FROM SEA TO SHINING SEA

200 YEARS OF CHARTING AMERICA'S COASTS

Surveyors heave a weighted line to measure the depths of a harbor in this 1854 watercolor—one of the oldest images of Coast Survey operations. Technologies have changed dramatically since then. Today, the Survey continues to collect data on the seas as well as on land to benefit our nation's commerce, security, and marine environment.

Strawberry Harbor, Straits of Rosario [Puget Sound, WA] (detail) by James Madison Alden, 1854
Courtesy Burke Museum of Natural History and Culture (catalog number L-3369/2)

Smithsonian

The Coast Survey

Working for You

The Coast Survey touches the lives of every American, every day, in ways that you may not realize.

Over the past two centuries, the Survey:

- mapped nearly 95,000 miles of coastline
- produced more than 20,000 nautical charts and maps
- set out more than 700,000 permanent survey markers
- installed more than 6,000 tide stations and 3,000 current-measurement stations
- produced charts and maps used in the Civil War and in World Wars I and II
- discovered the first known sea-floor canyon
- mapped the Panama Canal
- determined the speed of light
- established the Pacific Tsunami Warning System
- discovered magnetic stripes on the sea floor (evidence for continental drift)
- developed Radio Acoustic Ranging, the first technology to use sound for navigation rather than visual means.

Today, the Coast Survey's descendants:

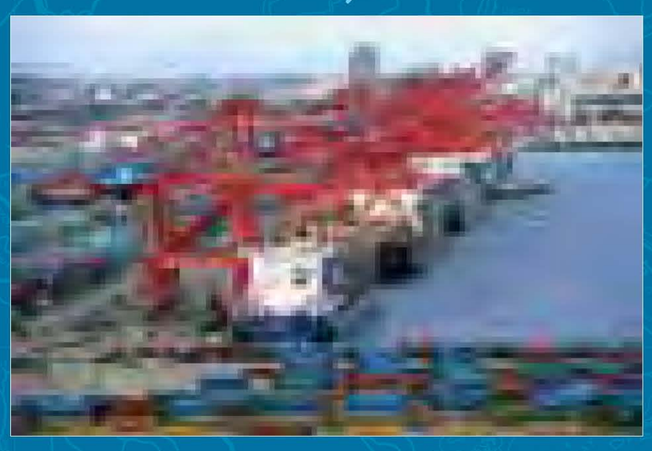
- provide charts and services that help move more than 200 billion tons of cargo a year through U.S. ports
- operate more than 200 permanent real-time tide gauges
- collect data used to monitor coral reefs, manage fisheries, protect marine mammals, and restore marshes
- help predict the movement of oil spills
- assess national security risks
- respond to hurricanes, airplane crashes, and other disasters
- map and remove marine debris
- maintain the national network of more than 1,000 Global Positioning System (GPS) reference sites.

The Coast Survey

Growing with the Nation

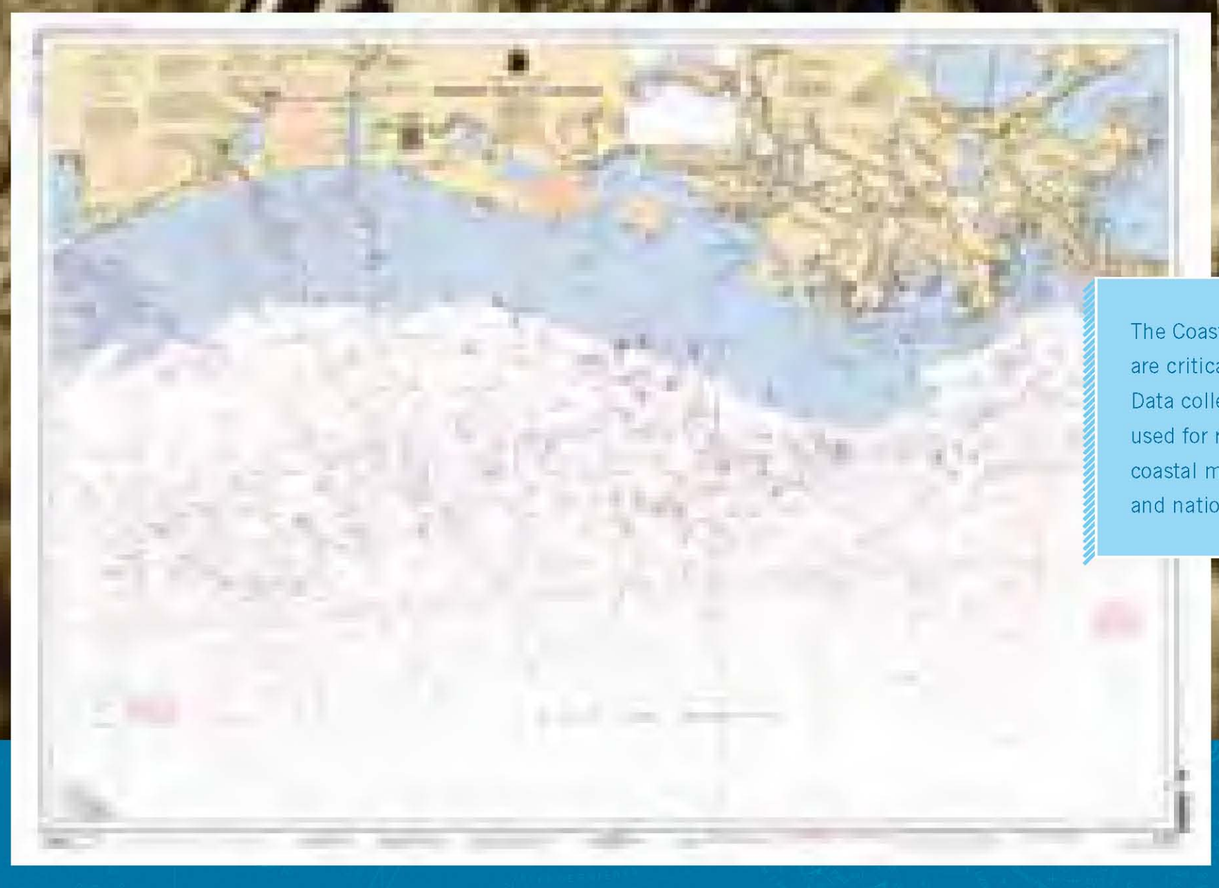
This exhibit celebrates the Coast Survey's 200-year legacy of science and service. The nation's first federal science agency, the Survey began as a small East Coast operation. Today, it is part of the world-renowned National Oceanic and Atmospheric Administration (NOAA), and its research, exploration, and other activities cover the globe.

The Survey's dedicated staff still pursue its original mission: to measure the depths of the nation's harbors, curves of our coastlines, positions of our peaks, and times and heights of the tides. Over the years, they have harnessed new technologies and taken on new challenges to respond to changing times and the needs of an expanding nation.



Busy ports like this one in Los Angeles demonstrate that maritime trade remains the backbone of the U.S. economy. Ships move two-thirds of everything Americans buy, eat, and wear—contributing more than $1 trillion a year to the U.S. economy.

Working under rugged conditions with basic tools, early Coast Survey teams laid the foundation of our knowledge about the nation's coastlines. In this 1921 photo, surveyors take measurements in Southeast Alaska.



The Coast Survey's nautical charts are critical for commercial shipping. Data collected to make them are also used for recreational boating, tourism, coastal management, disaster response, and national security.

The nation's ports, like Portland Harbor in Maine, bustled with ships in the early 1800s. Shipwrecks were common.

Thomas Jefferson

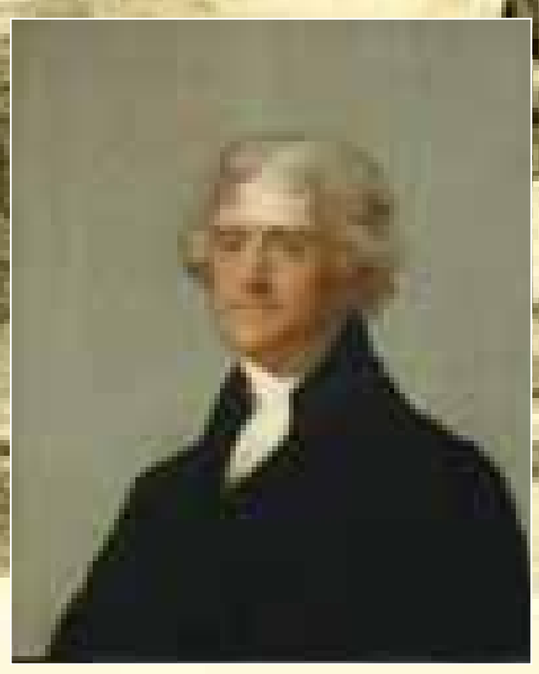
(1743–1826)

President with Foresight

In the early 1800s, our young nation had no railroads and few roads. The movement of people and goods depended on the sea. But navigating coastal waters was dangerous. Few sketches of the coastline existed, and they were rough at best. To expand commerce and hold on to its newly won independence, the United States had to create its own charts and maps.

Jefferson recognized the urgent need for accurate nautical charts that identified physical features and hazards. In 1807 he convinced Congress to pass an act authorizing the Survey of the Coast.

The *Thomas Jefferson*, one of a fleet of modern survey ships, honors the Coast Survey's founder. It recently discovered 20-foot-tall underwater dunes, huge glacial boulders, and several unknown shipwrecks off the coast of Massachusetts.



A surveyor himself, Jefferson knew that accurate nautical charts would reduce shipwrecks, expand commerce, and—most important of all—help secure the nation.

Courtesy National Portrait Gallery, Smithsonian Institution and the Thomas Jefferson Foundation

"…a survey to be taken of the coasts of the United States, in which shall be designated the islands and shoals, with the roads or places of anchorage, within twenty leagues of any part of the shores of the United States."

—An Act to provide for surveying the coasts of the United States, 1807

Ferdinand R. Hassler

(1770–1843)

Charting the Course

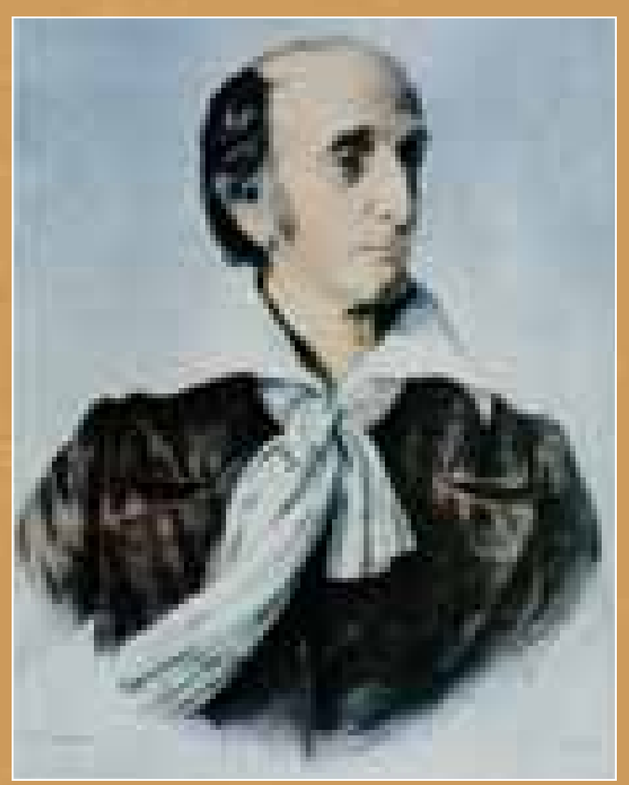
Swiss immigrant and mathematician Ferdinand R. Hassler became the Coast Survey's first superintendent. He built a thriving organization of scientists and a solid foundation for the Survey's future work.

Under Hassler's leadership, surveyors began charting the nation's shorelines as well as its harbors and offshore waters. The data was translated into the world's finest nautical charts. A stickler for details, Hassler insisted on excellence, precision, and accuracy. He set a standard the Survey has maintained to this day.

Hassler, standing at left, directs the movement of a 300-pound surveying instrument called the Great Theodolite on New York's Fire Island.

"We are apt to lose sight of the perils encountered by our early navigators…The various steps through which knowledge of the ocean has been acquired, and the hazards of ocean travel diminished, are illuminated headlands in the history of the world…"

— *Harper's New Monthly Magazine*, 1879



Some colleagues considered Hassler eccentric; others poked fun at his foreign accent and scientific rigor. But his unswerving devotion to scientific truth helped make the Coast Survey and American science what they are today.

Alexander Dallas Bache

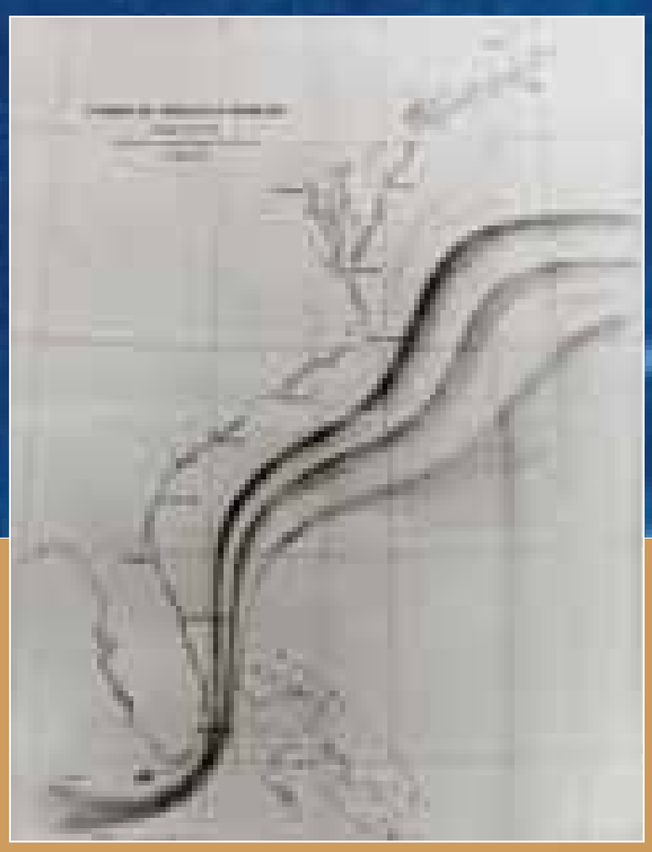
(1806–1867)

The Coast Survey Spreads Its Wings

The Survey's second superintendent was a great-grandson of Benjamin Franklin and the most influential figure in American science during the mid-19th century. Alexander D. Bache (pronounced *bashe*) significantly expanded the Survey's mission and geographical reach—to every inch of coastline and beyond in the rapidly expanding nation. He also developed the Survey into a political powerhouse that elevated the status of science.

Bache led the Survey through the Civil War, when the agency's output of maps and charts increased four-fold. While constructing defenses for the City of Philadelphia, Bache fell ill. He died three years later.

Bache peers through a sextant, an instrument used to determine location by measuring angular distances to the stars. During his career he served as one of the first presidents of the American Association for the Advancement of Science, first president of the National Academy of Sciences, and a regent of the Smithsonian Institution.



Under Bache's direction, the Coast Survey began systematically measuring the tides and studying the Gulf Stream. This chart is based on data collected over the course of 15 years.

"It seems a very simple task to make correct tidal observations; but, in all my experience, I have found no observations which require such constant care and attention . . ."

—Alexander D. Bache

George Davidson

(1825–1911)

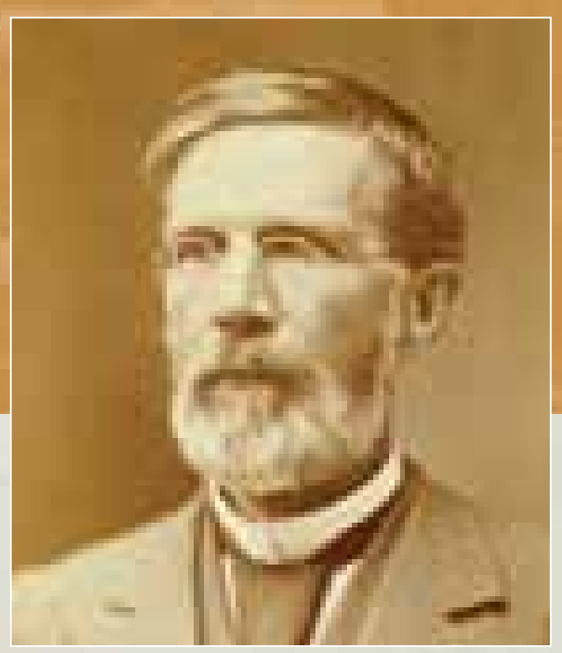
Mapping the Wild Pacific Coast

By 1850, the California gold rush was drawing boatloads of people to the Pacific Coast. Hundreds of ships sailed the treacherous waters without a single lighthouse, buoy, or beacon to guide them. An alarming number were wrecked. The situation was critical.

That year, George Davidson began charting the entire West Coast. One of the greatest scientists ever to work for the Coast Survey, Davidson and his crew traveled the coast for seven years. They located major headlands, observed tides and currents, uncovered dangerous shoals, and recommended sites for lighthouses and buoys that are still in use today. Davidson spent 45 years working for the Survey.

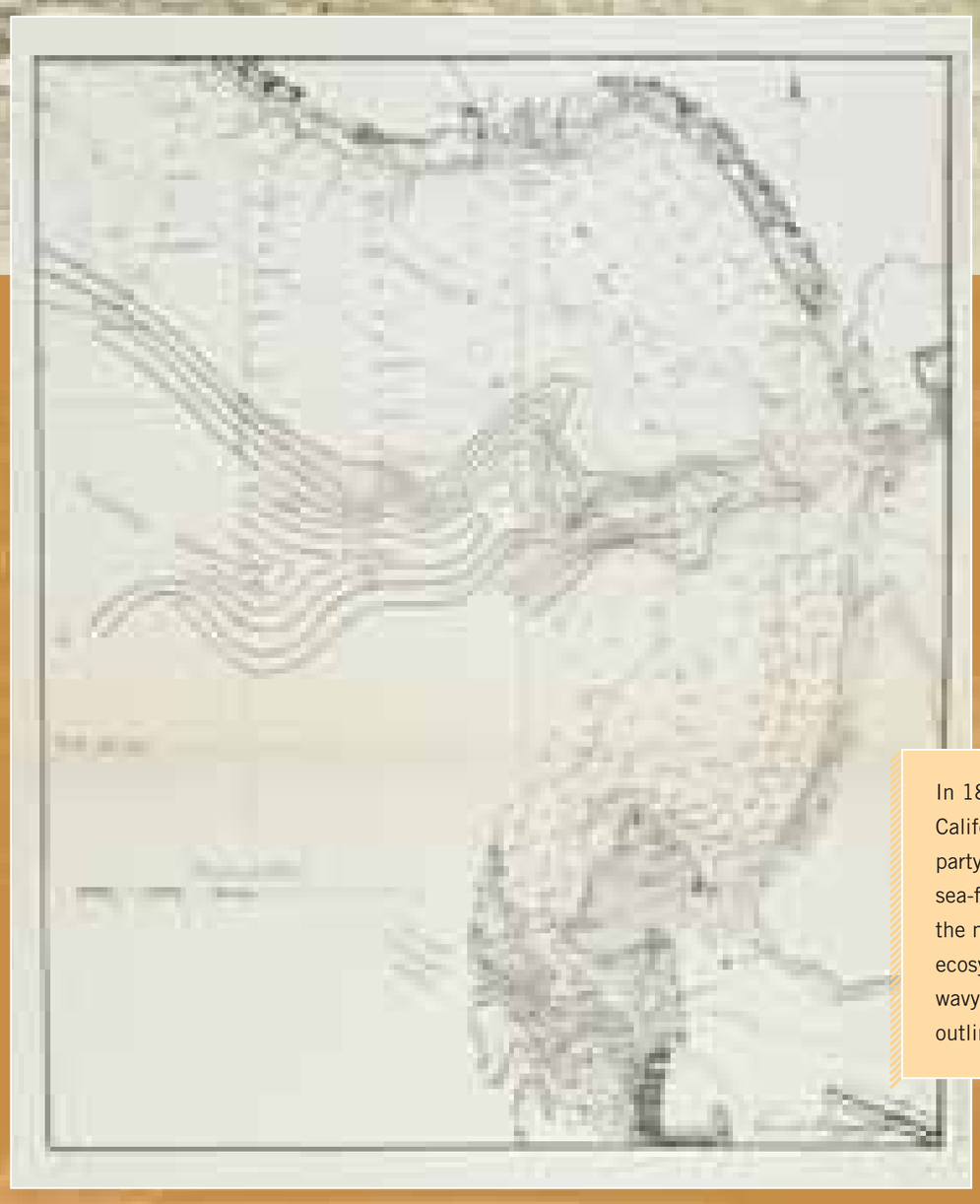
"I continue ceaselessly to work because I love it, because I have the constitution to stand it, and because I believe that I can add something to human knowledge . . ."

—George Davidson



Davidson's legacy lives on in dozens of geographical sites named after him—mountains, undersea banks, a glacier, and even a seamount.

At Davidson's camp in San Luis Obispo, California, a cabin protects delicate instruments from wind, dust, and rain.



In 1857, in Monterey Bay, California, a Coast Survey party discovered a large sea-floor canyon and one of the most abundant marine ecosystems in the world. The wavy lines on this 1897 map outline the canyon.

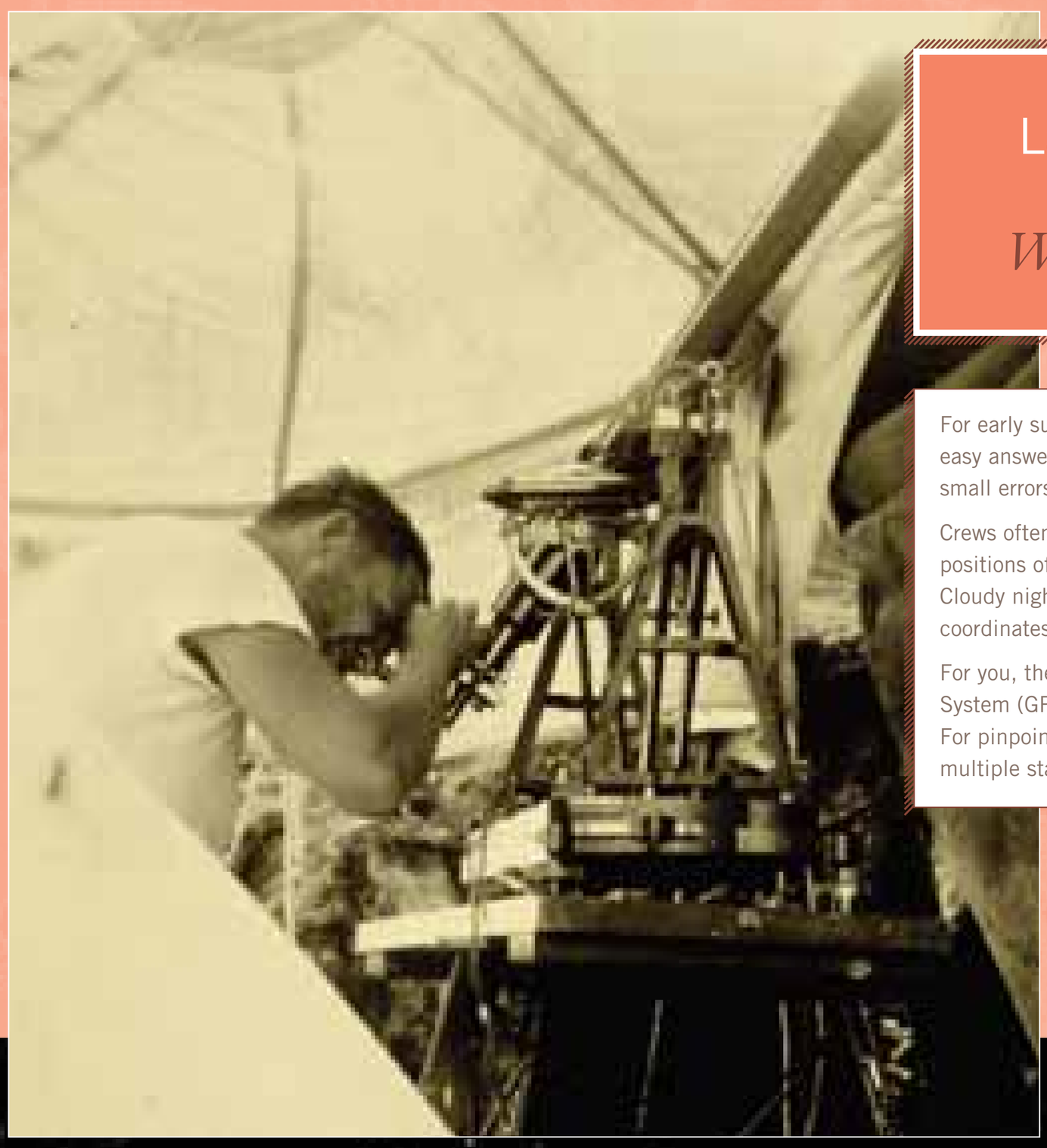
Latitude and Longitude

Where on Earth Are You?

For early surveyors mapping our uncharted coastlines, there was no easy answer. But locating their position accurately was critical. Even small errors meant their work could be off by miles.

Crews often spent their nights studying the heavens. They used the positions of the moon and stars to fix both latitude and longitude. Cloudy nights kept them waiting for days, even weeks, to find the coordinates of a single spot.

For you, the job is much simpler—handheld Global Positioning System (GPS) devices use satellites to locate any place on Earth. For pinpoint accuracy, the Coast Survey processes GPS data from multiple state-of-the-art scientific receivers.



A surveyor trains his complex telescope on the sky. This Davidson Meridian instrument was made especially to determine positions using astronomy.

Thirty GPS satellites orbit Earth and transmit radio signals to receivers on the ground. The time it takes for a signal to reach a receiver is used to compute the distance between the two. Simultaneous signals from any four satellites accurately locate any spot on Earth.

Courtesy Lockheed Martin

A Coast Survey party member operates a long-wave radio receiver to check the time at the zero meridian in Greenwich, England. Knowing that exact time and observing when various stars passed over their location enabled crews to determine longitude.

This tower of scaffolding allowed surveyors to climb and move around during observations without shaking the sensitive instruments mounted high in the tree. Towers gave surveyors a line of sight above trees or hills to distant survey points.

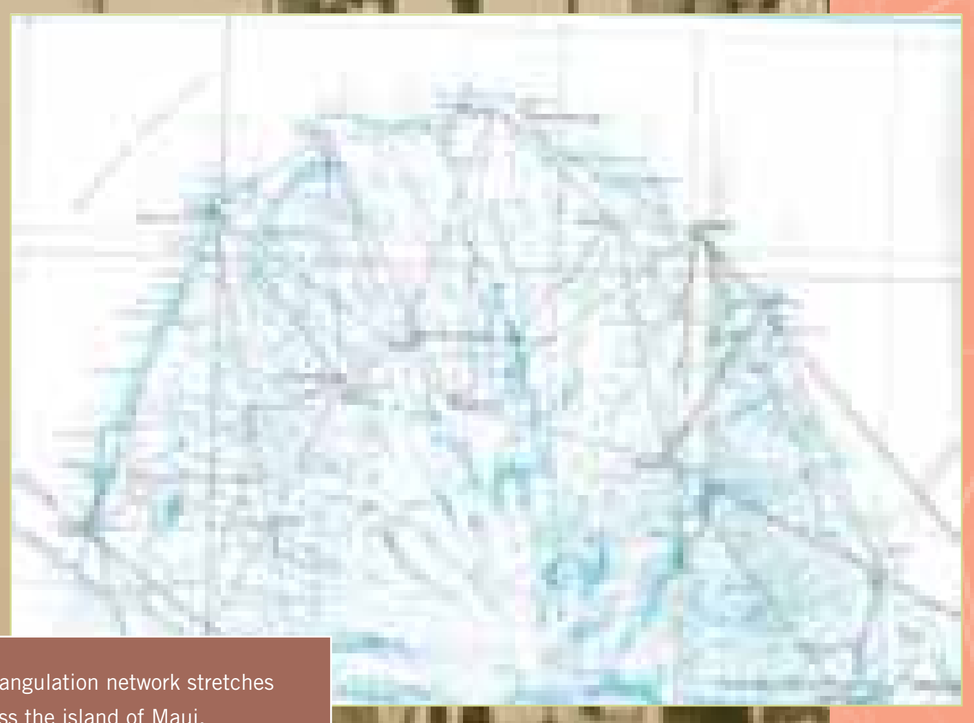
Triangulation

How Does Surveying Work?

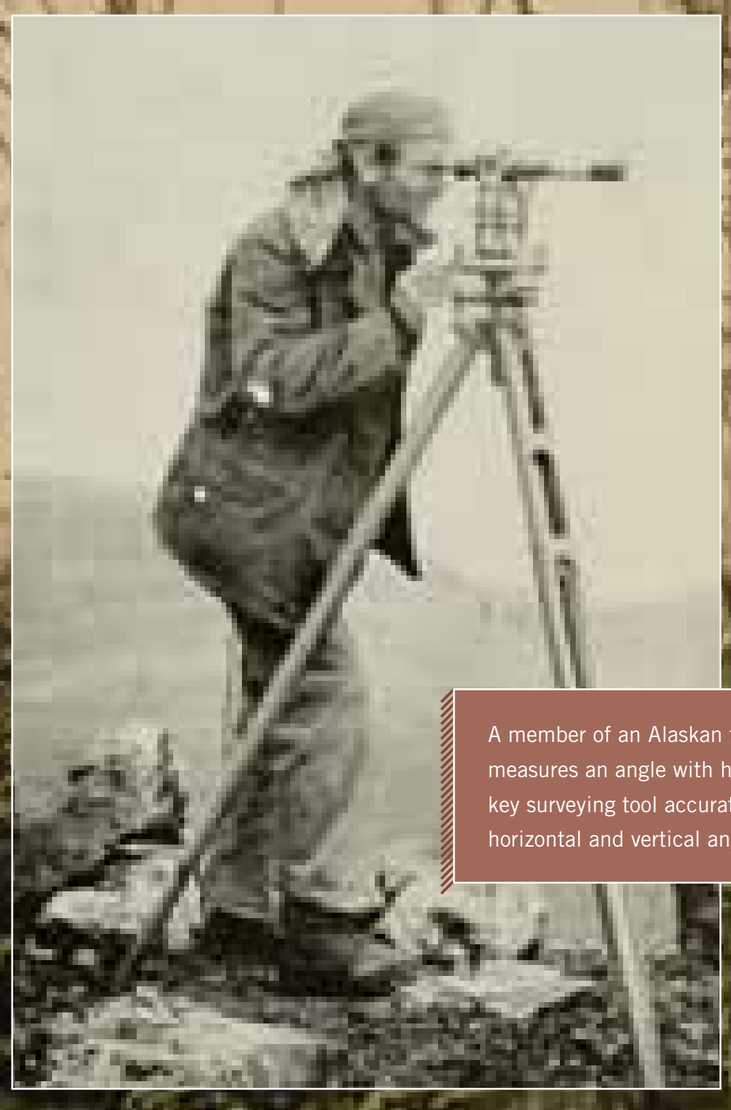
Traditional surveying, or triangulation, begins with a carefully measured baseline. Using trigonometry, surveyors then measure the three angles of the triangle created by the ends of the baseline and a distant point. They repeat the process over and over to form a series of interconnected triangles and create a chain of survey marks.

During the 19th century, Coast Survey parties used triangulation to pinpoint thousands of accurate locations along our coasts and across the country. Crews relied on this network of points to anchor coastal charts, extend land surveys, and build our roads and railways. Their work put America on the map—literally.

The Survey still bases much of its work on triangles, though scientists now rely on GPS satellite data to accurately determine positions.



A triangulation network stretches across the island of Maui.



A member of an Alaskan triangulation team measures an angle with his theodolite. This key surveying tool accurately determines horizontal and vertical angles.

Nautical Charts

How Do Mariners Plot a Safe Course?

They rely on charts, just as they have for centuries.

Since the Coast Survey began its work, advances in technology have yielded increasingly detailed charts of America's 95,000 miles of coastline and 3.4 million square nautical miles of water. Until recently, however, mariners maneuvered past dangerous shoals using paper charts and drafting tools to estimate their location as they traveled between known points. When ships drifted off course between position checks, they risked running aground.

Today, navigators use GPS, electronic navigation systems, and the Survey's Electronic Navigational Charts (ENC) to plan routes and pinpoint vessel locations. Some systems sound an alarm if the ship or boat is getting too close to a navigation hazard, like a rock or shallow water, shown on the NOAA ENC®.

The green line on this paper chart marks the *Exxon Valdez's* fateful course through Alaskan waters in 1989. Notice where the tanker detoured away from the shipping lane (purple) and turned back too late to avoid a clearly marked reef. With today's electronic charting systems, the ship might have avoided the rocks…and the costliest oil spill in U.S. history.

In this 1928 photo, a Coast Survey officer plots sextant readings with a three-armed protractor to determine his location.

Crewmembers on NOAA Ship *Rainier* track their location on an Electronic Navigational Chart downloaded from the Coast Survey's website.

Ocean Mapping

What Lies Below the Surface?

See the water depths on this Chesapeake Bay chart? Data from nearby tide gauges in Maryland and Virginia waters were used to adjust the sonar depth measurements to reflect the lowest average tide level. This chart marks the site of the shipwreck *Herbert D. Maxwell*, a schooner that sank in 1919, after colliding with the SS *Gloucester*.

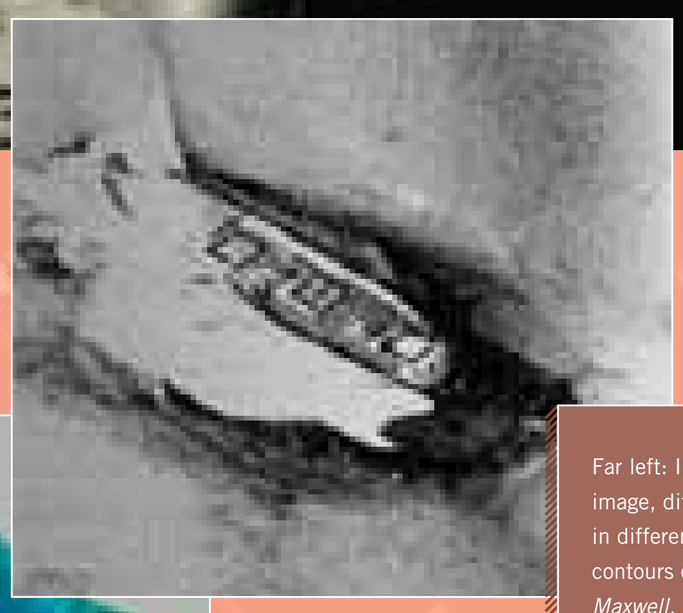
Sandbars, rocky reefs, and shipwrecks.

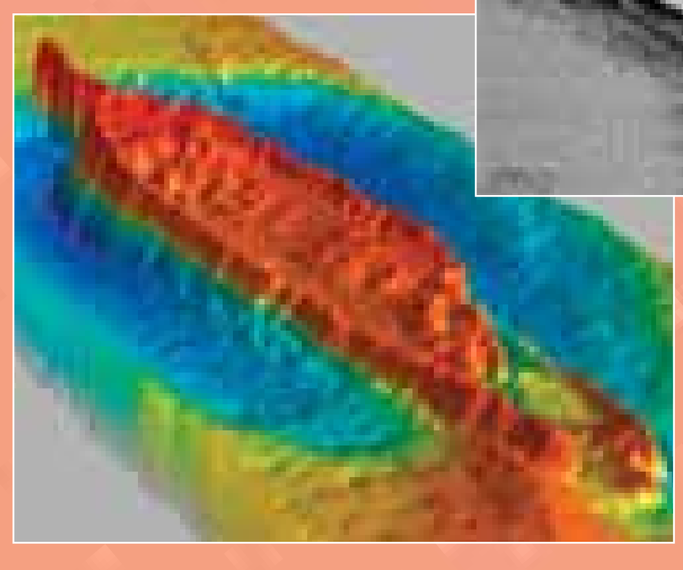
Without charts, the ocean bottom is hazardous territory for ships navigating above.

Early Coast Survey parties mapped coastal waters using only a rope with a seven-pound lead sinker. Again and again, they tossed the leadline overboard, carefully noting the ocean's depth and their location. Multiple measurements, or soundings, outlined the contours of the sea floor below. Today, some of this leadline data still appears on Survey charts.

Survey ships now scan the bottom with specialized sonar. One type, side-scan sonar, transmits sound and analyzes the echo from the sea floor to create a "picture" of a wreck or obstruction. Multibeam sonar records depths by measuring the time it takes a signal to travel to the sea floor and back.

A seaman casts a leadline to measure the water's depth.





Far left: In this multibeam sonar image, different depths appear in different colors and reveal the contours of the shipwreck *Herbert D. Maxwell,* in Chesapeake Bay. Left: Side-scan sonar analyzes return echoes from the sea floor, generating this "picture" of the ship.

Tides and Currents

Why Are They Important?

Ship captains time their comings and goings with the tides, waiting until channels are deep enough to navigate safely. Every six minutes, they find new water-level readings posted on the NOAA website—critical information that keeps the nation's waterborne commerce moving.

In 1854, the Coast Survey installed one of its first tide stations in San Francisco. Since then, gauges have evolved from punch tapes collected by tide observers to unmanned stations that communicate tide data via satellite. When a storm surge or tsunami threatens, tide gauges help predict how high water might rise.

Varying currents are harder to measure. But automated continuous-current observations implemented a few years ago are already making docking and navigating narrow passages safer.

A Coast Survey crew lowers a continuous-current meter overboard near Sitka, Alaska. Equipped with an acoustic sensor, the meter measures the speed of particles carried in the current.

A Coast Survey officer checks an automated tide gauge. The white cylinder rotates constantly, recording the water's rise and fall minute by minute.

With little room to spare, a shipload of cranes passes under San Francisco's Golden Gate Bridge. A nearby tide gauge provides real-time readings to ship captains so they know when it's safe to pass.

Courtesy 111th Aerial Photography Squadron

New York Harbor

The Charting Begins

In 1832, the Coast Survey set its sights on one of the era's busiest ports, New York Harbor. A series of submerged ledges and sandbars made navigating the entrance dangerous and time consuming. Survey Superintendent Ferdinand Hassler knew there had to be a safer, more direct passage into the harbor. He sent Lt. Thomas R. Gedney to find it.

The first sounding boats set out in October. The initial season showed nothing. But during the second year of painstaking work, crews found what they were looking for—a deep-water channel that led directly into the harbor. Named after the Survey lieutenant who helped discover it, Gedney Channel became a popular route into the bustling harbor. Today, thousands of ships pass safely through the harbor each year.

This 1817 land survey of the New York Harbor area laid the groundwork for the nautical survey of the harbor undertaken 17 years later.

A small sounding boat sets off from a Coast Survey schooner on a mission to measure and mark water depth.

This is one of the first nautical charts produced by the Coast Survey. It marks Gedney Channel into New York Harbor.

From Coast to Coast

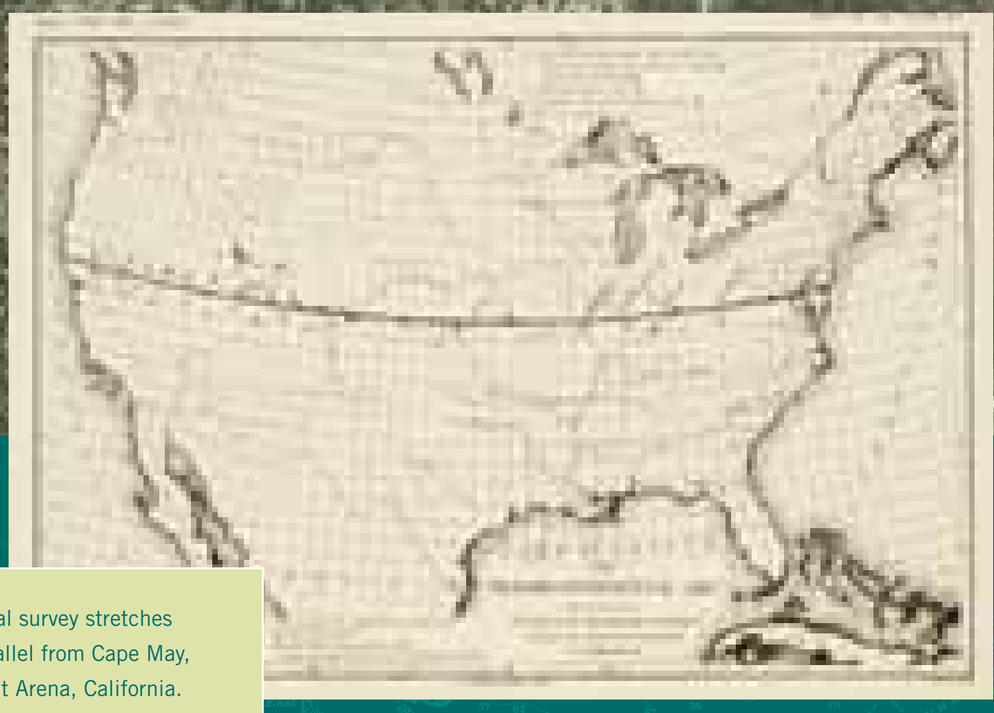
Mapping the Continent

From the beginning, Coast Survey Superintendent Ferdinand Hassler recognized the fundamental relationship between land and nautical surveys. Shipboard surveyors needed to get their bearings from fixed points on land before taking meaningful measurements at sea. And nautical surveys fit together more accurately when based on a framework of land surveys. It took Hassler and his successors decades to convince America's leaders of the connection.

In 1871, Congress finally authorized a transcontinental survey, paving the way for the greatest land survey in the Western Hemisphere. Today, this Transcontinental Arc Survey—or 39th Parallel Survey—remains the backbone of the national survey network and the foundation for almost every survey in the nation, including personal real estate surveys.

John A. Muir sketched this scene from Mount Shasta, California, while serving as a Coast Survey artist and guide. Like others on the 39th Parallel Survey, the renowned naturalist put his life on the line exploring the rugged wilderness of the American West.

Courtesy College of the Siskiyous Library



The transcontinental survey stretches along the 39th parallel from Cape May, New Jersey, to Point Arena, California. It took nearly 30 years and the efforts of countless Coast Survey guides, engineers, mapmakers, and surveyors to complete the 2,759-mile-long network.

A small survey boat works its way through icy Glacier Bay in 1907. Today the Coast Survey continues to chart Alaska's rugged coastline, countless waterways, and ice-covered oceans.

Alaska

Carrying the Flag Far North

During the 19th century, the United States steadily expanded across North America. The Coast Survey followed, meticulously charting the course of a growing nation. But in 1867, it was the Survey that led America into new territory.

That year, George Davidson headed the first American scientific expedition into the remote Alaskan frontier. Reports from this pioneering survey helped convince Congress to fund the purchase of Alaska from Russia—closing one of America's greatest land deals and adding another 34,000 miles to the nation's shoreline.

The purchase of Alaska expanded Coast Survey work into the Arctic Ocean and Bering Sea, where agency ships collected valuable information on sea depth, ocean currents, tides, and other data about the coast. This 1897 chart marks water depth.

An intrepid surveyor works his way up a sheer mountainside along the Alaska-Canada Boundary. When the U.S. purchased Alaska, its borders were unknown. It took hundreds of surveyors dozens of years to set 191 monuments along the demarcation line between Canadian and United States territory.

Philippines

Charting Tropical Waters

The Coast Survey's first major mission beyond North American shores followed the Spanish-American War in 1898. America found itself controlling the Philippines, a former Spanish colony it knew little about. With only inaccurate British and Spanish charts to go by, naval vessels quelling insurrections had a rough time. The War Department called for help.

The Survey set out re-mapping the 7,000-island archipelago. Three decades later—despite impenetrable jungles, treacherous reefs, and tropical storms—it completed the first extensive survey of the Philippines. It also gained valuable experience charting tropical waters—experience that would help in protecting future American interests.

A plane table used for drawing maps in the field sits precariously on a coral outcrop. Umbrellas shield sensitive measuring instruments from the intense sun.

This 1905 nautical chart guided U.S. vessels through the treacherous Rapurapu Strait in the Philippines. Notice the many small reefs meticulously measured and plotted on the chart.

"Reconnaissance was often on all fours behind a gang of knifemen slashing a tunnel through matted underbrush; at other times . . . it was a problem of waist-deep slimy swamps."

—E.R. Frisby, U.S. Coast and Geodetic Survey, 1921

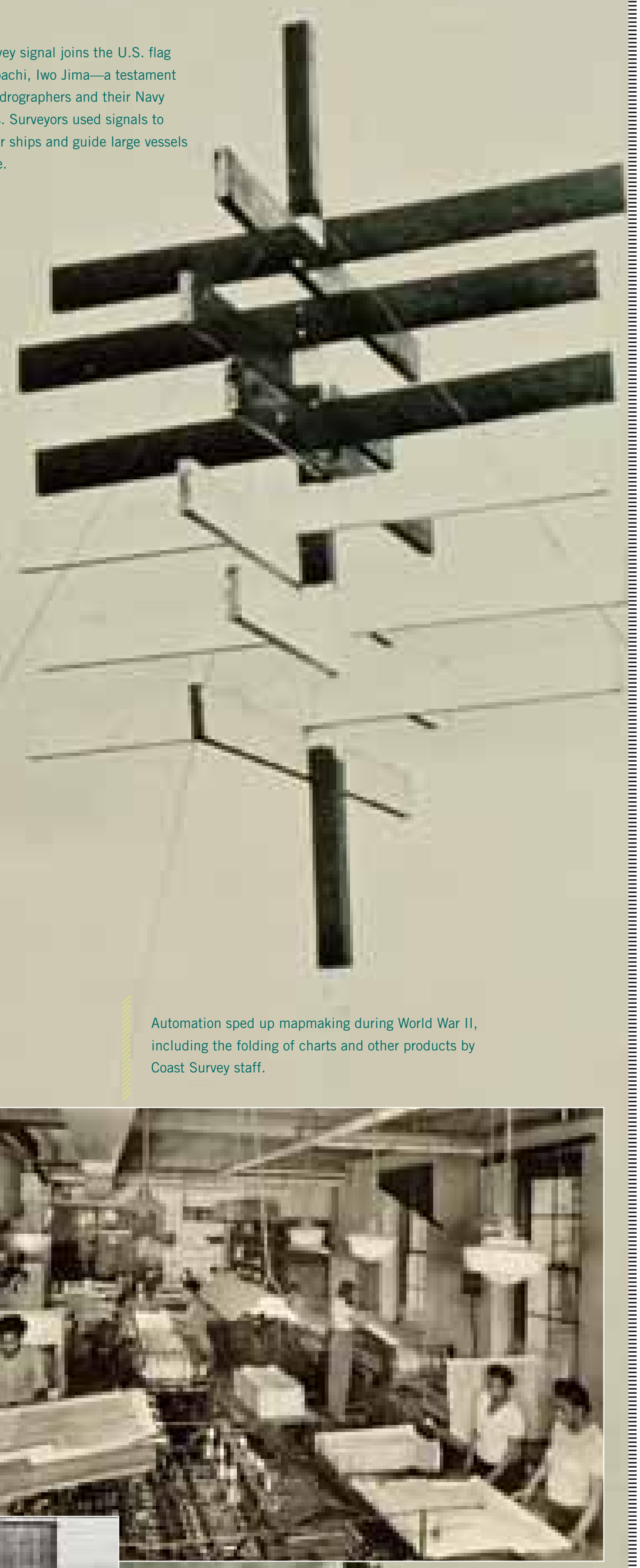
World War II

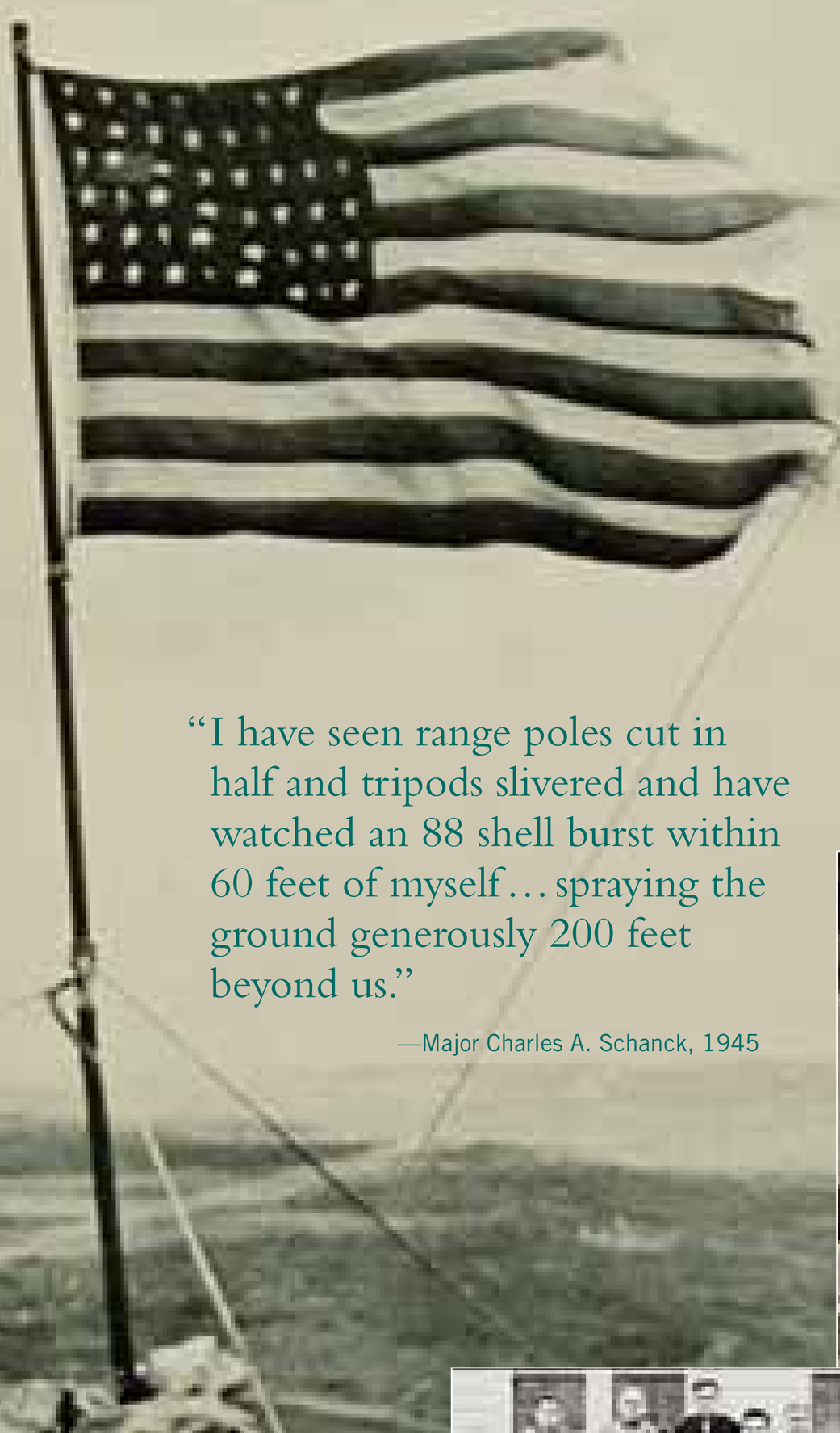
On the Front Lines

When the Japanese attacked Pearl Harbor in 1941, the Coast Survey responded. Lending expertise where it was needed most, staff served as artillery and reconnaissance surveyors, hydrographers, amphibious engineers, and intelligence officers.

Many risked and lost their lives on the front lines. At home, Survey civilians produced nearly 100 million charts and maps for the Allied forces. Small in number, but big in mission, the Survey helped save countless American and Allied lives.

A Coast Survey signal joins the U.S. flag on Mt. Suribachi, Iwo Jima—a testament to Survey hydrographers and their Navy counterparts. Surveyors used signals to position their ships and guide large vessels to anchorage.





"I have seen range poles cut in half and tripods slivered and have watched an 88 shell burst within 60 feet of myself… spraying the ground generously 200 feet beyond us."

—Major Charles A. Schanck, 1945

Automation sped up mapmaking during World War II, including the folding of charts and other products by Coast Survey staff.

Major Charles A. Schanck (1st row, far left) won a Bronze Star for his survey work in Luxembourg and Belgium. He was an officer with the U.S. Coast and Geodetic Survey Commissioned Corps, created in 1917 to protect surveyors working alongside military forces. Today's National Oceanic and Atmospheric Administration Corps is a descendant of this uniformed service.

Long Island, New York

Locating Loved Ones Lost at Sea

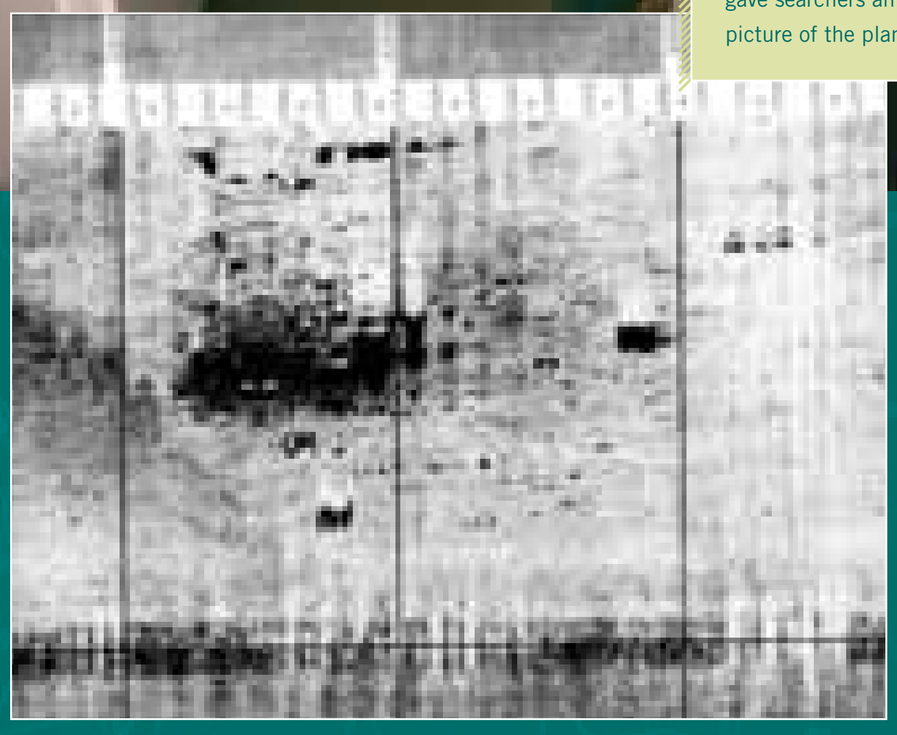
On July 17, 1996, TWA Flight 800 left New York bound for Paris. Shortly after takeoff, it exploded and plunged into the Atlantic, killing all 230 people on board. The NOAA Ship *Rude* (pronounced *roody*) and its survey crew helped locate the downed airplane hidden deep in the sea.

Systematically scanning the ocean floor with sonar, the *Rude* located the important wreckage. A shore-based data processing team created highly accurate maps of the debris from the ship's sonar data. Knowing the exact location of the submerged plane gave Navy divers the information they needed to recover the victims' remains and the flight recorder.

Small in size, but big in impact, the *Rude* is equipped with some of the most technically advanced hydrographic and navigation equipment available.

Coast Survey crew aboard the *Rude* recover a piece of TWA Flight 800's wing from the ocean floor.

This side-scan sonar image of TWA Flight 800's wreckage gave searchers an accurate picture of the plane's position.



"I posted a newspaper photo of an 11-year-old passenger on the flight in *Rude's* bridge … It helped keep us focused on finding the plane as quickly as possible, no matter what the conditions. She was my daughter's age. I knew what her parents must be going through … "

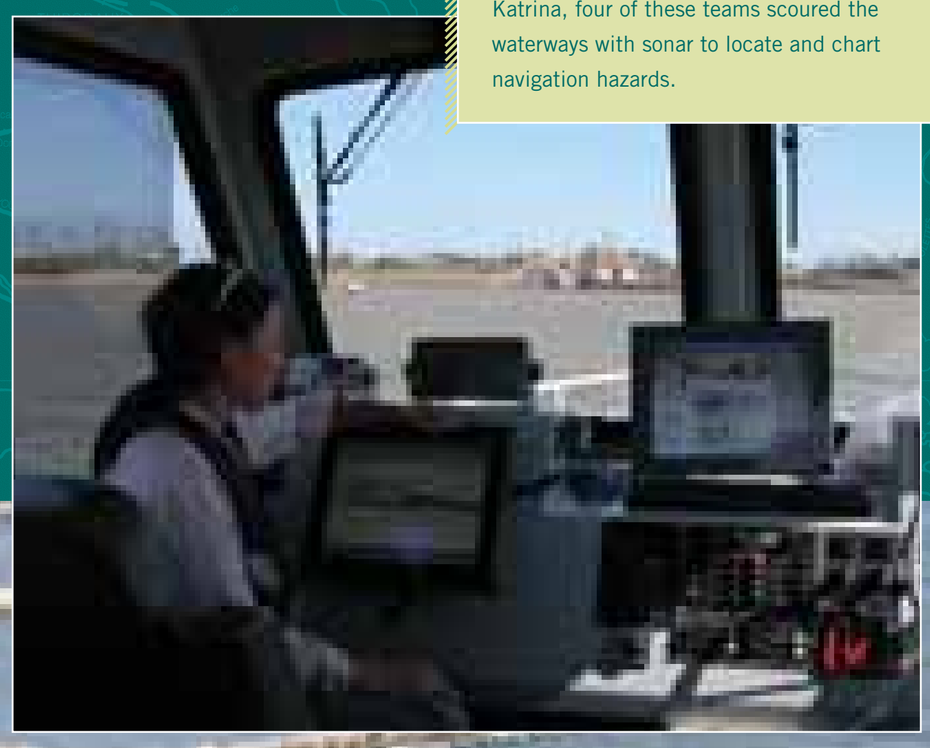
—Rear Admiral Samuel P. De Bow Jr.,
NOAA Corps, *Rude* Commanding Officer, 1996

U.S. Gulf Coast

Responding to Large-Scale Disaster

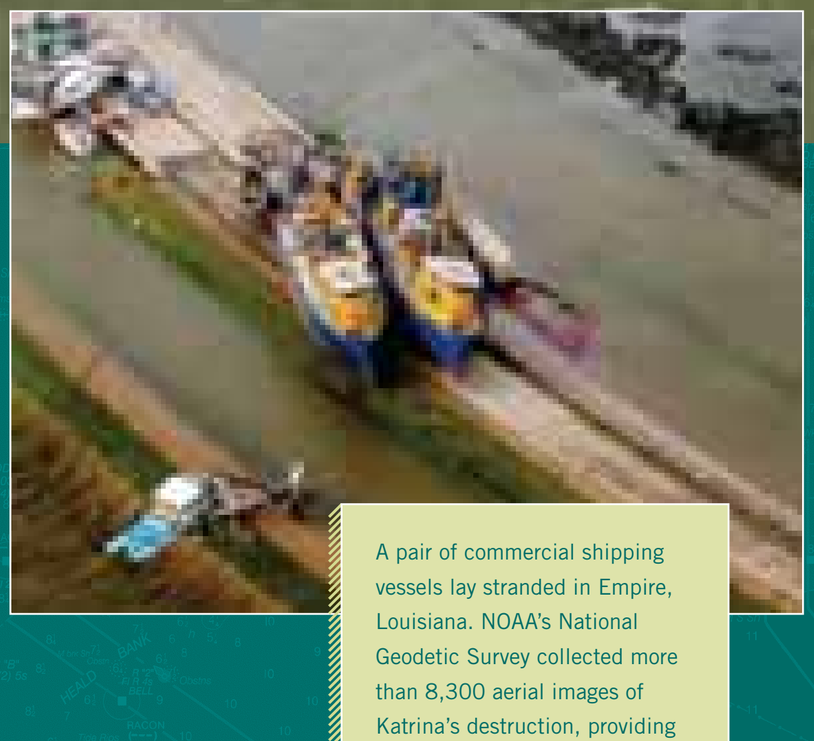
On August 29, 2005, Hurricane Katrina raged through the Gulf Coast, creating chaos on land and sea. The deadly storm left more than 1,500 people dead, countless lives uprooted, and tens of thousands of square miles of property destroyed.

The Coast Survey's Navigation Response Teams were among the first to arrive on the scene. They worked tirelessly alongside other NOAA navigation offices, re-surveying and re-charting vital waterways. In less than two weeks, all 13 major Gulf Coast ports and channels were safe for commerce and ship-based relief.



A Navigation Response Team searches for obstructions off New Orleans. Following Katrina, four of these teams scoured the waterways with sonar to locate and chart navigation hazards.

Strengthened against hurricanes, the Dauphin Island tide station off Alabama never failed during Katrina. It, along with 31 other tide stations, provided critical tide information to decision makers and emergency responders throughout the storm.



A pair of commercial shipping vessels lay stranded in Empire, Louisiana. NOAA's National Geodetic Survey collected more than 8,300 aerial images of Katrina's destruction, providing emergency responders with a clear picture of affected areas.

"The currents of the Mississippi River are so rapid that obstructions that are identified are sometimes washed away before they can be removed, requiring our Navigation Response Teams to go back and re-survey."

—Captain Roger Parsons, NOAA, 2005

200 YEARS LATER:

STILL GOING STRONG

The Coast Survey's contributions to the nation are as critical today as they were two centuries ago. Maritime commerce is still vital to the United States, and we still rely on accurate information collected by the Survey's descendants to keep our coastlines safe. Thomas Jefferson would be very proud of what he started.

Smithsonian

From Sea to Shining Sea is brought to you courtesy of the National Oceanic and Atmospheric Administration and the Smithsonian Institution.

Writing and image research by Sharon Barry, Robin Faitoute, and Elizabeth Jones
Design by Catalone Design Co. LLC