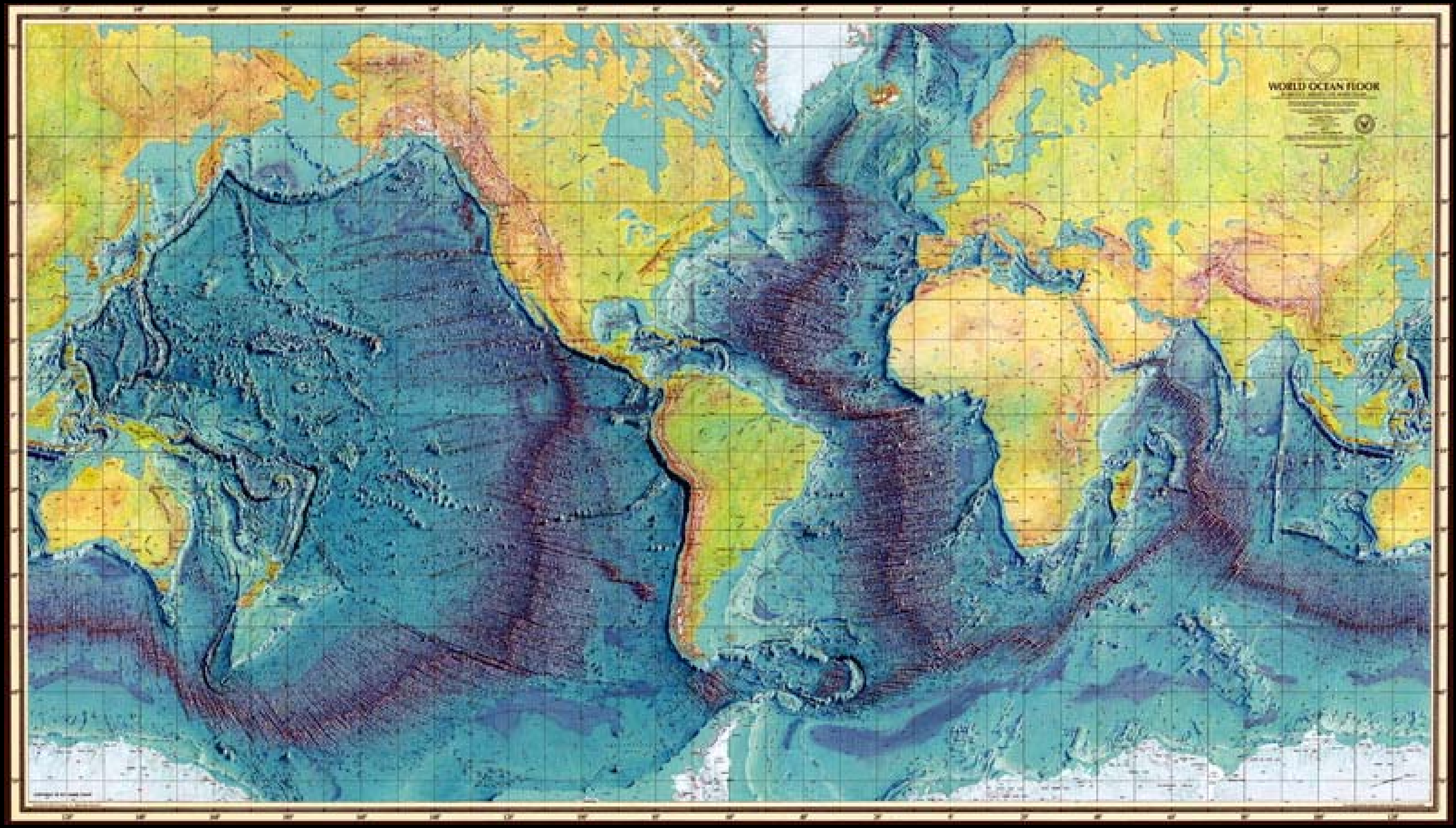
Figure 63 (*suite*). – Enregistreur du sondeur continu de MARTI : un enregistrement.

(photo Y. Berard)

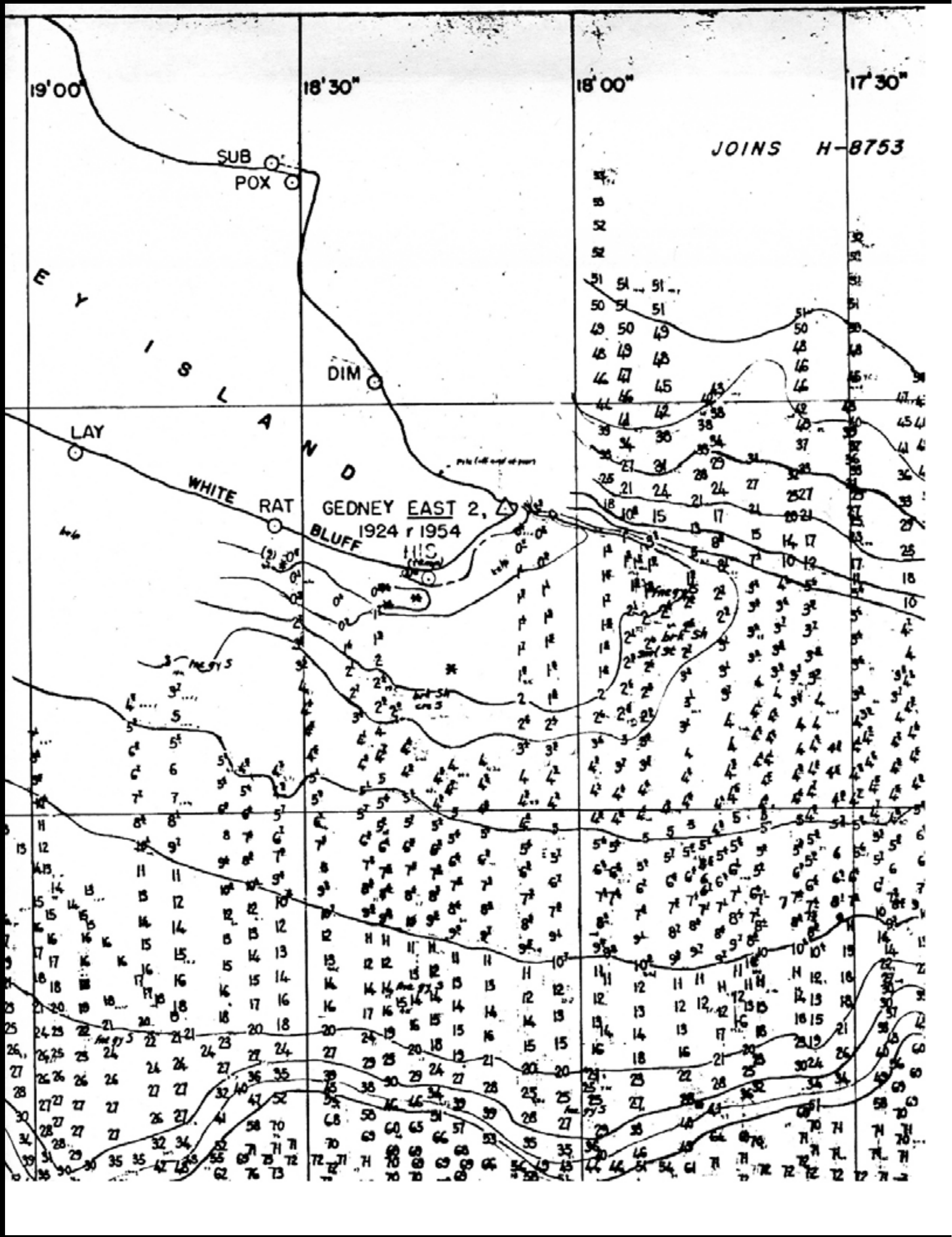
Marie Tharp, Lamont-Doherty, converting PDR records into physiographic maps, late '50's or early 60's



An example of a physiographic map of the type produced by Heezen, Tharp, Chase, and others

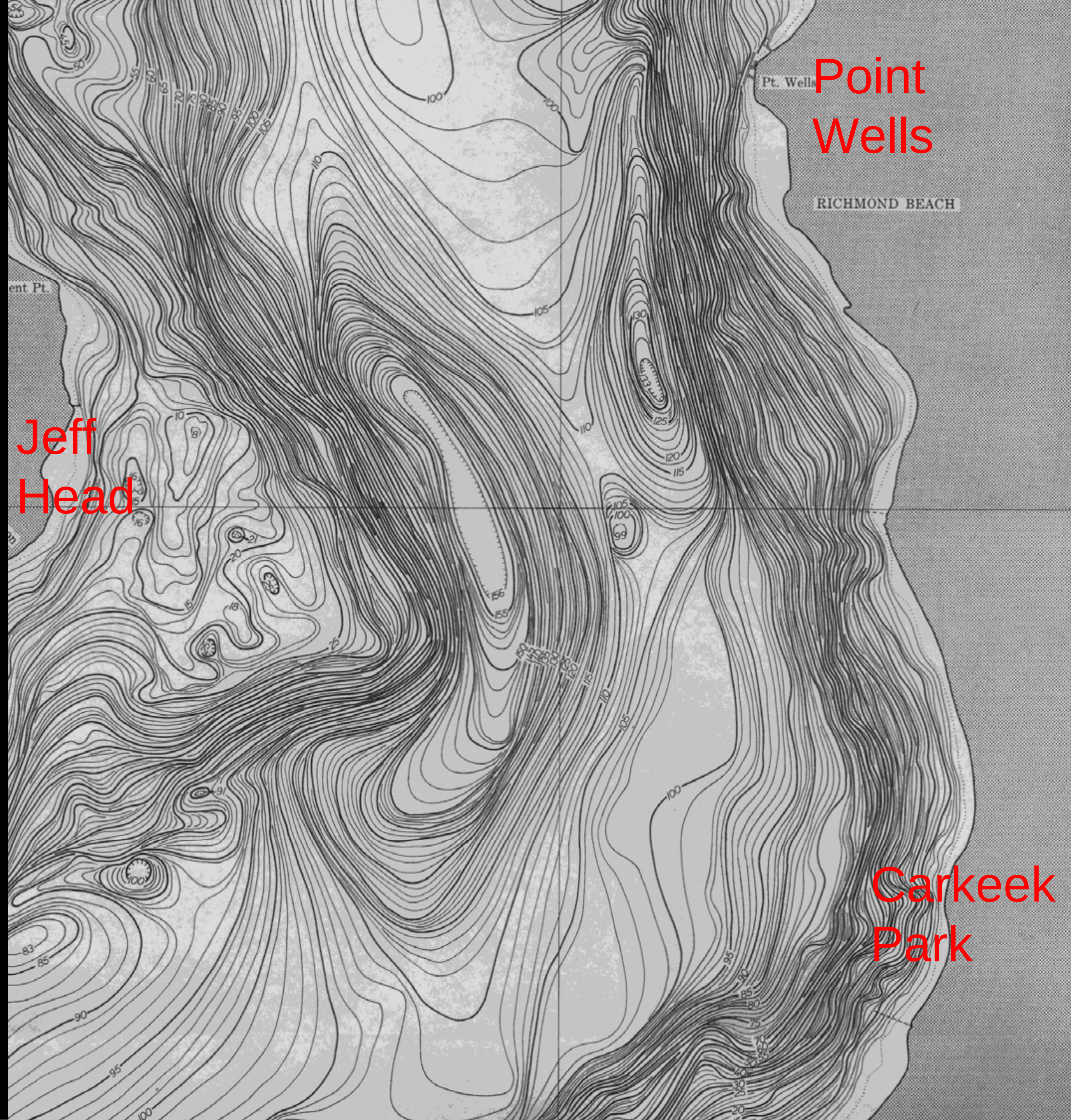


U.S. Coast and Geodetic Survey chart of the Gedney Island area, Port Gardner, 1963

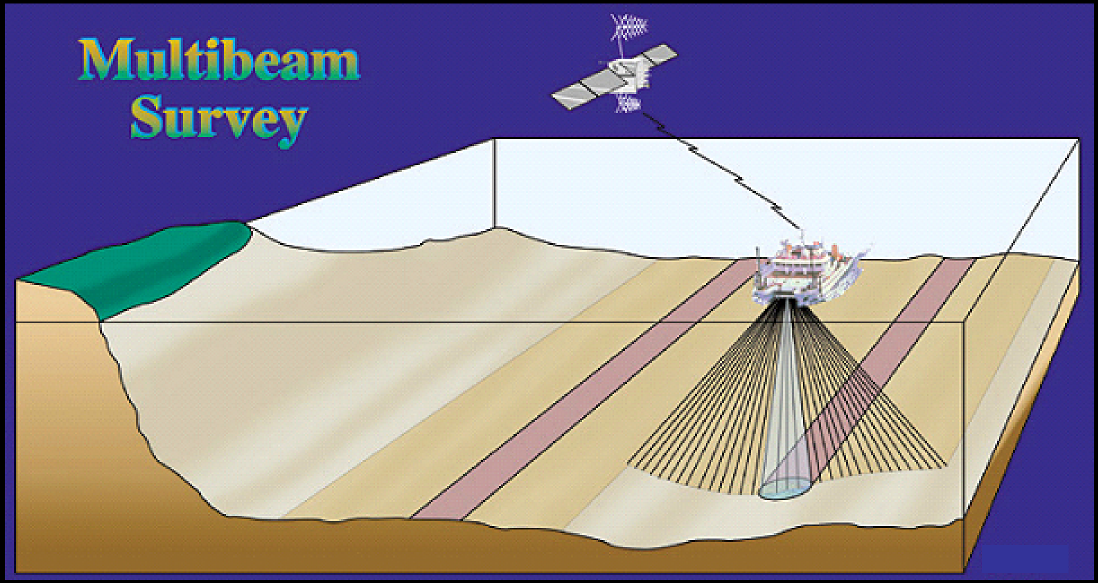


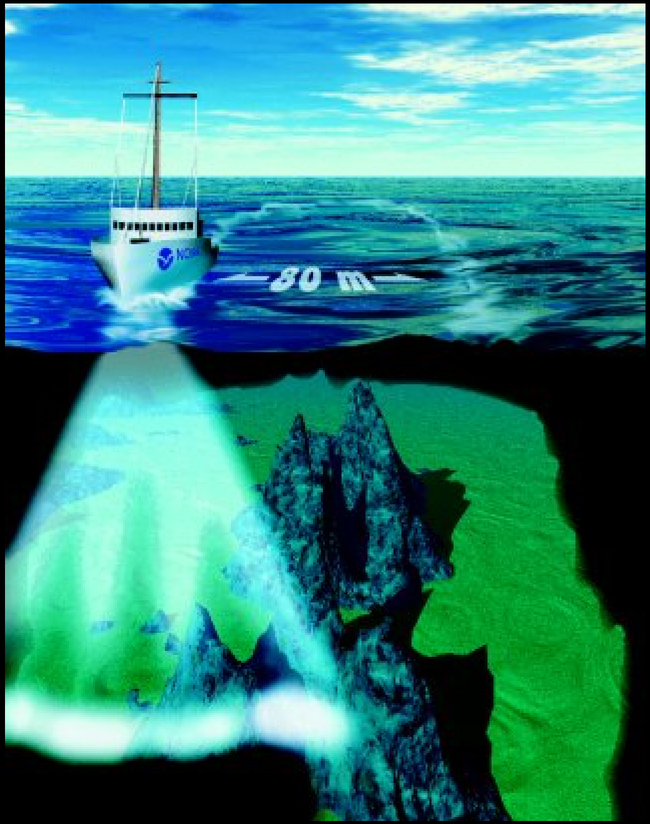
U.S Coast and Geodetic Survey bathymetry map of central Puget Sound, contour interval 1 fm(!).

Map is based on data obtained prior to 1953

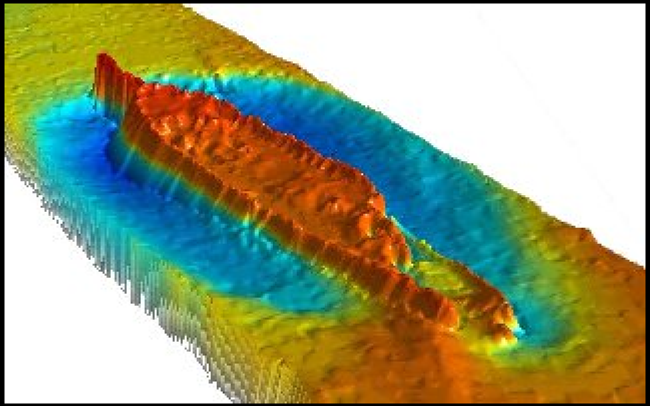


Multibeam sonar (SOund NAvigation and Ranging) employs active sensors that utilize acoustic energy to collect measurements of seafloor depth and character.





Multibeam sensors pulse the bottom with a series of soundings perpendicular to the track of the vessel. An array of receivers record the reflected echoes in an orientation parallel to the vessel track. This produces a swath of data that, depending on specific sensor, is normally several times the water depth. Like other acoustic sensors, multibeam sonars normally collect data in a series of transect lines that allow sufficient sidelap to avoid gaps in coverage.



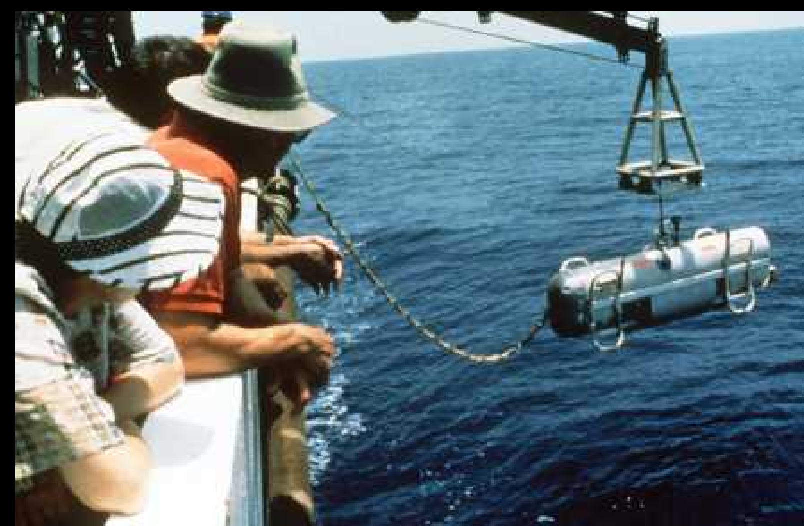
EM300

- Hull-Mounted
- 30kHz frequency
- max 135 beams
- 10m-5000m water depth
- ~30m @ 3000m

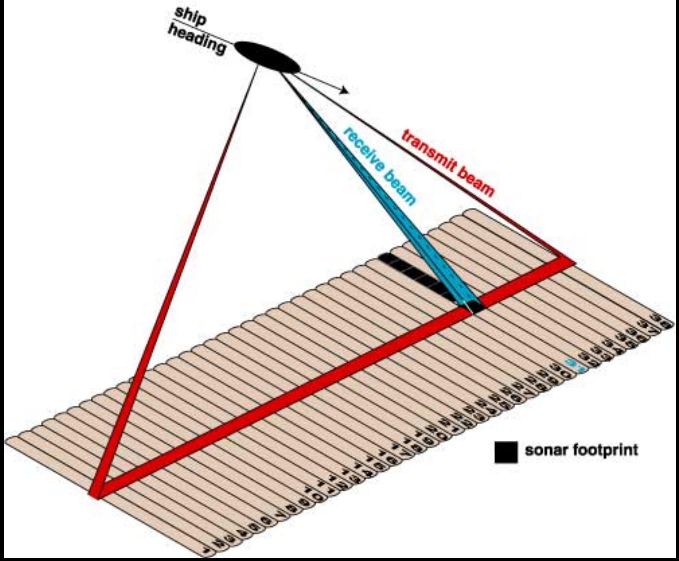
DSL-120

- Towed Fish
- 120 kHz
- 50-100m above sea floor
- Acoustic Backscatter

Regional: Large Areas: Moderate Resolution



Local: Target Areas: High Resolution



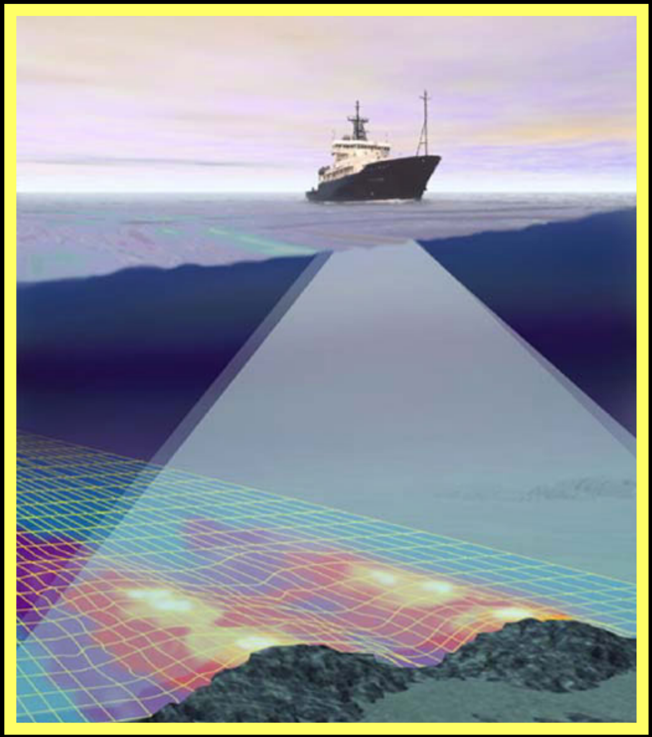
EM300 is a 30-kHz multibeam sonar system using up to 135 individual 1° (vertical) x 2° (horizontal) electronically formed beams.

The transducer array measures and records the time for the acoustic signal to travel to the seafloor and return to the receiver.

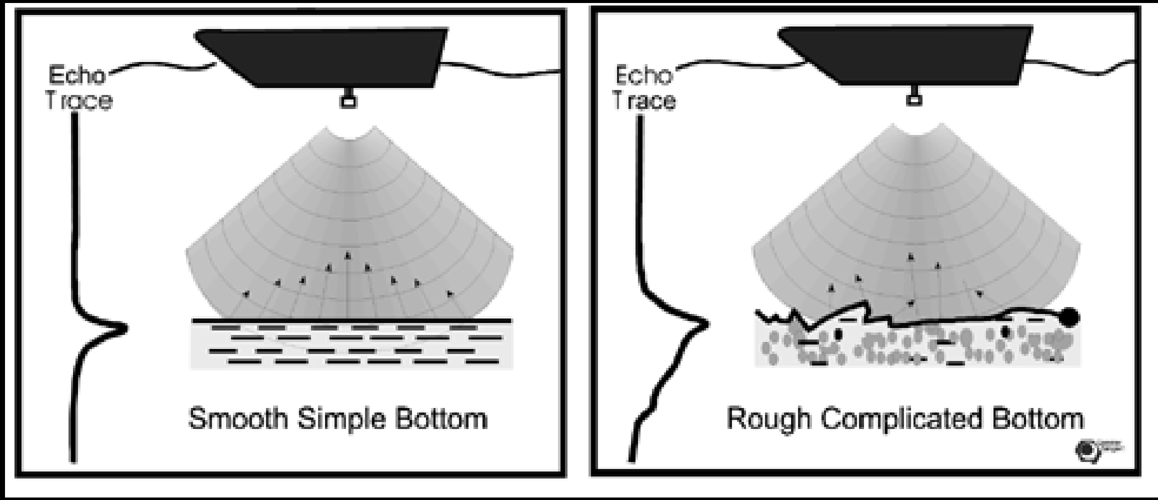
With hull mounted sensors, the instrument height is fixed and the coverage area (swath) on the seafloor is dependent on the depth of the water, typically two to four times the water depth.

This is an ideal system for mapping large areas rapidly, with 100 percent bottom coverage.

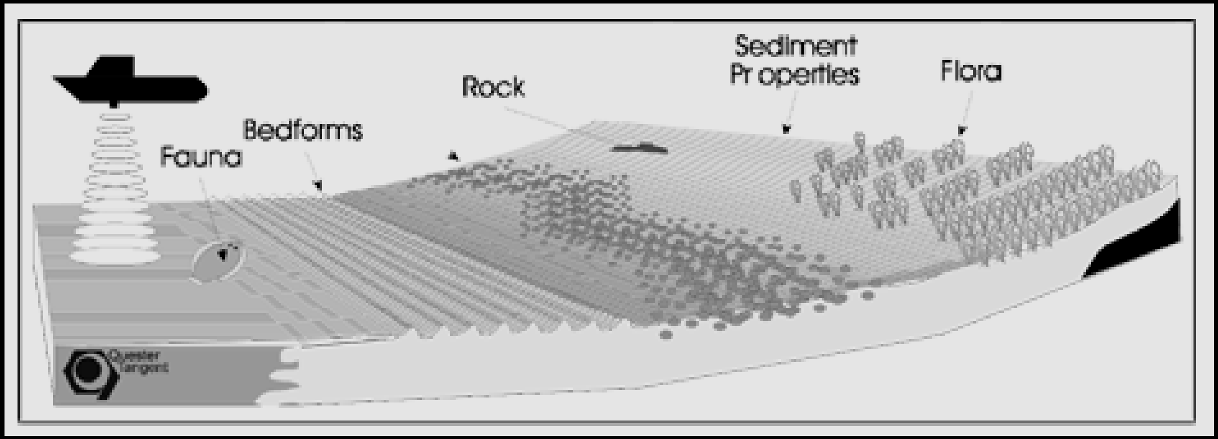
The number of beams varies with each manufacturer and ranges from 30 to more than 130; however, the outer beams on each side of the swath are subject to more errors and may not be useful.

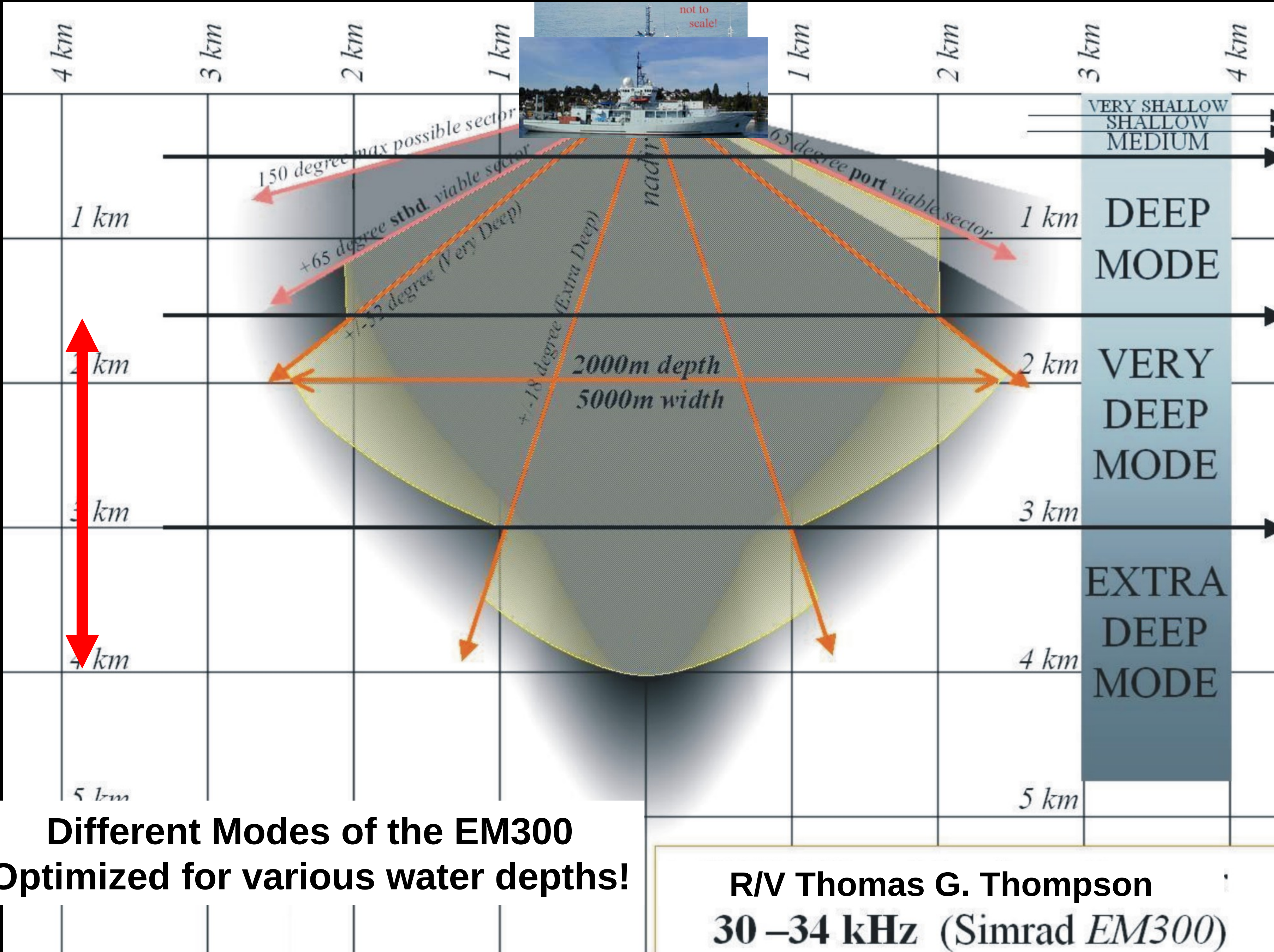


Backscatter

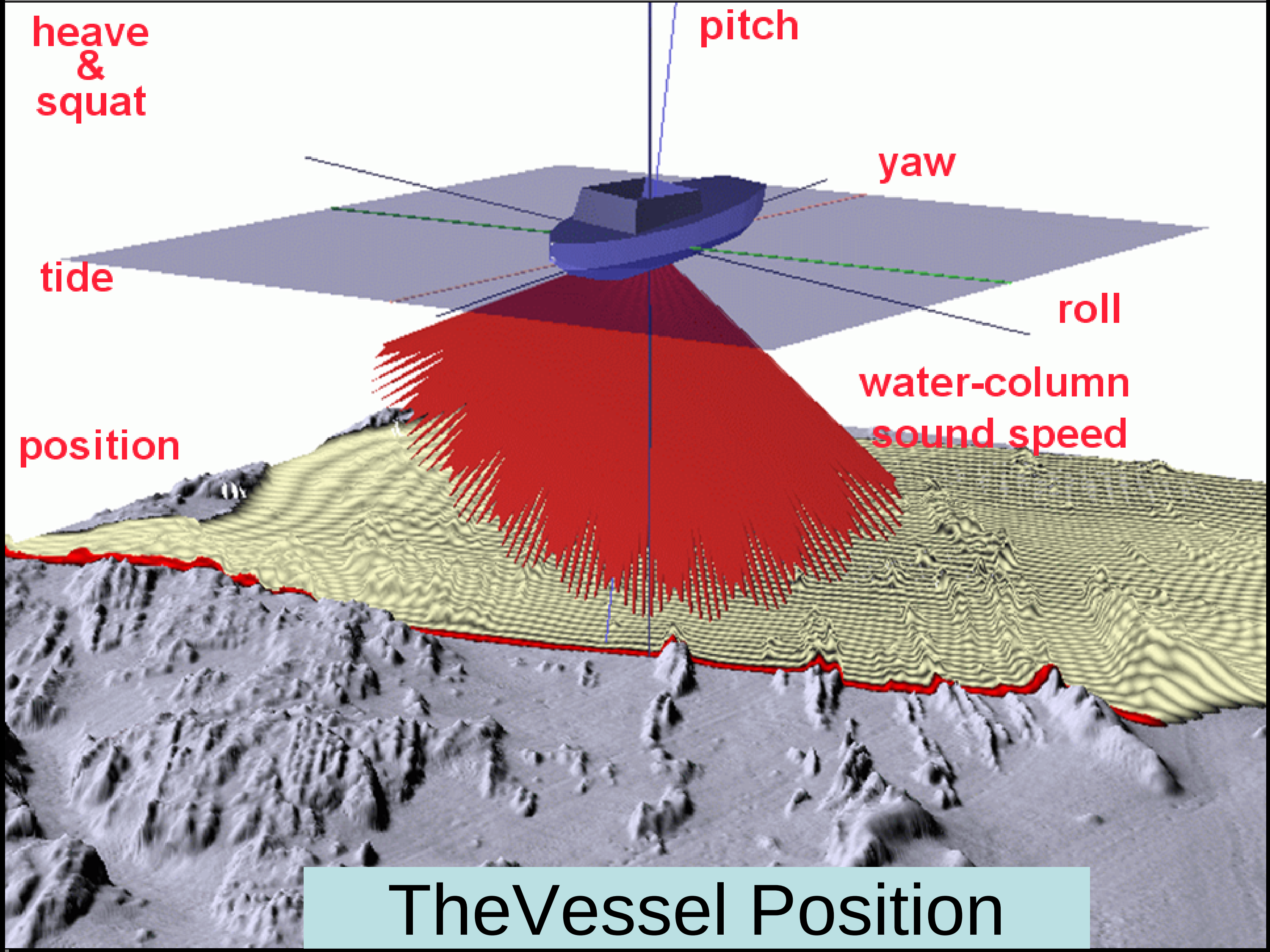


Backscatter can be thought of as a measurement of how strongly an acoustic pulse reflects from the seafloor combined with the amount of scattering. This ‘acoustic reflectivity’ can be used to evaluate the substrate type and texture or roughness.





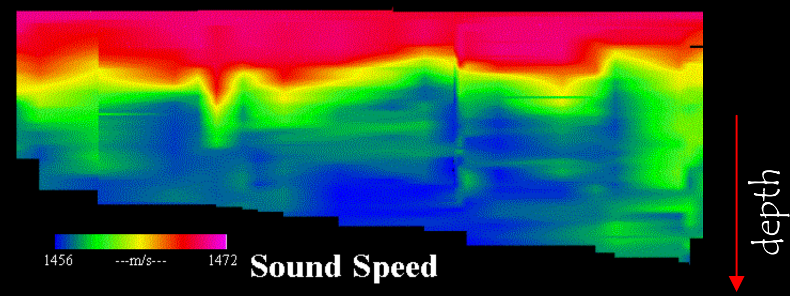
Different Modes of the EM300 Optimized for various water depths!

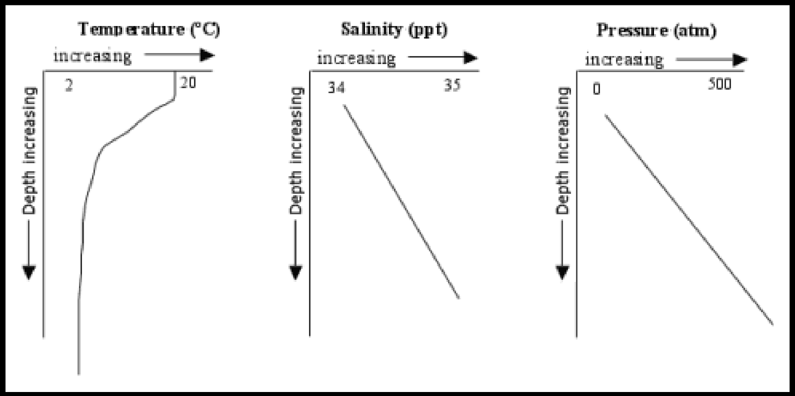


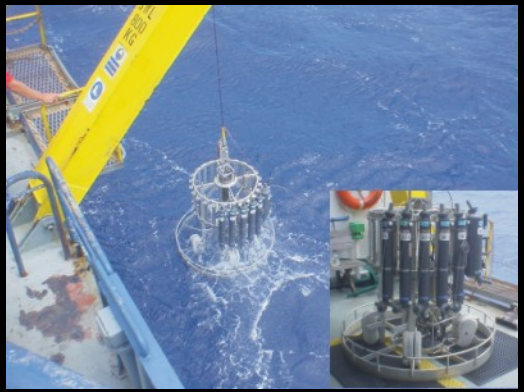
The EM300 incorporates roll, pitch, yaw, and heave compensations utilizing an Applied Analytic POS/MV motion sensor that detects motions to 0.01°. Combined with the differential global positioning system (DGPS), this provides a much more accurate geographic determination of the location of individual depth/backscatter values on the seafloor.

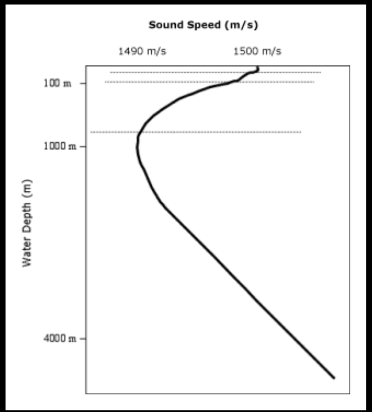
The Water Column

- The velocity of sound in water (~1500 m s^{-1}) changes with the salinity, water temperature, pressure and density.
- Sound velocity profiles are obtained by CTDs deployed daily to evaluate water column structure.
- The EM300 transducer arrays are also equipped with sound velocity profilers to determine the speed of sound in water directly at the transducer.
- All the SVP data are fed directly into the EM300 processor to eliminate offsets.







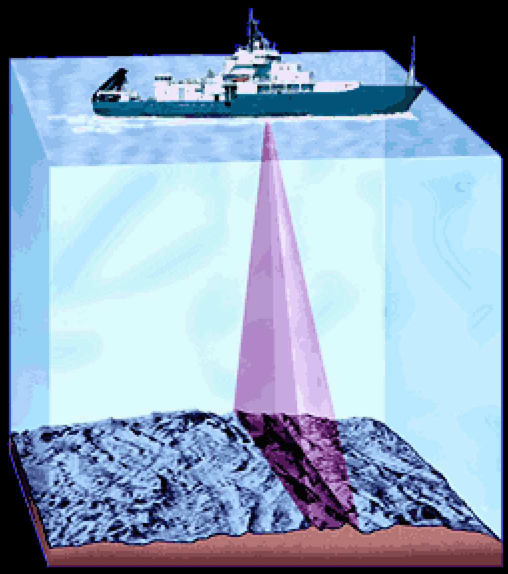


Sources of Error

- *Static offsets of the sensors* : distances between the sensors and the reference point of the vessel or the positioning antenna.
- *Transducer draft* : depth of the transducer head below the waterline of the vessel.
- *Time delay between the positioning system, sonar measurement, and HPR sensor :* delay must be compensated for in the processing of the hydrographic data.
- *Sound velocity measurement :* velocity of sound in the water column that must be accurately known so the correct depth can be measured.
- *Acceleration and translation measurements of the HPR* are critical for corrections to the vessel’s roll and pitch.
- All of parameters must be measured and corrected in the multibeam sonar system. It is assumed that the software used in the processing will accommodate these inputs and that the correct sign is used when entering the offsets and corrections.

Basic Data Processing Steps

- Data collected by the EM300 based on track lines
- Data files (line by line) are calibrated and prepared by ship technicians (using MB system)
- Data turned over to user
- Data processed for tides, datum offsets, etc, and gridded to appropriate cell spacing in Caris
- Data visualization, overlays, and 3d views prepared in Fledermaus
- Data interpretation and analysis….



http://www.mbari.org/data/mbsystem/

Free(!) and very powerful for post-processing of MB data. (Used by *Thompson* technicians)

http://www.caris.com/

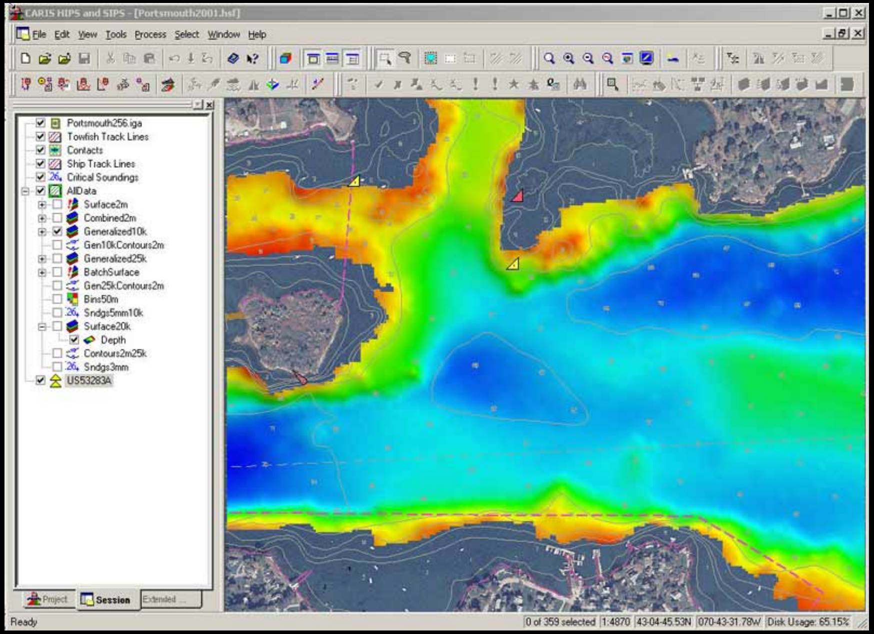
Caris is used to clean and validate the MB data. It is used to convert the raw soundings into grids, correct for the Gyro and HPR of the vessel, and to make adjustments for tides.

http://www.ivs3d.com/

Fledermaus is used to display and visualize the data in 3d, to drape imagery or backscatter and to overlay navigation charts or other georeferenced vector or raster data.

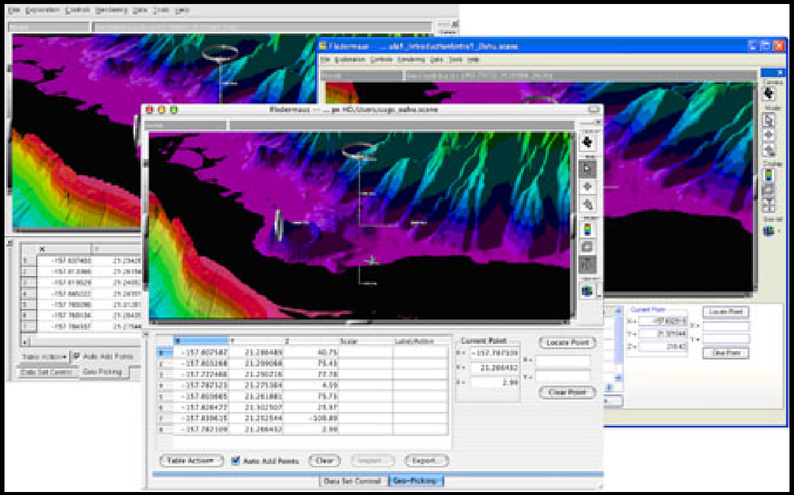
Caris HIPS Functionality

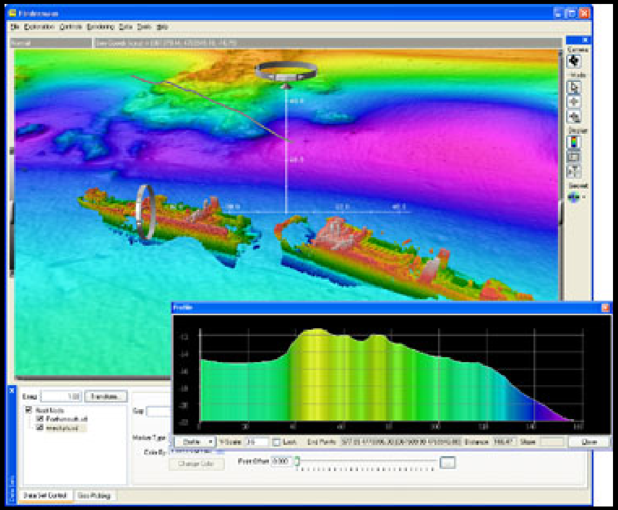
- Review and correct all sensor data including Gyro, Heave, Pitch, Roll, Tide, GPS…
- Correct for vessel motion, tides, sound velocity artifacts, sensor timing errors.
- Bulk removal of erroneous data.
- Produces high-resolution grid models from collected bathymetry data.
- Provides tools for area based editing which allows for powerful 2D and 3D data review for erroneous point removal.



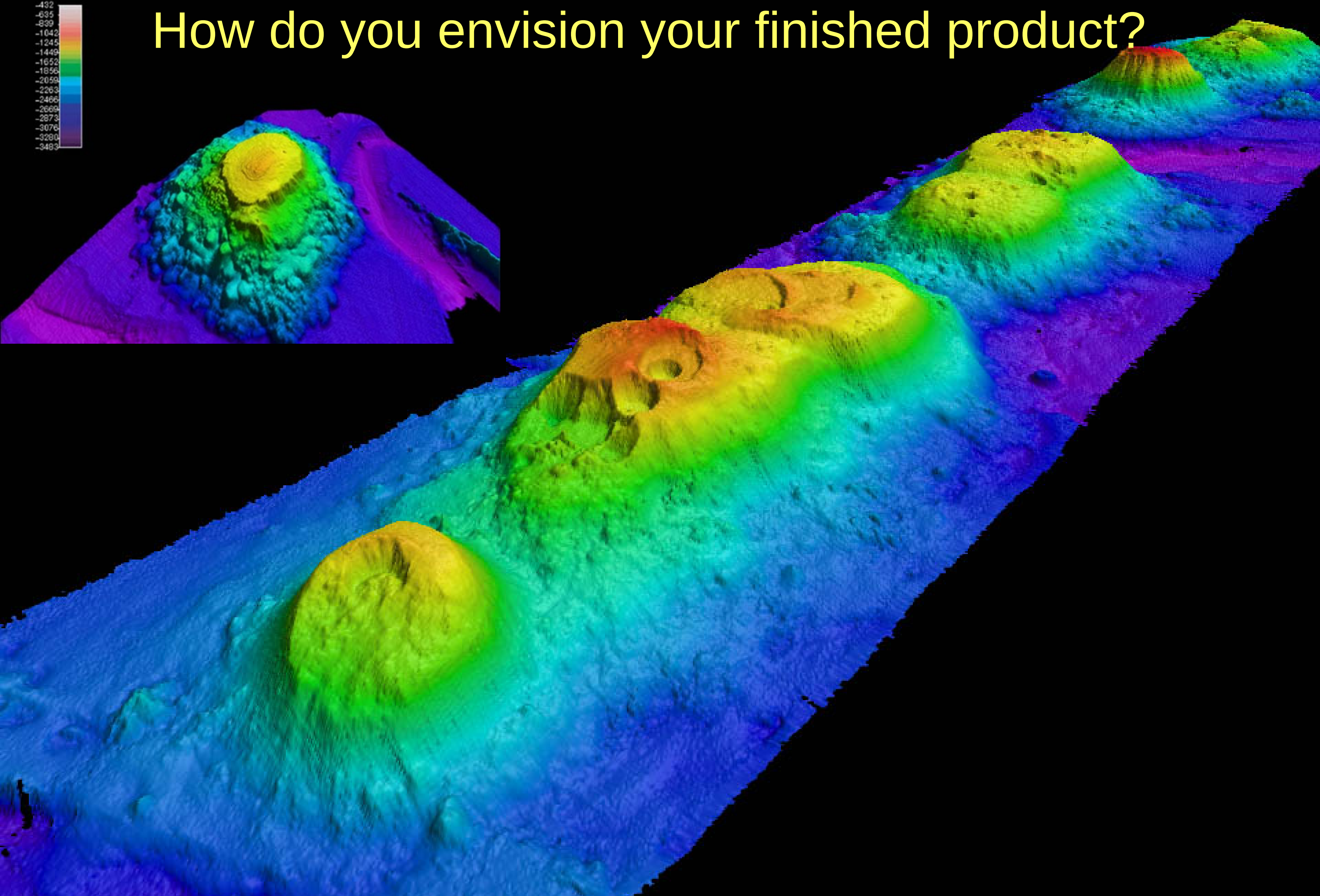
Fledermaus Functionality

- Powerful interactive 3D data visualization system
- Gridding application for point XYZ & attribute data
- Surfaces can be color coded for depth or other attribute
- Contour generation and output including labels
- Gradient tools
- Surface difference and volume computation tool
- Histogram tools
- Output of gridded surfaces, vectors, images, maps & movies





How do you envision your finished product?

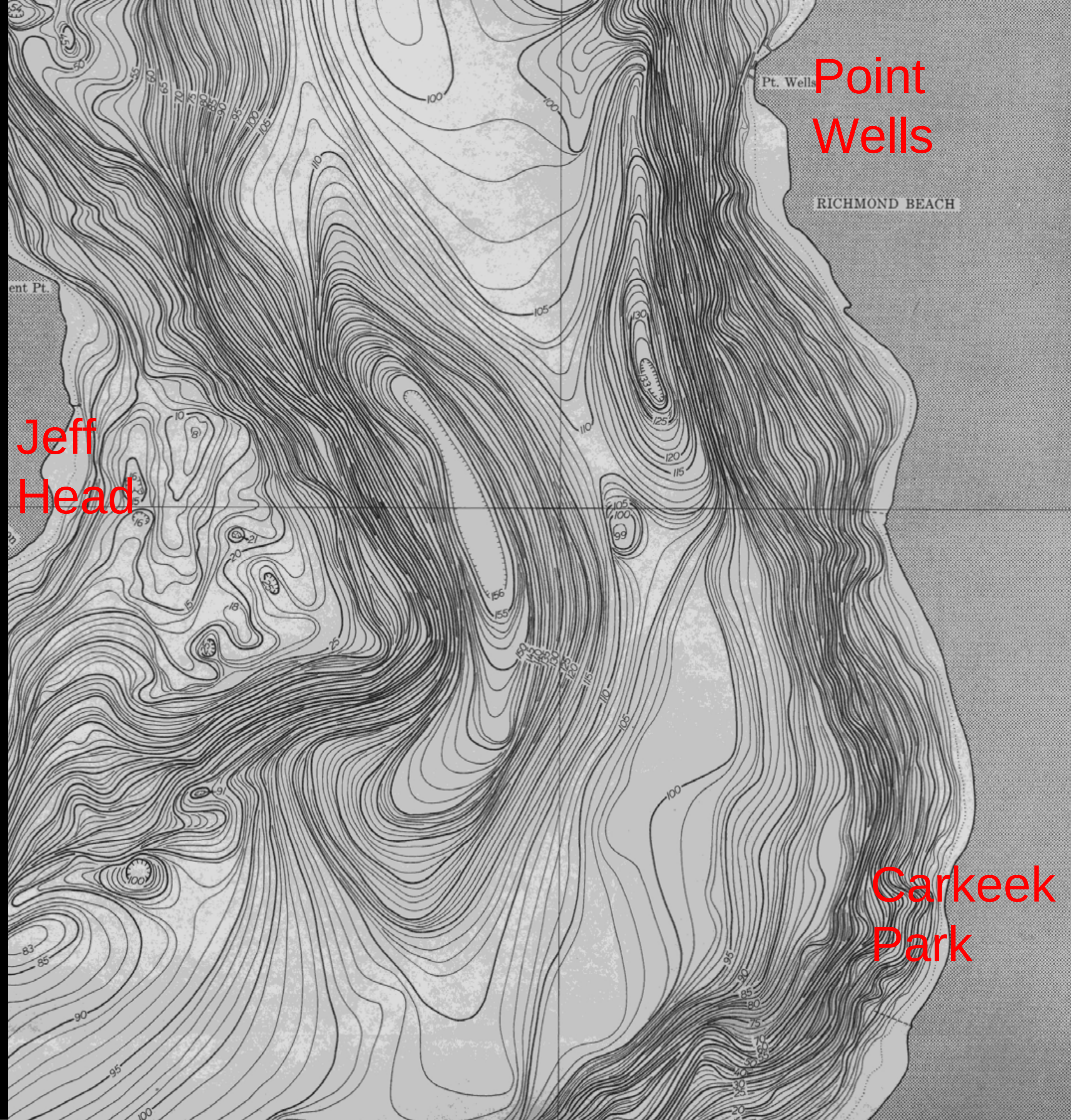


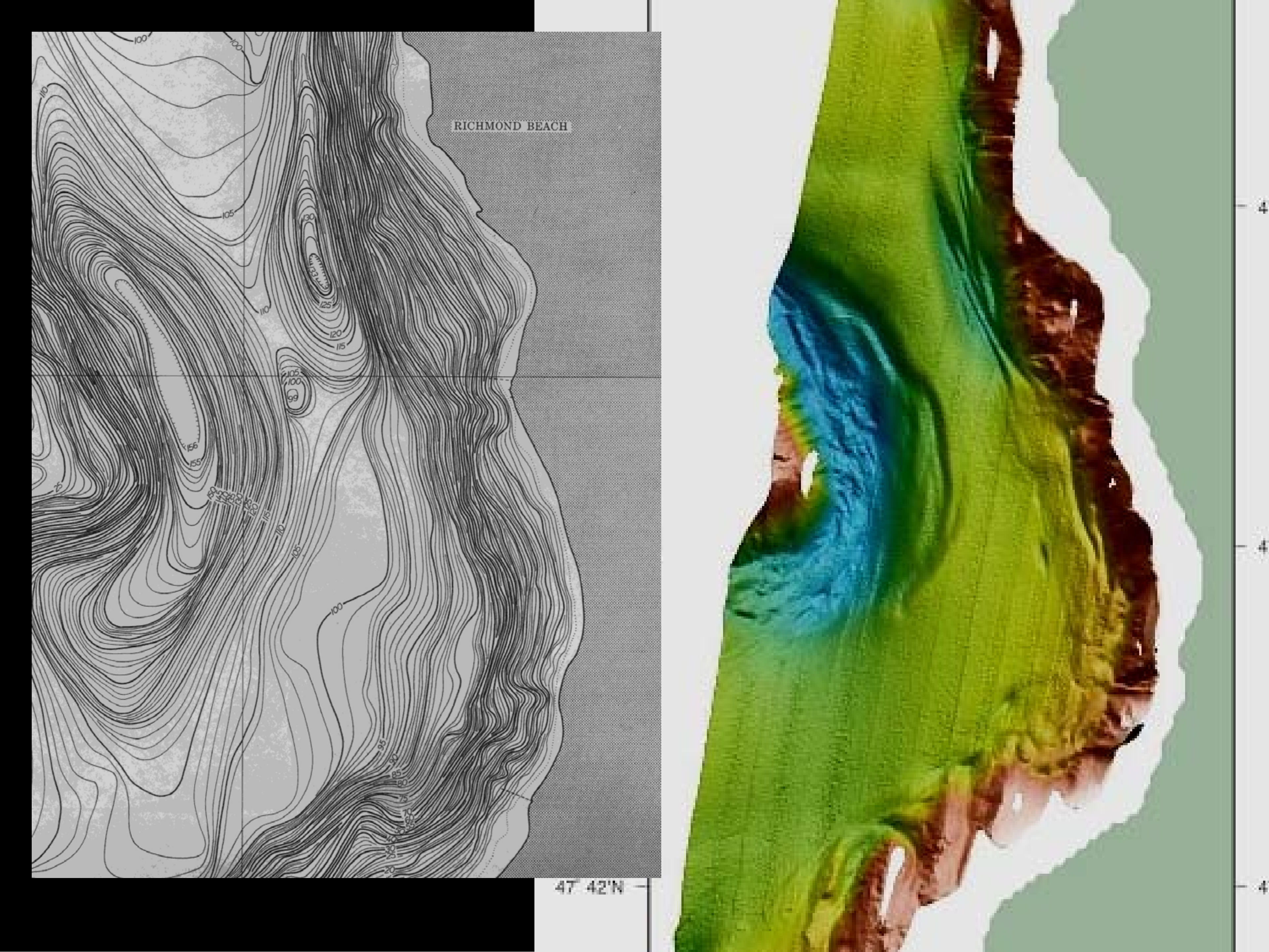
Complex Workflow

- (1) editing the navigation to flag bad fixes;
- (2) editing each ping of each beam, flagging outliers, and bad data;
- (3) merging depth and backscatter data with corrected navigation;
- (4) adjusting all depth values to mean low low water based on predicted tides;
- (5) performing additional refraction corrections for correct beam ray tracing;
- (6) separating out the amplitude measurements for conversion to backscatter;
- (7) gridding the depth and backscatter data at the highest resolution possible given the water depths;
- (8) regridding individual subareas of bathymetry and backscatter into final map sheets;
- (9) gridding and coutouring the bathymetry, and
- (10) generation of final maps

U.S Coast and Geodetic Survey bathymetry map of central Puget Sound, contour Interval 1 m(!).

Map is based on data obtained prior to 1953




RICHMOND BEACH
47° 42'N