# A Captain of the Port's Guide to NOAA Emergency Hydrographic Survey

Office of Coast Survey - NOAA

**June 2020**

**DEPARTMENT OF COMMERCE**
National Oceanic and Atmospheric Administration
National Ocean Service
Office of Coast Survey
Navigation Services Division
Silver Spring, Maryland, United States of America

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# ABOUT THIS GUIDE

## Purpose

The purpose of this guide is to help the United States Coast Guard Captain of the Port and their staff understand the full scope of navigation support services available to them through NOAA's Office of Coast Survey.

We know the Coast Guard shares our vision of providing navigation products and services that ensure safe and efficient maritime commerce on America's oceans, coastal waters, and in the Great Lakes. Coast Guard consistently demonstrates its dedication to protecting lives, property, and the environment during responses to emergency incidents. During emergency responses, Coast Survey works alongside the Coast Guard to reopen ports in the most efficient manner possible.

To that end, Coast Survey will develop, communicate, and apply practical and credible science while preparing for and responding to risks to mitigate the consequences from wrecks and other navigation hazards threatening the marine transportation system.

Coast Survey thanks the Coast Guard for making our organization an integral part of its response efforts.

## Disclaimer

The Office of Coast Survey's navigation response teams (NRT) are prepared to respond to any request from the U.S. Coast Guard or other authorities where there is an ***imminent*** threat to life, property, or the environment. For requests that do not represent an imminent threat, Coast Survey will document the request in our Survey User Request Files (SURF) database and note the requirement for priority action when COVID-19 restrictions are eased.

## Companion Guide

This guidebook is formatted to match "An FOSC's Guide to NOAA Scientific Support, " created by NOAA's Emergency Response Division within the Office of Response and Restoration to help the Coast Guard's Federal On-Scene Coordinators (FOSCs) and their staff understand the full scope of scientific support services available to them through NOAA when responding to environmental threats.

## Stay Updated on Coast Survey Activities

Coast Survey uses social networking platforms and newsletters to share information with its stakeholders and the public. You can get the latest updates on Coast Survey's work by:

- Subscribing to our monthly newsletter

- Subscribing to our blog
- Following us on: Facebook and Twitter

## Questions or Comments

If you have questions or comments about this guide, contact:

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# EXECUTIVE SUMMARY

This report is designed to assist United States Coast Guard Captain of the Port and their team to understand, utilize, and cooperate with NOAA's Office of Coast Survey during response situations.

Coast Survey's navigation managers are the go-to resource when requesting NOAA support, including emergency hydrographic surveys, aerial surveys, tide and current information, and ship support from NOAA's Office of Marine and Aviation Operations. Navigation managers staff Incident Command Posts as needed and serve as advisors and conduits for communication between the command posts and NOAA response assets.

Field operations require support from federal, state, and local entities to ensure safe and efficient execution. Coast Survey's navigation response teams are based around the country and require food, fuel, moorage, power, and boarding, depending on the response and its location. Team leads request local Coast Guard Station Commanding Officers' contact information to ensure needs are met before operations commence.

The standard product delivered by navigation response teams is a GeoPDF. This document can, to an extent, be tailored to meet specific requests by the Incident Command Post. Depth contours, color maps, positions, and soundings can all be manipulated to best depict vital information. The standard delivery timeframe for this product is the morning after survey operations ended, depending on how well staffed the navigation response teams are. This time is needed to ensure data accuracy. Other products may be available to support the U.S Army Corps of Engineers depending, on navigation response team resources.

Coast Survey prides itself on its ability to support the Coast Guard and other partners. Do not hesitate to reach out to any of the contacts provided within this document for more information, clarification, or specific guidance.

# 1. THE NAVIGATION SERVICES TEAM

One of Coast Survey's primary responsibilities is providing customer-driven maritime support services to ensure navigational safety, environmental protection, and the efficient and reliable flow of commerce through U.S. waterways. As the nation's authority on nautical charts, Coast Survey represents the most experienced hydrographic workforce in the federal government.

Within Coast Survey are two teams critical for emergency response:

- Navigation managers are the regional resource for the complete range of NOAA's navigation support services.
- Navigation response teams (NRT), which are strategically located around the country, can rapidly respond to surveying needs.

## Headquarters

Coast Survey headquarters is in Silver Spring, Maryland. While the navigation managers and navigation response teams are the outward facing representatives, the uniformed and civilian staff at headquarters oversee budgeting, survey planning, resource acquisition, and are the final say in operational decision-making. Personnel at HQ are also the link to other NOAA resources, such as ships and aircraft, are requested.

## Navigation Managers

NOAA's regional navigation managers are strategically stationed in port areas along U.S. coasts and Great Lakes (Figure 1). They work directly with the U.S. Coast Guard (USCG), pilot associations, mariners, port authorities, and recreational boaters to identify navigational challenges facing the marine transportation system and provide resources and services to enable safe and efficient navigation. Navigation managers are the primary point of contact for requesting emergency support. In addition to providing emergency support, the regional navigation managers provide numerous services:

- Expert navigation preparation and response information for severe weather or hurricane preparedness and post-storm response
- Charting of Dangers to Navigation (DtoN)
- Assistance in navigational project coordination
- Support for Harbor Safety Committee meetings, or other maritime-related conferences or workshops
- Information about NOAA's latest navigation technologies
- Objective information on hardware and software products for safe navigation and homeland security
- Advice to resolve navigational problems
- Assistance with NOAA nautical charts or data
- Serve as NOAA representative for navigation responses within an Incident Command Post (ICP)

Through the navigation manager, the USCG Captain of the Port (COTP) can request assistance from any of NOAA's experts or resources including:

- The Remote Sensing Division, which supports response requirements through acquisition and rapid dissemination of a variety of spatially-referenced datasets (stereo photogrammetry and LiDAR) to federal, state, and local government agencies, as well as the general public.
- The Hydrographic Services Division, which plans and oversees all non-emergency surveys commissioned by Coast Survey. These surveys are executed via NOAA's research fleet as well as via private party contract partners. Both of these mechanisms may be available for assistance during an emergency response.
- The NOAA ships operated by NOAA's Office of Marine and Aviation Operations which provide a wide assortment of hydrographic survey, oceanographic research, and fisheries research capabilities. Within the fleet, four ships focus on NOAA's hydrographic mission. NOAA often utilizes these ships when conditions or locations are unfavorable for Coast Survey's vessels.
- The Center for Operational Oceanographic Products and Services, which is the authoritative source for accurate, reliable, and timely water level and current measurements that support safe and efficient maritime commerce, sound coastal management, and recreation.
- Any of the six NOAA Line Offices and the 6,700+ scientists and engineers dedicated to understanding and stewardship of the environment as well as studying and monitoring our evolving planet.

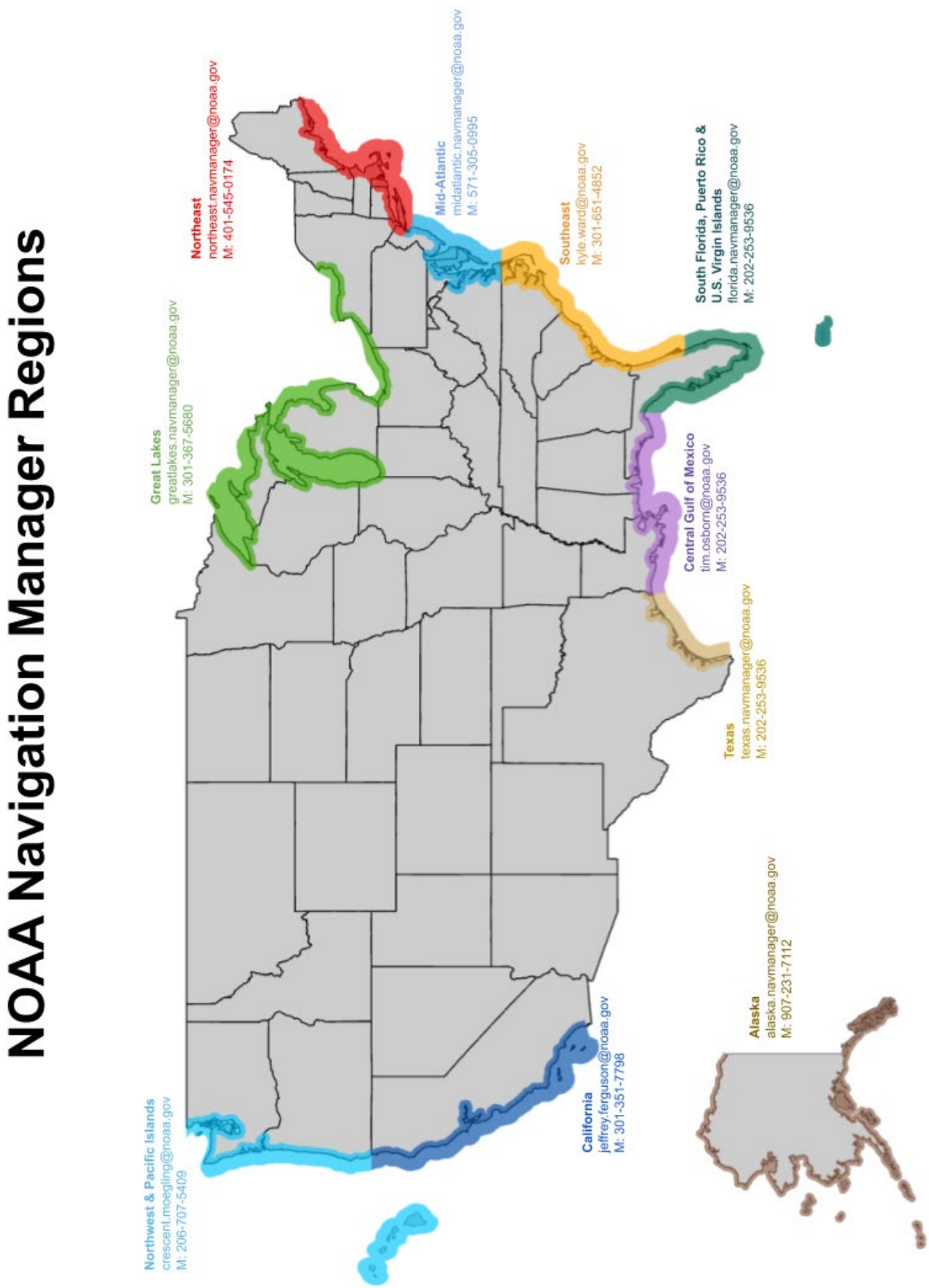



*Figure 1: Navigation managers' regions of responsibility.*

## Navigation Response Teams

Coast Survey's mobile NRTs (Figure 2) conduct hydrographic surveys to update NOAA's suite of nautical charts. The three-person teams are strategically located around the country (Figure 3) and remain on call to respond to emergencies. Their response efforts aim at speeding the resumption of shipping after storms, and protecting life and property from underwater dangers to navigation.

*Figure 2: NRT-New London (NRT5) alongside in Burlington, Vermont.*

When hurricanes make landfall, they often bring with them stronger-than-normal ocean currents that can shift navigational channels and bring debris that may threaten the ability of vessels to navigate safely along the coast.

Working with Coast Survey's regional navigation managers, NRTs work around-the-clock after a storm acquiring and processing data to speed the reopening of ports and waterways. The teams operate 30' trailer-able survey launches equipped with both a multibeam echo sounder (MBES) and a side scan sonar (SSS) used to help verify water depth and identify dangers to navigation.

During an emergency response, NRTs provide time-sensitive information to the ICP, and transmit data to NOAA cartographers for updating Coast Survey's suite of navigational charts. The teams also respond to maritime incidents as needed, such as vessel groundings, sinkings, or cargo losses that may require underwater searches to mitigate risk to life and property.

NOAA's NRTs dramatically improve navigation safety, protect homeland security, and speed economic recovery. Like navigation managers, NRTs are on call to respond to emergencies and are typically able to respond in the continental United States within 48 hours of notification, if necessary.

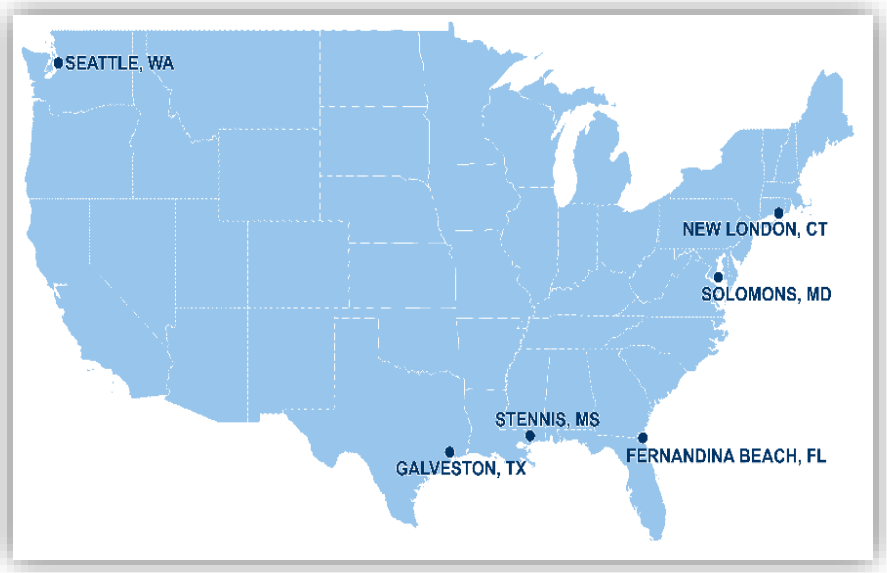



*Figure 3: Navigation response team locations.*

## R/V *Bay Hydro II*

Coast Survey's R/V *Bay Hydro II* (Figure 4), located in Solomons, Maryland, is the primary survey vessel for the Chesapeake and Delaware Bays and their associate ports. The vessel also acts as a testing platform for Coast Survey. At 57' the vessel is larger than the NRT vessels and is not trailer-able, but can respond to emergencies in the region within 48 hours.

*Figure 4: Bay Hydro II.*

## Mobile Integrated Survey Team

Coast Survey maintains two mobile integrated survey team (MIST) kits for deployment on vessels of opportunity (VOOP), such as a USCG trailer-able aids to navigation boat (TAN-B) (Figures 5 and 6). The MIST is a modular system that consists of a SSS, an MBES, a single beam echo sounder (SBES), an inertial measurement unit (IMU), and mounting pole designed to fit a wide range of vessels. The MIST's portable nature maximizes response efforts, as it fits in the back of a pickup truck or can be shipped around the country (~1,300 lbs).

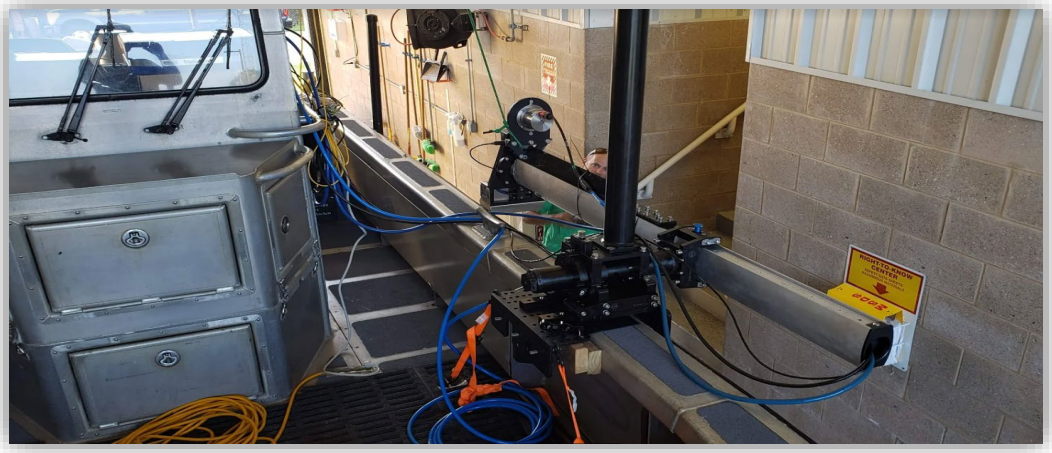


*Figure 5: MIST installed on a TAN-B.*

*Figure 6: Portside view of installed MIST.*

Coast Survey also maintains unmanned surface and subsurface systems, which can be deployed either independently or in concert with an NRT as a force multiplier (Figure 7). Work with your regional navigation manager to determine if these assets would be suitable for your desired application or response.

*Figure 7: Echoboat and NRT5 in Saint Albans, Vermont.*

# 2. WHAT TO EXPECT FROM COAST SURVEY DURING A DISASTER RESPONSE

## In the Incident Command Post

During disaster responses, Coast Survey works with stakeholders and partners to address survey needs and ensure safe navigation of affected waterways. Typically, this includes the United States Army Corps of Engineers (USACE) and the USCG. The navigation manager is Coast Survey's point of contact at the ICP and works with the USCG, USACE, within NOAA, and other stakeholders to determine the most effective use of NOAA's operational assets. Navigation managers then forward these requests to Coast Survey HQ to determine which assets are available for the response effort.

The navigation manager works under the operations chief as Coast Survey's representative. Typically, they work with an USACE peer to streamline priorities according to both the USCG and USACE needs. Once a series of priorities is determined, these are communicated to the field unit (i.e. the NRTs). Before operations commence, Coast Survey holds an internal conversation to ensure that NRT conducts deployments efficiently, in accordance with NOAA safety protocols and with proper risk mitigation practices in place.

During the response, the navigation manager will be the primary point contact within the ICP for the field unit. This ensures a smooth dissemination of survey products as well as clear communication of field unit limitations, progress, and requirements to the ICP.

## In the Field

Field units effectively and efficiently execute their mission once given surveying instructions. However, **logistical support for lodging, mooring, fuel, and other necessities may be required** from federal, state, and local entities to enable these efforts. More details on these requirements are provided in section three of this document.

The COTP should be aware that all data acquired by the field unit must first be processed and quality controlled prior to distribution within the ICP. This process takes time, and is dependent on both the amount of surveying accomplished as well as the availability of qualified personnel for processing. The field unit will endeavor to provide products within 12 hours of acquisition, however this may not be practical given personnel constraints. Please work with the regional navigation manager to set expectations at the start of response operations.

## Products

The standard product that is delivered to the ICP during a response is a GeoPDF. The GeoPDF allows the user to view the document spatially with the latitude and longitude of the cursor displayed on the

screen. GeoPDFs allow different layers to display independently of each other and without specialized software. For example, a typical GeoPDF delivered to the USCG will have a sounding layer, a layer with contours set to depths (often defined by USCG needs), a sounding plot layer, and the smallest scale chart. The user is able to turn these independent layers on and off depending on how they want to view the data. This allows the document to have a lot of information, but retains the ability to be displayed simply. Please refer to the appendix for a GeoPDF user guide.

Upon request, field units can provide other products to the USACE at the discretion of Coast Survey leadership.

## Survey Planning and Considerations

Field unit safety is a primary concern, and time must be taken to ensure that survey requests can be conducted safely and efficiently. Following a prioritization of survey areas from the ICP, the field unit will develop an acquisition plan. Along with prioritization, this plan will be based on many factors, including tides and currents, weather conditions, and operational constraints such as fuel and personnel. These factors may result in limitations that require the field unit to acquire data "out of order" as compared to the prioritization. The field unit will work with the ICP, via the navigation manager, to communicate these constraints as well as time estimates throughout the response effort.

## Survey Asset Coordination

The navigation manager may coordinate survey efforts with USACE based district capabilities and available resources. While NOAA's survey capabilities are streamlined across our fleet and geared toward insuring safe and efficient navigation, USACE's response is often focused on understanding how they might need to respond with emergency dredging.

USACE survey assets are equipped to support the primary mission of planning, prioritization, and contracting of dredging within a district. Data is used to accurately calculate volumetric measurements of sediment within a channel framework. Understanding the differences between their survey methods and capabilities is important to efficiently prioritize each organizations' resources in a response scenario.

USACE will often run SBES' on predetermined and repeatable tracklines within channels, commonly referred to as "centers and quarters." This method accurately locates shoaled areas where sediment has moved into the channel. Extrapolating this data gives the USACE an accurate volumetric estimation of sediment in need of removal. However it would not necessarily find an object, like a shipping container which fell between the single beam tracklines.

NOAA's survey methodologies, as explained in the following sections, are designed to map the entirety of the seafloor with specific attention paid to locating objects and other potential hazards to navigation. In post-distaster scenarios, NOAA's surveys will provide data that not only shows where shoaling has occurred, but also where objects might have moved into the channel. When data meets object

detection requirements, objects as small as 50 centimeters will be found. Single beam data can easily miss objects that are not located directly beneath a survey vessel's trackline.

# 3. COAST SURVEY FIELD UNIT SPECIFICATIONS AND REQUIREMENTS

- **Navigation response team vessels**

  **Specifications**
- Length: 33’
- Beam: 8.5’
- Draft: 2’
- Air Draft: 10’
- Fuel: 160 gal gasoline
- Crew: 3-4
- Power: 35 amps
- Restrictions: 3-4’ seas and 10 NM from safe harbor

  **Requirements**
- Berthing: 3-4 if hotels are not available
- Adequate ramp
- Fuel, if no public supply available
- Room to store trailer and two vehicles
- Food, if response extends a significant amount of time

- **R/V *Bay Hydro II***

  **Specifications**
- Length: 57’
- Beam: 24’
- Draft: 6’
- Air Draft: 28’
- Fuel: 1200 gal diesel with 2” fill port
- Crew: 3-4
- Power: 50 amp, 250 V
- Restrictions: 5’ seas and 20 NM offshore

  **Requirements**
- Berthing: 3-4 if hotels are not available
- Fuel, if no public supply available
- Food, if response extends a significant amount of time

- **Mobile integrated survey team**

  **Specifications**
- 1300 lbs of equipment in 22 pelican cases

- 1 REMUS 100, ~125lbs
- 3 small ASVs, ~150lbs/each
- Restrictions: vessel of opportunity dependent

**Requirements**

- Vessel of opportunity: preferably a TAN-B
- 110 V power or gasoline supply for generator
- Berthing: 3-4 depending if hotels are not available
- Food, if response extends a significant amount of time
- Partial canopy on vessel of opportunity to protect electronics from weather

# 4. AN INTRODUCTION TO HYDROGRAPHIC SURVEY

Hydrographic surveying is the science of determining the depth of a given body of water, generally for charting purposes. Hydrographic survey's importance has amplified in the last 60 years as maritime commerce has increased. Larger emphasis on the efficiency of ports, research of new survey technologies, and heightened value of survey data to other scientific and engineering disciplines has increased the demand for accurate surveys.

In the nineteenth and early twentieth centuries, surveys were conducted using lead lines. These surveys obtained a single point of data with each throw, and each throw was often many yards apart. As technologies evolved, the SBES was employed as a faster and more efficient mode of surveying. Single beam surveys greatly increased the density of soundings along a ship's trackline.

In the 1950s, 60s, and 70s SSS and MBES sonar technologies emerged as the premier surveying method (Figure 8). These systems acquired accurate data in larger swaths beneath the survey vessel, improving efficiency and accurate detection of objects as they cover the entire seafloor rather than just the area directly beneath the vessel.

Present day survey primarily uses SSS and MBES systems, which have continued to evolve in accuracy and performance, coupled with highly accurate positioning and attitude systems. These systems yield very impressive datasets that can be used for a variety of scientific purposes.

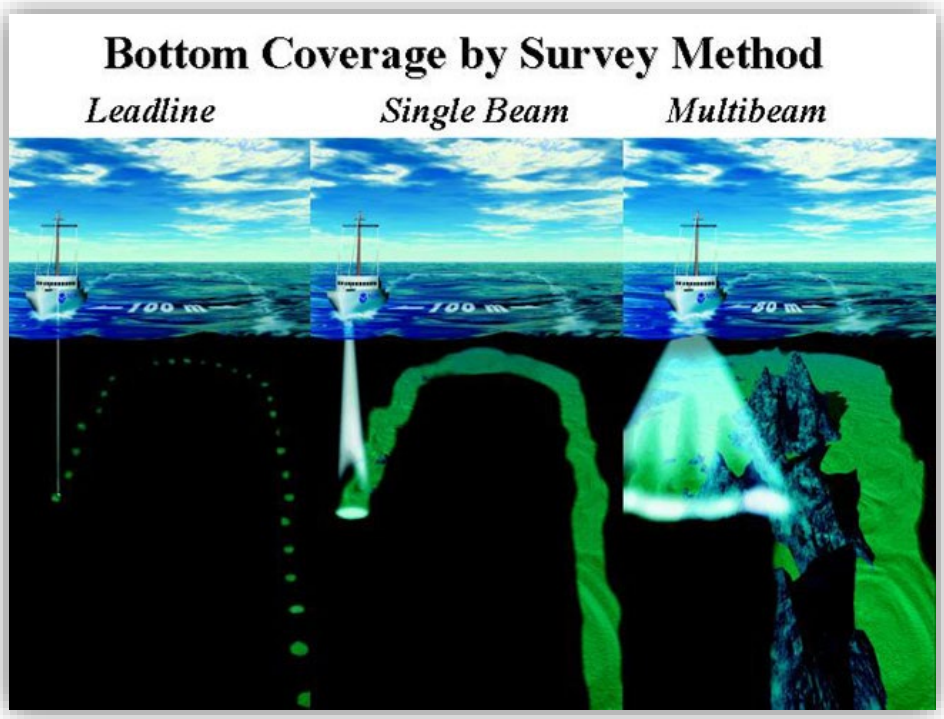



*Figure 8: Coverage achieved by different survey methods.*

## Survey Launch

A survey launch is a small boat or vessel specifically configured and calibrated for hydrographic surveying. Multiple computers and sensors on board are highly integrated to ensure acquired data is accurate and of high confidence.

## Survey Systems

A survey "system" consists of four main components, the sonar(s) for depth values and object detection, sound speed information for the sonar via a conductivity, temperature, and depth (CTD) instrument and/or probe, Global Navigation Satellite System (GNSS) for positioning, and a computer acquisition system to manage and record all of the data. Once integrated, all components act as a single system and are commonly referred to as the survey "system." These systems require specialized support to operate, as malfunctions in any component can jeopardize data integrity.

## Single Beam Echo Sounders

SBES systems provide simple but accurate depth information directly below the sensor. These sonars are often hull mounted, like those on NRT vessels, but can also be pole mounted, like those in MIST kits.

**PROS:**
- Minimal setup and configuration.
- Easy to operate and limited impact from environmental conditions.
- Can survey at a high speed (10+ kts).

**CONS:**
- Only acquires data directly below vessel, not suited for identifying objects.
- Not reliable for determining the least depth of objects.
- Data may be of limited use for analysis unless seafloor changes are drastic and/or a significant amount of survey line is acquired.

## Multibeam Echo Sounders

MBES sonars provide a swath of high-resolution depth data that is generally three to five times as wide as the water is deep. This means that in 30 feet of water, the swath width is generally 90 to 150 feet wide. These sonars are often hull mounted, like those on NRT vessels, but can also be pole mounted, like those in the MIST kits (Figure 9).

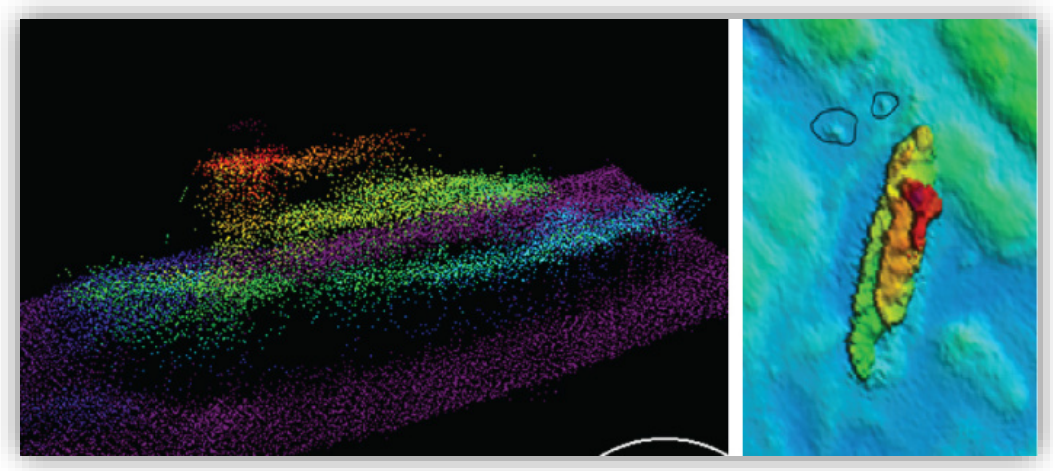


*Figure 9: MBES data of T/V Capt Mackentire and potential oil barrels, circled, off Kennebunkport, Maine*.

**PROS:**

- Full bottom ensonification, no area of the seafloor is missed, such as with single beam systems.
- Each ping is a data point, the data can be manipulated in order to be better interpreted.
- Extremely accurate depth and position on objects.
- Can survey at a higher speed (7-10 kts) than with the SSS system (4-9 kts).

**CONS:**

- MBES systems become less efficient in shallow water due to narrowing swath width.
- Requires rigorous environmental control including sound speed and vessel attitude due to susceptibility to data artifacts if not corrected.
- System configuration and operation requires a high level of expertise

## Side Scan Sonar System

SSS provides a wide swath of high-resolution imagery (Figure 10). Unlike MBES, they have fixed swath widths that do not vary with water depth and generally range between 25 and 100 meters depending on the sensor and mounting configuration. These sensors, often called “towfish” are generally towed behind the vessel but can also be hull or pole mounted. It is also important to note that while SSS is highly effective at identifying objects on the seafloor (Figure 11), it does not provide any usable depth information. MBES or SBES systems are needed in conjunction with SSS to provide depth data.

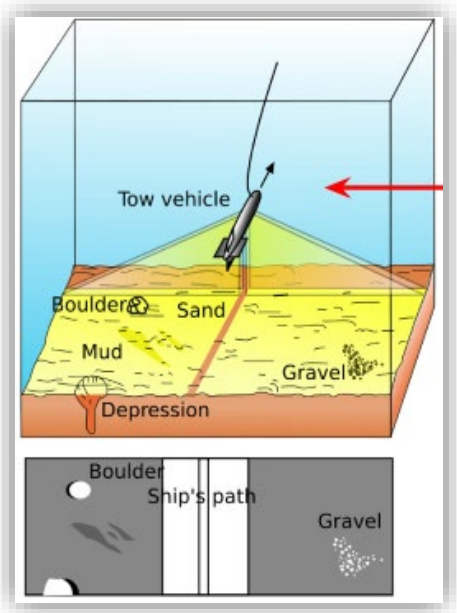



*Figure 10: Illustration of SSS swath width and path along the seafloor.*

*Figure 11: SSS image of a wreck.*

**PROS:**

- High resolution imagery of the seafloor, which is ideal for finding objects (wrecks, rocks, obstructions, etc.) that are not easy to find or identify in multibeam data.
- Fixed range scales that are user selectable.
- Highly efficient for shallow water surveying.

**CONS:**

- Additional risk management with towed systems, especially over dynamic seafloors due to risk of snagging towfish.
- SSS imagery does not provide depth data. An additional sensor (MBES or SBES) must be used to establish least depths.
- SSS survey speeds are significantly slower than equivalent MBES or SBES survey speeds.

In a response situation the SSS alone often provides enough information to make initial decisions on whether to keep a port closed or not, but true depths cannot be determined until a MBES or SBES data is acquired.

## Summary of MBES, SSS, and SBES Systems Pros and Cons

| System | Pros | Cons |
|---|---|---|
| **SBES** | -Not as affected by sound velocity changes.<br>-Very accurate depths due to sounding only being at nadir.<br>-Better than MBES at acquiring accurate depths through suspended sediments and liquefied mud. | -Does not achieve full bottom coverage, objects and features can be missed.<br>-Very inefficient way to survey large areas, time consuming and of lesser data quality. |
| **MBES** | -Full bottom ensonification, no area of the seafloor is missed, such as with SBES systems.<br>-Each ping is a data point; the data can be manipulated in order to be better interpreted.<br>-Extremely accurate depth and position on objects.<br>-Can survey at a higher speed than with the SSS system. | -MBES systems become less efficient in shallow water due to narrowing swath width.<br>-More susceptible to data artifacts from sound velocity and attitude, but these are corrected in the field.<br>-Not as efficient at finding small objects as a SSS. |
| **SSS** | -SSS yields a very high-resolution image of the seafloor, which makes it great for finding objects (wrecks, rocks, obstructions, etc.) that are not easy to find or identify in MBES data.<br>-Increased coverage efficiency with shallower depths than a MBES. | -A SSS system is not useful in steep and deep areas.<br>- Our SSS systems do not deliver any depth measurements and the position accuracy is degraded compared to MBES data. As a result, any significant object found with a SSS must be “developed” using a MBES system to accurately determine size, depth, and position.<br>- Running the SSS requires operating the boat at a lower speed, 4-9kts vs 7-10kts with the MB. |

## NOAA Survey Methodologies

Coast Survey utilizes two primary survey methodologies, object detection and complete coverage, to achieve its charting goals. These methodologies establish coverage and resolution requirements, as well as specific standards for statistical confidence. The specific methods for any survey are determined on mission objective and following consultation with the navigation manager. As a general rule, the higher the accuracy required, the slower data and processing will be.

**Object Detection**
Object detection surveys are *assigned for areas with critical under keel clearance.* This provides the highest data accuracy. It is accomplished in one of two ways:

- *Option A*: 100% bathymetric bottom coverage using MBES sonar with developments of features achieving 50-centimeter grid resolution (five soundings/grid node) at 20-meter depth.
- *Option B*: 200% SSS coverage with concurrent MBES and developments of features achieving 50-centimeter grid resolution (five soundings/grid node) at 20-meter depth.

**Compete Coverage**
Complete coverage surveys provide uniform and complete data within the survey area. As compared to object detection data, the data is coarser, but takes less time to acquire and process. It is acquired in two ways:

- *Option A*: 100% bathymetric bottom coverage using MBES sonar with developments of features achieving one-meter grid resolution at 20-meter depth.
- *Option B*: 100% SSS coverage with concurrent MBES developments of features achieving 1-meter grid resolution. Note that 100% SSS coverage is not sufficient to disprove a feature.

Figures 12 and 13 demonstrate the differences between object detection and complete coverage surveys as well as the visual difference between SSS and MBES data.

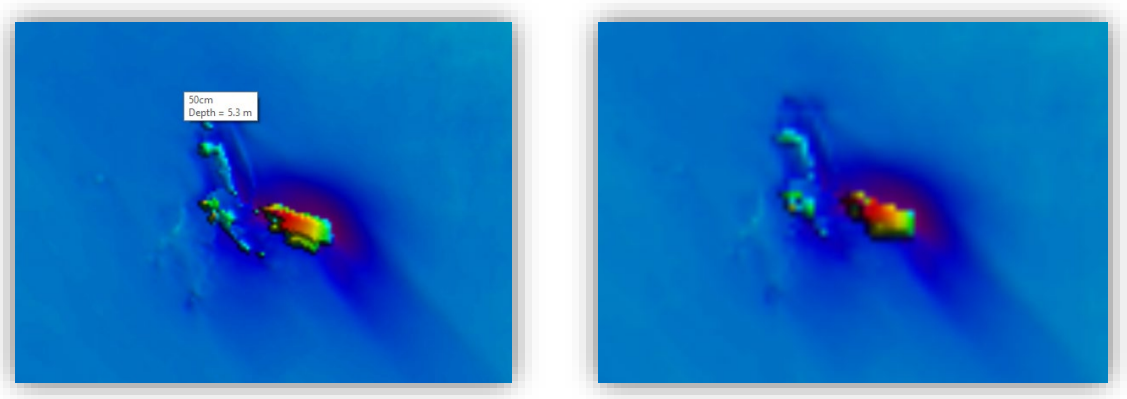



*Figure 12: MBES data of F/V Miss Debbie in Calibogue Sound, Georgia. Left image is 50-centimeter resolution (i.e. object detection) while the right image is 1-meter resolution (i.e. complete coverage).*

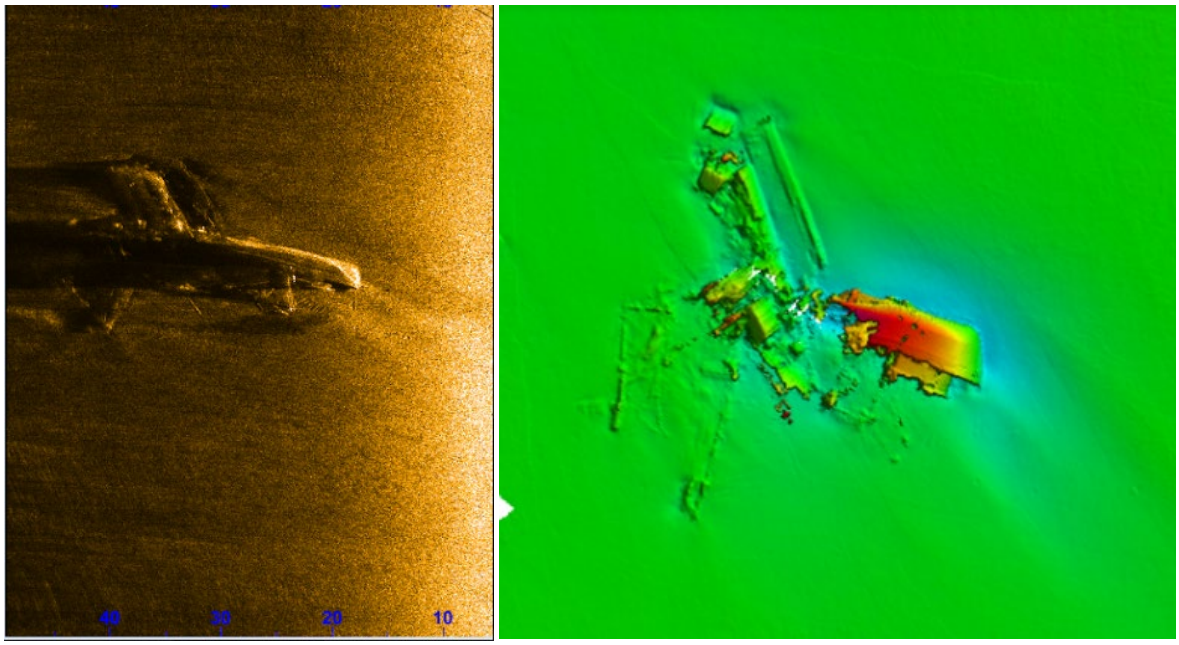



*Figure 13: SSS imagery (left), and high resolution, 10-centemeter MBES data (right), of F/V Miss Debbie.*

## Sound Speed

Sound speed is an especially important when surveying with a MBES system. Much like a looking at a straw in water, sound waves “bend” when passing through layers of water with different densities. As sound travels through these clines, its speed and angle of travel changes. Without correcting the sonar data for these changes in density, the sonar return would become less accurate the farther from the centerline of the sonar swatch.

Typically, sound speed errors manifest themselves as a “smile” or a “frown” in MBES data (Figure 14). This artificially creates shoaler or deeper soundings towards the outside of a MBES swath. In environments where the water column is very dynamic with lots of freshwater and tidal inputs, data can be skewed up to 2-3 meters in the outer beams. This is especially relevant during hurricanes and other weather based disasters where large amounts of precipitation fall.

To combat this, the boat has two means in which it measures sound speed. First, is a surface sound velocity probe that sits in the water at roughly the same depth as the sonar face. This probe continuously records sound speed data and transmits it back to the MBES processing unit where it is applied to correct for some of these errors. The second method is with a CTD cast. This is performed by lowering a device through the entire water column, which measures all three variables as it returns to the surface. Later, processing software can use this data to determine water density and hence the speed at which sound would be travelling. This is then applied to the data to correct for sound speed artifacts.

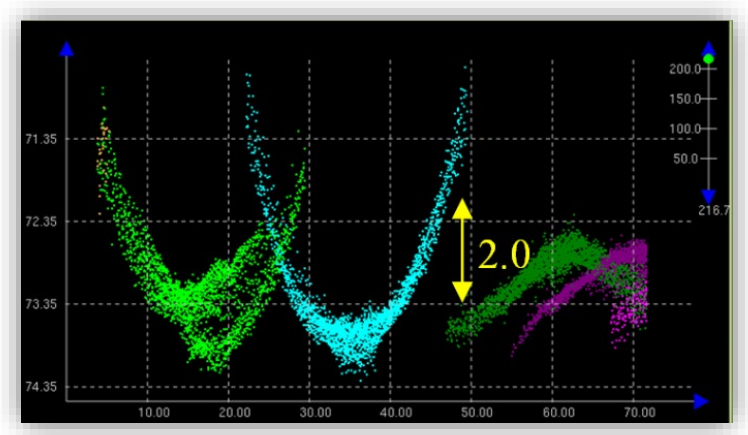



*Figure 14: "Smiling" data (left) from uncorrected sound velocity errors.*

## Attitude and Positioning

Vessels on the water (and in the air for that matter) have dynamic attitudes in four directions; pitch, roll, heave, and yaw. In a survey vessel, the attitude of the vessel must be accounted for. If it is not, all of that movement will be displayed in the data. NOAA survey vessels are equipped with a system that includes an inertial measurement unit, two GNSS Antenna, and a topside processing unit. Together, this system allows the vessel's position to be accurate to less than 10 cm (often less) and have angular accuracies (pitch, roll, and heading) of less than .03 degrees. As shown in Figure 15, any errors with this system (or lack of such a system) can cause significant data artifacts.

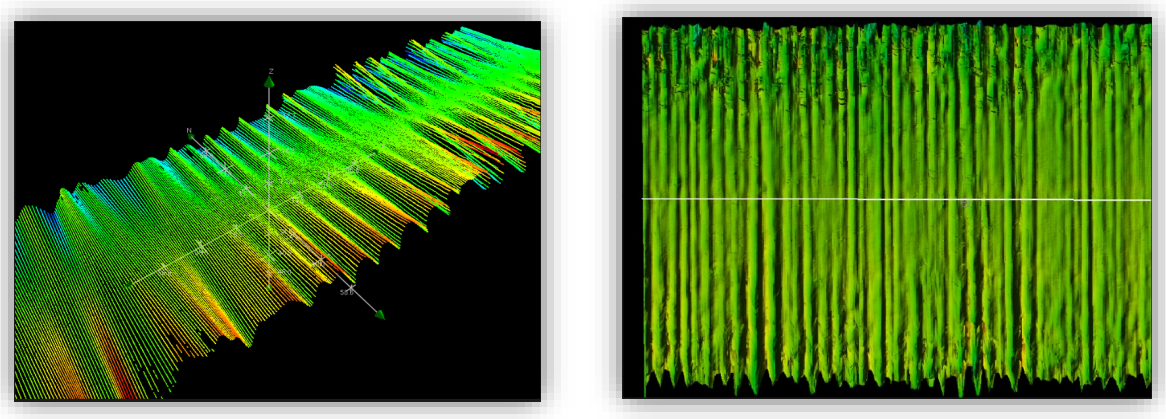


*Figure 15: Vessel roll (left) and heave (right) artifacts.*

## Processing Systems and Workflow

The survey day does not end when the boat is alongside. Once the data is ashore a few hours of processing is required, followed by additional analysis to ensure data quality and accuracy.

A typical day worth of MBES data takes between 60 to 120 minutes to transfer and load into the processing workflow. Next, additional correctors are applied (i.e. water level data) and the data is manually analyzed and cleaned of fliers or noise in the data. This may take multiple hours depending on the survey. Following this quality control, the result is either a MBES “surface” or a SSS “mosaic” which visually represents the data. Finally, another hour is spent building a GeoPDF for delivery to the ICP.

## Quality Control

After data is processed it must be assessed firsthand to ensure accuracy. Typically, a team member inches through the survey looking for noise in the data, which can falsely depict a shoal area. This “noise” is cleaned out meticulously as to not delete any accurate data. This process is time consuming and mentally exhausting as it takes an experienced eye and a sound understanding of survey to confidently clean data. Depending on the area surveyed and amount of noise and objects present, this process can take up to a few hours to complete.

SSS data must also be combed through for objects, however there is no noise to clean out due to the mosaic being an image rather than a data set. When reviewing SSS imagery, the reviewer finds and measures the shadows on objects to determine how proud the object is off the seafloor. If it is of significant height, or of interest to the response, the object is flagged and reported, then developed with the MBES the next day.

**Note:** While large-scale discoveries (i.e. the existence of significant differences between charted and actual depths) can be reported out quickly, **time is needed to fully process data for the ICP**. Field units work as fast as they can, but still need rest in order to operate safely. Work with the regional navigation manager to set and communicate expectations early and often during a response.

# 5. NOAA NAVIGATION SUPPORT BETWEEN INCIDENTS

## Routine Operations

For a majority of the year, when Coast Survey assets are not engaged in emergency response operations, they maintain a full schedule of surveying and processing in support of America's maritime commerce.

If you have or are aware of areas in need of modern surveys, please reach out to your regional navigation manager so that these needs can be documented.

## Emergent Needs and Requests

Coast Survey also provides navigation support for the USCG outside of large, national emergencies. These incidents could include aiding in the search for sunken vessels that are hindering the flow of traffic or posing an environmental hazard, or providing data that supports USCG waterway investigations. To request these services or to inquire about whether we can assist the USCG, please reach out to your regional navigation manager.

# 6. APPENDIX

## List of Acronyms:

- CO-OPS: Center for Operational Oceanographic Products and Services
- COTP: Captain of the Port
- CTD: conductivity, temperature, and depth (sensor)
- DOC: Department of Commerce
- DtoN: Danger to Navigation
- FOSC: Federal On Scene Coordinator
- GNSS: Global Navigation Satellite Systems
- HSD: Hydrographic Surveys Division
- ICP: Incident Command Post
- LiDAR: light distance and ranging
- MBES: multibeam echo sounder
- MIST: mobile integrated survey team
- NOAA: National Oceanic and Atmospheric Administration
- OMAO: Office of Marine and Aviation Operations
- RSD: Remote Sensing Division
- SBES: single beam echo sounder
- SSS: side scan sonar
- TAN-B: Trailer-able Aids to Navigation Boat
- USACE: United States Army Corps of Engineers
- VOOP: vessel of opportunity

## GeoPDF Standard Operating Procedure:

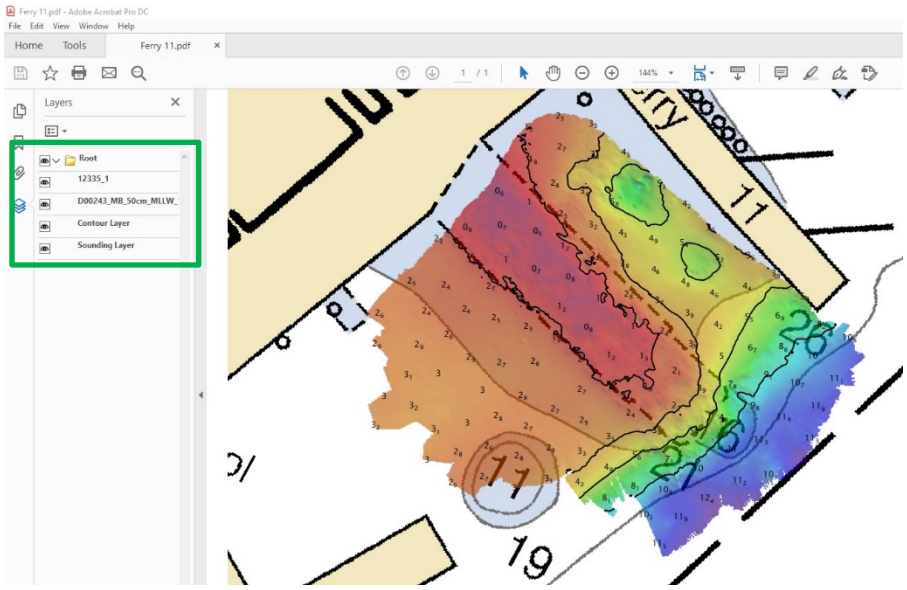
### Purpose

This section serves to instruct users on how use information within a hydrographic survey GeoPDF.

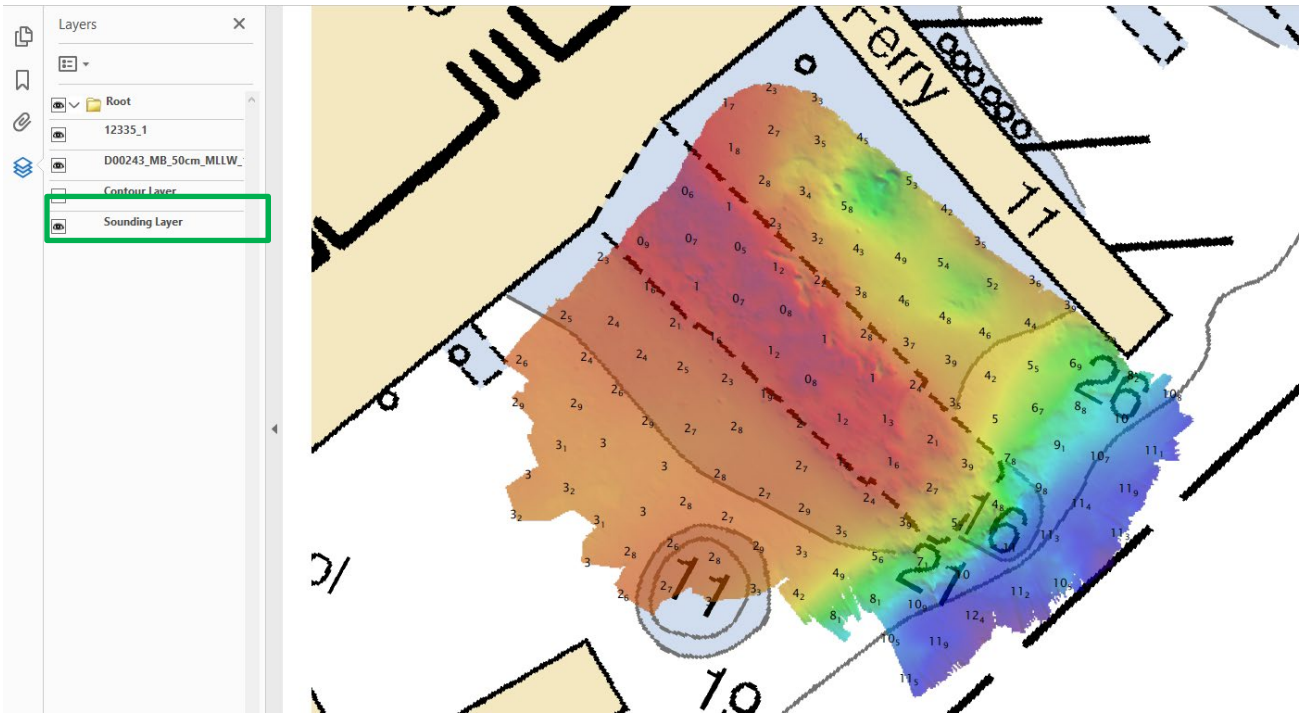
### Walkthrough

- Visualizing data layers
- The GeoPDF will likely contain 3 or 4 layers of information:
- Chart
- Bathymetric surface
- Soundings and/or…
- Contours

- By clicking the layers tab all of these layers can be toggled on/off within the GeoPDF so that only the relevant information is displayed.



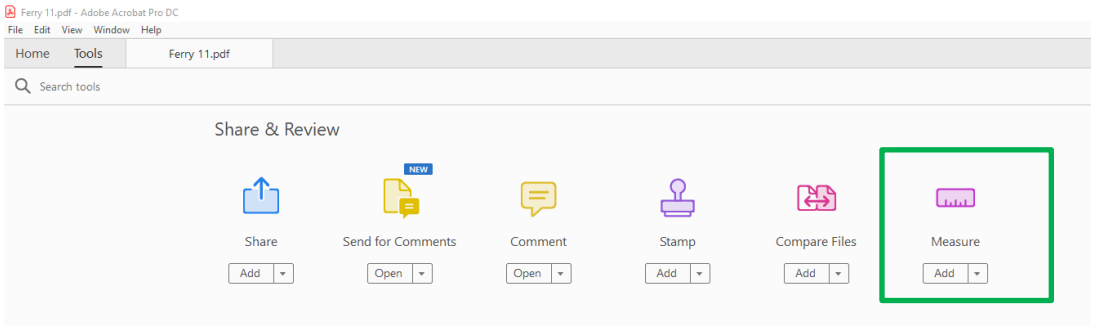
- By clicking the eyeball icon to the left of each layer, you can turn them on/off.




**Measure**

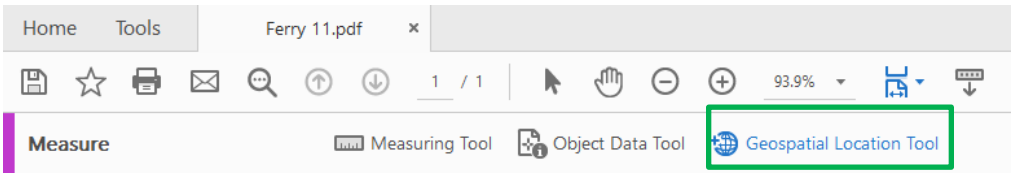
- The Measure application contains tools that are useful for:
  - Recording Latitude/Longitude
  - Measuring distance
  - Measuring area
  - Measuring a perimeter

- Navigate to the 'Tools' menu and select 'Measure'.

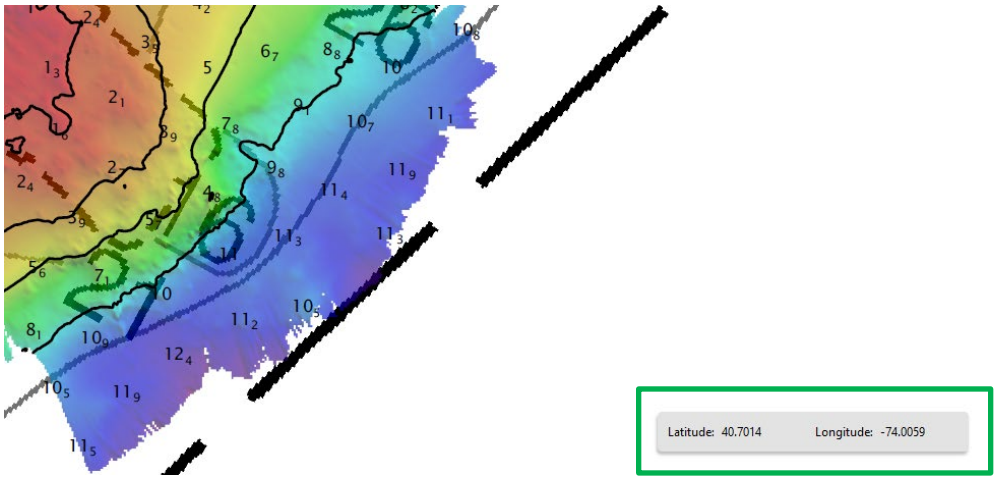


**Geospatial Location Tool**

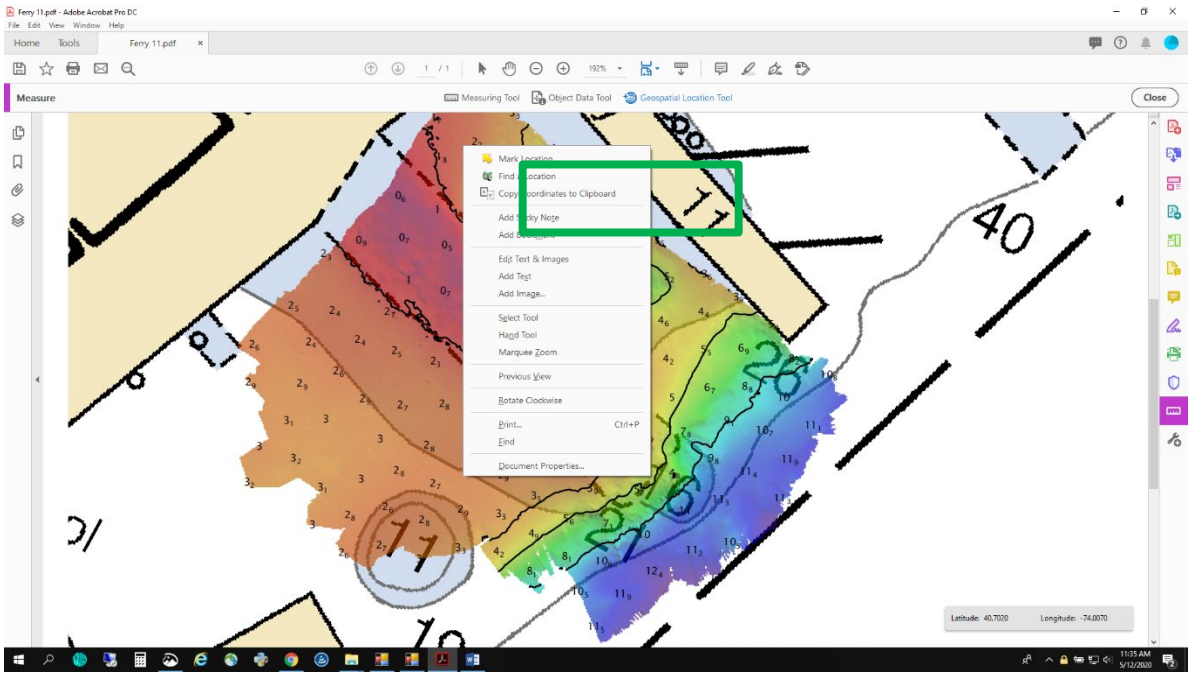
- Select the 'Geospatial Location Tool' to record Latitude/Longitude coordinates.



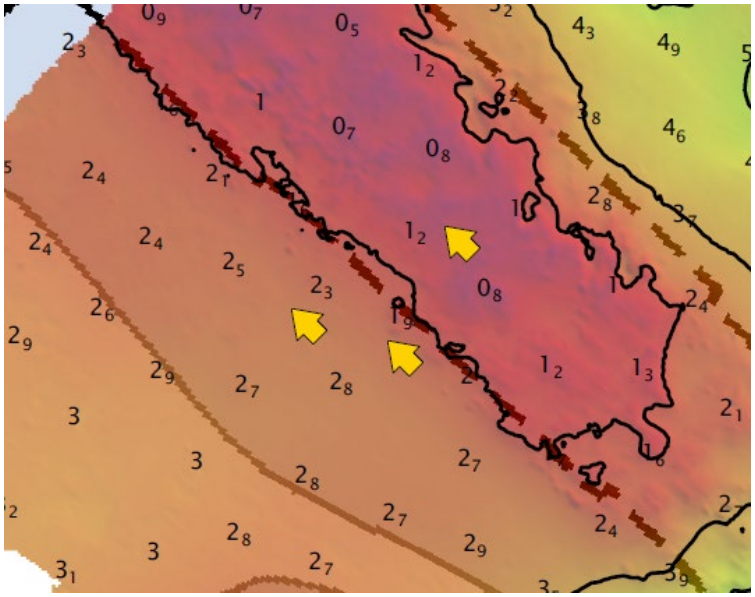

- Now as the cursor is moved around the main window, the geographic coordinates will be displayed in the lower right corner.




- By right-clicking in the main window, geographic coordinates can be marked for reference with 'Mark Location'.
- There is also the option to 'Find a Location' and to 'Copy Coordinates to Clipboard'.

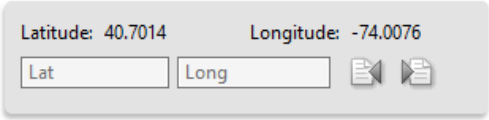


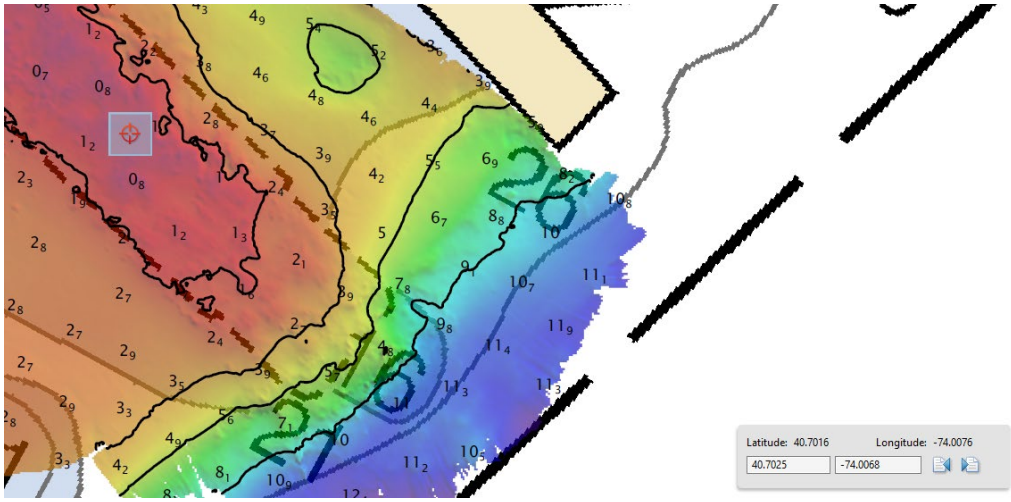

- Coordinates will be marked with yellow arrows when using the 'Mark Location Tool'.
- Marked locations can be deleted by right-clicking and selecting 'Delete'.



**Using 'Find a Location' brings up a Latitude/Longitude search window in the lower right corner. Enter in the Latitude/Longitude and the position will be marked with a target.**

- The 'Find a Location' tool can be turned off by right-clicking again and choosing to 'Hide Location Search'.



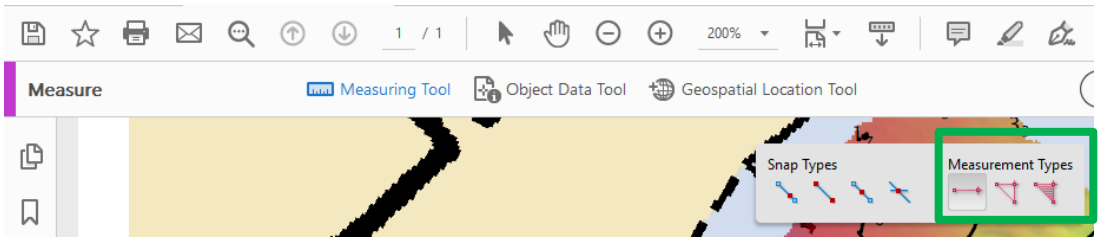




**Latitude/Longitude Marked as a Target**

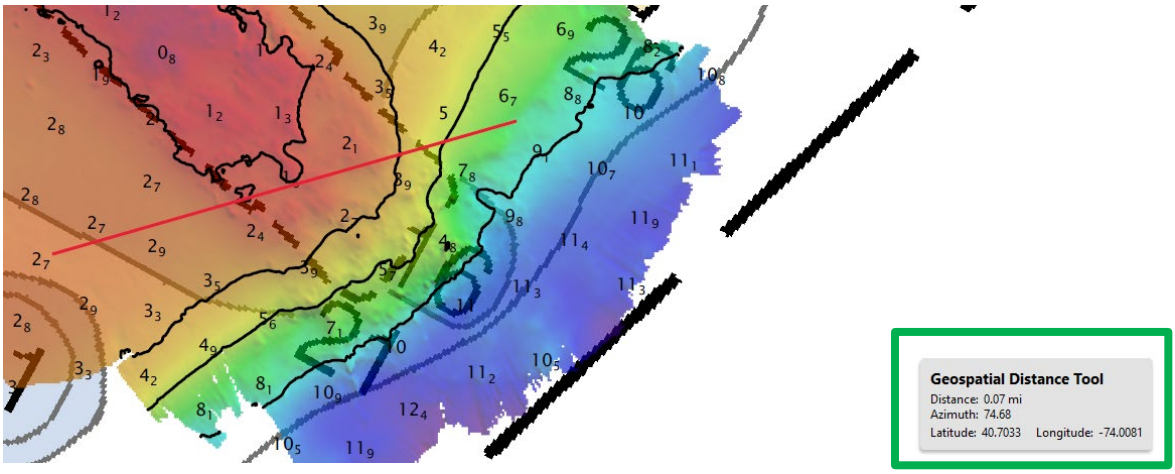
- By hovering over the desired location and selecting 'Copy Coordinates to Clipboard' this will copy the Latitude/Longitude coordinates so that they may be pasted into another document.

**Measuring Tool**

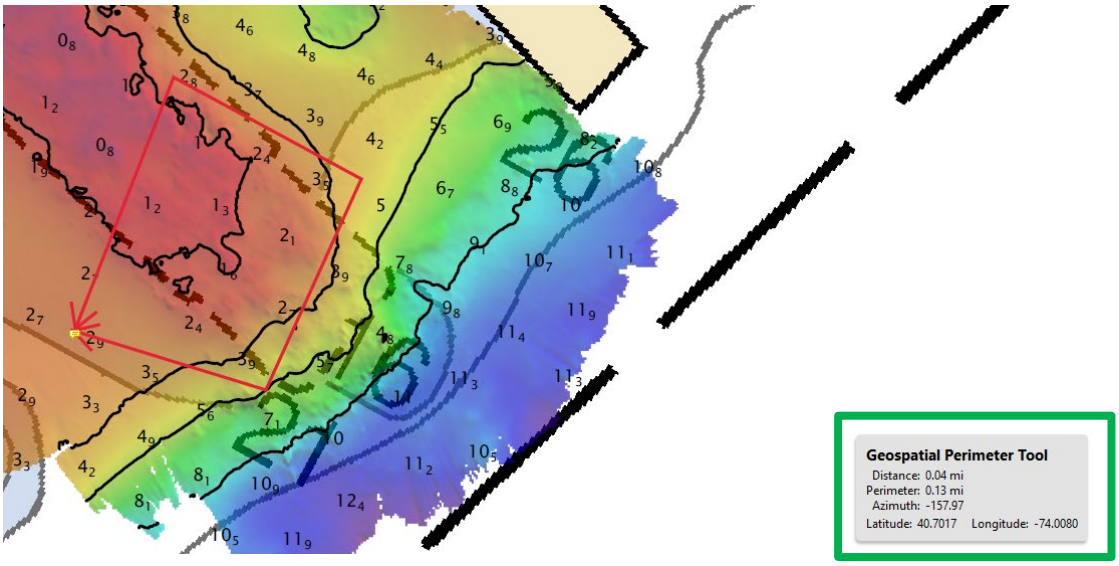
- The 'Measuring Tool' can be used to measure distances between two points, perimeters, and areas.



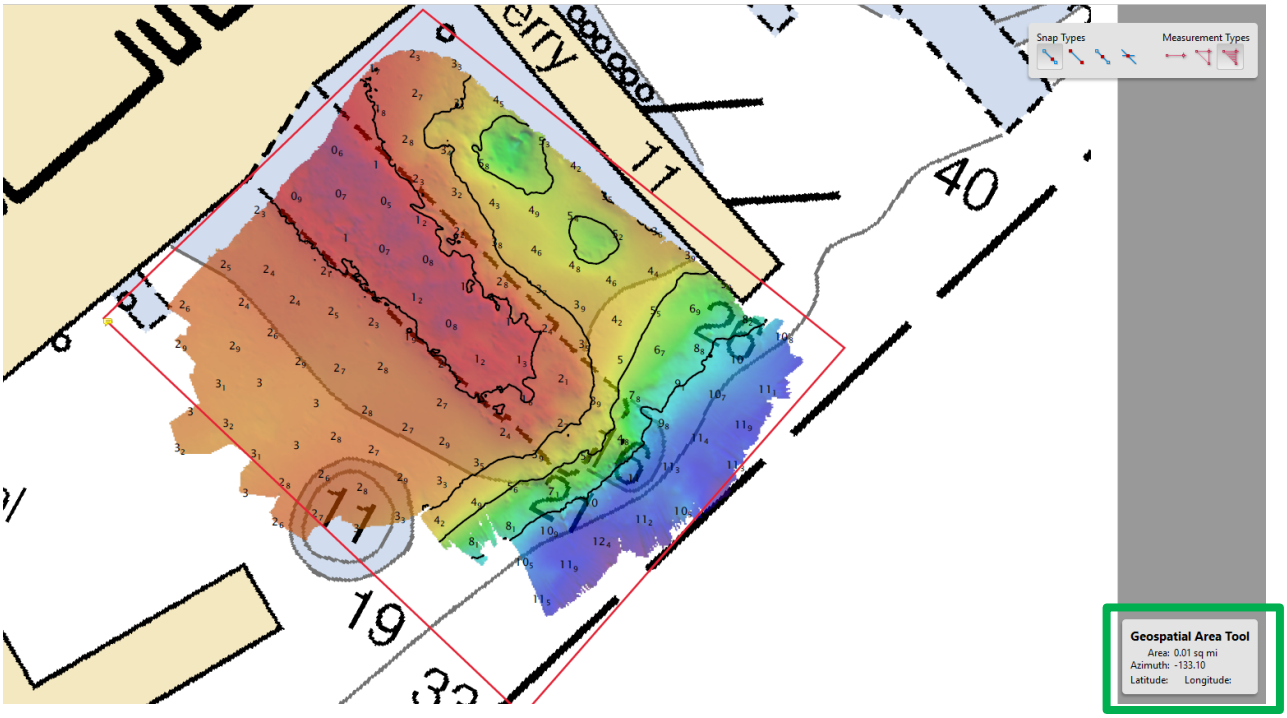

- To measure a distance, click at the origin point and then at the end of the desire line and the length will be automatically measured and displayed in the lower right corner.




- To measure a perimeter, click to drop coordinate points and then right-click to 'Complete Measurement'.




- To measure an area, click to drop coordinate points around an enclosed area. The cursor will lock onto the origin of the area to enclose the drawn space.


Snap Types
Measurement Types
Geospatial Area Tool
Area: 0.01 sq mi
Azimuth: -133.10
Latitude:
Longitude:

## The History of the Office of Coast Survey

The Office of Coast Survey, or Coast Survey for short, the Nation's first scientific agency, traces its history back to February 10, 1807 when President Thomas Jefferson signed "An Act to provide for surveying the coasts of the United States." After several years under the control of the Department of the Navy, the civilian U.S. Coast Survey was established in 1832, with Ferdinand Hassler as superintendent. Coast Survey has been the nation's chart maker ever since. In addition to conducting hydrographic surveys and producing nautical charts, U.S. Coast Survey conducted the first systematic study of the Gulf Stream, designed tidal prediction machines, and established the geodetic connection between the Atlantic and Pacific coasts.

Known as the Coast and Geodetic Survey beginning in 1878, the agency attracted the best and brightest scientists and naturalists who led scientific and engineering activities through the decades. During height of the Great Depression, Coast and Geodetic Survey (C&GS) organized surveying parties and field offices that employed over 10,000 people, including many out-of-work engineers.

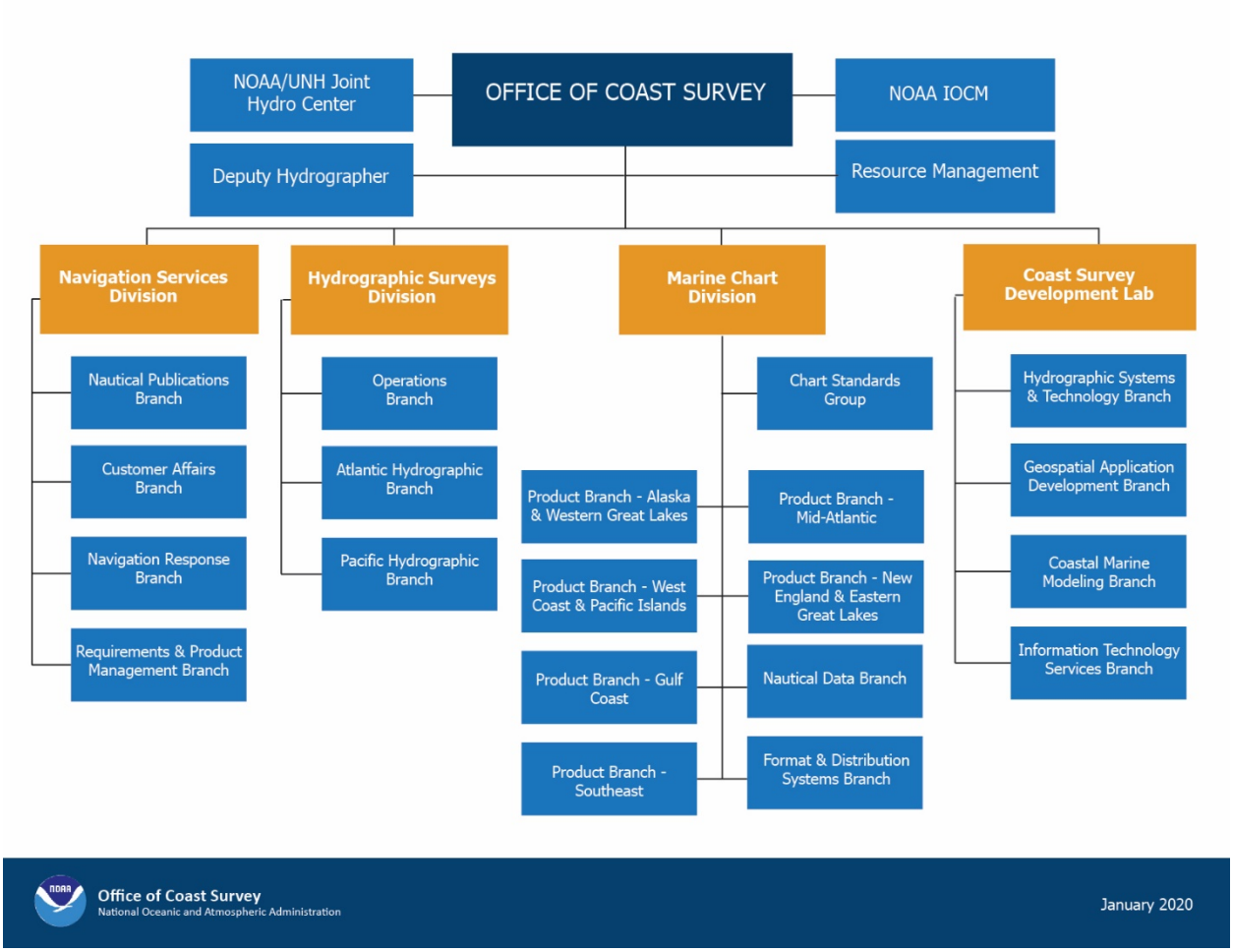
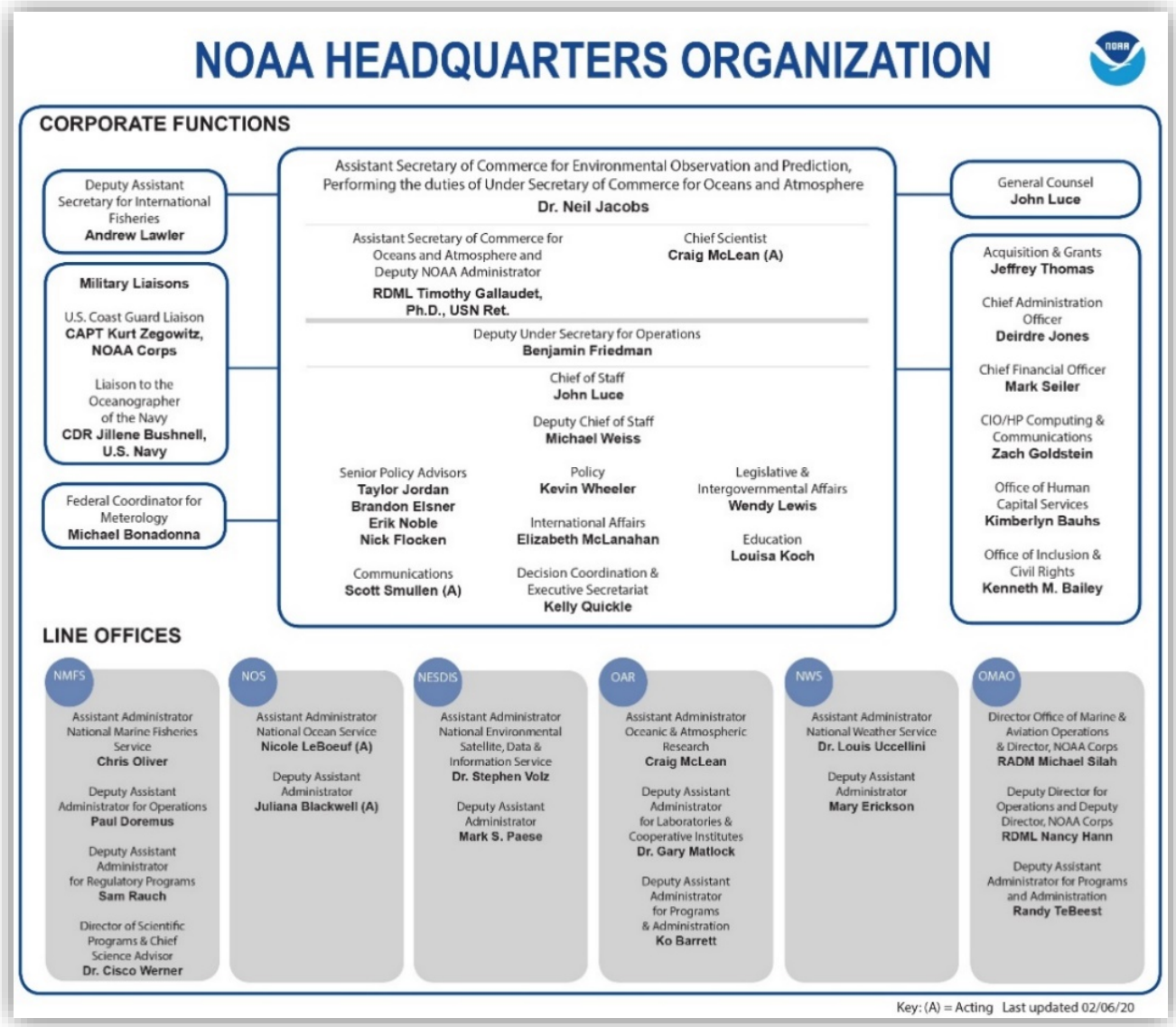
In World War II, C&GS sent over 1000 civilian members and more than half of its commissioned officers to the military services. They served as hydrographers, artillery surveyors, cartographers, army engineers, intelligence officers, and geophysicists in all theaters of the war. Civilians on the home front produced over 100 million maps and charts for the Allied Forces. Eleven members of the C&GS gave their lives during the war.

President Richard Nixon formed NOAA in 1970, bringing C&GS into the new scientific agency. Today, the Office of Coast Survey continues its tradition of commitment to employing the highest levels of science and technology to improve marine safety and to tackle the new challenges of the 21st century.

According to the Dictionary of American History, "the Survey is considered to have been one of the major birthplaces of modern American science, including many disciplines not generally associated with geodesy and hydrology. Its creation is a cornerstone of the rapid growth of science and technology and of the development of natural resources for commercial use in the United States."

## Organizational Charts:

[Office of Coast Survey]



## NOAA Headquarters