

Charting Sarasota Bay



The tides and waves are the sovereign forces of the seashore, shaping and reshaping the edge of the continent with their ceaseless motion. Year after year they nibble away cliffs and promontories, grind rocks into sands that form beaches and dunes, and carry the flotsam of the world to shore, where prowling beachcombers hunt for treasures. Beautiful shells, striking gemstones, grotesque pieces of driftwood and wondrous glass floats from far-off Japan are part of the water's bounty.

—The SeashoreWorld
David F. Costello
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Astrolabe, a medieval instrument used to determine the altitude of the sun or other celestial bodies. Sailors used an astrolabe on the open sea in charting their travels.

A nautical chart is a printed reproduction of hydrographic data carefully gathered for an area of interest. As the chart primarily serves the needs of the mariner, it shows not only the nature and form of the coast, the depths of the water, character of the bottom and locations of reefs, shoals and other dangers to navigation; but also the rise and fall of the tides, the locations of artificial aids to navigation, the direction and strength of currents and the behavior of the earth's magnetism as it affects the mariner's compass.

The chart includes appropriate land areas that are visible from the water, which may include landmarks of use to navigation. Historically, coastal charts were almost exclusively products of the United States Coast and Geodetic Survey (USC&GS), which based them primarily on its own topographic and hydrographic surveys, supplemented with the best available data from various other sources. The National Oceanic and Atmospheric Administration (NOAA), absorbed the functions of the USC&GS upon its founding in 1970.

Historic Methods of Charting

During the latter half of the 19th century, comprehensive hydrographic surveys by USC&GS produced the first charts of sufficient detail and accuracy to be of everyday use to mariners navigating Florida's coastal waterways. The methodology for nautical chart preparation differed from that of topographic mapping, which was applied to all land areas and features inshore of the high-water line. Topographic mapping was based on the planetable, a device that resulted in an essentially complete map when the field work was done. With the planetable, the topographer constructed a map during the actual survey, delineating the high-water line, sketching contours and locating roads and other cultural features, all with the terrain in full view. However, the planetable was not suited for use in a moving boat, and most of the "terrain" was hidden from the hydrographers, as we call makers of nautical charts.

Hydrographic surveys were undertaken to represent the water area of a portion of the earth's surface by means of soundings (depths) taken at various locations throughout an area, in sufficient numbers to enable the hydrographer to delineate all underwater features of special significance to the navigator, such as channels, reefs, banks, shoals, rocks and other characteristic submarine features. It was — and still is — understood that the resulting chart represented these features at the time of the survey, and that as the dynamic coastal environment changed, revisions would be necessary.

In the 1800s, the work of actually surveying the water area on a given project usually followed establishment of control points on land and completion of the topographic mapping in the vicinity. These operations furnished the latitudes and longitudes of the stations that were to be used in the hydrographic work for locating the boat's positions during the survey.

The hydrographer first prepared a working sheet, or "boat sheet," on which a projection (meridians of longitude and parallels of latitude) was laid down, the control points plotted and the high- and low-water lines transferred from the planetable survey. Occasionally, additional control stations were established by the hydrographic party. Proposed sounding lines were plotted in pencil on the working sheet in accordance with a planned system designed for most effective depiction of known bottom features. The hydrographer attempted to follow these lines as the work progressed.

On the water, the hydrographer recorded information in a "sounding volume," to be later plotted in the office as a "smooth sheet," which became the official record of the survey. A complete smooth sheet is a record of the soundings taken during the field survey, together with other data necessary for a proper interpretation of the survey, such as depth curves, bottom characteristics, names of geographic features, control station designations and locations and tide records used to relate soundings to a reference datum.

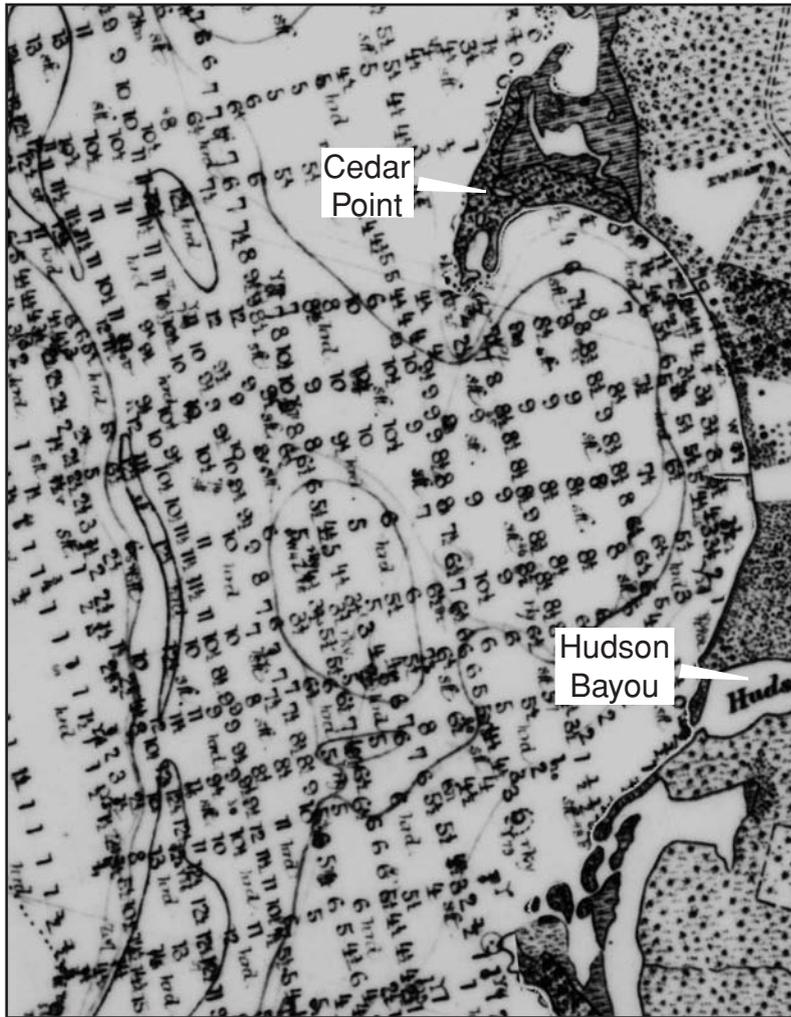
Soundings were generally made from small boats. The early boats may have carried sails, but during actual sounding operations the boat would have been powered solely by crew members manning oars, providing the necessary maneuverability and precise handling at low speeds or while stopped.

A typical field party engaged in inshore hydrography usually included two hydrographers or engineers (one to direct operations and one to operate a sextant for locating the survey boat's position by measuring angles between shore stations), a leadsman to take the soundings, a recorder to transcribe the soundings and the observed angles and the crewmen necessary to operate the boat. In some instances, additional personnel on shore assisted in determining the boat's location.

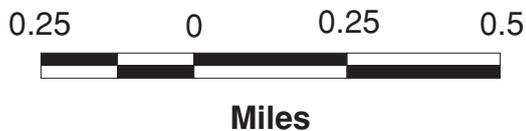
Two essential operations were performed simultaneously: measurement of depths (soundings) and determination of the geographic positions (latitudes and longitudes) of the soundings so they could be charted in correct relation to each other and to the surrounding topographical features.

Sextant angles taken in the survey boat between pairs of control stations on shore gave an accurate position. When feasible, theodolite angles could be taken at two shore stations upon a flag hoisted in the boat.

For sounding in depths up to 15 feet, the leadsman used a graduated pole with a disk on the lower end to prevent its sinking into a muddy bottom; at greater depths, he would employ a leadline. A skilled leadsman could employ either device with the boat moving forward, but the boat would necessarily be stopped for the sextant readings to determine position. Another method of determining position was by running out ranges from shore and fixing the positions by time. This method, which allowed collection of many more soundings in a work day, became practicable when the oarsmen were replaced by an engine that allowed the boat to move at a constant speed.



Map 1.
Composite of 1883 Hydrographic (H)
and Topographic (T) Sheets
for Sarasota Waterfront



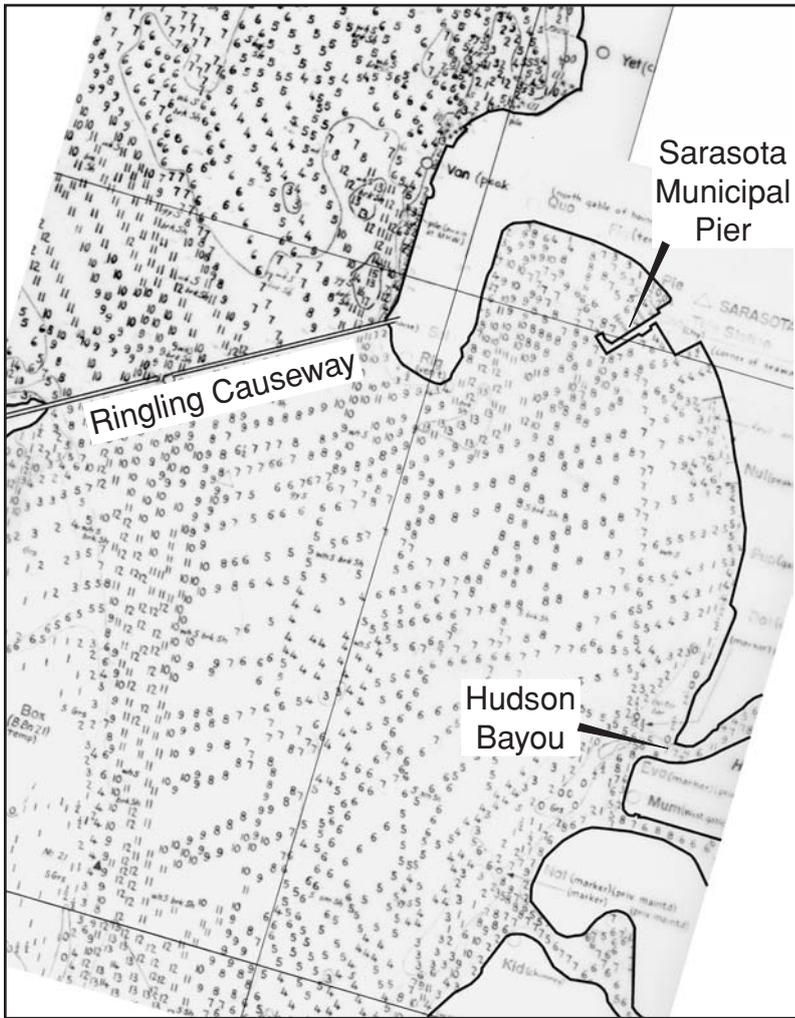
Each recorded sounding needed correction for the height of the tide at the time of measurement, in order to refer the depth to the sounding datum or reference plane, usually mean low water. During the hydrographic work, personnel at a nearby tide station would maintain a log of the tide's rise and fall. The hydrographer would later use this information to adjust each sounding for the state of the tide.

During the survey, the boat crew recorded the nature of the bottom encountered as soundings were made. On the finished chart, this information would be of use to mariners evaluating suitability of the bottom for anchoring. The crew also recorded positions and condition of man-made aids to navigation.

Upon completion of field work, the hydrographer would have collected and assembled all the information necessary to prepare a nautical chart. The smooth sheet, relevant topographic maps and other information would be passed to the cartographers responsible for producing the final chart in a form suitable for printing in large quantities. Map 1 is a composite assembled from portions of hydrographic and topographic sheets of Sarasota Bay near the City of Sarasota, resulting from surveys ending in 1883. It does not represent the finished nautical chart. However, these intermediate products clearly reflect the immense labor involved.

The skill and dedication of the hydrographers, expressed through the artistry of the cartographers, gave charts of immense practical value to the mariners for whom they were created. Today they are admired for their esthetic value and for the realization they instill of the immense labor and care that went into their creation. To chart just one typical bay on Florida's coast, hydrographers spent many weeks or months making and recording thousands of soundings — along with a position and tide correction for each — using techniques that could be accurately described as “paper and pencil” before the word “electronic” had been coined. Yet where the positional accuracy of early nautical charts can be evaluated, it is almost always found to be excellent. And the basic approach created by the early hydrographers, from data collection to production of the finished chart, was sufficiently sound that it is still in use today; only the tools have changed.

Mid-20th Century



Map 2.
1954 Hydrographic Sheet of Sarasota Waterfront



After World War II, hydrographers creating nautical charts benefited from technological advances that made possible small, portable, accurate electronic depth sounders. Even with the increased efficiency afforded by the new devices, however, the old technique for position determination — use of a sextant to measure angles between stations on shore — remained the state of the art. And the leadsmen still had a role to play: Coast and Geodetic Survey “Descriptive Report 8034,” dated 1953, reported that “portable depth recorder” (Model 808-J) was used “where the depths and character of the bottom permitted. On the extensive shoal flats, in areas where marine vegetation cut out the fathometer return and in investigating shoal spots, a wooden pole, graduated in feet, was used.”

The 1953 report and others from 1954 provide further insights into the equipment and methods. In the 1953 survey of the waters from Longboat Pass to Tampa Bay, the primary vessel was to be the USC&GS’s vessel “Sosbee,” which was 68 feet in length. She had a wooden hull, a turn radius of 100 meters at 1000 rpm and a speed of seven knots. She had been used only part of one day when she was found to be too unhandy in strong winds. Remaining soundings were done from a 25-foot skiff, powered by two 10-hp outboard motors. The skiff was based at Cortez for most of the survey, then moved to a shipyard near the mouth of the Manatee River for operations in that area.

A portable, automatic tide gauge was maintained at Cortez. Hourly heights were used “without correction” — no allowance was made for distance from the gauge. The tidal datum was mean low water, and “headquarters” determined the gauge elevation.

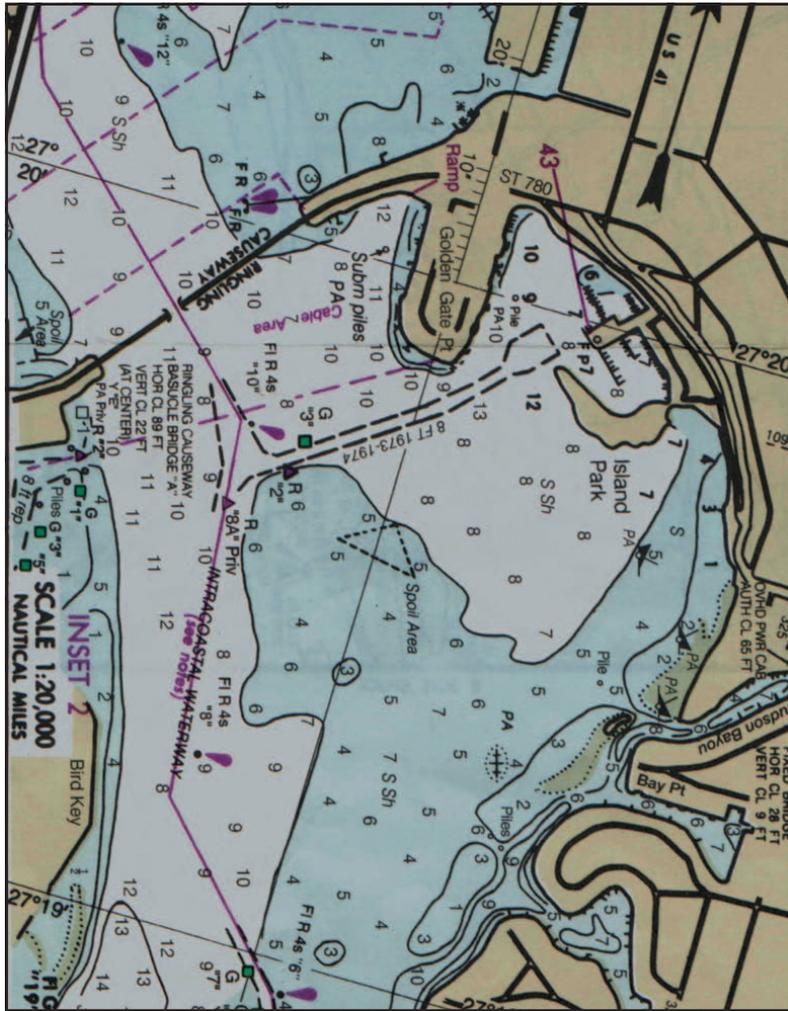
Reflecting another technological advance, control stations were located on aerial photographs, and shorelines and topography were determined from “photogrammetric sheets.” Still, sounding positions were determined by “the usual three-point fix method,” using a sextant where possible but otherwise “estimated from shoreline details.” Bottom samples were taken to allow better definition than “hard” and “soft,” which were the only annotations on earlier charts.

In all, 16.5 square miles were surveyed, with 3,170 positions mapped. Pole soundings totaled 6,849. Transects totaled 486.7 miles, including 24.1 by the “Sosbee.” The hydrographers were confident that one-foot accuracy had been achieved.

In 1954, the USC&GS completed hydrographic surveys of Sarasota and Little Sarasota Bays, with the “Sosbee” and the 25-foot skiff based at the Sarasota Municipal Pier. The “Sosbee” served as survey vessel for deeper parts of Sarasota Bay, the skiff for all other work. Tides were read directly from a “portable automatic tide gauge” at Sarasota Municipal pier.

In the Sarasota Bay survey (January 5-September 16, 1954) the “sounding lead” was used briefly. Navigating by 26 triangulation stations, the crew recorded 3,992 positions and 4,532 pole soundings, with 618.4 statute miles traversed. In Little Sarasota Bay (January 29-March 21, apparently with work done in both areas during part of the time), the numbers were 13 triangulation stations, 2,950 positions, 5,981 pole soundings, and 338.2 statute miles traversed.

Map 2 shows results from the 1954 hydrographic survey of Sarasota Bay, again in the vicinity of Sarasota.



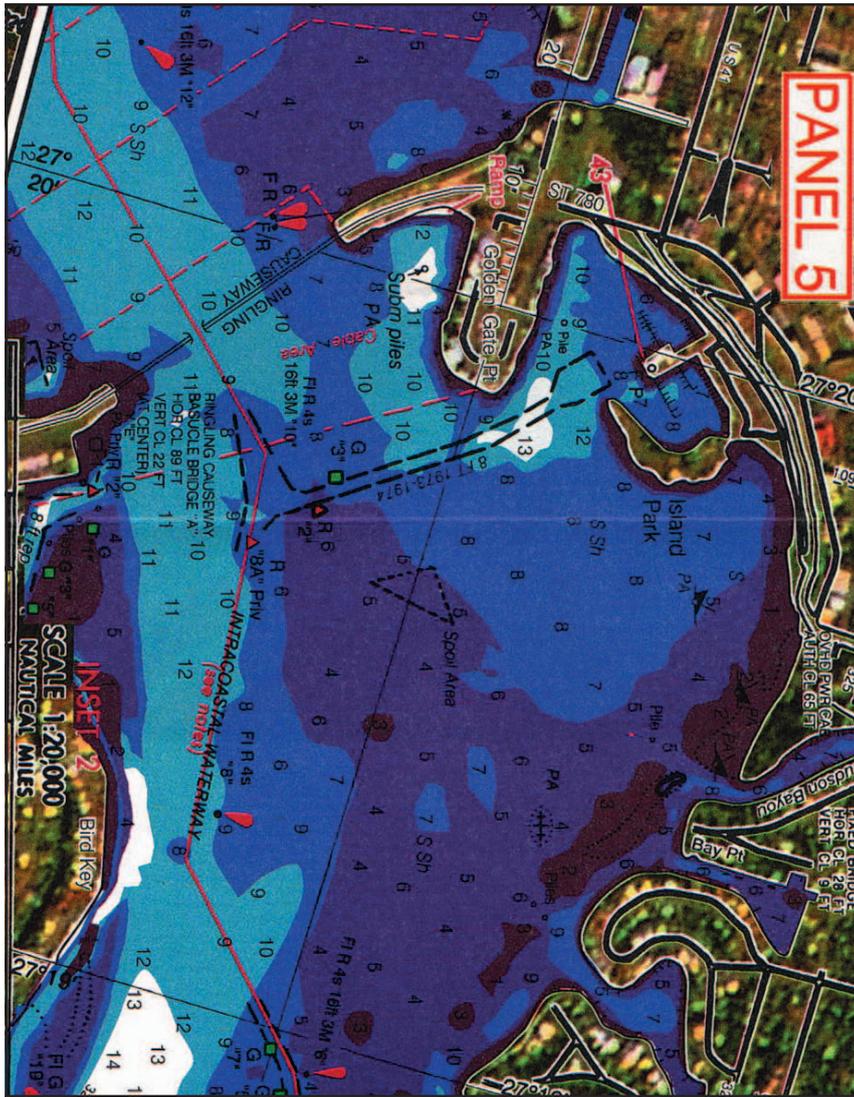
Map 3.
Modern Nautical Chart
1996 Hydrographic Chart of Sarasota Waterfront

Charting in the 1990s

Nautical chart makers in the 1990s benefit from additional technological advances since the 1950s. Most significant is computerization, which allows efficient management and manipulation of the immense quantities of data resulting from measuring depths at many thousands of places in a body of water. The calculations involved to correct the field data for tides and other variables must be performed for each datum, an extremely labor-intensive task when done with pencil on paper but one readily managed by computers. The computer programs called Geographic Information Systems (GIS) are important to today's chart-creation process, as they automate precise placement on the chart of depth data and readily assist such tasks as creation of depth contours. Also, workers using GIS in other fields, such as environmental planning, marine animal migration studies, oil spill cleanup, etc., can share the data.

Specialized mapping programs and graphics applications have almost completely supplanted the traditional methods of cartography; rarely does a draftsman apply ink to vellum to create a nautical chart or map. Instead, the cartographer guides a mouse or uses a pressure-sensitive stylus on a graphics tablet to transform the plethora of high-quality, precise data into an understandable, useful and esthetically pleasing product for the boater. Map 3 is a portion of NOAA Intracoastal Waterway chart 11425 (31st edition, October 1996), showing the same location, at the same scale, as Maps 1, 2 and 4.

Another technology that has transformed cartography in the 1990s is the Global Positioning System (GPS), a satellite-based means of determining positions on the earth's surface. Using the most accurate kind of GPS, known as Differential GPS (DGPS), positions can quickly and easily be measured to one meter (about 1.1 yard) or better. When the workboat arrives at a desired site, the DGPS system records the depth, the time (for use in tide correction) and the location. In ideal situations, the DGPS data collector can be connected directly to the depth sounder, so the only action required by the field personnel is one touch of a button, if that. However, depth sounders are still sufficiently fallible that personnel on the boat will often have to heave a lead line or dip a staff to measure the depth or verify the fathometer's reading. The leadsman lives on. Still, eliminating the need to pause for sextant readings to fix a position for each sounding yields a huge increase in data-collection efficiency. Today a crew of one or two persons can measure several times more depths in a workday than was possible with a larger crew as recently as 10 years ago, with much improved accuracy.



Map 4.

1999 Prototype Photo-chart of Sarasota Bay



The Near Future

Nautical cartography is on the verge of even more dramatic improvements as technology continues to advance. Increasing availability of high resolution, rectified (spatially correct, undistorted) imagery from aircraft or satellites will make it feasible to include realistic views of land features on charts. Mainland and island topography and vegetation, bridges, piers, roads, etc., can be shown in a way recognizable to most boaters. This will not only aid navigation, but also will contribute to enjoyment and understanding of the marine environment and the land adjoining our coastal waters. Map 4 was scanned from a prototype of such a chart.

Data collection methods being developed will allow rapid measurement of depths, and perhaps bottom characteristics, over large areas by remote sensing from air or space; these sensors include water-penetrating laser radar. Use of remote sensing will greatly increase efficiency of data collection, compared with today's methods.

This all-digital approach to data collection and presentation will facilitate widespread use of charts as real-time displays in a boat's instrumentation and on home computers used for trip planning and reminiscing. But for the foreseeable future, the most common form of nautical chart will remain a paper one carried on board for ready reference. The chart of the future will be unfolded by skippers and consulted for plotting the day's course, for finding shelter in storms and for deciding where to drop the hook at day's end.

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