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Frequently Asked Questions: Mapping of U.S. Ocean and Coastal Waters

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Ocean and coastal mapping involves activities that collect data and information about the underwater terrain (i.e., seafloor or lakebed). These data and information may be used to support marine-based economies, enhance homeland security, and protect and restore the marine environment. As of January 2023, approximately 50% of the terrain beneath U.S. coastal, ocean, and Great Lakes waters remains unmapped.

For more than a century, Congress has directed multiple federal agencies, including the National Oceanic and Atmospheric Administration (NOAA), U.S. Geological Survey (USGS), Bureau of Ocean Energy Management, U.S. Army Corps of Engineers, and others, to support and complete ocean and coastal mapping of the terrain beneath U.S. waters. Congress has provided direction through the Ocean and Coastal Mapping Integration Act of 2009 (P.L. 111-11) and the James M. Inhofe National Defense Authorization Act for Fiscal Year 2023 (Division J, Title CIII, P.L. 117-263), among other authorizing laws, as well as through appropriations laws and accompanying explanatory language. In addition, executive actions have encouraged federal ocean and coastal mapping efforts, especially efforts to map the terrain beneath certain U.S. ocean and coastal waters that are least mapped (e.g., off the coast of Alaska). One such executive action (Executive Order 13840) established the Ocean Policy Committee, an interagency body that helps guide federal ocean policy; the Ocean Policy Committee was codified by the William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021 (Title X, Subtitle E, P.L. 116-283). In 2020, the Ocean Policy Committee's Ocean Science and Technology Subcommittee developed the National Strategy for Mapping, Exploring, and Characterizing the U.S. Exclusive Economic Zone (EEZ), which identified several goals for federal ocean and coastal (including the Great Lakes) mapping activities. This strategy is commonly known as the NOMECS (National Ocean Mapping, Exploration, and Characterization) Strategy.

Goals of the NOMECS Strategy include mapping the terrain beneath certain ocean and coastal areas by 2030 and 2040. These timeframes also apply to mapping the lakebeds of the Great Lakes even though this lake system is neither part of the U.S. EEZ nor marine. To help achieve these goals, the NOMECS Strategy recommended the creation of the NOMECS Council, which includes membership from 11 federal agencies and is led by NOAA and the USGS. The council was established in 2020 and oversees two interagency working groups (IWGs): the IWG on Ocean and Coastal Mapping and the IWG on Ocean Characterization and Exploration. Together, the NOMECS Council and these two IWGs coordinate ocean and coastal mapping activities across several U.S. departments and agencies. Since the establishment of the NOMECS Council, certain federal agencies and their partners have prioritized mapping the entire U.S. ocean and coastal areas, including the Great Lakes, through the collection of modern *bathymetric data*—the depth of the underwater terrain relative to the surface water level as collected by LiDAR or sonar instruments. The seafloor surrounding Alaska and the lakebeds of the Great Lakes remain the least mapped areas (by percentage) of U.S. ocean and coastal waters.

Congress influences U.S. ocean and coastal mapping efforts by authorizing or appropriating funding to specific agencies to engage in or support mapping activities. Congress also has directed and funded agencies to focus mapping efforts on specific states and regions, such as offshore Alaska and the Great Lakes system. Congress may wish to continue prioritizing specific ocean and coastal mapping efforts through appropriations. Congress also may consider approaches to overcome stakeholder-identified U.S. ocean and coastal mapping challenges by directing federal agencies to standardize technical protocols for acquiring bathymetric data and providing additional support for collaboration between public and private mapping efforts and data sharing, among others.

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Introduction

Ocean and coastal mapping involves activities that collect data and information about the underwater terrain (i.e., seafloor or lakebed). Ocean and coastal mapping provides useful information for maritime commerce, seafood production, commercial and recreational fisheries, offshore energy production, marine tourism and recreation, environmental protection and restoration, national and homeland security, and other activities.¹ For more than a century, Congress has shown interest in ocean and coastal mapping activities. Congress has directed and funded certain federal departments and agencies to collect relevant data and information about U.S. ocean and coastal waters. Executive actions also have encouraged federal agencies to map the terrain beneath certain U.S. ocean and coastal waters. One such executive action, Executive Order (E.O.) 13840, established the Ocean Policy Committee, an interagency body that helps guide federal ocean policy.² Several federal departments and agencies that participate in ocean and coastal mapping activities aim to completely map the terrain beneath U.S. ocean waters by 2030 and the terrain beneath U.S. coastal waters by 2040. These goals were identified by the Ocean Policy Committee’s Ocean Science and Technology Subcommittee in the *National Strategy for Mapping, Exploring, and Characterizing the U.S. Exclusive Economic Zone (EEZ)*.³ This strategy is commonly known as the NOMECS (National Ocean Mapping, Exploration and Characterization) Strategy. This report answers questions about ocean and coastal mapping activities and relevant U.S. mapping efforts.

What Are Some Benefits of Ocean and Coastal Water Mapping?

Various stakeholders have cited benefits of ocean and coastal water mapping. For example, Congress, in its 2022 amendments to several ocean and coastal mapping laws, noted that “mapping, exploration, and characterization of the ocean provides basic, essential information to protect and restore the marine environment, stimulate economic activity, and provide security for the United States.”⁴ According to a group of federal agencies directed to support ocean and coastal mapping, “Ocean mapping, exploration, and characterization (MEC) is necessary to advance maritime commerce, domestic seafood production, healthy and sustainable fisheries,

¹ Ocean Policy Committee, Ocean Science and Technology Subcommittee, National Ocean Mapping, Exploration, and Characterization (NOMECS) Council, *Implementation Plan for the National Strategy for Ocean Mapping, Exploring, and Characterizing the United States Exclusive Economic Zone*, January 2021, p. 3. Hereinafter referred to as NOMECS Council, *Implementation Plan*.

² The Ocean Policy Committee was created on January 19, 2018 by Executive Order 13840 “Regarding the Ocean Policy to Advance the Economic, Security, and Environmental Interests of the United States” and was later codified by the William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021 (P.L. 116-283), Title X, Subtitle E (Executive Order 13840, “Ocean Policy to Advance the Economic, Security, and Environmental Interests of the United States,” 86 *Federal Register* 29431, June 19, 2018).

³ The Ocean Science and Technology Subcommittee of the Ocean Policy Committee developed the *National Strategy for Mapping, Exploring, and Characterizing the United States Exclusive Economic Zone* pursuant to 2019 presidential memorandum (Executive Office of the President, “Ocean Mapping of the United States Exclusive Economic Zone and the Shoreline and Nearshore of Alaska,” 84 *Federal Register* 64699, November 22, 2019 [hereinafter referred to as Presidential Memorandum on Ocean Mapping of the U.S. EEZ, 2019]).

⁴ James M. Inhofe National Defense Authorization Act for Fiscal Year 2023 (P.L. 117-263), Division J, Title CIII, §10301(6).

coastal resilience, energy production, tourism and recreation, environmental protection, conservation, national and homeland security, and other interests.”⁵

Ocean and coastal mapping can aid in a range of activities, including

- exploring for and extracting offshore oil and gas and seabed minerals,⁶
- siting telecommunication and offshore wind turbine-related cables,⁷
- identifying navigational hazards for recreational boating and commercial shipping,⁸
- determining the extent of the U.S. continental shelf,⁹
- assessing marine geohazards,¹⁰ and
- protecting marine environments and ecosystems of interest.¹¹

What Is Ocean and Coastal Mapping?

Mapping of ocean and coastal waters involves activities that collect data and information about the underwater terrain (i.e., seafloor or lakebed).¹² In general, U.S. ocean mapping involves mapping the seafloor beneath the U.S. EEZ, whereas U.S. coastal mapping involves mapping the seafloor beneath state waters (at least 3 nautical miles from the shoreline).¹³ The James M. Inhofe National Defense Authorization Act for Fiscal Year 2023 (P.L. 117-263) addressed national ocean exploration; specifically, Division J, Title CIII, of the act defined *mapping* as “activities that provide comprehensive data and information needed to understand seafloor characteristics, such as depth, topography, bottom type, sediment composition and distribution, underlying geologic structure, and benthic flora and fauna.”¹⁴

Section 12208 of the Ocean and Coastal Mapping Integration Act of 2009 (Title XII, Part II, Subtitle B, of P.L. 111-11), as amended, defined *ocean and coastal mapping* as

⁵ NOME Council, *Implementation Plan*, p. 3. For more on the NOME Council, see “How Have Congress and the President Directed Federal Agencies to Support Ocean and Coastal Mapping Efforts?”

⁶ Bureau of Ocean Energy Management (BOEM), “BOEM Mapping Resources,” at <https://www.boem.gov/environment/boem-mapping-resources>. For more information on applications of bathymetric data related to nonliving natural resources, see CRS Report R47021, *Federal Involvement in Ocean-Based Research and Development*, by Caitlin Keating-Bitonti.

⁷ National Oceanic and Atmospheric Administration (NOAA), “Why Map the Seafloor? To Keep Us—and Natural Resources—Safe,” at <https://oceanexplorer.noaa.gov/world-oceans-day-2015/why-map-the-seafloor-to-keep-us-and-natural-resources-safe.html>.

⁸ *Ibid.*

⁹ For more information about the extent of the U.S. continental shelf, see CRS Report R41153, *Changes in the Arctic: Background and Issues for Congress*, coordinated by Ronald O'Rourke.

¹⁰ U.S. Geological Survey (USGS), “Marine Geohazards,” at <https://www.usgs.gov/science/science-explorer/ocean/marine-geohazards>.

¹¹ NOAA, “How Is Bathymetric Data Used?,” at <https://oceanservice.noaa.gov/facts/bathyuses.html>.

¹² Congress included the Great Lakes as part of a federal ocean and coastal mapping plan (33 U.S.C. §3501).

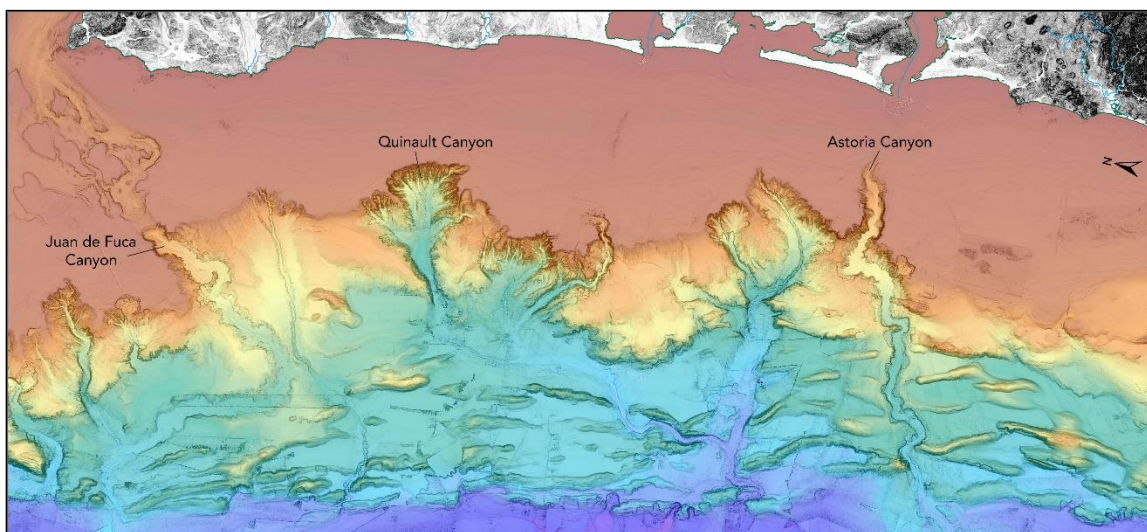
¹³ The U.S. exclusive economic zone is the ocean area located generally between 3 and 200 nautical miles from the shoreline. White House, “Proclamation 5030: Exclusive Economic Zone of the United States of America,” 48 *Federal Register* 10605, March 10, 1983.

¹⁴ The National Ocean Exploration Title of the James M. Inhofe National Defense Authorization Act for Fiscal Year 2023 modified Section 12001 of the Omnibus Public Land Management Act of 2009 (33 U.S.C. §3401) by inserting this definition of *mapping*. It also applies the definition to *map* (P.L. 117-263, Division J, Title CIII, §10305(h)).

the acquisition, processing, management, maintenance, interpretation, certification, and dissemination of physical, biological, geological, chemical, and archaeological characteristics and boundaries of ocean and coastal areas, resources, and sea beds through the use of acoustics, satellites, aerial photogrammetry, light and imaging, direct sampling, and other mapping technologies.¹⁵

One aspect of mapping underwater terrain is the collection of data regarding the ocean or lake depth relative to the surface water level, known as *bathymetric data*.¹⁶ Similar to topographic maps on land, bathymetric maps reveal three-dimensional features of the underwater terrain (Figure 1).

Figure 1. Bathymetric Map of Offshore Washington State



Source: U.S. Geological Survey, Pacific Coastal and Marine Science Center, “Bathymetric Map of Offshore Washington,” at <https://www.usgs.gov/media/images/bathymetric-map-offshore-washington>.

Notes: This bathymetric map reveals the seafloor features, including submarine canyons, offshore Washington state. The red color represents shallower water depths, and the blue color represents deeper water depths. The grayscale area at the top of the map is the relief of the land (i.e., topography); white represents lower elevation, and black represents higher elevation.

Bathymetric maps can inform site selection for *exploration* and *characterization* (Figure 2).¹⁷ The James M. Inhofe National Defense Authorization Act for Fiscal Year 2023 defined *exploration* as “activities that provide (A) a multidisciplinary view of an unknown or poorly understood area of the seafloor, sub-bottom, or water column; and (B) an initial assessment of the physical, chemical, geological, biological, archeological, or other characteristics of such an area.”¹⁸ The act defined *characterization* as “activities that provide comprehensive data and interpretations for a specific area of interest of the sea floor, sub-bottom, water column, or hydrologic features, including water masses and currents, in direct support of specific research, environmental protection, resource management, policy making, or applied mission objective.”

¹⁵ §10307(g) of the National Ocean Exploration Act (P.L. 117-263, Division J, Title CIII) amended the definition of *ocean and coastal mapping* by replacing “processing, and management” with “processing, management, maintenance, interpretation, certification, and dissemination.”

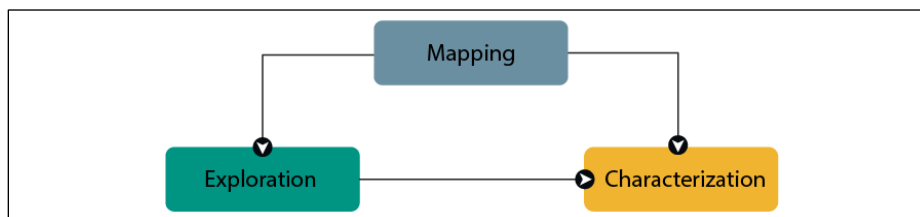
¹⁶ NOAA, “What Is Bathymetry?,” at <https://oceanservice.noaa.gov/facts/bathymetry.html>.

¹⁷ NOME Council, *Implementation Plan*, p. 7.

¹⁸ P.L. 117-263, Division J, Title CIII.

The focus of this report is on ocean and coastal mapping activities.

Figure 2. Relationship Between Mapping, Exploration, and Characterization



Source: Congressional Research Service (CRS); Ocean Science and Technology Subcommittee and Ocean Policy Committee, National Ocean Mapping, Exploration, and Characterization Council, *Implementation Plan for the National Strategy for Ocean Mapping, Exploring, and Characterizing the United States Exclusive Economic Zone*, January 2021, p. 6.

Note: Ocean and coastal mapping can inform both exploration and characterization activities. Exploration can inform in-depth characterization.

What Are U.S. Goals for Ocean and Coastal Mapping?

In June 2020, the Ocean Science and Technology Subcommittee of the Ocean Policy Committee announced the NOMECS Strategy (for more information about federal committees, councils, and interagency working groups focused on ocean and coastal mapping, see “How Are Federal Ocean and Coastal Mapping Efforts Coordinated?”). The NOMECS Strategy established five goals.¹⁹

1. Coordinate interagency efforts and resources to map, explore, and characterize the U.S. EEZ
2. Map the U.S. EEZ
3. Explore and characterize priority areas of the U.S. EEZ²⁰
4. Develop and mature new and emerging science and technologies to map, explore, and characterize the U.S. EEZ
5. Build public and private partnerships beyond federal agencies to map, explore, and characterize the U.S. EEZ

The NOMECS Strategy also provides deadlines to meet certain goals. For example, the strategy aims to map the terrain beneath certain U.S. ocean waters (water depths greater than 40 meters [m], or 43.7 yards) by 2030.²¹ Water depths greater than 40 m within the U.S. EEZ represent approximately 90% of the U.S. EEZ area.²² The strategy aims to map the terrain beneath U.S. coastal waters (water depths less than 40 m), which includes state waters and some areas of the U.S. EEZ, by 2040.²³ According to the NOMECS Strategy, mapping U.S. coastal waters is

¹⁹ Ocean Policy Committee, Ocean Science and Technology Subcommittee, *National Strategy for Mapping, Exploring, and Characterizing the United States Exclusive Economic Zone*, June 9, 2020, p. 2. Hereinafter referred to as NOMECS Strategy, 2020.

²⁰ U.S. exploration and characterization activities are focused on waters 40 meters and deeper. NOMECS Council, *Implementation Plan*, p. 15.

²¹ NOMECS Strategy, 2020, p. 9.

²² *Ibid.*

²³ *Ibid.*

estimated to require two-thirds of the total level of effort required to map the entire U.S. EEZ.²⁴ Mapping of the lakebeds of the Great Lakes is also included in the NOMECS Strategy even though the Great Lakes are not a part of the U.S. EEZ.²⁵

The NOMECS Strategy's goals to map the terrain beneath U.S. ocean and coastal waters may align with larger global goals. For instance, in 2022, the National Oceanic and Atmospheric Administration (NOAA) Administrator signed a memorandum of understanding that formalized U.S. participation in the Nippon Foundation-General Bathymetric Chart of the Oceans Seabed 2030 Project (Seabed 2030).²⁶ Seabed 2030 aims to map the entire global seafloor by 2030.²⁷

How Much of U.S. Ocean and Coastal Waters Are Mapped?

NOAA periodically analyzes available modern (post-1960²⁸) bathymetric data to evaluate U.S. ocean and coastal mapping progress.²⁹ NOAA completed its first such analysis in 2017. Following a 2019 presidential memorandum entitled "Ocean Mapping of the United States Exclusive Economic Zone and the Shoreline and Nearshore Alaska" (hereinafter referred to as the 2019 presidential memorandum on ocean mapping of the U.S. EEZ),³⁰ NOAA has released an annual progress report of unmapped U.S. waters (i.e., ocean and coastal waters and the Great Lakes).³¹ These annual progress reports quantify the area of U.S. waters mapped during the previous year and present this information as the percentage of U.S. waters (i.e., ocean and coastal waters and the Great Lakes) unmapped (**Table 1**), also known as the "gap analysis."³² For example, the annual progress report published in January 2023 revealed that 50% of U.S. coastal, ocean, and Great Lakes waters were unmapped as of 2022 (**Figure 3**).³³ For this dataset, *unmapped areas* can mean that "either no direct measurements of the seafloor have been acquired over these areas or data has been collected and not shared for broader use" (for more on data acquisition, see "How Are U.S. Bathymetric Data Coordinated and Made Available?").³⁴ According to NOAA, a specified area of the seafloor or lakebed of the Great Lakes is considered

²⁴ Ibid.

²⁵ The Great Lakes are considered *internal waters* of the United States. See Article 8 of the United Nations Framework Convention on the Law of the Sea (United Nations, "United Nations Convention on the Law of the Sea of 10 December 1982, Overview and full text," at https://www.un.org/depts/los/convention_agreements/convention_overview_convention.htm).

²⁶ NOAA, "Seabed 2030," June 29, 2022, at <https://oceanservice.noaa.gov/news/jun22/seabed-2030.html>.

²⁷ The Nippon Foundation—General Bathymetric Chart of the Oceans Seabed 2030 Project, "About the Seabed 2030 Project," at <https://seabed2030.org/about-us>.

²⁸ *Post-1960* refers when the U.S. Navy declassified multibeam sonar technology for civil use (see Hydro International, "A Note on Fifty Years of Multi-beam," May 22, 2013, at <https://www.hydro-international.com/content/article/a-note-on-fifty-years-of-multi-beam>).

²⁹ NOAA, "U.S. Bathymetric Coverage and Gap Analysis," at <https://iocm.noaa.gov/seabed-2030-bathymetry.html> (hereinafter referred to as NOAA, Bathymetric Gap Analysis) and NOAA, "United States Bathymetric Gap Analysis," at <https://noaa.maps.arcgis.com/home/item.html?id=4d7d925fc96d47d9ace970dd5040df0a>.

³⁰ Presidential Memorandum on Ocean Mapping of the U.S. EEZ, 2019.

³¹ The first annual progress report of unmapped U.S. waters was published in January 2020 (NOAA, "Progress Report: Unmapped U.S. Waters," March 2020, at <https://iocm.noaa.gov/seabed-2030/mapping-progress-report2020.pdf>).

³² NOAA, Bathymetric Gap Analysis.

³³ NOAA, "Progress Report: Unmapped U.S. Waters," March 2023, at <https://iocm.noaa.gov/documents/mapping-progress-report2023.pdf>.

³⁴ NOAA, "Status of Seafloor Mapping Within U.S. Waters," at <https://iocm.noaa.gov/seabed-2030-status.html>.

mapped when at least one sonar (sound navigation and ranging) or LiDAR (Light Detection and Ranging) measurement has been collected for that area (for more on sonar and LiDAR, see “How Are Ocean and Coastal Waters Mapped?”).³⁵

Table 1. Percentage of Unmapped U.S. Coastal, Ocean, and Great Lakes Waters

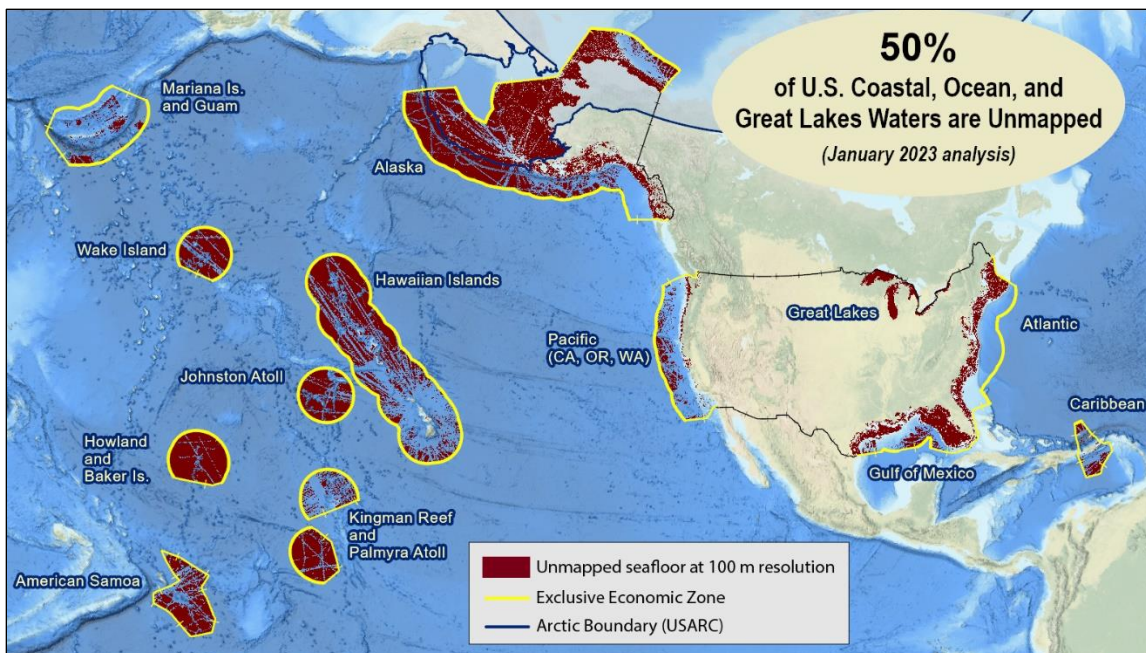
Region	Total Area (snm)	Percentage Unmapped					
		2017	2018	2019	2020	2021	2022
All U.S. Waters	3,590,500	59%	57%	54%	53%	52%	50%
Atlantic and Gulf of Mexico	472,200	49%	48%	43%	41%	40%	37%
Caribbean (USVI, PR)	61,600	45%	44%	42%	43% ^a	42%	30%
Alaska	1,080,200	74%	73%	72%	72%	69%	66%
Pacific (CA, OR, WA)	239,700	29%	29%	24%	22%	20%	19%
Hawaii and Pacific Remote Islands	1,691,700	55%	53%	50%	49%	48%	47%
Great Lakes	45,100 ^b	96%	96%	95%	95%	93%	92%

Source: CRS; National Oceanic and Atmospheric Administration, “Progress Report: Unmapped U.S. Waters,” March 2020, at <https://iocm.noaa.gov/seabed-2030/mapping-progress-report2020.pdf>; March 2021, at <https://iocm.noaa.gov/seabed-2030/mapping-progress-report2021.pdf>; March 2022, at <https://iocm.noaa.gov/documents/mapping-progress-report2022.pdf>; and March 2023, at <https://iocm.noaa.gov/documents/mapping-progress-report2023.pdf>.

Notes: CA = California; OR = Oregon; PR = Puerto Rico; snm = square nautical miles; USVI = U.S. Virgin Islands; WA = Washington. The Pacific Remote Islands include the Commonwealth of the Northern Mariana Islands, Guam, American Samoa, Wake Island, Johnston Atoll, Howland Island, Baker Island, Kingman Reef, and Palmyra Atoll.

- a. The Caribbean “lost” 600 snm, equating to 1%, of mapping area in 2020 due to a minor correction to remove known bad/poor bathymetric data from the calculation
- b. In 2021, the total area of the Great Lakes lakebeds was adjusted from 46,600 snm to 45,100 snm due to the removal of some land features.

³⁵ NOAA considers a specific area (i.e., a grid cell measuring 100x100 meters) of the seafloor *minimally mapped* if the area contains at least one sonar or LiDAR measurement. NOAA refers to a grid cell that has three or more measurements as *better mapped*. NOAA, “U.S. Bathymetric Coverage and Gap Analysis,” at <https://iocm.noaa.gov/seabed-2030-bathymetry.html>.

Figure 3. Unmapped U.S. Coastal, Ocean, and Great Lakes Waters in January 2023

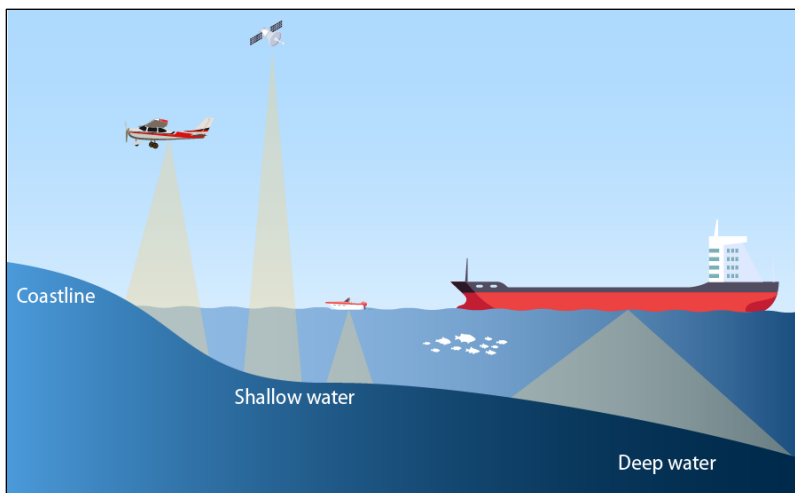
Source: Modified by CRS; National Oceanic and Atmospheric Administration (NOAA), “Progress Report: Unmapped U.S. Waters,” March 2023, at <https://iocm.noaa.gov/documents/mapping-progress-report2023.pdf>.

Notes: A January 2023 NOAA analysis estimated that 50% of U.S. Coastal, Ocean, and Great Lakes waters are unmapped (red areas). The seaward extent of the U.S. exclusive economic zone is denoted by the yellow line, and the Arctic boundary is denoted by the navy blue line. The Arctic Research and Policy Act of 1984 (P.L. 98-373) defined the U.S. Arctic as the “territory north and west of the boundary formed by the Porcupine, Yukon, and Kuskokwim Rivers; all contiguous seas, including the Arctic Ocean and the Beaufort, Bering, and Chukchi Seas; and the Aleutian chain.”

How Are Ocean and Coastal Waters Mapped?

Underwater terrain is mapped using bathymetric data.³⁶ Federal agencies, academic institutions, and private companies collect bathymetric data using sonar or LiDAR instruments (for more information on the involvement of federal agencies and departments, see “How Are Federal Ocean and Coastal Mapping Efforts Coordinated?”). In general, sonar instruments map the seafloor beneath the surface of the ocean and LiDAR instruments map the seafloor beneath coastal waters (up to a water depth of 80 m); sonar and LiDAR instruments also are used to map the lakebeds of the Great Lakes and other lakes (**Figure 4**). The NOMECS Strategy’s goal to map U.S. waters with a depth greater than 40 meters by 2030 would rely primarily on data collected via sonar instruments; whereas, goal to map U.S. waters with a depth less than 40 meters by 2040 would rely on data collected via sonar and LiDAR instruments.

³⁶ For more information about oceanographic data and approaches for ocean mapping and characterization, see CRS Report R47021, *Federal Involvement in Ocean-Based Research and Development*, by Caitlin Keating-Bitonti.

Figure 4. Selected Assets Equipped with Multibeam Sonar and LiDAR Instruments

Source: CRS; National Oceanic and Atmospheric Administration, “Progress Report: Unmapped U.S. Waters,” March 2023, at <https://iocm.noaa.gov/documents/mapping-progress-report2023.pdf>.

Notes: The underwater terrain of the shallow coastal areas is generally mapped using aircraft and satellites equipped with LiDAR instruments. LiDAR instruments can collect bathymetric data in certain waters up to 80 meters water depth. Small boats equipped with multibeam sonar instruments can be used to map the underwater terrain of shallow coastal areas but may be limited by navigation concerns. Large vessels equipped with multibeam sonar technology are best suited for mapping the deep underwater terrain beneath open waters free of navigation hazards.

Sonar data provide information about the depths and shapes of the underwater terrain, and these data are used to create bathymetric maps. Sonar systems send sound pulses from a sensor—called a *transducer array*—attached to the bottom of a ship, or another water vehicle, to the underwater terrain. The amount of time it takes for sound pulses to leave the array, bounce off the underwater terrain, and return to the array is used to calculate the distance to the seafloor (i.e., water depth).³⁷ The faster a sound pulse returns to the array, the shallower the water depth. Commonly used sonar systems are *single beam sonars*, which use a single vertical sound pulse to collect data of the underwater terrain directly beneath the ship, and *multibeam sonars*, which use multiple splayed sound pulses to collect data of the underwater terrain directly beneath and out to each side of the ship.³⁸

In addition to providing information about water depth, multibeam sonars can collect backscatter measurements, which correspond to the return beam’s intensity. The return beam’s intensity provides information about the seafloor’s composition. For example, a mud surface absorbs most of the sound pulse, returning a weak signal to the receiver, whereas a rocky surface absorbs little of the sound pulse, returning a strong signal.³⁹

³⁷ NOMECE Council and the Interagency Working Group on Ocean and Coastal Mapping (IWG-OCM), “Draft Standard Ocean Mapping Protocol,” February 2023, at https://iocm.noaa.gov/standards/Standard_Ocean_Mapping_Protocol_draft_Feb2023.pdf, p. 31. Hereinafter referred to as NOMECE and IWG-OCM, Draft Standard Ocean Mapping Protocol.

³⁸ Ibid.

³⁹ Ibid, pp. 31-32, and NOAA, “Sea Floor Mapping,” at https://oceanexplorer.noaa.gov/explorations/lewis_clark01/background/seafloormapping/seafloormapping.html.

Coastal waters can be challenging and time-consuming to map, because shallow waters may be inaccessible to oceanographic research vessels.⁴⁰ Remote sensing technology can be used to overcome some of these challenges. LiDAR is a remote sensing method commonly used on aircraft, but some satellites are also equipped with LiDAR instruments.⁴¹ A LiDAR instrument primarily consists of a laser emitter-receiver scanning unit and a specialized global positioning system (GPS) unit; bathymetric LiDAR uses a laser emitting green light that penetrates through water. Similar to sonar, the amount of time it takes pulsed laser beams to reach the underwater terrain and return to a receiver fixed to an aircraft or satellite is used to calculate water depth.⁴² LiDAR is limited to relatively clear and calm coastal waters, because breaking waves or water containing sediment, marine vegetation, and other materials reduce the laser light's ability to penetrate through the water.⁴³

As directed by Congress,⁴⁴ a group of federal agencies and departments, including NOAA, developed a draft Standard Ocean Mapping Protocol, which encourages consistency in data acquisition, stewardship, and data management for ocean and coastal mapping.⁴⁵ The draft protocol aims to address some stakeholder concerns about the lack of consistency in the types and specifications of bathymetric data acquired by NOAA.

How Are U.S. Bathymetric Data Coordinated and Made Available?

NOAA National Center for Environmental Information (NCEI) bathymetry holdings are the primary source of bathymetric data.⁴⁶ NCEI serves as the central repository and archive for global single-beam and multibeam sonar bathymetry.⁴⁷ Bathymetric LiDAR is archived by NCEI and NOAA's Digital Coast.⁴⁸ NCEI bathymetric holdings are compliant with the Geospatial Data Act

⁴⁰ Shallow coastal waters may present hazards for ships and, in high latitude regions, coastal waters are more prone to freezing, thereby limiting data collection to ice-free seasons.

⁴¹ Imaging and environment-monitoring instruments on commercial satellites, such as the Maxar satellite series, can be applied to coastal water mapping projects (Maxar, "The Power of Bathymetry Now Available in SecureWatch," April 8, 2020, at <https://blog.maxar.com/earth-intelligence/2020/the-power-of-bathymetry-now-available-in-securewatch>). Some federally owned (i.e., Landsat 8, Landsat 9, and ICESat-2) satellites are also equipped with LiDAR technology that can be used to map coastal waters (USGS, "Satellite-Derived Bathymetry," at <https://www.usgs.gov/special-topics/coastal-national-elevation-database-%28coned%29-applications-project/science/satellite#overview>; and National Aeronautics and Space Administration [NASA], "Sounding the Seafloor with Light," at <https://earthobservatory.nasa.gov/images/148246/sounding-the-seafloor-with-light>. For more information, see CRS Report R46560, *Landsat 9 and the Future of the Sustainable Land Imaging Program*, by Anna E. Normand).

⁴² NOMECS and IWG-OCM, Draft Standard Ocean Mapping Protocol, p. 46.

⁴³ *Ibid.*, pp. 44, 46.

⁴⁴ P.L. 117-263, Division J, Title CIII, §10304(i)(2)(I), and NOMECS Strategy, 2020, pp.17-18.

⁴⁵ See, NOAA, "Request for Public Comment on a Draft Standard Ocean Mapping Protocol," 88 *Federal Register* 11900, February 24, 2023.

⁴⁶ Email correspondence with NOAA, Congressional Affairs Specialist, Office of Legislative and Intergovernmental Affairs (OLIA), June 15, 2023.

⁴⁷ *Ibid.* NOAA NCEI is also the repository for bathymetric grids created for the U.S. Extended Continental Shelf Project. For more information about the U.S. Extended Continental Shelf Project, see CRS Report R41153, *Changes in the Arctic: Background and Issues for Congress*, coordinated by Ronald O'Rourke.

⁴⁸ See, NOAA, "Coastal Topographic LiDAR," at <https://coast.noaa.gov/digitalcoast/data/coastallidar.html>.

of 2018 (P.L. 115-254, Title VII, Subtitle F) as all of these data can be accessed and viewed through the NOAA Bathymetric Data Viewer.⁴⁹

NCEI's bathymetric holdings include data collected by the federal government, states, academic institutions, non-governmental institutions, the private sector, and crowdsource providers.⁵⁰ To establish a working relationship with NCEI, data providers must enter into a submission agreement with NCEI. These data providers are required to submit their data in standardized formats with appropriate metadata to ensure equal access and useability.⁵¹ In cases where NCEI acquires data that are not in standardized format, NCEI may need to process data to extract bathymetric information.⁵²

NCEI may not share bathymetric data for several reasons. First, some data may have been collected and cannot be shared for broader use until NCEI has processed and converted the data into the standardized format—data processing could delay public access by a year or more.⁵³ Second, some scientific journals require scientists to publish primary data alongside research results, which could also delay public access to these data. Other data restrictions include business proprietary, ownership issues, and national security concerns, among others.

What Are Some Challenges to Ocean and Coastal Water Mapping Efforts?

The NOMECE implementation plan provides a blueprint to coordinate federal and non-governmental efforts needed to achieve the goals of the NOMECE Strategy. During the development of the NOMECE implementation plan, the NOMECE Council identified several limitations to ocean and coastal water mapping. These limitations included the need to

- improve engagement with stakeholder groups to implement the NOMECE Strategy;
- incorporate marine cultural heritage, underwater archaeology, and paleolandscapes in ocean and coastal mapping priorities;⁵⁴
- strengthen collaboration with the private sector to advance innovative development and use of uncrewed systems (e.g., remotely operated vehicles, drones);
- align the types and specifications of data (e.g., bathymetric resolution, time series data, imaging) across sectors;
- manage and store data and make data accessible and usable;
- engage the next generation of hydrographers, ocean explorers, and scientists; and

⁴⁹ See, NOAA, "Bathymetric Data Viewer," at <https://www.ncei.noaa.gov/maps/bathymetry/>. For more information on the Geospatial Data Act of 2018, see CRS Report R45348, *The Geospatial Data Act of 2018*, by Peter Folger.

⁵⁰ NOAA Bathymetric Gap Analysis.

⁵¹ Email correspondence with NOAA, Congressional Affairs Specialist, Office of Legislative and Intergovernmental Affairs (OLIA), June 15, 2023.

⁵² *Ibid.*

⁵³ *Ibid.*

⁵⁴ A *paleolandscape* is an ancient area of land that may preserve information about how people inhabited, occupied, and used the land. For example, see NOAA, "Paleolandscapes, Paleoecology, and Cultural Heritage on the Southern California Continental Shelf – Geophysical Mapping Phase," at <https://oceanexplorer.noaa.gov/explorations/21paleolandscapes/welcome.html>.

- streamline the permitting process for ocean and coastal mapping activities.⁵⁵

Federal ocean and coastal mapping efforts also may be limited by the availability of oceanographic research vessels (ORVs) with mapping capability, including vessels with partnerships with the federal government and U.S.-owned vessels (**Table 2**).⁵⁶ Two vessels in NOAA’s fleet, *Fairweather* and *Rainier*, are over 55 years old. The pending retirement of these two vessels will result in the loss of 100% of NOAA’s mapping capacity in the Pacific and Arctic Oceans.⁵⁷ NOAA anticipates the forthcoming acquisition of two new replacement vessels will allow for mapping activities to continue in the Pacific.⁵⁸ Other resource considerations associated with ORVs include staffing levels, funding (e.g., operational sea days), and competing research projects and priorities.⁵⁹

Table 2. Selected U.S.-Owned Oceanographic Research Vessels

Name	Type	Owner (Operator)
Atlantis*	Oceanographic	U.S. Navy (WHOI)
Fairweather	Hydrographic	NOAA (NOAA)
Ferdinand R. Hassler	Hydrographic	NOAA (NOAA)
Nancy Foster	Oceanographic	NOAA (NOAA)
Okeanos Explorer	Oceanographic	NOAA (NOAA)
Rainier	Hydrographic	NOAA (NOAA)
Roger Revelle*	Oceanographic	U.S. Navy (Scripps Institution of Oceanography)
Ronald H. Brown*	Oceanographic	NOAA (NOAA)
Thomas Jefferson	Hydrographic	NOAA (NOAA)
Thompson*	Oceanographic	U.S. Navy (UW School of Oceanography)

Source: CRS; National Oceanic and Atmospheric Administration (NOAA), “Observation Platforms: Vessels,” at <https://oceanexplorer.noaa.gov/technology/vessels/vessels.html>; NOAA “Ship-Finder,” at <https://www.oma.noaa.gov/mo/ship-finder>; University-National Oceanographic Laboratory System (UNOLS), “UNOLS Designated Vessels,” at <https://www.unols.org/ships-facilities/unols-vessels>; and email correspondence with NOAA, Congressional Affairs Specialist, Office of Legislative and Intergovernmental Affairs, April 18, 2023.

Notes: UW = University of Washington; WHOI = Woods Hole Oceanographic Institution. Asterisk (*) denotes a UNOLS-designated vessel as part of the U.S. Academic Research Fleet.

Some have argued that ORV limitations, such as challenges associated with the vessels’ operation in shallow coastal waters or their availability, may be overcome by the use of other technologies. The National Aeronautics and Space Administration (NASA), NOAA, and the U.S. Army Corps of Engineers (USACE) operate and use airborne LiDAR instruments equipped with a laser

⁵⁵ NOME Council, *Implementation Plan*, Appendix A.

⁵⁶ For example, while NOAA provides funding for research and mission input for *Nautilus*, an exploration vessel owned and operated by the Ocean Exploration Trust, NOAA does not directly task or assign missions to this vessel (email correspondence with NOAA, Congressional Affairs Specialist, Office of Legislative and Intergovernmental [OLIA] Affairs, April 18, 2023). *Nautilus* is equipped with multibeam sonar that has been used to map the seafloor (NOAA, “Exploration Vessel *Nautilus*,” at <https://oceanexplorer.noaa.gov/technology/vessels/nautilus/nautilus.html>).

⁵⁷ NOAA, “The NOAA Fleet Plan: Building NOAA’s 21st Century Fleet,” October 31, 2016, pp. 24, 27.

⁵⁸ The Consolidated Appropriations Act, 2023 provided funds to NOAA for the acquisition and construction of vessels and aircraft (P.L. 117-328, Division B, Title I). Email correspondence with NOAA, Congressional Affairs Specialist, OLIA, April 18, 2023.

⁵⁹ Email correspondence with NOAA, Congressional Affairs Specialist, OLIA, April 18, 2023.

emitting green light to map and chart coastal waters (up to 80 m water depth). For example, the Joint Airborne Lidar Bathymetry Technical Center of Expertise (JALBTCX), a multiagency effort led by USACE, operates and uses airborne LiDAR bathymetry technology to map and chart coastal waters worldwide.⁶⁰ According to USACE, there is capacity in the JALBTCX sensor/aircraft fleet and calendar to accommodate additional mapping activities to complement the goals of NOMECS if funds are made available to do so.⁶¹ As another example, NASA collects coastal bathymetric data using LiDAR and radar instruments on satellites (e.g., Ice, Cloud and Land Elevation Satellite 2 [ICESat-2] and Surface Water and Ocean Topography [SWOT]),⁶² the International Space Station,⁶³ and aircraft.⁶⁴ Such satellite instruments were not necessarily designed primarily to collect bathymetric data, but their capabilities can be used for that purpose and others, such as measuring surface water, ice, and forests.⁶⁵

Where Are U.S. Ocean and Coastal Waters the Least Mapped?

Federal ocean and coastal areas are not evenly mapped across the United States and its territories (see **Table 1**). To help identify where U.S. mapping efforts should focus, the Interagency Working Group on Ocean and Coastal Mapping (IWG-OCM), a federal group established under law,⁶⁶ surveys ocean and coastal mapping partners and those who rely on mapping data for their priority areas. For example, one survey asked NOAA program offices to determine which areas of the ocean and Great Lakes they needed mapped, and why.⁶⁷ The IWG-OCM reviews these surveys to determine overlapping mapping interests to “coordinate and leverage resources where there is a shared mapping need.”⁶⁸

Two areas that have received attention for being the least mapped are the ocean and coastal waters of Alaska and the lakebeds of the Great Lakes. Both Congress and the President have directed specific federal agencies to map the seafloor off Alaska’s coast and the lake beds of the Great Lakes. For example, in the explanatory statement accompanying the Consolidated Appropriations Act, 2023 (P.L. 117-328), Congress directed NOAA to use certain funds “to continue coordinating and implementing an interagency mapping, exploration, and characterization strategy for the U.S. Exclusive Economic Zone, as well as the Strategy for

⁶⁰ Federal agencies included in the Joint Airborne Lidar Bathymetry Technical Center of Expertise (JALBTCX) are the U.S. Army Corps of Engineers (USACE), U.S. Naval Meteorology and Oceanography Command, NOAA, and USGS. USACE, “About JALBTCX,” at <https://jalbtcx.usace.army.mil/>.

⁶¹ While the USACE owns airborne LiDAR instruments, USACE contracts for the aircraft to fly the instruments (USACE, remote briefing to CRS, April 25, 2023). NOAA, “Integrated Ocean & Coastal Mapping, Interagency Working Group—Ocean and Coastal Mapping,” at <https://iocm.noaa.gov/about/iwg-ocm.html>.

⁶² NASA, “Sounding the Seafloor with Light,” at <https://earthobservatory.nasa.gov/images/148246/sounding-the-seafloor-with-light>; and NASA, “Oceanography,” <https://swot.jpl.nasa.gov/science/oceanography/>.

⁶³ NASA, “Global Ecosystem Dynamics Investigation (GEDI),” at <https://www.earthdata.nasa.gov/sensors/gedi>.

⁶⁴ NASA generally flies prototype instruments, which may include LiDAR, on aircraft before they are deployed into space on satellites (NASA, remote briefing to CRS, May 24, 2023).

⁶⁵ Ibid.

⁶⁶ 33 U.S.C. §3502. For information about the composition of IWG-OCM, see “How Are Federal Ocean and Coastal Mapping Efforts Coordinated?”

⁶⁷ For example, NOAA, *NOAA Nationwide Spatial Priorities Study*, NOAA Technical Memorandum NOS CS 46, October 2021.

⁶⁸ NOAA, “Spatial Priority Studies,” at <https://iocm.noaa.gov/planning/priorities.html>.

Mapping the Arctic and Sub-Arctic Shoreline and Nearshore of Alaska.”⁶⁹ (For more information, see “How Have Congress and the President Directed Federal Agencies to Support Ocean and Coastal Mapping Efforts?”)

Ocean and Coastal Waters of Alaska

According to the November 19, 2019 Presidential Memorandum on Ocean Mapping of the United States Exclusive Economic Zone and the Shoreline and Nearshore of Alaska, Alaska “lack[s] the comprehensive shoreline and nearshore maps available for much of the rest of the Nation” (see **Table 1**).⁷⁰ As directed by this presidential memorandum, in 2020, NOAA, the State of Alaska, and the Alaska Mapping Executive Committee developed an Alaska coastal mapping strategy.⁷¹ The strategy focuses on terrestrial nearshore and coastal waters that can be mapped with LiDAR (aircraft and satellite), roughly 2 miles landward from the coast to the seaward extinction depth of LiDAR technology (roughly 80 m below sea level). In addition, the NOMECS Strategy calls for mapping federal ocean water areas offshore Alaska.⁷² Seascope Alaska is a regional mapping campaign in collaboration with federal, tribal, state, and non-governmental partners to help map U.S. EEZ off the coast of Alaska using modern multibeam sonar and LiDAR instruments.⁷³ The percentage of unmapped ocean and coastal waters offshore Alaska has decreased from 72% in 2020 to 66% in 2022 (**Table 1**).

Lakebeds of the Great Lakes

The Great Lakes are the least-mapped areas of the United States that are included in the NOMECS Strategy (**Table 1**). As of January 2023, 92% of the lakebeds of the Great Lakes remained unmapped with modern technology at a 100 m resolution.⁷⁴ According to the Great Lakes Observing System (GLOS),⁷⁵ a binational network of organizations from the United States and Canada that receives funding from NOAA, many existing bathymetric maps of the Great Lakes were created using old, sparsely collected, or low-resolution data (e.g., water depth measurements were collected using lead lines dropped off the edges of boats or pre-1960 using single-beam sonar instruments).⁷⁶ A priority of GLOS is the Lakebed 2030 initiative.⁷⁷ Lakebed 2030 aims to harmonize new and existing (domestic and international) governmental and nongovernmental

⁶⁹ Senator Patrick Leahy, “Regarding H.R. 2617, Consolidated Appropriations Act, 2023,” remarks in the Senate, *Congressional Record*, daily edition, vol. 168 (December 20, 2022), p. S7907 (hereinafter referred to as Senator Leahy, *Congressional Record*).

⁷⁰ Presidential Memorandum on Ocean Mapping of the U.S. EEZ, 2019.

⁷¹ The Alaska Mapping Executive Committee (AMEC) is composed of executives from the State of Alaska and 15 federal agencies and departments (AMEC, *Alaska Coastal Mapping Strategy: Implementation Plan 2020-2030*, June 22, p. 1).

⁷² *Ibid.*, pp. 2, 4.

⁷³ Seascope Alaska, “Introducing Seascope Alaska,” at <https://storymaps.arcgis.com/stories/094abb14281e4b2489146a3f3e030961>.

⁷⁴ NOAA, “Progress Report: Unmapped U.S. Waters,” March 2023, at <https://iocm.noaa.gov/documents/mapping-progress-report2023.pdf>.

⁷⁵ The Great Lakes Observing System (GLOS) was established in 2016. GLOS, “Lakebed 2030,” at <https://glos.org/priorities/lakebed-2030/>.

⁷⁶ *Ibid.*; NOAA, “Great Lakes Bathymetry,” at <https://www.ncei.noaa.gov/products/great-lakes-bathymetry>; and Great Lakes Now, “Researchers Race to Understand What Lies Beneath the Great Lakes,” July 21, 2022, at <https://www.greatlakesnow.org/2022/07/researchers-race-to-understand-what-lies-beneath-the-great-lakes/>.

⁷⁷ GLOS, “Lakebed 2030,” at <https://glos.org/priorities/lakebed-2030/>.

bathymetric data to create new, higher-resolution maps of the Great Lakes by 2030.⁷⁸ Some stakeholders have noted that modern bathymetric data are “critical for effective management, research, and innovation, particularly under mounting climate change threats and growing blue economy in the Great Lakes region.”⁷⁹

How Have Congress and the President Directed Federal Agencies to Support Ocean and Coastal Mapping Efforts?

Congress has directed multiple federal agencies to support and complete ocean and coastal mapping over several decades. For example, Congress authorized and directed NOAA to carry out ocean and coastal mapping activities under the Coast and Geodetic Survey Act of 1947 (P.L. 80-737), the Hydrographic Services Improvement Acts (P.L. 105-384, P.L. 107-372, and P.L. 110-386), and the Ocean and Coastal Mapping Integration Act of 2009 (P.L. 111-11), among other laws.⁸⁰ Various entities, such as the IWG-OCM, have identified additional statutory authorities related to ocean and coastal mapping (**Table 3**).⁸¹ Congress has amended some of these authorities over time or provided additional directives in appropriations laws and accompanying congressional reports and explanatory statements;⁸² those amendments and additional directives are not listed in **Table 3**. For example, the Hydrographic Services Improvement Act (P.L. 105-384) has been amended twice (P.L. 107-372 and P.L. 110-386).

Table 3. Chronology of Selected Federal Ocean and Coastal Mapping-Related Authorities

Year	Name	P.L. Number or Statute at Large
1870	Organic Act of 1870 (established the National Weather Service)	16 Stat. 369
1879	Organic Act of 1879 (established the United States Geological Survey)	20 Stat. 394
1916	Organic Act of 1916 (established the National Park Service)	P.L. 64-235
1938	Federal Food, Drug, and Cosmetic Act	P.L. 75-717

⁷⁸ Partners of Lakebed 2030 include GLOS, USGS, NOAA, Northwestern Michigan College, and the Canadian Hydrographic Service. Ibid.

⁷⁹ GLOS, “Lakebed 2030,” at <https://glos.org/priorities/lakebed-2030/>. In general, the *blue economy* refers to the collective economic value of the resources, uses, and activities of the ocean and coasts. For more information about the blue economy, see CRS In Focus IF12188, *What Is the Blue Economy?*, by Caitlin Keating-Bitonti and Eva Lipiec.

⁸⁰ Email correspondence with NOAA, Congressional Affairs Specialist, OLIA, April 18, 2023.

⁸¹ NOAA, “Integrated Ocean & Coastal Mapping, Mandates and Drivers,” at <https://iocm.noaa.gov/about/mandates.html>.

⁸² For example, in the explanatory statement accompanying the Consolidated Appropriations Act, 2023, Congress directed NOAA to use certain funds for “a NOAA Center of Excellence for Operational Ocean and Great Lakes Mapping,” specifying that, “Working in unison with and leveraging existing capabilities, including the Joint Hydrographic Center, the Center shall work across NOAA line offices, including [the National Ocean Service (NOS)], [the Office of Oceanic and Atmospheric Administration], and the Office of Marine and Aviation Operations (OMAO), to support and grow the Nation’s deep water, shallow water, and coastal mapping capabilities and data holdings, in partnership with industry.” The statement also directed “NOS to continue coordinating and implementing an interagency mapping, exploration, and characterization strategy for the U.S. Exclusive Economic Zone, as well as the Strategy for Mapping the Arctic and Sub-Arctic Shoreline and Nearshore of Alaska consistent with prior year direction adopted in Public Law 117–103” (Senator Leahy, Congressional Record).

Year	Name	P.L. Number or Statute at Large
1947	Coast and Geodetic Survey Act of 1947	P.L. 80-737
1950	National Science Foundation Act of 1950	P.L. 81-507
1953	Submerged Lands Act	P.L. 83-31
	Outer Continental Shelf Lands Act	P.L. 83-212
1958	National Aeronautics and Space Act of 1958	P.L. 85-568
1966	Soil Surveys Act	P.L. 89-560
	National Historic Preservation Act	P.L. 89-665
	National Wildlife Refuge System Administration Act	P.L. 89-669
1969	National Environmental Policy Act	P.L. 91-190
1972	Marine Mammal Protection Act	P.L. 92-522
	National Marine Sanctuaries Act	P.L. 92-532, Title III
	Coastal Zone Management Act	P.L. 92-583
1973	Endangered Species Act	P.L. 93-205
1974	Deepwater Port Act of 1974	P.L. 93-627
1976	Magnuson-Stevens Fishery Conservation and Management Act	P.L. 94-265
1979	Archaeological Resources Protection Act of 1979	P.L. 96-95
1984	Arctic Research and Policy Act of 1984	P.L. 98-373
1986	Emergency Wetlands Resources Act of 1986	P.L. 99-645
	Water Resources Development Act of 1986	P.L. 99-662
1987	Great Lakes Shoreline Mapping Act of 1987	P.L. 100-220, Title III, Subtitle B
1990	Oil Pollution Act of 1990	P.L. 101-380
	Global Change Research Act of 1990	P.L. 101-606
1998	Hydrographic Services Improvement Act	P.L. 105-384
2002	Maritime Transportation Security Act of 2002	P.L. 107-295
2005	Energy Policy Act of 2005	P.L. 109-58
2007	Energy Independence and Security Act	P.L. 110-140
2009	Omnibus Public Land Management Act	P.L. 111-11
	NOAA Undersea Research Program Act of 2009	P.L. 111-11, Title XII, Subtitle A, Part II
	Ocean and Coastal Mapping Integration Act of 2009	P.L. 111-11, Title XII, Subtitle B
	Integrated Coastal and Ocean Observation System Act of 2009	P.L. 111-11, Title XII, Subtitle C
2011	National Defense Authorization Act for Fiscal Year 2012	P.L. 112-81, Title III, Subtitle G
2015	Consolidated Appropriations Act, 2016 ^a	P.L. 114-113
2017	Weather Research and Forecasting Innovation Act of 2017	P.L. 115-25

Year	Name	P.L. Number or Statute at Large
2018	Geospatial Data Act of 2018	P.L. 115-254, Title VII, Subtitle F
2020	Digital Coast Act	P.L. 116-223
2022	National Defense Authorization Act for Fiscal Year 2023	P.L. 117-263, Division J, Title CIII

Source: CRS; NOAA, “Integrated Ocean & Coastal Mapping, Mandates and Drivers,” at <https://iocm.noaa.gov/about/mandates.html>.

Notes: The table does not include a comprehensive list of laws pertaining to ocean and coastal mapping. Laws passed before 2017 were in part identified from a list provided on the website of the Interagency Working Group on Ocean and Coastal Mapping.

- a. The Consolidated Appropriations Act, 2016, established the Great Lakes Restoration Initiative.

In addition to congressional directives, IWG-OCM identified executive actions that further direct federal ocean and coastal mapping. These actions include E.O. 13547, “Stewardship of the Ocean, Our Coasts, and the Great Lakes;”⁸³ E.O. 13817, “A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals;”⁸⁴ E.O. 13840, “Ocean Policy to Advance the Economic, Security, and Environmental Interests of the United States”; and the 2019 Presidential Memorandum on Ocean Mapping of the United States Exclusive Economic Zone and the Shoreline and Nearshore of Alaska.

Federal departments and agencies engage in ocean and coastal mapping activities under both specific and general authorities provided by Congress that guide each agency’s mission. For example, NOAA conducts mapping activities in state, federal, and international waters. In the Department of the Interior, the Bureau of Ocean Energy Management (BOEM) participates in ocean mapping activities in federal waters as part of its management of offshore energy and mineral development; the USGS conducts ocean mapping activities in state and federal waters for geologic, mineral, and hazard-related assessments; and the FWS maps wetlands and submerged aquatic vegetation habitats within the coastal zone of the United States. In the Department of Defense, USACE conducts coastal mapping for its water resource projects and responsibilities, which primarily occur in state waters, and the U.S. Navy carries out ocean mapping activities worldwide in support of naval missions and for some civilian purposes. **Table 4** provides a summary of selected federal department and agency ocean and coastal mapping activities.

Table 4. Selected Federal Department and Agencies Involved in U.S. Ocean and Coastal Mapping

(listed alphabetically by department and agency)

Department	Agency	Summary of Mapping Activities
Department of Agriculture	Natural Resources Conservation Service (NRCS)	NRCS maps soil resources, including those in coastal zone areas.
	U.S. Forest Service (FS)	FS works with the USGS to create topographic mapping products of U.S. surface waters, such as lakes and rivers.

⁸³ Executive Order 13547, “Stewardship of the Ocean, Our Coasts, and the Great Lakes,” 75 *Federal Register* 43021, July 22, 2010.

⁸⁴ Executive Order 13817, “A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals,” 82 *Federal Register* 60835, December 26, 2017.

Department	Agency	Summary of Mapping Activities
Department of Commerce	National Oceanic and Atmospheric Administration (NOAA)*	NOAA collects, uses, and manages ocean and coastal mapping data to support its research, stewardship, and public outreach missions. NOAA partners with federal, state, and local agencies; academia; nongovernmental organizations; and the private sector to develop mapping standards and techniques, manage data, and implement projects.
Department of Defense	National Geospatial-Intelligence Agency (NGA)*	NGA provides mapping resources for coastal flood hazard analysis.
	U.S. Army Corps of Engineers (USACE)*	The USACE National Coastal Mapping Program collects elevation and imagery data around certain U.S. coastlines about every five years in support of its civil works activities, including for the purposes of regional sediment management. USACE collaborates with the U.S. Navy, NOAA, and USGS, along with contractor support, to conduct its coastal mapping and charting. This collaboration is known as the Joint Airborne Lidar Bathymetry Technological Center of Expertise.
	U.S. Navy*	The U.S. Navy collects oceanographic, hydrographic, bathymetric, geophysical, and acoustic data to provide the warfighter knowledge of the battlespace. The Office of Naval Research maps and characterizes the seafloor and water column in support of naval missions and for some civilian purposes.
Department of Homeland Security	Federal Emergency Management Agency (FEMA)*	FEMA uses LiDAR data of the U.S. coast collected by NOAA and USACE to conduct mapping studies to produce Flood Insurance Rate Maps and other products to inform coastal communities about flood risk and other natural hazards. FEMA evaluates and updates flood maps along populated U.S. coastlines in collaboration with other federal agencies, states, local communities, nonprofits, academic institutions, and the private sector.
	U.S. Coast Guard (USCG)*	USCG maintains more than 50,000 navigation aids, including buoys, lighthouses, beacons, and radio-navigation signals, on U.S. waterways.
Department of the Interior	Bureau of Ocean Energy Management (BOEM)*	BOEM collects and uses ocean mapping data as part of its management of offshore energy and mineral development. The data inform resource assessments, site characterization, and environmental analysis, among other purposes. BOEM collaborates with partners including NOAA and USGS to map, explore, and characterize deepwater benthic (i.e., seafloor) environments. BOEM also collects and manages data, such as geological and geophysical survey data, from offshore permittees and lessees.

Department	Agency	Summary of Mapping Activities
	National Park Service (NPS)*	NPS administers more than 80 ocean and coastal parks and engages in benthic habitat mapping at and around these locations. NPS's Ocean and Coastal Resources Program has partnered with government agencies and universities to map submerged habitat in parks.
	U.S. Fish and Wildlife Service (FWS)*	FWS uses coastal and ocean mapping data to manage resources within the U.S. marine and coastal zone, including Marine National Monuments and National Wildlife Refuges, among others. FWS also uses these data to identify future waters for resource management. FWS manages the National Wetlands Inventory, which provides information on the extent of wetland and submerged aquatic vegetation habitats within the U.S. coastal zone.
	U.S. Geological Survey (USGS)*	The USGS collects, uses, and manages ocean and coastal mapping data for geologic, mineral, and hazard-related assessments. The USGS Coastal National Elevation Database develops integrated topobathymetric models for U.S. coastal areas, the Great Lakes, and certain Western Pacific islands and atolls. Topobathymetric models are used to map flood zones from hurricanes and sea-level rise. ^a
Department of State	Bureau of Oceans and International Environmental and Scientific Affairs	The Office of Polar and Ocean Affairs facilitates diplomatic marine scientific research consent for U.S. scientists to conduct research cruises in certain coastal countries while allowing foreign scientists to conduct research in U.S. waters.
Independent	Environmental Protection Agency (EPA)*	The EPA maintains an interactive mapping application comprising over 500 maps, including maps displaying scenarios of sea level rise inundation modeled by NOAA. Most of these maps are for the onshore continental United States.
	National Aeronautics and Space Administration (NASA)*	NASA uses ocean remote sensing technologies to map and characterize coastal regions as part of its ocean observing and modeling strategy. Satellite missions that have contributed to bathymetric mapping include the Ice, Cloud and Land Elevation Satellite 2 (ICESat-2); Surface Water and Ocean Topography (SWOT); and Joint Altimetry Satellite Oceanography Network (JASON) series. ^b

Department	Agency	Summary of Mapping Activities
	National Science Foundation (NSF)*	NSF's Geosciences Directorate provides federal funding for basic research at academic institutions, and its Division of Ocean Sciences (OCE) supports ocean science-based projects. All ocean mapping and characterization data collected under OCE awards, the Academic Research Fleet, or other mechanisms are made publicly available within two years of collection. NSF also supports the Global Multi-Resolution Topography Data Synthesis initiative, a compilation of edited multibeam sonar data collected by scientists and institutions worldwide.

Source: CRS; NOAA, “Integrated Ocean & Coastal Mapping, Interagency Working Group—Ocean and Coastal Mapping,” at <https://iocm.noaa.gov/about/iwg-ocm.html>; and NOAA, “Integrated Ocean & Coastal Mapping, NOAA IOCM Coordination Team,” at <https://iocm.noaa.gov/about/noaa-iocm-team.html>.

Notes: Agencies followed by an asterisk (*) are required to be a part of the Interagency Working Group on Ocean and Coastal Mapping (IWG-OCM; 33 U.S.C. §3502(b)). Other selected agencies included in the table were in part identified from a list provided on the IWG-OCM’s website.

- a. Topobathymetric models rely on LiDAR technologies to measure three types of surfaces: land, water, and underwater terrain.
- b. For more information on selected satellites, see CRS Report R46560, *Landsat 9 and the Future of the Sustainable Land Imaging Program*, by Anna E. Normand, and CRS Report R47021, *Federal Involvement in Ocean-Based Research and Development*, by Caitlin Keating-Bitonti.

How Are Federal Ocean and Coastal Mapping Efforts Coordinated?

The 2019 Presidential Memorandum on Ocean Mapping of the United States Exclusive Economic Zone and the Shoreline and Nearshore of Alaska directed certain departments and agencies to support federal ocean and coastal mapping efforts.⁸⁵ This presidential memorandum required the Ocean Policy Committee, working through its Ocean Science and Technology Subcommittee (both established under E.O. 13840), to develop a mapping strategy for the U.S. EEZ.⁸⁶ The mapping scope includes both the U.S. EEZ and state waters. The strategy recommended the creation of the National Ocean Mapping, Exploration, and Characterization (NOMECE) Council.⁸⁷ The James M. Inhofe National Defense Authorization Act for Fiscal Year 2023 codified the NOMECE Council.⁸⁸

The NOMECE Council includes members from 11 federal departments and agencies: BOEM, Department of Defense, Department of Transportation, NASA, NOAA, NSF, Office of the Director of National Intelligence, U.S. Coast Guard, USGS, White House Office of Management

⁸⁵ Presidential Memorandum on Ocean Mapping of the U.S. EEZ, 2019

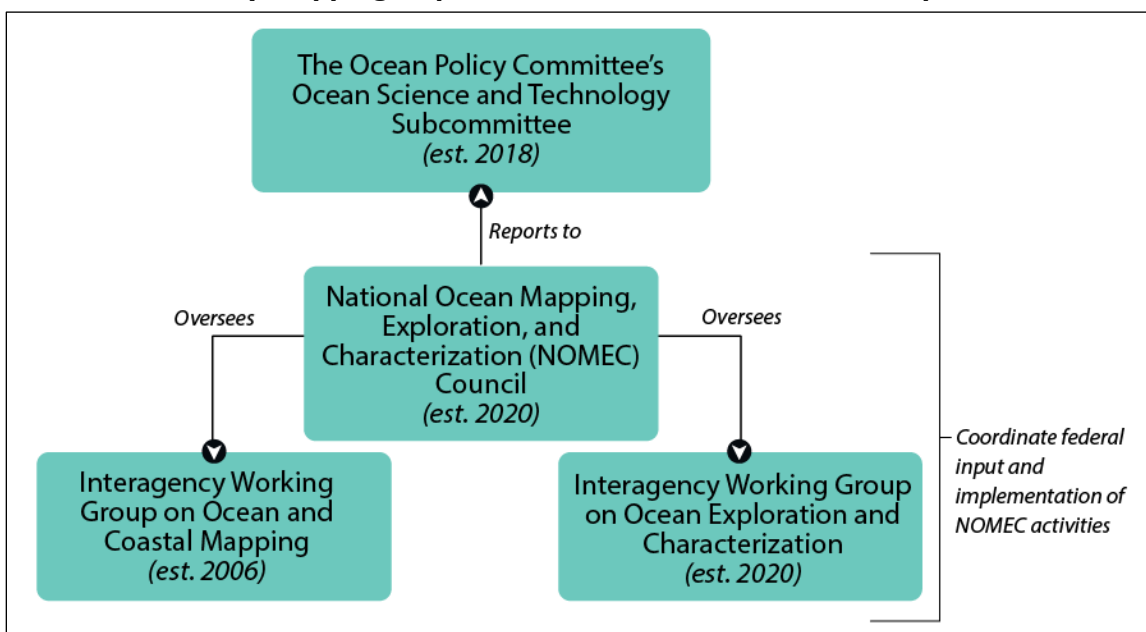
⁸⁶ The Ocean Policy Committee was codified by the William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021 (P.L. 116-283), Title X, Subtitle E. For more information on the structure of the Office of Science and Technology Policy, see CRS Report R47410, *The Office of Science and Technology Policy (OSTP): Overview and Issues for Congress*, by Emily G. Blevins.

⁸⁷ NOMECE Strategy, 2020, p. 6.

⁸⁸ P.L. 117-263, Division J, Title CIII.

and Budget, and White House Office of Science and Technology Policy.⁸⁹ The NOMECE Council is cochaired by two senior-level representatives from NOAA and one senior-level representative from the Department of the Interior.⁹⁰ Congress passed the James M. Inhofe National Defense Authorization Act for Fiscal Year 2023 requiring the NOMECE Council to report to the Ocean Science and Technology Subcommittee and to oversee the work of the IWG-OCM and the Interagency Working Group on Ocean Exploration and Characterization (**Figure 5**).⁹¹ Federal agency membership may overlap or differ across the NOMECE Council, IWG-OCM, and the Interagency Working Group on Ocean Exploration and Characterization (**Table A-1**).

Figure 5. Structure of the Interagency Committees, Councils, and Working Groups with Primary Mapping, Exploration, and Characterization Responsibilities



Source: CRS; Ocean Policy Committee, Ocean Science and Technology Subcommittee, *National Strategy for Mapping, Exploring, and Characterizing the United States Exclusive Economic Zone*, June 2020, p. 7.

Notes: Ocean Policy Committee was created on January 19, 2018 by Executive Order 13840 “Regarding the Ocean Policy to Advance the Economic, Security, and Environmental Interests of the United States” and was later codified by the James M. Inhofe National Defense Authorization Act for Fiscal Year 2021 (Title X, Subtitle E, P.L. 116-283). NOMECE = National Ocean Mapping, Exploration, and Characterization.

⁸⁹ NOAA, “NOMECE Council and Member Agencies,” at <https://www.noaa.gov/nomece/nomece-council-and-member-agencies>.

⁹⁰ A representative from the USGS serves as a cochair of the NOMECE Council for the Department of the Interior. Ibid and P.L. 117-263, Division J, Title CIII, §10304(e).

⁹¹ P.L. 117-263, Division J, Title CIII.

How Are Nonfederal Partners and Crowdsourced Data Involved in Federal Ocean and Coastal Mapping Efforts?

Crowdsourced bathymetric data have supported U.S. federal efforts to map U.S. ocean and coastal waters.⁹² Crowdsourced bathymetric data are water-depth measurements collected using standard navigation instruments (e.g., from vessels engaged in routine maritime operations).⁹³ These data may supplement current bathymetric coverage and help determine whether an ocean or coastal area needs to be remapped. They also may fill data gaps, such as data for complex coastline areas that are difficult for traditional survey vessels to access. NOAA manages crowdsourced bathymetric data contributed by several providers, including GLOS.⁹⁴ International seabed mapping efforts, including Seabed 2030, Lakebed 2030, and the International Hydrographic Organization, also use crowdsourced data.⁹⁵

Federal agencies participate in nonfederal partnerships to help map U.S. ocean and coastal waters. Nonfederal partners may contribute bathymetric data and provide resources to help collect data. For example, the USACE contracts for the aircraft to fly its LiDAR instruments.⁹⁶ Offshore energy developers also generate some ocean mapping data that are shared with the federal government. Oil and gas companies and offshore wind developers collect geological and geophysical survey data to locate resources or inform project siting on the outer continental shelf.⁹⁷ Under the Outer Continental Shelf Lands Act (43 U.S.C. §§1331-1356c) and implementing regulations, BOEM is authorized to acquire such industry-collected data.⁹⁸ BOEM uses the information to support its energy resource assessments, studies of the composition and volume of seafloor sediment deposits, identification of geological hazards and benthic habitats, and other activities.⁹⁹ However, privileged and proprietary data must be kept confidential for specified time periods (generally ranging from 10 to 50 years), pursuant to statutory provisions.¹⁰⁰

Nonfederal partners also may help the federal government meet its NOMECS goals (see “What Are U.S. Goals for Ocean and Coastal Mapping?”).¹⁰¹ According to the NOMECS Strategy,

Academic and non-profit institutions and cooperative institutes provide the expertise for ocean and coastal mapping, exploration, and characterization. These partnerships provide

⁹² For example, see NOAA, “NOAA Announces Launch of Crowdsourced Bathymetry Database,” May 31, 2018, at <https://nauticalcharts.noaa.gov/updates/noaa-announces-launch-of-crowdsourced-bathymetry-database/>.

⁹³ The Nippon Foundation-GEBCO Seabed 2030 Project, “Crowd Sourced Bathymetry,” at <https://seabed2030.org/crowd-sourced-bathymetry#>.

⁹⁴ NOAA, “Bathymetric Data Viewer,” at <https://www.ncei.noaa.gov/maps/bathymetry/>.

⁹⁵ See *Ibid*; GLOS, “GLOS-Funded Crowdsourced Bathymetry Is Now Live on a Public Database,” October 18, 2022, at <https://glos.org/glos-funded-crowdsourced-bathymetry-is-now-live-on-a-public-database/>; International Hydrographic Organization (IHO), “IHO Crowdsourced Bathymetry Initiative” at <https://www.ngdc.noaa.gov/ih/>.

⁹⁶ USACE, remote briefing to CRS, April 25, 2023.

⁹⁷ For more information, see BOEM, “Geological and Geophysical (G&G) Surveys,” fact sheet, at <https://www.boem.gov/sites/default/files/about-boem/BOEM-Regions/Atlantic-Region/GandG-Overview.pdf>.

⁹⁸ 43 U.S.C. §1352; 30 C.F.R. Part 551 and §§585.610-585.611.

⁹⁹ See, for example, BOEM, *Gulf of Mexico OCS Proposed Geological and Geophysical Activities: Final Programmatic Environmental Impact Statement*, August 2017, chapter 1, p. 4, at <https://www.boem.gov/sites/default/files/environmental-stewardship/Environmental-Assessment/NEPA/BOEM-2017-051-v1.pdf>.

¹⁰⁰ 43 U.S.C. §1352(c); 30 C.F.R. §551.14.

¹⁰¹ NOMECS Strategy, 2020, p. 17.

access to a wealth of ocean exploration resources, including ships, autonomous and remotely operated vehicles, expertise, and opportunities for technology testing and development.¹⁰²

In the James M. Inhofe National Defense Authorization Act for Fiscal Year 2023, Congress directed the NOMECE Council to “promote new and existing partnerships among Federal and State agencies, Indian Tribes, private industry, academia, and non-governmental organizations to conduct or support ocean mapping, exploration, and characterization activities and technological development needs.”¹⁰³ These partnerships may be employed through mechanisms such as federal contracts, competitive grants, and cooperative research and development agreements. For example, in 2021, NOAA entered into a memorandum of agreement with an offshore wind development company (Ørsted Wind Power North America LLC). The company agreed to share data collected within their leased waters subject to U.S. jurisdiction with NOAA to help fill in ocean mapping gaps.¹⁰⁴ In another example, NOAA announced the creation of the Brennan Matching Fund (BMF) in 2021 to encourage nonfederal entities to partner with NOAA to acquire more ocean and coastal survey data.¹⁰⁵ In 2022, Congress codified the BMF through the James M. Inhofe National Defense Authorization Act for Fiscal Year 2023. In FY2023, NOAA provided funding for two BMF projects.

1. NOAA’s partnership with the Connecticut Department of Energy and Environmental Protection aims to use multibeam and backscatter approaches to identify potential constraints for the installation of offshore wind electric transmission cables.
2. NOAA’s partnership with the Cordova, AK, Electric Cooperative aims to use LiDAR to support the laying of an undersea power cable to a regional Federal Aviation Administration flight station.¹⁰⁶

Congress may wish to evaluate the work and progress of congressionally directed or funded federal and nonfederal partnerships aimed at collecting and analyzing new bathymetric data. Congressional oversight may determine if the efforts of these partnerships are contributing to the goals of the NOMECE Strategy. In addition, Congress may consider whether to continue providing funding to public-private ocean and coastal mapping partnerships.

¹⁰² Ibid, pp. 17-18.

¹⁰³ P.L. 117-263, Division J, Title CIII, §10304(i)(2)(G).

¹⁰⁴ Ørsted bathymetric data are made available on NOAA’s Bathymetric Data Viewer (<https://www.ncei.noaa.gov/maps/bathymetry/>). NOAA, “NOAA Signs Data-Share Agreement with Offshore Wind energy Company,” at <https://www.noaa.gov/media-release/noaa-signs-data-share-agreement-with-offshore-wind-energy-company>.

¹⁰⁵ For example, NOAA, “Notice of Matching Fund Opportunity for Ocean and Coastal Mapping and Request for Partnership Proposals,” 87 *Federal Register* 35509, June 10, 2022.

¹⁰⁶ Email correspondence with NOAA, Congressional Affairs Specialist, OLIA, April 14, 2023.

Appendix.

Over 20 federal agencies, departments, and offices participate in aspects of ocean and coastal mapping, exploration, or characterization. Federal agency membership may overlap or differ across the National Ocean Mapping, Exploration, and Characterization (NOMECE) Council, Interagency Working Group on Ocean and Coastal Mapping (IWG-OCM), and Interagency Working Group on Ocean Exploration and Characterization (IWG-OEC). (See **Table A-1**.)

Table A-1. Selected Federal Departments, Agencies, and Offices Involved in U.S. Ocean and Coastal Mapping

Federal Department, Agency, or Office	Coordination Body Membership		
	NOMECE Council ^a	IWG-OCM ^b	IWG-OEC ^c
Bureau of Ocean Energy Management	X	X	X
Department of Defense	X	—	—
Department of Energy	—	—	X
Department of the Interior, Office of the Assistant Secretary for Fish, Wildlife, and Parks	—	X	—
Department of Transportation	X	—	—
Environmental Protection Agency	—	X	—
Federal Emergency Management Agency	—	X	—
National Aeronautics and Space Administration	X	X	X
National Geospatial-Intelligence Agency	—	X	—
Office of the Secretary of Defense	—	—	—
National Oceanic and Atmospheric Administration	X	X	X
National Park Service	—	X	—
National Science Foundation	X	X	X
U.S. Coast Guard	X	X	—
U.S. Fish and Wildlife Service	—	X	—
U.S. Food and Drug Administration	—	—	X
U.S. Geological Survey	X	X	X
U.S. Army Corps of Engineers	—	X	—
U.S. Navy	—	X	X
U.S. Park Service	—	—	—
White House Office of Management and Budget	X	—	X
White House Office of the Director of National Intelligence	X	—	X
White House Office of Science and Technology Policy	X	—	X

Source: Congressional Research Service.

Notes: IWG-OCM = Interagency Working Group on Ocean and Coastal Mapping; IWG-OEC = Interagency Working Group on Ocean Exploration and Characterization (IWG-OEC); NOMECE = National Ocean Mapping, Exploration, and Characterization.

- a. Membership identified from National Oceanic and Atmospheric Administration, “NOMECE Council and Member Agencies,” at <https://www.noaa.gov/nomec/nomec-council-and-member-agencies>.
- b. Membership identified in 33 U.S.C. §3502(b).
- c. Membership identified from the IWG-OEC, *Strategic Priorities for Ocean Exploration and Characterization of the United States Exclusive Economic Zone*, October 2022, p. 4.

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