4.0 CUMULATIVE IMPACTS

Cumulative impacts are defined by the Council on Environmental Quality (CEQ) regulations in 40 Code of Federal Regulations (CFR) 1508.7 (1978) as the "impact on the environment which results from the incremental impact of the [proposed] action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such actions. Cumulative impacts can result from individually minor, but collectively significant, actions taking place over a period of time."

Cumulative effects may be additive or interactive. Additive effects are the sum of the effects on a resource; for example, groundwater pumping for agricultural irrigation, domestic consumption, and industrial cooling and process activities that all contribute incrementally and additively to drawing down a groundwater aquifer. Interactive effects may be either countervailing – where the net adverse cumulative effect is less than the sum of the individual effects – or synergistic – where the net adverse cumulative effect is greater than the sum of the individual effects. An example of a countervailing effect is when particulate matter and aerosol air pollutants, which tend to block or reflect insolation (sunlight or incoming solar radiation) and thus cool the planet surface, counteract the warming or radiative forcing effect of carbon dioxide emitted at the same time. The discharge of nutrients and heated water to a river that combine to cause an algal bloom and subsequent loss of dissolved oxygen greater than the additive effects of each individual pollutant is an example of a synergistic effect. CEQ recommends that the cumulative impact analysis be narrowed as much as possible to focus on important issues at a national, regional, or local level (CEQ, 1997). The first step in the cumulative impacts analysis is to identify cumulative actions. The second step is to analyze how, if at all, the effects of the Proposed Action may contribute to the effects of the cumulative actions thereby resulting in cumulative impacts (Section 4.2).

4.1 CUMULATIVE ACTIONS

Per 40 CFR 1508.25(a)(2), cumulative actions are those past, present, and reasonably foreseeable future actions that must be addressed in a cumulative effects analysis because their environmental effects may combine with the effects of the Proposed Action addressed in the National Environmental Policy Act (NEPA) document (CEQ, 1997a). Based on the scope of the National Ocean Service (NOS) Proposed Action and the amount of information available regarding the past, present, and reasonably foreseeable future actions taking place in the action area that was defined in Chapter 2, NOS has considered actions taking place during a 17-year period spanning from 2010 to 2027. Due to the volume and diversity of these cumulative actions, this section identifies specific projects and programs, both public and private sector, but also relevant environmental and economic trends.

In addition to the more substantial or widespread cumulative actions described in Sections 4.1.1-4.1.12, the resources in the action area, particularly biological resources, are sensitive to other human activities that should also be considered in the cumulative impact analysis, when appropriate. These additional activities include:

- Accumulation of marine debris from marine or terrestrial sources (e.g., plastics, polystyrene, glass, metals, or rubber);
- Accidental or illicit discharges (e.g., oil or fuel spills or other introduction of chemical contaminants);
- Habitat encroachment from onshore and nearshore development (e.g., as a function of coastal population growth);

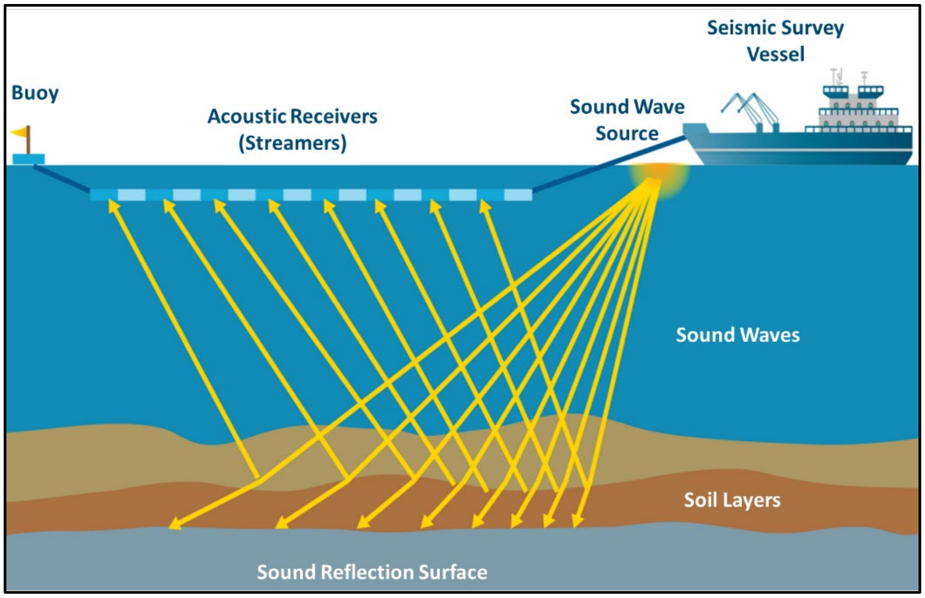
- Illegal, unreported, and unregulated (IUU) fishing;
- Flows of non-point source pollutants, contaminants, sediments, and nutrients from urbanized and agricultural areas in watersheds into coastal waters, with the greatest adverse effects experienced in waters with limited circulation such as bays, sounds, and estuaries.

As a result of the ongoing global COVID-19 pandemic, there has been a measurable decrease in maritime activities, including the delay and cancelation of ocean research projects, to ensure the health and safety of maritime workers and the coastal population. The reduction in overall maritime activity such as shipping, fishing operations, recreation/tourism, and research efforts would be expected to reduce long-term and short-term impacts on coastal environments and the ambient ocean sound level; however, impacts are not fully known (NOAA, 2020c). At the same time, the ongoing pandemic is expected to reduce the beneficial economic impacts of many maritime activities (NMFS, 2021). Despite the potential short- and long- term cumulative effects of the ongoing global COVID-19 pandemic on the resources evaluated in this Draft PEIS, the pandemic is not considered in this analysis the because its effects are not fully known. In general, decreases in maritime activity would be expected to decrease impacts to the coastal environment; therefore, the conservative assumption is to assess cumulative impacts under pre-pandemic cumulative actions.

4.1.1 Other Surveying and Mapping Efforts in the Action Area

As of the summer of 2010, only 906,496 square kilometers (km^2) (350,000 square miles [mi^2]) of seafloor, less than 8 percent of the EEZ, had been mapped in the Atlantic, Pacific, Gulf of Mexico, and Arctic (NSTC, 2013). As of 2020, 43 percent of the 8,905,960 km^2 (3.4 million square nautical miles [nm^2]) of U.S. underwater territory is mapped to modern standards (NOAA, 2020b). Given the many applications of the collected data, agencies at all governmental levels, universities, non-profit research institutions, and the private sector, conduct surveying and mapping projects in the action area.

Other agencies or private groups performing hydrographic surveys would use echo sounders and equipment similar to those described in Chapter 2. Surveying and mapping projects that use a combination of different equipment and techniques can be referred to by what they are mapping rather than by the type of surveying equipment used. Benthic (ocean floor or lake bottom) habitat mapping entails using a combination of techniques, such as acoustics and lidar, to create a spatially explicit way to identify submerged features (NPS, 2018b). Geological and geophysical (G&G) surveys are used to map gas hydrate deposits, bedrock characteristics, and marine mineral resources (BOEM, 2018b; USGS, 2020b). Marine seismic surveys are a type of G&G survey that use a variety of acoustic sources to image sediment and rock deep below the seafloor (USGS, 2020b). For example, deep penetration seismic airgun surveys are conducted by vessels towing an array of airguns that produce low frequency sound pulses that penetrate deep into the subsurface and are then reflected and recorded by receivers to image deep geological features (BOEM, 2018b). This mechanism is illustrated in **Figure 4.1-1** below.



Source: BOEM 2018a

Figure 4.1-1. Deep Penetration Seismic Airgun Surveying

High resolution geophysical (HRG) surveys are another type of G&G survey which use sound waves that are reflected off submerged structures to collect data on conditions both at the seafloor and the shallow subsurface. HRG equipment generally includes the sonar survey equipment described in Chapter 2 (e.g., multibeam echo sounders, side-scan sonars, sub-bottom profilers). HRG systems usually use higher frequencies than those used in seismic airgun surveys and image smaller structures with a higher level of detail (BOEM, 2018b). HRG surveys, deep penetration seismic surveys, and other types of G&G surveys are used during the preliminary resource assessment phases for O&G exploration, renewable energy siting, and marine mineral projects (BOEM, 2018b).

Surveying and mapping projects can also involve the collection of “core” (samples that preserve surface and subsurface sediment layers) and “grab” samples from the seafloor. Additional equipment used in these projects can include pressure gauges for measuring waves and currents, Acoustic Doppler Current Profilers (ADCPs) for measuring water depth, autonomous and towed instrumentation for characterizing ocean chemistry, and optical backscatter remote-sensing instruments for estimating the concentration of sediment in the water column (USGS, 2020a).

Coordination within the ocean and coastal mapping community is facilitated through the Interagency Working Group on Ocean and Coastal Mapping (IWG-OCM) under the National Ocean Council (NSTC, 2016; IOCM, 2018). In addition to NOAA, other federal agencies that undertake or permit surveying and mapping projects include BOEM, Federal Emergency Management Agency (FEMA), National Park Service (NPS), Naval Oceanographic Office (NAVO), United States Army Corps of Engineers (USACE), and United States Geological Survey (USGS).

Universities, Non-Profit Research Institutions, and Other Private Sector Efforts. Many of the federal agencies that undertake or permit surveying and mapping projects support research conducted at universities, non-profits, and other institutions. Ocean use activities are coordinated through the University-National Oceanographic Laboratory System (UNOLS), an organization of academic institutions and National Laboratories (UNOLS, No Date). UNOLS vessels conduct a wide array of research activities including marine seismic research and oceanographic aircraft research (UNOLS, 2019).

Given the exceptional variability and vast number of surveying and mapping activities in the action area, it is not possible to provide an exhaustive list of all projects in the action area; however, by identifying regional surveying and mapping needs and using incidental take authorization data, reasonably foreseeable surveying and mapping projects are described for each region.

Due to their potential impact to marine mammals, surveying and mapping projects that use active acoustic sources require incidental take authorizations granted by the National Marine Fisheries Service (NMFS) under the Marine Mammals Protection Act (MMPA) (NMFS, 2019e). A list of recent surveying and mapping projects that require incidental take authorization is presented for each region below as a representative, not exhaustive, list of other surveying and mapping projects. These projects are categorized as G&G surveys, ecological monitoring, or fisheries management and research because of the difference in potential impact. G&G surveys are typically localized and require the use of high intensity active acoustic sources that penetrate the surface of the seafloor, while ecological monitoring and fisheries management and research generally use lower intensity active acoustic sources. Projects with an active take authorization status and projects with a take authorization application in-process are considered reasonably foreseeable to occur within the next five years and are categorized as ongoing activities. Projects that have been granted take authorizations that have expired within the past 10 years are considered activities that have occurred within the past 10 years. Smaller data acquisition projects and hydrographic surveys that did not require incidental take authorization are not captured in **Tables 4.1-1-4.1-5**. Although projects that require take authorization are not the only projects occurring in the action area, they are used as a representative list because projects that require take authorization are expected to be the projects with the greatest impact.

4.1.1.1 Greater Atlantic Region

The Chesapeake Bay is the largest of 130 estuaries in the U.S. and much of it has not been charted since the 1930s and 1940s, causing great interest in new surveying and mapping of the area (NOAA, No Date-b). Additionally, the National Science Foundation (NSF) has funded marine geophysical surveys off the New Jersey coast and Cape Hatteras and has previously partnered with the USGS to conduct seismic surveys throughout the Atlantic (NSF, No Date). Additional surveying and mapping projects are expected to occur in the region for offshore renewable energy project siting, ecological monitoring, fisheries management, and navigational purposes; a representative list of these projects is presented below in **Table 4.1-1** (NOAA, No Date-b; NMFS, 2019e).

Table 4.1-1. Representative List of Surveying and Research Projects within the Greater Atlantic Region

Type of Surveying and Mapping Activity	Project Category	General Location / Geographic Scope	Project Lead	Project/Permit Description
Ongoing Activities				
Ecological Monitoring	Research/Other	Eastern MA NWRs	USFWS	Seabird and shorebird monitoring and research

Type of Surveying and Mapping Activity	Project Category	General Location / Geographic Scope	Project Lead	Project/Permit Description
Fisheries Management and Research	Research/Other	Atlantic Coast Region	NMFS NEFSC	Northeast fisheries and ecosystem research activities
		Atlantic Ocean south of Long Island	NMFS SEFSC	Fisheries and ecosystem research activities in the Atlantic Ocean
G&G Survey	Offshore Wind	NY	Equinor Wind LLC	Offshore wind surveys
		Offshore New England	Orsted Ocean Wind LLC	Marine site characterization surveys, offshore NJ
		Offshore of DE and MD	Skipjack	Site characterization surveys
Activities within the Past 10 years				
Ecological Monitoring	Research/Other	Cape Cod MA NWRs; Eastern MA NWRs	USFWS	Seabird and shorebird monitoring and research
G&G Survey	Offshore Wind	Nantucket Sound, MA	Cape Wind Associates	High-resolution seismic survey in Nantucket Sound, MA
		Offshore RI	Deepwater Wind LLC	Marine site characterization surveys, offshore NY
		Offshore RI	Deepwater Wind New England LLC	Marine site characterization surveys, offshore NY, RI
		MA	DONG Energy MA LLC	Geophysical and Geotechnical Surveys Offshore MA
		Offshore DE	Garden State Offshore Energy LLC	Marine site characterization (geophysical and geotechnical) surveys for Skipjack Wind farm
		Offshore Atlantic City, NJ	Ocean Wind LLC	Marine site characterization surveys, offshore NJ
		NY	Statoil	Offshore wind surveys
	Research/Other	Atlantic Ocean off NJ	Lamont Doherty Earth Observatory / NSF	Marine seismic survey in Atlantic Ocean off NJ
		Atlantic Ocean off the Eastern Seaboard	USGS	Marine seismic survey in the Atlantic Ocean off the Eastern Seaboard

Type of Surveying and Mapping Activity	Project Category	General Location / Geographic Scope	Project Lead	Project/Permit Description
		Northwest Atlantic	USGS	Geophysical surveys

Source: NMFS, 2019e

NEFSC = Northeast Fisheries Science Center; NMFS = National Marine Fisheries Service; NSF = National Science Foundation; NWR = National Wildlife Refuge; SEFSC = Southeast Fisheries Science Center; USFWS = U.S. Fish and Wildlife Service; USGS = U.S. Geological Survey

4.1.1.1.1 Great Lakes

There are no projects that require incidental take authorizations in the Great Lakes because there are no marine mammals; however, the Great Lakes region is one of NPS's current benthic mapping priorities. NPS has collected multibeam sonar and backscatter data at all the Great Lakes Parks (NPS, 2018b). More surveying and mapping projects are likely to occur in the Great Lakes region for habitat conservation and navigational purposes.

4.1.1.2 Southeast Region

Additional surveying and mapping projects are expected to occur in the Southeast region for oil and gas siting, offshore renewable energy project siting, ecological monitoring, fisheries management, and navigational purposes; a representative list of these projects is presented below in **Table 4.1-2** (NOAA, No Date-d; NMFS, 2019e).

Table 4.1-2. Representative List of Surveying and Research Projects within the Southeast Region

Type of Surveying and Mapping Activity	Project Category	General Location / Geographic Scope	Project Lead	Project/Permit Description
Ongoing Activities				
Ecological Monitoring	Research/Other	10 Major Bay systems of TX	Texas Parks and Wildlife	Fishery independent monitoring activities
Fisheries Management and Research	Research/Other	Eastern Caribbean; Gulf of Mexico; Western Caribbean	NMFS SEFSC	Fisheries and ecosystem research activities in the Atlantic Ocean
G&G Survey	Offshore Wind	Offshore NC	Avangrid Renewables, LLC	Site characterization surveys off NC
	Oil and Gas	Gulf of Mexico	BOEM	Seismic surveys in the Gulf of Mexico

Type of Surveying and Mapping Activity	Project Category	General Location / Geographic Scope	Project Lead	Project/Permit Description
Activities within the Past 10 years				
G&G Survey	Offshore Wind	Offshore VA	Dominion Energy Virginia	Unexploded Ordinance Survey in Lease of Submerged Lands for Renewable Energy Development on the Outer Continental Shelf (OCS-A 0497) (Lease Area)
	Research/Other	Atlantic Ocean off NC	Lamont Doherty Earth Observatory / NSF	Seismic survey in the Atlantic Ocean off NC
		Northwest Gulf of Mexico	USGS	Seismic survey in the deep water of the Gulf of Mexico

Source: NMFS, 2019e

BOEM = Bureau of Ocean Energy Management; NMFS = National Marine Fisheries Service; NSF = National Science Foundation; SEFSC = Southeast Fisheries Science Center; USGS = U.S. Geological Survey

4.1.1.3 West Coast Region

Hydrographic surveying projects planned along the Pacific Coast include geologic hazard assessments, seafloor mapping projects in the area provide multibeam bathymetry, acoustic backscatter data, and water column data that are used for earthquake, tsunami, and landslide hazard assessments and situational awareness products (NOAA, No Date-f). The NSF has funded marine geophysical surveys off the coasts of Oregon, Washington, and Central California and more specifically, the Cascadia Subduction Zone, which extends from northern Vancouver Island to Northern California (NSF, No Date). Additional surveying and mapping projects are expected to occur in the region for offshore energy siting, ecological monitoring, fisheries management, hazard assessment, and navigational purposes; a representative list of these projects is presented below in **Table 4.1-3** (NOAA, No Date-f; NMFS, 2019e).

Table 4.1-3. Representative List of Surveying and Research Projects within the West Coast Region

Type of Surveying and Mapping Activity	Project Category	General Location / Geographic Scope	Project Lead	Project/Permit Description
Ongoing Activities				
Ecological Monitoring	Research/Other	CA and OR	UC Santa Cruz	PISCO rocky intertidal monitoring in CA and OR

Type of Surveying and Mapping Activity	Project Category	General Location / Geographic Scope	Project Lead	Project/Permit Description
Fisheries Management and Research	Research/Other	California Current Research Area; Lower Columbia River Research Area; Puget Sound Research Area	NMFS NWFSC	Northwest fisheries and ecosystem research activities
		California Current Research Area	NMFS SWFSC	Fisheries and ecosystem research activities in the Pacific Ocean
G&G Survey	Research/Other	Northeast Pacific	Lamont Doherty Earth Observatory / NSF	Marine Geophysical Survey in the Northeast Pacific
		Off Oregon North; Off Oregon South	Scripps Institution of Oceanography	Seismic survey in the Northeastern Pacific Ocean
Activities within the Past 10 years				
Ecological Monitoring	Research/Other	Palmer's Point; Point Dume; Point Arena; Ten Mile	UC Santa Cruz	PISCO rocky intertidal monitoring in CA and OR
G&G Survey	Research/Other	Southeast Farallon Islands, CA	Gulf of the Farallones NMS, CA	Abalone survey, CA
		Line Islands	Lamont Doherty Earth Observatory / NSF	Low-energy seismic survey in the Pacific Ocean, Line Islands
		Cascadia Thrust Zone north, WA; Cascadia Thrust Zone south, OR; Juan de Fuca Plate study area, Pacific Northwest	Lamont Doherty Earth Observatory / NSF	Seismic survey in the Northeast Pacific Ocean
		Central Pacific Ocean	Scripps	Research seismic survey in the Central Pacific Ocean

Source: NMFS, 2019e

NMFS = National Marine Fisheries Service; NMS = National Marine Sanctuary; NSF = National Science Foundation; NWFSC = Northwest Fisheries Science Center; PISCO = Partnership for Interdisciplinary Studies of Coastal Oceans; SWFSC = Southwest Fisheries Science Center; UC = University of California

4.1.1.4 Alaska Region

Some parts of the Alaska coastline, including the vast majority of the Lisianski Inlet next to Chichagof Island in the Alexander Archipelago, were last surveyed in 1917 (NOAA, No Date-a). Some soundings in the Arctic region date back to the work of Captain Cook in the 18th century. In the time since these surveys, the retreat of arctic sea ice has increased vessel traffic in the region, resulting in an even greater need for updated maps. The Port of Kodiak has seen many groundings and near misses due to the number of dangers to navigation that exist in this area. Additional surveying and mapping projects are expected to occur in these areas for navigational purposes, ecological monitoring, fisheries management, offshore energy siting, and offshore Liquified Natural Gas (LNG) projects; a representative list of these projects is presented below in **Table 4.1-4** (NOAA, No Date-a; NMFS, 2019e).

Table 4.1-4. Representative List of Surveying and Research Projects within the Alaska Region

Type of Surveying and Mapping Activity	Project Category	General Location / Geographic Scope	Project Lead	Project/Permit Description
Ongoing Activities				
Ecological Monitoring	Research/Other	Boulder Island; Flapjack Island; Geikie Rock; Lone Island	NPS - Glacier Bay National Park	Seabird research and monitoring in Glacier Bay National Park, AK
		Kachemak Bay; Katmai National Park and Preserve; Kenai Fjords National Park	NPS - SWAN	Research and Monitoring Activities in Southern Alaska National Parks
Fisheries Management and Research	Research/Other	Bering Sea and Aleutian Islands; Chukchi and Beaufort Seas; Gulf of Alaska	NMFS AFSC	Fisheries Research
G&G Survey	Offshore LNG	Cook Inlet, AK	ExxonMobil Alaska LNG LLC	Geophysical and geotechnical survey in Cook Inlet, AK
	Oil and Gas	Cook Inlet, AK	Apache Alaska Co.	Seismic survey in Cook Inlet, AK
	Research/Other	Alaska	Lamont Doherty Earth Observatory / NSF	Marine Geophysical Survey in the Gulf of Alaska
Activities within the Past 10 years				
Ecological Monitoring	Research/Other	Boulder Island; Flapjack Island; Geikie Rock; Lone Island	NPS - Glacier Bay National Park	Seabird research and monitoring in Glacier Bay National Park, AK

Type of Surveying and Mapping Activity	Project Category	General Location / Geographic Scope	Project Lead	Project/Permit Description
G&G Survey	Offshore LNG	Cook Inlet, AK	ExxonMobil Alaska LNG LLC	Geophysical and geotechnical survey in Cook Inlet, AK (2016)
	Oil and Gas	Cook Inlet, AK	Apache Alaska Co.	Seismic survey in Cook Inlet, AK
		Beaufort Sea, AK	BP	Open water seismic survey
		Prudhoe Bay, AK	BP	Prudhoe Bay, AK seismic survey
		Foggy Island Bay, AK	BP	Shallow geohazard surveying Foggy Island Bay, AK
		Beaufort Sea, AK	Hilcorp	Shallow geohazard survey in the Beaufort Sea, AK
		Beaufort and Chukchi Seas, AK	ION Geophysical	Seismic surveys in the Beaufort and Chukchi Seas, AK
		Zone 1 Cook Inlet, AK; Zone 2 Cook Inlet, AK	SAExploration Inc.	Seismic survey in Cook Inlet, AK
		Beaufort Sea, AK	SAExploration Inc.	Seismic surveys in Beaufort Sea, AK
		Ice gouge survey Beaufort Sea, AK	Shell	Open water survey in the Beaufort and Chukchi Seas, AK
		Ice gouge survey Chukchi Sea, AK	Shell	Open water survey in the Beaufort and Chukchi Seas, AK
		Shallow hazards survey Beaufort Sea, AK	Shell	Open water survey in the Beaufort and Chukchi Seas, AK
		Strudel scour survey Beaufort Sea, AK	Shell	Open water survey in the Beaufort and Chukchi Seas, AK
		Chukchi Sea, AK	Shell	Seismic survey in the Chukchi Sea, AK
		Chukchi and Beaufort Seas, AK	Shell Gulf of Mexico Inc.	Ice overflight surveys in the Chukchi and Beaufort Seas, AK

Type of Surveying and Mapping Activity	Project Category	General Location / Geographic Scope	Project Lead	Project/Permit Description
		Chukchi Sea, AK	StatOil	3D seismic survey in Chukchi Sea, AK
		Alaskan Chukchi Sea	StatOil	Shallow hazards seismic survey in the Alaskan Chukchi Sea
		Chukchi Sea, AK	TGS-NOPEC Geophysical Co.	Seismic survey in the Chukchi Sea, AK
	Research/Other	Unidentified island, Eastern Aleutian Islands, AK	BLM	Survey activities in the Eastern Aleutian Islands, AK
		Western Gulf of Alaska	Lamont Doherty Earth Observatory / NSF	Seismic survey in the Western Gulf of Alaska
		Central Gulf of Alaska	USGS	Geophysical survey in the Central Gulf of Alaska
		Central-Western Bering Sea	USGS	Geophysical survey in the Central-Western Bering Sea
		Central Gulf of Alaska	USGS	Research seismic survey in the Central Gulf of Alaska

Source: NMFS, 2019e

AFSC = Alaska Fisheries Science Center; BLM = Bureau of Land Management; LNG = Liquified Natural Gas; NMFS = National Marine Fisheries Service; NPS = National Parks Service; NSF = National Science Foundation; SWAN = Southwest Alaska Inventory and Monitoring Network; USGS = U.S. Geological Survey

4.1.1.5 Pacific Island Region

The USGS plans to map coral reefs including sediment- or pollutant-impacted reefs, and those of special significance and concern such as reefs in state or national parks, national wildlife refuges, or national marine sanctuaries as part of a Pacific Coral Reefs Project (USGS, No Date-i). Additional surveying and mapping projects are expected to occur in the region for habitat conservation, fisheries management, and navigational purposes; a representative list of these projects is presented below in **Table 4.1-5** (NMFS, 2019e).

Table 4.1-5. Representative List of Surveying and Research Projects within the Pacific Island Region

Type of Surveying and Mapping Activity	Project Category	General Location / Geographic Scope	Project Lead	Project/Permit Description
Ongoing Activities				
Fisheries Management and Research	Research/ Other	American Samoa Archipelago Research Area; Hawaiian Archipelago Research Area; Mariana Archipelago Research Area; Western and Central Pacific Research Area	NMFS PIFSC	Pacific Islands fisheries and ecosystem research activities
Activities within the Past 10 years				
G&G Survey	Research/ Other	Central Pacific Ocean	Lamont Doherty Earth Observatory / NSF	Seismic survey in Central Pacific Ocean
		CNMI	Lamont Doherty Earth Observatory / NSF	Seismic survey in CNMI
		Emperor Seamounts; Main Hawaiian Islands	Lamont-Doherty Earth Observatory	Marine Geophysical Surveys by the R/V Marcus G. Langseth in the North Pacific Ocean, 2018/2019
		Wake island	Scripps Institution of Oceanography	Low-energy seismic survey in the Western Tropical Pacific Ocean
		Central Pacific Ocean	University of Hawaii	Marine Geophysical Survey in the Central Pacific Ocean

Source: NMFS, 2019e

CNMI = Commonwealth of the Northern Mariana Islands; NMFS = National Marine Fisheries Service; PIFSC = Pacific Island Fisheries Science Center; SWFSC = Southwest Fisheries Science Center; NSF = National Science Foundation

4.1.1.6 Expected Increases in Ocean Surveying and Mapping

Over the next decade, surveying and mapping projects are expected to increase throughout the action area to meet the existing regional needs described above and to meet new mapping goals. The November 2019 *Presidential Memorandum on Ocean Mapping of the United States Exclusive Economic Zone and the*

Shoreline and Nearshore of Alaska (2019 Presidential Memo) cited the importance of the ocean economy to the nation and the need for updated and complete mapping of the EEZ to support it. Sections 2 and 3 of the memorandum specifically address the need to develop a strategy for mapping the entire EEZ and Alaska, respectively (The White House, 2019). In light of the 2019 Presidential Memo, the number and frequency of surveying and mapping projects in the action area, specifically in the Alaska region, are expected to increase.

NOAA has also committed to supporting and contributing to Seabed 2030, an international joint project between the Nippon Foundation and the General Bathymetric Chart of the Oceans (GEBCO) Guiding Committee with the goal of producing a complete, high-resolution bathymetric map of the world's seabed from the coasts to the deepest trenches by the year 2030 (OCS, 2018). While the majority of the project is outside the geographic scope of this analysis, future hydrographic surveys and mapping within the U.S. EEZ will be driven by data gap assessments completed in support of this project and the 2019 Presidential Memo. Future hydrographic surveying methods could include collaborative mapping missions, crowdsourced bathymetry from essential partners such as fishing boats, ocean-going carriers, and recreational vessels, and technological innovations that force-multiply capacities to collect sonar data efficiently in remote and challenging locations (OCS, 2018).

Both Seabed 2030 and the 2019 Presidential Memo make comprehensive ocean mapping a priority for the coming decade (IOCM, 2019). With this increase, new and more efficient technologies to rapidly characterize the ocean are expected to be developed. For example, NOAA has announced a four-year Cooperative Research and Development Agreement (CRADA) with a private company, Ocean Infinity, to develop deep-water autonomous technologies that can gather ultra-high-resolution ocean information (NOAA, 2020b).

In addition to the use of various active acoustic sources, other impact causing factors associated with all types of surveying and mapping projects include seafloor disturbance to collect bottom samples, vessel presence, impacts to the water column, vessel and equipment noise, and the potential for accidental discharges. Other surveying and mapping efforts in the action area would likely contribute cumulative impacts related to all resources covered in this PEIS.

4.1.2 Offshore Oil and Natural Gas Development

The Bureau of Ocean Energy Management (BOEM) manages the exploration and development of offshore energy by the Oil and Gas (O&G) industry on the 2.5 billion-acre U.S. outer continental shelf (BOEM, 2018b). The U.S. outer continental shelf comprises the portion of the seabed lying seaward of State coastal waters to the out border of the EEZ. As per the Outer Continental Shelf Lands Act (OCSLA), BOEM can grant leases for the exploration, development, and production of O&G and other mineral resources on the outer continental shelf. Each lease covers up to 2,331 hectares (ha) (6.8 nm^2) and is generally a square measuring 4.8 by 4.8 km (3 by 3 mi) (BOEM, 2019j).

Interested companies must submit plans to BOEM prior to initiating any activity to explore a block for resources and/or to develop and produce O&G resources (BOEM, 2019e). Following the preliminary G&G surveys described in Section 4.1.1, offshore oil and natural gas development generally involve the following phases with corresponding impact causing factors:

1) <u>Exploration</u>, which may include the use of mobile drilling units to drill a series of individual wells to locate and test the recoverability of oil and gas reserves and increased vessel traffic to and from the site;

2) Development, which generally involves continued vessel traffic in the area, barge operations, drilling multiple wells in close proximity to each other, and the construction and installation of a platform to collect recovered oil and gas and a pipeline to transfer the oil and gas to the shore;

3) Production/extraction, which involves continued vessel traffic and the extraction of the oil and gas and its transport to shore for processing; and

4) Decommissioning/platform removal, which involves the demolition of oil and gas infrastructure or abandonment of structures; demolition involves increased boat and barge traffic to and from the site and could potentially involve the use of explosives.

Each phase of oil and natural gas development would involve active underwater acoustic sources, seafloor disturbance including sampling and drilling, dredging, vessel presence, vessel and equipment noise, impacts to the water column, potential accidental discharges and oil spills, and air emissions (BOEM, 2019i).

4.1.2.1 Oil and Gas Energy Programs

The National Outer Continental Shelf Oil and Gas Leasing Program (National Outer Continental Shelf Program) specifies the size, timing, and location of potential leasing activity. For this reason, reviewing the program lease sale schedules in addition to reviewing the incidental take authorizations granted to oil and gas projects by NMFS under the MMPA provides a good understanding of previous, current, and reasonably foreseeable O&G projects. Projects which are currently in the preliminary G&G surveying phase were presented in the previous section (Section 4.1.1). Currently, BOEM is working under the 2017-2022 National Outer Continental Shelf Program. However, BOEM has published a draft proposed National Outer Continental Shelf Program for 2019-2024 that will, upon being finalized, replace the 2017-2022 Program (BOEM, 2019b; BOEM, 2018c). The 2019-2024 Draft Proposed Program Lease Sale Schedule is summarized in **Table 4.1-6** below.

Table 4.1-6. BOEM 2019–2024 Draft Proposed Program Lease Sale Schedule

Sale Year	Region	Program Area
2019	Alaska	Beaufort Sea
2020	Alaska	Chukchi Sea
	Pacific	Southern California
	Gulf of Mexico	Western, Central, and Eastern Gulf of Mexico*
		Western, Central, and Eastern Gulf of Mexico*
	Atlantic	South Atlantic
		Mid-Atlantic
2021	Alaska	Beaufort Sea
		Cook Inlet
	Pacific	Washington/Oregon
		Northern California
		Central California
	Atlantic	North Atlantic
	Gulf of Mexico	Western, Central, and Eastern Gulf of Mexico*
		Western, Central, and Eastern Gulf of Mexico*
2022	Alaska	Chukchi Sea

Sale Year	Region	Program Area
	Pacific	Southern California
	Atlantic	Mid-Atlantic
		South Atlantic
	Gulf of Mexico	Western, Central, and Eastern Gulf of Mexico*
		Western, Central, and Eastern Gulf of Mexico*
2023	Alaska	Beaufort Sea
		Cook Inlet
		Hope Basin
		Norton Basin
		St. Matthew-Hall
		Navarin Basin
		Aleutian Basin
		St. George Basin
		Bowers Basin
		Aleutian Arc
		Shumagin
		Kodiak
		Gulf of Alaska
	Pacific	Central California
		Northern California
	Gulf of Mexico	Western, Central, and Eastern Gulf of Mexico*
		Western, Central, and Eastern Gulf of Mexico*
		Eastern and Central Gulf of Mexico **
	Atlantic	Straits of Florida
		North Atlantic
2024	Alaska	Chukchi Sea
	Gulf of Mexico	Western, Central, and Eastern Gulf of Mexico*
		Western, Central, and Eastern Gulf of Mexico*
		Eastern and Central Gulf of Mexico **
	Atlantic	South Atlantic
		Mid-Atlantic

Source: BOEM, 2018c

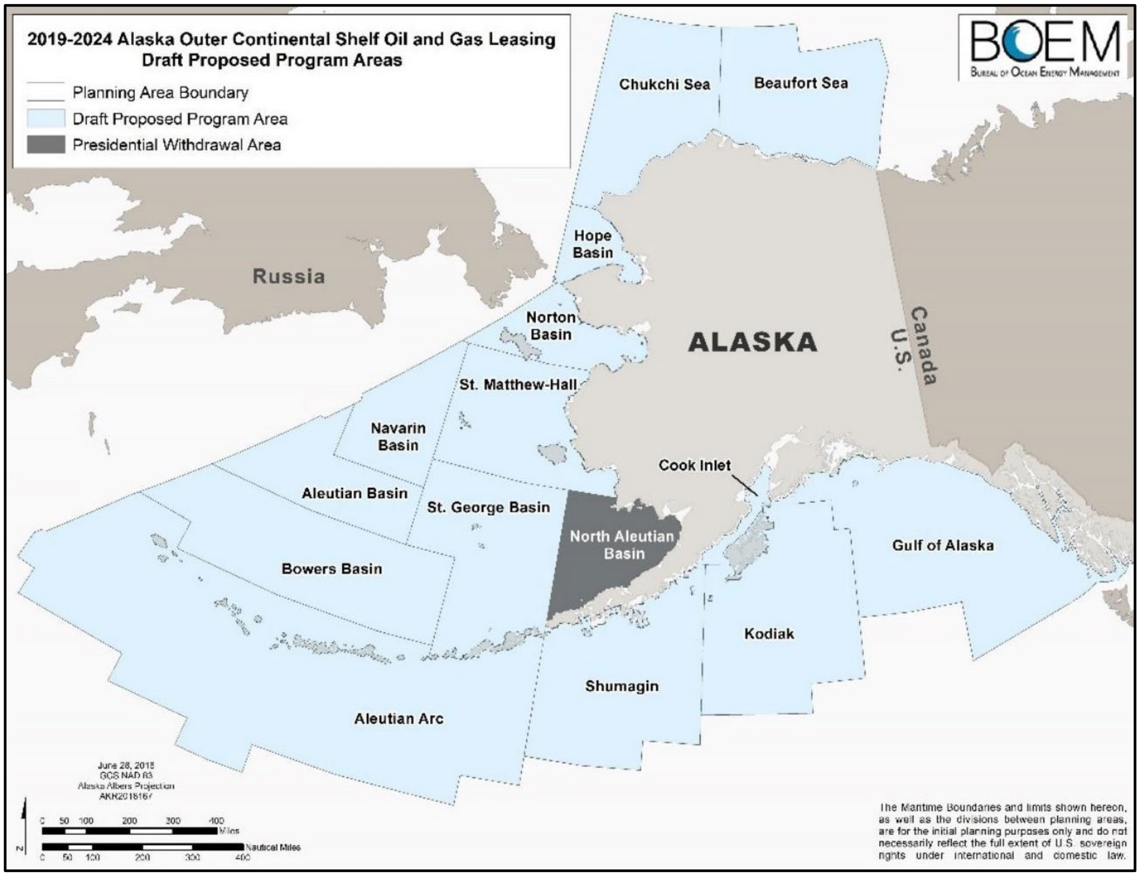
*All available areas, not including those subject to the Gulf of Mexico Energy Security Act (GOMESA) moratorium through June 30, 2022. The GOMESA mandates that the states of Texas, Louisiana, Mississippi, and Alabama receive a portion of revenues from new oil and natural gas development in federal waters adjacent to the respective state (BOEM, 2018c).

**Those areas available following the expiration of the GOMESA moratorium.

4.1.2.2 Alaska Outer Continental Shelf Region

The Arctic region in total contains an estimated 13 percent of the world's undiscovered oil and 30 percent of undiscovered natural gas (USCG, 2018b). The Alaska outer continental shelf encompasses the Beaufort and Chukchi Seas, the Bering Sea, Cook Inlet, and the Gulf of Alaska, spanning more than 404,685,642 ha

(1,179,875 nm^2). Alaska contains more than 9,656 km (6,000 mi) of coastline – more coastline than in the rest of the U.S. combined (BOEM, 2019b). There are 54 active leases in the Alaska region (BOEM, 2019c; BOEM, 2019a). The O&G leasing program areas are depicted below in **Figure 4.1-2**.



Source: BOEM, 2019b

Figure 4.1-2. Alaska Outer Continental Shelf Program Areas

Decreasing sea ice and diminishing onshore oil production are creating incentives for further exploration offshore in the Arctic region as a whole (USCG, 2018b). With the exception of the take authorization granted to ExxonMobil in the Santa Barbara Channel, all projects that have been granted incidental take authorizations for construction and operation relating to oil and gas development have occurred in the Alaska region (NMFS, 2019e). A summary of these projects is presented below in **Table 4.1.7** as a representative, not exhaustive, list of offshore oil and gas development projects. Projects with an active take authorization status and projects with a take authorization application in-process are considered reasonably foreseeable to occur within the next five years and are categorized as ongoing activities. Projects that have been granted the requested take authorizations that have expired within the past 10 years are considered activities that have occurred within the past 10 years. Although projects that require take authorization are not the only projects occurring in the action area, they are used as a representative list because projects that require take authorization are expected to be the projects with the greatest impact.

Table 4.1-7. Representative List of Oil and Gas Projects within the Alaska Region

General Location/ Geographic Scope	Project Lead	Project/Permit Description
Ongoing Activities		
Cook Inlet, AK	Hilcorp Alaska LLC	Oil and Gas activities
Cook Inlet, AK	Harvest Alaska (Hilcorp)	Cook Inlet Pipeline Cross Inlet Extension
Arctic AK	Hilcorp Alaska	Liberty Drilling and Production Island
North Slope Alaska	Hilcorp Alaska, Eni	Ice road Construction
Activities within the Past 10 years		
Chukchi Sea, AK	Shell Gulf of Mexico Inc.	Drilling program in the Chukchi Sea, AK
Beaufort Sea, AK	BP Exploration (Alaska) Inc.	Operation of NorthStar facility in the Beaufort Sea, AK
Beaufort Sea, AK	Shell	Beaufort Sea exploratory drilling
Chukchi Sea, AK	Shell	Chukchi Sea exploratory drilling

Source: NMFS, 2019e

4.1.2.3 Atlantic Outer Continental Shelf Region

The Atlantic outer continental shelf region is divided into four planning areas: North Atlantic, Mid-Atlantic, South Atlantic, and Straits of Florida. No active O&G leases currently exist in the Atlantic outer continental shelf region; and none are proposed under the current 2017-2022 Outer Continental Shelf Oil and Gas Leasing Program (BOEM, 2019d).

4.1.2.4 Gulf of Mexico Outer Continental Shelf Region

The Gulf of Mexico outer continental shelf consists of three planning areas (Western, Central, and Eastern Gulf of Mexico); however, the Gulf of Mexico region also manages the four Atlantic outer continental shelf planning areas which all together span 174,014,826 ha (507,346 nm^2). The Gulf's Central and Western planning areas (offshore Texas, Louisiana, Mississippi, and Alabama) remain the nation's primary offshore source of O&G, generating about 97 percent of all offshore O&G production (BOEM, 2019g). As described in BOEM's Gulf of Mexico region Oil and Gas Production Forecast: 2018-2027, annual oil production is anticipated to continue to increase through 2024. Annual gas production volumes are anticipated to remain relatively consistent from 2018 to 2027 with an average rate of decline of less than 1 percent annually (BOEM, 2019n).

4.1.2.5 Pacific Outer Continental Shelf Region

The Pacific outer continental shelf region has issued 470 leases and currently has 34 active leases, which together cover 72,248 ha (211 nm^2) in offshore California, Oregon, Washington, and Hawaii. O&G production facilities have been installed in 23 of the active leases, all of which are located off the coast of California (BOEM, 2019l). However, NMFS granted a marine mammal take authorization to only one project in the region (ExxonMobil conductor pipe installation activities at Harmony Platform in Santa Barbara Channel, CA in 2014), which has since expired (NMFS, 2019e).

Offshore oil and natural gas development would likely contribute cumulative impacts related to all of the resources covered in this Draft PEIS.

4.1.3 Offshore Renewable Energy Development

Offshore renewable energy consists of several sources, including wind energy and ocean wave and current energy, also known as hydrokinetic energy. BOEM is the agency responsible for overseeing offshore renewable energy development in federal waters (BOEM, 2020).

4.1.3.1 Wind Energy

Both nationally and globally, wind power is one of the fastest growing forms of electricity generation. Wind turbines convert the kinetic energy of wind into electricity. Offshore winds tend to blow harder and more uniformly than on land (without mountains, trees, and artificial structures to obstruct them). Since higher wind speeds can produce much more electricity, and do so more reliably than onshore wind farms, developers are increasingly interested in pursuing offshore wind energy resources. There are extensive, potentially productive areas for wind energy available offshore on the continental shelf (DOSITS, 2019).

Offshore wind facility design and engineering depends on site-specific conditions, particularly water depth, seabed geology, and wave loading. Following the preliminary G&G surveys described in Section 4.1.1, the remaining three phases of a wind farm's life cycle entail underwater sounds of varying intensity and duration:

1) Construction, which may include drilling, pile driving, use of explosives, dredging, cable laying, increased vessel traffic to and from the site, and barge operations;
2) Operation, including long-duration sound associated with mechanical vibrations when the turbine blades are spinning as well as periodic maintenance vessel traffic, continuing over the 20- to 25-year lifetime of the installation; and
3) Decommissioning, which may include mechanical cutting and explosive detonation as well as increased boat and barge traffic to and from the site.

In the coming years, the majority of offshore wind project activity is expected to be in the pre-construction and construction phase. During the operational phase (**Figure 4.1-3**), by far the longest of these phases, low-frequency sound is generated when the turbine blades are spinning. Vibrations inside the nacelle (housing for the generator, gearbox, and other parts) are transmitted down the main turbine shaft and into its foundation under the seabed. These vibrations then propagate both into the seafloor and the water column. The sound is primarily below 1 kilohertz (kHz) (generally below 700 hertz [Hz]), with a source level of 80-150 decibels (dB) re 1 µPa @ 1 m. Aerodynamic noise produced by the motion of the rotor blades through the air may also penetrate the water through an airborne path. Sound levels increase somewhat as wind speed increases and blades rotate faster. The type of wind turbine foundation also affects the propagation of underwater sound (DOSITS, 2019).

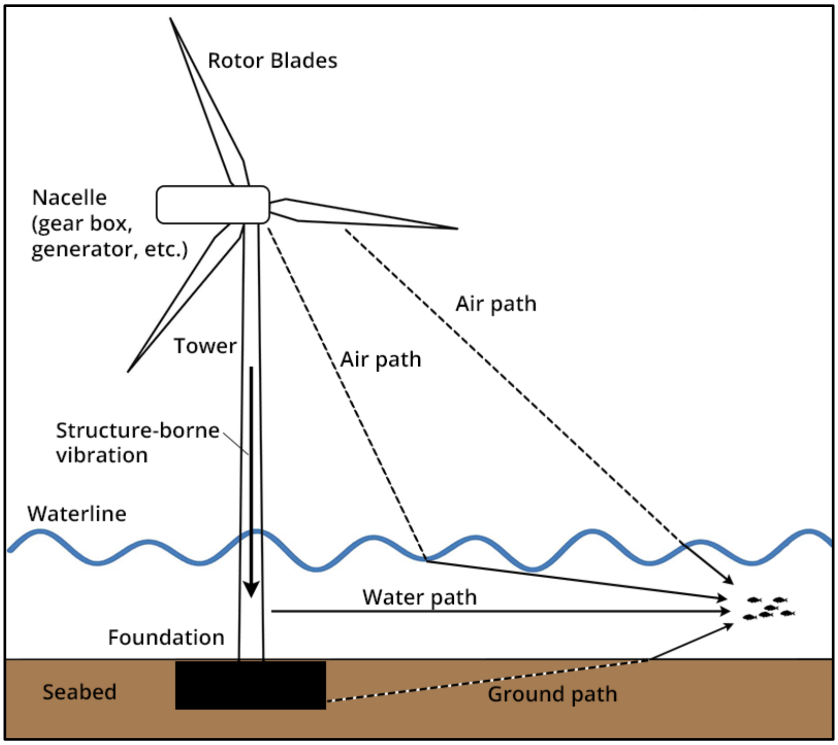


Figure 4.1-3. Acoustic Pathways for Underwater Noise from an Offshore Wind Turbine in Operation

Image Credit: DOSITS (2019), modified from Kikuchi (2010)

The first U.S. wind farm known as the Block Island Wind Farm began operating in December 2016 off the shore of Rhode Island. The Block Island Wind Farm is a 30-megawatt (MW) project with five turbines located three miles off the coast of Block Island, Rhode Island (AWEA, 2018). As of June 2018, the U.S. has a total project pipeline of 25,434 megawatts (MW) of offshore wind energy. Out of this pipeline, project developers have announced that roughly 2,000 MW of new offshore wind capacity is expected to be operational by 2023. States including Maryland, Massachusetts, Rhode Island, and Connecticut have completed solicitations for nearly 1,770 MW of offshore wind energy, and additional solicitations are planned for the near future (AWEA, 2018).

BOEM has issued twelve active commercial wind energy leases to date. Another four projects have submitted unsolicited lease applications to BOEM, while four demonstration projects have obtained exclusive development rights to a site from federal or state authorities; however, the exact size and phase of development that these potential projects will reach within the next several years is uncertain. A majority of the nearer-term activity is concentrated in the Atlantic off the Northeast coast (AWEA, 2018). The DOE is also funding the development of a demonstration-scale offshore wind project located off the shore of Cleveland, Ohio in Lake Erie. Lake Erie Energy Development Corporation's (LEEDCo's) Project Icebreaker, or Icebreaker Wind, will consist of six wind turbine generators erected on foundations constructed on the lakebed that will generate approximately 21 MW of electricity (DOE, 2018). Construction and subsequent operation are expected in 2022 (LEEDCo, 2020). With continued development of offshore wind projects, the U.S. would see new jobs and investments in manufacturing and port infrastructure (AWEA, 2018).

4.1.3.2 Other Offshore Renewable Energy

Tidal, wave, and current energy are clean, renewable resources that can be harnessed wherever changing tides, waves, or currents move a significant volume of water, especially off the coasts of urban centers where there is high electricity demand. Marine and Hydrokinetic (MHK) energy is an untapped resource for the U.S. and though still a new industry, the U.S. Department of Energy's (DOE) Water Power Program is researching projects to accelerate wave, tidal, and current projects and overall development of the MHK market. These projects include project siting activities, market assessments, environmental impact analyses, and research supporting technology commercialization (DOE, 2019a). Due to the relatively steep continental slope and deep water off the West Coast and Hawaii, different types of offshore renewable energy technologies have been proposed for the Pacific region than for the Atlantic region (BOEM, 2019k). While the U.S. is pursuing ocean current energy, it is still in the early stages of development. Submerged water turbines, similar to wind turbines, may also be deployed on the outer continental shelf in the coming years to extract energy from ocean currents (BOEM, 2019m).

Ocean Thermal Energy Conversion (OTEC) is a process to power a turbine to produce electricity by harnessing the temperature differences (thermal gradients) between ocean surface waters and deep ocean waters. OTEC systems using seawater as the working fluid can use the condensed water to produce desalinated water. As of 2015, the Natural Energy Laboratory of Hawaii Authority, a leading test facility for OTEC technology, has supplied electricity to the local electricity grid. Conditions for OTEC systems exist in tropical coastal areas such as Hawaii, south Florida, and the Caribbean (DOE, 2019b).

Impact causing factors associated with other offshore renewable energy projects would likely include vessel presence, vessel and equipment noise, impacts to the water column, potential accidental discharges, the construction and installation of structures and cables connected to the shore (BOEM, 2019i). The development of offshore renewable energy would likely contribute cumulative impacts related to all resources covered in this PEIS.

4.1.4 Climate Change

In order to fully understand the impacts of climate change, the spatial boundary for analysis will be increased in this section to include international waters. For more than 200 years, since the beginning of the industrial revolution, the concentration of carbon dioxide (CO_2) in the atmosphere has increased due to the burning of fossil fuels and land use change (e.g., increased vehicular and power plant emissions and deforestation). The U.S. Global Change Research Program's National Climate Assessment indicates that the increase in human-caused carbon emissions influences ocean ecosystems through three main processes: ocean warming, acidification, and deoxygenation (USGCRP, 2018).

Warming. Between 1900 and 2016, global ocean surface waters have warmed on average 0.7° ± 0.08°C (1.3° ± 0.14°F) per century, with more than 90 percent of the extra heat linked to carbon emissions being "contained" by the ocean. The warming of the ocean impacts sea levels, circulation and currents, productivity, and the functioning of entire ecosystems (USGCRP, 2018). For example, higher global temperatures have led to the melting of glaciers and icecaps which has caused sea levels to rise. Sea levels in the U.S. have risen up to 0.6 meters (m) (2 feet [ft]) in the past century. As much as 4,921 km^2 (1,900 mi^2) of coastal wetlands have been lost in Louisiana alone during this period. The amount of future sea-level rise will depend on the expansion of ocean volume and the response of glaciers and polar ice sheets. A rise in sea level of up to 1.2 m (4 ft) in this century has been predicted, but even another 0.6-m (2-ft) rise would cause major loss of coastal wetlands (USGCRP, 2009).

Acidification. The ocean absorbs about 30 percent of the CO_2 that is released in the atmosphere and as levels of atmospheric CO_2 increase, so do the levels in the ocean. When CO_2 is absorbed by seawater, a series of chemical reactions occur, resulting in the increased concentration of hydrogen ions. Acidity is measured as a function of the concentration of hydrogen ions (pH), so the increased concentration of hydrogen ions causes the seawater to be more acidic. A portion of the excess hydrogen ions react with carbonate (CO_3^{2-}) ions to form bicarbonate (HCO_3^-), this causes carbonate ions to be relatively less abundant (Hardt and Safina, 2008; NOAA, 2013). Carbonate (CO_3) ions are a critical component of calcium carbonate ($CaCO_3$), which many marine macroinvertebrates use to manufacture shells and exoskeletons. When the concentration of carbonate ions in ocean water is low enough, exposed $CaCO_3$ structures such as shells, exoskeletons, and coral skeletons are more difficult to build and maintain and can even begin to dissolve or disintegrate (NOAA, 2013; USGCRP, 2018).

Deoxygenation. Increased CO_2 levels in the atmosphere are also causing a decline in ocean concentrations of dissolved oxygen (DO). Ocean warming leads to deoxygenation because temperature has a direct influence on how much oxygen is soluble in water. Oxygen is less soluble in warmer waters; therefore, the concentration of DO is lower in waters that have been warmed by climate change. Deoxygenation can also occur from “oxygen demanding” pollutants entering the water, mostly from nitrogen and phosphorus nutrients associated with agricultural/fertilizer runoff (USGCRP, 2018).

The three processes (warming, acidification, and deoxygenation) interact with one another and with other agents of environmental stress in the ocean environment, resulting in a wide array of cumulative impacts (USGCRP, 2018). Impact causing factors associated with climate change include changes to water characteristics (including temperature, acidity, and oxygen concentration), sea level rise, increased storm severity and frequency, and coastal erosion, all of which contribute to coastal infrastructure damage and the increased need to construct protective infrastructure such as barriers and seawalls (BOEM, 2019i). Climate change would likely contribute cumulative impacts related to habitats; marine mammals; sea turtles; fish; aquatic macroinvertebrates; EFH; seabirds, shorebirds and coastal birds, and waterfowl; cultural and historic resources; and Environmental Justice.

4.1.5 Commercial Shipping and Recreational Boating

About 90 percent of imports and exports enter and exit by ship through the nation’s 40,233 km (25,000 mi) of navigable channels. By 2025, global demand for waterborne commerce is expected to more than double, which will increase the level of vessel traffic in the action area. Compared to land-based transportation by road and rail, the transportation of goods by waterways is considered to be a more economical, efficient, and environmentally sound mode of transport. For example, one Great Lakes bulk carrier has approximately the same cargo capacity as seven 100-car freight trains (USCG, 2018b). Part of maintaining waterways for safe navigation includes dredging to maintain channel depths in harbors and inland waterways. The USACE dredges nearly 300 million cubic yards of material each year to keep the nation's waterways navigable. Much of this dredged material is reused for environmental restoration projects, including the creation of wetlands (USACE, No Date-b).

Designated shipping lanes occur throughout all regions of the action area with a higher concentration around urban centers with major ports. Shipping lanes and other areas with operational restrictions within the action area are shown below in **Figure 4.1-4**.

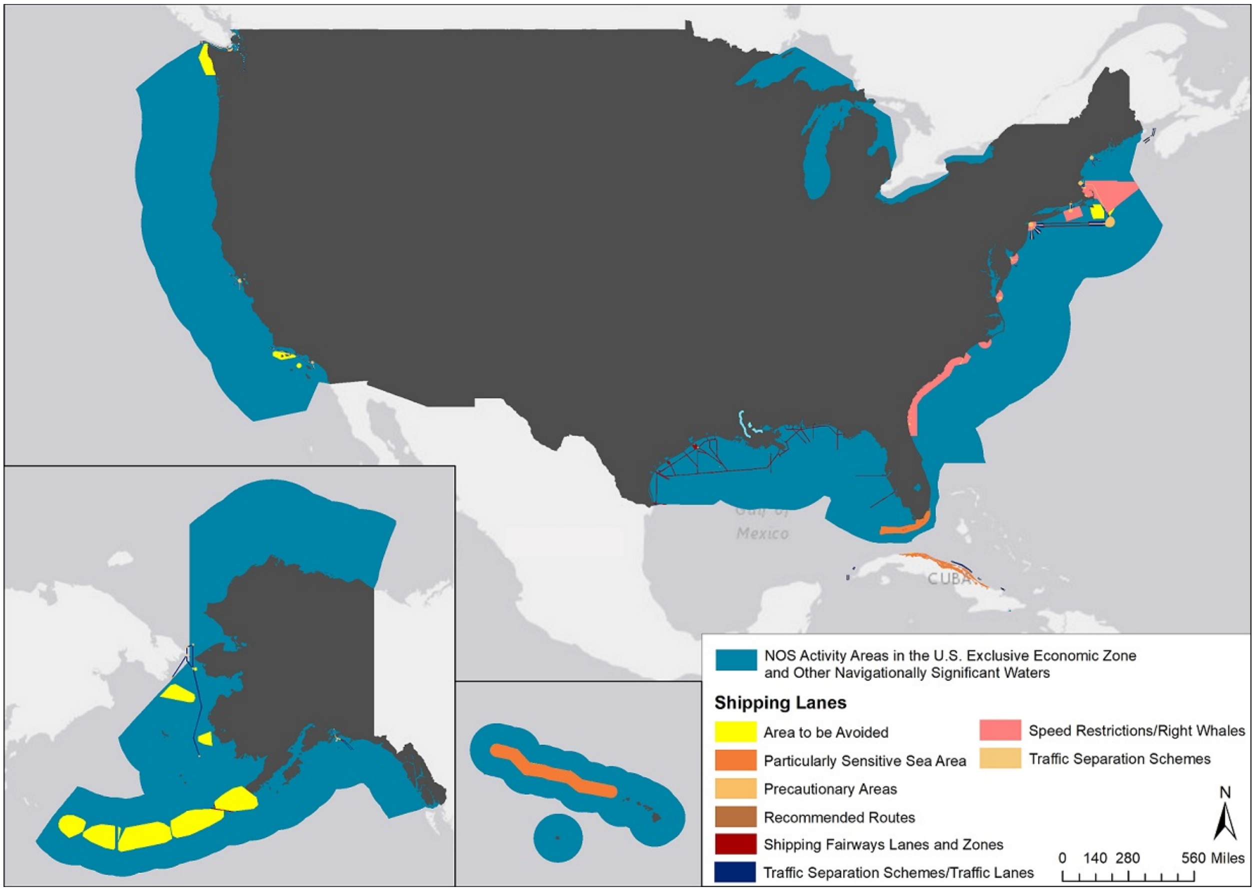


Figure 4.1-4. Shipping Lanes and Vessel Traffic Restrictions within the Action Area

Shipping trends in the Alaska region are expected to vary in the near-term future because the Arctic region is undergoing dramatic changes due to the effects of climate change. Temperatures in the Arctic are rising more than two times faster than the rest of the planet, and increasing ocean temperatures have caused a decrease in the amount of seasonal sea ice (Ocean Conservancy, 2017; Hoegh-Guldberg and Bruno, 2010). The loss of sea ice has facilitated the growth of industrial interests in the region. While vessel traffic in many areas of the Arctic dipped slightly after 2014, it is anticipated to increase in future years as more areas of the Arctic Ocean are uncovered by sea ice (Ocean Conservancy, 2017). Three principal Arctic shipping routes connect the Atlantic and Pacific: The Northwest Passage, the Northern Sea Route, and the Transpolar Sea Route illustrated in **Figure 4.1-5** below (Ocean Conservancy, 2017).

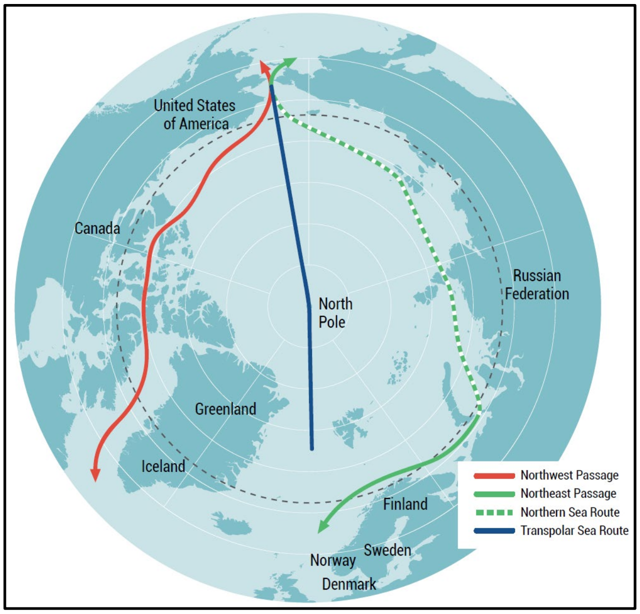


Figure 4.1-5 Arctic Vessel Routes

Source: Ocean Conservancy, 2017

The Northwest Passage (shown in red in **Figure 4.1-5**) refers to a variety of routes that connect the North Atlantic and North Pacific Oceans via the Arctic Ocean, traversing north of mainland North America. The passage is up to 30 percent shorter than traveling between Northwest Europe and Asia and up to 20 percent shorter than a Panama Canal voyage. The decrease in seasonal sea ice increases the viability of the Northern Sea Route (shown with a green dotted line in **Figure 4.1-5**) and the Northwest Passage for commercial shipping during summer months. These shorter sea routes have the potential to reduce the time it takes to transport goods between Asian and European ports by several days (USCG, 2018b). In the U.S. Arctic, predictions show anywhere from a 100 percent (low-growth economic scenario) to 500 percent (high-growth economic scenario) increase in vessel traffic through the Bering Strait. The variation between the low and high growth predictions stems from uncertainties relating to expansion of onshore and offshore O&G development in the region, infrastructure development, the numbers of vessels transiting the Northern Sea Route and Northwest Passage, and other variables (Ocean Conservancy, 2017).

With an increase in vessel traffic, secondary trends to consider include an increase in operational and illicit vessel emissions, anthropogenic sounds in the sea, opportunities for the propagation and spread of invasive species, and an increased risk of vessel strikes. Impact causing factors associated with commercial shipping and recreational boating include vessel presence, vessel noise, impacts to the water column, potential accidental discharges, and air emissions (BOEM, 2019i). Increases in commercial shipping and recreational boating within the action area would likely contribute cumulative impacts related to all resources covered in this PEIS.

4.1.6 Assessment and Extraction of Marine Minerals

BOEM is responsible for identifying non-energy resources on the outer continental shelf; this includes managing the use of mineral and sand resources (BOEM, 2019h). BOEM's Marine Minerals Program (MMP) manages non-energy minerals (primarily sand and gravel) for coastal restoration, and commercial leasing of gold, manganese, and other hard minerals (BOEM, 2019h). Following preliminary G&G surveys, marine mineral projects typically involve the dredging of sediment using either a hopper dredge which suctions the material or a cutterhead dredge which pumps material to be closer to the project area at which point the material is transferred to a pipeline connected to the shore (BOEM, 2019i).

As of 2018, the MMP has executed 55 negotiated agreements and completed 45 coastal restoration projects for more than 512 km (318 mi) of shoreline in Florida, Louisiana, Maryland, Mississippi, New Jersey, North Carolina, South Carolina, and Virginia. To complete these projects, the MMP has provided nearly 150 million cubic yards of offshore sand resources to coastal communities and federal agencies—that amount of sand would cover Manhattan, New York to a depth of more than 1.8 m (6 ft). In the past few years, BOEM has experienced a substantial increase in the number of requests for negotiated agreements from governmental agencies to use offshore sand resources. This trend is most likely due to a diminishing supply of available material in near shore waters, increased coastal erosion as a result of more frequent and intense storms, and sea level rise. The MMP is planning to sponsor new offshore sediment surveys from Maine to Texas that build on MMP's plans following Hurricane Sandy in 2012, when BOEM supported coastal restoration projects in several Atlantic states. Sediment studies are also being conducted offshore of California (BOEM, 2019h).

In addition to using mineral resources for restoration projects, pursuant to Executive Order 13817 issued in December 2017, the MMP and the USGS are collaborating to research 35 critical minerals (i.e., minerals used in manufacturing, consumer products, or are otherwise economically important) along the outer continental shelf (BOEM, 2019h).

In addition to seafloor disturbance and dredging, impact causing factors associated with these activities would likely include vessel presence, vessel and equipment noise, impacts to the water column, potential accidental discharges, and air emissions (BOEM, 2019i). The assessment and extraction of marine minerals would likely contribute to cumulative impacts related to habitats; marine mammals; sea turtles; fish; aquatic macroinvertebrates; EFH; seabirds, shorebirds and coastal birds, and waterfowl; cultural and historic resources; and socioeconomic resources.

4.1.7 Offshore Carbon Storage Resource Assessments

Carbon storage is the process of removing carbon from the atmosphere or capturing it and depositing it for storage in a reservoir beneath the earth's surface. While there are no offshore carbon storage or sequestration projects currently underway or planned, the National Energy Technology Laboratory (NETL) in coordination with the DOE, BOEM, state geologic surveys, and other institutions have and continue to support offshore carbon storage resource assessments in the Mid-Atlantic, Southeast, and Gulf Coast regions. These projects utilize existing G&G data from existing or abandoned wells, available seismic surveys, and existing core samples to conduct prospective storage resource assessments. These projects have identified offshore sites with the potential to store at least 30 million metric tons (MMT) of CO_2 and are preliminary steps to identify regions of interest for offshore carbon storage projects (NETL, No Date). Once a site is identified and leased, carbon storage projects would likely require building infrastructure including the drilling of CO_2 injection wells and construction of a pipeline to transport CO_2 from the shore (BOEM, 2019i; Cameron et al., 2018). Following preliminary G&G surveys, offshore carbon storage projects would likely involve seafloor disturbance including drilling carbon injection wells, anchoring, and constructing structures and pipelines to shore. The operation of an offshore carbon storage project would include the capture of CO_2 emissions and transport via submarine pipeline to injection wells; however, within the next several years these projects are unlikely to progress beyond the initial G&G surveying phase (BOEM, 2019i).

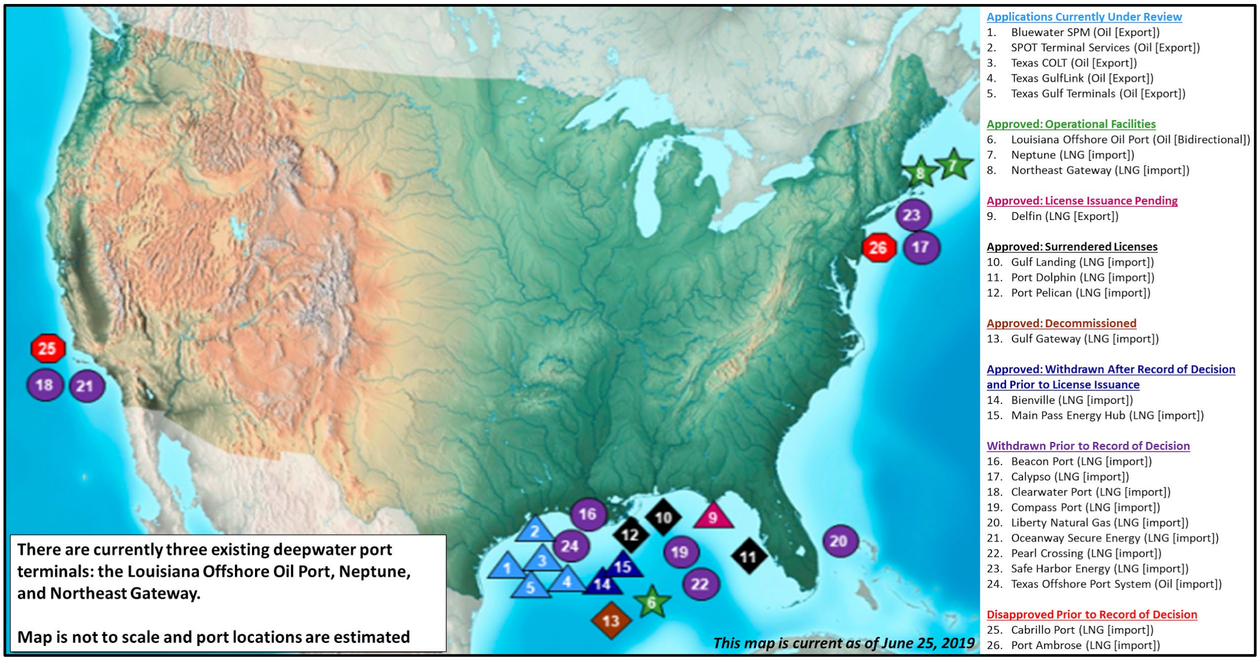
Impact causing factors associated with offshore carbon storage resource assessments would likely include vessel presence, vessel and equipment noise, impacts to the water column, potential accidental discharges, and air emissions. Offshore carbon storage resource assessments would likely contribute cumulative impacts to habitats; marine mammals; sea turtles; fish; aquatic macroinvertebrates; EFH; seabirds, shorebirds and coastal birds, and waterfowl; socioeconomic resources; and Environmental Justice.

4.1.8 Construction and Operation of Offshore Liquified Natural Gas (LNG) Terminals

Liquefied natural gas (LNG) is a form of natural gas that has been cooled down so that it has a reduced volume (only 1/600th of its gaseous state) such that it can be more readily transported across the ocean via specialized ships (EIA, 2019a). At terminals on the coasts, the liquid is re-gasified and distributed via pipeline networks. LNG is imported to and exported from the U.S. through both offshore and onshore terminals. Licensing of offshore LNG terminals (deepwater ports) is under the jurisdiction of the U.S. Coast Guard (USCG) and the Maritime Administration (MARAD) (BOEM, 2014b).

The design and construction activities required to build new offshore LNG terminals varies depending on the capacity needed and location of the terminal. New LNG terminals use existing infrastructure if possible or require the construction of new infrastructure such as platforms and underwater pipelines and cables (CEE, 2006). To ensure the stability of these structures, the company constructing the LNG facility typically conducts G&G surveys of the area to determine if the seabed is suitable for such infrastructure installations. These preliminary G&G surveys are described above in Section 4.1.1. Following these preliminary surveys, LNG projects generally involve three phases: construction and installation, operation, and decommissioning (BOEM, 2019i).

There are currently three operational facilities: Louisiana Offshore Oil Port and Neptune and Northeast Gateway, which are both located offshore Massachusetts. Other deepwater port license and application statuses located around the continental U.S. are shown in **Figure 4.1-6** below (MARAD, 2019).



Source: Adapted from MARAD Deepwater Port Licensing Program Map, (MARAD, 2019)

Figure 4.1-6. Deepwater Port Location and Status Map

Overall, activities pertaining to the operation and construction of offshore LNG terminals are expected to continue at current levels or increase over the next several years in the Greater Atlantic, Southeast, and West Coast regions of the action area. The impact causing factors associated with the construction and installation of LNG terminals would involve seafloor disturbance for construction, vessel presence, vessel and equipment noise, impacts to the water column, potential accidental discharges, and air emissions. Similarly, the operation of LNG terminals would include vessel presence, vessel and equipment noise, impacts to the water column, potential accidental discharges, and air emissions. The decommissioning of LNG facilities may include demolition activities and structure removal (BOEM, 2019i). The construction and operation of offshore LNG terminals would likely contribute cumulative impacts related to all the resources considered in this Draft PEIS.

4.1.9 National Defense and Homeland Security Activities

The U.S. Navy, USCG, U.S. Customs and Border Protection, U.S. Air Force, U.S. Marine Corps, and U.S. Army conduct operations and training exercises within the EEZ to ensure national security (NOS, 2016; NMFS, 2019e). Operations that are not compatible with commercial or recreational transportation are confined to Operating Areas (OPAREAs) away from commercially used waterways and/or inside Special Use Airspace (U.S. Fleet Forces, 2009). Military activities can include fleet training and testing, submarine and anti-submarine training, gunnery exercises, launch activities, missile training, and other training activities. These activities can involve the deployment of surface and subsurface vessels from small craft to large ships, high speed pursuits, live fire actions, underway refueling, and vessel anchoring (NOS, 2016). In addition to these activities, the Navy uses Surveillance Towed Array Sensor System (SURTASS) Low Frequency Active (LFA) sonar systems, Mid-Frequency Active Sonar (MFAS), and High-Frequency Active Sonar (HFAS) for training and testing activities.

SURTASS LFA sonar systems are long-range sensors that transmit in the low frequency band (i.e., below 1 kHz). The two basic types of sonar used in the SURTASS LFA sonar system are passive and active sonar.

Passive sonar detects sound created by a source and active sonar detects objects by creating a sound pulse that is transmitted through the water, reflects off a target object, and returns in the form of an echo to be detected. The Navy plans to upgrade SURTASS LFA sonar systems to a more compact LFA (CLFA) system that has a transmission frequency between 100 to 500 Hz; however, the operational characteristics and environmental impacts are expected to remain the same. The typical LFA sonar signal is not a constant tone but rather a series of sound transmissions referred to as a "wavetrain," lasting on average 60 seconds with 6 to 15 minutes between wavetrains. Hydrophones on the vessel then detect the returning echoes from submerged objects. The Navy plans to increase the annual number of LFA sonar transmission hours from 496 to 592 hours within the next five years and expects to continue operating at this higher level into the foreseeable future. Prior to 2018, the Navy used SURTASS LFA sonar in the non-polar areas of the Atlantic, Pacific, and Indian oceans and the Mediterranean Sea. The Navy currently uses SURTASS LFA sonar in the western and central North Pacific and eastern Indian oceans, overlapping with the Pacific Island region of the action area (Navy, 2018b).

Similar to LFA sonar, the Navy uses MFAS and HFAS emit non-impulsive sound waves to detect objects, safely navigate, and communicate. MFAS transmits sound at frequencies between 1 kHz and 10 kHz. MFAS is the Navy's primary tool for detecting and identifying submarines. HFAS transmits sound at frequencies between 10 kHz and 100 kHz. HFAS has a small effective range, but provides higher resolution of objects and is able to detect smaller objects. Active sonar is rarely used continuously during training and testing activities and operates using a low duty cycle when in use. Training activities that use sonar typically employ several hours to hundreds of hours of sonar use per exercise. These sources are expected to continue to be used in training and testing activities throughout the action area (Navy, 2015; Navy, 2018a).

A summary of national defense and homeland security projects that have required incidental take authorizations from NMFS is presented below in **Table 4.1-8** as a representative, not exhaustive, list of projects. Projects with an active take authorization status and projects with a take authorization application in-process are considered reasonably foreseeable to occur within the next five years and are categorized as ongoing activities. Projects that have been granted the requested take authorizations that have expired within the past 10 years are considered activities that have occurred within the past 10 years. Although projects that require take authorization are not of the only projects occurring in the action area, they are used as a representative list because projects that require take authorization are expected to be the projects with the greatest impact.

Table 4.1-8. Representative List of National Defense and Homeland Security Projects within the Action Area

Military Branch	General Location/ Geographic Scope	Project/Permit Description
Greater Atlantic Region		
Activities within the Past 10 years		
U.S. Navy	Eastern seaboard and PR, USVI	Atlantic Fleet Training and Testing (AFTT)
	North East Atlantic	Operations of SURTASS low frequency active sonar
Southeast Region		
Ongoing Activities		
U.S. Air Force	Gulf of Mexico	Testing and training activities in the Eglin Gulf Test and Training Range (EGTTR)

Military Branch	General Location/ Geographic Scope	Project/Permit Description
U.S. Marine Corps	Brandt island, Pamlico Sound, NC	Training activities in Pamlico Sound, NC
	Piney island, Pamlico Sound, NC	Training activities in Pamlico Sound, NC
U.S. Navy	Eastern seaboard and PR, USVI	Atlantic Fleet Training and Testing (AFTT)
	Gulf of Mexico	Atlantic Fleet Training and Testing (AFTT)
	Camp Lejeune, NC	Joint logistics over-the-shore training in VA and NC
	Fort Story, VA	Joint logistics over-the-shore training in VA and NC
	Little Creek, VA	Joint logistics over-the-shore training in VA and NC
	Eastern Indian Ocean	Operations of SURTASS low frequency active sonar
Activities within the Past 10 years		
U.S. Air Force	Eglin AFB, FL	Eglin AFB gunnery exercises, FL
	Eglin AFB, FL	Eglin AFB NEODS training operations
	Eglin AFB, FL	Eglin AFB precision strike weapons and air-to-surface gunnery exercises, FL
	Eglin AFB, FL	Maritime strike operations at Eglin AFB, FL
	FL panhandle	Maritime weapon systems evaluation program (WSEP) near FL panhandle
	offshore FL	Maritime weapons systems evaluation program, offshore FL
	offshore FL	Maritime weapons systems evaluation program, offshore FL
U.S. Marine Corps	Brandt island, Pamlico Sound, NC	Training activities in Pamlico Sound, NC
	Piney island, Pamlico Sound, NC	Training activities in Pamlico Sound, NC
U.S. Navy	Gulf of Mexico	Atlantic Fleet Training and Testing (AFTT)
	Cherry Point, NC	Cherry Point (CHPT) range complex mission activities, NC
	Corpus Christi OPAREA	Gulf of Mexico (GOMEX) range complex training exercises
	Pensacola OPAREA	Gulf of Mexico (GOMEX) range complex training exercises
	Jacksonville, FL	Jacksonville range complex, FL
	Jacksonville, FL	Jacksonville range complex, FL
	Panama City, FL	Naval Surface Warfare Center Panama City, FL
	South West Atlantic	Operations of SURTASS low frequency active sonar
	Panama City test range, FL	Testing mine reconnaissance sonar system at Panama City test range, FL
	Virginia capes, VA	Virginia capes (VACAPES) range complex, VA

Military Branch	General Location/ Geographic Scope	Project/Permit Description
West Coast Region		
Ongoing Activities		
U.S. Air Force	North sites Vandenburg AFB, CA	Vandenberg AFB launch activities, CA
	South sites Vandenburg AFB, CA	Vandenberg AFB launch activities, CA
U.S. Navy	Southern California Range Complex	Hawaii Southern California Training and Testing (HSTT)
	San Nicolas Island, CA	Missile launches from San Nicolas Island, CA
	Pacific Northwest	Northwest training and testing activities (NWTT)
	North Pacific	Operations of SURTASS low frequency active sonar
Activities within the Past 10 years		
U.S. Air Force	North sites Vandenburg AFB, CA	Vandenberg AFB launch and harbor maintenance activities, CA
	South sites Vandenburg AFB, CA	Vandenberg AFB launch and harbor maintenance activities, CA
	Vandenburg AFB, CA	Vandenburg AFB space launch vehicle and missile operations, CA
U.S. Navy	Southern California Range Complex	Hawaii Southern California Training and Testing (HSTT)
	Dabob Bay, WA	Keyport range complex expansion and activities, WA
	Keyport, WA	Keyport range complex expansion and activities, WA
	Quinalt site, coastal WA	Keyport range complex expansion and activities, WA
	San Nicolas Island, CA	Missile launches from San Nicolas Island, CA
	North Pacific	Operations of SURTASS low frequency active sonar
	Western Pacific	Operations of SURTASS low frequency active sonar
	San Diego Bay, CA	Silver Strand Training Complex exercises near San Diego Bay, CA
	Northwest Training Range Complex	Training in the Northwest Training Range Complex (NWTRC)
	Silver Strand Training Complex, CA	Training in the Silver Strand Training Complex, CA
	Ports of LA/Long Beach, CA	West Coast civilian port defense activities
Alaska Region		
Ongoing Activities		
U.S. Navy	Gulf of Alaska	Training activities in the Gulf of Alaska temporary maritime activities area
Activities within the Past 10 years		
U.S. Navy	Beaufort Sea, Arctic Ocean	2018 IceX

Military Branch	General Location/ Geographic Scope	Project/Permit Description
	Gulf of Alaska	Training activities in the Gulf of Alaska temporary maritime activities area
Pacific Island Region		
Ongoing Activities		
U.S. Air Force	Kauai, HI	Weapon Systems Evaluation Program
U.S. Navy	Hawaii Range Complex	Hawaii Southern California Training and Testing (HSTT)
	Mariana Islands	Mariana Islands Training and Testing (MITT)
	Central Pacific	Operations of SURTASS low frequency active sonar
Activities within the Past 10 years		
U.S. Air Force	Kauai, HI	Long Range Strike Weapon Systems Evaluation Program
U.S. Navy	Hawaii	Hawaii range complex
	Hawaii Range Complex	Hawaii Southern California Training and Testing (HSTT)
	South Pacific	Operations of SURTASS low frequency active sonar
	Mariana Islands Range Complex	Training in the Mariana Islands Range Complex (MIRC)

Source: NMFS, 2019e

AFB = Air Force Base; NEODS = Naval Explosive Ordnance Disposal School; SURTASS = Surveillance Towed Array Sensor System

Impact causing factors associated with national defense and homeland security activities would likely include the use of active underwater acoustic sources, the use of explosives, seafloor disturbance, dredging, vessel presence, vessel and equipment noise, impacts to the water column, potential accidental discharges, and air emissions (BOEM, 2019i). Prior to testing and training activities, the Navy issues notices to mariners and will clear the ocean range; therefore, it is unlikely that impact causing factors from the majority of these activities will overlap with those of other cumulative actions considered or NOS activities. NOS will coordinate with the Navy to ensure that surveys would not occur on or near ranges during exercises. Overall, national defense and homeland security activities are expected to increase above the present level due to the ongoing and planned programs, and would likely contribute to cumulative impacts for habitats; marine mammals; sea turtles; fish; aquatic macroinvertebrates; EFH; seabirds, shorebirds and coastal birds, and waterfowl; and Environmental Justice.

4.1.10 Construction of New Submarine Telecommunication Cable Infrastructure

Submarine cables play a critical role in global interconnected networks, carrying about 99 percent of international communications traffic. Sharp growth in demand for data, fueled by bandwidth-intensive applications such as video and a proliferation of cloud-based services, has driven a considerable increase in global submarine cable deployments (Brake, 2019). The U.S.'s existing submarine cable infrastructure is already substantial and is concentrated along coastal urban centers such as New York City, Washington D.C., and San Francisco where demand on communication networks is larger; however, new cable infrastructure is needed to support growing capacity demand throughout the action area. Submarine cables typically have a 25-year lifespan, so the replacement and repair of existing cables is also expected in the next several years as current cables reach the end of their effective lifespan or become obsolete.

Within the EEZ, installing or laying telecommunication cable infrastructure involves coordination with the Federal Communications Commission (FCC), USACE, and NOAA. Depending on the particular project and route characteristics, construction and maintenance of submarine cable infrastructure may include surveys of proposed cable routes; the use of specialized vessels, equipment, and divers to lay the cable; the use of equipment to bury the cable; construction of connection to onshore systems; and operation and maintenance of the cables (BOEM, 2019i).

Following preliminary G&G surveys of the cable route, the construction of new submarine telecommunication cable infrastructure generally involves the use of equipment to lay and bury the cables, the construction of a coastal landing station to connect the cables to onshore systems, maintenance and repairs, and eventual removal of cables. The impact producing factors associated with these activities include seafloor disturbance, vessel presence, vessel and equipment noise, impacts to the water column, potential accidental discharges, and air emissions (BOEM, 2019i). The construction of new submarine telecommunication cable infrastructure would likely contribute cumulative impacts related to habitats; marine mammals; sea turtles; fish; aquatic macroinvertebrates; EFH; seabirds, shorebirds and coastal birds, and waterfowl; cultural and historic resources; and Environmental Justice.

4.1.11 Commercial and Recreational Fishing

Commercial fishing is catching and selling fish and shellfish for profit, while recreational fishing is for sport or pleasure. The annual total landings, or poundage of fish, brought in by commercial fisheries has fluctuated between 4.3 and 4.4 billion kilograms (kgs) (9.4 and 9.6 billion pounds [lbs]) from 2011 to 2018. Alaska contributes the most to commercial fisheries, accounting for 58 percent of landings in 2018, followed by the Gulf of Mexico (16 percent), Atlantic (14 percent), Pacific (12 percent) and Hawaii and the Great Lakes (less than 1 percent each) (NMFS, 2020). Over the past decade, while the amount of wild-caught seafood has remained relatively consistent from year to year, the amount raised through aquaculture has increased, though it is still less than 10 percent of the wild harvest by weight. National marine aquaculture production increased an average of 3.3 percent per year from 2009-2014 and in 2017, freshwater and marine aquaculture production was 284 million kgs (626 million lbs) (NMFS, No Date-ad; NMFS, 2020). Most marine aquaculture production consists of oysters, clams, salmon, mussels, and shrimp. In addition to contributing to the seafood industry, aquaculture is also a tool to restore habitats and species. Hatchery stock is used to rebuild oyster reefs, grow wild fish populations, and rebuild threatened and endangered abalone and corals (NMFS, No Date-ad).

Recreational fishing includes fishing from private/rental boats, party/charter boats, and onshore (e.g., a dock or the shore). In 2018, recreational fishers took approximately 194 million saltwater fishing trips, with 55 percent in estuaries, 35 percent in state territorial seas, and 10 percent in the U.S. EEZ. Of the 163 million kgs (359 million lbs) of harvested fish, the majority were from the Atlantic (60 percent) and Gulf of Mexico (37 percent) (NMFS, 2020). All saltwater recreational fishing together harvested about 1/30th the combined catch (by weight) of commercial fishing in 2018.

Commercial and recreational fishing activities directly impact fishery stocks and indirectly impact seabirds and marine mammals that prey and depend on fishery stocks. Additionally, commercial and recreational fishing contribute to overall vessel traffic in the action area and therefore, the cumulative noise in the ocean. Over the 5-year project period, the amount of commercial and recreational fishing in the action area is expected to remain the same or increase. Impact causing factors associated with commercial and recreational fishing include seafloor disturbance, dredging, vessel presence, vessel and equipment noise, impacts to the water column, potential accidental discharges, and air emissions (BOEM, 2019i).

Commercial and recreational fishing would likely contribute cumulative impacts related to habitats; marine mammals; sea turtles; fish; aquatic macroinvertebrates; EFH; seabirds, shorebirds and coastal birds, and waterfowl; cultural and historic resources; and Environmental Justice.

4.1.12 Coastal Development

Coastal development includes the construction, maintenance, renovation, and removal of infrastructure such as piers, lighthouses, shipping ports and storage facilities, harbors, dams, bridges, roads, buildings, and other structures to support increased levels of safe navigation, tourism, and residential, commercial, and industrial land uses. While coastal construction is concentrated along urban centers, it is expected to occur throughout the U.S. coastline in all regions of the action area. The expected increase in marine traffic, fishing operations, and offshore energy development would increase the use of existing coastal infrastructure and increase demand for the construction of new infrastructure and port facilities (BOEM, 2019i). Due to their potential impact to marine mammals, coastal construction projects require incidental take authorizations granted by NMFS under the MMPA (NMFS, 2019e). A summary of these projects is presented below in **Table 4.1-9** as a representative, not exhaustive, list of coastal development projects. Projects with an active take authorization status and projects with a take authorization application in-process are considered reasonably foreseeable to occur within the next five years and are categorized as ongoing activities. Projects that have been granted the requested take authorizations that have expired within the past 10 years are considered activities that have occurred within the past 10 years. Although projects that require take authorization are not of the only projects occurring in the action area, they are used as a representative list because projects that require take authorization are expected to be the projects with the greatest impact.

Table 4.1-9. Representative List of Coastal Development Projects within the Action Area

General Location/ Geographic Scope	Project Lead	Project/Permit Description
Greater Atlantic Region		
Ongoing Activities		
Off NY and NJ	Transcontinental Gas Pipe Line Company, LLC	Construction Activities for Raritan Bay Pipeline
New London, CT	U.S. Navy	Dock construction project
Kittery, ME	U.S. Navy	Dock expansion project
Activities within the Past 10 years		
DE and NJ	Bluewater Wind, LLC	Meteorological tower installation
Atlantic City windfarm, NJ	Fishermen's Atlantic City Windfarm, LLC	Pile placement
Eastport, ME	Maine DOT	Pier and breakwater replacement project
Kittery, ME	U.S. Navy	Waterfront improvement project
Southeast Region		
Ongoing Activities		
Tampa Bay, FL	USACE	Tampa Harbor Bay Big Bend Channel expansion
Jacksonville, FL	U.S. Navy	South Quay Wall recapitalization project
Kings Bay, GA	U.S. Navy	Submarine base waterfront construction

Activities within the Past 10 years		
Port of Miami, FL	USACE	Blasting operations
Chesapeake Bay entrance	Chesapeake Tunnel Joint Venture	Parallel Thimble Shoal Tunnel Project
Jacksonville, FL	U.S. Navy	Wharf maintenance project
West Coast Region		
Ongoing Activities		
Coos Bay, OR	USACE	North Jetty Maintenance and Repairs Project
Santa Cruz, CA	Caltrans	Murray Street Bridge seismic retrofit project
CA	Carnival Corp, City of Alameda, San Francisco Bay Area Water Emergency Transportation Authority, and Port of San Francisco	Three ferry and cruise terminal improvement and construction projects
Richmond, CA	Chevron	Wharf maintenance project
Kalama, WA	Port of Kalama	Proposed construction activities
Sant Cruz, CA	Sant Cruz Port District	Aldo's Seawall Replacement Project
Jenner, CA	Sonoma County Water Agency	Estuary Management Activities
Columbia River	USACE	Jetty System Rehabilitation, King Pile Markers Project, and Sand Island Pile Dike Test Project
Seal Beach, CA	U.S. Navy	Construction of Pier and Turning Basin
Puget Sound, WA	U.S. Navy	Structure maintenance and pile replacement
Bangor, WA	U.S. Navy	Pier extension project
Bremerton, WA	WA DOT	Dolphin Relocation project
WA	WA DOT	Two multimodal construction projects
Aberdeen, WA	WA DOT	US 101/Chehalis River Bridge-Scour Repair
Activities within the Past 10 years		
Columbia River	USACE	Jetty rehabilitation
San Francisco, CA	USACE	Pier 36/ Brannan Street wharf project
Newport, OR	Bergerson Construction, Inc.	Front Street transload facility construction
Elkhorn Slough, Monterey, CA	California Dept of Fish and Wildlife	Tidal marsh restoration project
San Francisco, CA	Caltrans	Bridge construction and demolition and seismic safety tests
Trinidad Pier, CA	Cher-Ae Heights Indian Community	Pile-driving and renovation operations
Carpinteria, CA	Chevron	Casitas Pier Fender Pile Replacement Project
Richmond, CA	Chevron	Wharf Maintenance project
WA	City of Astoria and Kitsap Transit	Two dock construction and expansion projects

Monterey County, CA	NOAA Restoration Center	Parsons slough project
Friday Harbor, WA	Port of Friday Harbor	Marina reconstruction project
Kalama, WA	Port of Kalama	Proposed construction activities
San Francisco Bay, CA	Port of San Francisco	Activities for the America's Cup
Port of Vancouver, WA	Port of Vancouver	Port of Vancouver, WA
San Diego, CA	San Diego	Construction and demolition activities and Coast Blvd sidewalk Improvements
CA	San Francisco Bay Area Water Emergency Transportation Authority	Three ferry terminal expansion and reconstruction projects and Central Bay operations and maintenance project
Seattle, WA	Seattle DOT	Seawall and pier restoration projects
Russian River estuary	Sonoma County Water Agency	Estuary management project
San Francisco, CA	The Exploratorium	Exploratorium relocation
Monterey, CA	USCG	USCG Monterey Waterfront Improvement Project
Naval Base Kitsap, WA	U.S. Navy	Naval Base Kitsap Bangor pile replacement program, test pile program, and wharf construction project.
WA	U.S. Navy	Three pier maintenance projects
San Diego, CA	U.S. Navy	Naval Base Point Loma fuel pier replacement project
San Nicolas Island, CA	U.S. Navy	County Roads and Airfield Repairs Project
Vandenburg AFB, CA	United Launch Alliance	Harbor activities related to the Delta IV/EEL vehicle
Aberdeen, WA	WA DOT	Chehalis River Bridge Repair
Woodard Bay, WA	WA Dept of Natural Resources	Restoration activities
Anacortes, WA	WA DOT	Anacortes tie-up slips replacement
WA	WA DOT	Dolphin Relocation project and wingwall replacement project
Whidbey Island, WA	WA DOT	Coupeville timber towers preservation project
Manette Bridge, WA	WA DOT	Manette Bridge replacement project
WA	WA DOT	Four multi-modal construction projects
WA	WA DOT	Two ferry terminals construction projects
Vashon Island, WA	WA DOT	Vashon Ferry Terminal trestle seismic project
WA	WA Ferries	Span replacement project
Alaska Region		
Ongoing Activities		
AK	Alaska DOT	Four ferry terminal construction projects

AK	Alaska DOT, Federal Aviation Administration (FAA), Skagway, AK, and White Pass and Yukon Route	Five dock construction, replacement, and expansion projects
Ketchikan, AK	City of Ketchikan	Removal of Berth II Rock Pinnacles
Hoonah, AK	Duck Point Development II, LLC	Cruise Ship Berth Construction
Juneau, AK	Jim Erickson	Erickson residence marine access project
Juneau, AK	Juneau	Three harbor and waterfront projects
Sitka, AK	Sitka Alaska	Lightering float pile replacement project
Activities within the Past 10 years		
AK	Alaska DOT and Huna Totem Co.	Four ferry terminal improvement projects
AK	City of Unalaska, UniSea, Inc., FAA, Sitka Alaska, and Ketchikan Dock Co	Five dock construction, replacement, and expansion projects
St. Paul Island, AK	NMFS Alaska Region	Repair of observation towers and walkways
Port of Anchorage	Port of Anchorage	Test pile program
Pacific Island Region		
Activities within the Past 10 years		
Honolulu, HI	Honolulu Seawater Air Conditioning, LLC	Honolulu seawater air conditioning project, HI

Source: NMFS, 2019e

DOT = Department of Transportation; USACE = U.S. Army Corps of Engineers; USCG = U.S. Coast Guard

Impact causing factors associated with coastal construction include seafloor disturbance, vessel presence, vessel and equipment noise, impacts to the water column, potential accidental discharges, and air emissions (BOEM, 2019i). Coastal construction would likely contribute cumulative impacts related to habitats; marine mammals; sea turtles; fish; aquatic macroinvertebrates; EFH; and seabirds, shorebirds and coastal birds, and waterfowl.

4.2 Cumulative Effects on the Environment

As described in Section 4.1, NOS is considering actions taking place in the action area during a 17-year period from 2010 to 2027 in the assessment of cumulative effects. The following sections analyze the cumulative impacts for each resource covered in Chapter 3. The analysis first summarizes the cumulative effects of the cumulative actions identified in 4.1, then considers how the NOS-related incremental impacts of Alternatives A, B, and C, when added to or acting synergistically with the cumulative effects of other past, present, and reasonably foreseeable future actions, would contribute to overall cumulative impacts. The analysis of cumulative effects also considers other human actions and activities that contribute to the existing condition of coastal habitats, including encroachment from onshore, nearshore, and offshore development (e.g., coastal population growth, light pollution); flows and runoff of pollutants into coastal waters from onshore land uses, including urban, residential, industrial, and agricultural; and accidental or illicit discharges of oil, fuel, chemicals, or waste.

4.2.1 Habitats

All past, present, and reasonably foreseeable actions described in Section 4.1 would contribute cumulative effects to habitats. The following section addresses habitats in general, but discussion of cumulative impacts on habitats for other more specific resources may be found in these other sections of this chapter: 4.2.2.4 (Marine Mammals), 4.2.3.3 (Sea Turtles), 4.2.4.4 (Fish), 4.2.5.3 (Aquatic Macroinvertebrates), 4.2.6 (Essential Fish Habitat), and 4.2.7.3 (Sea Birds, Shorebirds and Coastal Birds, and Waterfowl).

The cumulative impacts in the following subsections are categorized by their relevance to the following essential characteristics of habitat:

- space needed for individual and population growth and normal behavior;
- food, water, air, light, minerals, and other nutritional or physiological requirements;
- cover or shelter requirements;
- sites needed for breeding, reproduction, or rearing of offspring.

4.2.1.1 Physical Impacts to Habitat Bottom Substrate

NOS activities under the Proposed Action including anchoring, collection of bottom grab samples, installation of tide gauges and remote GPS reference systems, use of dropped/towed camera systems, and SCUBA operations could contribute to overall cumulative impacts associated with the presence and movement of vessels and construction, operation, and decommissioning of long-term installations (e.g., LNG terminals, energy infrastructure, and submarine telecommunications) on the bottom substrate throughout marine, freshwater, and estuarine areas in the action area. These cumulative impacts could reduce the availability of space, shelter, cover, and nutrients for dependent species.

The agitation of ocean, lake, or river bottom sediments during NOS projects and other cumulative actions requiring the presence and movement of crewed vessels or the construction, operation, and decommissioning of long-term installations could cumulatively reduce the availability of space, shelter, cover, and nutrients for dependent species throughout the action area by physically removing or altering underwater structure. Many cumulative actions requiring crewed vessel operations could also entail anchoring, collection of bottom samples, or trailing of camera systems and other equipment. Equipment, vessels, or displaced water from vessel wakes could potentially contact bottom substrate throughout the action area, removing or damaging underwater structures such as submerged vegetation, macroalgae, and coral reefs.

This reduction of underwater structure would reduce the shelter and cover necessary for the survival or offspring development of many marine and freshwater taxa, particularly those organisms at lower levels of the aquatic food chain, and could potentially reduce the overall aquatic biodiversity of the area through cascading trophic impacts (i.e., reduced prey availability reduces the abundance of higher-level predators). However, impacts from NOS activities to bottom substrates would be temporary and would be mitigated by avoiding repeated NOS surveys in the same location. For both NOS projects and other actions these impacts would be largely confined to the immediate vicinity of their source and would not likely appreciably impact the total amount of underwater structure within the action area. Long-term installations, including renewable or fossil fuel energy installations, could also damage underwater structural features and would likely cumulatively reduce the total amount of space available to dependent species for the lifetime of the installation. However, any potential reductions in space would be limited to the immediate vicinity of constructed manmade structures, which could also serve as settlement strata for many species of marine and freshwater macroinvertebrates and subsequently attract and retain organisms from higher levels of the aquatic food chain.

The majority of cumulative impacts on bottom substrates would be limited to the immediate vicinity of vessels, trailed equipment, or onshore, nearshore, and offshore renewable and fossil fuel energy development and would not likely cause long term changes in the availability of space, shelter, cover, or nutrients for dependent species outside of the range of natural variation. The above-described NOS effects can also occur in almost all human use of water. These effects would be indistinguishable in type from other human uses. Overall, aggregate cumulative bottom substrate impacts would occur regardless of the chosen alternative, would be short-term and long-term, and could result in **negligible** to **minor** impacts on habitat areas throughout the action area. The contribution to these aggregate, adverse cumulative impacts on bottom substrate from any of the three NOS alternatives would be **negligible**.

4.2.1.2 Increase in Sedimentation, Turbidity, and/or Chemical Contaminants in Habitats

Crewed vessel , ROV, and autonomous vehicle operations; anchoring; dropped/towed camera systems; collection of bottom grab samples; installation of tide gauges and remote GPS reference systems; and SCUBA operations under the Proposed Action could contribute to overall cumulative impacts associated with the presence and movement of vessels, construction, operation, and decommissioning of long-term installations (e.g., LNG terminals, energy infrastructure, and submarine telecommunications), coastal erosion resulting from climate change, and runoff from expanding coastal development in conjunction with coastal population growth. The result would be a cumulative increase in sedimentation, turbidity and the presence of chemical contaminants throughout marine, freshwater, and estuarine areas in the action area, reducing the availability of space, shelter, cover, and nutrients for dependent species.

The presence and movement of vessels and trailing equipment during both NOS projects and other cumulative actions, in conjunction with underwater construction activities, such as blasting and leveling, could potentially stir up bottom sediment, cumulatively increasing the level of sedimentation and turbidity within the action area. Rising sea levels as a result of climate change will also continually erode coastlines along the EEZ over the next six years and could further contribute to increased turbidity within these areas. High levels of sedimentation and turbidity can potentially cause direct respiratory damage to aquatic species and block sunlight necessary for photosynthesis by aquatic plants, macroalgae, and phytoplankton.

These impacts could cumulatively lower the overall nutrient availability or reduce the cover and structure available to dependent species from submerged vegetation or macroalgae within the action area. Furthermore, increases in sedimentation and turbidity reduce the penetration of sunlight through the water column, which changes the wavelengths of light reaching fish and benthic species. Photosynthetic marine species are dependent on sunlight and often have a narrow band of wavelengths of light that they are able to use; increased sedimentation and turbidity could cumulatively hinder or prohibit photosynthesis in oceanic habitat areas, reducing nutrient cycling and primary production by marine phytoplankton and reducing shelter and cover provided by submerged plants and macroalgae. Suspended material may also react with dissolved oxygen (DO) in the water and result in temporary or short-term oxygen depletion to aquatic resources, including vegetation and aquatic macroinvertebrates, and could further exacerbate impacts to habitat areas from reduced nutrient and cover availability.

During both NOS projects and other cumulative actions, the presence and movement of vessels, construction and presence of long-term renewable or fossil fuel energy installations could cumulatively increase the concentration of contaminants within the water column when considered in tandem with current agricultural or urban runoff from onshore commercial development in conjunction with coastal population growth and accidental or illicit discharges of oil, fuel, or chemical contaminants. The magnitude of the majority of these impacts is contingent on the size, location, and chemical composition of the source discharge or spill. The majority of contaminants, including oil and fuel, currently entering the aquatic environment are less dense than water and float on the surface until they evaporate, typically within several days. Floating contaminants typically do not affect habitat characteristics below the surface of the water, however contaminants introduced to shallow marine habitat areas harm seagrass ecosystems close to the water surface and could potentially cause extensive mortality of the seabed and reduce the available cover and shelter that many marine species require to avoid predation, reproduce, and rear or develop offspring.

Additionally, seagrass mortality reduces the nutrient availability for seagrass foragers in these areas, including echinoderms, fish, manatees, and sea turtles. Chemical contaminants also cling or adhere to structural features in all aquatic habitat areas, which serve as additional exposure vectors to fish and aquatic macroinvertebrates and result in changes in growth rates or behavior, injuries, and death of exposed individuals. Coastal runoff includes chemical contaminants such as fertilizers or detergents with high levels of nitrates and phosphates. Influxes of nutrients or chemicals in shallow marine, estuarine, and coastal wetland habitat areas elicit algal blooms, which often are toxic for many marine species and reduce DO concentrations as dying algae are oxidized, thereby reducing the overall habitat quality of the affected area. Denser contaminants sink below the surface of the water and negatively impact coral colonies in shallow marine habitat areas through mortality, tissue death, reduced growth, impaired reproduction, bleaching, and reduced photosynthetic rates. Ongoing reduction of coral coverage reduces the structure and shelter necessary for prey species and will continue to reduce the overall biodiversity of affected areas through cascading impacts throughout the food chain. Bioaccumulation of some toxic chemicals also disproportionately impacts higher level predators which consume contaminated prey items and ultimately reduces top-down ecosystem regulation and nutrient availability of affected habitat areas.

Overall, increased sedimentation, turbidity, and chemical contamination within the action area would predominantly be dissipated by prevailing currents or winds in seconds to minutes. Temporary reductions in water quality are not expected to cumulatively reduce the availability of space, shelter/cover, nutrients, or breeding/rearing grounds in any of the habitat types found throughout the action area outside the range of natural variability. It is also an NOS practice to generally avoid repeated NOS surveys in the same location, thereby mitigating impacts of increased sedimentation, turbidity, and chemical contamination within the action area. The above-described NOS effects can also occur in almost all human use of water. These effects would be indistinguishable in type from other human uses. Overall, aggregate cumulative impacts to all aquatic habitat areas from increased sedimentation, turbidity, and/or chemical contamination would be adverse and **negligible** to **minor** in magnitude. The contribution to these aggregate, adverse cumulative impacts from any of the three NOS alternatives would be **negligible**.

4.2.1.3 Increased Ambient Sound Levels in Habitats

Crewed vessel, ROV, and autonomous vehicle operations and the use of echo sounders, acoustic communications systems and ADCPs under the Proposed Action, could contribute to overall cumulative impacts on ambient sound levels associated with the presence and movement of vessels, other surveying and mapping activities, and construction, operation, and decommissioning of long-term installations (e.g., LNG terminals, energy infrastructure, and submarine telecommunications). These could result in a cumulative increase in the ambient sound environment throughout marine, freshwater, and estuarine areas in the action area, reducing the availability of space, shelter, cover, and nutrients for dependent species.

Crewed vessel, ROV, and autonomous vehicle operations from both NOS projects and other actions and underwater construction activities in support of long-term installations, would generate underwater sound and vibrations at low- to mid-frequencies that overlap with the hearing ranges of many aquatic prey species. Increases in the ambient sound level of aquatic habitat areas could potentially reduce the habitat quality of preferred feeding or breeding grounds and displace disturbed animals from these areas. Increased ambient sound can also mask biologically important sounds which elicit predator-avoidance or mating behaviors, cause hearing loss, and/or generally have an adverse effect on an organism's stress levels and immune system. Reduction of prey species would reduce food and nutrient availability for top-level predators in aquatic habitat areas and could potentially result in cascading impacts throughout the local aquatic food chain and reduced biodiversity. However, crewed vessel transits would be infrequent in any given area and the exposure of prey species to vessel sound would be limited to the immediate vicinity of vessels and would only persist for the duration of vessel transit through the habitat area. The cumulative contribution to background sound in the ocean from vessels operated by NOS would not be substantial and the exposure of prey species to these sounds at the levels and lengths of time that may cause anything other than minimal adverse effects would be unlikely. NOS sound sources would be localized and short term and would not likely overlap with other sound sources.

The use of active underwater acoustic sources in other surveying mapping activities, national defense and homeland security activities, and oil, gas, carbon storage, or renewable energy assessments would involve directional and brief repeated signals which could cumulatively increase the ambient sound environment of aquatic habitat areas. Although the active underwater acoustic sources described in Chapter 2 would not be perceptible to most marine prey species, other active underwater acoustic sources commonly used in support of cumulative actions have a greater propensity to injure marine prey due to the high intensity and large-scale propagation of the broadband sound they produce. These high intensity sources, including airguns, could have a more substantial impact on habitat areas than the sources described in Section 3.4, especially when considered cumulatively. Exposure of marine prey to this sound could result in the same adverse impacts to the aquatic food chain as those discussed in the preceding paragraph. However, active underwater acoustic sources are typically only operated while a ship is in motion and habitat areas would only be exposed to emitted acoustic energy for a very short duration. Furthermore, these sources are highly directional in nature, and the energy of their emitted acoustic signals would drop off rapidly with distance from the source. Therefore, impacts on marine prey species would be predominantly limited to temporary behavioral and stress-startle response, and the likely cumulative impact on the overall habitat quality would be negligible to minor in any given area.

Sound from vessel operations (both NOS and other) and underwater construction activities from other actions, which would generate sounds in the mid- and low-level frequencies, are within the hearing range of most prey species but would be infrequent, geographically widely distributed, and likely to cumulatively elicit a minimal or temporary response. It is also an NOS practice to generally avoid repeated surveys by NOS in the same location, thereby mitigating increased ambient sound levels within the action area. A majority of the sounds generated by underwater acoustic sources are well above the hearing frequencies of the most prey species, thus they are unlikely to cause cumulative behavioral disturbance and hearing impairment. Increased ambient sound levels throughout the action area would not likely cause cumulative long-term changes in the availability of space, shelter, cover, or nutrients for dependent species outside of the range of natural variation. The above-described NOS effects can also occur in almost all human use of water. These effects would be indistinguishable in type from other human uses. Overall, the cumulative impact of increased ambient sound levels throughout the action area would be **adverse** and **negligible** to **minor** in magnitude. The contribution to these aggregate, adverse cumulative impacts on ambient underwater sound levels from any of the three NOS alternatives would be **negligible**.

4.2.1.4 Facilitated Dispersal of Invasive Species in Habitats

All activities under the Proposed Action which entail the use of the same physical equipment and instruments in geographically disparate regions (e.g., crewed vessel, ROV, and autonomous vehicle operations; anchoring; and the use of echo sounders), could contribute to cumulative impacts from all actions detailed in Section 4.1 in conjunction with ongoing climate change. Cumulatively, they could facilitate the dispersal of invasive species throughout marine, freshwater, and estuarine areas in the action area, reducing the availability of space, shelter, cover, and nutrients for dependent endemic species.

Cumulative actions from both NOS and other entities would occur in all freshwater and marine regions of the action area and could involve transit and surveying across large swaths of the action area using the same physical equipment and survey instrumentation. These larger voyages or projects could potentially inadvertently transport invasive macroinvertebrate larvae, vertebrate eggs or animals, plant seeds, or algae propagules in ballast water or on equipment surfaces to novel areas, thereby facilitating their dispersal and establishment. Invasive species often have large numbers of offspring and limited or no natural threats or predators outside of their native habitat, allowing them to outcompete locally endemic species for space and nutrients.

Over time, invasive species could propagate far beyond the initial site of establishment, which could cumulatively result in cascading impacts to the local food chains through the extirpation of local predators and prey due to reduced nutrient cycling and availability. These impacts would cumulatively change habitat structure and reduce the habitat value of affected areas in the long-term or permanently after the establishment of invasives; these species and their resulting impacts would persist until all invasive organisms were removed from a given area through aggressive trapping, harvesting, or use of pesticides such as glyphosate. Global rising sea temperatures as a result of ongoing climate change could cumulatively exacerbate these impacts by shifting the distribution of ideal abiotic habitat conditions (e.g., water temperature or acidity) for endemic species. Invasive species typically have wider ranges of tolerability for abiotic environmental conditions, allowing them to withstand climate-related stresses and either outcompete less tolerant endemic species or establish themselves in habitat areas vacated by endemic species dispersed by altered abiotic environmental conditions.

Physical equipment and instruments used in consecutive projects in disparate geographically regions could potentially serve as transmission vectors for invasive species, which could cumulatively reduce the habitat value of their area of introduction by outcompeting endemic plants, animals, and algae. After establishment, cumulative impacts could potentially spread beyond project areas and persist until invasive species are suppressed or removed from these areas via aggressive management techniques and procedures, reducing the availability of space, shelter, cover, or nutrients for dependent species outside of the range of natural variation. However, vessel crews on NOS projects would implement invasive species control procedures such as deballasting or equipment washing as required by law, reducing the likelihood of invasive propagation. It is also an NOS practice to generally avoid repeated surveys by NOS in the same location, thereby mitigating dispersal of invasive species within the action area. The above-described NOS effects can also occur in almost all human use of water. These effects would be indistinguishable in type from other human uses. Overall, given its relatively low likelihood of occurrence, the aggregate, **adverse** cumulative impact of invasive species dispersal would be **minor** to **moderate** in magnitude. The contribution to these aggregate, adverse cumulative impacts on invasive species dispersal from any of the three NOS alternatives would be **negligible**.

4.2.1.5 Impacts to the Water Column in Habitats

Crewed vessel, ROV, and autonomous vehicle operations; use of sound speed data collection equipment and bottom grab samplers; operation of drop/towed cameras and video systems; and SCUBA operations under the Proposed Action could contribute to cumulative impacts from the presence and movement of vessels associated with all cumulative actions, raising and lowering of equipment, and construction, operation, and decommissioning of long-term installations (e.g., LNG terminals, energy infrastructure, and submarine telecommunications). In aggregate, these could cumulatively disturb the water column throughout marine, freshwater, and estuarine areas in the action area, reducing the availability of space, shelter, cover, and nutrients for dependent species.

Wakes from crewed vessels, ROVs, and autonomous vehicles used in support of other surveying and mapping activities; fossil fuel, renewable, or carbon storage assessments; homeland security activities; and expanded recreational boating and commercial fishing would create turbulence and generate wave and surge effects in the water column. This displacement of water could cumulatively disrupt important environmental gradients, including temperature, salinity, DO, turbidity, and nutrient supply. Propellers from vessels could also cause water column destratification and elevated water temperatures. Vessel movements through the water column could cumulatively disrupt benthic communities in shallow areas and other prey species and cause mortality to floating eggs and larvae by physically damaging them with the hull or other ship parts, including the propulsion system. These disruptions would likely reduce the availability of space, shelter, and nutrients for dependent species within oceanic and shallow marine habitat areas and could cumulatively disrupt food chains, ultimately reducing the overall biodiversity of the study area. However, the vast majority of cumulative disturbance impacts to habitat areas would be limited to the immediate vicinity of vessels, and would only persist for the duration of transit or survey activities within the affected area.

Instruments, gear, and personnel that interact with the water column, including anchors and chains, bottom sampling equipment, echo sounders, airguns, and fishing lines or nets could cumulatively disturb or displace nearby benthic communities and other prey species. Reduction of prey species would reduce food and nutrient availability for top-level predators in aquatic habitat areas and could potentially result in cascading impacts throughout the local aquatic food chain and reduced biodiversity. Lines connecting equipment to a vessel could also become entangled with, damage, or kill underwater structural habitat features such as seagrass or corals. Reduction of underwater structure would likely cumulatively reduce the space, shelter, and cover necessary for the avoidance of predators by prey species and the rearing or development of offspring. Additionally, the expansion of commercial or recreational fishing could disturb, entangle, or directly target aquatic predators and prey species, which could drastically cumulatively alter food chains and energy flows throughout the action area. However, the vast majority of cumulative disturbance impacts to habitat areas would be limited to the immediate vicinity of instruments, gear, or personnel and would only persist for the duration of the activity. Mobile species would likely only be minimally displaced from project areas and would not experience long-term changes in the availability of space, structure, shelter, or nutrients outside the range of natural variability.

Most of the cumulative disturbance and displacement impacts to the water column would still likely be limited to the immediate vicinity of the source and would not persist beyond the conclusion of a project. It is also an NOS practice to generally avoid repeated surveys by NOS in the same location, thereby mitigating increased disturbance and displacement impacts to the water column within the action area. The above-described NOS effects can also occur in almost all human use of water. These effects would be indistinguishable in type from other human uses. Overall, aggregate impacts of all actions described in Section 4.2.1.5 would not likely cause cumulative, long-term changes in the availability of space, shelter, cover, or nutrients for dependent species in habitat areas throughout the action area outside of the range of natural variation; thus, aggregate, adverse cumulative impacts would be considered **negligible** to **minor** in magnitude. The contribution to these aggregate, adverse cumulative impacts from any of the three NOS alternatives would be **negligible**.

4.2.1.6 Impacts to Terrestrial Habitats

Installation of tide gauges and remote GPS reference systems under the Proposed Action could contribute to cumulative impacts on terrestrial habitats from construction, operation, and decommissioning of long-term installations (e.g., LNG terminals, energy infrastructure, and submarine telecommunications), coastal erosion resulting from climate change, and currently expanding coastal development in conjunction with coastal population growth. Cumulatively, these actions could degrade or reduce terrestrial habitat areas throughout the action area, reducing the availability of space, shelter, cover, and nutrients for dependent species.

The installation of or access to semi-permanent to permanent structures or equipment, such as LNG terminals, energy infrastructure, submarine telecommunications, and coastal commercial development, in conjunction with ongoing coastal erosion resulting from climate change could cumulatively reduce the quantity and quality of coastal terrestrial habitat throughout the action area. Many species of marine and terrestrial animals, including all ESA-listed bird species described in Section 3.10 and ESA-listed sea turtles, breed and nest along the coast. During onshore access or construction activities, vegetation in and adjacent to the project area could be trampled by foot traffic, damaged, or cleared, cumulatively reducing cover and shelter necessary for terrestrial or marine animals to avoid predation, breed, and nurture offspring. Repeated disturbances could result in long-term changes in terrestrial prey distributions and could ultimately reduce the overall biodiversity of habitat areas due to reduced nutrient cycling and availability. Light pollution from these structures could also disorient terrestrial animals, further disrupting terrestrial and aquatic food chains within the area.

Similarly, ongoing coastal erosion and commercial and residential development of coastal areas will continue to encroach upon existing coastal terrestrial habitat areas in all directions, further cumulatively reducing the space available for terrestrial animals. However, the majority of NOS onshore installations would only occupy very small portions of terrestrial habitat and any affected terrestrial components would likely recover post-installation. Disturbances resulting from the accessing of NOS installations would be limited to the immediate vicinity of the project area and would not persist beyond the conclusion of activity in the area. Onshore installations are not expected to reduce the availability of space, shelter, cover, or nutrients necessary for dependent species in the long term.

Generally, cumulative impacts to terrestrial habitat areas would persist for the entirety of the foreseeable future, but would not cumulatively reduce the availability of space, shelter, cover, or nutrients for dependent aquatic or terrestrial species. Disturbances to terrestrial taxa would also be limited to the immediate vicinity of onshore installations or activities and would only persist for the duration of the activity in question. It is also an NOS practice to generally avoid repeated surveys by NOS in the same location, thereby mitigating increased disturbance to terrestrial habitat within the action area. The above-described NOS effects can also occur from almost all human uses of water. These effects would be indistinguishable in type from other human uses. Overall, the aggregate, adverse cumulative impacts to terrestrial habitat would likely be **negligible** to **minor** in magnitude. The contribution to these aggregate, adverse cumulative impacts on terrestrial habitats from any of the three NOS alternatives would be **negligible**.

4.2.1.7 Conclusion

When considered in tandem with the NOS Proposed Action, other surveying and mapping efforts in the action area, offshore oil and natural gas development, offshore renewable energy development, climate change, commercial shipping and recreational boating, assessment and extraction of marine minerals, offshore carbon storage resource assessments, construction and operation of offshore LNG terminals, national defense and homeland security activities, construction of new submarine telecommunication cable infrastructure, commercial and recreational fishing, and coastal development would create adverse cumulative impacts to habitats. Adverse impacts to habitats could occur through bottom substrate contact, increased sedimentation, turbidity and/or chemical contamination, increased ambient sound level, facilitated dispersion of invasive species, disturbances to the water column, and terrestrial disturbance within the action area. In the short-term, the presence and movement of vessels; use of active acoustic sound sources; vessel sound; and underwater activities in conjunction with current accidental or illicit discharges of oil, fuel, chemicals, or waste and ongoing onshore, nearshore, and offshore development could temporarily adversely affect habitat by degrading water quality and displacing marine or terrestrial prey species in the immediate vicinity of NOS activities. Disturbances and displacements resulting from activities are not expected to persist beyond the duration of activities. Onshore, nearshore, and offshore development in conjunction with ongoing anthropogenic climate change would reduce the total amount of available terrestrial habitat in the long-term, however no other activities or actions would contribute long-term impacts to habitat areas except the unlikely occurrence of widespread propagation of invasive species facilitated by a given cumulative action.

Overall, the short and long-term aggregate adverse cumulative impacts from the cumulative effects scenario (i.e., actions described in Section 4.1) on habitats throughout the action area are **negligible** to **moderate** in magnitude, with **moderate** impacts occurring only in the event of widespread propagation of invasive species, and are therefore expected to result in insignificant impacts to habitats.

Cumulative, adverse impacts from the Proposed Action in combination with the cumulative effects scenario could potentially be considered either synergistic or additive depending on the timing and location of activities and impacts. Synergistic impacts could result if any activities or actions occur in close spatial or temporal proximity within the study area. Similarly, additive cumulative impacts to habitat areas could occur if activities or actions are conducted sequentially within adjacent areas of the study area. Although the exact timing and location of projects have not been finalized and are subject to change, the Southeast and Alaska regions contain the largest proportion of total vessel transit miles of the EEZ (Section 2.4.1) and relatively high levels of marine oil and gas development. Therefore, synergistic or additive cumulative impacts are most likely to occur in either of these regions. The vast majority of cumulative impacts are confined to the immediate vicinity of project areas and would likely not impact the overall availability of space, shelter, cover, or nutrients within habitat areas outside of the range of natural variability.

The NOS Proposed Action would contribute to and have the potential to increase these cumulative impacts, but their relative contribution would be **negligible** as compared to the aggregate contributions of other cumulative actions. These impacts would occur regardless of the chosen alternative since projects under each alternative would be composed of similar activities and take place in the same geographic areas and timeframes; however, Alternatives B and C would be expected to have slightly higher cumulative impacts because these alternatives include more projects, activities, and nautical miles traveled than Alternative A.

4.2.2 Marine Mammals

All past, present, and reasonably foreseeable future actions described in Section 4.1 would contribute cumulative effects on marine mammals. Based on the analysis presented in Section 3.5 Marine Mammals, impacts of the Proposed Action would result in negligible to minor, or possibly moderate, impacts to marine mammals. The main impacts from the Proposed Action that could contribute to cumulative impacts on marine mammals are injury acoustic exposures [permanent threshold shifts or PTS] due to underwater acoustic sources; entanglement; exposure to oil, fuel, and other contaminants; and a very low likelihood of vessel strikes) and disturbance or behavioral modification (from acoustic exposures due to underwater acoustic sources; vessel noise and masking; presence and movement of vessels; and human activity). The analysis also considers that additional actions and activities contribute to the existing condition of marine mammals, including the accidental or illicit discharge of oil, fuel, chemicals, or waste. To a lesser degree, the Proposed Action could also contribute cumulative impacts to animal fitness, habitat alteration, and even animal mortality.

The following analysis considers how the NOS-related incremental impacts of the NOS Proposed Action, when added to or acting synergistically with other past, present, and reasonably foreseeable future actions, would contribute to overall cumulative impacts.

4.2.2.1 Mortality and Injury to Marine Mammals

Marine mammal mortality and injury from other cumulative actions could result from contact with spilled oil and other contaminants, vessel strikes, fishing bycatch, and entanglement. Accidental or illicit discharges of oil, fuel, chemicals, or waste contribute to the existing mortality and injury of marine mammals. Contact with spilled oil leads to loss of life or life-threatening injury to marine mammals, and can seriously threaten the continued viability of the population, potentially having a major impact if the level of mortality or debilitating injury was in sufficiently high numbers that the continued viability of the population was seriously threatened.

Vessel strikes have been and will continue to be a cause of marine mammal mortality and injury. In particular, the most vulnerable marine mammals are likely those that spend extended periods at or just below the water surface, slow-moving species, or species whose unresponsiveness to vessel sound makes them more susceptible to vessel collisions (Gerstein, 2002; Nowacek et al., 2004). Marine mammals such as dolphins, porpoises, and pinnipeds that can move quickly throughout the water column are not as susceptible to vessel strikes. Vessel strikes likely have a less than perceptible impact on the status of most marine mammal populations, but for small populations, vessel strikes may have considerable population-level impacts. Commercial fishing activities are expected to result in some injury and mortality of marine mammals because of animals taken as fisheries bycatch or entangled in fishing gear. NOS does not expect any mortality and very little injury of marine mammals as a result of the Proposed Action. The probability for project vessel collisions with most marine mammal species is unlikely considering the relatively slow speeds of survey vessels, visual observation, and the speed and agility of most marine mammal species.

Likewise, the likelihood of occurrence of an accidental spill from a project vessel would be very low. In the event that an accidental spill does occur, the volume of oil, fuel, and/or chemicals would be fairly small given the small amounts of fuel and other chemicals used for consumption that are typically onboard, as well as the proper handling of all hazardous or regulated materials in accordance with applicable laws. Injury that might occur under the NOS actions would be additive to injury and mortality associated with other cumulative actions. NOS does not anticipate mortalities to marine mammals as a result of any of the NOS alternatives. The relative contribution of the Proposed Action to overall injury would be negligible compared to other cumulative actions. Thus overall, all three alternatives would be expected to contribute negligible cumulative impacts due to mortality and injury of marine mammals.

In addition to injury impacts associated with vessel strikes, bycatch, and entanglement as discussed above, marine mammals could also be injured by underwater noise. Such noise can occur from activities including use of Navy sonar systems, seismic airgun surveys, HRG surveys, underwater drilling, underwater pile driving, and underwater use of explosives, all of which produce low to high frequency underwater noise. If they occurred at the same time and place, they would synergistically contribute to adverse cumulative sonic impacts on marine mammals; if they do not occur at the same time and place, they would additively contribute to adverse cumulative impacts. However, the vast majority of impacts expected from underwater noise are behavioral in nature, temporary and comparatively short in duration, relatively infrequent, but which may result in behavioral disruption exposures (disturbance and behavior modification). The NOS Proposed Action could also result in both injury and behavioral disruption exposures to individuals of some marine mammal species from underwater acoustic sound sources. Although it is possible that injury that might occur under the NOS actions would be additive to injury associated with other cumulative actions, NOS projects are not likely to occur at the same time and place as other cumulative actions because conducting the NOS activities near other active acoustic activities could cause survey interference. It is also possible that the proposed action could cause a more serious behavioral response in an animal already injured by another activity. However, injury exposures would not likely be accumulative because other acoustic activities would not likely overlap in time and space with NOS projects. In addition, acoustic activities are typically temporary and localized. Additionally, the relative contribution of all three alternatives to the overall injury exposures of marine mammals in the action area would be negligible as compared to other cumulative actions.

Overall, the aggregate, adverse cumulative impacts to marine mammals from mortality and injury would likely be **minor** to **moderate** in magnitude. The contribution to these aggregate, adverse cumulative impacts from all three NOS alternatives would be **negligible**.

4.2.2.2 Marine Mammals Disturbance and Behavioral Modifications

Disturbance and behavioral modifications of marine mammals are associated with underwater surveying and mapping equipment and construction sounds, vessel and aircraft sound, and vessel and human presence. Low frequency vessel sound occurs in the same bands in which most large whale calls and songs occur (Richardson et al., 1995) and could interfere with animals' abilities to detect important sounds (Francis and Barber, 2013). Noise is of particular concern to marine mammals because many species use sound as a primary sense for navigating, finding prey, and communicating with other individuals. Noise can cause behavioral disturbances, mask other sounds (including their own vocalizations), and result in injury (as discussed above) (Tyack, 2009).

Other anthropogenic sound sources in the action area include dredging, O&G operations, nearshore construction activities, geophysical research operations, and military training and testing exercises. Increasing ambient sound levels may steadily erode marine mammals' abilities to communicate, find food, mate, and navigate. Noise and visual presence of aircraft would similarly disturb and stress marine mammals. Overall, there would be localized disturbance and behavioral impacts due to vessel sound, vessel movement, and human presence within specific portions of the action area during NOS projects. However, impacts are expected to be spatially localized and temporary or short-term in duration. Implementation of best management practices (BMPs) such as animal approach restrictions and low vessel speeds (see Section 3.5.2.3) are expected to minimize potential impacts on animal behavior. Other cumulative actions are unlikely to overlap in time and space with NOS projects because these activities are dispersed and the sound sources are intermittent. It is likely that distant shipping sound, which is more universal and continuous, would overlap in time and space with actions under the NOS Proposed Action. However, the Proposed Action would likely only contribute negligible cumulative impacts caused by disturbance and behavior modification of marine mammals.

Overall, the aggregate, adverse cumulative impacts to marine mammals from disturbance and behavioral modifications would likely be **minor** in magnitude. The contribution to these aggregate, adverse cumulative impacts from all three NOS alternatives would be **negligible**.

4.2.2.3 Reduced Fitness of Marine Mammals Due to Pollutants

Pollutants from multiple sources are present in, and continue to be released into, the oceans. Long-term exposure to pollutants poses potential risks to the health and fitness of marine mammals (Reijnders et al., 2008). Reduced animal fitness associated with air emissions and water pollution due to the accidental leakage or spillage of oil, fuel, and chemicals could have potential impacts such as organ anomalies and impaired reproduction and immune function (Reijnders et al., 2008). In an oil spill, whales, dolphins, and pinnipeds may be exposed to volatile chemicals during inhalation. Marine mammals with hair, such as fur seals or sea otters, would be at risk of insulation effects. Oil and other chemicals on skin and body may result in skin and eye irritation, burns to the mucous membranes of the eyes and mouth, and increased susceptibility to infection. For mysticetes, oil can foul the baleen they use to filter-feed, thereby potentially decreasing their ability to eat.

Inhalation of volatile organics from oil or dispersants can result in respiratory irritation, inflammation, emphysema, or pneumonia. Ingestion of oil or dispersants may result in gastrointestinal inflammation, ulcers, bleeding, diarrhea, and maldigestion. If the health of an individual marine mammal were compromised by long-term exposure to pollutants, it is possible that it could alter the animal's expected response to other environmental stresses, such as underwater noise.

Considering that the amount of air emissions from project vessels would continue to be a tiny fraction as compared to emissions from all other vessel activity, and the small number of vessels used by NOS that could accidently spill oil, fuel, and chemical contaminants into the ocean, as well as the small amounts of fuel and other chemicals used for consumption that are typically onboard, the incremental increase in cumulative impacts of the NOS alternatives on marine mammal health and fitness would be negligible. The potential also exists for the impacts of ocean pollution associated with the NOS Proposed Action to be additive or synergistic as it is possible that the response of a previously stressed animal would be more severe than the response of an unstressed animal.

Overall, the aggregate, adverse cumulative impacts to marine mammals from reduced fitness would likely be **minor** in magnitude. The contribution to these aggregate, adverse cumulative impacts from all three NOS alternatives would be **negligible**.

4.2.2.4 Alteration of Marine Mammal Habitat

Habitat alteration is associated with reduced prey/food sources and degraded water quality due to other cumulative actions, and to climate change. Overfishing of many fish stocks has resulted in significant changes in trophic structure, species assemblages, and pathways of energy flow in marine ecosystems (Jackson et al., 2001; Myers and Worm, 2003). These ecological changes may have adverse consequences for populations of marine mammals (DeMaster et al., 2001) as prey food sources are reduced. Air and water pollution can not only have adverse impacts on marine mammals themselves, as discussed above, but also on habitat as air and water quality are degraded. Increased emissions of anthropogenic greenhouse gases (GHG) [CO_2, methane (CH_4), and nitrous oxide (N_2O)] are warming the atmosphere, and rising levels of CO_2 in particular are producing changes in seawater carbon chemistry. Climate change effects include changes in air and sea temperatures, precipitation, the frequency and intensity of storms, pH level of sea water, and sea level. These changes could affect overall marine productivity, leading to altered migratory routes and timing, and changes in prey/food availability and reproductive success of marine mammals. Although the NOS Proposed Action would have some adverse impacts on fish and aquatic macroinvertebrates that make up the prey/food sources for marine mammals (see Sections 3.7 Fish and 3.8 Aquatic Macroinvertebrates), these impacts would be very small as compared to other cumulative actions affecting these resources. Likewise, the impacts of the Proposed Action from accidental spills and air emissions that could contribute to degraded water quality in marine mammal habitat or to climate change would also be negligible as compared to all other cumulative actions affecting water quality and climate change. Thus, the NOS Proposed Action would only contribute negligible cumulative impacts that could alter marine mammal habitat.

Overall, the aggregate, adverse cumulative impacts to marine mammals from alteration of their habitat would likely be **minor** to **moderate** in magnitude. The contribution to these aggregate, adverse cumulative impacts from all three NOS alternatives would be **negligible**.

4.2.2.5 Conclusion

When considered in tandem with activities associated with the NOS Proposed Action, other surveying and mapping efforts in the action area, offshore oil and natural gas development, offshore renewable energy development, climate change, commercial shipping and recreational boating, assessment and extraction of marine minerals, offshore carbon storage resource assessments, construction and operation of offshore LNG terminals, national defense and homeland security activities, construction of new submarine telecommunication cable infrastructure, commercial and recreational fishing, and coastal development would create adverse cumulative impacts to marine mammals. These adverse impacts occur through mortality and injury (due to vessel strikes, bycatch in fisheries, entanglement in fishing and other gear, contact with contaminants, and underwater noise); disturbance and behavior modification (due to underwater equipment and construction sounds, vessel and aircraft sounds, and vessel and human presence); reduced animal fitness (due to air and water pollution); and habitat alteration (due to reduced prey/food sources, degraded water quality, and climate change).

These past, present, and reasonably foreseeable future actions are expected to result in insignificant impacts to most marine mammal species, and significant impacts on some marine mammals in the action area. Overall, the cumulative impacts of all actions described in Section 4.1 affecting disturbance and behavioral modification, animal fitness, and habitat alteration are **adverse** and **moderate** as the continued viability of populations would not be threatened. These impacts would therefore be insignificant. Other impacts are considered **major** and thus significant because the cumulative effects of other cumulative actions described in Section 4.1 (particularly from vessel strikes, bycatch, entanglement, and reduced prey) are expected to result in relatively high rates of injury and mortality that could cause population declines in some marine mammal species. Therefore, cumulative impacts on marine mammals would be significant without consideration of the impacts of the Proposed Action.

Cumulative, adverse impacts from any of the alternatives in combination with the cumulative effects scenario could potentially be considered either synergistic or additive depending on the timing and location of activities and impacts. Cumulative adverse impacts could be synergistic if activities associated with the NOS Proposed Action and other cumulative actions occur in close spatial or temporal proximity. Similarly, additive effects to marine mammals may occur if actions taken by others are performed sequentially with activities associated with the NOS Proposed Action. The Proposed Action would contribute to and have the potential to increase cumulative impacts, but their relative contribution would be **negligible** as compared to aggregate contributions from other cumulative actions because the NOS impacts would be temporary or short-term, would be confined to the immediate vicinity of project areas, and would be small as compared to impacts from all other cumulative actions. NOS impacts would occur regardless of the chosen alternative since projects under each alternative would be composed of similar activities and take place in the same geographic areas and timeframes; however, Alternatives B and C would be expected to have slightly higher cumulative impacts because these alternatives include more projects, activities, and nautical miles traveled than Alternative A.

4.2.3 Sea Turtles

All past, present, and reasonably foreseeable actions described in Section 4.1 would contribute cumulative effects to sea turtles. The analysis of cumulative effects also considers that other actions and activities contribute to the existing condition of sea turtles, including habitat encroachment from onshore and nearshore development (e.g., coastal population growth, light pollution) and accidental or illicit discharge of oil, fuel, chemicals, or waste.

4.2.3.1 Mortality and Injury to Sea Turtles

Crewed vessel operations and active acoustic surveying under the Proposed Action would contribute to cumulative impacts from the use of high intensity active underwater acoustic sources used by several cumulative activities, such as seismic surveys or piledriving, and the presence and movement of vessels associated with any of the past, present, or reasonably foreseeable actions. In combination, these actions would likely cumulatively contribute direct injury impacts to sea turtles or their prey. Sea turtles may be able to hear low frequency sources that go down to 0.5 kHz. These low frequency sources are used in deeper water, so sea turtles exposed would likely be farther away from the source. However, underwater sound produced by active underwater acoustic sources would mostly be at frequencies reaching up to orders of magnitude above the documented sea turtle hearing range and would therefore be imperceptible to sea turtles. As such, there would not likely be cumulative effects from NOS sources even when considering that the active acoustic sources commonly used in other surveying and mapping activities, assessment and exploration of marine minerals, and offshore carbon storage assessments have a propensity to injure sea turtles. The presence and movement of crewed vessels within the action area, including all vessels used in conjunction with activities under the Proposed Action and all past, present, and reasonably foreseeable actions of the cumulative effects scenario, would likely cumulatively contribute to collisions or entanglement of sea turtles or their prey.

There is also a very small possibility of temporary or permanent hearing threshold shifts in sea turtles resulting from low-frequency vessel sound from the transit of vessels through the action area. Accidental or illicit discharges of fuel, chemicals, or waste accompanying all vessel operations within the study area contribute to the existing direct injury of turtles and prey through ingestion and interaction with spilled substances, although the intensity of the impact would be contingent upon the size and location of the spill in question. Contaminated prey or forage could also potentially serve as an additional source of spill exposure to sea turtles, particularly of bioaccumulated hazardous materials. Expanded commercial fishing operations would likely increase sea turtles or their prey in bycatch, particularly in longline or trawled fisheries where operators cannot continuously monitor trailed lines, hooks, and nets for protected species. As such, the overall abundance of sea turtle macroinvertebrate prey would likely be reduced.

Light pollution from onshore and nearshore commercial, residential, or O&G development in close proximity to sea turtle nesting beaches contributes to the currently reduced likelihood of offspring survival to reproductive maturity. NOS night operations, although not commonly conducted, could potentially contribute to cumulative coastal light pollution. Light pollution disorients sea turtle hatchlings or nesting sea turtle adult females, which navigate beaches using moonlight. Rising temperatures as part of ongoing climate change will continue to skew sea turtle sex-ratios due to temperature-dependent sex determination of sea turtle offspring. Over time, generally warmer incubation temperatures will skew the overall sex-ratio towards females and result in the reduction of overall sea turtle population numbers and genetic diversity. Ocean acidification accompanying climate change will harm the sea turtle macroinvertebrate prey species that are particularly sensitive to environmental conditions during their larval stages and will likely reduce their availability to sea turtles.

The majority of cumulative direct injury impacts would be limited to the immediate vicinity of vessels or O&G development and would not likely cause long-term changes in turtle behavioral patterns, habitat availability and use, or the demographic structure and abundance of turtle and prey populations. Similarly, climate-related impacts would not likely substantially affect turtles, although impacts would likely continue to increase over time. Overall, the aggregate, adverse cumulative impacts to sea turtles from direct injury would likely be **minor** to **moderate**. The contribution to these aggregate, adverse cumulative impacts from all three NOS alternatives would be **negligible** to **minor**.

4.2.3.2 Disturbance and Displacement of Sea Turtles

Sound from vessel operations under the Proposed Action could contribute to the disturbance of sea turtles in conjunction with other cumulative oceanic anthropogenic activities. Sound from survey vessels, shipping vessels, commercial fishing vessels, recreational boats and underwater construction activities in support of energy infrastructure, LNG terminals, and submarine telecommunications infrastructure could also cumulatively disturb and displace turtles and their prey from the respective project areas for the duration of the activity in question. The visual presence of vessels would also likely serve as an additional source of disturbance and displacement.

Sea turtles are low frequency specialists with a generalized hearing range of 30 to 2,000 Hz (0.03 to 2 kHz) and are most sensitive to sound between 200 and 400 Hz (0.2 and 0.4 kHz). Sea turtles may be able to hear low frequency sources that go down to 0.5 kHz. Low frequency underwater acoustic sources are used in deeper water, so animals exposed would likely be farther away from the source. However, underwater sound produced by active underwater acoustic sources would mostly be at frequencies reaching up to orders of magnitude above the documented sea turtle hearing range and would therefore be imperceptible to sea turtles and unlikely to cause behavioral changes. Vessel sound has the potential to disrupt normal sea turtle behavior because of their high hearing sensitivity between 200 and 400 Hz.

The NOS Proposed Action would contribute to cumulative underwater disturbance from vessel movement and presence and bottom sampling. Reduced water quality and increased turbidity would result from the ongoing erosion of coastlines by rising sea levels, bottom sampling, or underwater construction activities, all of which could disturb and displace sea turtles/prey. Climate change will continue to raise sea levels globally for the foreseeable future, which results in continual erosion throughout the coastlines of the EEZ. Coastal erosion occurs at varying rates around the EEZ, but would be most pronounced near sea turtle breeding grounds along the Atlantic coastline, which carry a greater risk of impacting the overall sea turtle population. The ongoing accidental or illicit discharges of fuel, chemicals, or waste from vessel operations and marine infrastructure contributes to currently disturbed and displaced sea turtles and their prey from contaminated areas for the lifetime of the spill. The intensity of the impact is contingent upon the size and location of the spill in question and most small spills are dissipated by ocean conditions on a timescale of minutes to hours. However, energy installations included in the cumulative effects scenario carry a larger probability of large spills than NOS activities, particularly in offshore oil/gas installations with tankers and pipelines.

Cumulative disturbance and displacement impacts would still likely be limited to the immediate vicinity of the source and would not persist beyond the conclusion of activities, although impacts could be magnified in the unlikely occurrence of a large spill. These aggregate, adverse cumulative impacts are not expected to cause long-term changes in habitat availability, overall turtle behavioral patterns, or overall prey availability and would be considered **negligible** to **minor**. The contribution to these aggregate, adverse cumulative impacts from all three NOS alternatives would be **negligible**.

4.2.3.3 Degradation and Reduction of Sea Turtle Habitat

Onshore tide gauge installations and remote GPS reference station installations under the Proposed Action could contribute to cumulative impacts associated with the construction and eventual decommissioning of long-term installations (e.g., LNG terminals, energy infrastructure, and submarine telecommunications). In combination, these actions would likely reduce the total amount of oceanic habitat available to sea turtles and their prey for the lifetime of the installation. Sea turtles and their prey would likely be displaced from these areas for the duration of the installation due to reduced water quality and various disturbances related to the operation and maintenance of the infrastructure, such as vessel traffic, low flying aircraft, waste discharge, underwater disturbance from welders, divers and wakes, and vessel sound. Following decommissioning, the development area would be reclaimed and should return to previous habitat conditions.

The ongoing accidental or illicit discharges of fuel, chemicals, or waste from vessel operations and marine infrastructure contributes to currently degraded sensitive coastal beach sea turtle nesting habitat. The intensity of the impact is contingent upon the size and distance of the spill in question from nesting beaches; most small spills are dissipated by ocean conditions on a timescale of minutes to hours. However, the operation of energy installations included in the cumulative effects scenario carry a greater probability of large spills with larger and longer-lasting impacts than do NOS activities, particularly in the case of offshore oil/gas installations with tankers, drilling rigs, production platforms, and pipelines.

Coastal population growth contributes to currently degraded sea turtle nesting habitat through a variety of factors, including coastal water quality reductions from urban/agricultural runoff, encroachment by coastal development, and increased light pollution. Rising sea levels as result of climate change will continually erode coastlines along the EEZ over the next six years and could potentially destroy or degrade sensitive sea turtle nesting beaches. Global rising temperatures could also shift sea turtle habitat and prey distributions northwards towards colder waters, and could ultimately reduce the total amount of available habitat or prey if the species dispersal rate is relatively lower than that of the rate of temperature changes. Seagrass, an important turtle forage, and coral reefs which shelter macroinvertebrate prey items are also particularly susceptible to changes in abiotic environmental conditions and could be damaged or displaced from sea turtle habitat areas by eroding coastlines, rising temperatures, or ocean acidification.

Generally, cumulative impacts to sea turtle habitat would persist for the foreseeable future, but would not substantially reduce overall habitat availability or quality and would not substantially impact the overall structure or abundance of sea turtle or prey populations. Nesting habitat reductions could potentially impact the overall sea turtle population since turtles return to the same beach to nest annually and would not be able to relocate in the event of the destruction or degradation of their predetermined nesting beach. However, nesting beaches are generally avoided by development given the federal protection of sea turtles. Aggregate cumulative impacts to sea turtle habitat from all actions and activities would likely be adverse, and **minor** to **moderate**. The contribution to these aggregate, adverse cumulative impacts from all three NOS alternatives would be **negligible**.

4.2.3.4 Conclusion

Activities associated with the Proposed Action and the cumulative effects scenario have the potential to contribute cumulatively to direct injury, disturbance and displacement, and habitat reduction impacts from past, present, and reasonably foreseeable actions within the action area. In the short-term, the presence and movement of vessels could potentially result in direct injury to turtles from collisions or entanglements and would likely disturb or displace nearby sea turtles for the duration of activities. Similarly, active acoustic sound sources; vessel sound; underwater construction activities; accidental or illicit discharges of oil, fuel, chemicals, or waste; and onshore, nearshore, and offshore development would displace sea turtles and their prey in the immediate vicinity of activities. Onshore and nearshore development and the accidental or illicit discharges of oil, fuel, chemicals, or waste contribute to the currently reduced total amount of sea turtle habitat. Climate change would reduce the total amount of available sea turtle habitat in the long-term, however no other activities or actions would contribute long-term impacts to sea turtles, except the unlikely occurrence of a large oil, fuel, or chemical spill. The vast majority of cumulative impacts would be confined to the immediate vicinity of project areas and would likely not impact the overall abundance or structure of sea turtle or prey populations outside of the range of natural variability. Overall, the cumulative impacts of all actions described in Section 4.1 would contribute **negligible** to **moderate** short-term and long-term adverse cumulative effects on sea turtles, depending on the timing and location of impacts within the 17-year timespan of this analysis.

Cumulative, adverse impacts from the Proposed Action in combination with the cumulative effects scenario could potentially be considered either synergistic or additive depending on the timing and location of activities and impacts. Synergistic impacts could result if any activities or actions occur in close spatial or temporal proximity within the study area. Similarly, additive cumulative impacts to sea turtles, their prey, or their associated habitat could occur if activities or actions are conducted sequentially within adjacent areas of the study area. Although the exact timing and location of projects have not been finalized and are subject to change, the Southeast and Alaska regions contain the largest proportion of total vessel transit miles of the EEZ (Section 2.4.1) and relatively high levels of marine O&G development. Therefore, synergistic or additive cumulative impacts are most likely to occur in either of these regions. However, most affected animals would be located in the Southeast, because sea turtles are only occasional visitors to Alaska's Gulf Coast waters.

The NOS Proposed Action would contribute to and have the potential to increase these cumulative impacts, but their relative contribution would be **negligible** as compared to the aggregate contributions of other cumulative actions. These impacts would occur regardless of the chosen alternative since projects under each alternative would be composed of similar activities and take place in the same geographic areas and timeframes; however, Alternatives B and C would be expected to have slightly higher cumulative impacts because these alternatives include more projects, activities, and nautical miles traveled than Alternative A. The contribution to these aggregate, adverse cumulative impacts from all three NOS alternatives would be **negligible**.

4.2.4 Fish

All past, present, and reasonably foreseeable future actions described in Section 4.1 would contribute cumulative effects on fish and fish habitat. Based on the analysis presented in Section 3.7 Fish, impacts of the NOS Proposed Action would result in negligible to minor impacts on fish and fish habitat. The Proposed Action could contribute to cumulative impacts on fish, including injury (hearing loss from underwater noise), disturbance or behavioral modification (from underwater sound, vessel wake and underwater turbulence, and bottom disturbance), and habitat alteration (from vessel wake and underwater turbulence; bottom disturbance; and air emissions). The analysis also considers that other actions and activities contribute to the existing condition of fish, including the accidental or illicit discharge of oil, fuel, chemicals, or waste which can cause mortality and marine debris (e.g., plastics, glass, metals, or rubber) and flows of pollutants, contaminants, sediments, and nutrients, which can reduce the fitness of fish. The following analysis considers how the NOS-related incremental impacts of the NOS Proposed Action, when added to or acting synergistically with other past, present, and reasonably foreseeable future actions, would contribute to overall cumulative impacts on fish.

4.2.4.1 Mortality and Injury to Fish

Fish mortality and injury from other cumulative actions could result from vessel strikes, underwater noise, fishing bycatch, and entanglement. Ongoing accidental or illicit discharges of oil, fuel, chemicals, or waste contribute to the existing mortality and injury of fish. All vessel operations, as well as other cumulative actions such as drilling and construction and placement of structures within the action area could cumulatively contribute to the mortality and injury of fish through ingestion and contact with spilled oil and fuel or released contaminants. Although most adult fish are mobile enough to avoid areas with higher concentrations of contaminants, less mobile eggs, larvae, and juvenile fish would be more susceptible than adults. Vessels and in-water devices do not normally collide with adult fish, most of which can detect and avoid them. However, early life stages of most fishes could be displaced by vessels and a vessel's propeller movement or propeller wash could entrain early life stages.

The cumulative potential effects from underwater acoustic sources on any stock of fish from injury (i.e., permanent loss of hearing) are considered low because NOS acoustic sources are generally outside of fish hearing ranges, although these sources could affect shad, herring, and other fish that can hear these sounds if they are within several meters of a sound source. It is possible that shipping and aircraft sounds (which are pervasive and continuous) and sound associated with underwater explosions and sonar would overlap in time and space; however, there is no evidence that the co-occurrence of these sounds would result in harmful additive impacts on fish.

Overfishing is the most serious threat that has led to the listing of ESA-protected marine fish due to mortality and population declines (Kappel, 2005; Cheung et al., 2007; Dulvy et al., 2003; Limburg and Waldman, 2009). Approximately 17 percent of the U.S.-managed fish stocks are overfished (NMFS, 2018d). Overfishing occurs when fishes are harvested in quantities above a sustainable level. Overfishing impacts targeted species, and non-targeted species (i.e., bycatch species) that often are prey for other fish and marine organisms. Commercial fishing and overfishing are also the primary causes of fish entanglement. Entanglement in abandoned commercial and recreational fishing gear has also caused declines for some marine fishes (Musick et al., 2009).

Although impacts that could occur under the Proposed Action would be additive to the injury and mortality of fish associated with other cumulative actions, NOS does not expect any mortality and very little injury of fish as a result of implementing any of the alternatives. The likelihood of occurrence of an accidental spill from a project vessel would be very low. In the event that an accidental spill does occur, the volume of oil, fuel, and/or chemicals would be fairly small given the size of project vessels and the amounts of fuel and other chemicals they typically carry, as well as the proper handling of all hazardous or regulated materials in accordance with applicable laws. Likewise, the probability for strikes by vessels or underwater devices is unlikely. For fish species, the greatest potential for adverse impacts as a result of active underwater acoustic sources would be related to changes in behavior (see below) rather than auditory injury. The relative contribution of the Proposed Action to the overall mortality and injury of fish would be minimal as compared to other cumulative actions. The aggregate, adverse cumulative impacts to fish from mortality and injury would likely be **minor** to **major** in magnitude. The NOS Proposed Action would be expected to contribute **negligible** cumulative mortality and injury impacts to fish.

4.2.4.2 Fish Disturbance and Behavioral Modifications

Disturbance and behavioral modifications in fish from other cumulative actions are associated with vessel operations, underwater sound, emplacement of structures, and use of underwater equipment. A significant amount of vessel traffic has taken place and is expected to continue for the foreseeable future under the cumulative effects scenario. Some studies found that most adult fish exhibit avoidance responses to vessels (Jørgensen et al., 2004; Misund, 1997) showing sudden escape responses when a vessel passes over them, including lateral avoidance or downward compression of the school. Conversely, Rostad et al. (2006) observed that some fishes are attracted to different types of vessels (e.g., research vessels, commercial vessels) of varying sizes, sound levels, and habitat locations. Fish behavior in the vicinity of a vessel is therefore variable, depending on the type of fish, its life history stage, behavior, time of day, and the sound propagation characteristics of the water. Anthropogenic contributions to ambient sound in the ocean come primarily from vessel traffic, but also include other cumulative actions such as O&G operations, construction activities, dredging, and sonar. Most ambient sound is broadband and encompasses almost the entire frequency spectrum, with vessel traffic recognized as a major contributor to ocean sound in the low-frequency bands (< 1,000 Hz). The majority of soniferous fishes are adapted to perceive and produce sounds in the low-frequency band, thus increased underwater sound could alter normal, biologically relevant behavior, disturbing basic life functions such as foraging, predator detection, and reproduction (Vasconcelos et al., 2007; Codarin et al., 2009). Other cumulative actions would contribute numerous sources of sound during the time period when NOS projects would take place, adding to ambient sound levels within the action area. Cumulative, low-frequency sound from multiple anthropogenic activities could have additive or synergistic behavioral effects on fish and contribute to auditory masking.

Fish could also be disturbed by structures and equipment in the water. Other cumulative actions, including O&G exploration, offshore renewable energy, carbon storage, and LNG terminals, have the potential for the emplacement of structures within the action area. Permanent and temporarily moored structures, including drilling rigs, barges, buoys, wind turbines, platforms, and other structures, would attract pelagic and demersal fish causing potential diversion of species from normal migratory pathways, feeding areas, and/or spawning areas. In addition, fish attracted to structures would then be subjected to chronic sound, routine discharges, and increased vulnerability to overfishing. Lights used at these structures could also enhance attractiveness for some species that are active at night. Water disturbance by underwater equipment used in other cumulative actions could also temporarily disturb and displace nearby fish. Because a towed in-water device is continuously moving, most fishes are expected to move away from it or to follow behind it, in a manner similar to their responses to a vessel. When the device is removed, most fishes are expected to return to the area and resume normal activities.

As vessels used by NOS would represent a negligible proportion of all vessel traffic in the action area, disturbance and behavioral modifications due to vessel operations under the Proposed Action would be minimal. Sound from NOS activities would be project-based, occurring on an intermittent basis over the period of interest. Because only small sound impacts are expected from NOS activities, impacts associated with the Proposed Action would only have a negligible incremental increase in ambient sound levels. NOS would not place any structures under the Proposed Action. The mobile nature of NOS surveys and the propensity of fishes to temporarily move away from water turbulence that is affecting them would only lead to very small behavioral impacts on fish from the Proposed Action. The aggregate, adverse cumulative impacts to fish from disturbance and behavioral modification would likely be **minor** to **moderate** in magnitude. The relative contribution of the NOS Proposed Action to the overall disturbance and behavioral modification of fish would be minimal as compared to other cumulative actions, and each alternative would be expected to contribute **negligible** cumulative impacts on fish behavior.

4.2.4.3 Reduced Fitness of Fish Due to Pollutants

Pollutants from multiple sources are present in, and continue to be released into, the oceans. A significant amount of vessel traffic is expected to occur under the cumulative effects scenario. All vessel operations are associated with a risk of oil and fuel spills and release of contaminants. Long-term exposure to pollutants from the accidental leakage or spillage of oil, fuel and chemicals; marine debris (e.g., plastics, glass, metals, or rubber); and flows of pollutants, contaminants, sediments, and nutrients in coastal waters stresses the health and fitness of fish. Pollution primarily impacts coastal fishes that occur near the sources of land-based pollution and areas of heavy vessel traffic. However, global oceanic circulation patterns result in a considerable amount of marine pollutants and debris scattered throughout the open ocean (Crain et al., 2009).

Contaminants in the marine environment that may impact marine fishes include organic pollutants (e.g., pesticides, herbicides, polycyclic aromatic hydrocarbons, flame retardants, and oil), inorganic pollutants (e.g., heavy metals), and debris (e.g., plastics and wastes from dumping at sea) (Pews Oceans Commission, 2003). High chemical pollutant levels in marine fishes may cause behavioral changes, physiological changes, or genetic damage in some species (Moore, 2008; Pews Oceans Commission, 2003; van der Oost et al., 2003), contributing to overall reduced health and fitness of species. Bioaccumulation of pollutants (e.g., metals and organic pollutants) is also a concern that can reduce animal fitness. Bioaccumulation is the net buildup of substances (e.g., chemicals or heavy metals) in an organism directly from contaminated water or sediment through the gills or skin, from ingesting food containing the substance, or from ingestion of the substance itself (Newman, 1998; Moore, 2008).

The aggregate, adverse cumulative impacts on the fitness of fish would likely be **moderate** in magnitude. The relative contribution of the NOS Proposed Action to the overall fitness of fish would be minimal compared to other cumulative actions, and each alternative would be expected to contribute **negligible** cumulative impacts on fish fitness.

4.2.4.4 Alteration of Fish Habitat

Habitat alteration is associated with reduced prey/food sources, degraded water quality, and disturbance of bottom habitat due to other cumulative actions and to climate change. Prey and food sources are significantly directly reduced by overfishing, but also indirectly by changes in water quality from increased turbidity and sedimentation that create changes in the ecosystem that affect prey species and habitats. Spilled oil, fuel, and chemicals also stress the existing condition of fish habitat. Degraded water quality caused by other cumulative actions can cause increases in turbidity and sedimentation, increased water temperature, decreases in primary productivity and DO levels, introduction of invasive plant and animal species, and chemical contamination. Seafloor disturbance can damage or alter hard or soft demersal habitats important to fisheries resources. Other cumulative actions that would disturb the sea floor include commercial fishing (bottom trawling and dredging), carbon storage, dredged material disposal, LNG terminal placement, and new cable infrastructure. Seafloor disturbance can disturb, alter, or damage bottom habitat and can potentially smother demersal biota. However, these actions would affect a relatively small area of sea floor within the action area, and incremental impacts to fish habitat attributed to seafloor disturbance are expected to be minor.

Climate change effects include changes in air and sea temperatures, precipitation, the frequency and intensity of storms, pH level of seawater, currents, and sea level. These changes could affect overall marine productivity, which could affect the food resources, distribution, and reproductive success of fish. Pelagic fish stocks have unique spatial and temporal distribution patterns related to their bioclimatic niche. Climate change and the associated shifts in primary and secondary production therefore have impacts on the distribution range, migratory habits, and stock size of many marine fish species. Some species may shift away from shallow coastal waters and semi-enclosed areas, where temperatures increase fastest, into deeper cooler waters. In general, fish tend to live near their tolerance limits of a range of factors, and as a result, increased temperature and acidity, lower DO, and changes to salinity may have deleterious effects on their populations (ClimeFish, 2020).

Habitat alteration expected from the NOS Proposed Action would be caused by bottom sampling, anchoring, accidental spills of oil, fuel, and contaminants, and underwater turbulence from vessels and equipment. The small footprint of seafloor impacts under the NOS Proposed Action would account for a tiny fraction of the total sea floor in the action area, would only contribute an extremely small amount of contaminants to the ocean environment, if any, as compared to all other cumulative actions; and vessels operated by NOS would represent a negligible proportion of all vessel traffic in the action area. The aggregate adverse cumulative impacts from all actions on fish habitat would be **minor** to **moderate** and the contribution of the NOS Proposed Action to these impacts would be **negligible**.

4.2.4.5 Conclusion

All of the NOS alternatives would contribute to aggregate, adverse cumulative impacts on fish and fish habitat. This would occur through mortality and injury (vessel strikes, underwater sound, fishing bycatch, and entanglement); disturbance and behavior modification (due to vessel operations, underwater sound, emplacement of structures, and use of underwater equipment); and habitat alteration (reduced prey/food sources, degraded water quality, disturbance of bottom habitat, and climate change). Other actions and activities also contribute to the existing condition of fish, including the accidental or illicit discharge of oil, fuel, chemicals, or waste which can cause mortality and marine debris (e.g., plastics, glass, metals, or rubber) and flows of pollutants, contaminants, sediments, and nutrients, which can reduce the fitness of fish.

The aggregate, cumulative impacts of past, present, and reasonably foreseeable future actions are expected to result in insignificant impacts to most fish species, and may have significant impacts on some fish populations in the action area. The combined impacts of other cumulative actions affecting disturbance and behavioral modification, animal fitness, and habitat alteration would be **moderate** and **adverse** as the continued viability of populations would not be threatened, and therefore cumulative impacts would be insignificant. However, overfishing, bycatch, entanglement and reduced prey associated with other cumulative actions are expected to result in high rates of injury and mortality that could cause population declines to ESA-listed species or inhibit species recovery, resulting in **major** impacts that are significant. Although the impacts of commercial fishing are a concern for fisheries worldwide, fisheries in the action area are generally managed conservatively and in keeping with the requirements of the Magnuson-Stevens Fishery Conservation and Management Act. Many fish stocks within the action area that were historically overfished have recovered or are recovering from their overfished status and contributing to the overall trend of increasing abundance of U.S. marine fish stocks (NMFS, 2018d).

Cumulative, adverse impacts from any of the alternatives in combination with the cumulative effects scenario could potentially be considered either synergistic or additive depending on the timing and location of activities and impacts. Cumulative adverse impacts from the activities in the cumulative effects scenario could be synergistic if activities associated with the NOS Proposed Action and other cumulative actions occur in close spatial or temporal proximity. Similarly, additive effects on fish may occur if activities associated with the NOS Proposed Action and other cumulative actions are considered sequentially. Overall, cumulative impacts to fish would range from **minor** to **major**. The NOS Proposed Action would contribute to and have the potential to increase these cumulative impacts, but their relative contribution would be **negligible** because impacts would be temporary or short-term, would be confined to the immediate vicinity of project areas, and would be small as compared to impacts from all other cumulative actions. These impacts would occur regardless of the chosen alternative since projects under each alternative would be composed of similar activities and take place in the same geographic areas and timeframes; however, Alternatives B and C would be expected to have slightly higher cumulative impacts because these alternatives include more projects, activities, and nautical miles traveled than Alternative A.

4.2.5 Aquatic Macroinvertebrates

All past, present, and reasonably foreseeable actions described in Section 4.1 would contribute cumulative effects on aquatic macroinvertebrates. Based on the analysis presented in Section 3.8 Aquatic Macroinvertebrates, impacts of the NOS Proposed Action would result in negligible to minor impacts on invertebrates and their habitat. The impacts from the Proposed Action that could contribute to cumulative impacts on aquatic macroinvertebrates are direct and indirect injury and disturbance (from vessel sound, vessel wake and underwater turbulence, and bottom disturbance), and habitat alteration (from vessel wake and underwater turbulence; bottom disturbance; and air emissions).

The analysis of cumulative effects also considers that the other human actions and activities enumerated above contribute to the existing condition of macroinvertebrates, including habitat encroachment from onshore and nearshore development (e.g., coastal population growth), non-point sources of pollution, and accidental or illicit discharge of oil, fuel, chemicals, or waste. The following analysis considers how the NOS-related incremental impacts of the three NOS alternatives, when added to or acting synergistically with other past, present, and reasonably foreseeable future actions, would contribute to overall cumulative impacts on aquatic macroinvertebrates.

4.2.5.1 Direct and Indirect Injury to Aquatic Macroinvertebrates

Sound from crewed vessel operations under the NOS Proposed Action would contribute to cumulative impacts from all of the past, present, or reasonably foreseeable actions. However, based on what is known of their ability to detect underwater sound, NOS sound sources would be unlikely to cumulatively contribute to direct injury impacts to aquatic macroinvertebrates. For example, the active acoustic underwater sources used by NOS would mostly not be perceptible to aquatic macroinvertebrates. However, other active acoustic sources commonly used in other surveying and mapping activities, assessment and exploration of marine minerals, and offshore carbon storage assessments may have a greater propensity to adversely affect some aquatic macroinvertebrates, at least at close range, due to the high intensity and widespread propagation of the broadband sound they generate. These high intensity sources, including airguns, could have somewhat greater effects on aquatic macroinvertebrates than the sources described in Section 3.8, especially when considered cumulatively. In addition, the presence and movement of crewed vessels within the action area, including all vessels used in conjunction with activities under the Proposed Action and all past, present, and reasonably foreseeable actions of the cumulative effects scenario, would likely cumulatively contribute to collisions or entanglement of certain aquatic macroinvertebrates in the water column.

Accidental or illicit discharges of fuel, chemicals, or waste accompanying all vessel operations within the action area contribute to the existing direct harm to aquatic macroinvertebrates through ingestion and interaction with spilled substances, although the intensity of the impact would depend on the size and location of the spill in question. A major problem for aquatic macroinvertebrates is nutrient pollution from non-point sources onshore, principally fertilizers applied to farmlands; these nutrient loadings can cause red tides in coastal waters on both East and West Coasts, as well as a large “dead zone” of hypoxic or anoxic waters at the mouth of the Mississippi River in the Gulf of Mexico.

Rising ocean temperatures as part of ongoing climate change will continue to damage coral reefs in particular, by thermally stressing coral polyps, leading to their bleaching (expelling their symbiotic algae known as zooxanthellae) and possible mortality. Ocean acidification accompanying climate change, in particular increasing atmospheric carbon dioxide concentrations, will interfere with shell and skeleton formation by certain marine calcifying macroinvertebrates that use calcium carbonate.

Most cumulative direct injury impacts would occur in the immediate vicinity of vessels or O&G development. Over the time period of analysis, climate-related impacts that have already led to the listing of many species of corals described in Section 3.8 would continue to stress these species. Aggregate, cumulative direct and indirect injury impacts from all actions range from short-term to long-term, and could result in **minor to major** impacts on aquatic macroinvertebrates. The contribution of the NOS Proposed Action to these aggregate, adverse impacts would be **negligible**.

4.2.5.2 Disturbance and Displacement of Aquatic Macroinvertebrates

Sound-producing and vessel operation activities under the NOS Proposed Action could potentially contribute to aggregate, adverse cumulative impacts along with other active underwater sound sources, especially from high intensity sources used in O&G surveying, by temporarily displacing macroinvertebrates at sites throughout the EEZ. Sound from survey vessels, shipping vessels, commercial fishing vessels, recreational boats and underwater construction activities in support of energy infrastructure, LNG terminals, and submarine telecommunications infrastructure could also cumulatively disturb and displace invertebrates from the respective project areas for the duration of the activity in question.

Underwater disturbance from vessel movement and presence, and bottom sampling under the Proposed Action, in combination with reduced water quality and increased turbidity resulting from the ongoing erosion of coastlines by rising sea levels, bottom sampling, or underwater construction activities, would also disturb and displace aquatic macroinvertebrates. Climate change will continue to raise sea levels globally for the foreseeable future, which results in continual erosion throughout the coastlines of the EEZ. The ongoing accidental or illicit discharges of fuel, chemicals, or waste from vessel operations and marine infrastructure contributes to currently disturbed and displaced macroinvertebrates from contaminated areas for the lifetime of the spill, though most small spills are dissipated by ocean conditions on a timescale of minutes to hours.

Cumulative disturbance and displacement impacts would still likely be limited to the immediate vicinity of the source and would not persist beyond the conclusion of activities. These aggregate, adverse impacts are not expected to cause long-term changes in habitat availability, or overall behavioral patterns, and would be considered **negligible to minor** in magnitude. The contribution of the NOS Proposed Action to these aggregate, adverse cumulative impacts would be **negligible**.

4.2.5.3 Degradation and Reduction of Aquatic Macroinvertebrate Habitat

Onshore tide gauge installations and remote GPS reference station installations under the Proposed Action would contribute to cumulative impacts related to the degradation and reduction of aquatic macroinvertebrate habitats from the construction, operation, and decommissioning of long-term installations such as LNG terminals, energy infrastructure, and submarine telecommunications. Cumulatively, these actions would likely reduce the total amount of oceanic habitat available to aquatic macroinvertebrates for the lifetime of the installation. Macroinvertebrates would likely be displaced from these areas for the duration of the installation due to reduced water quality and various disturbances related to the operation and maintenance of the infrastructure, such as vessel traffic, waste discharge, and underwater disturbance from welders, divers and wakes. After the lifetime of the installation, the development area would be reclaimed and should return to previous habitat conditions.

The ongoing accidental or illicit discharges of fuel, chemicals, or waste from vessel operations and marine infrastructure contribute to currently degraded estuarine and marine habitats. The intensity of these impacts depends on the size and distance of the spill in question from invertebrate habitats; most small spills are dispersed and dissipated by ocean conditions on a timescale of minutes to hours. Coastal population growth and elevated nutrient loadings, other contaminants, and non-point source discharges and runoff contribute to currently degraded habitat conditions for aquatic macroinvertebrates through a variety of factors, including coastal water quality reductions from urban/agricultural runoff, and encroachment by coastal development. This degradation is especially pronounced in bays and sounds with restricted water circulation, such as Chesapeake Bay in the Greater Atlantic Region and Puget Sound in the West Coast Region. The 7,000-square mile (18,130-square km) hypoxic (low-oxygen) "dead zone" that appears during the summer months in the Gulf of Mexico at the mouth of the Mississippi River is an effect of the widespread use of fertilizers (nitrogen and phosphorus nutrients) in the large Mississippi Basin.

Rising sea levels as a result of climate change will continually erode coastlines along the EEZ over the next six years and could potentially destroy or degrade habitats for aquatic macroinvertebrates. Global rising temperatures could also shift aquatic macroinvertebrate ranges northward towards cooler waters.

Generally, ongoing cumulative impacts to aquatic macroinvertebrate habitats would persist for the entirety of the foreseeable future; these impacts would not substantially reduce overall habitat quantity or availability but would continue to substantially degrade macroinvertebrate habitat quality, although populations would be unlikely to be further adversely affected in the near term. Aggregate cumulative impacts to macroinvertebrate habitat would likely be **minor to major** in magnitude and the contribution of the NOS Proposed Action to these would be **negligible**.

4.2.5.4 Conclusion

Activities associated with the Proposed Action and the cumulative effects scenario have the potential to contribute cumulatively to direct and indirect injury, disturbance and displacement, and habitat reduction and degradation impacts from past, present, and reasonably foreseeable actions within the action area. In the short-term, the presence and movement of vessels could potentially result in direct injury to macroinvertebrates from collisions or entanglements and would likely disturb or displace nearby organisms for the duration of activities. Similarly, vessel sound and underwater construction activities could potentially displace aquatic macroinvertebrates in the immediate vicinity of activities. Disturbances and displacements resulting from activities are not expected to persist beyond the duration of activities, and short-term cumulative impacts would likely range from **negligible** to **moderate** in magnitude. Onshore and nearshore development, non-point source pollution, and the accidental or illicit discharges of oil, fuel, chemicals, or waste all contribute to the currently reduced total amount of aquatic macroinvertebrate habitat. In conjunction with the NOS Proposed Action, ongoing climate change would reduce the total amount of available macroinvertebrate habitat in the long-term. As such, the long-term, aggregate, adverse cumulative impact of habitat reduction on aquatic macroinvertebrates would likely range from **minor** to **major** in magnitude.

Cumulative, adverse impacts from any of the alternatives in combination with the cumulative effects scenario could potentially be considered either synergistic or additive depending on the timing and location of activities and impacts. Synergistic impacts could result if any activities or actions occur in close spatial or temporal proximity within the study area. Similarly, additive cumulative impacts to aquatic macroinvertebrates, or their associated habitat, could occur if activities or actions are conducted sequentially within adjacent areas of the study area. Although the exact timing and location of projects have not been finalized and are subject to change, the Southeast and Alaska regions contain the largest proportion of total vessel transit miles of the EEZ (Section 2.4.1) and relatively high levels of marine O&G development. Therefore, synergistic or additive cumulative impacts are most likely to occur in either of these regions. Most cumulative impacts would be confined to the immediate vicinity of project areas and would likely not impact the overall abundance or structure of invertebrate populations outside of the range of natural variability. Overall, the Proposed Action would contribute **negligible** short-term and long-term adverse cumulative effects, depending on the timing and location of impacts within the 17-year timespan of this analysis. These impacts would occur regardless of the chosen alternative since projects under each alternative would be composed of similar activities and take place in the same geographic areas and timeframes; however, Alternatives B and C would include more projects, activities, and nautical miles traveled than Alternative A, and would therefore have slightly greater impacts.

4.2.6 Essential Fish Habitat

All past, present, and reasonably foreseeable future actions described in Section 4.1 would contribute cumulative effects on EFH, including Habitat Areas of Particular Concern (HAPCs). Based on the analysis presented in Section 3.9 Essential Fish Habitat, impacts of the NOS Proposed Action would result in negligible to minor impacts on EFH. The impacts from the Proposed Action that could contribute to cumulative impacts on EFH are physical impacts to bottom habitat (e.g., from anchoring, collection of bottom grab samples, tide gauge installation, and SCUBA operations); increase in sedimentation, turbidity, and/or chemical contaminants (e.g., from operation of crewed sea-going vessels; operation of ROVs and autonomous vehicles; anchoring; collection of bottom grab samples; installation of tide gauges and GPS reference stations; and SCUBA operations); increase in sound (e.g., from operation of crewed sea-going vessels; operation of ROVs and autonomous vehicles; use of echo sounders; ADCPs; and acoustic communication systems); and impacts to the water column (e.g., from operation of crewed sea-going vessels; operation of ROVs and autonomous vehicles; anchoring; use of sound speed data collection equipment and bottom grab samplers; operation of drop/towed cameras and video systems; and SCUBA operations). The following analysis considers how the incremental impacts of the NOS Proposed Action, when added to or acting synergistically with other past, present, and reasonably foreseeable future actions, would contribute to overall cumulative impacts on EFH.

4.2.6.1 Physical Impacts to Essential Fish Habitat Bottom Habitat

Physical impacts to bottom habitat from other cumulative actions could result from such activities as commercial fishing (bottom trawling), dredging, carbon storage, O&G development, dredged material disposal, structure emplacement, and new cable infrastructure. Seafloor disturbance can alter or damage bottom habitat and can potentially smother demersal biota.

Adverse impacts from fishing, especially those using bottom-contact fishing gear, could be substantial in heavily fished areas and could affect EFH and component HAPC areas to various degrees. Bottom trawl fishing intensity has seen a rapid global expansion since the 1950s in order to meet an increasing global food demand (Watson et al., 2006); and although the highest trawling intensities are found in shallow coastal waters, bottom trawling is expanding into deeper waters (Eigaard et al., 2016).

In addition to seafloor disturbance from fishing, other cumulative actions that sample, anchor, dredge, cover, drill into, or otherwise come into contact with ocean bottom habitat can cause re-suspension of sediments into the water column, changes in bathymetric contours, and potential alteration or loss of benthic habitat. Dredging activities within the coastal zone have greatly intensified in recent decades in connection to harbor expansion work, maintenance and deepening of navigable waterways, land reclamation, coastal protection, and energy provision through the construction of wind farms (OSPAR Commission, 2017).

Globally, dredging involves the excavation of greater than 2 billion tons of sediment per year, of which approximately 80 percent is redeposited in the marine environment (EuDA, 2005). Some activities, such as mining, destroy hard substrate and severely disturb the seabed and the benthic soft substrate community. Recolonization can occur from unmined areas; but reestablishment of a community similar to that originally present is usually not possible (Thiel, 1992). Other activities also directly or indirectly introduce marine debris into the water (e.g., monofilament fishing line, nets, plastic) that often ends up on the sea floor or wrapped onto a shallow reef and causes stress on bottom habitat in EFH areas.

Although impacts that could occur under the NOS Proposed Action would be additive to the physical impacts of bottom habitat associated with other cumulative actions, NOS activities such as anchoring, installation of equipment on the sea floor, and sample collection would cause relatively very small footprints of disturbance over the very large action area as compared to all of the seafloor disturbance of all other cumulative actions. The relative contribution of the NOS Proposed Action to the overall disturbance of bottom habitat would be minimal. While aggregate, adverse cumulative impacts on bottom habitat in EFH areas from all actions and activities throughout the EEZ would be considered **moderate**, the contribution of the NOS Proposed Action to these adverse cumulative effects would be **negligible**.

4.2.6.2 Increase in Sedimentation, Turbidity, and/or Chemical Contaminants in Essential Fish Habitat

Increase in sedimentation, turbidity, and chemical contaminants in EFH from other cumulative actions are associated with the activities that would disturb bottom habitat as discussed above, as well as activities that deposit sediments into receiving waters, and vessel operations. Disturbance of the sea floor would stir up bottom sediment and cause turbidity in the vicinity of the activity. Additionally, sedimentation and turbidity can occur due to input of sediments into the ocean environment from upland activities that cause erosion (e.g., coastal development, beach nourishment, mining, timber harvesting, and agriculture) and from water-based actions (e.g., dam construction, port activities, drag fishing, dredging, and water diversions). Sedimentation can cause loss of important or sensitive aquatic habitat, decrease in fishery resources, loss of coral reef communities, changes in fish migration, loss of wetlands, nutrient balance changes, circulation changes, loss of submerged vegetation, and coastline alteration (Pollution Issues, No Date). Turbidity affects organisms that are directly dependent on light, like aquatic plants, because it limits their ability to carry out photosynthesis. Other organisms that depend on these plants for food and oxygen are then also impacted. For example, turbidity can harm fish by reducing food supplies, degrading spawning beds, and affecting gill function.

In addition to sedimentation and turbidity, there are large numbers of potential sources of both direct and indirect marine contamination, including tankers and other marine vessels, derelict fishing gear, military operations, ocean dumping, airborne deposition, and runoff from industrial and agricultural sources on land. The accidental leakage or spillage of oil, fuel and chemicals; marine debris (e.g., plastics, glass, metals, or rubber); and flows of pollutants, contaminants, sediments, and nutrients in coastal waters stresses the condition of EFH. A significant amount of vessel traffic is expected to occur under the cumulative effects scenario. All vessel operations are associated with a risk of oil and fuel spills and release of contaminants. Contamination from spills and discharges can accumulate in the sea floor and marine life and have a toxic effect on plants, animals, and humans through the food chain. Some chemical compounds, such as polychlorinated biphenyls (PCBs) and pesticides, can persist for many years while others, such as petroleum products, breakdown and get diluted relatively quickly. Pollution is a long-term and widespread issue in the marine environment, although it varies substantially in intensity on a local basis.

NOS activities associated with the Proposed Action, including vessel and ROV operations, anchoring, collection of bottom grab samples, installation of tide gauges and GPS reference stations, and SCUBA operations, could increase sedimentation, turbidity, and chemical discharges in EFH. As vessels used by NOS would only represent a negligible proportion of all vessel traffic in the action area, increases in sedimentation and turbidity due to vessel operations under the NOS Proposed Action would be minimal. While there would be no intentional discharges of pollutants from vessels used by NOS, there is potential for accidental spills to occur. However, the likelihood of occurrence of an accidental spill and the magnitude of a potential spills are likely to be very small and the contribution to the cumulative effects of contamination is considered negligible. Likewise, sedimentation and turbidity from NOS anchoring and land-based projects would be minimal given that they would be conducted infrequently and across a geographically widespread area, and that the footprints of disturbance would be small. Thus, the relative contribution of the NOS Proposed Action to the overall increases in sedimentation, turbidity, and chemical contaminants in EFH would be minimal as compared to other cumulative actions. Aggregate, adverse cumulative impacts on EFH from all sources of water pollution would be **moderate**, while the contribution from the NOS Proposed Action would be expected to be **negligible**.

4.2.6.3 Increase in Sound in Essential Fish Habitat

Increases in sound from other cumulative actions could result from vessel and aircraft operations; sonar and other underwater acoustic sources; construction, which may include drilling, pile driving, use of explosives, and dredging; and operation of facilities and structures, such as long-duration sound associated with mechanical vibrations when wind turbine blades are spinning. Noise from other cumulative actions would affect EFH by impacting different life stages of fish and aquatic macroinvertebrate prey species (prey is a potential habitat characteristic of EFH). Behavioral changes can occur, resulting in animals leaving feeding or breeding grounds (Slabbekoorn et al., 2010) or becoming more susceptible to mortality through decreased predator-avoidance responses (Simpson et al., 2016). Noise can also mask biologically important sounds and alter the natural soundscape, cause hearing loss, and/or have an adverse effect on an organism's stress levels and immune system. Cumulative sound impacts on fish are discussed in Section 4.2.4 and on aquatic macroinvertebrates in Section 4.2.5.

NOS activities under the Proposed Action that could result in an increase in underwater sound in EFH would consist of operation of crewed sea-going vessels; operation of ROVs, ASVs, and AUVs; and use of underwater acoustic equipment including echo sounders, ADCPs, and acoustic communication systems. The potential effects of sound associated with project vessel operations, which would represent less than 0.3 percent of total vessel traffic in the action area, would be minimal as compared to the effects from sound generated by vessels and aircraft from all other cumulative actions. Sound associated with underwater acoustic sources used by NOS would be intermittent and highly directional, potential impacts on prey species would be limited to temporary behavioral and stress-startle responses, and adverse impacts are unlikely to occur due to the much higher frequencies of these instruments relative to the hearing capabilities of most prey species. The relative contribution of NOS Proposed Action to the overall increase in sound in EFH would be minimal compared to the contributions from all other cumulative actions. Overall, the aggregate, adverse cumulative impact from the increase in sound in EFH areas would be **minor** to **moderate**, while the contribution from the NOS Proposed Action would be **negligible**.

4.2.6.4 Impacts to the Water Column in Essential Fish Habitat

Impacts to the water column are caused by vessels or equipment moving through the water as part of activities that are part of other cumulative actions. Impacts on EFH due to climate change are also considered here. Wakes from vessels and other disturbance to the water column from equipment moving through it would create turbulence and generate wave and surge effects in the water column where habitat gradients including temperature, salinity, DO, turbidity, and nutrient supply would be temporarily disrupted. Vessel propellers could also cause water column destratification and elevated water temperatures. Vessel and equipment movement through the water column may disrupt benthic communities and other prey species in shallow areas and cause mortality to floating eggs and larvae by physically damaging them with the hull or other ship parts, including the propulsion system. Lines connecting equipment to a vessel could also become entangled with, damage, or kill submerged aquatic vegetation such as seagrass.

Climate change may affect the marine environment in a variety of ways, including changes in sea level, changes in water temperatures, more frequent or extreme weather events, and alteration of ocean currents (NMFS, 2015d). These changes and others are expected to continue over the reasonably foreseeable future and could aggregate with the effects of other cumulative actions to impact the physical water environment. These changes would in turn contribute to changes in the population and distribution of prey species such as fish and aquatic macroinvertebrates; and changes in the population and distribution of fishery resources harvested in commercial fisheries, with related socioeconomic effects (see Section 4.2.9). In addition to changes in air and water temperatures, a related effect of climate change is increased acidification in the ocean caused by dissolved CO_2. Changes in the acidity of the world's oceans are expected to continue and accelerate over the reasonably foreseeable future. Ocean acidification can harm organisms that build shells of $CaCO_3$, including calcareous phytoplankton and zooplankton, corals, bryozoans, mollusks, and crustaceans. These organisms provide shellfish resources for humans, play vital roles in marine food webs, generate sand for beaches, and add to the physical structure of the ocean floor. Although the dynamics of climate change and the potential magnitude and timing of its effects are poorly understood, there is general acknowledgement that the potential impacts resulting from climate change could be substantial.

Impacts to the water column expected from the NOS Proposed Action would be caused by vessels or equipment moving through the water column in activities including operation of crewed sea-going vessels; operation of ROVs, ASVs, and AUVs; anchoring; use of sound speed data collection equipment and bottom grab samplers; operation of drop/towed cameras and video systems; and SCUBA operations. These impacts would be temporary, mobile prey species would not likely move too far away, and conditions would be expected to stabilize and species would return once water column turbulence ceased. The NOS Proposed Action would only contribute a very small impact on the water column as compared to all other cumulative actions. Although CO_2 emissions from vessels used by NOS would contribute to atmospheric CO_2 levels, the contribution would be a very small fraction compared to other anthropogenic CO_2 sources. Aggregate, adverse cumulative impacts to the water column in EFH from all actions would be **moderate**. When aggregated with the impacts of past, present, and reasonably foreseeable future actions in the action area, the NOS Proposed Action would make a **negligible** additive contribution to cumulative adverse effects on the water column in EFH.

4.2.6.5 Conclusion

NOS actions would contribute to the adverse cumulative impacts from all actions on EFH. This would occur through physical impacts to bottom habitat (from other cumulative actions could result from such activities as commercial fishing, carbon storage, O&G development, dredged material disposal, structure emplacement, and new cable infrastructure), increase in sedimentation, turbidity, and chemical contaminants (from activities that would disturb bottom habitat, activities that deposit sediments into receiving waters, and vessel operations), increases in sound (from vessel and aircraft operations; sonar and other underwater acoustic sources; construction, which may include drilling, pile driving, use of explosives, and dredging; and operation of facilities and structures), and impacts to the water column (from vessels or equipment moving through the water column and climate change).

The aggregate impacts of past, present, and reasonably foreseeable future actions are expected to result in insignificant impacts to EFH in the action area. The cumulative impacts of other cumulative actions affecting physical impacts to bottom habitat; increase in sedimentation, turbidity, and chemical contaminants; and increase in sound would be **moderate** and adverse as EFH would not be degraded over the long term or permanently, would continue to support sustainable fisheries, and the continued viability of prey populations would not be threatened; therefore, cumulative impacts would be insignificant. In recent years, there have been efforts to reduce pollution of ocean environments through restrictions on discharges and design features of ocean-going vessels that reduce the probability and severity of spills. As a result, more recent incidents involving unauthorized spills or discharges have either been localized and limited or, if large and widespread, have generated cleanup and mitigation responses. However, impacts to the water column from climate change could be substantial; therefore, cumulative impacts on EFH would be overall **moderate** to **major** from other cumulative actions contributing large atmospheric CO_2 levels leading to increased rates of climate change. Overall, aggregate, adverse cumulative impacts of all actions described in Section 4.1 result in **moderate** cumulative impacts.

Cumulative, adverse impacts from any of the alternatives in combination with the cumulative effects scenario could potentially be considered either synergistic or additive depending on the timing and location of activities and impacts. Cumulative adverse impacts from these activities could be synergistic if activities associated with the NOS Proposed Action and other cumulative actions occur in close spatial or temporal proximity. Similarly, additive effects on EFH may occur if activities associated with the NOS Proposed Action and other cumulative actions are considered sequentially. Overall, cumulative impacts would be considered **negligible** under the NOS Proposed Action because the impacts would be temporary or short-term, would be confined to the immediate vicinity of project areas, and would be small as compared to impacts from all other cumulative actions. The Proposed Action would contribute to and have the potential to increase cumulative impacts on EFH, but their relative contribution would be **negligible** as compared to the aggregate contributions of other cumulative actions. These impacts would occur regardless of the chosen alternative since projects under each alternative would be composed of similar activities and take place in the same geographic areas and timeframes; however, Alternatives B and C would include more projects, activities, and nautical miles traveled than Alternative A, and would therefore have slightly greater impacts.

4.2.7 Seabirds, Shorebirds and Coastal Birds, and Waterfowl

Given the ecological concordance between bird groups, impacts that would affect all groups are hereafter referred to as impacts on birds. Specific impacts based on behavior or habitat of an individual group or species are explicitly stated throughout the analysis.

All past, present, and reasonably foreseeable actions described in Section 4.1 would contribute cumulative effects to birds. The analysis of cumulative effects also considers other actions and activities on birds, including habitat encroachment from onshore and nearshore development (e.g., coastal population growth); marine debris (e.g., plastics, glass, metals, or rubber) and accidental or illicit discharge of oil, fuel, chemicals, or waste.

4.2.7.1 Direct Injury to Sea Birds, Shorebirds and Coastal Birds, and Waterfowl

Crewed vessel operations and active acoustic surveying under the NOS Proposed Action would contribute to cumulative impacts on birds along with the use of high intensity active underwater acoustic sources and the presence and movement of vessels associated with any of the past, present, or reasonably foreseeable actions. In aggregate, they would likely cumulatively contribute direct injury impacts to birds or their prey. Although exposure to the active underwater acoustic sources proposed by NOS would only occur for diving birds and would not likely be harmful, other active acoustic sources commonly used in other surveying and mapping activities, assessment and exploration of marine minerals, and offshore carbon storage assessments have a greater propensity to injure diving birds due to the high intensity and large-scale propagation of the broadband sound they produce. These high intensity sources, including airguns, could have a more substantial impact on birds than the sources described in Section 3.4, especially when considered cumulatively.

The presence and movement of crewed vessels within the action area, including all vessels used in conjunction with activities under the Proposed Action and all past, present, and reasonably foreseeable actions of the cumulative effects scenario and offshore renewable energy installations, would likely cumulatively contribute to collisions or entanglement of all species of birds or their prey. All vessel movements could potentially result in collisions with airborne or floating birds and would cumulatively contribute direct injury or mortality impacts. Offshore renewable energy installations, particularly wind turbines, could similarly contribute to cumulative collision impacts since birds often are unable to recognize and avoid dangerous features of installations. Expanded commercial fishing operations would likely increase numbers of birds or their prey in bycatch, particularly in longline or trawled fisheries where operators cannot continuously monitor trailed lines, hooks, and nets for protected species. As such, the overall abundance of birds and their finfish prey would likely be reduced. Accidental or illicit discharges of fuel, chemicals, or waste accompanying all vessel operations within the study area contribute to the existing direct injury of birds and prey through ingestion and interaction with spilled substances, although the intensity of the impact would be contingent upon the size and location of the discharge in question. Contaminated prey could also potentially serve as an additional source of spill exposure to birds, particularly of bioaccumulated hazardous materials. Discharged waste is of particular concern to birds, given their propensity to ingest and entangle themselves in many forms of marine debris (e.g., plastics, glass, metals, or rubber).

When considered in tandem with crewed vessel operations, tide gauge installations, and remote GPS reference station installations under the Proposed Action, changing abiotic environmental characteristics related to ongoing climate change could potentially contribute direct injury impacts to birds or their prey. Other actions and activities that are sources of environmental stress, including ongoing habitat encroachment from onshore or nearshore development and coastal development, contribute to the current direct injury of birds. Increased light pollution from onshore and nearshore commercial or O&G development attracts or disorients bird fledglings, particularly alcids, and causes them to land in dangerous areas. Artificial-light-induced landings can result in broken limbs, internal injuries, or even fatalities when fledglings collide with buildings, electric wires and pylons, fences, and posts. Grounded fledglings are sometimes unable to take flight again, and light-induced landings leave fledglings vulnerable to predation by terrestrial animals, collisions with terrestrial vehicles or to starvation and dehydration in the event they are unable to find their way back to sea.

Similarly, ongoing climate change will continually alter marine environmental conditions throughout the timespan of this analysis, which could result in direct injury of bird prey. Although environmental conditions will not likely change to the point of directly injuring birds, ocean acidification accompanying climate change could potentially harm macroinvertebrate prey species (bivalves, gastropods, and cephalopods) that are particularly sensitive to environmental conditions during their larval stages and will likely reduce their availability to birds. Rising surface water temperatures will also reduce the solubility of oxygen in seawater and could inhibit or stress the respiration of all marine prey species, further cumulatively reducing prey availability for birds within the EEZ.

The majority of cumulative direct injury impacts would be limited to the immediate vicinity of vessels or O&G development, and would not likely cause long-term changes in bird behavioral patterns, habitat availability and use, or the demographic structure and abundance of bird and prey population. Similarly, climate-related impacts would not likely substantially affect birds, although the magnitude of the impact will likely continue to increase over time. Overall, cumulative direct injury impacts on birds would occur regardless of the chosen alternative, would be short-term to long-term and **negligible** to **minor**. The contribution of the NOS Proposed Action to these aggregate, adverse cumulative impacts would be **negligible**.

4.2.7.2 Disturbance and Displacement of Sea Birds, Shorebirds and Coastal Birds, and Waterfowl

Sound-producing and vessel operation activities under the NOS Proposed Action would contribute to cumulative effects produced by other active acoustic sound sources, especially from high intensity sources used in O&G surveying. In combination, these actions could temporarily displace diving birds and their prey throughout the EEZ and cause cumulative adverse impacts to birds. Sound from survey vessels, shipping vessels, commercial fishing vessels, recreational boats, and underwater construction activities in support of energy infrastructure, LNG terminals, and submarine telecommunications infrastructure could also cumulatively disturb and displace all species of birds and their prey from the respective project areas for the duration of the activity in question. The visual presence of vessels would also likely serve as an additional source of disturbance and displacement.

When considered in tandem with underwater disturbance from vessel movement and presence and bottom sampling under the NOS Proposed Action, reduced water quality and increased turbidity resulting from the ongoing erosion of coastlines by rising sea levels, bottom sampling, or underwater construction activities would also disturb and displace birds and prey. Climate change will continue to raise sea levels globally for the foreseeable future, which results in continual erosion throughout the coastlines of the EEZ. Coastal erosion occurs at varying rates around the EEZ, but would be most pronounced along the Atlantic coastline. Reduced water quality and increased turbidity in these areas from ongoing coastal erosion would likely shift prey distributions and could result in increased bird foraging effort; travel time to foraging areas could increase due to shifted prey distributions; and foraging success could decrease due to reduced visibility of prey species in turbid waters. The ongoing accidental or illicit discharges of fuel, chemicals, or waste from vessel operations and marine infrastructure contributes to currently disturbed and displaced birds and their prey from contaminated areas for the lifetime of the spill. The intensity of the impact is contingent upon the size and location of the spill in question; most small spills are dissipated by ocean conditions on a timescale of minutes to hours.

Cumulative disturbance and displacement impacts would still likely be limited to the immediate vicinity of the source and would not persist beyond the conclusion of activities. These impacts are not expected to cause long-term changes in habitat availability, overall bird behavioral patterns, or overall prey availability and would be considered **negligible** to **minor**. The contribution of the NOS Proposed Action to these adverse cumulative impacts would be **negligible**.

4.2.7.3 Degradation and Reduction of Habitat for Sea Birds, Shorebirds and Coastal Birds, and Waterfowl

Onshore tide gauge installations and remote GPS reference station installations under the NOS Proposed Action would contribute to cumulative impacts along with the construction, operation, and decommissioning of long-term installations such as LNG terminals, energy infrastructure, and submarine telecommunications. In aggregate, these would likely reduce the total amount of oceanic and coastal habitat available to birds and their prey for the lifetime of the installations. Long-term installations would occupy space within viable habitat areas, reducing the total habitat available to birds and their prey. Furthermore, activities or actions related to the maintenance and operation of these long-term structures would degrade the habitat quality of surrounding areas. After the lifetime of the installation, the development area would be reclaimed and should return to current habitat conditions.

The ongoing accidental or illicit discharges of fuel, chemicals, or waste from vessel operations and marine infrastructure contributes to currently degraded sensitive coastal nesting habitat. Coastal ground-nesting birds such as piping plovers and red knots breed and nest in areas below the high-water line that are particularly susceptible to contamination from spilled materials. The overall intensity of the impact is contingent upon the size and distance of the spill in question from nesting beaches; most small spills are dissipated by ocean conditions on a timescale of minutes to hours.

The existing stress from coastal population growth also contributes to the degradation of bird habitat through a variety of factors, including coastal water quality reductions from urban/agricultural runoff, encroachment by coastal development, and increased light pollution. Rising sea levels as a result of climate change will continually erode coastlines along the EEZ over the next six years and could potentially destroy or degrade coastal nesting areas, particularly of sensitive coastal ground-nesting species. However, the magnitude of these impacts is contingent upon the amount of coastal erosion within a given area and could potentially be mitigated in part by ongoing coastal restoration projects included in the BOEM MMP.

Reduced water quality would also displace finfish prey species from eroded areas and could potentially increase the foraging energy expenditures of birds. Changing climate conditions, such as rising surface water temperatures, shifting currents, and shifting wind patterns, will change the location and intensity of deep-water upwellings, an important source of oceanic nutrients. Prey distributions will likely shift along with oceanic nutrients, which could ultimately reduce the total amount of available prey if the bird dispersal rate is relatively lower than that of their prey. Seabirds are particularly susceptible to habitat reduction because their high levels of behavioral resilience and experience-based learning limit their ability to disperse to new areas and follow shifting prey distributions.

Generally, cumulative impacts to bird habitat would persist for the entirety of the foreseeable future, but would not substantially reduce overall habitat availability or quality and would not substantially impact the overall structure or abundance of bird or prey populations. Shifting prey distributions in response to changes in oceanic nutrient cycling could potentially impact the overall population of some seabird species that return to the same areas or islands to breed or forage annually. These birds have high levels of behavioral resilience and foraging specialization and would not likely be able to follow their original prey or adapt to include new species in their diet. However, nesting areas are generally avoided by development given the federal protection of most birds under the MBTA, and aggregate, adverse cumulative impacts to bird habitat would likely be **minor**. The contribution of the NOS Proposed Action to these aggregate, adverse cumulative impacts would be **negligible**.

4.2.7.4 Conclusion

Activities associated with the Proposed Action and the past, present, and reasonably foreseeable actions described in the cumulative effects scenario have the potential to contribute cumulatively to direct injury, disturbance and displacement, and habitat reduction in the action area. In the short-term, the presence and movement of vessels and the development of offshore renewable energy installations could potentially result in direct injury to birds from collisions or entanglements and would likely disturb or displace nearby birds for the duration of activities. Similarly, changing abiotic environmental conditions resulting from ongoing climate change and the stress already placed on birds due to habitat encroachment from onshore or nearshore development could serve as additional sources of cumulative direct injury to birds and their prey. Active acoustic sound sources; vessel sound; underwater activities; and ongoing climate change would displace birds and their prey in the immediate vicinity of activities. Disturbances and displacements resulting from activities are not expected to persist beyond the duration of activities, and short-term cumulative impacts would likely range from **negligible** to **moderate**. Onshore and nearshore development and accidental discharges of oil, fuel, chemicals or waste already reduce the total amount of available bird habitat and climate change would cumulatively impact the total amount of available bird habitat in the long term. As such, the long-term cumulative impact of habitat reduction on birds would likely be **minor**.

Cumulative adverse impacts from any of the alternatives in combination with the cumulative effects scenario could potentially be considered either synergistic or additive depending on the timing and location of activities and impacts. Synergistic impacts could result if any activities or actions occur in close spatial or temporal proximity within the action area. For example, a mapping project in close proximity to an operating offshore oil well could substantially disturb birds through the visual presence and sound of both the project vessel and the installation and could result in bird avoidance of project areas for longer periods of time than would be elicited by either of the impact-causing factors independently.

Similarly, additive cumulative impacts to birds, their prey, or their associated habitat could occur if activities or actions are conducted sequentially within adjacent areas of the action area. For example, water quality in coastal areas could be additively degraded if a bottom sampling project was conducted shortly after the installation of a wind turbine. Although the exact timing and location of projects have not been finalized and are subject to change, the Southeast and Alaska regions contain the largest proportion of total vessel transit miles of the EEZ (Section 2.4.1) and relatively high levels of marine O&G development. Therefore, synergistic or additive cumulative impacts are most likely to occur in either of these regions. The vast majority of cumulative impacts are confined to the immediate vicinity of project areas and would likely not impact the overall abundance or structure of bird or prey populations outside of the range of natural variability.

Overall, the Proposed Action would contribute a **negligible** amount to the aggregate cumulative effects from all actions described in Section 4.1 depending on the timing and location of impacts within the six-year forward projection of the entire 17-year timespan of the analysis. These impacts would occur regardless of the chosen alternative since projects under each alternative would be composed of similar activities and take place in the same geographic areas and timeframes; however, Alternatives B and C would include more projects, activities, and nautical miles traveled than Alternative A, and thus contribute slightly greater impacts.

4.2.8 Cultural and Historic Resources

All past, present, and reasonably foreseeable future actions described in Section 4.1 would contribute cumulative effects to cultural and historic resources. The analysis of cumulative effects also considers the impact of other actions and activities on cultural and historic resources, including IUU fishing; accidental or illicit discharges (e.g., nutrient runoff, oil spills, or other introduction of contaminants); and flows of pollutants, contaminants, sediments, and nutrients into coastal waters.

4.2.8.1 Damage and Destruction of Submerged Cultural and Historic Resources

Anchoring, bottom sampling, and other activities that would disturb the sea floor, such as the installation of ADCPs, under the Proposed Action would contribute to cumulative impacts associated with increases in the number of vessels and boats anchoring or conducting surveying and mapping throughout the EEZ, the construction, operation, and decommissioning of long-term installations such as LNG terminals and submarine telecommunications cable and associated infrastructure, offshore and OCS oil and natural gas development, offshore renewable energy development, and the assessment and extraction of marine minerals. In combination, all these actions would likely cumulatively increase the risk of damage to submerged cultural and historic resources.

Coral reefs, vital to subsistence cultures and thus considered a cultural resource, would also be at increased risk of cumulative damage from these activities. Coral reefs host more than one quarter of all marine fish species, in addition to many other marine animals. Reefs also provide subsistence food and sustain the fishing and tourism industries (IUCN, No Date). Cultural and historic resources (including coral reefs) could be impacted by physical contact with anchors, submarine cables, equipment used for mineral extraction, and other underwater construction activities. As with vessels used by NOS operators, most vessels would anchor whenever practicable in designated areas and would avoid anchoring on shipwrecks and downed aircraft, coral reefs, and hard bottomed areas. This practice would also be followed during construction of underwater infrastructure and other activities described in Section 4.1. This practice would limit the likelihood of direct damage to known submerged cultural and historic resources, including coral reefs.

Inadvertent discovery of cultural and historic resources during construction of infrastructure such as LNG terminals is often associated with damage or destruction of the resource. These impacts would be adverse and permanent. It is possible that the inadvertent discovery of cultural and historic resources could be considered a beneficial impact due to the research potential that discovery would afford if the resource were not damaged or destroyed. For federal activities (including those requiring a federal authorization or permit), adverse impacts could be avoided or minimized to some degree through consultation between the lead agency and the State Historic Preservation Officer (SHPO) in compliance with Section 106 of the National Historic Preservation Act (NHPA) prior to construction. This communication serves to ensure avoidance of known culturally and historically significant sites, and to ensure that if cultural and historic resources are encountered, standard protocols related to protection and documentation of the resource would be followed. Generally, if a cultural or historic resource is discovered during construction, work stops until the SHPO can properly evaluate the resource.

The majority of cumulative damage impacts would be limited to the locations in which anchors are dropped or bottom sampling related to NOS projects and activities occurs, and in the immediate vicinity of offshore O&G development, assessment and extraction of marine minerals, and construction of submarine infrastructure, and would cause permanent impacts to cultural and historic resources, including coral reefs. Impacts could be either adverse or beneficial, depending on whether the resources were damaged or destroyed or protected and documented. Overall cumulative impacts to submerged cultural and historic resources from direct damage would likely be **negligible** to **moderate**; the contribution of any of the NOS alternatives to these adverse, cumulative impacts would be **negligible**.

Submerged cultural and historic resources are currently stressed due to accidental leakage or spillage of oil, fuel, and chemicals and the unintentional disposal of trash and debris, though NOS does not contribute to these actions (See Section 3.15). While not considered a cumulative impact, the stress has contributed to the existing condition of cultural and historic resources and is noteworthy. Cultural and historic resources may be exposed to hydrocarbon contamination (the result of oil spills). The effects of oil vary depending on the type of material and the condition it is in— sun-dried wood, for example, may absorb the oil more readily than shells in middens (NPS, 2010). The absorption of oil by cultural and historic resources can make radiocarbon dating impossible. Impacts from oil spills to cultural and historic resources could be permanent. Other contaminants, sediments, and nutrients can adversely impact the structural integrity of cultural and historic resources, with the greatest adverse effects occurring in waters with limited circulation such as bays, sounds, and estuaries. Impacts to cultural and historic resources from these actions and activities depend on the extent of contamination and the nature of the pollutant or other substance introduced by vessels throughout the action area.

When considered in tandem with all past, present, and reasonably foreseeable projects listed in Section 4.1, impacts stemming from climate change would cumulatively increase the likelihood of damage to submerged cultural and historic resources. Increased temperatures cause accelerated rusting in submerged resources, more rapid decay of organic materials, damage from increased biological activity at shallow underwater sites, and increased risk of damage due to decline and loss of protective sea grass or nearby coral reefs. Rising temperatures also lead to faster deterioration of newly exposed artifacts and sites. Ocean acidification will cause increased risk of damage to shipwrecks due to loss/decline of protective concretions and/or nearby coral reefs. It will also cause decline in reefs from coral bleaching.
Adverse climate change impacts will occur regardless of the chosen alternative, are long-term, and could result in **minor** to **moderate** impacts on cultural and historic resources within the next six years; the contribution of any of the NOS alternatives to these cumulative impacts would be **negligible**.

4.2.8.2 Degradation of Cultural and Historic Viewsheds

Installation of tide gauges and GPS reference stations under the Proposed Action would contribute to cumulative effects on historic viewsheds from the activities listed in Section 4.1 that involve nearshore or coastal construction activities. In aggregate, these individually negligible to minor actions would change historic viewsheds and thus cause cumulative, adverse impacts to cultural and historic viewsheds. Activities occurring within the viewshed of a nearshore historic property or designed cultural landscape could change these designed views, vistas, or view corridors and impact the integrity of the property's design, not simply cause visual effects on the integrity of a historic property's setting or other historic characteristics.

However, federal construction work proposed within the area of potential effect (APE) of coastal structures listed or eligible for listing on the National Register of Historic Places (NRHP) generally requires consultation with the appropriate SHPO prior to construction. Adherence to this protocol would help to minimize or avoid potential impacts to coastal structures listed or eligible for listing on the NRHP. Thus, the likelihood of adverse impacts to cultural and historic resources for which viewshed is a contributing element would be low, given the likely avoidance of NRHP-listed sites during the site selection process or avoidance of impacts to historic coastal structures following communication with the SHPO. Impacts would occur only within the APE of the cultural or historic resource, and would be **minor**; the contribution of any of the NOS alternatives to these adverse cumulative impacts would be **negligible**.

4.2.8.3 Disruption to Subsistence Hunting and Fishing, Including in TCPs

Activities producing sound and visual disturbances under the Proposed Action (e.g., the use of active underwater acoustic sources, vessel and equipment sound, physical presence of vessels and equipment in water, and human activities such as tide gauge and GPS reference station installation, and SCUBA operations), the operation and presence of vessels, equipment, and humans would contribute to cumulative impacts on subsistence hunting and fishing associated with any of the past, present, or reasonably foreseeable actions described above. Together, these would create short- and long-term adverse cumulative impacts to subsistence hunting and fishing, including those taking place in Traditional Cultural Places (TCPs). Activities that create sound and visual disturbance would cause species to move away from the shore, and subsistence hunters could be forced to temporarily abandon common hunting areas. Increased recreational and commercial fishing could reduce the availability of species important to subsistence communities; this could have long-term adverse impacts on these communities. Subsistence harvests in the marine environment could be disrupted or prolonged, or subsistence resources could be unavailable for use.

In the short-term, the presence and movement of vessels could potentially result in disturbance of traditional use in TCPs and subsistence hunting and fishing areas for the duration of project activities. Disturbance to subsistence activities and sociocultural systems are discussed in greater detail in Section 4.2.10.1. Impacts could also occur if a species important to subsistence communities were overfished or contaminated. Subsistence resources are currently stressed due to accidental leakage or spillage of oil, fuel, and chemicals and the unintentional disposal of trash and debris. Contaminated, or perceived contaminated, resources could make subsistence resources unavailable or undesirable for use (BOEM, 2015b). Contamination from oil/chemical spills would render the affected subsistence resource unsafe to eat. If the skin or fur of the animal is coated with oil, the pelt would no longer be desirable to be made into coats and other handicrafts. Spill cleanup operations could result in the closure of harvesting areas until cleanup is complete. Other actions and activities causing the contamination of subsistence resources are discussed further in Section 4.2.10.3.

However, federal actions that would have effects within a reservation or Alaska Native village; affect tribal trust resources or the rights of a federally recognized Tribe; affect a facility or entity owned or operated by a tribal government; affect Tribes, tribal governments, or a Tribe’s traditional way of life; or affect TCPs or Traditional Use Areas would trigger the need for communication with Tribes. It is possible that projects that would occur in traditional hunting and fishing areas would be coordinated to avoid peak hunting and fishing seasons (e.g., whales, seals, and salmon) or times of year to the extent possible, based on information obtained from the Tribes. Activities planned to occur in any NRHP-listed TCP would need to comply with federal regulations related to the protection of these culturally significant places. Even if peak seasons and times are not avoided, cumulative disruption of subsistence hunting and fishing and other traditional practices by tribes from additional vessels in TCPs and Traditional Use Areas would be temporary and **negligible** to **moderate**.

When considered in tandem with all past, present, and reasonably foreseeable projects listed in Section 4.1, impacts stemming from climate change would cumulatively increase the likelihood of impacts to subsistence hunting and fishing, including in TCPs. Climate change-induced factors such as changes in thickness and extent of sea ice, increased snowfall, drier summers and falls, and increased storms and coastal erosion could adversely affect subsistence harvest patterns by altering traditional hunting locations, impacting subsistence travel, and result in resource patterns shift and seasonal availability changes, making access to subsistence resources more difficult (NOAA, 2016). The impacts of changes in sea ice and other vital components of subsistence hunting and fishing areas on subsistence communities are described in detail in Section 4.2.10.2.

Overall, climate change could lead to changes in diversity, abundance, and distribution of traditional subsistence resources and harvest patterns, leading to long-term impacts on the availability of some subsistence resources. This could potentially threaten indigenous lifestyle and subsistence practices (NOAA, 2016). Adverse, cumulative climate change impacts will occur regardless of the chosen alternative, are long-term, and could result in **moderate** to **major** impacts on subsistence hunting and fishing; the contribution of any of the NOS alternatives to these adverse, cumulative impacts would be **negligible**.

4.2.8.4 Conclusion

When considered with the NOS Proposed Action, other surveying and mapping efforts in the action area, offshore oil and natural gas development, offshore renewable energy development, climate change, commercial shipping and recreational boating, assessment and extraction of marine minerals, offshore carbon storage resource assessments, construction and operation of offshore LNG terminals, national defense and homeland security activities, construction of new submarine telecommunication cable infrastructure, commercial and recreational fishing, and coastal development would create adverse cumulative impacts to cultural and historic resources. Adverse impacts to cultural and historic resources could occur through the damage and destruction of submerged cultural and historic resources including coral reefs, degradation of historic viewsheds, and disruption of subsistence hunting and fishing, including in TCPs.

Overall, the short-term and long-term adverse cumulative impacts from the cumulative effects scenario on cultural and historic resources range from **negligible** to **major.** Cumulative impacts to submerged cultural and historic resources from direct damage would likely be negligible to moderate. These impacts would be permanent, since damage cannot be reversed. Adverse climate change impacts will occur regardless of the chosen alternative, are long-term, and could result in minor to moderate impacts on cultural and historic resources within the next six years. Ongoing damage to cultural and historic resources from other actions and activities such as oil spills and flows of other pollutants, contaminants, sediments, and nutrients into coastal waters would be negligible to moderate, depending on the extent of contamination and the nature of the pollutant or other substance introduced by vessels throughout the project area. The likelihood of adverse cumulative impacts to cultural and historic resources for which viewshed is a contributing element from nearshore or coastal construction activities would be low, given the likely avoidance of NRHP-listed sites during the site selection process or avoidance of impacts to historic coastal structures following communication with the SHPO. Impacts would occur only within the APE of the cultural or historic resource, and would be minor. Even if peak seasons and times for subsistence hunting and fishing are not avoided, cumulative disruption of these and other traditional practices by tribes from additional vessels in TCPs and Traditional Use Areas would have negligible to moderate impacts. Impacts stemming from climate change would cumulatively increase the likelihood of impacts to subsistence hunting and fishing, including in TCPs. Adverse climate change impacts will occur to subsistence hunting and fishing practices regardless of the chosen alternative and are long-term. Impacts would be moderate to major. Cumulative impacts from climate change on subsistence hunting and fishing practices are therefore significant. As such, cumulative impacts on cultural and historic resources would be significant without consideration of the impacts of the Proposed Action.

Cumulative, adverse impacts from any of the alternatives in combination with the cumulative effects scenario could be considered as either synergistic or additive depending on the timing and location of activities and impacts. Synergistic impacts could result if any activities or actions occur in close spatial or temporal proximity within the study area. Similarly, additive cumulative impacts to cultural and historic resources could occur if activities or actions are conducted sequentially within adjacent areas of the action area. Although the exact timing and location of projects have not been finalized and are subject to change, the Southeast and Alaska regions contain the largest proportion of total vessel transit miles of the EEZ (Section 2.4.1) and relatively high levels of marine O&G development. Therefore, synergistic or additive cumulative impacts are most likely to occur in either of these regions. The vast majority of cumulative impacts are confined to the immediate vicinity of project areas and are not likely to occur within TCPs, where certain types of activity and development are not permitted.

The NOS Proposed Action would contribute to and have the potential to increase these cumulative impacts, but their relative contribution would be **negligible** as compared to the aggregate contributions of other cumulative actions. These impacts would occur regardless of the chosen alternative since projects under each alternative would be composed of similar activities and take place in the same geographic areas and timeframes; however, Alternatives B and C would include more projects, activities, and nautical miles traveled than Alternative A and thus contribute slightly greater impacts.

4.2.9 Socioeconomic Resources

Other surveying and mapping efforts in the action area, offshore oil and natural gas development, offshore renewable energy development, commercial shipping and recreational boating, assessment and extraction of marine minerals, offshore carbon storage resource assessments, the construction and operation of offshore LNG terminals, construction of new submarine telecommunication cable infrastructure, commercial and recreational fishing, and coastal development described in Section 4.1 would all contribute cumulative beneficial impacts to socioeconomic resources.

4.2.9.1 Economic Benefits to the Ocean Economy

All mapping and surveying activities under the NOS Proposed Action would contribute to cumulative impacts along with other surveying and mapping efforts in the action area associated with the past, present, and future reasonably foreseeable actions (including offshore carbon storage and carbon storage assessments, offshore O&G development, offshore renewable energy development, and the assessment and extraction of marine minerals). In aggregate, these actions would likely cumulatively contribute indirect economic benefits described in Section 3.12.2.

The high-resolution oceanographic data collected during mapping and surveying activities would be used by collecting agencies or third parties to create or improve navigational maps/charts and forecasts/nowcasts of ocean or meteorological conditions. The increased accuracy and precision of these resulting data products would benefit all major sectors of the ocean economy, including health and safety activities (including coastal or climate resilience planning), recreational activities, transportation, energy, and commercial fishing. These sectors would primarily benefit through operational cost reductions from optimized route or development planning, enhanced risk management from enhanced ocean condition forecasts and nowcasts, and increased revenues from higher landed values or enhanced precision and accuracy in the location, quantification, and extraction of oceanic energy resources. Indirect, cumulative effects would occur from further increasing operational efficiency and reducing risks (e.g., route-planning, fishing ground selection, targeting of O&G resources, closing/opening recreational areas).

Although mapping and surveying activities would not directly create large numbers of jobs or stimulate migrations of workers, mapping and surveying related to offshore carbon storage assessments and offshore development of renewable and fossil fuel energy sources would have greater indirect economic cumulative impacts compared to other sectors. The oceanographic data collected would facilitate the leasing and development of future oceanic carbon storage or offshore/nearshore energy projects, which would entail large scale job creation and capital expenditures in coastal areas near project sites.

These impacts would persist as long as the data collected and resulting data products are available for review by the public, and certainly for the entirety of the duration considered in the cumulative effects analysis. As such, other surveying and mapping efforts in the action area would cumulatively contribute long-term, indirect, **moderate,** beneficial impacts to socioeconomic resources. The contribution of the NOS Proposed Action to these aggregate, beneficial cumulative effects would likewise be long-term, indirect, **moderate**, and beneficial.

4.2.9.2 Indirect Effects on Jobs and Revenue

Indirect economic benefits resulting from all mapping and surveying activities under the Proposed Action would contribute to cumulative effects on jobs and revenue from all past, present, and future reasonably foreseeable revenue-generating actions. In combination, these would cumulatively result in indirect cumulative economic benefits to the ocean economy. Offshore O&G development, offshore renewable energy development, the expansion of commercial shipping and recreational boating, assessment and extraction of marine minerals, and the construction of LNG terminals would all generate substantial amounts of revenue within the study area. Although mapping and surveying would not directly impact these economic sectors, the enhanced accuracy and precision of ocean data resulting from mapping efforts would expedite and facilitate greater development of offshore energy resources, both from fossil fuels and renewable energy. Marine energy developments create large numbers of jobs related to the construction, operation and maintenance, and eventual reclamation in coastal areas near project sites.

Similarly, the expansion of commercial shipping will require hiring of additional crewmembers and port employees. The majority of revenue-generating cumulative actions would also require large capital expenditures in coastal regions for raw materials or necessary equipment. Second order economic benefits would be generated in coastal economies from consumer or retail expenditures by newly employed workers or the growing number of recreational boaters. These impacts would persist for the entirety of the duration of the cumulative effects analysis and beyond into the foreseeable future.

The enhanced accuracy and precision of ocean data resulting from mapping efforts would expedite and facilitate greater development of offshore energy resources. Due to the resulting revenue and jobs that would be created, cumulative impacts on socioeconomic resources would be long-term, indirect, **moderate**, and beneficial; the contribution of the NOS Proposed Action would also be long-term, indirect, **moderate**, and beneficial.

4.2.9.3 Conclusion

When considered with the NOS Proposed Action, other surveying and mapping efforts in the action area, offshore oil and natural gas development, offshore renewable energy development, commercial shipping and recreational boating, assessment and extraction of marine minerals, offshore carbon storage resource assessments, the construction and operation of offshore LNG terminals, construction of new submarine telecommunication cable infrastructure, commercial and recreational fishing, and coastal development would create cumulative impacts to socioeconomic resources. Impacts to socioeconomic resources could include impacts to the ocean economy and on jobs and revenue.

Overall, the short- and long-term beneficial cumulative impacts from the cumulative effects scenario on socioeconomics would be **moderate**. All NOS projects and activities associated with the Proposed Action and other surveying and mapping efforts considered in the cumulative effects scenario have the potential to contribute indirect cumulative impacts to socioeconomic resources through the collection of high-resolution oceanographic data. Data products (e.g., maps and charts) resulting from these collection efforts would benefit all sectors of the ocean economy primarily through operational cost savings, improvement of risk management, and coastal or climate resilience planning. These data products would enhance and facilitate revenue-producing activities, advantaging future oceanic carbon storage and offshore energy projects in particular, which would subsequently cause job creation and capital expenditures within coastal regions closest to project sites. Indirect, cumulative economic benefits would result from consumer or retail expenditures in coastal areas by newly employed workers or the growing number of recreational boaters. All cumulative socioeconomic impacts would likely persist for the duration of the cumulative effects study period and beyond. As such, the socioeconomic cumulative indirect benefits of these actions would be short-term and long-term and moderate in magnitude. No cumulative adverse impacts to socioeconomic resources are expected from any of the actions or activities.

Potential cumulative, adverse impacts from the Proposed Action in combination with the cumulative effects scenario could be considered either synergistic or additive depending on the timing and location of activities and impacts. Synergistic impacts could result if any activities or actions occur in close spatial or temporal proximity within the study area. For example, updated charts around popular coastal recreational areas would increase operational efficiency and safety of local boating activities; these synergistic benefits would likely result in larger expansions of recreational boating in these areas than in areas that are not surveyed. Similarly, increased accuracy and precision of ocean condition forecasts and nowcasts within a given area would act synergistically to facilitate greater implementation of local coastal or climate resilience planning in the development of commercial real estate or onshore/nearshore energy infrastructure. Additive socioeconomic cumulative impacts could also occur if activities or actions are conducted sequentially within adjacent areas of the study area. Although the exact timing and location of projects have not been finalized and are subject to change, the Southeast and Alaska regions contain the largest proportion of total vessel transit miles of the EEZ (Section 2.4.1) and relatively high levels of marine O&G development. Therefore, synergistic or additive cumulative impacts are most likely to occur in either of these regions.

The contribution of the NOS Proposed Action to beneficial, aggregate cumulative impacts would be **moderate** depending on the timing and location of impacts within the 17-year timespan of this analysis. These impacts would occur regardless of the chosen alternative since projects under each alternative would be composed of similar activities and take place in the same geographic areas and timeframes; however, Alternatives B and C would include more projects, activities, and nautical miles traveled than Alternative A and thus contribute slightly greater impacts.

4.2.10 Environmental Justice

All past, present, and reasonably foreseeable actions described in Section 4.1 would contribute cumulative effects on environmental justice. The cumulative effects analysis also considers that other actions and activities contributing to the existing condition of subsistence resources, including marine debris (e.g., plastics, glass, metals, or rubber); illegal, unreported and unregulated (IUU) fishing; and accidental or illicit discharges (e.g., nutrient runoff, oil spills, or other introduction of contaminants).

4.2.10.1 Disturbance to Subsistence Activities and Sociocultural Systems

Activities producing sound and visual disturbances under any of the three NOS alternatives (e.g., the use of active underwater acoustic sources, vessel and equipment sound, physical presence of vessels and equipment in water, and human activities such as tide gauge and GPS reference station installation, and SCUBA operations), the operation and presence of vessels, equipment, and humans would contribute to cumulative impacts associated with any of the past, present, or reasonably foreseeable actions mentioned above. In combination, these actions would create short- and long-term adverse cumulative impacts to environmental justice communities. Activities creating sound and visual disturbances would cause species to move away from the shore, and subsistence hunters could be forced to temporarily abandon common hunting areas. Subsistence harvests in the marine environment could be disrupted, prolonged; or subsistence resources could be unavailable for use. Communities which are primarily dependent on marine mammals for subsistence, such as the bowhead harvesters of northern and western Alaskan villages, would be especially impacted. Subsistence users may be required to travel farther to harvest subsistence foods at a greater cost in terms of time, fuel, wear and tear on equipment and people, and lost wages. A decline in the harvest efficiency of marine resources would likely lead to an increase in hunting pressure on terrestrial wildlife, and to an increase in competition and territorial conflicts among subsistence harvesters (BOEM, 2015b).

Activities producing sound and visual disturbances under any of the three NOS alternatives (e.g., vessel and equipment sound, physical presence of vessels and equipment in water, and SCUBA operations) would contribute to cumulative impacts that potentially disrupt subsistence fishing from the operation and presence of vessels, equipment, and humans associated with any of the past, present, or reasonably foreseeable actions and commercial and recreational fishing activities. The presence of NOS and other vessels could startle fish, making them harder to catch by subsistence fishers. Subsistence fish species could become less available or unavailable from overfishing due to commercial and recreational fishing activities, particularly in Alaska. Also, as mentioned in Section 4.2.8.3, illegal, unreported, and unregulated (IUU) fishing activities already contribute to the reduced availability of fish, other marine species, or coral reefs important to subsistence cultures. However, in the Gulf of Mexico the impact of such activities on subsistence fishing communities would be negligible since their largest source of subsistence foods are from removals from commercial fishery catches and from activities similar to recreational harvesting (BOEM, 2012).

The cumulative impacts of past and present actions that cause disturbance to subsistence activities would adversely affect the rates of sharing between communities (NMFS, 2016d). This could adversely impact sociocultural systems by disrupting the social organization and/or institutional formation of communities, eroding cultural values, and/or disrupting the economy of households and village communities through changes in employment, personal income, and overall community prosperity. Sharing efforts among core kinship relations would likely intensify, but diminish among more remote networks of exchange. Such pressures could potentially undermine transmission of cultural aspects of subsistence activities to youth populations (BOEM, 2015b).

In general, the sound and visual disruptions from vessels, equipment, and humans are considered a common source of disturbance in the marine environment. Relative to most other cumulative actions described in Section 4.1, there would be lower impacts from the sound generated by the active underwater acoustic sources proposed by NOS. The vessels used for NOS projects would be smaller than most industrial and commercial vessels and cause less disruption. The sound and visual impacts from vessels, equipment, and humans would cause disturbances in their immediate vicinity and would not persist beyond the conclusion of project activities. To minimize adverse impacts to subsistence communities, repeated surveys by NOS in the same area would be avoided. However, due to limited prior exploration in the Alaska region and the 2019 Presidential Memorandum on Ocean Mapping, the number and frequency of cumulative actions mentioned above, particularly surveying and mapping projects, is expected to increase over the next six years. Overall, cumulative impacts of the actions described in Section 4.1 could result in **minor** to **moderate** aggregate, cumulative impacts on EJ communities, depending on the type of activity, seasonal timing, and animal migration. The contribution of the NOS Proposed Action to these adverse, cumulative impacts would be **minor**.

4.2.10.2 Disturbance to Subsistence Activities and Sociocultural Systems from Climate Change

Air emissions under any of the three NOS alternatives would contribute to cumulative effects on climate from greenhouse gas emissions associated with past, present, and reasonably foreseeable actions, particularly related to oil and natural gas development and operation of offshore LNG terminals. In aggregate, these actions would lead to long-term adverse cumulative impacts to environmental justice communities. However, these impacts would result from the overall global climate change phenomenon, since potential air emission impacts from NOS activities are expected to be imperceptible or non-detectable as described in Section 3.15.1. In recent years, Alaska has experienced concerning trends in subsistence harvest activities due to climate change-induced factors such as changes in thickness and extent of sea-ice, increased snowfall, drier summers and falls, and increased storms and coastal erosion. These could adversely affect subsistence harvest patterns by altering traditional hunting locations, impacting subsistence travel, and resulting in resource patterns shift and seasonal availability changes; making access to subsistence resources more difficult (NMFS, 2016d).

Changes in sea-ice could have dramatic impacts on marine mammal migration routes which could impact harvest patterns of subsistence communities and increase the danger of hunting on sea-ice. Thawing of permafrost and melting of sea-ice could result in the habitat loss of important subsistence species. Warmer summers have already started impacting the timing of subsistence hunting. For example, whalers in Kaktovik are accustomed to hunting in August, but now whaling season occurs primarily in September. It is also becoming increasingly difficult to preserve meat during the warmer months. Common hunting and harvesting areas could recede away from the shore, requiring subsistence harvesters to travel farther to harvest subsistence foods at a greater cost in terms of time, fuel, wear and tear on equipment and people, and lost wages.

Shore erosion has become increasingly common in certain Alaskan communities, which delays sea-ice formation, allowing wave action from storms to cause greater damage to the shoreline and change use patterns of local and regional subsistence use areas. As described in Section 4.1.6, the BOEMMMP has several coastal restoration projects that could slow down these impacts in the long-term. Changes to subsistence harvest patterns caused by climate change could also disrupt the social organization in subsistence communities and impact harvest sharing activities. Serious declines in productivity could result in stresses within a community or between communities, affecting the way of life for the residents (NMFS, 2016d).

Climate change, with resultant loss of summer sea ice and open Northwest Passage and other shipping lanes, will likely attract visitors associated with recreation and tourism industries and encourage increase in commercial shipping along those routes. The addition of vessel traffic, especially cruise ship traffic, local traffic, and cargo ships could impede subsistence harvests, resulting in impacts similar to the ones described in detail in Section 4.2.10.1.

As mentioned in Section 4.2.4.4, effects of climate change may include changes to the water temperatures and increased acidification of the ocean caused by dissolved carbon dioxide (CO_2). These changes are expected to continue over the reasonably foreseeable future and would contribute to changes in the population and distribution of fishery resources harvested by subsistence communities. While the dynamics of climate change and the potential magnitude and timing of its effects are poorly understood, it is expected that rising temperatures and increase in ocean acidification would disrupt subsistence harvest patterns by decreasing the fish species available for harvest, disrupting the seasonality of harvest activities and locations of fishing areas, and inducing stress within or between communities by adversely impacting subsistence resource sharing activities.

Overall, climate change could lead to changes in diversity, abundance, and distribution of traditional subsistence resources and harvest patterns, leading to long-term impacts on the availability of some subsistence resources. This could potentially threaten indigenous lifestyle and subsistence practices (NMFS, 2016d). These impacts would occur regardless of the chosen alternative and could result in **moderate** to **major** impacts on EJ communities. The contribution of the NOS Proposed Action to these adverse, cumulative, climate-change related impacts on EJ communities would be **negligible**.

4.2.10.3 Contamination of Subsistence Resources

Subsistence resources are currently stressed due to accidental leakage or spillage of oil, fuel, and chemicals and the unintentional disposal of trash and debris, though NOS does not contribute to these actions (see Section 3.15). Such events associated with any of the past, present, or reasonably foreseeable actions mentioned above, particularly offshore and OCS oil and natural gas development, construction and operation of offshore LNG terminals, and commercial fishing would further stress subsistence resources. While not technically considered a cumulative impact to environmental justice communities, the additional stress that could occur to subsistence resources is noteworthy and is therefore described below.

Contaminated resources, or those perceived to be contaminated, from an accidental oil, fuel, or chemical leak or spill could make subsistence resources unavailable or undesirable for use (BOEM, 2015b). For example, contamination from oil/chemical spills would render the affected subsistence resource unsafe to eat. If the skin or fur of the animal is coated with oil, that pelt would no longer be desirable to be made into coats and other handicrafts. Spill cleanup operations could result in the closure of harvesting areas until cleanup is complete. Any impacts to known archaeological or cultural sites from spill events would also result in adverse impacts to EJ communities in the affected region; these impacts are discussed further in Section 4.2.8 (BOEM, 2016).

Contaminated, or perceived contaminated, resources from marine debris could also render subsistence resources undesirable for consumption if plastics and other marine debris are found in whales and other marine species. Contaminants present in small quantities may be deemed harmless, but may accumulate and have serious, long-term, and ongoing health consequences for subsistence communities and the species they rely on for subsistence (MMS, 2007). Plastic debris could adsorb and concentrate potentially damaging toxic compounds from sea water, further contaminating subsistence resources (NCBI, 2009). Additionally, entanglement in commercial fishing debris such as trawl net webbing, plastic packing straps, ropes, and monofilament line could cause drowning, death from injury, starvation, and/or general debilitation of subsistence resources, making them less available to, or more difficult to harvest by subsistence hunters and fishers (NMFS, 2016d).

Minority and low-income fishing communities, like the Louisiana Vietnamese fisherfolk community in the Gulf of Mexico region, would be particularly sensitive to any oil spill and related fishery closures. Further stress to the condition of fisheries in the region would interrupt access to subsistence-based activities and resources (BOEM, 2012). Similarly, in the North Slope region in Alaska, the contamination of waters with fuel, oil, antifreeze, and other chemicals from military and oil and gas development activities in the mid- to late-20th century period resulted in the avoidance of these sites by subsistence harvesters and disrupted subsistence harvest patterns by impacting several acres of subsistence species habitat (BOEM, 2015b). Aggregate cumulative impacts would be considered **moderately adverse** and the contribution of the NOS Proposed Action to these adverse cumulative effects would be **negligible**.

4.2.10.4 New Mapping and Charting Information

Surveying and mapping activities under any of the three NOS alternatives would contribute to cumulative impacts from other surveying and mapping efforts in the action area associated with any of the past, present, or reasonably foreseeable actions mentioned above. In aggregate, these actions would lead to long-term beneficial cumulative impacts to environmental justice communities. The availability of new and updated charts, maps, and data would result in safer navigation, availability of better forecasts of weather and storm surge events that affect local communities, and historic wrecks. However, the availability of such information about previously uncharted areas, or regions that have not been recently surveyed, particularly the Alaska Region, would elicit interest that could result in additional projects in the area, such as greater surveying and mapping efforts and oil and gas exploration and development, which would have the same adverse impacts on EJ communities as those described in detail above. The overall cumulative impacts to subsistence activities from the availability of new mapping and charting information would be beneficial, long-term and **minor**, and the contribution of the NOS Proposed Action would also be beneficial, long-term, and **minor**.

4.2.10.5 Conclusion

When considered in tandem with activities associated with the NOS Proposed Action, other surveying and mapping efforts in the action area, offshore oil and natural gas development, offshore renewable energy development, climate change, commercial shipping and recreational boating, assessment and extraction of marine minerals, offshore carbon storage resource assessments, construction and operation of offshore LNG terminals, national defense and homeland security activities, construction of new submarine telecommunication cable infrastructure, commercial and recreational fishing, and coastal development would create adverse and beneficial cumulative impacts to EJ communities.

Adverse impacts would occur through a potential decrease in the total annual subsistence catch numbers of a species hunted by low-income or minority communities, or increase in the time required and distance traveled to harvest the same amount compared to previous years in which NOS surveying and mapping activities did not occur, or both (due to sound and visual disturbances generated by vessels, equipment and humans, climate change, and commercial and recreational fishing); reduced availability of fish, other marine species, or coral reefs important to subsistence cultures (due to IUU fishing); and contamination of subsistence resources (due to accidental spills of oil, fuel, chemicals, and/or marine debris). Beneficial impacts would occur through the availability of new mapping and surveying data and would result in safer navigation and more accurate weather forecasts for subsistence harvesters.

These past, present, and reasonably foreseeable future actions are expected to result in insignificant impacts to EJ communities. Overall, the adverse cumulative impacts of all actions described in Section 4.1 affecting the ability of EJ communities to secure subsistence resources are **minor** to **moderate**. The beneficial cumulative impacts from those actions resulting in higher quality data pertaining to hunting/fishing resources, navigation, and weather conditions are **minor**. These impacts would therefore be insignificant.

Cumulative impacts from any of the alternatives in combination with the cumulative effects scenario could potentially be considered either synergistic or additive depending on the timing, location of activities and impacts, and the communities impacted. Synergistic impacts could result if any activities or actions occur in close spatial or temporal proximity within the study area. Similarly, additive cumulative impacts to EJ communities could occur if activities or actions are conducted sequentially within adjacent areas of the study area. Although the exact timing and location of projects have not been finalized and are subject to change, the Southeast and Alaska regions contain the largest proportion of total vessel transit miles of the EEZ (Section 2.4.1) and relatively high levels of marine oil and gas development. Therefore, synergistic or additive cumulative impacts are most likely to occur in either of these regions. For example, cumulative, adverse impacts would be synergistic and additive if activities producing sound and visual disturbances under the Proposed Action, oil and gas exploration in the Alaska region and the increased surveying and mapping associated with the 2019 Presidential Memorandum on Ocean Mapping, offshore and OCS oil and natural gas development, commercial shipping in the Northwest Passage, as well as other actions including the operation and presence of vessels, equipment, and humans take place at the same time in the Alaska region. Impacts to subsistence hunting or fishing patterns that affect the availability and/or the quality of subsistence resources, community sociocultural practices and systems would be synergistic and additive. Additive beneficial impacts would occur in terms of better information pertaining to hunting/fishing resources, navigation, and weather conditions. The NOS Proposed Action would contribute to and have the potential to increase these cumulative impacts, but their relative contribution would be **negligible** as compared to the aggregate contributions of other cumulative actions because the NOS impacts would be temporary or short-term, would be confined to the immediate vicinity of project areas, and would be small as compared to impacts from all other cumulative actions. These impacts would occur regardless of the chosen alternative since projects under each alternative would be composed of similar activities and take place in the same geographic areas and timeframes; however, Alternatives B and C would be expected to have slightly higher cumulative impacts because these alternatives include more projects, activities, and nautical miles traveled than Alternative A.