

## 2.0 DESCRIPTION OF THE PROPOSED ACTION AND THE ALTERNATIVES

The National Environmental Policy Act (NEPA) requires federal agencies to analyze a proper range of reasonable alternatives to satisfy the Purpose and Need (see Section 1.2). To be considered a reasonable alternative, the National Ocean Service (NOS) determined that a proposed alternative must:

- Be technically feasible;
- Not violate any federal statute or regulation;
- Be consistent with reasonably foreseeable funding levels; and
- Meet national, regional, and local data needs.

Based on these criteria, NOS identified two action alternatives that meet the stated purpose of the proposed federal action and thus have been analyzed in detail. These alternatives are presented in Sections 2.5.2 and 2.5.3.

NOS also analyzed a “No Action” alternative that allows the reader to compare the potential impacts of either action alternative with the effects that would occur if NOS continued coastal and marine data collection at current levels using current technology and methods (i.e., the status quo). The No Action alternative is presented in Section 2.5.1.

### 2.1 ALTERNATIVES CONSIDERED BUT ELIMINATED FROM FURTHER ANALYSIS

Early in the NEPA planning process, NOS considered a range of alternatives to the Proposed Action before arriving at the three alternatives presented in this Draft Programmatic Environmental Impact Statement (PEIS). The alternatives presented below were eliminated from further analysis because they did not meet one or more of the screening criteria listed above.

#### 2.1.1 Protected Species Avoidance

NOS considered whether to discontinue hydroacoustic surveying, mapping, charting or related data gathering in waters with known populations of federally protected species such as marine mammals. However, because many such animals are migratory, or are distributed across very large areas, NOS determined that the remaining areas in which active acoustics could be used would be minimal and insufficient under this alternative. This alternative would prevent NOS from providing the coastal and marine data necessary for safe navigation, economic security, and environmental sustainability in large parts of U.S. waters. Therefore, NOS rejected this alternative because it did not allow national, regional, and local data needs to be met.

#### 2.1.2 Use of Lidar Exclusively

Bathymetric Light Detection and Ranging (lidar) technology measures depths of nearshore waters using laser pulses emitted from a scanner on board a low-altitude airplane typically flying at speeds of 140 to 175 knots. The aircraft typically flies at altitudes of 300 to 365 meters (m) (1,000 to 1,200 feet [ft]) for up to five hours per flight. Lidar systems used for bathymetry emit visible green laser pulses to measure the timed sea floor bottom return, and near-infrared laser pulses measure the sea surface return. Depth is determined by the time of the return back to the lidar sensor from the energy reflected off the seafloor.

Lidar technology can efficiently survey large areas, identify features in a short period of time, and safely survey nearshore areas that are hazardous to mariners. However, lidar has distinct limitations in deeper water and under challenging environmental conditions. Variables such as water clarity (turbidity), sea

state, and sea surface limit the effectiveness of bathymetric lidar. In particular, lidar does not produce good results when used in turbid waters. Under non-ideal conditions, lidar systems often fail to identify small, potentially hazardous objects on the seafloor. Even in the best conditions, reliable laser “returns” from the seafloor diminish in waters deeper than 20 to 30 m (65-98 ft).

NOS rejected this alternative because it does not meet national, regional, and local data needs, and thus fails to meet the stated purpose and need. Relying on lidar exclusively would not meet the accuracy standards needed for reliable charts, maps, and other products.

NOS may use lidar on individual projects, where appropriate, such as for shoreline verification. However, these lidar surveys are not within the scope of this document.

### **2.1.3 Use of Satellite-Derived Bathymetry Exclusively**

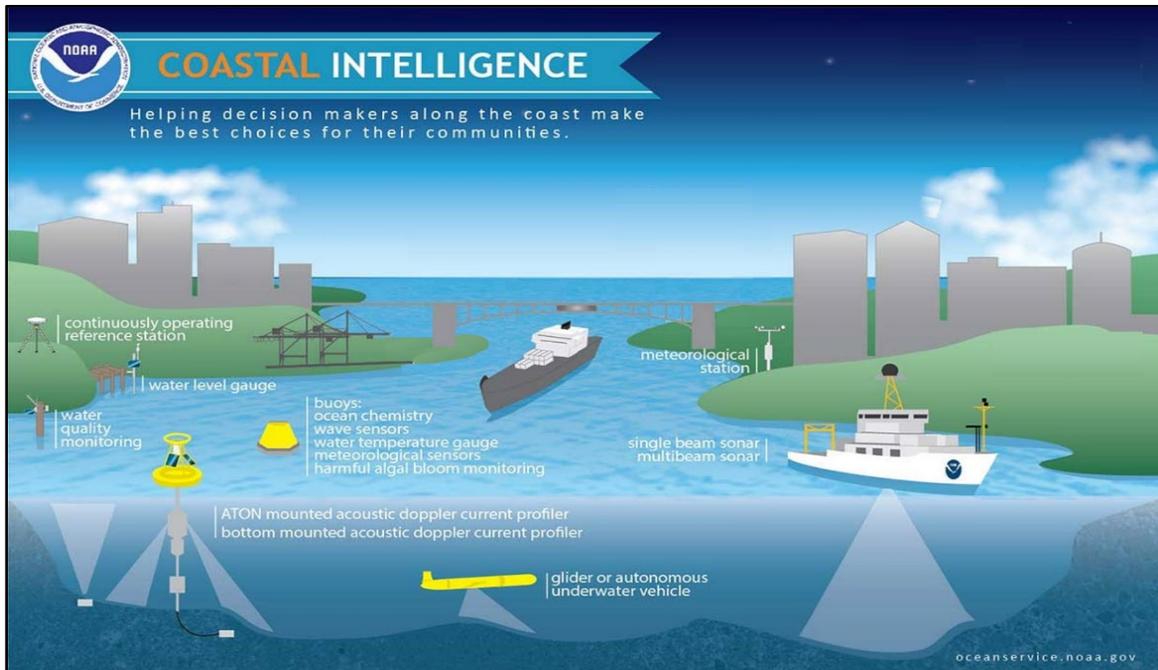
Satellite-derived bathymetry (SDB) refers to data from optical satellite imagery. SDB begins with using multi-spectral satellite imagery, such as Landsat, Sentinel-2 and WorldView2, and calculating a ratio between green and blue color bands. Because of the optical nature of green light to attenuate faster in the water column than blue light, the blue/green band ratio can help to infer relative depths of the water. Using control points, SDB results can be referenced to chart datum. Unlike “active” depth measurement techniques that measure depths directly using “time-of-flight”, such as echo sounders or lidar, where controlled signals are transmitted and the return time is measured and used to calculate the water depth, SDB is a “passive” technology and is simply measuring the reflected sunlight intensity that is used to infer the water depth.

Similar to optical systems like lidar, environmental conditions (e.g., water turbidity, cloud cover, and sun glint) can degrade accuracy, which prevents SDB from being used exclusively as a replacement for hydroacoustic methods. Therefore, NOS rejected this alternative because it does not meet national, regional, and local data needs, and thus fails to meet the purpose and need for this Proposed Action.

NOS may use SDB as a reconnaissance tool on a case-by-case basis for investigating coastal areas before performing a high-resolution hydrographic survey with traditional methods. However, this use of SDB is not within the scope of this document.

## **2.2 COMPONENTS OF THE ALTERNATIVES: PROJECTS AND ACTIVITIES**

NOS collects data in United States (U.S.) waters each year by undertaking a number of discrete surveying and mapping projects, which comprise the alternatives evaluated in this Draft PEIS. Projects include, but are not limited to, hydrographic surveys, marine debris surveys, tide gauge installation, and benthic habitat characteristic surveys. A project would typically consist of several individual components, which are referred to in this document as “activities.” **Figure 2.2-1** depicts many of the activities which are combined by NOS program offices to compose a given project.



**Figure 2.2-1. Common Activities Used in NOS Projects**

The nature and scope of projects can vary based on the combination of activities. For example, a habitat characteristic survey could consist of crewed vessel use, diving using Self-contained Underwater Breathing Apparatus (SCUBA), Remotely Operated Vehicle (ROV) use, multibeam echo sounder use, and bottom sampling. The individual activities are described in Section 2.4 below.

Another example is an NOS Office of Coast Survey (Coast Survey) hydrographic survey project performed to update nautical charts for waters off the coast of California. Once planners identify the area that requires updating, a vessel such as the National Oceanic and Atmospheric Administration (NOAA) Ship *Rainier* would be tasked with the project, sailing from its home port in Newport, Oregon to the project area. Once there, the ship's crew would map the seafloor of the project area with multibeam echo sounders while also collecting water column data, and determine seafloor type by collecting and examining sediment. Once all of the required data are collected, *Rainier* might return to port, or head directly to its next project. In this example, the survey project includes the activities of crewed vessel operation (Section 2.4.1), echo sounder use (Section 2.4.4), conductivity, temperature, and depth (CTD) instrument use (Section 2.4.7), and collection of bottom grab samples (Section 2.4.9).

Some NOS projects involve or include terrestrial work. For example, a field crew from the NOS Center for Operational Oceanographic Products and Services (CO-OPS) may take a small boat to a coastal area where planners have determined that more precise data on local tides and currents are needed. Upon arrival, the crew would determine where a new tide gauge station should be located (such as on an existing pier) and what type of gauge is needed. A SCUBA diver would enter the water to install the underwater elements of the pressure sensor for the tide gauge. The crew would install other components, and then test the gauge to ensure that it is operating correctly before leaving the site. The activities for this project therefore include crewed vessel operation (Section 2.4.1), tide gauge installation (Section 2.4.12), and SCUBA operations (Section 2.4.11).

The responsible NOS program office(s) sets the goals and purpose of a given project and determines the specific equipment and protocols to be used. For instance, Coast Survey conducts hydrographic surveys using a combination of high-frequency side scan sonar and single beam and multibeam echo sounders. During a Coast Survey hydrographic survey, a vessel equipped with one or more echo sounders "mows the lawn" at a slow speed to ensonify (or visualize) the seafloor bottom and ensure full coverage of the seafloor within the project area. Coast Survey conducts surveys primarily in shallower waters critical for safe navigation, where depths are low and the need for precision is high. As a result, Coast Survey uses primarily high-frequency (40 to 1,000 kilohertz) echo sounders during survey operations, but may use low- to mid- frequency echo sounders in deeper areas where high resolution charting is not necessary. When large ships are surveying for an NOS mapping project, they often operate the echo sounders 24 hours per day. Surveys using small vessels are typically shorter in duration (8 to 12 hours). These survey protocols are determined by project needs. Other program offices similarly select equipment and protocols commensurate with the goals of a given project.

In many cases, a single NOS program office is responsible for a project; in other cases, multiple NOS offices may cooperate, or an office may work with colleagues from other parts of NOAA or other federal agencies. For example, Coast Survey routinely collaborates with the Office of Marine and Aviation Operations (OMAO - a NOAA component separate from NOS) to have vessels such as NOAA Ship *Fairweather* undertake a project with a crew of NOAA Corps officers, OMAO civilian mariners, and Coast Survey scientists.

Although NOS projects occur year-round, the timing of a given project may be limited by seasonal environmental conditions of its location. For example, projects in the Arctic or Bering Sea typically take place between June and September to avoid dangerous, icy conditions, while projects in the West Coast, Northeast, and Mid-Atlantic regions most often take place between March and November. Projects in the Southeast or Gulf of Mexico are conducted year-round. The total duration of a project can vary from a few days to several months over multiple years. For Coast Survey hydrographic surveys, actual time surveying averages approximately 15 days per month over the course of a survey project, although larger ships can often survey 20 to 25 days per month under good conditions. When possible, program offices coordinate the location and timing of projects to ensure that areas are not unnecessarily repeatedly surveyed. This ensures that the potential environmental impacts directly resulting from the projects are not exacerbated by repeated surveys within a given area.

## 2.3 SCOPE

In this Draft PEIS, scope refers to both the geographic and temporal range of the Proposed Action and alternatives. Geographic scope is the spatial extent of the areas potentially affected by the Proposed Action and alternatives. Temporal scope is the timeframe over which the Proposed Action and alternatives are evaluated. NOS determined the scope of this document on the basis of the current extent of NOS project work and the ability of NOS program offices to reliably predict their future level of activity. Activities which occur outside of the parameters outlined in the below subsections were not considered in the analyses.

### 2.3.1 Geographic Scope

The "action area" for this Draft PEIS encompasses rivers; states' offshore waters; the U.S. territorial sea; the contiguous zone; the U.S. Exclusive Economic Zone; and coastal and riparian lands for projects such as the installation, maintenance, and removal of tide gauges. This includes the U.S. portions of the Great Lakes and internal waters such as Lakes Tahoe, Mead, Champlain, Okeechobee, and parts of major rivers

such as the Mississippi, Missouri, Hudson, and Columbia rivers. NOS projects would occur within freshwater bodies far less frequently than in marine environments and would likely only occur within or near the habitat of most freshwater species on a limited basis or not at all. From 2016 to 2021, less than three percent of NOS projects occurred in freshwater. Vessels and autonomous surface vehicles used by NOS may transit through international waters to get to project sites, but no data collection occurs in international waters.

The action area assessed in this Draft PEIS is organized and analyzed by geographic regions (**Figure 2.3-1**). The regions are:

- Greater Atlantic Region, which includes the U.S. portions of the Great Lakes, New England and the mid-Atlantic;
- Southeast Region, which includes the southern portion of the U.S. Eastern Seaboard, the U.S. Caribbean Islands (Puerto Rico and the U.S. Virgin Islands), and the Gulf of Mexico;
- West Coast Region, which includes coastal California, Oregon, and Washington;
- Alaska Region, which includes Alaskan waters and the Arctic; and
- Pacific Islands Region, which includes Hawaii and the Pacific territories of the U.S.



**Figure 2.3-1. Geographic Scope of Draft PEIS**

### 2.3.2 Temporal Scope

As with any planning process, the confidence with which an agency can foresee and evaluate its actions, and the environmental effects of those actions, decreases at longer time intervals. Changes in spending levels, the environment, the data needs of the public, and technologies and field methods available to NOS can all change how surveying projects are executed. Based on NOS experience with these factors, this Draft PEIS analyzes data collection activities for a time period of six years. For the purposes of this Draft PEIS, a specific project could take place at any time of year.

Consistent with Council on Environmental Quality (CEQ) guidance that “[NEPA documents] that are more than 5 years old should be carefully reexamined to determine if the criteria in Section 1502.9 compel preparation of a [NEPA] supplement.” (CEQ, 1981a), NOS would reevaluate the Final PEIS to determine if the analysis contained within remains sufficient, or if new analysis is required. If necessary, this new analysis may take the form of a supplemental PEIS, a new PEIS, or more extensive project-level analysis.

## 2.4 ACTIVITIES COMMON TO ALL ALTERNATIVES

Under all alternatives, NOS would operate a variety of equipment and technologies to gather accurate and timely data on the nature and condition of the marine and coastal environment. In the context of project activities, references to NOS include NOS personnel, its contractors, grantees, partners, and permit/authorization recipients. The subsections below describe the technology, equipment, and techniques which would be used in NOS projects regardless of the selected alternative. This Draft PEIS would also cover activities not specifically listed below as long as the relevant NOS program office(s) determined that the activities are comparable in operating characteristics (e.g., similar source level ranges, intensities, and frequencies) and extent of use (e.g., similar likelihood, duration, and frequency of use).

### 2.4.1 Project-Related Crewed Vessel Operations

Collecting coastal and marine data requires NOS to be able to reach the environments of interest. The most common platform for this purpose is a crewed sea-going surface vessel (remotely operated and autonomous vehicles are considered in Section 2.4.3). NOS operates these vessels under one of three arrangements:

- The vessel may be operated directly by NOS or by a partner funded under a cooperative agreement or contract;
- The vessel may be operated by OMAO for an NOS project; or
- The vessel may be owned and/or operated by an entity external to NOS under a contract by NOS or a partner. These are referred to as “contractor vessels” or “chartered vessels.”

Vessels used range from small, unpowered personal watercraft to large research ships. For example, Navigation Response Team (NRT) vessels are typically 9-m (28-ft) boats towed by a truck to the general project area (**Figure 2.4-1**). There are also larger vessels such as NOAA Ship *Rainier*, a 1,600-metric-ton (1,800-ton), 70-m (231-ft) hydrographic ship crewed by OMAO officers and sailors (**Figure 2.4-2**). Ships such as *Rainier* also typically carry one or more “launches” – small boats that are deployed into the water directly from the ship. Chartered vessels can be of various sizes and types, depending on the project needs and availability. NOS uses the term “ship” for vessels with sleeping accommodations, or berthing capacity, that may anchor overnight during a project. NOS uses the term “boat” for vessels without berthing capacity that would anchor only in an emergency.



**Figure 2.4-1. A Navigation Response Team Boat Being Placed in the Water**

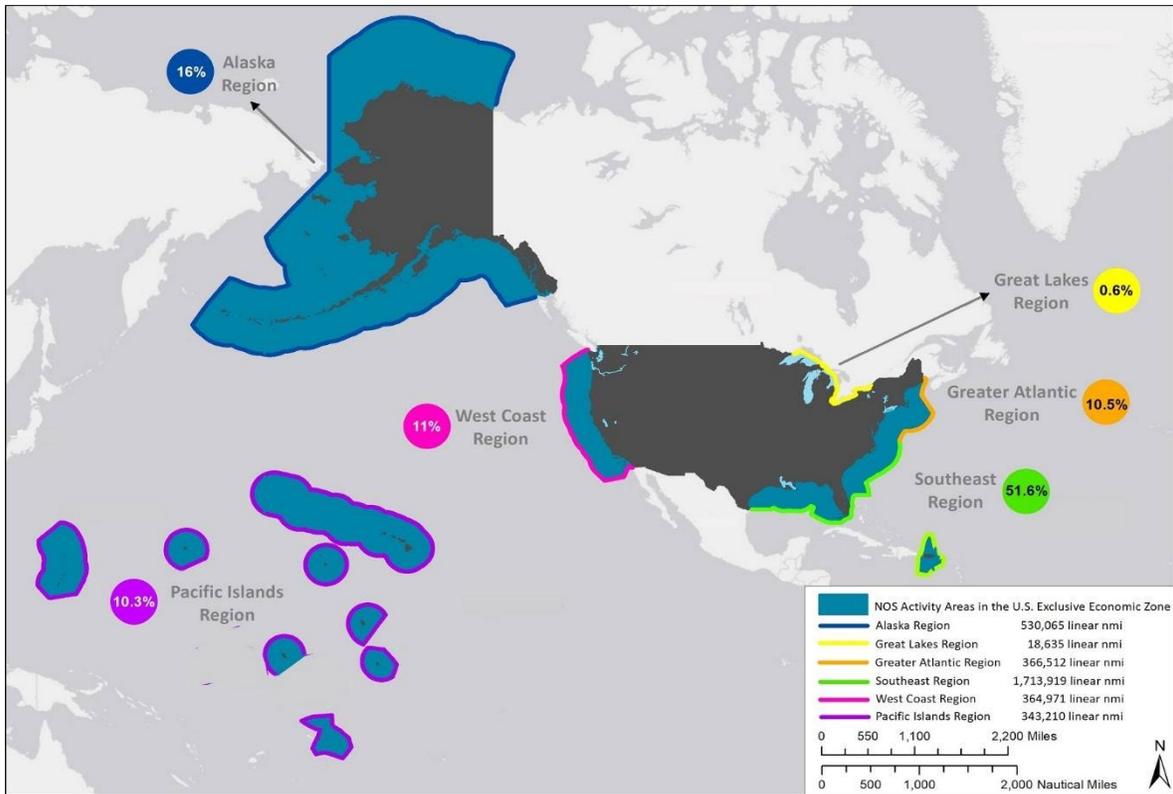


**Figure 2.4-2. NOAA Ship *Rainier* in Alaska, with its Survey Launches**

Survey vessels would travel to and from project sites and during projects as required. Vessel transit speeds vary by location, but are typically lower than 25 knots. Vessels are typically limited to speeds of 13 knots during survey activities. Depending on the duration of a project, a vessel might return to port periodically for fuel, supplies, or crew changes. NOS does not routinely have contractor vessels perform long transits; local contractors are hired for projects. This document analyzes the environmental impact of all vessel transits (i.e., movements) to the project area, during the project, and back to a port for all projects undertaken or funded by NOS. Vessel transits and project activities may occur at either day or night. Based upon comparison with GPS data collected from automatic identification system (AIS) transponders onboard commercial vessels in 2017, vessels used for NOS projects account for a very small proportion of U.S. vessel traffic<sup>2</sup>. **Figure 2.4-3** shows the estimated regional distribution of NOS activities for the six-year timeframe of the PEIS based on nautical miles of vessel movement, regardless of the selected alternative.

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<sup>2</sup> Compared to AIS data for commercial vessels in 2017, vessels used or funded by NOS account for 0.3 percent of all nautical miles traveled within the EEZ. However, because AIS transponders are not required for recreational vessels and recreational boating data were not available for inclusion in this analysis, vessels used and funded by NOS likely represent orders of magnitude less than 0.3 percent of total vessel use within the EEZ.



**Figure 2.4-3. Geographic Distribution of NOS Crewed Vessel Operations Based on Six Years of Projected Funding**

Note that this Draft PEIS does not consider the following:

- Vessel operations that are not related to NOS projects, such as transits to a new homeport or to a dry dock, to a non-NOS project, or from a non-NOS project to a port;
- Vessel construction, acquisition, repairs, maintenance, or upgrades, such as the installation of new scientific equipment;
- Any chartered vessel operations that are not undertaken as part of an NOS contract or cooperative agreement.

These forms of crewed vessel use are neither under NOS control nor connected to NOS projects, and therefore are not considered here.

## 2.4.2 Anchoring

When a vessel is not collecting data, it may anchor either within the project area or nearby. Small boats and survey launches used for NOS projects return to port or to the ship each day and do not typically anchor, except in an emergency. During any NOS project, a vessel may anchor to avoid adverse weather or in the unlikely event of an equipment malfunction, regardless of vessel size. For multi-day efforts, ships may anchor within or near the project area to reduce the transit time to the project area and to save fuel.

The choice of anchoring location is at the discretion of the ship's officers, who select the anchor location based on depth, protection from seas and wind, and bottom type. Preferred bottom types are sticky mud or sand, as those characteristics allow the flukes of the anchor to dig into the bottom and hold the chain in place. NOS would not anchor in known areas of coral, except in an emergency. When working in an un-

surveyed area or in an area that has not been surveyed in many years, the ship will try to anchor in bays where data have already been collected, providing the ship with better information on where to drop the anchor. Existing mooring buoys are used when available. Ships are typically anchored for a time period of hours, but during weather events (e.g., tropical storm or hurricane) ships may anchor for multiple days.

### 2.4.3 Operation of Remotely Operated Vehicles (ROVs), Autonomous Surface Vehicles (ASVs), and Autonomous Underwater Vehicles (AUVs)

In addition to crewed vessels, NOS proposes to use remotely operated and autonomous vehicles to collect data. Remotely Operated Vehicles (ROVs) are controlled remotely at all times by a human operator and are often tethered to a crewed vessel. Autonomous vehicles operate with various levels of autonomy and include Autonomous Surface Vehicles (ASVs) and Autonomous Underwater Vehicles (AUVs). These systems use a variety of propulsion sources, including diesel, diesel/electric, battery, solar, buoyancy driven, and wave-gliding propulsion systems.

ASVs often look similar to boats, ranging in size from the 1.8-m (6-ft) Teledyne Z-Boat (**Figure 2.4-4**) to the 5-m (16-ft) ASV Global Seaworker 5 (**Figure 2.4-5**).



Figure 2.4-4. Teledyne Z-Boat



Figure 2.4-5. ASV Global Seaworker 5

AUVs often have a “torpedo”-like appearance, and can range in size from small systems deployed by two to three people, such as the 1.7-m (6-ft) REMUS-100 (**Figure 2.4-6**), or larger systems requiring winches or other deployment equipment, such as the 5.5-m (18-ft) REMUS-600 (**Figure 2.4-7**).



Figure 2.4-6. REMUS-100 AUV



Figure 2.4-7. REMUS-600 AUV

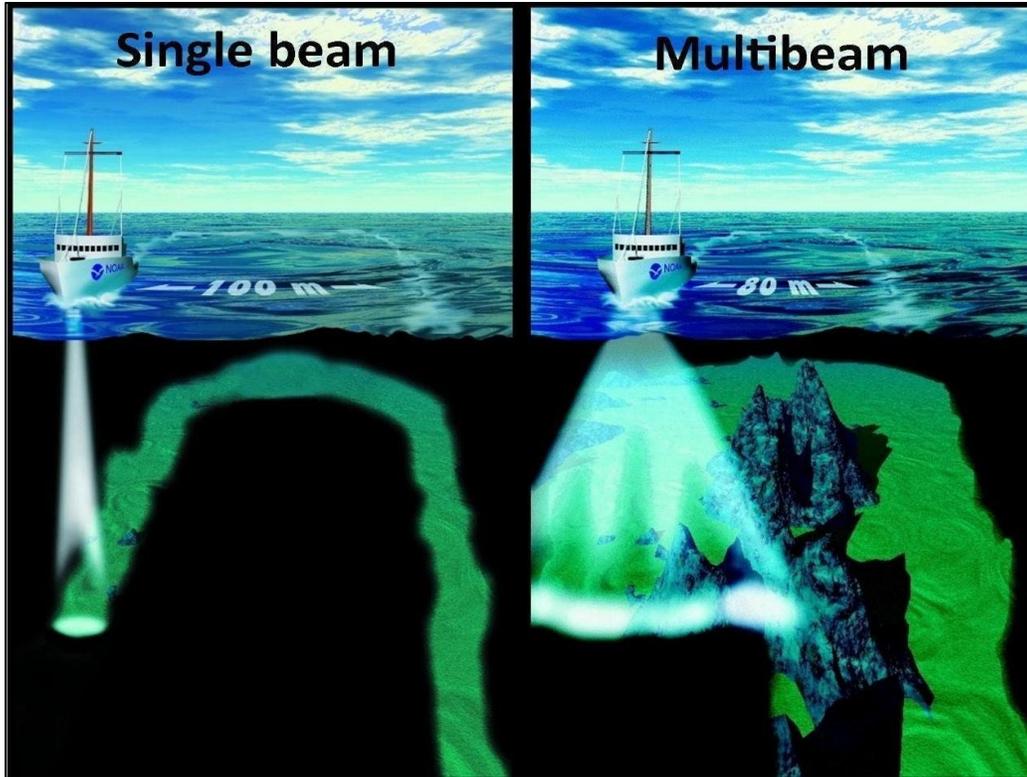
#### 2.4.4 Use of Echo Sounders

NOS echo sounders (also referred to as sonars [sound navigation and ranging]) are typically attached to a crewed vessel, ROV, ASV, or AUV, and are one of the most common categories of active acoustics used in ocean navigation, remote sensing, and ocean and habitat mapping. In rare instances, NOS may place echo sounders directly on the seafloor or the echo sounders may be operated by divers.

Echo sounders transmit a repeated series of short sound signals (on the order of milliseconds) into the water column. These signals continue until they reach an object of a different acoustic impedance (typically the seafloor, but also potentially objects in the water column) and reflect back to the echo sounder's receiver; echo sounders do not transmit while listening for an echo. By measuring the amount of time for the sound to return from the seafloor or object, the depth of the water (or the distance to the object) can be determined. Echo sounders used for mapping can generally be divided into three categories: single beam systems, multibeam systems, and side-scan sonars.

Single beam echo sounders transmit one focused acoustic beam, typically directly below the vessel (**Figure 2.4-8**). Sub-bottom profilers are a specific type of single beam echo sounder, designed to penetrate seafloor sediments and reveal sub-surface features. The sound energy emitted by the sub-bottom profiler is typically of a lower frequency than other echo sounders. These lower frequencies allow the sound signal to penetrate the seafloor and reflect back to the vessel when it encounters different types of buried sediments and rock (NOAA, 2014b). Single beam systems relied on by NOS, including sub-bottom profilers, are typically mounted on the bottom of the vessel hull.

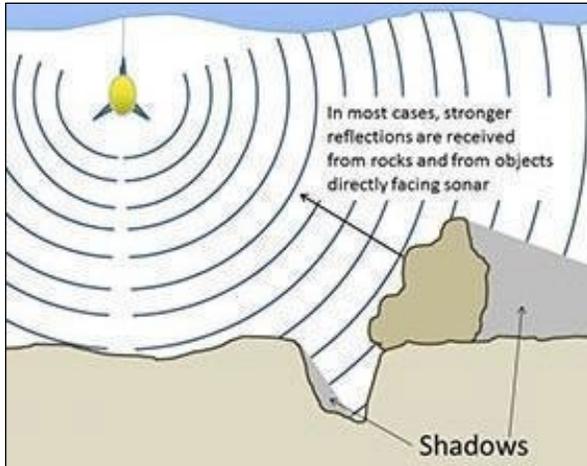
Multibeam echo sounders transmit a fan of acoustic energy and can resolve individual depths across the return beam (**Figure 2.4-8**). Multibeam systems are the most commonly employed echo sounders for mapping the seafloor, as they allow for "full bottom coverage" of the area of interest. Many multibeam systems are capable of recording data on acoustic backscatter – data artifacts that may interfere with the accuracy of depth soundings. Multibeam backscatter is intensity data collected from multibeam systems that can be processed to create low-resolution imagery. Backscatter is co-registered with the bathymetry data and is often used to assist with bathymetric data interpretation. Multibeam systems are typically mounted on the bottom of the vessel hull.



Note the greatly improved bottom coverage of the multibeam system which reduces the time and number of vessels required to survey a given area.

**Figure 2.4-8. Artist's Rendering of Single Beam and Multibeam Echo Sounder Operation**

Side-scan sonars (sometimes referred to as "imaging sonars") are a specialized system for detecting objects on the seafloor that typically use fans of acoustic energy to look down and to the side of the sensor platform (**Figure 2.4-9**). In a side scan, the transmitted energy is formed into the shape of a fan that sweeps the seafloor from directly under the unit to either side, typically to a distance of 100 m (328 ft). The strength of the return echo is continuously recorded, creating a "picture" of the ocean bottom (**Figure 2.4-10**). For example, objects that protrude from the bottom create a light area (strong return) and shadows from these objects are dark areas (little or no return). Side-scan systems are either mounted underneath the vessel or towed behind the vessel on a cable (NOAA, 2018d).



**Figure 2.4-9. Diagram of Side Scan Sonar Operation**



**Figure 2.4-10. A Side Scan Sonar Image of Herbert D. Maxwell, a Schooner that Sank in the Chesapeake Bay on May 16, 1910**

Different echo sounders are designed to produce sound at different frequencies. Single beam echo sounders used by NOS can range from one kilohertz (kHz) up to 200 kHz or more. Multi-beam echo sounders used by NOS typically range from 40 kHz up to 900 kHz or more. Side scan sonars used by NOS typically range from 300 kHz to 1600 kHz.

In general, higher-frequency echo sounders provide higher precision than lower frequency systems. However, because higher frequency sound is absorbed in seawater much faster than lower frequencies, high frequency systems are limited in range and are therefore used in shallower water. Lower frequency echo sounders, by comparison, are typically used in deeper water. The source level of these echo sounders can range as high 229 decibels (dB) re: 1 microPascal ( $\mu\text{Pa}$ ) m.<sup>3</sup>

### **2.4.5 Use of Acoustic Doppler Current Profilers (ADCPs)**

Acoustic Doppler Current Profilers (ADCPs) are active acoustic systems used to measure the velocity of water by measuring the relative shifts in sound frequency (i.e., the Doppler shift) associated with relative motion. These profilers provide detailed and important data on oceanographic conditions, including current patterns, waves, and turbulence. ADCPs (**Figure 2.4-11**) are often operated from tethered systems, buoys, or fixed moorings. Mobile ADCPs are hull mounted. The majority of these systems used by NOS operate at high to extremely high frequency (75-1,200 kHz) and are moderate in terms of source levels (< 160-180 dB re: 1  $\mu\text{Pa}$  m).

<sup>3</sup> Here and throughout this document, source levels are expressed in decibels with a reference pressure of 1 micropascal (dB re: 1  $\mu\text{Pa}$  m).



**Figure 2.4-11. Example of Subsurface ADCP Buoys Currently in Use by NOS (shown: Streamlined Underwater Buoyancy System Model A2 Coastal ADCP)**

#### 2.4.6 Use of Acoustic Communication Systems

Many underwater devices and platforms communicate with one another by emitting and receiving sound, such as simple “pingers”, altimeters, and acoustic telemetry systems, including acoustic modems. Pingers are typically used to indicate the location of an underwater device and have short-duration chirp signals in the 10s of kHz range at moderate source levels (160 to 180 dB re: 1  $\mu$ Pa m). Acoustic modems may include encoded (modulated) signals relaying navigational or operational data more easily which can then be decoded by receivers. These systems are commonly used in sub-surface operations, between remotely deployed buoys, in navigational channels, or on sub-surface vehicles. Because they are commonly used to communicate data over km or greater ranges, NOS typically uses mid-frequency ranges (10s of kHz) at moderate to relatively high source levels (160 to 200 dB re: 1  $\mu$ Pa m). Sound Velocity Profilers are active acoustic devices that measure sound speed for echo sounding corrections using the two-way travel time of a very high frequency sound signal across a short distance.

#### 2.4.7 Use of Sound Speed Data Collection Equipment

NOS collects sound speed data throughout mapping surveys to determine the speed of sound in the water column at a given location and time, which allows crews to correct for refraction errors in the echo sounder data. Taken together, the two-way travel time of the acoustic signal from a single beam or multibeam echo sounder and the speed of sound in water determine seafloor depths.

Sound speed data are collected periodically in one of three ways. In the first method, every one to four hours a survey technician slowly lowers a sound speed profiler – known as a CTD instrument – from a stationary vessel to the seafloor and back (**Figure 2.4-12**). Passive collection of conductivity, temperature, and depth with CTD systems involves remote sampling of these parameters that are used in oceanographic sampling and to inform site-specific sound propagation models. CTDs do not produce and measure sound, but rather measure environmental conditions that can be used to reconstruct how sound propagates through the water column.

A second method involves a moving vessel profiler, which is automatically lowered and raised through the water column at regular intervals while the vessel is in motion (**Figure 2.4-13**). Mobile vessel profilers are submerged for time periods ranging in minutes.



**Figure 2.4-12. CTD Instrument**



**Figure 2.4-13. Moving Vessel Profiler Mounted on the Fantail of a Ship**

A third method is the use of expendable bathythermographs (XBTs) for profiling the water column. An XBT is a probe dropped from a ship that measures the temperature as it falls through the water (**Figure 2.4-14**). A resistance in the head of the probe and a very thin twin-wire, connecting the probe to the equipment on the ship, compose the electronic circuit for measuring the water temperature. The probe is designed to fall at a known rate, so that the depth of the temperature profile can be inferred from the time since it entered the water. Deployments can be made using manual or automatic launchers (**Figure 2.4-15**).

When XBTs are used, a small portion of the probe (5 to 8 cm (2 to 3 inches [in]) long and approximately 0.7 kg (1.5 pounds [lbs]) remains on the seafloor. The probes, constructed of metal and plastic, fall to the seafloor and detach from the connecting line. The connecting line then retracts back to the vessel.



Figure 2.4-14. XBT Probe



Figure 2.4-15. XBT Hand Launcher

#### 2.4.8 Operation of Drop/Towed Cameras, Video Systems, and Magnetometers

NOS uses drop/towed cameras for delineation and identification of seafloor habitats (i.e., ground truthing) through visual observations. Magnetometers, passive instruments which measure changes in the magnetic field of the earth, also are commonly drop/towed to survey cultural heritage sites and to geologically characterize the seafloor. Drop/towed cameras and magnetometers are launched from the ship or small boats and lowered on a cable using a power winch or by hand using a line. Drop/towed cameras and magnetometers are tethered at all times and are operated at approximately 1 m (3 ft) above the seafloor usually on predetermined transects. The total time of equipment submersion varies by project, but typically occurs on the scale of hours.

#### 2.4.9 Collection of Bottom Grab Samples

Some NOS surveys require the collection of seafloor sediment samples by lowering a grab sampler at a rate of about 1 m per second (3 ft per second) through the water column to the sea floor. Bottom samples are collected for a variety of reasons (for example, selecting anchorages, ground truthing the seafloor, and verifying benthic habitat maps). Typically, crews use a clamshell bottom snapper (6" by 6") or similar type of grab sampler or sediment corer to obtain samples of the surface sediment layer (approximately the first 5 cm (2 in) of sediment). As the sampler is lowered, two hinged upper lids swing open to let water pass through. When the sampler reaches the bottom, the overlapping spring-loaded scoops are tripped on the line, and the lids close to contain the sediment and prevent sample washout. Corers such as box corers work similarly but can sample different volumes and depths of sediment. Depending on the goals of a particular project, the sediment sample is collected, analyzed, and photographed, and under some circumstances released from the sampler underwater.

Samples are characterized by color, type of bottom material and other characteristics. Field personnel may have a bottom sample plan as a guideline of sampling density, but sampling can also occur based on ground-truthing needs identified in the mapping products, and researchers are given discretion on the

exact location of sampling. Crews do not typically collect samples in waters deeper than 80 m (262 ft). Additionally, in areas surveyed within the last 30 years, the surveyor might not need to collect samples at all. In some cases, the surveyor can use backscatter or side scan data acquired during the survey operation to determine the best place to sample. Grab samples may also be used for current survey site reconnaissance.

#### 2.4.10 Use of Passive Listening Systems

Passive listening systems are hydrophones that receive sounds present in the environment from either natural sources or active acoustic systems. These systems do not produce sound but record it for monitoring and research purposes. Passive listening systems are often integrated into the housing of other equipment, such as ADCPs, or moored in place to the sea floor. NOS does not use expendable passive listening systems.

#### 2.4.11 SCUBA Operations

Some projects include deploying SCUBA divers. NOS conducts SCUBA operations to verify and validate benthic habitat classifications, collect samples, conduct fish and benthic habitat surveys, or install or retrieve small sensors or other scientific instrumentation, including installation of tide gauges. In-water diver activities include benthic and fish monitoring that would be conducted usually on hard bottom and coral reef habitats and near cultural and historic resources such as shipwrecks.

Divers are deployed from crewed vessels, typically small boats, and traverse small areas in support of specific tasks. The majority of NOS dives are performed by CO-OPS and OCS for tide gauge installation, maintenance, or removal (73 percent), which requires relatively quick dives that are only a small component of the entire installation process. Twenty-one percent of NOS dives are performed by ONMS; NCCOS and ORR together account for the remaining six percent.

#### 2.4.12 Installation, Maintenance, and Removal of Tide Gauges

A tide gauge is a device fitted with sensors that continuously record the height of the surrounding water level. These data are critical for many coastal activities, including safe navigation, sound engineering, and habitat restoration/preservation. Local and national networks of tide gauges measure water levels, provide the vertical reference system required to describe water level variations, and help develop tidal predictions. A tide gauge measures the changes in water levels and transmits the data by satellite to a computer database for processing. The tide gauge station consists of a sensor, data collection platform, solar panels, and satellite transmitter. The four types of gauge conformations listed below are the most commonly used by NOS:

- An **acoustic sensor** uses sound waves to measure the distance between the sensor and the water level surface (**Figure 2.4-16**). It is most often used when an existing pier or dock is available on which to mount the sensor and includes a protective well that houses the sounding tube. These sensors typically emit 1.05 kHz acoustic signals at low source levels (-45 dB re: 1  $\mu$ Pa m). Both short-term and long-term acoustic tide gauges include some or all of the following non-permanent equipment: tide house (located on a pier), data collection platform, sensor (typically an “aquatrak”) housed in a 30” x 30” portable plastic case, benchmarks, and satellite transmitter (tripod station with antenna and solar panel). A long-term acoustic tide station typically includes some or all of the following equipment: primary and backup water level sensors; primary and backup data collection platforms; a Geostationary Operational Environmental Satellite (GOES) transmitter and antenna; Global Positioning System (GPS) antenna; batteries; solar panels; water

temperature sensors; mast or tower on which to mount wind sensors; barometric pressure sensor; and air temperature sensor. The acoustic sensor requires a 6-inch-diameter polyvinyl chloride protective well to house the sounding tube; the well is attached to the pier with stainless steel brackets to maintain sensor stability.

- A **pressure sensor** measures the pressure of the water column above an underwater orifice that is securely attached to maintain its position (**Figure 2.4-17**). It is used when there is little infrastructure available or as a backup sensor. A constant supply of air is pumped through a tube to the orifice to establish a zero point from which to measure the changes in pressure in the water column.



**Figure 2.4-16. Pier-mounted Acoustic Sensor Tide Gauge Station**



**Figure 2.4-17. Pressure Sensor Tide Gauge Station (and Tubing)**

- A **microwave water level radar sensor (MWWL)** uses radar waves to measure the distance from the sensor to the water (**Figure 2.4-18**). It is used when the existing infrastructure allows its installation in a location overlooking the water surface. This is the only type of sensor that is not in direct contact with the water. Station components may include some or all of the following equipment as noted in the acoustic sensor above: primary and backup water level sensors; primary and backup data collection platforms; a GOES transmitter and antenna; GPS antenna; batteries; solar panels; water temperature sensors; mast or tower on which to mount wind sensors; barometric pressure sensor; and air temperature sensor.
- A **GPS tide buoy** employs a GPS receiver that measures both horizontal and vertical position using GPS technology (**Figure 2.4-19**). It is used primarily during hydrographic surveys to obtain data in remote locations without existing infrastructure on which to mount a gauge. Some buoys may also be used to collect current data observations with a mounted acoustic sensor in an identified region. These buoys are acoustic mounted sensors on either an existing navigation buoy (i.e., owned by the U.S. Coast Guard [USCG]) or buoys deployed with ADCPs as noted in Section 2.4.5. They are also used to collect data in shipping channels. Examples of tide buoys are the two Hydrolevel™ GPS tide buoys currently owned by the Coast Survey Development Laboratory. They are approximately 26" in diameter, weigh 58 kgs (128 lbs), have amber USCG light emitting diode (LED) lights visible from 3 miles away, and use sealed lithium batteries. A typical mooring configuration includes 45 to 68 kgs (100 to 150 lbs) of anchoring mass (usually a combination of a

23-kg (50-lb) primary anchor and several 7-kg (15-lb) “mushroom” anchors) and a heavy chain, with a total footprint of approximately 1 square meter (3 ft).



**Figure 2.4-18. Microwave Sensor and Instrument in Bridgeport, Connecticut**



**Figure 2.4-19. A GPS Tide Buoy**

Although some of these tide gauges are operated only for the duration of a single project, most NOS tide gauges belong to a larger network of more permanent gauges. NOS (through CO-OPS) manages a permanent observing system of over 200 long-term, continuously operating data-collection platforms called the National Water Level Observation Network (NWLON). The NWLON measures tide levels and other oceanographic and meteorological parameters. The observing stations contribute to NOAA’s forecast models which provide tsunami and storm surge warnings. Some tide gauge stations also include additional co-located sensors, such as High Frequency Radar Systems (HFR), which collect currents data and support currents prediction models collected by boat or mounted ADCPs.

Approximately one quarter of the NWLON is located in the Great Lakes (non-tidal), providing water level data for the international management of those water resources. The NWLON provides the national standards for tide and water level reference datums used for nautical charting, coastal engineering, International treaty regulation, and boundary determination. CO-OPS also installs and operates approximately 100 short-term water level stations annually in support of a variety of programs including hydrographic and shoreline mapping projects, marine boundary determination, real time navigation systems, coastal habitat and marsh restoration projects, and other projects (NOAA, No Date-e).

#### **2.4.12.1 Tide Gauge / Tide Buoy Installation**

Tide gauge installation occurs primarily out of the water. Tide gauges are typically secured to existing piers, docks, and bulkheads. Rocks are the most common natural structures used to secure sensors in remote locations for short-term stations. Equipment includes primary and backup systems for sensors, data processing, and data transmission. All equipment is installed to last several years before needing

service or replacement. Short-term stations typically involve one primary system with no backups. They are less extensive, easier to install and remove, and usually only stay in place for the length of the data collection period (1 to 3 months). Geodetic “benchmarks” must be installed near each water level station and are long-term reference points to which the tidal datums can be related through standard surveying techniques.

A long-term station requires a network of ten benchmarks to “level” to the tide gauge during operations, while a short-term station only requires five benchmarks. The larger number of marks required for a long-term station is proportional to the investment made over time in the data collection and tidal datums determined. Additional marks ensure that there are at least five marks, even if future construction destroys several marks at once. The benchmarks are spaced at least 61 m (200 ft) apart to strengthen the leveling data and reduce the chance of losing several marks at a time. They are typically established in a variety of permanent structures, including surface markers, or deep driven stainless-steel rods when existing structures are not available.

A field crew of three to six people installs the equipment. Crews travel to most gauge sites over land, but a few locations – especially in remote areas of Alaska – can only be reached by boat, seaplane or helicopter. Installation equipment includes both hand and power tools. When a tide gauge is installed on land it is located beyond the mean high tide line, so any disturbed sediments from installation do not reach the water.

During tide buoy installation, a buoy is tethered to the anchoring hardware with a 15-m (50 ft), 2.5-cm (1-in) diameter rubber cord, followed by a section of 0.5-cm (3/16-in) Amsteel rope. The rubber cord attaches to the bottom of the buoy, and the rope attaches the rubber cord to the anchor. The combined length of the rubber cord and the rope exceeds the nominal water depth by a factor of approximately two (i.e., “mooring scope”). The GPS buoy is deployed by floating the buoy away from the vessel to the extent of the rubber cord and rope. The anchor is then lowered slowly to the point where the rope attaches to the rubber cord, at which point the anchor is released. Tide buoys are typically operated for one month before being removed.

### **2.3.12.2 Tide Gauge / Tide Buoy Maintenance**

Once installed, tide gauges operate autonomously, collecting data on water levels and transmitting the data by satellite to a computer database for processing. The gauge operates under its own power - typically solar, sometimes with a battery back-up. Short-term stations may be operational for as little as one month, or they may operate for up to one year. Personnel would return to the long-term stations periodically for water level measurements and maintenance, typically once per year. Maintenance visits would also be used to equip existing tide gauges with MWWL sensors and upgraded weather/storm-proofing.

Very little maintenance of tide buoys is required. NOAA tide buoys are programmed to send out a “health message” email to a predetermined distribution list at regular intervals via satellite. For example, Coast Survey tide buoys send messages hourly. If the buoy reports its position outside of a certain radius (“watch circle”), it issues a separate alert. Field personnel respond to situations where the buoy breaks its mooring or stops sending messages. Occasionally the batteries must be replaced or recharged, and field personnel must retrieve the buoy with a small boat and bring it back to the ship or shore. When they bring the buoy on board, the team attaches a temporary float to the end of the mooring so that it can be reused after

the buoy batteries have been refreshed. At the end of the survey, the field personnel recover all components of the buoy.

#### **2.4.12.3 Tide Gauge / Tide Buoy Removal**

Long-term stations, such as those of the NWLON, remain in operation indefinitely. They receive a preventative maintenance visit once a year that involves a standard inspection of all equipment, leveling from sensors to benchmarks to determine sensor stability, GPS observations, and diving operations to inspect the underwater components if present. Emergency repair visits would address failed components. Temporary gauges would only be repaired in the event of a specific equipment failure.

Once a temporary tide gauge is no longer needed, field personnel would be sent to remove the gauge. Personnel level the gauges when they remove them. SCUBA diving may or may not be involved, depending on the location and the type of sensor installed. Field personnel would also remove a long- or short-term gauge upon project completion. All equipment is removed from the site, although the benchmarks would remain as established spatial reference points. To recover a tide buoy, the buoy float is brought aboard the vessel along with the length of rubber cord. The total anchoring hardware is then hauled in by rope.

#### **2.4.13 Installation of GPS Reference Stations**

NOS installs GPS reference stations to support ellipsoidally referenced surveys, where height and depth are measured with respect to a geodetic datum (“ellipsoid”) rather than to a tidal datum. Ellipsoidally referenced surveys improve the efficiency of hydrographic surveys by removing the requirement for concurrent water level observations and hydrographic survey data collection.

Equipment used in ellipsoidally referenced surveys includes a ship-based inertially-aided GPS system and a shore-based GPS reference station. If an existing network, such as the Continually Operating Reference Stations, is not available, field personnel must establish a new network by using a tripod, an antenna, a receiver housed in a hardened waterproof “suitcase,” and data storage connected to a radio modem for remote downloads. If electrical service is not available at the reference station site, the network system requires a set of 12-volt marine, deep-cycle rechargeable batteries and a solar panel array. The site chosen on shore must provide an obstruction-free view to GPS satellites and accommodate line-of-sight radio communications. No equipment maintenance is required, although if no remote data download capability is available, field personnel must visit the site periodically to download data vital for survey processing.

### **2.5 ALTERNATIVES A, B, AND C**

NOS identified a “No Action” alternative (Alternative A), which represents the actions and resulting effects that would occur given continued coastal and marine data collection at current levels of effort using current technology and methods (i.e., the status quo), and two action alternatives (Alternatives B and C) that satisfy the purpose and need for the action as outlined in Section 1.2. These alternatives use many of the same technologies, equipment, and methods for surveying and mapping (as described in Section 2.4) and differ from each other primarily in their overall level of survey effort.

#### **2.5.1 Alternative A: No Action - Conduct Surveys and Mapping for Coastal and Marine Data Collection with Current Technology and Methods, at Current Funding Levels**

CEQ regulations (40 Code of Federal Regulations 1502.14) require the assessment of the No Action alternative in Environmental Impact Statements. The No Action alternative provides the baseline

condition of the existing environment from which to compare all other alternatives. In the case of an ongoing agency action, the No Action alternative represents adherence to current management direction or intensity.

Under Alternative A, NOS would continue to conduct the activities listed in Section 2.4 to gather accurate and timely data on the nature and condition of the marine and coastal environment. This alternative reflects the technology, equipment, scope, and methods currently in use by NOS, at the level of effort reflecting NOS fiscal year 2019<sup>4</sup> funding levels. The level of activity for Alternative A is described in **Table 2.6-1** in terms of nautical miles of survey effort and the overall number of projects that would continue to occur using each activity.

### **2.5.2 Alternative B: Conduct Surveys and Mapping for Coastal and Marine Data Collection with Equipment Upgrades, Improved Hydroacoustic Devices, and New Tide Stations - NOS Preferred Alternative**

NOS constantly seeks to improve the design and implementation of coastal and marine data collection. Alternative B therefore consists of Alternative A plus the more widespread adoption of new techniques and technologies (such as ROVs, MWWL sensors, etc.) to more efficiently perform surveying, mapping, charting and related data gathering. The introduction of these technologies, combined with continued, more traditional data collection methods, would allow NOS to perform more projects covering more survey miles annually than would be possible under Alternative A. Specific examples of adaptive methods and equipment that NOS programs are likely to promote, plan for, and adopt under Alternative B in the next six years include:

- Greater use of ROVs with echo sounder technologies;
- Greater use of AUVs with echo sounder technologies;
- Conversion of one or more existing 10-m (33 feet) crewed survey boats into ASVs;
- Greater use of more efficient, wide-beam sonar systems (phase-differencing bathymetric systems) for nearshore hydrographic surveys;
- Expanded geographic distribution of projects that use hydroacoustic sampling methodologies;
- Increased field operations in the National Marine Sanctuary system with associated requirements for hydroacoustic charting, surveying, mapping and associated activities; and
- Installation, operation, and maintenance of additional water level stations by CO-OPS, including transitioning to mostly MWWL sensors and upgraded storm strengthening to make stations more climate resilient.

Under Alternative B, all of the activities described in Alternative A would continue, many at a higher level of effort. The nature of these actions would not change from those described above in Section 2.4, but the overall level of activity would be increased as described in **Table 2.6-1**.

Alternative B is NOS's preferred alternative because it takes advantage of newer, more efficient technology, provides increased support for national marine sanctuaries, and more effectively addresses the nation's needs for coastal and marine data.

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<sup>4</sup> NOS is using 2019 as the baseline year for funding, as that was the last year of normal NOS operations prior to COVID-19 disruptions.

### 2.5.3 Alternative C: Upgrades and Improvements with Greater Funding Support

Like Alternative B, Alternative C adopts new techniques and technologies to encourage greater program efficiencies regarding surveying, mapping, charting, and related data gathering activities. In addition, Alternative C would consist of NOS program implementation with an overall funding increase of 20 percent relative to Alternative B.

Under Alternative C, all of the activities described in Alternative B would continue, many at a higher level of effort. The nature of these actions would not change from those described above in Section 2.4, but the overall level of activity would be augmented as described in **Table 2.6-1**.

## 2.6 COMPARISON OF ALTERNATIVES

In order to compare the alternatives, NOS collected data on the projected number of projects and activities that would be conducted annually by its program offices under the three alternatives selected for analysis. In some cases, the exact number of times an activity would take place is not known in advance. For example, a crew's decision to deploy an anchor is based on schedule constraints, fuel supplies, safety, weather, availability of anchorages, and other concerns. Similarly, the decision to deploy a sound speed data collection instrument can be contingent upon data gathered during the survey itself. Therefore, these activities were enumerated by the number of projects where the equipment would be expected to be used based on a review of previous NOS projects. This approach allows the reader to compare the prevalence of these activities by alternative, as shown in **Table 2.6-1**.

It is also important to note that project estimates for each activity were reported by NOS program offices non-exclusively. As noted in Section 2.2, a single project typically consists of multiple activities. For example, a single Coast Survey project may include the activities of vessel operation, echo sounder operation, anchor deployment, and sound speed data collection. Non-exclusive reporting allows for more robust comparisons of activities between the alternatives, but it results in a greater total number of projects reported from that which would actually occur. For example, one nautical mile of data collection for a mapping survey project is reported as both one mile of the "crewed vessel use" activity and one mile of the "echo sounder use" activity, as the vessel and the echo sounder are operated simultaneously. As another example, many tide gauge installation projects would be counted as both a tide gauge installation activity and as a SCUBA dive activity, as the installation of many gauges requires diving to install the pressure gauge component of a tide gauge.

While both the total number of nautical miles surveyed by crewed vessels and the discrete number of projects increase by approximately 10 percent between each subsequent alternative, the magnitude of individual activities does not increase uniformly between alternatives, reflecting priorities in funding allocation and technology use. For example, ROV/ASV/AUV use increases 201.7 percent from Alternative A to B and 18.5 percent from Alternative B to C. The proportionally greater increase in ROV activity compared to that of overall crewed vessel activities demonstrates the building movement towards automated survey activities and the overall commitment of NOS agencies towards methodological innovation and efficiency. Likewise, mobile ADCP use increases 90.2 percent from Alternative A to B and 35.7 percent from Alternative B to C, also reflecting NOS's commitment to improved technology and efficiency.

It is important to note that the high number of SCUBA operations reported is related to the high number of tide gauge installation/maintenance/removal projects, as the majority of SCUBA projects

(approximately 73 percent) are tide gauge projects. Tide gauge projects usually involve short SCUBA dives that are not a large component of the overall project.

**Table 2.6-1. Comparison of Annual NOS Planned Surveying and Mapping Activities under Alternatives A, B, and C**

| Activity   | Described in Section | Alternative A                                 | Percent Increase from Alternative A to Alternative B | Alternative B                                   | Percent Increase from Alternative B to Alternative C | Alternative C                                   |
|--|----------------------|---|--|---|--|---|
| Crewed vessel operations                                   | 2.4.1                | 518,000 nm (959,000 km)                       | 11.4%  | 577,000 nm (1,070,000 km)                       | 10.4%  | 637,000 nm (1,180,000 km)                       |
| Anchoring**  | 2.4.2                | 55 projects                                   | 6.9%   | 59 projects                                     | 8.1%   | 64 projects                                     |
| ROV/ASV/AUV movement                                       | 2.4.3                | 28,600 nm (53,000 km)                         | 201.7%   | 86,300 nm (160,000 km)                          | 18.5%  | 102,300 nm (189,000 km)                         |
| Use of echo sounders                                       | 2.4.4                | 479,000 nm (887,000 km)                       | 11.5%  | 534,000 nm (988,000 km)                         | 10.3%  | 589,000 nm (1,090,000 km)                       |
| Use of sub-bottom profilers                                | 2.4.4                | 3,210 nm (5,940 km)                           | 65.4%  | 5,310 nm (9,830 km)                             | 45.2%  | 7,710 nm (14,300 km)                            |
| Use of mobile ADCPs  | 2.4.5                | 5,890 nm (10,900 km)                          | 90.2%  | 11,200 nm (20,700 km)                           | 35.7%  | 15,200 nm (28,200 km)                           |
| Stationary ADCPs installed/visited for maintenance/removed | 2.4.5                | 37 installed/78 maintenance visits/33 removed | 5.4%/1.3%/0%   | 39 installed /79 maintenance visits /33 removed | 2.6%/0%/0%   | 40 installed /79 maintenance visits /33 removed |
| Use of acoustic communication systems                      | 2.4.6                | 24 projects                                   | 37.5%  | 33 projects                                     | 18.2%  | 39 projects                                     |
| Sound speed data collection                                | 2.4.7                | 56 projects                                   | 14.3%  | 64 projects                                     | 10.9%  | 71 projects                                     |
| Drop/towed cameras/video system operation                  | 2.4.8                | 31 projects                                   | 16.1%  | 36 projects                                     | 13.9%  | 41 projects                                     |
| Bottom sample collection                                   | 2.4.9                | 54 projects                                   | 13.0%  | 61 projects                                     | 11.5%  | 68 projects                                     |
| Use of passive listening systems***                        | 2.4.10               | 21 projects                                   | 14.3%  | 24 projects                                     | 20.8%  | 29 projects                                     |
| SCUBA operations   | 2.4.11               | 248 projects                                  | 2.4%   | 254 projects                                    | 5.9%   | 269 projects                                    |

| Activity  | Described in Section | Alternative A                                    | Percent Increase from Alternative A to Alternative B | Alternative B                                    | Percent Increase from Alternative B to Alternative C | Alternative C                                    |
|---|----------------------|--|--|--|--|--|
| Tide gauges installed/visited for maintenance/removed | 2.4.12               | 32 installed /305 maintenance visits /30 removed | 15.6%/0%/16.7%                                       | 37 installed /305 maintenance visits /35 removed | 8.1%/0%/8.6%   | 40 installed /305 maintenance visits /38 removed |
| GPS reference system installation                     | 2.4.13               | 12 installed                                     | 8.3%   | 13 installed                                     | 15.4%  | 15 installed                                     |

\*All numbers are approximate and represent an annual level of effort. Projects for each activity were reported by NOS agencies without respect to the combination of activities within projects (e.g., a project involving both crewed vessel operation and echo sounder use would be reported as one crewed vessel project and one echo sounder project).

\*\*NOS estimates that 20 percent of crewed vessel projects include an anchoring component.

\*\*\*In addition to the projects presented in the table, CO-OPS uses passive listening systems on an as-needed basis. This entails the use of transponder or interrogator sensors during the deployment or retrieval of ADCPs.