OCS EIS/EA
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Programmatic Environmental Assessment of Environmental Studies Funded by the Bureau of Ocean Energy Management

National Environmental Policy Act Documentation for the Environmental Studies Program (ESP)

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Abbreviations and Acronyms

BOEM	Bureau of Ocean Energy Management
CE	categorical exclusion
DNA	Determination of NEPA Adequacy
DoD	Department of Defense
DOI	Department of the Interior
DPS	distinct population segment
EEZ	exclusive economic zone
EFH	Essential Fish Habitat
EPA	Environmental Protection Agency
ESA	Endangered Species Act
ESP	Environmental Studies Program
G&G	geological and geophysical
GOM	Gulf of Mexico
HRG	high-resolution geophysical
MFCMA	Magnuson-Stevens Fishery Conservation and Management Act
MMPA	Marine Mammal Protection Act
NASA	National Aeronautics and Space Administration
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NMS	National Marine Sanctuaries
NOAA	National Oceanic and Atmospheric Administration
NSL	National Studies List
OCS	Outer Continental Shelf
OCSLA	Outer Continental Shelf Lands Act
OMB	Office of Management and Budget
PEA	Programmatic Environmental Assessment
PEIS	Programmatic Environmental Impact Statement
PI	principal investigator
PRA	Paperwork Reduction Act
SHPO	State Historic Preservation Office
THPO	Tribal Historic Preservation Office
USFWS	U.S. Fish and Wildlife Service

1 Background

This Programmatic Environmental Assessment (PEA) describes the environmental impacts of typical activities associated with conducting Bureau of Ocean Energy Management (BOEM) environmental studies on the Outer Continental Shelf (OCS) and surrounding areas.

Mandated by Section 20 of the Outer Continental Shelf Lands Act of 1953 (OCSLA), as amended (43 United States Code 1331 *et seq.*), BOEM's Environmental Studies Program (ESP) develops, funds, and manages scientific research specifically to inform policy decisions on the development of energy and mineral resources on the OCS (BOEM 2020a). Research disciplines include physical oceanography, atmospheric sciences, biology, protected species, social sciences, economics, submerged cultural resources, and environmental fates and effects. These BOEM-funded studies inform decision-making related to leasing and associated activities for energy development and marine mineral extraction on the OCS, and the development of measures to mitigate potential impacts of these activities.

1.1 National Environmental Policy Act (NEPA) Review Process for BOEM Studies

BOEM considers the funding of environmental studies to be a major Federal action, as defined in 40 CFR § 1508.1(q), and therefore subject to the Council on Environmental Quality (CEQ) NEPA regulations (40 CFR Parts 1500–1508) and the Department of the Interior's (DOI) NEPA regulations (43 CFR part 46). According to section 46.100(a) of the DOI regulations, the procedural requirements of NEPA apply if an action

> "…*would cause effects on the human environment* (40 CFR § 1508.14), *and is subject to bureau control and responsibility* (40 CFR § 1508.18). *The determination of whether a proposed action is subject to the procedural requirements of NEPA depends on the extent to which bureaus exercise control and responsibility over the proposed action and whether Federal funding or approval are necessary to implement it."*

BOEM's NEPA review of proposed studies typically occurs in stages. First, the BOEM Office of Environmental Programs reviews proposed studies on the National Studies List (NSL), or specific study methodologies when they are available, to determine what level of NEPA review is needed (**Figure 1**):

1. If the proposed study activities do not have the potential to cause any effects, then NEPA is not triggered.
2. If the proposed study activities do not have the potential to cause significant individual or cumulative effect, and do not trigger a DOI extraordinary circumstance review (43 CFR § 46.205(c)), then they can be covered by the existing categorical exclusion (CE). No documentation is needed; however, a note of this determination may be placed in the contract file.
    a. If an extraordinary circumstance is triggered, BOEM will prepare necessary activity- or project-specific NEPA documentation.
3. For proposed study activities that may have the potential to cause effects, further NEPA evaluation is needed.

a. If the proposed study activities are within the range of activities analyzed in an existing NEPA review, including this PEA, BOEM will prepare a Determination of NEPA Adequacy (DNA) memo for the contract file.

b. If the proposed study activities are not covered by this PEA or existing NEPA reviews (e.g., use of a new technology or a new category of activities), BOEM will prepare the necessary activity- or project-specific NEPA documentation.

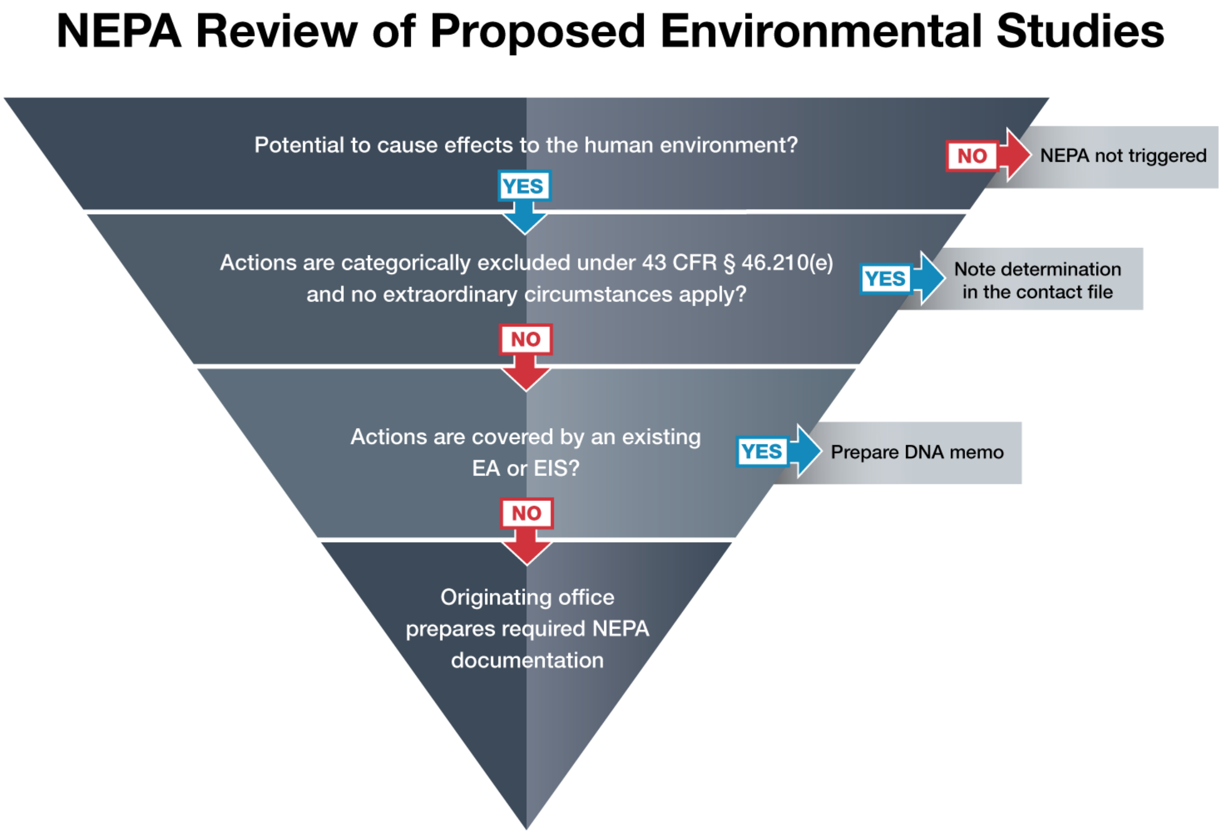

Figure 1. BOEM's NEPA review of proposed environmental studies

Prior to contract award, or when study methodologies are known, BOEM prepares the proper NEPA documentation and ensures that changes during proposal development (e.g., a change in methodology) do not invalidate the completed environmental compliance (i.e., have not shifted the needed compliance level). If contracts have a substantial modification after award, BOEM reviews the NEPA documentation again to ensure it covers the new or modified activities, and the review is appropriately documented in the contract files.

1.2 Development of the Proposed Action for this Programmatic Environmental Assessment

To determine the scope of the Proposed Action for this PEA, BOEM reviewed the studies included in the NSL for fiscal years (FYs) 2014, 2015, and 2016 to determine the types of impact-producing activities typically associated with BOEM studies and past practices. The review concluded that activities associated with most BOEM-funded studies meet the requirements for application of DOI's CE at 43 CFR § 46.210(e), which covers "nondestructive data collection, inventory (including field, aerial, and satellite surveying and mapping), study, research, and monitoring activities." Bureau-level guidance at 516 DM 15.4(A)(1) also identifies activities that are categorically excluded with similar language: "[i]nventory, data, and information collection, including the conduct of environmental monitoring and nondestructive research programs."

Therefore, these activities—which require no study-specific CE review—include the following:

- Data collection using satellites and aerial platforms; and passive acoustic, magnetic sensing, and digital optical scanning methods (e.g., imaging, sonar)
- Modeling, data synthesis, and analyses that rely on existing data
- Compilation of annotated bibliographies, compendiums, and literature reviews
- Conferences, meetings, and other forms of information sharing

This PEA takes a hard look at and analyzes the following studies activities that have the potential for adverse impacts, some of which may be destructive:

- Geological and geophysical (G&G) surveys associated with environmental studies
- Tagging, capture, handling, study, and mortality of marine species (e.g., fish, invertebrates, marine mammals, sea turtles, birds)
- Seafloor disturbance (e.g., sediment sampling, biological sampling)
- Sampling at archaeological or historic sites
- Ethnographic and other cultural interviews
- Other sociocultural and socioeconomic studies
- Unknown or highly controversial effects

2 Purpose and Need for the Proposed Action

The purpose of the Proposed Action is to facilitate BOEM funding and support for environmental studies conducted by Federal agencies, academic organizations, non-profits, and commercial enterprises. The need for BOEM's ESP, mandated by Section 20 of OCSLA, is to support the collection of scientific information to assess and manage the impacts of OCS activities on the human, marine, and coastal environments. BOEM studies support informed decision-making related to the development of energy and mineral resources on the OCS, as well as the development of measures to mitigate potential impacts of OCS activities.

3 Alternatives Including the Proposed Action

3.1 Proposed Action

BOEM proposes to fund environmental studies to collect information, such as through observations, interviews, and sampling of the physical environment and environmental resources. BOEM staff engage with external scientists (e.g., from academia, other government agencies, private sector), who then conduct the studies. Typically, these studies would affect only a small portion of the targeted resources; be short-term, lasting a few days to several field seasons; be limited in area, from a few square meters to a partial OCS planning area; and incorporate standard mitigation measures (e.g., **Appendix B**) to protect the environment and resources. Hence, standard mitigation measures are included in the Proposed Action.

Agreements and contracts follow the Federal Acquisition Regulations and Federal Financial Assistance processes, as well as departmental and bureau-specific policies.

Specific activities are listed below.

G&G Surveys: G&G surveys use instrumentation on a vessel or remotely operated platform to collect information about the marine environment. Geological surveys include passive remote sensing (e.g., via magnetometer or gravitometer) and sampling of the seafloor (e.g., grab samples, box cores, shallow coring) for sediment analysis and testing for geotechnical properties. Geophysical surveys generally use high-resolution, shallow-penetrating acoustic sources (e.g., side-scan sonars, sub-bottom profilers, multibeam echosounders, sparkers, boomers, and more) to detect archaeological resources, seafloor features, and near-surface geologic features. Typically, these sources emit short "pings" of sound between quiet periods and are considered non-impulsive in nature.

The Proposed Action does not include geophysical surveys involving seismic airguns, as they are not typically used in BOEM-funded studies. Any study requesting use of airguns would be evaluated separately under NEPA. Additionally, the Proposed Action does not include any activities related to resource evaluation.

Fish and Invertebrate Capture Studies: For purposes of this document, "fish" includes freshwater fish, saltwater fish, and marine invertebrates in the water column. Fish capture for tagging or subsequent analysis provides important information about distribution and behavior to understand potential interactions with OCS activities. Fish capture involves various methods of standard fishing and capture techniques, as appropriate for the specific target species, and may result in injury or mortality of the captured fish. These techniques include, but are not limited to, Fyke nets (stationary), beach seines (from shore), 3-meter plumb staff beach trawls, and 83-112 survey trawls (standard National Oceanic and Atmospheric Administration (NOAA) survey trawls).

Tagging, Capture, Handling, and Study of Marine Mammals, Sea Turtles, and Birds: Studies of marine species such as marine mammals, sea turtles, and birds generally consist of two types: 1) those that are "non-invasive," which do not require the capture of live individuals; and 2) those that involve tagging or capture of live individuals. Non-capture study approaches include remote sensing and use of instrumentation (e.g., hydrophones, long-term passive acoustic recorders) installed in the ocean, on boats, or nearshore; people serving as “observers” who are specifically looking (or listening, in the case of acoustic studies) for observations of particular fauna; aerial observation and image surveys; and necropsy of deceased individuals. For studies that involve capture or tagging of live individuals, measurements (e.g., size) and other information (e.g., gender) may be recorded after the individual has been captured. Once the appropriate information is collected, the individuals are then often “tagged” with instrumentation and subsequently released back into the environment. Tagging allows for collecting data, such as location and behavior, over time. Tagging also occurs without capture, e.g., approaching a marine mammal with a small vessel and attaching a tag (e.g., via pole system or crossbow). Common tags used for marine mammals and sea turtles include satellite-tracked radio telemetry tags (S-tags) and digital-recording acoustic tags (D-tags). Tag instrumentation commonly includes radio transmitters, time-depth recorders, geographic location time-depth recorders, and satellite-linked transmitters. For birds, specifically, banding is a common practice that involves capturing birds and placing a uniquely numbered band or ring on the leg.

Seafloor-disturbing Activities: The Proposed Action includes instances where studies may have seafloor disturbance that is outside the scope of the CE described above. Seafloor disturbance can be associated with studies of seafloor geology, sediments, contamination, faunal communities, benthic habitats, and archaeological or historic resources. In addition to the use of state-of-the-art remote sensing technology, methodologies for studying the seafloor include collecting samples of surface and near-surface sediments, landforms, biota, and potential archaeological or historic resources. Bottom disturbance may occur incidentally from study activities such as anchoring to the seafloor, placing or attaching instrumentation (e.g., receivers) on the seafloor, or use of trawl instrumentation or nets. In such cases, regulations, stipulations, or other conditions of approval require avoidance of known sensitive resources.

Devices used to collect sediment samples include grab samplers, sediment corers (e.g., gravity, Kasten, piston), shallow drilling, and submersibles (e.g., physical samples, imagery). Sediment samples are analyzed to identify rock types, sediment composition, contamination, and depositional environments. Coring data also are used in conjunction with high-resolution remote sensing data to identify potential submerged cultural landforms. Studies in rocky intertidal and shallow subtidal (< 15 m water depth) areas often involve human divers who conduct census of habitats and biological communities. For census-type activities, temporary transit lines or grid patterns can be constructed on the seafloor to provide sampling spatial distribution and location information for statistical analyses and/or mapping. Epibenthic fauna (organisms living on the surface of the seafloor) and infauna (organisms living in the sediments) also can be analyzed from sediment samples or biological sampling that support community assessments and help identify high-productivity habitats.

Environmental studies activities may occur in any of BOEM’s four OCS regions (Alaska, Pacific, Gulf of Mexico [GOM], and Atlantic), state waters, and adjacent onshore areas. The types and numbers of studies vary each year, depending on agency priorities and funding, as do their durations.

3.2 Studies Not Analyzed

The following categories of studies have been determined to be outside the scope of this PEA and will not be analyzed further in this document. These studies activities fall under 43 CFR § 46.210 (e), which covers “nondestructive data collection, inventory (including field, aerial, and satellite surveying and mapping), study, research, and monitoring activities." In general, studies that fall into these categories do not have the potential to cause significant effects (40 CFR § 1508.27).

Sampling at Archaeological or Historic Sites: BOEM has a robust archaeological/historical resources protection program and conducts studies to identify potential resource sites, gather data about specific sites (including environmental samples), and monitor performance and effectiveness of required impact mitigation measures (54 § 302304(b)(1)). These studies may involve limited sampling at such sites, such as removal of biological specimens, sediment cores or small grab samples of sediments, collection of small pieces of disarticulated wood or ship fasteners, water samples, and other samples to assist in determining the environmental conditions at a site. Sampling would be conducted with appropriate methods and best practices to avoid and minimize impacts. BOEM has determined that a CE normally would apply to this category of sampling. Therefore, these activities are outside the scope of this PEA and will not be addressed further in this document.

Any studies proposing additional activities that may constitute extraordinary circumstances, such as the removal of archaeological objects of significance, would undergo more robust NEPA analysis and consultations under Section 106 of the National Historic Preservation Act (NHPA). In those instances, BOEM will take the following actions:

- Require the preparation of a robust data recovery plan to discuss why the removal is necessary, recovery methodology, proposed analyses on the objects, storage and transport, and conservation and curation of the objects.
- Develop methods to avoid and minimize impacts to the recovered artifacts and the site.
- Consult with the appropriate State Historic Preservation Office (SHPO), Tribal Historic Preservation Office (THPO), and the Advisory Council on Historic Preservation.
- Ensure that studies activities comply with the mitigation requirements identified through the consultations.

Ethnographic and Other Cultural Interviews: BOEM received comments from subsistence communities on Alaska's North Slope that the large number of meetings involving individual or group interviews has an adverse effect on the villages' ability to effectively pursue their subsistence, cultural, and community activities. In 2011, BOEM established a Tribal and Community Liaison position (formerly the Community Liaison position established in 2000) in BOEM's Alaska Region Office to work directly with potentially affected communities to schedule and coordinate meetings. The Alaska Region's approach was adapted in BOEM's Pacific, GOM, and Atlantic Regions. BOEM's ESP proactively seeks input on proposed studies from potentially affected communities and makes substantial effort to report back to the Tribes and villages on the results of the studies with which they were involved. Meetings associated with studies activities involve a small proportion of coordination efforts relative to scoping, public hearings, and events related to non-studies activities. Additionally, under the Paperwork Reduction Act (PRA), data collection must be defensibly useful, and not duplicative nor burdensome to the public. These measures help address the concerns previously expressed by these communities, and ethnographic and other cultural interviews can be covered by CE because there are no anticipated effects from these activities. Therefore, this category of studies activities is outside the scope of this PEA and will not be addressed further in this document.

Other Sociocultural and Socioeconomic Studies: Most BOEM-funded sociocultural and socioeconomic studies rely on secondary data covered under DOI's CE (43 CFR § 46.210 (e)). Activities that include primary data collection have established requirements to avoid impacts and ensure non-burdensome and ethical data collection. PRA requirements are applicable to sociocultural and socioeconomic studies, and are used to determine whether Office of Management and Budget (OMB) approval is necessary. In addition to OMB clearance, studies that involve human research subjects (such as surveys) and are conducted by academic institutions require approval from the appropriate Institutional Review Board , which reviews and monitors research involving human subjects to ensure ethical practices. When BOEM studies involve engaging with communities, engagement is voluntary and through proper channels within the community. Therefore, sociocultural and socioeconomic studies can be covered by CE because there are no anticipated effects from these activities; this category of studies activities is outside the scope of this PEA and will not be addressed further in this document.

Unknown or Highly Controversial Effects: Future environmental studies may propose using new or variations of technologies or techniques for which the potential effects may be unknown or highly controversial. In such cases, BOEM will complete a study-specific environmental review under NEPA. The potential effects of such activities cannot be analyzed at this time. This category of studies activities is outside the scope of this PEA and will not be addressed further in this document.

All Other Studies within the Scope of the CE: Any proposed study that involves nondestructive data collection activities and presents no extraordinary circumstances, even if the study otherwise falls within the categories defined in the Proposed Action, is outside the scope of this PEA and requires no further NEPA review.

3.3 Rationale for No Additional Alternatives, Including a No Action Alternative

DOI regulations, currently at 43 CFR § 46.310, state the following:

> *"[W]hen the Responsible Official determines that there are no unresolved conflicts about the proposed action with respect to alternative uses of available resources, the environmental assessment need only consider the proposed action and does not need to consider additional alternatives, including the no action alternative."*

BOEM found that there are no unresolved conflicts for BOEM-funded environmental studies with respect to alternative uses of available and potentially affected resources examined or sampled in the studies (**Table 1**). Furthermore, BOEM determined that the benefit of completing research to better understand the environment and the long-term gain of improved mitigation measures outweighs any short-term harm or disturbance that may occur as a result of the studies. Therefore, this PEA does not require any additional alternatives.

Table 1. Available and potentially affected resources considered to reach a determination of no unresolved conflicts

Resource	Consideration of Alternative Uses
Fish and invertebrates	Alternative uses of fish and invertebrates include subsistence harvest, recreational fishing, commercial fishing, and other research activities. Species population, range, prey, physiological, and contamination studies involve capture of a small number of individuals, which would have no measurable effect on the overall populations or fishing success rates. If required, the originating BOEM office/program must consult with and obtain permits from the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) (e.g., Magnuson-Stevens Fishery Conservation and Management Act [MFCMA] or Endangered Species Act [ESA]), and studies must comply with any mitigation requirements identified. *The small areal and temporal footprints of these studies, and any required mitigation identified through consultations, would avoid potential conflicts between the proposed studies and alternative uses of fish and invertebrates.*
Marine mammals and other protected species	Alternative uses of these species include subsistence harvest and other research activities. BOEM and NMFS have addressed potential effects to marine mammals from the presence of vessels and the introduction of noise into the marine environment in multiple NEPA documents (**Appendix A**). Through these NEPA analyses, a robust suite of mitigation measures has been developed (**Appendix B**), including requirements for onboard protected species observers to help prevent collisions and cessation of operations when marine mammals or other protected species are nearby. In the Arctic, studies contractors are required to coordinate with the Alaska Eskimo Whaling Commission and the Eskimo Walrus Commission to avoid adverse effects on subsistence harvest activities. Proposed tagging or capture of a small number of protected species for research purposes would be conducted after completion of required consultations and permitting authority under the ESA and, where appropriate, authorizations under the Marine Mammal Protection Act (MMPA). *These measures, the small areal and temporal footprints of these studies, and any other required mitigation identified through consultations or permits would resolve potential conflicts between proposed studies and alternative uses of marine mammals and other protected species.*
Seafloor resources, including marine benthic communities and habitats	Disturbance from sediment, biological, and other sampling would be short term (a few days to several field seasons) and affect small areas (a few square meters to a partial OCS planning area). Consultation under the ESA or MFCMA, including essential fish habitat (EFH), may be required for studies activities that disturb the seafloor and seafloor resources. *The small areal and temporal footprints of these studies and any required mitigation identified through consultations would avoid potential conflicts between the studies and alternative uses of seafloor resources.*

4 Potentially Affected Environmental Resources and Impact Analysis

This section provides a brief description of the affected environment and BOEM's analysis of the environmental impacts associated with the Proposed Action. The affected environment includes both the current state of resources and future baseline conditions, defined as the status of the resource over time given the range of ongoing natural and human activities other than the Proposed Action.

BOEM considered physical, biological, and sociocultural resource categories in the context of the range of potential environmental studies activities expected to occur. The sections below describe the OCS resources that may be potentially impacted by the selected categories of environmental studies activities. These resources include the following:

- Fish and invertebrates
- Marine mammals
- Sea turtles
- Birds
- Marine benthic communities and habitats

Appendix A lists representative NEPA and consultation documents that address the potential effects of activities similar to the studies activities analyzed in this PEA. These analyses are summarized below.

Additional resources—air quality, water quality, geology, commercial and recreational fisheries, and archaeological and cultural resources—were considered but are not expected to be impacted by studies activities; these resources are not analyzed further. Studies activities can involve days-at-sea that are infrequent and distributed throughout the entire OCS, and so are unlikely to impact air quality. Additionally, the port facilities used by BOEM have NEPA documentation that cover air emissions from marine vessel traffic and impacts to water quality under National Pollutant Discharge Elimination System permits issued by the U.S. Environmental Protection Agency (EPA). Environmental studies are not likely to impact geology related to energy and mineral resources due to the small spatial scale and magnitude of activities relative to the geological resources. However, impacts to geomorphology that influences biological communities is discussed in the seafloor-disturbing activities section. Commercial and recreational fisheries are not expected to be impacted by studies activities due to the small number of individuals involved, which would have no measurable effect on fish populations. There are no anticipated impacts to archaeological and cultural resources from studies activities because BOEM has measures and requirements in place to avoid them (**Section 3.2**).

4.1 Affected Environment

4.1.1 Fish and Invertebrates

This document analyzes fish (including both freshwater and saltwater fish) and pelagic invertebrates. Many species of ecologically, culturally, and commercially important fish occur in the U.S. OCS. EFH is a management term that refers to the waters and substrate designated as necessary for federally managed fish to grow. On a national scale, commercial and recreational fisheries, combined, generated

$73.4 billion in labor income, $117.7 billion in value added, and supported 1.79 million jobs in 2019; **Table 2** lists the top commercial and recreational species in each region (NMFS 2022a).

Table 2. Top commercial and recreational fisheries species in each region

Region	Most Commercially Valuable Species (based on landings revenue)	Popular Recreational Fisheries Species
Alaska	Salmon, Alaska pollock, flatfish, crab	Salmon (e.g., coho, pink, chinook), Pacific halibut, rockfish
Pacific	Crab (e.g., Dungeness), shellfish (e.g., oysters), shrimp, whiting (hake), salmon, albacore tuna, flatfish, sablefish, squid	Mackerel, rockfish, salmon, lingcod, tuna, bocaccio, barracuda, surfperch
Gulf of Mexico	Shrimp, red snapper, grouper, blue crab, menhaden, oyster	Seatrout, Spanish mackerel, red drum, Atlantic croaker, red snapper, sheepshead, striped mullet, kingfish, grouper
Atlantic	American lobster, sea scallop, blue crab, shrimp	Striped bass, Atlantic mackerel, tautog, summer flounder, Atlantic croaker, spot, snapper, drum, bluefish, black sea bass, flounder, scup, striped bass, wrasse

Source: NMFS (2022a)

In **Alaska**, major currents bring in warm, low-salinity, nutrient-rich waters that help drive some of the world's highest primary productivity (Stabeno et al. 2004). Protected fish species include five ESA-listed subspecies of steelhead and nine ESA-listed subspecies of salmon (Colway and Stevenson 2007; Good et al. 2005), among others. EFH for the marine juvenile and adult stages of five species of salmon occurs from Alaska's coast to the U.S. exclusive economic zone (EEZ) boundary (Echave et al. 2012).

Along the U.S. **Pacific** Coast, a significant upwelling zone of cold, nutrient-rich water leads to high levels of primary productivity, especially in the summer months (Schwing et al. 1996). Coastal and estuarine habitats support a wide variety of biological communities, including habitat and nursery areas for juvenile fish and shellfish (Beck et al. 2003). More than 90 species of bottom-dwelling groundfish (including rockfish, flatfish, and shark) are managed along the U.S. West Coast and have EFH throughout the Pacific OCS (Pacific Fishery Management Council 2020). ESA-listed salmon and steelhead occur in marine waters in all Pacific planning areas; the ESA-endangered Gulf grouper may occur offshore southern California; and the ESA-threatened southern distinct population segment (DPS) of green sturgeon, which also can be found in Alaska, has critical habitat (which is designated for ESA-listed species) from northern California to the U.S.-Canada border (Colway and Stevenson 2007; Craig et al. 2006; Good et al. 2005).

In the **GOM**, the U.S. coastline comprises more than 750 bays, estuaries, and sub-estuary systems (Engle 2012), which provide important nursery grounds and adult habitat for numerous species of fish, including some protected species. For example, the Flower Garden Banks National Marine Sanctuary in the northern GOM is an important nursery habitat for the ESA-threatened giant manta ray (Miller and Klimovich 2017; Stewart et al. 2018), and the ESA-listed oceanic whitetip and scalloped hammerhead sharks are both found in GOM offshore waters (Barker et al. 2021; Carlson and Gulak 2012). Other GOM fish species include menhaden, seatrout, snapper, tuna, bristlemouth, blue marlin, bigeye tuna, dusky shark, and shortfin mako shark (Lingo and Szedlmayer 2006; Meinert et al. 2020).

Most GOM coastal waters are designated as EFH. Pelagic species (like blue marlin, tuna, and shark) can travel long distances and occupy a wide geographic area, resulting in EFH designations that cover the whole GOM. GOM coral reefs provide important fish habitat and are EFH for many species like snapper and grouper (Gulf of Mexico Fishery Management Council 2005).

Critical habitat is found throughout the GOM, including for the ESA-endangered smalltooth sawfish (Brame et al. 2019) and the ESA-threatened Gulf sturgeon, which has designated critical habitat in select rivers and coasts of Louisiana, Mississippi, Alabama, and Florida (Ross et al. 2009).

The *Deepwater Horizon* oil spill variably affected EFH (e.g., deep coral, mesophotic, and shallow marsh) used by a variety of managed species (Deepwater Horizon Natural Resource Damage Assessment Trustees 2016). Fish communities generally showed dramatic declines in abundance (for multiple species) immediately following the spill but have displayed resilience since then (Deepwater Horizon Natural Resource Damage Assessment Trustees 2016); however, sublethal and long-term effects of the spill on fish and their environments are still under investigation (Murawski et al. 2021).

Along the **Atlantic** Coast, estuaries, tidal rivers, marshes, and stream habitats support a wide variety of aquatic, estuarine, and marine communities, including habitat and nursery areas for juvenile fish (Litvin et al. 2018). The Atlantic canyons, which contain corals and hard substrate that provide complex habitat for many marine animals, are important areas to highly migratory and deep-water fish and are sites of intense commercial and recreational fisheries (e.g., tilefish, tuna, swordfish) (Ross et al. 2018). Additionally, the ESA-listed oceanic whitetip shark and Central and Southwest DPSs of scalloped hammerhead shark occur throughout the Atlantic (Barker et al. 2021; Carlson and Gulak 2012). The ESA-threatened giant manta is also present although not commonly encountered (Miller and Klimovich 2017). Pelagic, highly migratory, managed fish species include 5 tuna, 30 shark, and 6 billfish species. Most of these species (e.g., bluefin tuna, blue shark, and white marlin) have EFH throughout the Atlantic (82 FR § 42329). The anadromous, ESA-listed Atlantic and shortnose sturgeon are bottom-dwelling species ranging from the South Atlantic to the North Atlantic (NMFS 2021f). Atlantic salmon EFH occurs in 30 freshwater, coastal, and brackish areas from Maine to Connecticut (Bardarson et al. 2020). ESA-endangered smalltooth sawfish occur in the Straits of Florida and have coastal critical habitat (NMFS 2021g).

4.1.2 Marine Mammals

Marine mammals spend all or part of their lives in the ocean and include both semi-aquatic mammals (e.g., seals, sea lions, walrus, sea otters, and polar bears) and fully aquatic mammals (e.g., manatees, baleen whales, and toothed whales). They are found in all BOEM OCS regions (Alaska, Pacific, GOM, and Atlantic (NMFS 2009), and are all protected under the MMPA.

Table 3. Marine mammal species found in the OCS regions

Region	Marine Mammal Species
Alaska	Bearded seal, harbor seal, northern fur seal, ribbon seal, ringed seal, spotted seal, Steller sea lion, Baird's beaked whale, beluga whale, bowhead whale, Cuvier's beaked whale, Dall's porpoise, fin whale, harbor porpoise, gray whale, humpback whale, killer whale, minke whale, North Pacific right whale, Pacific white-sided dolphin, sperm whale, Stejneger's beaked whale, polar bear, sea otter, walrus
Pacific	California sea lion, Guadalupe fur seal, harbor seal, Hawaiian monk seal, northern elephant seal, northern fur seal, Baird's beaked whale, Blainville's beaked whale, blue whale, bottlenose dolphin, Bryde's whale, common dolphin, Cuvier's beaked whale, Dall's porpoise, dwarf sperm whale, false killer whale, fin whale, Fraser's dolphin, harbor porpoise, humpback whale, killer whale, long-beaked common dolphin, Longman's beaked whale, melon-headed whale, mesoplodont beaked whale, minke whale, northern right whale dolphin, Pacific white-sided dolphin, pantropical spotted dolphin, pygmy killer whale, pygmy sperm whale, Risso's dolphin, rough-toothed dolphin, sei whale, short-finned pilot whale, sperm whale, spinner whale, striped dolphin, sea otter
Gulf of Mexico	Atlantic spotted dolphin, Blainville's beaked whale, bottlenose dolphin, Rice's whale, clymene dolphin, Cuvier's beaked whale, dwarf sperm whale, false killer whale, Fraser's dolphin, Gervais' beaked whale, killer whale, melon-headed whale, pantropical spotted dolphin, pygmy killer whale, pygmy sperm whale, Risso's dolphin, rough-toothed dolphin, short-finned pilot whale, sperm whale, spinner dolphin, striped dolphin, West Indian manatee
Atlantic	Grey seal, harbor seal, harp seal, hooded seal, Atlantic spotted dolphin, Atlantic white-sided dolphin, blue whale, bottlenose dolphin, clymene dolphin, common dolphin, Cuvier's beaked whale, dwarf sperm whale, fin whale, Fraser's dolphin, harbor porpoise, humpback whale, killer whale, long-finned pilot whale, melon-headed whale, mesoplodont beaked whale, minke whale, north Atlantic right whale, northern bottlenose whale, pantropical spotted dolphin, pygmy killer whale, pygmy sperm whale, Risso's dolphin, sei whale, short-finned pilot whale, sperm whale, spinner dolphin, striped dolphin, white-beaked dolphin, West Indian manatee

Source: NMFS (2009)

Many different types of marine mammal species are found throughout the **Alaska** Region. They include the ESA-endangered western DPS of Steller sea lion; three stocks of northern sea otter, the Southwest stock of which is ESA-threatened; many whale species; and ice-associated marine mammals such as seals (including the ESA-threatened Beringia DPS of bearded seal), walrus, and ESA-threatened polar bears, which have designated critical habitat along the coast and offshore in the Chukchi, Beaufort, and East Bering Seas (Beatty et al. 2021; FWS 2021d; Muto et al. 2021). Whale species found in Alaskan waters include beluga, bowhead, gray, North Pacific Right, and humpback (Moore et al. 2006; NMFS 2009). There are five distinct stocks of beluga whales in Alaskan waters (Hauser et al. 2014), including the ESA-endangered Cook Inlet DPS. The ESA-endangered North Pacific right whale occurs in the Gulf of Alaska and East Bering Sea with designated critical habitat located throughout these areas (73 FR § 19000). Three humpback whale DPSs visit the East Bering Sea in the summer to feed on zooplankton and small forage fish (Smith et al. 2017b).

Marine mammals are abundant in the **Pacific** Region; some migrate through the area, while others are year-round residents. Several distinct stocks of humpback and blue whales travel to the Pacific Coast to feed, and gray whales travel through nearshore waters of the region each year during their migration between Alaska and Mexico (NMFS 2009). Harbor porpoises have resident populations in waters < 131 ft (200 m) along the northern Pacific Coast (NMFS 2009). Similarly, ESA-endangered southern resident killer whales generally reside in nearshore and inland waterways along the coast in the Washington/Oregon Planning Area (NMFS 2009). Six species of pinnipeds occur in the Pacific Region with harbor seals one of the most commonly found (NMFS 2022b). Two species are ESA-listed: the threatened Guadalupe fur seal (NMFS 2021b) and the endangered western DPS of Steller sea lion (NMFS 2021h).

Twenty-two species of marine mammals regularly occur in the **GOM:** ESA-endangered Rice's whale (baleen whale), 20 species of toothed whales and dolphins, and the ESA-threatened West Indian manatee (NMFS 2009). Several species (Rice's whale, ESA-endangered sperm whale, and bottlenose dolphin) have resident populations in the GOM (Van Parijs 2015).

Thirty-four species of marine mammals occur in U.S. **Atlantic** waters: 6 species of baleen whales, 23 species of toothed whales and dolphins, 4 species of seals (gray, harbor, harp, and hooded), and 1 species of manatee (NMFS 2009). This includes five ESA-endangered whales (North Atlantic right, blue, fin, sei, and sperm), as well as the ESA-threatened Florida subspecies of the West Indian manatee. The North Atlantic right whale is the only ESA-listed cetacean with critical habitat in the North Atlantic (81 FR § 4837): feeding grounds in the Gulf of Maine and a calving habitat about 62.1 mi (100 km) wide off the coast of northern Florida, Georgia, and South Carolina (White and Veit 2020).

4.1.3 Sea Turtles

Sea turtles spend most of their lives at sea and come to shore only to lay eggs; upon hatching, young sea turtles immediately move back to the sea). Sea turtles are found in all BOEM OCS regions. The ESA-endangered leatherback turtle—the largest of all sea turtles—is the only turtle normally occurring in **Alaska**, where its range is limited to the Gulf of Alaska (NMFS 2021d). Other species may occur as vagrant in Alaskan waters (Hodge and Wing 2000). No sea turtle species nest in Alaska.

Four ESA-listed sea turtles feed in or pass through the waters of the **Pacific** Region, though there are no turtle nesting areas along the Pacific Coast. ESA-endangered leatherback turtle critical habitat occurs throughout Pacific Region waters, but the species is most prevalent in Washington and Oregon (NMFS 2021d). The West Pacific DPS of leatherback turtle, which has shown continued decline, undergoes one of the longest migrations, traveling to U.S. Pacific waters from the Indo-Pacific (NMFS 2021d; Tiwari et al. 2013). The ESA-threatened East Pacific DPS of green turtle may occur from southern Alaska to Baja California Sur, Mexico, but these sea turtles are mostly found in southern California (NMFS 2021a). The ESA-endangered North Pacific Ocean DPS of loggerhead turtle and ESA-threatened olive ridley turtle occasionally occur off the coast of California (NMFS 2014b; 2021e).

Five species of ESA-listed sea turtles occur in the **GOM**: loggerhead, green, hawksbill, Kemp's ridley, and leatherback (NMFS 2014a; 2021a; 2021c; 2021d; 2021e). GOM beaches provide important nesting habitat for sea turtles; for example, the ESA-threatened Northwest Atlantic DPS of loggerhead turtle has designated critical habitat on beaches and in coastal waters of Florida, Alabama, and Mississippi (NMFS 2021e). Large swaths of the GOM where *Sargassum* seaweed occurs have also been designated critical habitat for the loggerhead turtle (79 FR § 39855).

In the **Atlantic** Region, beaches on the mainland, barrier islands, and sea islands provide vital nesting habitat for five ESA-listed sea turtles. The ESA-threatened Northwest Atlantic DPS of loggerhead turtle occurs along the U.S. southeastern coast; this species nests extensively in Florida, with more sporadic nesting as far north as Virginia (NMFS 2021e). Critical habitat for varying life stages of loggerhead turtles has been designated on nesting beaches, in nearshore waters, and offshore from North Carolina to Florida (NMFS 2021e). ESA-endangered leatherback turtles occur in the open ocean from Maine to Florida and have minor nesting colonies in southeast Florida (NMFS 2021d). The ESA-threatened North Atlantic DPS of green turtle and ESA-endangered Kemp's ridley turtle inhabit waters along the Atlantic, with the latter ranging farther north during warmer months and moving south during the winter and early spring (NMFS 2021a; 2021c). ESA-endangered hawksbill turtles spend time in both pelagic and coastal areas; this species is primarily tropical and sub-tropical and is found regularly offshore of Florida (NMFS 2014a).

4.1.4 Birds

Seabirds, shorebirds, wetland birds, and marine waterfowl are found in all BOEM OCS regions and live entirely at sea, migrate over parts of the ocean, or live in coastal areas.

Many species of marine birds are found in the **Alaska** Region, with its rocky coasts providing habitat for colonies of breeding birds and its high abundance of forage fish and crustaceans providing ample food. An estimated 87% of U.S. seabirds nest along Alaska's East Bering Sea coastline, including fulmars, storm-petrels, cormorants, jaegers, gulls, kittiwakes, terns, murres, guillemots, murrelets, auklets, and puffins (Denlinger 2006). Additionally, many migratory seabirds forage in the Bering Sea to build body-fat reserves on their way to nesting grounds in the Arctic (Denlinger 2006). Over 90% of the North American population of marbled murrelet breeds in Alaska along the coasts of the Bering Sea and Aleutian Islands (Denlinger 2006); this species is ESA-threatened in Washington, Oregon, and California. The Chukchi Sea provides breeding, feeding, and staging areas for millions of seabirds, shorebirds, and waterfowl, including auklets, kittiwakes, murres, shearwaters, fulmars, gulls, loons, phalaropes, and eiders (Gall et al. 2013). The Beaufort Sea also supports many migratory birds, including auks, kittiwakes, guillemots, terns, loons, brants, and eiders (Dickson and Gilchrist 2002). ESA-listed species found in Alaska include the endangered short-tailed albatross, threatened Steller's eider, threatened spectacled eider, and endangered Eskimo curlew (FWS 2022b).

The **Pacific** Region's bird community is large and diverse, and includes far-ranging species that come from the Pacific Ocean, Bering Sea, and Arctic Ocean, as well as from inland North America. Species found in the Pacific Region include storm-petrels, pelicans, auklets, cormorants, murres, murrelets, guillemots, gulls, plovers, oystercatchers, and rails (FWS 2022d; NPS 2016). The Pacific Region has several ESA-listed species, including the endangered short-tailed albatross, endangered Hawaiian petrel, endangered band-rumped storm-petrel, threatened marbled murrelet (in California, Oregon, and Washington), threatened Western snowy plover (Pacific Coast DPS), endangered California clapper rail, and endangered light-footed clapper rail (California Department of Fish and Wildlife 2014).

In the **GOM**, wetland and coastal habitats provide key foraging and resting areas for more than 400 species of seabirds, shorebirds, wetland birds, waterfowl, and songbirds (FWS 2013). Common seabirds found in the GOM include shearwaters, storm-petrels, boobies, gannets, jaegers, phalaropes, petrels, gulls, and terns (Duncan and Havard 1980). Five ESA-listed birds occur in the GOM: threatened piping plover (FWS 2021c), endangered whooping crane (FWS 2022e), endangered Mississippi sandhill crane (FWS 2022c), threatened eastern black rail (FWS 2022a), and threatened roseate tern (FWS 2021f).

Portions of the shoreline have been designated as critical habitat for wintering piping plovers (Stucker and Cuthbert 2006). Additionally, hundreds of millions of migratory birds use the Central, Mississippi, and Atlantic Flyways, parts of which converge on diverse coastal and terrestrial habitats along the northern Gulf Coast, where some birds stay, while others continue to other destinations (Gallardo et al. 2004).

Numerous species of resident and migratory birds occur in the **Atlantic** Region, including seabirds (gulls, terns, cormorants, frigatebirds, gannets, boobies, tropicbirds, petrels, and shearwaters); shorebirds (sandpipers, plovers, oystercatchers, and stilts); wetland birds (egrets, herons, storks, ibises, spoonbills, cranes, and rails); and waterfowl (loons, grebes, and sea ducks) (Brinker et al. 2007). Five ESA-listed marine and coastal bird species occur in this region: endangered Bermuda petrel, threatened red knot, endangered roseate tern, threatened wood stork, and threatened piping plover (FWS 2021a; 2021c; 2021e; 2021f; 2021g). Migratory birds use the Atlantic Flyway, which spans from the Caribbean to the Arctic and covers the entire Atlantic Region (FWS 2021b). Atlantic coastal habitats serve as critical stopover areas for migratory birds to feed and rest; other species use specific coastal areas for nesting (Erwin 1996).

4.1.5 Marine Benthic Communities and Habitats

Marine benthic communities and habitats are living organisms and their associated seafloor environments that they occur on, within, or near. This resource is found in all BOEM OCS regions and does not include fish, marine mammals, sea turtles, and birds, which are discussed separately.

In the **Alaska** Region, the Bering Sea supports diverse benthic communities, including soft corals, worms, bivalves, snails, sea stars, shrimp, and crabs (Wang et al. 2014). Many of these benthic species (such as red king crab, snow crab, and tanner crab) have EFH in Alaska (North Pacific Fishery Management Council 2021) and provide critical food sources for humans and other marine animals (NMFS 2018b). In the Chukchi Sea, the continental shelf supports high benthic biodiversity—including snow crabs, lyre crabs, snails, sea urchins, and sea stars (Goddard et al. 2014; Konar et al. 2014; Smith et al. 2017b)—and provides critical foraging grounds for species like walrus (Sheffield and Grebmeier 2009). The Beaufort Sea supports diverse marine benthic communities, including species such as kelps, algae, corals, brittle stars, mussels, and worms (Smith et al. 2017b). The Alaska Region is also home to 137 species of deep-water coral, especially along the Aleutian Islands (Stone and Cairns 2017).

Submarine canyons, banks, and seamounts on the **Pacific** Region continental shelf are characterized by diverse marine benthic communities, including species such as feather stars, brittle starts, sea urchins, sea cucumbers, worms, bivalves, snails, crabs, other crustaceans, and sponges (Bergen et al. 2001; Levin et al. 2016; Tissot et al. 2007). Additionally, several species of deep-water corals occur in the Pacific Region, including high abundances of octocorals, other soft corals, and sea pens (Everett and Park 2018). The ESA-endangered white abalone occurs off the coast of southern California, and crustaceans (such as Dungeness and red rock crabs) support valuable commercial fisheries (Iribarne et al. 1995; NMFS 2018b). The Pacific region also hosts many chemosynthetic habitats (Seabrook et al. 2018) and an oxygen minimum zone (Bograd et al. 2008), which shape marine benthic communities and the overlying water column.

The **GOM's** nearly ubiquitous soft bottom environments are home to marine benthic communities including worms, bivalves, crabs, lobsters, other crustaceans, sea cucumbers, sea anemones, and brittle stars (Rowe and Kennicutt II 2009). Nearshore and shelf habitat may serve as EFH for managed species like shrimp, stone crab, and spiny lobster (Gulf of Mexico Fishery Management Council 2005) (70 FR § 76216). GOM coral reefs provide important habitat for many marine species and provide EFH for species like snappers and groupers (Lingo and Szedlmayer 2006). There are many chemosynthetic communities in the GOM (Ross et al. 2012), which attract sponges, corals, and tubeworms that create shelter, feeding, and nursery grounds for other species (Fraser and Sedberry 2008).

In the **Atlantic** Region, soft bottom habitats host highly diverse marine benthic communities, including worms, crustaceans, bivalves, and snails (Hale 2010). Coral reefs in the Atlantic Region provide important habitat for a variety of invertebrates and serve as foraging areas for ESA-endangered hawksbill turtles (NMFS 2014a). In deeper waters of the Atlantic, hard bottom habitats support sponges, corals, worms, bivalves, crustaceans, and brittle stars (Posey and Ambrose Jr. 1994). Hydrocarbon seeps in the Atlantic Region are home to chemosynthetic communities that include bacterial mats, mussels, clams, and tubeworms (McVeigh et al. 2018).

4.2 Future Baseline Conditions

The resources discussed about (fish, invertebrates, marine mammals, sea turtles, birds, and marine benthic communities and habitats) may be affected by a variety of stressors, including bottom and land disturbance; vessel traffic; commercial and recreational fishing; oil and gas development; renewable energy development; marine minerals leasing; marine debris and pollution; climate change; and changes to coastal and estuarine habitats. The compounding effects of these stressors may create additional pressure on these resources.

Bottom and land disturbance from a variety of activities may potentially impact fish, invertebrates, marine mammals, sea turtles, birds, and benthic communities. Bottom disturbance may temporarily displace benthic-feeding marine mammals (e.g., bearded seals, walrus, gray whales) from foraging areas (Pirotta et al. 2013). Land disturbance may affect polar bear denning (Linnell et al. 2000) and key haul-out areas for other marine mammals (Andersen et al. 2012). Increased suspended sediments and reduced water quality may diminish the quantity and quality of bird prey and make prey harder to hunt, especially in coastal habitats (Henkel 2006; Lovvorn et al. 2001). Activities that lead to degradation or loss of estuarine and wetland areas may displace birds that use this habitat to forage and breed (Lotze et al. 2006). Bottom and land disturbance may affect marine benthic communities by physically disturbing the habitat and associated fauna, as well as introducing suspended sediments that may smother organisms (Clark et al. 2019).

Vessel traffic is an increasing concern; the average size of container ships is getting larger (Merk et al. 2015), and global trade is continually growing. With respect to waterborne tonnage, six out of the 10 busiest U.S. ports are in the GOM; the other four ports are in the Pacific and Atlantic Regions (USACE 2021). Vessel collisions, noise, and invasive species are expected to increase and intensify in future years (Sardain 2017). Marine mammals and sea turtles are at risk of vessel collisions, especially in major shipping lanes (Rockwood et al. 2017). As vessel traffic increases in the future, these areas would continue to be high-risk zones for marine mammals and sea turtles. The expected expansion of some ports also may result in increased risk of vessel collisions, which has been implicated in injuries and fatalities for several large whale species (Hill et al. 2017; Laist et al. 2014; Muirhead et al. 2018). Increases in noise due to vessel traffic may have a chronic, low-intensity impact on fish species, e.g., physiological stress responses (Celi et al. 2016). Acoustic masking is a phenomenon in which noise in the marine environment interferes with communication in species ranging from fish to marine mammals (Clark et al. 2009; Erbe et al. 2016). Vessel noise also may lead to acoustic masking, increased stress, and changes in migration routes of marine mammal species; these impacts have already been document for the North Atlantic right whale (Davis et al. 2017; Parks et al. 2007; Parks et al. 2011; Pirotta et al. 2012).

Commercial and recreational fishing increase vessel traffic and resource consumption, which may impact marine species. Commercial fishing intensity is expected to persist in future years, which will continue to strain marine species and marine benthic communities (Anticamara et al. 2011). The stress of fisheries may impact some fish species that are currently overfished or threatened with habitat destruction (Dulvy et al. 2021). Fisheries operations often use equipment that may inadvertently harm and result in catch of non-targeted species (i.e., bycatch). For example, trawl fisheries have some of the highest bycatch rates of any fishery (Kelleher 2005). Mortality and injury due to fisheries interactions continue to be a problem for marine mammals and sea turtles. North Atlantic right whales are particularly vulnerable to entanglement in fishing, crab, and lobster pot lines (Knowlton et al. 2012). Entanglements may lead to mortality or decreased body condition due to the difficulty in foraging or swimming with additional drag from entangled gear (Knowlton and Kraus 2001). The stress from entanglement makes it particularly difficult for females to bear offspring and nurse their calves (Pettis et al. 2017). Increases in fishing activity may continue to disturb benthic habitat and affect both target species and bycatch. Fisheries may cause impacts by removing fauna and damaging or destroying benthic habitat, which may degrade overall habitat quality (Althaus et al. 2009).

Oil and gas development in Federal and state waters may affect marine species and habitats. These activities may result in disturbance from vessel or aircraft traffic, vessel collisions (Schoeman et al. 2020), behavioral disturbance (e.g., acoustic masking) or displacement due to increased noise (Erbe et al. 2016), bottom disturbance (Pirotta et al. 2013), routine discharges (Holdway 2002), or non-routine events such as spills (Deepwater Horizon Natural Resource Damage Assessment Trustees 2016). Vessel traffic and noise from deep-penetration seismic surveys or decommissioning may cause physiological harm or behavioral disturbance to marine mammals and sea turtles (Ellison et al. 2012). Benthic features and habitat value may continue to be degraded or lost if impacted by discharges (drilling muds, cuttings, debris) or other bottom disturbance, especially for particularly unique or sensitive habitats (e.g., corals, chemosynthetic habitats, Habitat Areas of Particular Concern) (Sulak et al. 2007). Expected decommissioning of oil and gas infrastructure and future offshore renewable energy development may also likely have localized, short-duration impacts on marine benthic communities (Burdon et al. 2018).

Renewable energy development is expected to continue (BOEM 2020b; EIA 2021), which may impact marine habitats and associated fauna. Construction, installation, associated cabling, and decommissioning of offshore wind turbines may cause bottom disturbance, which may lead to incidental mortality of both pelagic and benthic species, damage to habitat, and/or alterations to food web dynamics (Gasparatos et al. 2017). These renewable energy development activities may increase vessel traffic (e.g., for G&G surveys and routine monitoring), which may increase risk of vessel collisions and noise in the area (Schoeman et al. 2020). The presence of offshore wind turbines may be beneficial to some species by providing hard substrate and aggregation sites (Glarou et al. 2020), but displace and cause avoidance for others (Cook et al. 2018).

Marine minerals leasing (such as for beach replenishment) is likely to increase to meet a predicted increase in need for marine minerals (BOEM 2020b). Coastal restoration projects to address chronic and increasing erosion often involve excavating sand from one area and placing it in another, which may directly impact marine benthic communities and coastal habitat (Erftemeijer and Lewis III 2006). In addition, marine minerals activities may pose a risk to sea turtles and ESA-listed fish species (such as sturgeon) from possible entrainment in the dredge draghead. Marine minerals G&G survey activities may lead to an increase in vessel traffic, which may increase risk of vessel collisions and noise in the area. Seabed mining for critical minerals may occur in the future and has the potential to impact both the pelagic and benthic environments due to bottom disturbance and exploration activities (Drazen et al. 2020; Orcutt et al. 2020; Simon-Lledó et al. 2019), although the magnitude of potential impact is still uncertain.

Marine debris and pollution, from at-sea disposal or transported from land, are becoming increasing concerns for many marine species. Offshore pelagic and highly migratory species such as sharks, marine mammals, sea turtles, and birds increasingly encounter abandoned fishing gear and plastic debris. This stressor may increase their risk of mortality through entanglement, choking, and ingestion of indigestible and toxic materials (Floren and Shugart 2017; Jepsen and de Bruyn 2019; Schuyler et al. 2016). It is now common to find marine debris that has been ingested by marine mammals, sea turtles, and birds (Choy and Drazen 2013; Good et al. 2020; Lynch 2018). Additionally, contaminants—both in the water and in sediments—can potentially impact the health and reproductive success of marine species, possibly resulting in mortality and/or broader population-level impacts (Khayatzadeh and Abbasi 2010). Some marine mammals, such as sea otters, are particularly vulnerable to marine pollution, especially oil, because their fur must remain clean to keep its insulating properties (Jessup et al. 2004). While grooming, sea otters also may ingest harmful or toxic contaminants (Harwell et al. 2010).

Climate change impacts related to increases in global atmospheric and oceanic temperature, shifting weather patterns, rising sea levels, and changes in atmospheric and oceanic chemistry are expected to continue (Doney et al. 2012). As the Arctic open-water season lengthens, stressors to the marine environment from commercial shipping, tourism (including cruise ships), and research activities are expected to increase (Pizzolato et al. 2014). Ice-associated marine mammals may face challenges with changing future conditions, particularly the loss of sea ice. Arctic sea ice is diminishing in amount and thickness, making it less viable as a platform for hunting, resting, breeding, and molting (Wassmann et al. 2011). As a result, some species may have to use nearshore areas for these activities, pushing them farther from their feeding grounds and into closer proximity with humans (Fischbach et al. 2007; Jay et al. 2012; MacCracken 2012).

Increased warming may impact fish and other pelagic species that are highly vulnerable to changes in the intensity and mixing of currents, due to their sensitivity to changes in concentrations of oxygen, carbon, and nutrients (Hoegh-Guldberg and Poloczanska 2017). Primary productivity and marine food webs may shift in future years, posing additional challenges for fish species. In northern waters, changes to seasonal ice melt related to climate change may prevent algae blooms and subsequent peak phytoplankton production from coinciding with seasonal zooplankton reproductive periods or hatching times of pelagic fishes (Eisner et al. 2014; Wassmann et al. 2011). Such mismatches in timing may result in population and recruitment declines for pelagic organisms that feed on primary producers (Edwards and Richardson 2004). The population decrease in turn may impact larger species of fish, marine mammals, and seabirds by reducing prey availability and feeding success (Lynam et al. 2017). These changes are expected to continue as oceans become warmer.

In addition to potential food scarcity resulting from seasonal shifts, there may be other effects to marine species. As species' ranges shift, native species may be displaced or face increasing competition (Sorte et al. 2010), which may particularly impact species that are already at the edge of their tolerable environmental conditions and have few options for range shifts (Ershova et al. 2015). Range shifts to higher latitudes are expected for species that are critical components of regional food webs, such as copepods (Beaugrand et al. 2002) and forage fish (Rose 2005). In addition, populations of commercially valuable fishes, like Atlantic cod, may decline as waters continue to warm (Pershing et al. 2015). While some species may shift northward, other more adaptive species could thrive under new conditions (Brodeur et al. 2019). For example, some baleen whales are already exploiting new geographic areas for feeding and may benefit from further shifts in the planktonic community, while fish-eating beluga whales may struggle with food scarcity (George et al. 2015; Harwood et al. 2015; Moore et al. 2006).

Warming waters may also expose more marine species to harmful algal blooms (Lefebvre et al. 2016). Harmful algae blooms may be lethal for animals, including sea lions, sea otters, and gray, humpback, and fin whales (Jones et al. 2017; McCabe et al. 2016; Miller et al. 2010). Warm-water anomalies may become more common due to climate change and exacerbate these blooms (McCabe et al. 2016; Van Dolah 2000) and affect water quality.

Marine benthic communities and habitat are also vulnerable to climate change, including warming temperatures. Changes in regional water and air temperatures may particularly affect shallow-water rocky intertidal species (Helmuth et al. 2006) and may be related to large disease events in sea stars (Miner et al. 2018) and other U.S. West Coast echinoderms. Climate change models show a high likelihood of extinction of many local species by 2050, with species invasion and replacements also occurring but less prominent (Cheung et al. 2009). As species ranges change, novel interactions among predator-prey combinations and competitors will likely affect the long-term success of individual species and marine benthic communities (Smith et al. 2017a). Potential consequences of ongoing and future range shifts to the overall benthic community due to the arrival of new species are not fully understood.

Impacts of ocean acidification on calcifying (shell-building) organisms are an additional concern associated with climate change. Shell-building animals are affected by ongoing and future ocean acidification in the form of decreased size, slower growth, and range shifts (Kroeker et al. 2010). These effects may impact population sizes and dynamics, along with influencing the benthic habitats formed by many of these fauna (Zunino et al. 2021). Changes to shell-building fauna populations may affect predators (like seals, walruses, and whales), which may lose prey resources or need to adapt their diet (Fabry et al. 2009). Additionally, calcifying organisms, such as commercially important crabs and clams, support fisheries and are the prey of many other harvested species (Marshall et al. 2017), which would in turn be affected. Like other shell-building organisms, corals may have decreased size or slower growth due to ocean acidification (Cornwall et al. 2021). This impact may have important habitat implications, as corals form important habitat both in shallow, warm-water areas and in the cold, deep sea (Cordes et al. 2008).

Changes to coastal and estuarine habitats may impact the many fishes, marine mammals, sea turtles, and birds that use these habitats. Warming temperatures, ocean acidification, deoxygenation, and eutrophication may create inhospitable areas in estuaries and may have adverse consequences for fish populations, particularly when the impacts are combined (Keppel et al. 2016; Miller et al. 2016). Degradation of coastal ecosystems may affect marine mammals that utilize these areas to rest and birth or nurse their young (Laist et al. 2013), as well as resident and migrating birds (Klingbeil et al. 2021). Increases in storms and sea level rise associated with climate change may inundate and damage coastal habitat, which in turn may impact birds and nesting sea turtles, especially on barrier islands (Morton 2003). If barrier islands continue to diminish, beach nourishment activities may increase turbidity of nearshore waters and species entrainment (Speybroeck et al. 2006), especially of sea turtles (Ramirez et al. 2017). Populations of coastal birds may continue to be stressed by exposure to routine and accidental discharges and increasing vessel traffic (Wiese and Robertson 2004).

4.3 Impact Analysis

4.3.1 Vessel Traffic and Noise

This section analyses potential impacts from vessel traffic and noise associated with BOEM-funded environmental studies.

4.3.1.1 Vessel Traffic

4.3.1.1.1 Fish

Vessels cause a path of physical disturbance in the water, which may affect the health and behavior of certain fish species, depending on the type of vessel, life history of the fish species, and water depth. - Non-swimming and weakly swimming fish life stages and fish prey may experience displacement, injury, or mortality from pressure waves from vessel hulls, bubble cavitation generated by hull structures, and vibrations from vessel pumps (Bickel et al. 2011; Casper et al. 2017; Kucera-Hirzinger et al. 2008). Free-swimming fish in the immediate vicinity can avoid the vessel, while fish species in the coastal and marine environments may be disturbed by the presence of passing vessels (Xie et al. 2008). Vessel activities may disturb pelagic and benthic fish, potentially displacing them from preferred habitat.

4.3.1.1.2 Marine Mammals

Survey vessel traffic may impact marine mammals in all BOEM regions. Vessel traffic may disturb or displace marine mammals and direct collisions with vessels may result in injury or death. Recent work suggests that some species (e.g., beaked whales, (Pirotta et al. 2012); harbor porpoises, (Wisniewska et al. 2018)) may alter their foraging behavior in the presence of vessels. Although the probability of occurrence is low, marine mammals may be injured or killed by vessel collisions (Schoeman et al. 2020), which would have population-level consequences for species with particularly small populations like the North Atlantic right whale (Hayes et al. 2020). Most reports of vessel collisions with marine mammals involve large whales, but collisions with smaller species also occur (Van Waerebeek et al. 2007). Most severe and lethal whale injuries involve large ships (> 262 ft [80 m]) at higher speeds (> 14 knots (kn) [16 mph]) (Crum et al. 2019; Laist et al. 2001; NMFS 2020). Seismic operations generally are conducted at relatively slow speeds of 4 to 6 kn (4.6 to 7 mph), with a maximum speed < 8 kn (9 mph), but small crew change or support vessels move faster. In certain areas where highly vulnerable populations occur, regulations (50 CFR § 224) require certain sized ships to limit their speeds to 10 kn (11 mph) to minimize mortalities (Laist et al. 2014; van der Hoop et al. 2015). NOAA is currently working on amendments to the North Atlantic Right Whale Vessel Strike Reduction Rule (87 FR 46921).

4.3.1.1.3 Sea Turtles

Vessel traffic may impact sea turtles in the Pacific, GOM, and Atlantic Regions but not particularly in Alaska, where sea turtles very rarely occur. Sea turtles spend at least 20 to 30% of their time at the water's surface for breathing, basking, feeding, orientation, and mating (Lutcavage and Lutz 1996), making them vulnerable to collisions with moving vessels. Any vessel collision with a sea turtle is expected to result in injury or death. Sea turtles also are known to startle at the presence of boats and ships, causing additional metabolic expenditure (DeRuiter and Doukara 2012).

4.3.1.2 Noise from Vessel Operations and Active Acoustic Sources

Noise may affect marine animals in several ways. The severity of impact depends on the frequency, range, intensity, and duration of the sound; the hearing abilities of the species of interest; and the distance from the source to the receiver. Within a given species, responses vary widely, depending on behavioral context (e.g., feeding, spawning, migrating, calving) at the time of exposure, as well as prior exposure (Ellison et al. 2012). Noise may impact marine species in all BOEM regions (Gordon et al. 2003). Vessel noise is generated primarily by propeller cavitation and is a combination of tonal (energy concentrated in a narrow part of the spectrum or at a single frequency) and broadband (energy is distributed over a wide range of frequencies) sound (Hildebrand 2009). Sound from vessels radiates outward in all directions, unlike the focused beams of sound emitted by active acoustic sources. Source levels depend on vessel size and speed (McKenna et al. 2013); small vessels (e.g., crew boats, tugs) are typically quieter but higher in frequency (50–5,000 Hz) than larger vessels (e.g., commercial vessels, cruise ships, supertankers, icebreakers, with frequencies of 50–1,000 Hz). Both ranges overlap some animals' vocalizations and hearing ranges, which may lead to acoustic masking (Clark et al. 2009).

Some active acoustic sources (i.e., HRG sources, such as boomers, bubble guns, sparkers) and some sub-bottom profilers produce low-frequency sounds that overlap with the hearing ranges of fish, sea turtles, and some marine mammals. Other sources like multibeam echosounders, side-scan sonars, and certain oceanographic instruments (e.g., ADCPs) are above the hearing range of most fishes and sea turtles, as well as baleen whales, which generally hear low-frequency sounds (Crocker et al. 2019; NMFS 2018a; Popper et al. 2014). When the frequency range of a sound source does not overlap with the hearing range of an animal, it means that the sounds are not audible and generally would not have any effect.

Aside from acoustic frequency, it is important to examine other characteristics of active acoustic sources when considering potential impacts to marine species (BOEM 2017). For example, many HRG sources have very narrow beamwidths, meaning the probability of an animal entering their ensonification zone is quite low. In addition, many active acoustic sources emit very short pulses of sound with quiet time in between; this means that animals in the proximity of an HRG survey are only likely to receive a certain number of "pings" above a given acoustic threshold, as outlined in NMFS (2018a) and Popper et al. (2014). Ruppel et al. (2022) provides a detailed analysis of many HRG sources.

4.3.1.2.1 Fish

Although vessel noise may increase stress (Celi et al. 2016; Wysocki et al. 2006) or affect schooling (Sarà et al. 2007) or antipredator behaviors (Simpson et al. 2016), the most likely impact on fish is likely to be acoustic masking (Clark et al. 2009; Erbe et al. 2016). Because many fish use acoustic communication to coordinate spawning events or attract mates, a reduction in communication space due to the presence of vessel noise may temporarily affect these behaviors (Stanley et al. 2017).

Fish responses to noise are expected to differ among fish species. Fish with swim bladders are generally more sensitive to sound and thus may be affected over larger spatial scales (Popper et al. 2014). Fish that lack a swim bladder, or a connection between the swim bladder and the ear, are only sensitive to acoustic particle motion, and therefore would only be affected while in very close proximity to a vessel. Primarily because of the small number of fish affected, impacts from vessel noise are not expected to have measurable population-level effect.

4.3.1.2.2 Marine Mammals

Marine mammals may be impacted by noise in all BOEM regions. The presence of vessel noise may mask important auditory cues, interrupt normal behaviors (e.g., feeding, mating), or increase stress (Rolland et al. 2012), which may have secondary effects on fitness (Kight and Swaddle 2011; Wright et al. 2007). Whales that are sensitive to low-frequency sound, such as the ESA-listed subpopulation of Rice's whale in the GOM, may be impacted by noise throughout their range (Van Parijs 2015). In addition, sounds from the most powerful HRG sources (Kavanagh et al. 2019; Mate et al. 1994; Miller et al. 2009; Robertson et al. 2013) may cause behavioral disturbance the absence of appropriate mitigation measures, but with mitigation, these effects are unlikely (Ruppel et al. 2022). In general, the likelihood of harm is very low because noise from studies surveys is typically high frequency, low energy, and limited in area. Mitigation measures (**Appendix B**) and avoidance behavior on the part of the animals makes it unlikely that the animals would be very close to the noise source.

4.3.1.2.3 Sea Turtles

Sea turtles may be impacted by vessel noise in the Pacific, GOM, and Atlantic Regions (Nelms et al. 2016) but not particularly in Alaska, where sea turtles very rarely occur. It is generally accepted that sea turtles can detect sounds between 100 Hz–2 kHz, although there is relatively little data on hearing sensitivity (Moein Bartol and Musick 2003; Popper et al. 2014). Behavioral disturbance or acoustic masking may be more widespread, but little is known about noise levels that induce such changes in sea turtles (McCauley et al. 2000; Moein et al. 1994). Generally, turtles are less sensitive to sound than marine mammals, so they would be affected over small spatial scales.

4.3.1.3 Mitigation Measures

A robust suite of mitigation measures has been developed to mitigate the potential impacts of G&G surveys (see **Appendix B**). Each study would have a project-specific suite of mitigation measures, including those developed through any required consultations (e.g., ESA), as applied through the project development and contract negotiation processes. These measures include the requirement of protected species observers on-board the survey vessels to help prevent collisions and ceasing operations when marine mammals or other protected species are near, distance restrictions on vessels, exclusion zones, and temporal closures. In the Arctic, studies contractors are required to coordinate with the Alaska Eskimo Whaling Commission and the Eskimo Walrus Commission to avoid adverse effects on subsistence harvest activities. All these mitigation measures could reduce or minimize the impacts described above.

4.3.1.4 Conclusions

Studies involving active acoustic surveys support developing a better understanding of the marine environment and enable BOEM to carry out its objectives more efficiently and effectively. Potential impacts of studies involving active acoustic surveys on fish, marine mammals, and sea turtles are expected to be minimal due to the short duration of active acoustic noise, localized nature these studies, and mitigation measures implemented while carrying out these studies.

4.3.2 Fish Capture Studies and Marine Mammal, Sea Turtle, and Bird Studies

Fish capture studies involve capturing small numbers of fish or invertebrates and often target specific species for sampling. The number of fish and invertebrates captured in ESP studies is usually very small in comparison with the overall population size (Holladay et al. 1999; Siemann and Smolowitz 2017). Disturbance to and effects on the general community are minimized through approaches that enable minimizing bycatch, releasing only healthy fauna back into the environment, limiting take to non-breeding individuals (typically males), or setting a minimum size or age requirement for individuals that may be kept (Francis et al. 2007). Some low level of incidental mortality, including bycatch, is expected. Captured and tagged fauna are handled with care to ensure they remain healthy and experience minimal stress before release back into the environment (Sloman et al. 2019). Laboratory studies, including those that involve analysis of tissue samples, rely on the careful handling and preservation of small numbers of captured fauna and any associated samples. As a result, impacts from these studies are expected to be minimal and only include fish or invertebrates that are used for samples. In instances where targeted species are ESA-listed, the originating BOEM office/program would work with the principal investigator (PI) to consult with the appropriate resource agency, employ all required mitigation measures, and acquire all necessary authorizations and permits.

Marine mammal, sea turtle, and bird studies often involve collection of observational data (including those that do not require capture of the animal) and necropsy of already-dead individuals. These types of studies are considered “non-invasive” and thus are not typically associated with negative impacts to the individuals being studied. Studies that involve capture or pursuit of these marine species typically involve capturing an individual, taking measurements and samples, tagging, and releasing the live animal back into the environment (McClintock et al. 2017); another method is to approach an animal to attach a tag without capture (Andrews et al. 2008). Live individuals are handled carefully to minimize potential impacts such as from stress and/or injury (Gales et al. 2009). Sampling and tagging are done in such a way as to not adversely impact the individual’s health or chances of survival upon release (Baker and Johanos 2002). Direct mortality from capture study activities is not expected for marine mammals or sea turtles, as these studies do not typically collect whole-body samples and instead release the live animals. An exception may be studies that collect information from animals captured as part of subsistence activities. Like marine mammals and sea turtles, bird studies are typically non-invasive and not associated with negative impacts to the individuals being studied. In most cases, captured birds are released back into the environment (Lescroël et al. 2009). However, mortality is expected for some live birds collected for specific research purposes, such as stomach content analysis, that require whole-body dissection. Active collection of birds requires a USFWS permit.

4.3.2.1 Mitigation Measures

Mitigation measures implemented while carrying out the study could further minimize potential impacts of study activities. Some relevant examples from **Appendix B** include vessel strike avoidance when transiting and marine debris awareness especially when using nets and fishing gear. In addition, studies involving ESA-listed species (pursuant to ESA) and/or marine mammals (pursuant to MMPA) require consultation and subsequent implementation of any mitigation measures required by the consultation and resulting permit authority. For example, studies involving any of the six ESA-listed sea turtles found in U.S. waters require BOEM consultation with the appropriate resource agency and implementation of identified mitigation measures. BOEM implements all required mitigation measures to ensure minimal disturbance or harm to protected marine species. Studies involving bottom-contact capture techniques that could affect EFH and/or archaeological resources may require EFH and NHPA consultations, respectively, to identify mitigation measures to protect habitats and archaeological and/or historic resources. In partnership with the PI, the originating BOEM office/program would identify and complete all required consultations on a project-by-project basis.

Development of measures to mitigate adverse effects to fish and marine species will be enhanced by information developed through these studies. However, the overall impacts of the studies are expected to be short-term, localized, and limited to small numbers of individuals in the immediate vicinity. Therefore, impacts to fish, marine mammals, sea turtles, and birds from capture studies are expected to be minimal.

4.3.2.2 Conclusion

Fish, marine mammal, sea turtle, and bird capture studies support developing a better understanding of these marine resources and enable BOEM to carry out its objectives more efficiently and effectively. Potential impacts of capture studies on fish and marine species populations, as well as EFH, are expected to be small due to the nature of these studies. These studies are either “non-invasive” or generally only collect small numbers of individuals to study, while the majority are released back into the environment. Minor, temporary disturbances to or displacement of fauna in the vicinity of the study area (e.g., by vessels or equipment supporting the studies) may occur.

4.3.3 Seafloor-disturbing Activities

Seafloor-disturbing activities range from sediment sampling (e.g., coring, sediment grabs) to benthic biological sampling (e.g., bottom trawls, physical sampling of fauna via submersibles). These activities may potentially impact benthic communities and habitats. Epifauna may be disturbed, displaced, injured, or removed by sediment sampling activities, such as coring and sediment grabs that directly disrupt the seafloor. In extreme cases, incidental mortality of fauna may occur. Biological sampling of fauna may result in removal of organisms or potentially disturb habitat and associated fauna in areas surrounding where sampling takes place. Physical disturbance to the seafloor may result in temporary or permanent geomorphology and habitat alteration, which is compounded by the potential impacts from biological sampling.

In addition to physical disturbance of habitat and fauna, seafloor-disturbing activities may result in resuspension of sediments (Martín et al. 2014) and potential release of contaminants stored in the sediments (Bancon-Montigny et al. 2019). This effect may result in “smothering” of benthic fauna and/or increases in contaminant levels in fauna in affected areas (Jones et al. 2019), potentially impairing their health. Sensitive benthic communities, such as live hard-bottom and corals (in both shallow and deep water), are particularly susceptible to a wide variety of seafloor-disturbing activities and consequently may experience a decline or loss of health and habitat value (Hiddink et al. 2017).

Some of these activities, seafloor-disturbing and otherwise, may contribute to marine debris in the form of unrecovered equipment. Every effort is made to recover lost and/or sacrificial items. Some equipment are not meant to be recovered (e.g., mooring anchors, satellite tracking tags); these items are generally inert (e.g., steel). The total amount of debris released with studies activities is small relative to other sources of marine debris (Galgani et al. 2015).

4.3.3.1 Mitigation Measures

Studies are typically designed with specific mitigation measures to minimize potential impacts. For example, avoidance of sensitive marine benthic ecosystems could reduce or eliminate potential impacts on these habitats (Ban et al. 2019) (**Appendix B**). Avoidance can be challenging, however, when these are the habitats and faunal communities that are being studied. In such cases, additional measures may be taken to ensure that impacts are kept to the minimum extent possible while still allowing for desired studies activities to take place. Suspected historic and prehistoric sites also would likely be avoided (**Appendix B**).

Studies that disturb the seafloor in areas where protected species occur may require consultations with the NMFS or USFWS under the ESA or other laws. Many benthic habitats serve as EFH (Peterson et al. 2000) and, as such, may require consultation with the NMFS under the MFCMA. Any studies that include sampling of archaeological or historic resources would require additional NEPA documentation, consultation under NHPA, and coordination with the appropriate SHPO and THPO, if applicable. These consultations would help determine the most appropriate approaches to avoid, minimize, or mitigate impacts to potentially affected resources.

Overall, impacts from studies that include seafloor-disturbing activities are anticipated to be small or even negligible due to their limited scope and extent, and implementation of appropriate mitigation measures.

When reviewing each study to determine whether it falls within the scope of this PEA, the BOEM reviewer will determine concurrently whether the appropriate mitigation from **Appendix B** is included in the study methodology or, alternatively, whether mitigation is not included and further NEPA review is required. For example, impacts may be long-term and lead to long recovery times for sensitive and slow-growing species, such as corals (Gouezo et al. 2019).

4.3.3.2 Conclusion

BOEM-funded studies that include seafloor-disturbing activities aim to develop a better understanding of the seafloor and its associated biological resources, which is critical to BOEM’s mission. Except for removal or incidental mortality of benthic fauna, potential impacts from seafloor-disturbing activities associated with studies to most benthic communities generally are expected to be short-lived, occur over small areas, and/or be localized.

5 Consultations and Coordination

5.1 Consultations

BOEM-funded studies that have the potential to “take” marine mammals, sea turtles, or ESA-listed species, require consultation with NMFS and/or USFWS. If a BOEM-funded study has the potential to “take” an ESA-listed marine mammal, an MMPA take authorization may be required as well. Note that, even if BOEM is funding the study, it is the PI physically conducting the study in the field who must obtain the MMPA authorization if marine mammals are involved. For example, BOEM is currently consulting with NMFS on a BOEM-funded FY20 study titled *Behavioral and Spatial Ecology of the Endangered Giant Manta Ray (*Manta birostris*)* in the GOM. Such consultations are completed on a project-by-project basis and have not often been necessary in the past. BOEM may consider programmatic approaches as warranted.

Further, in some cases, a BOEM-funded study may be contracted to another Federal agency. For these studies, the originating BOEM office/program will work with the other agency to engage in ESA and/or MMPA consultation.

Finally, in collaboration with NMFS and USFWS, BOEM has ongoing efforts to streamline the ESA consultation and MMPA authorization processes. These efforts span all BOEM program areas (oil and gas, renewable energy, and marine minerals). Some examples include developing best management practices and mitigation measures for proposed BOEM permitted projects, as well as a decision-making tool to determine whether use of particular sound sources would result in “take” requiring MMPA authorization or formal ESA consultation. Some components of these streamlining efforts may be relevant to proposed studies, i.e., cover similar activities when determining ESA consultation and MMPA authorization needs.

5.2 Public Involvement

BOEM has made this PEA and the Findings available on BOEM’s webpage on Environmental Documents.

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7 References

Althaus F, Williams A, Schlacher TA, Kloser RJ, Green MA, Barker BA, Bax NJ, Brodie P, Schlacher-Hoenlinger MA. 2009. Impacts of bottom trawling on deep-coral ecosystems of seamounts are long-lasting. Marine Ecology Progress Series. 397:279–294. doi:10.3354/meps08248.

Andersen SM, Teilmann J, Dietz R, Schmidt NM, Miller LA. 2012. Behavioural responses of harbour seals to human-induced disturbances. Aquatic Conservation: Marine and Freshwater Ecosystems. 22(1):113–121. doi:10.1002/aqc.1244.

Andrews RD, Pitman RL, Ballance LT. 2008. Satellite tracking reveals distinct movement patterns for Type B and Type C killer whales in the southern Ross Sea, Anarctica. Polar Biology. 31:1461–1468. doi:10.1007/s00300-008-0487-z.

Anticamara JA, Watson R, Gelchu A, Pauly D. 2011. Global fishing effort (1950–2010): trends, gaps, and implications. Fisheries Research. 107(1-3):131–136. doi:10.1016/j.fishres.2010.10.016.

Baker JD, Johanos TC. 2002. Effects of research handling on the endangered Hawaiian monk seal. Marine Mammal Science. 18(2):500–512. doi:10.1111/j.1748-7692.2002.tb01051.x.

Ban NC, Gurney GG, Marshall NA, Whitney CK, Mills M, Gelcich S, Bennett NJ, Meehan MC, Butler C, Ban S, et al. 2019. Well-being outcomes of marine protected areas. Nature Sustainability. 2(6):524–532. doi:10.1038/s41893-019-0306-2.

Bancon-Montigny C, Gonzalez C, Delpoux S, Avenzac M, Spinelli S, Mhadhbi T, Mejri K, Sakka Hlaili A, Pringault O. 2019. Seasonal changes of chemical contamination in coastal waters during sediment resuspension. Chemosphere. 235:651–661. doi:10.1016/j.chemosphere.2019.06.213.

Bardarson H, Buoro M, Dillane M, Douglas S, Ensing D, Freese M, Gillson J, Jepsen N, Jones D, Murphy J, et al. 2020. ICES compilation of microtags, finclip and external tag releases 2019 by the working group on North Atlantic salmon (WGNAS 2020 addendum). Copenhagen (DK): International Council for the Exploration of the Sea. 25 p.

Barker AM, Frazier BS, Adams DH, Bedore CN, Belcher CN, Driggers III WB, Galloway AS, Gelsleichter J, Grubbs RD, Reyier EA, et al. 2021. Distribution and relative abundance of scalloped (*Sphyrna lewini*) and Carolina (*S. gilberti*) hammerheads in the western North Atlantic Ocean. Fisheries Research. 242:106039. doi:10.1016/j.fishres.2021.106039.

Beatty WS, St. Martin M, Wilson RR. 2021. Evaluating the current condition of a threatened marine mammal population: estimating northern sea otter (*Enhydra lutris kenyoni*) abundance in southwest Alaska. Marine Mammal Science. 37(4):1245–1260. doi:10.1111/mms.12807.

Beaugrand G, Reid PC, Ibañez F, Lindley JA, Edwards M. 2002. Reorganization of North Atlantic copepod biodiversity and climate. Science. 296(5573):1692–1694. doi:10.1126/science.1071329.

Beck MW, Heck Jr. KL, Able KW, Childers DL, Eggleston DB, Gilanders BM, Halpern BS, Hays CG, Hoshino K, Minello TJ, et al. 2003. The role of nearshore ecosystems as fish and shellfish nurseries. Issues in Ecology. 11:2–12. doi:10.1201/b14821-2.

Bergen M, Weisberg SB, Smith RW, Cadien DB, Dalkey A, Montagne DE, Stull JK, Velarde RG, Ranasinghe JA. 2001. Relationship between depth, sediment, latitude, and the structure of benthic infaunal assemblages on the mainland shelf of southern California. Marine Biology. 138:637–647. doi:10.1007/s002270000469.

Bickel SL, Hammond JDM, Tang KW. 2011. Boat-generated turbulence as a potential source of mortality among copepods. Journal of Experimental Marine Biology and Ecology. 401(1-2):105–109. doi:10.1016/j.jembe.2011.02.038.

BOEM. 2017. Gulf of Mexico OCS proposed geological and geophysical activities: Western, Central, and Eastern planning areas, final programmatic environmental impact statement. Volume I: chapters 1-9. New Orleans (LA): U.S. Department of the Interior, Bureau of Ocean Energy Management, Gulf of Mexico OCS Region. 792 p. Report No.: OCS EIS/EA BOEM 2017-051.

BOEM. 2020a. Environmental Studies Program strategic framework. Sterling (VA): U.S. Department of the Interior, Bureau of Ocean Energy Management, Environmental Studies Program. 12 p.

BOEM. 2020b. Marine Minerals Program fact sheet: preserving and restoring the nation's beaches and promoting coastal resilience. Sterling (VA): U.S. Department of the Interior, Bureau of Ocean Energy Management, Office of Public Affairs. 2 p.

Bograd SJ, Castro CG, Di Lorenzo E, Palacios DM, Bailey H, Gilly W, Chavez FP. 2008. Oxygen declines and the shoaling of the hypoxic boundary in the California Current. Geophysical Research Letters. 35(12):L12607. doi:10.1029/2008gl034185.

Brame AB, Wiley TR, Carlson JK, Fordham SV, Grubbs RD, Osborne J, Scharer RM, Bethea DM, Poulakis GR. 2019. Biology, ecology, and status of the smalltooth sawfish *Pristis pectinata* in the USA. Endangered Species Research. 39:9–23. doi:10.3354/esr00952.

Brinker DF, McCann JM, Williams B, Watts BD. 2007. Colonial-nesting seabirds in the Chesapeake Bay region: where have we been and where are we going? Waterbirds: The International Journal of Waterbird Ecology. 30(SP1):93–104. doi:10.1675/1524-4695(2007)030[0093:CSITCB]2.0.CO;2.

Brodeur RD, Hunsicker ME, Hann A, Miller TW. 2019. Effects of warming ocean conditions on feeding ecology of small pelagic fishes in a coastal upwelling ecosystem: a shift to gelatinous food sources. Marine Ecology Progress Series. 617-618:149–163. doi:10.3354/meps12497.

Burdon D, Barnard S, Boyes SJ, Elliott M. 2018. Oil and gas infrastructure decommissioning in marine protected areas: system complexity, analysis and challenges. Marine Pollution Bulletin. 135:739–758. doi:10.1016/j.marpolbul.2018.07.077.

California Department of Fish and Wildlife. 2014. Nongame wildlife species. Sacramento (CA): State of California, Department of Fish and Wildlife.

Carlson JK, Gulak SJB. 2012. Habitat use and movements patterns of oceanic whitetip, bigeye thresher, and dusky sharks based on archival satellite tags. Collective Volume of Scientific Papers. 68(5):1922–1932.

Casper BM, Halvorsen MB, Carlson TJ, Popper AN. 2017. Onset of barotrauma injuries related to number of pile driving strike exposures in hybrid striped bass. The Journal of the Acoustical Society of America. 141(6):4380–4387. doi:10.1121/1.4984976.

Celi M, Filiciotto F, Maricchiolo G, Genovese L, Quinci EM, Maccarrone V, Mazzola S, Vazzana M, Buscaino G. 2016. Vessel noise pollution as a human threat to fish: assessment of the stress response in gilthead sea bream (*Sparus aurata*, Linnaeus 1758). Fish Physiology and Biochemistry. 42(2):631–641. doi:10.1007/s10695-015-0165-3.

Cheung WWL, Lam VWY, Sarmiento JL, Kearney K, Watson R, Pauly D. 2009. Projecting global marine biodiversity impacts under climate change scenarios. Fish and Fisheries. 10(3):235–251. doi:10.1111/j.1467-2979.2008.00315.x.

Choy CA, Drazen JC. 2013. Plastic for dinner? Observations of frequent debris ingestion by pelagic predatory fishes from the central North Pacific. Marine Ecology Progress Series. 485:155–163. doi:10.3354/meps10342.

Clark CW, Ellison WT, Southall BL, Hatch L, Van Parijs SM, Frankel A, Ponirakis D. 2009. Acoustic masking in marine ecosystems: intuitions, analysis, and implication. Marine Ecology Progress Series. 395:201–222. doi:10.3354/meps08402.

Clark MR, Bowden DA, Rowden AA, Stewart R. 2019. Little evidence of benthic community resilience to bottom trawling on seamounts after 15 years. Frontiers in Marine Science. 6:63. doi:10.3389/fmars.2019.00063.

Colway C, Stevenson DE. 2007. Confirmed records of two Green Sturgeon from the Bering Sea and Gulf of Alaska. Northwestern Naturalist. 88(3):188–192. doi:10.1898/1051-1733(2007)88[188:CROTGS]2.0.CO;2.

Cook ASCP, Humphreys EM, Bennet F, Madsen EA, Burton NHK. 2018. Quantifying avian avoidance of offshore wind turbines: current evidence and key knowledge gaps. Marine Environmental Research. 140:278–288. doi:10.1016/j.marenvres.2018.06.017.

Cordes EE, McGinley MP, Podowski EL, Becker EL, Lessard-Pilon S, Viada ST, Fisher CR. 2008. Coral communities of the deep Gulf of Mexico. Deep Sea Research Part I: Oceanographic Research Papers. 55(6):777–787. doi:10.1016/j.dsr.2008.03.005.

Cornwall CE, Comeau S, Kornder NA, Perry CT, van Hooidonk R, DeCarlo TM, Pratchett MS, Anderson KD, Browne N, Carpenter R, et al. 2021. Global declines in coral reef calcium carbonate production under ocean acidification and warming. PNAS. 118(21):e2015265118. doi:10.1073/pnas.2015265118.

Craig MT, Pondella II DJ, Lea RN. 2006. New records of the flag cabrilla, *Epinephelus labriformis* (Serranidae: Epinephelinae), from the Pacific coast of Baja California, Mexico, and San Diego, California, USA with notes on the distribution of other groupers in California. California Fish and Game. 92(2):91–97.

Crocker SE, Fratantonio FD, Hart PE, Foster DS, O'Brien TF, Labak S. 2019. Measurement of sounds emitted by certain high-resolution geophysical survey systems. IEEE Journal of Oceanic Engineering. 44(3):796–813. doi:10.1109/JOE.2018.2829958.

Crum N, Gowan T, Krzystan A, Martin J. 2019. Quantifying risk of whale-vessel collisions across space, time, and management policies. Ecosphere. 10(4):e02713. doi:10.1002/ecs2.2713.

Davis GE, Baumgartner MF, Bonnell JM, Bell J, Berchok C, Bort Thornton J, Brault S, Buchanan G, Charif RA, Cholewiak D, et al. 2017. Long-term passive acoustic recordings track the changing distribution of North Atlantic right whales (*Eubalaena glacialis*) from 2004 to 2014. Scientific Reports. 7(1):13460. doi:10.1038/s41598-017-13359-3.

Deepwater Horizon Natural Resource Damage Assessment Trustees. 2016. *Deepwater Horizon* oil spill: final programmatic damage assessment and restoration plan and final programmatic environmental impact statement. Silver Spring (MD): U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of Response and Restoration. 1659 p.

Denlinger LM. 2006. Alaska seabird information series. Anchorage (AK): U.S. Department of the Interior, Fish and Wildlife Service, Migratory Bird Management, Nongame Program. 104 p.

DeRuiter SL, Doukara KL. 2012. Loggerhead turtles dive in response to airgun sound exposure. Endangered Species Research. 16(1):55–63. doi:10.3354/esr00396.

Dickson DL, Gilchrist HG. 2002. Status of marine birds of the southeastern Beaufort Sea. Arctic. 55(5):46–58. doi:10.14430/arctic734.

Doney SC, Ruckelshaus M, Duffy JE, Barry JP, Chan F, English CA, Galindo HM, Grebmeier JM, Hollowed AB, Knowlton N, et al. 2012. Climate change impacts on marine ecosystems. Annual Review of Marine Science. 4(1):11–37. doi:10.1146/annurev-marine-041911-111611.

Drazen JC, Smith CR, Gjerde KM, Haddock SHD, Carter GS, Choy CA, Clark MR, Dutrieux P, Goetze E, Hauton C, et al. 2020. Opinion: midwater ecosystems must be considered when evaluating environmental risks of deep-sea mining. PNAS. 117(30):17455–17460. doi:10.1073/pnas.2011914117.

Dulvy NK, Pacoureau N, Rigby CL, Pollom RA, Jabado RW, Ebert DE, Finucci B, Pollock CM, Cheok J, Derrick DH, et al. 2021. Overfishing drives over one-third of all sharks and rays toward a global extinction crisis. Current Biology. 31(21):4773–4787. doi:10.1016/j.cub.2021.08.062.

Duncan CD, Havard RW. 1980. Pelagic birds of the northern Gulf of Mexico. American Birds. 34(2):122–132.

Echave K, Eagleton M, Farley E, Orsi J. 2012. A refined description of essential fish habitat for Pacific salmon within the U.S. Exclusive Economic Zone in Alaska. Juneau (AK): U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center. 113 p. Report No.: NOAA Technical Memorandum NMFS-AFSC-236.

Edwards M, Richardson AJ. 2004. Impact of climate change on marine pelagic phenology and trophic mismatch. Nature. 430:881–884. doi:10.1038/nature02808.

EIA. 2021. November 2021 monthly energy review. Washington (DC): U.S. Department of Energy, U.S. Energy Information Administration, Office of Energy Statistics. 276 p. Report No.: DOE/EIA-0035(2021/11).

Eisner LB, Napp JM, Mier KL, Pinchuk AI, Andrews III AG. 2014. Climate-mediated changes in zooplankton community structure for the eastern Bering Sea. Deep Sea Research Part II: Topical Studies in Oceanography. 109:157–171. doi:10.1016/j.dsr2.2014.03.004.

Ellison WT, Southall BL, Clark CW, Frankel AS. 2012. A new context-based approach to assess marine mammal behavioral responses to anthropogenic sounds. Conservation Biology. 26(1):21–28. doi:10.1111/j.1523-1739.2011.01803.x.

Engle V. 2012. National Coastal Condition Report IV. Washington (DC): U.S. Environmental Protection Agency, Office of Research and Development, Office of Water. 334 p. Report No.: EPA-842-R-10-003.

Erbe C, Reichmuth C, Cunningham K, Lucke K, Dooling R. 2016. Communication masking in marine mammals: a review and research strategy. Marine Pollution Bulletin. 103:15–38. doi:10.1016/j.marpolbul.2015.12.007.

Erftemeijer PLA, Lewis III RRR. 2006. Environmental impacts of dredging on seagrasses: a review. Marine Pollution Bulletin. 52(12):1553–1572. doi:10.1016/j.marpolbul.2006.09.006.

Ershova EA, Hopcroft RR, Kosobokova KN, Matsuno K, Nelson RJ, Yamaguchi A, Eisner LB. 2015. Long-term changes in summer zooplankton communities of the western Chukchi Sea, 1945–2012. Oceanography. 28(3):100–115. doi:10.5670/oceanog.2015.60.

Erwin RM. 1996. Dependence of waterbirds and shorebirds on shallow-water habitats in the mid-Atlantic coastal region: an ecological profile and management recommendations. Estuaries. 19(2A):213–219. doi:10.2307/1352226.

Everett MV, Park LK. 2018. Exploring deep-water coral communities using environmental DNA. Deep Sea Research Part II: Topical Studies in Oceanography. 150:229–241. doi:10.1016/j.dsr2.2017.09.008.

Fabry VJ, McClintock JB, Mathis JT, Grebmeier JM. 2009. Ocean acidification at high latitudes: the bellwether. Oceanography. 22(4):160–171. doi:10.5670/oceanog.2009.105.

Fischbach AS, Amstrup SC, Douglas DC. 2007. Landward and eastward shift of Alaskan polar bear denning associated with recent sea ice changes. Polar Biology. 30(11):1395–1405. doi:10.1007/s00300-007-0300-4.

Floren HP, Shugart GW. 2017. Plastic in Cassin's Auklets (*Ptychoramphus aleuticus*) from the 2014 stranding on the northeast Pacific Coast. Marine Pollution Bulletin. 117(1–2):496–498. doi:10.1016/j.marpolbul.2017.01.076.

Francis RC, Hixon MA, Clarke ME, Murawski SA, Ralston S. 2007. Ten commandments for ecosystem-based fisheries scientists. Fisheries. 32(5):217–233. doi:10.1577/1548-8446(2007)32[217:TCFBFS]2.0.CO;2.

Fraser SB, Sedberry GR. 2008. Reef morphology and invertebrate distribution at continental shelf edge reefs in the South Atlantic Bight. Southeastern Naturalist. 7(2):191–206. doi:10.1656/1528-7092(2008)7[191:RMAIDA]2.0.CO;2.

FWS. 2013. Vision for a healthy Gulf of Mexico watershed. Washington (DC): U.S. Department of the Interior, Fish and Wildlife Service. 24 p.

FWS. 2021a. Bermuda petrel (*Pterodroma cahow*). Washington (DC): U.S. Department of the Interior, Fish and Wildlife Service; [accessed 2021 Nov 23]. https://ecos.fws.gov/ecp/species/3507.

FWS. 2021b. Flyways. Washington (DC): U.S. Department of the Interior, Fish and Wildlife Service; [accessed 2021 Nov 23]. https://www.fws.gov/birds/management/flyways.php.

FWS. 2021c. Piping plover (*Charadrius melodus*). Washington (DC): U.S. Department of the Interior, Fish and Wildlife Service; [accessed 2021 Nov 23]. https://ecos.fws.gov/ecp/species/6039.

FWS. 2021d. Polar bear (*Ursus maritimus*). U.S. Department of the Interior, Fish and Wildlife Service; [accessed 2021 Nov 23]. https://web.archive.org/web/20210322211339/https://ecos.fws.gov/ecp/species/4958.

FWS. 2021e. Red knot (*Calidris canutus rufa*). Washington (DC): U.S. Department of the Interior, Fish and Wildlife Service; [accessed 2021 Nov 23]. https://ecos.fws.gov/ecp/species/1864.

FWS. 2021f. Roseate tern (*Sterna dougallii dougallii*). Washington (DC): U.S. Department of the Interior, Fish and Wildlife Service; [accessed 2021 Nov 23]. https://ecos.fws.gov/ecp/species/2083.

FWS. 2021g. Wood stork (*Mycteria americana*). Washington (DC): U.S. Department of the Interior, Fish and Wildlife Service; [accessed 2021 Nov 23]. https://ecos.fws.gov/ecp/species/8477.

FWS. 2022a. Eastern black rail (*Laterallus jamaicensis ssp. jamaicensis*). Washington (DC): U.S. Department of the Interior, Fish and Wildlife Service; [accessed 2022 Aug 25]. https://ecos.fws.gov/ecp/species/10477.

FWS. 2022b. Listed species believed to or known to occur in Alaska. Washington (DC): U.S. Department of the Interior, Fish and Wildlife Service; [accessed 2022 Aug 25]. https://ecos.fws.gov/ecp/report/species-listings-by-state?stateAbbrev=AK&stateName=Alaska&statusCategory=Listed.

FWS. 2022c. Mississippi sandhill crane (*Grus canadensis pulla*). Washington (DC): U.S. Department of the Interior, Fish and Wildlife Service; [accessed 2022 Aug 25]. https://ecos.fws.gov/ecp/species/1222.

FWS. 2022d. Seabirds of the Pacific Northwest. Washington (DC): U.S. Department of the Interior, Fish and Wildlife Service; [accessed 2022 Aug 25]. https://www.fws.gov/story/seabirds-pacific-northwest.

FWS. 2022e. Whooping crane (*Grus americana*). Washington (DC): U.S. Department of the Interior, Fish and Wildlife Service; [accessed 2022 Aug 25]. https://ecos.fws.gov/ecp/species/758.

Gales NJ, Bowen WD, Johnston DW, Kovacs KM, Littnan CL, Perrin WF, Reynolds III JE, Thompson PM. 2009. Guidelines for the treatment of marine mammals in field research. Marine Mammal Science. 25(3):725–736. doi:10.1111/j.1748-7692.2008.00279.x.

Galgani F, Hanke G, Maes T. 2015. Global distribution, composition and abundance of marine litter. In: Bergmann M, Gutow L, Klages M, editors. Marine anthropogenic litter. New York (NY): Springer. Chapter 2; p. 29–56.

Gall AE, Day RH, Weingartner TJ. 2013. Structure and variability of the marine-bird community in the northeastern Chukchi Sea. Continental Shelf Research. 67:96–115. doi:10.1016/j.csr.2012.11.004.

Gallardo JC, Velarde E, Arreola R. 2004. Birds of the Gulf of Mexico and the priority areas for their conservation. In: Caso M, Pisantry I, Ezcurra E, Withers K, Nipper M, editors. Environmental analysis of the Gulf of Mexico. Corpus Christi (TX): Harte Research Institute for Gulf of Mexico Studies. Chapter 9; p. 180–194.

Gasparatos A, Doll CNH, Esteban M, Ahmed A, Olang TA. 2017. Renewable energy and biodiversity: implications for transitioning to a Green Economy. Renewable and Sustainable Energy Reviews. 70:161–184. doi:10.1016/j.rser.2016.08.030.

George JC, Druckenmiller ML, Laidre KL, Suydam R, Person B. 2015. Bowhead whale body condition and links to summer sea ice and upwelling in the Beaufort Sea. Progress in Oceanography. 136:250–262. doi:10.1016/j.pocean.2015.05.001.

Glarou M, Zrust M, Svendsen JC. 2020. Using artificial-reef knowledge to enhance the ecological function of offshore wind turbine foundations: implications for fish abundance and diversity. Journal of Marine Science and Engineering. 8(5):332. doi:10.3390/jmse8050332.

Goddard P, Lauth R, Armistead C. 2014. Results of the 2012 Chukchi Sea bottom trawl survey of bottomfishes, crabs, and other demersal macrofauna. Seattle (WA): U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center. 123 p. Report No.: NOAA Technical Memorandum NMFS-AFSC-278.

Good TP, Samhouri JF, Feist BE, Wilcox C, Jahncke J. 2020. Plastics in the Pacific: assessing risk from ocean debris for marine birds in the California Current Large Marine Ecosystem. Biological Conservation. 250:108743. doi:10.1016/j.biocon.2020.108743.

Good TP, Waples RS, Adams P. 2005. Updated status of federally listed ESUs of West Coast salmon and steelhead. Seattle (WA): U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. 637 p. Report No.: NOAA Technical Memorandum NMFS-NWFSC-66.

Gordon J, Gillespie D, Potter J, Frantzis A, Simmonds MP, Swift R, Thompson D. 2003. A review of the effects of seismic surveys on marine mammals. Marine Technology Society Journal. 37(4):16–34. doi:10.4031/002533203787536998.

Gouezo M, Golbuu Y, Fabricius K, Olsudong D, Mereb G, Nestor V, Wolanski E, Harrison P, Doropoulos C. 2019. Drivers of recovery and reassembly of coral reef communities. Proceedings of the Royal Society B: Biological Sciences. 286(1897):20182908. doi:10.1098/rspb.2018.2908.

Gulf of Mexico Fishery Management Council. 2005. Final generic amendment number 3 for addressing essential fish habitat requirements, habitat areas of particular concern, and adverse effects of fishing in fishery management plans of the Gulf of Mexico. Tampa (FL): Gulf of Mexico Fishery Management Council. 106 p.

Hale SS. 2010. Biogeographical patterns of marine benthic macroinvertebrates along the Atlantic coast of the northeastern USA. Estuaries and Coasts. 33(5):1039–1053. doi:10.1007/s12237-010-9332-z.

Harwell MA, Gentile JH, Johnson CB, Garshelis DL, Parker KR. 2010. A quantitative ecological risk assessment of the toxicological risks from *Exxon Valdez* subsurface oil residues to sea otters at the Northern Knight Island, Prince William Sound, Alaska. Human and Ecological Risk Assessment. 16(4):727–761. doi:10.1080/10807039.2010.501230.

Harwood LA, Smith TG, George JC, Sandstrom SJ, Walkusz W, Divoky GJ. 2015. Change in the Beaufort Sea ecosystem: diverging trends in body condition and/or production in five marine vertebrate species. Progress in Oceanography. 136:263–273. doi:10.1016/j.pocean.2015.05.003.

Hauser DDW, Laidre KL, Suydam RS, Richard PR. 2014. Population-specific home ranges and migration timing of Pacific Arctic beluga whales (*Delphinapterus leucas*). Polar Biology. 37(8):1171–1183. doi:10.1007/s00300-014-1510-1.

Hayes SA, Josephson E, Maze-Foley K, Rosel PE. 2020. US Atlantic and Gulf of Mexico marine mammal stock assessments - 2019. Woods Hole (MA): U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northeast Fisheries Science Center. 479 p. Report No.: NOAA Technical Memorandum NMFS-NE-264.

Helmuth B, Broitman BR, Blanchette CA, Gilman S, Halpin P, Harley CDG, O'Donnell MJ, Hofmann GE, Menge B, Strickland D. 2006. Mosaic patterns of thermal stress in the rocky intertidal zone: implications for climate change. Ecological Monographs. 76(4):461–479. doi:10.1890/0012-9615(2006)076[0461:MPOTSI]2.0.CO;2.

Henkel LA. 2006. Effect of water clarity on the distribution of marine birds in nearshore waters of Monterey Bay, California. Journal of Field Ornithology. 77(2):151–156. doi:10.1111/j.1557-9263.2006.00035.x.

Hiddink JG, Jennings S, Sciberras M, Szostek CL, Hughes KM, Ellis N, Rijnsdorp AD, McConnaughey RA, Mazor T, Hilborn R, et al. 2017. Global analysis of depletion and recovery of seabed biota after bottom trawling disturbance. PNAS. 114(31):8301–8306. doi:10.1073/pnas.1618858114.

Hildebrand JA. 2009. Anthropogenic and natural sources of ambient noise in the ocean. Marine Ecology Progress Series. 395:5–20. doi:10.3354/meps08353.

Hill AN, Karniski C, Robbins J, Pitchford T, Todd S, Asmutis-Silvia R. 2017. Vessel collision injuries on live humpback whales, *Megaptera novaeangliae*, in the southern Gulf of Maine. Marine Mammal Science. 33(2):558–573. doi:10.1111/mms.12386.

Hodge RP, Wing BL. 2000. Occurences of marine turtles in Alaska waters: 1960–1998. Herpetological Review. 31(3):148–151.

Hoegh-Guldberg O, Poloczanska ES. 2017. Editorial: the effect of climate change across ocean regions. Frontiers in Marine Science. 4:361. doi:10.3389/fmars.2017.00361.

Holdway DA. 2002. The acute and chronic effects of wastes associated with offshore oil and gas production on temperate and tropical marine ecological processes. Marine Pollution Bulletin. 44(3):185–203. doi:10.1016/s0025-326x(01)00197-7.

Holladay BA, Norcross BL, Blanchard A. 1999. A limited investigation into the relationship of diet to the habitat preferences of juvenile flathead sole. Fairbanks (AK): U.S. Department of the Interior, Minerals Management Service. 33 p. Report No.: OCS Study MMS 99-0025.

Iribarne O, Armstrong D, Fernandez M. 1995. Environmental impact of intertidal juvenile dungeness crab habitat enhancement: effects on bivalves and crab foraging rate. Journal of Experimental Marine Biology and Ecology. 192(2):173-194. doi:10.1016/0022-0981(95)00060-5.

Jay CV, Fischbach AS, Kochnev AA. 2012. Walrus areas of use in the Chukchi Sea during sparse sea ice cover. Marine Ecology Progress Series. 468:1–13. doi:10.3354/meps10057.

Jepsen EM, de Bruyn PJN. 2019. Pinniped entanglement in oceanic plastic pollution: a global review. Marine Pollution Bulletin. 145:295–305. doi:10.1016/j.marpolbul.2019.05.042.

Jessup DA, Miller M, Ames J, Harris M, Kreuder C, Conrad PA, Mazet JAK. 2004. Southern sea otter as a sentinel of marine ecosystem health. EcoHealth. 1(3):239–245. doi:10.1007/s10393-004-0093-7.

Jones R, Fisher R, Bessell-Browne P. 2019. Sediment deposition and coral smothering. PLoS ONE. 14(6):e0216248. doi:10.1371/journal.pone.0216248.

Jones T, Parrish JK, Punt AE, Trainer VL, Kudela R, Lang J, Brancato MS, Odell A, Hickey B. 2017. Mass mortality of marine birds in the Northeast Pacific caused by *Akashiwo sanguinea*. Marine Ecology Progress Series. 579:111–127. doi:10.3354/meps12253.

Kavanagh AS, Nykänen M, Hunt W, Richardson N, Jessopp MJ. 2019. Seismic surveys reduce cetacean sightings across a large marine ecosystem. Scientific Reports. 9(1):19164. doi:10.1038/s41598-019-55500-4.

Kelleher K. 2005. Discards in the world's marine fisheries: an update. Rome (IT): Food and Agriculture Organization of the United Nations. 131 p. Report No.: FAO Fisheries Technical Paper 470.

Keppel AG, Breitburg DL, Burrell RB. 2016. Effects of co-varying diel-cycling hypoxia and pH on growth in the juvenile Eastern oyster, *Crassostrea virginica*. PLoS ONE. 11(8):e0161088. doi:10.1371/journal.pone.0161088.

Khayatzadeh J, Abbasi E. 2010. The effects of heavy metals on aquatic animals. In: 1st International Applied Geological Congress; 2020 Apr 26–28; Mashhad (IR). p 688–694.

Kight CR, Swaddle JP. 2011. How and why environmental noise impacts animals: an integrative, mechanistic review. Ecology Letters. 14(10):1052–1061. doi:10.1111/j.1461-0248.2011.01664.x.

Klingbeil BT, Cohen JB, Correll MD, Field CR, Hodgman TP, Kovach AI, Lentz EE, Olsen BJ, Shriver WG, Wiest WA, et al. 2021. High uncertainty over the future of tidal marsh birds under current sea-level rise projections. Biodiversity and Conservation. 30(2):431–443. doi:10.1007/s10531-020-02098-z.

Knowlton AR, Hamilton PK, Marx MK, Pettis HM, Kraus SD. 2012. Monitoring North Atlantic right whale *Eubalaena glacialis* entanglement rates: a 30 yr retrospective. Marine Ecology Progress Series. 466:293–302. doi:10.3354/meps09923.

Knowlton AR, Kraus SD. 2001. Mortality and serious injury of northern right whales (*Eubalaena glacialis*) in the western North Atlantic Ocean. Journal of Cetacean Research and Management. 2:193–208. doi:10.47536/jcrm.vi.288.

Konar B, Ravelo A, Grebmeier J, Trefry JH. 2014. Size frequency distributions of key epibenthic organisms in the eastern Chukchi Sea and their correlations with environmental parameters. Deep-Sea Research Part II. 102:107–118. doi:10.1016/j.dsr2.2013.07.015.

Kroeker KJ, Kordas RL, Crim RN, Singh GG. 2010. Meta-analysis reveals negative yet variable effects of ocean acidification on marine organisms. Ecology Letters. 13(11):1419–1434. doi:10.1111/j.1461-0248.2010.01518.x.

Kucera-Hirzinger V, Schludermann E, Zornig H, Weissenbacher A, Schabuss M, Schiemer F. 2008. Potential effects of navigation-induced wave wash on the early life history stages of riverine fish. Aquatic Sciences. 71(1):94–102. doi:10.1007/s00027-008-8110-5.

Laist DW, Knowlton AR, Mead JG, Collet AS, Podesta M. 2001. Collisions between ships and whales. Marine Mammal Science. 17(1):35–75. doi:10.1111/j.1748-7692.2001.tb00980.x.

Laist DW, Knowlton AR, Pendleton D. 2014. Effectiveness of mandatory vessel speed limits for protecting North Atlantic right whales. Endangered Species Research. 23(2):133–147. doi:10.3354/esr00586.

Laist DW, Taylor C, Reynolds III JE. 2013. Winter habitat preferences for Florida manatees and vulnerability to cold. PLoS ONE. 8(3):e58978. doi:10.1371/journal.pone.0058978.

Lefebvre KA, Quakenbush L, Frame E, Huntington KB, Sheffield G, Stimmelmayr R, Bryan A, Kendrick P, Ziel H, Goldstein T, et al. 2016. Prevalence of algal toxins in Alaskan marine mammals foraging in a changin arctic and subarctic environment. Harmful Algae. 55:13–24. doi:10.1016/j.hal.2016.01.007.

Lescroël A, Dugger KM, Ballard G, Ainley DG. 2009. Effects of individual quality, reproductive success and environmental variability on survival of a long-lived seabird. Journal of Animal Ecology. 78:798–806. doi:10.1111/j.1365-2656.2009.01542.x.

Levin LA, Girguis PR, German CR, Brennan ML, Tüzün S, Wagner J, Smart C, Kruger A, Inderbitzen K, Le J, et al. 2016. Exploration and discovery of methane seeps and associated communities in the California borderland. Oceanography. 29(1):40–43.

Lingo ME, Szedlmayer ST. 2006. The influence of habitat complexity on reef fish communities in the northeastern Gulf of Mexico. Environmental Biology of Fishes. 76(1):71–80. doi:10.1007/s10641-006-9009-4.

Linnell JDC, Swenson JE, Andersen R, Barnes B. 2000. How vulnerable are denning bears to disturbance? Wildlife Society Bulletin. 28(2):400–413.

Litvin SY, Weinstein MP, Sheaves M, Nagelkerken I. 2018. What makes nearshore habitat nurseries for nekton? An emerging view of the nursery role hypothesis. Estuaries and Coasts. 41(6):1539–1550. doi:10.1007/s12237-018-0383-x.

Lotze HK, Lenihan HS, Bourque BJ, Bradbury RH, Cooke RG, Kay MC, Kidwell SM, Kirby MX, Peterson CH, Jackson JBC. 2006. Depletion, degradation, and recovery potential of estuaries and coastal seas. Science. 312(5781):1806–1809. doi:10.1126/science.1128035.

Lovvorn JR, Baduini CL, Hunt Jr. GL. 2001. Modeling underwater visual and filter feeding by planktivorous shearwaters in unusual sea conditions. Ecology. 82(8):2342–2356. doi:10.1890/0012-9658(2001)082[2342:MUVAFF]2.0.CO;2.

Lutcavage ME, Lutz PL. 1996. Diving physiology. In: Lutz PL, Musick JA, editors. The biology of sea turtles. Boca Raton (FL): CRC Press. Chapter 10; p. 277–296.

Lynam CP, Llope M, Möllmann C, Helaouët P, Bayliss-Brown GA, Stenseth NC. 2017. Interaction between top-down and bottom-up control in marine food webs. PNAS. 114(8):1952–1957. doi:10.1073/pnas.1621037114.

Lynch JM. 2018. Quantities of marine debris ingested by sea turtles; global meta-analysis highlights need for standardized data reporting methods and revels relative risk. Environmental Science and Technology. 52(21):12026–12038. doi:10.1021/acs.est.8b02848.

MacCracken JG. 2012. Pacific walrus and climate change: observations and predictions. Ecology and Evolution. 2(8):2072–2090. doi:10.1002/ece3.317.

Marshall KN, Kaplan IC, Hodgson EE, Hermann AI, Busch DS, McElhany P, Essington TE, Harvey CJ, Fulton EA. 2017. Risks of ocean acidification in the California Current food web and fisheries: ecosystem model projections. Global Change Biology. 23(4):1525–1539. doi:10.1111/gcb.13594.

Martín J, Puig P, Palanques A, Ribó M. 2014. Trawling-induced daily sediment resuspension in the flank of a Mediterranean submarine canyon. Deep-Sea Research Part II. 104:174–183. doi:10.1016/j.dsr2.2013.05.036.

Mate BR, Stafford KM, Ljungblad DK. 1994. A change in sperm whale (*Physeter macroephalus*) distribution correlated to seismic surveys in the Gulf of Mexico. The Journal of the Acoustical Society of America. 96(5):3268–3269. doi:10.1121/1.410971.

McCabe RM, Hickey BM, Kudela RM, Lefebvre KA, Adams NG, Bill BD, Gulland FMD, Thomson RE, Cochlan WP, Trainer VL. 2016. An unprecedented coastwide toxic algal bloom linked to anomalous ocean conditions. Geophysical Research Letters. 43(19):10366–10376. doi:10.1002/2016GL070023.

McCauley RD, Fewtrell J, Duncan AJ, Jenner C, Jenner MW, Penrose JD, Prince RIT, Adhitya A, Murdoch J, McCabe K. 2000. Marine seismic surveys: a study of environmental implications. APPEA Journal. 40(1):692–708. doi:10.1071/AJ99048.

McClintock BT, Mondon JM, Cameron MF, Boveng PL. 2017. Bridging the gaps in animal movement: hidden behaviors and ecological relationships revealed by integrated data streams. Ecosphere. 8(3):e01751. doi:10.1002/ecs2.1751.

McKenna MF, Wiggins SM, Hildebrand JA. 2013. Relationship between container ship underwater noise levels and ship design, operational and oceanographic conditions. Scientific Reports. 3(1):1760. doi:10.1038/srep01760.

McVeigh D, Skarke A, Dekas AE, Borrelli C, Hong WL, Marlow J, Pasulka A, Jungbluth SP, Barco RA, Djurhuus A. 2018. Characterization of benthic biogeochemistry and ecology at three methane seep sites on the northerm U.S. Atlantic margin. Deep-Sea Research Part II. 150:41–56. doi:10.1016/j.dsr2.2018.03.001.

Meinert CR, Clausen-Sparks K, Cornic M, Sutton TT, Rooker JR. 2020. Taxonomic richness and diversity of larval fish assemblages in the oceanic Gulf of Mexico: links to oceanography conditions. Frontiers in Marine Science. 7:579. doi:10.3389/fmars.2020.00579.

Merk O, Busquet B, Aronietis R. 2015. The impact of mega-ships: case-specific policy analysis. Paris (FR): Organisation for Economic Cooperation and Development, International Transport Forum. 108 p.

Miller MA, Kudela RM, Mekebri A, Crane D, Oates SC, Tinker MT, Staedler M, Miller WA, Toy-Choutka S, Dominik C, et al. 2010. Evidence for a novel marine harmful algal bloom: cyanotoxin (microcystin) transfer from land to sea otters. PLoS ONE. 5(9):e12576. doi:10.1371/journal.pone.0012576.

Miller MH, Klimovich C. 2017. Endangered Species Act status review report: giant manta ray (*Manta birostris*) and reef manta ray (*Manta alfredi*). Silver Spring (MD): U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. 128 p.

Miller PJO, Johnson MP, Madsen PT, Biassoni N, Quero M, Tyack PL. 2009. Using at-sea experiments to study the effects of airguns on the foraging behavior of sperm whales in the Gulf of Mexico. Deep Sea Research Part I: Oceanographic Research Papers. 56(7):1168–1181. doi:10.1016/j.dsr.2009.02.008.

Miller SH, Breitburg DL, Burrell RB, Keppel AG. 2016. Acidification increases sensitivity to hypoxia in important forage fishes. Marine Ecology Progress Series. 549:1–8. doi:10.3354/meps11695.

Miner CM, Burnaford JL, Ambrose RF, Antrim L, Bohlmann H, Blanchette CA, Engle JM, Fradkin SC, Gaddam R, Harley CDG, et al. 2018. Large-scale impacts of sea star wasting disease (SSWD) on intertidal sea stars and implications for recovery. PLoS ONE. 13(3):e0192870. doi:10.1371/journal.pone.0192870.

Moein Bartol S, Musick JA. 2003. Sensory biology of sea turtles. In: Lutz PL, Musick JA, Wyneken J, editors. The biology of sea turtles, volume II. Boca Raton (FL): CRC Press. Chapter 3; p. 79–102.

Moein SE, Musick JA, Keinath JA, Barnard DE, Lenhardt ML, George R. 1994. Evaluation of seismic sources for repelling sea turtles from hopper dredges, final report. Vicksburg (MS): U.S. Department of the Army, Corps of Engineers, Engineer Research and Development Center, Waterways Experiment Station. 42 p.

Moore SE, Stafford K, Mellinger DK, Hildebrand J. 2006. Listening for large whales in the offshore waters of Alaska. BioScience. 56(1):49–55. doi:10.1641/0006-3568(2006)056[0049:LFLWIT]2.0.CO;2.

Morton RA. 2003. An overview of coastal land loss: with emphasis on the southeastern United States. St. Petersburg (FL): U.S. Department of the Interior, Geological Survey, Center for Coastal and Watershed Studies. 29 p. Report No.: Open File Report 03-337.

Muirhead CA, Warde AM, Biedron IS, Mihnovets AN, Clark CW, Rice AN. 2018. Seasonal acoustic occurrence of blue, fin, and North Atlantic right whales in the New York Bight. Aquatic Conservation: Marine and Freshwater Ecosystems. 28(3):744–753. doi:10.1002/aqc.2874.

Murawski SA, Grosell M, Smith C, Sutton TT, Halanych KM, Shaw RF, Wilson C, A. 2021. Impacts of petroleum, petroleum components, and dispersants on organisms and populations. Oceanography. 34(1):136–151. doi:10.5670/oceanog.2021.122.

Muto MM, Helker VT, Delean BJ, Young NC, Freed JC, Angliss RP, Friday NA, Boveng PL, Breiwick JM, Brost BM, et al. 2021. Alaska marine mammal stock assessments, 2020. Seattle (WA): U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center. 407 p. Report No.: NOAA Technical Memorandum NMFS-AFSC-421.

Nelms SE, Piniak WED, Weir CR, Godley BJ. 2016. Seismic surveys and marine turtles: an underestimated global threat? Biological Conservation. 193:49–65. doi:10.1016/j.biocon.2015.10.020.

NMFS. 2009. Our living oceans: report on the status of U.S. living marine resources. Silver Spring (MD): U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. 385 p. Report No.: NOAA Technical Memorandum NMFS-F/SPO-80.

NMFS. 2014a. Hawksbill turtle (*Eretmochelys imbricata*). Silver Spring (MD): U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service; [accessed 2021 Nov 23]. https://web.archive.org/web/20211220221421/https://www.fisheries.noaa.gov/species/hawksbill-turtle.

NMFS. 2014b. Olive ridley turtle (*Lepidochelys olivacea*). Silver Spring (MD): U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service; [updated 2014 Oct 30; accessed 2021 Nov 23]. https://web.archive.org/web/20151203060133/http://www.nmfs.noaa.gov/pr/species/turtles/oliveridley.html.

NMFS. 2018a. 2018 revisions to: technical guidance for assessing the effects of anthropogenic sound on marine mammal hearing (version 2.0). Underwater thresholds for onset of permanent and temporary threshold shifts. Silver Spring (MD): U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources. 178 p. Report No.: NOAA Technical Memorandum NMFS-OPR-59.

NMFS. 2018b. Fisheries economics of the United States 2016. Silver Spring (MD): U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. 264 p. Report No.: NOAA Technical Memorandum NMFS-F/SPO-187a.

NMFS. 2020. North Atlantic right whale (*Eubalaena glacialis*) vessel speed rule assessment. Silver Spring (MD): U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources. 53 p.

NMFS. 2021a. Green turtle (*Chelonia mydas*). Silver Spring (MD): U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service; [accessed 2021 Nov 23]. https://web.archive.org/web/20211124084046/https://www.fisheries.noaa.gov/species/green-turtle.

NMFS. 2021b. Guadalupe fur seal (*Arctocephalus townsendi*). Silver Spring (MD): U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service; [updated 2021 Aug 11; accessed 2022 Mar 11]. https://web.archive.org/web/20220310023341/http://www.fisheries.noaa.gov/species/guadalupe-fur-seal.

NMFS. 2021c. Kemp's ridley turtle (*Lepidochelys kempii*). Silver Spring (MD): U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service; [accessed 2021 Nov 23]. https://web.archive.org/web/20211220005929/https://www.fisheries.noaa.gov/species/kemps-ridley-turtle.

NMFS. 2021d. Leatherback turtle (*Dermochelys coriacea*). Silver Spring (MD): U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service; [accessed 2021 Nov 23]. https://web.archive.org/web/20211124083038/https://www.fisheries.noaa.gov/species/leatherback-turtle.

NMFS. 2021e. Loggerhead turtle (*Caretta caretta*). Silver Spring (MD): U.S. Department of the Interior, National Oceanic and Atmospheric Administration, National Marine Fisheries Service; [accessed 2021 Nov 23]. https://web.archive.org/web/20211220004405/https://www.fisheries.noaa.gov/species/loggerhead-turtle.

NMFS. 2021f. Shortnose sturgeon (*Acipenser brevirostrum*). U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service; [accessed 2021 Nov 23]. https://web.archive.org/web/20211130193557/https://www.fisheries.noaa.gov/species/shortnose-sturgeon.

NMFS. 2021g. Smalltooth sawfish (*Pristis pectinata*). Silver Spring (MD): U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service; [accessed 2021 Nov 23]. https://web.archive.org/web/20211128024856/https://www.fisheries.noaa.gov/species/smalltooth-sawfish.

NMFS. 2021h. Steller sea lion (*Eumetopias jubatus*). Silver Spring (MD): U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service; [updated 2021 Dec 6; accessed 2022 Mar 11]. https://web.archive.org/web/20220310202626/https://www.fisheries.noaa.gov/species/steller-sea-lion.

NMFS. 2022a. Fisheries economics of the United States 2019. Silver Spring (MD): U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. 248 p. Report No.: NOAA Technical Memorandum NMFS-F/SPO-229A.

NMFS. 2022b. Harbor seal (*Phoca vitulina*). Silver Spring (MD): U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service; [updated 2022 Feb 1; accessed 2022 Mar 11].

https://web.archive.org/web/20220314203703/https://www.fisheries.noaa.gov/species/harbor-seal.

North Pacific Fishery Management Council. 2021. Fishery management plan for Bering Sea/Aleutian Islands, king and tanner crabs. Anchorage (AK): North Pacific Fishery Management Council.

NPS. 2016. Seabirds & shorebirds. Ventura (CA): U.S. Department of the Interior, National Park Service, Channel Islands National Park; [updated 2016 Jun 25; accessed 2021 Nov 23]. https://www.nps.gov/chis/learn/nature/seabirds.htm.

Orcutt BN, Bradley JA, Brazelton WJ, Estes ER, Goordial JM, Huber JA, Jones RM, Mahmoudi N, Marlow JJ, Murdock S, et al. 2020. Impacts of deep-sea mining on microbial ecosystem services. Limnology and Oceanography. 65(7):1489–1510. doi:10.1002/lno.11403.

Pacific Fishery Management Council. 2020. Pacific Coast groundfish fishery management plan for the California, Oregon, and Washington groundfish fishery. Portland (OR): Pacific Fishery Management Council. 159 p.

Parks SE, Clark CW, Tyack PL. 2007. Short- and long-term changes in right whale calling behavior: the potential effects of noise on acoustic communication. The Journal of the Acoustical Society of America. 122(6):3725–3731. doi:10.1121/1.2799904.

Parks SE, Johnson M, Nowacek DP, Tyack PL. 2011. Individual right whales call louder in increased environmental noise. Biology Letters. 7(1):33–35. doi:10.1098/rsbl.2010.0451.

Pershing AJ, Alexander MA, Hernandez CM, Kerr LA, Le Bris A, Mills KE, Nye JA, Record NR, Scannell HA, Scott JD, et al. 2015. Slow adaptation in the face of rapid warming leads to collapse of the Gulf of Maine cod fishery. Science. 350(6262):809–812. doi:10.1126/science.aac9819.

Peterson CH, Summerson HC, Thomson E, Lenihan HS, Grabowski J, Manning L, Micheli F, Johnson G. 2000. Synthesis of linkages between benthic and fish communities as a key to protecting essential fish habitat. Bulletin of Marine Science. 66(3):759–774.

Pettis HM, Rolland RM, Hamilton PK, Knowlton AR, Burgess EA, Kraus SD. 2017. Body condition changes arising from natural factors and fishing gear entanglements in North Atlantic right whales *Eubalaena glacialis*. Endangered Species Research. 32:237–249. doi:10.3354/esr00800.

Pirotta E, Laesser BE, Hardaker A, Riddoch N, Marcoux M, Lusseau D. 2013. Dredging displaces bottlenose dolphins from an urbanised foraging patch. Marine Pollution Bulletin. 74(1):396–402. doi:10.1016/j.marpolbul.2013.06.020.

Pirotta E, Milor R, Quick N, Moretti D, Di Marzio N, Tyack PL, Boyd I, Hastie G. 2012. Vessel noise affects beaked whale behavior: results of a dedicated acoustic response study. PLoS ONE. 7(8):e42535. doi:10.1371/journal.pone.0042535.

Pizzolato L, Howell SEL, Derksen C, Dawson J, Copland L. 2014. Changing sea ice conditions and marine transportation activity in Canadian Arctic waters between 1990 and 2012. Climatic Change. 123(2):161–173. doi:10.1007/s10584-013-1038-3.

Popper AN, Hawkins AD, Fay RR, Mann DA, Bartol S, Carlson TJ, Coombs S, Ellison WT, Gentry RL, Halvorsen MB, et al. 2014. Sound exposure guidelines for fishes and sea turtles: a technical report prepared by ANSI-accredited standards committee S3/SC1 and registered with ANSI. Melville (NY): Acoustical Society of America. 87 p. Report No.: ASA S3/SC1.4 TR-2014.

Posey MH, Ambrose Jr. WG. 1994. Effects of proximity to an offshore hard-bottom reef on infaunal abundances. Marine Biology. 118:745–753. doi:10.1007/BF00347524.

Ramirez A, Kot CY, Piatkowsi D. 2017. Review of sea turtle entrainment risk by trailing suction hopper dredges in the U.S. Atlantic and Gulf of Mexico and the development of the ASTER decision support tool. Sterling (VA): U.S. Department of the Interior, Bureau of Ocean Energy Management. 276 p. Report No.: OCS Study 2017-084.

Robertson FC, Koski WR, Thomas TA, Richardson WJ, Würsig B, Trites AW. 2013. Seismic operations have variable effects on dive-cycle behavior of bowhead whales in the Beaufort Sea. Endangered Species Research. 21(2):143–160. doi:10.3354/esr00515.

Rockwood RC, Calambokidis J, Jahncke J. 2017. High mortality of blue, humpback and fin whales from modeling of vessel collisions on the U.S. West Coast suggests population impacts and insufficient protection. PLoS ONE. 12(8):e0183052. doi:10.1371/journal.pone.0183052.

Rolland RM, Parks SE, Hunt KE, Castellote M, Corkeron PJ, Nowacek DP, Wasser SK, Kraus SD. 2012. Evidence that ship noise increases stress in right whales. Proceedings of the Royal Society B: Biological Sciences. 279(1737):2363–2368. doi:10.1098/rspb.2011.2429.

Rose GA. 2005. Capelin (*Mallotus villosus*) distribution and climate: a sea “canary” for marine ecosystem change. ICES Journal of Marine Science. 62(7):1524–1530. doi:10.1016/j.icesjms.2005.05.008.

Ross S, Brooke S, Baird E, Katherine C, Davies A, Demopoulos A, France S, Kellogg C, Mather R, Mienis F, et al. 2018. Exploration and research of Mid-Atlantic deepwater hard bottom habitats and shipwrecks wth emphasis on canyons and coral communities: Atlantic deepwater canyons study. Volume I: final technical report. Sterling (VA): U.S. Department of the Interior, Bureau of Ocean Energy Management, Atlantic OCS Region. 1035 p. Report No.: OCS Study 2017-060.

Ross ST, Slack WT, Heise RJ, Dugo MA, Rogillio H, Bowen BR, Mickle P, Heard RW. 2009. Estuarine and coastal habitat use of Gulf Sturgeon (*Acipenser oxyrinchus desotoi*) in the north-central Gulf of Mexico. Estuaries and Coasts. 32(2):360–374. doi:10.1007/s12237-008-9122-z.

Ross SW, Demopoulos AWJ, Kellogg CA, Morrison CL, Nizinski MS, Ames CL, Casazza TL, Gualtieri D, Kovacs K, McClain JP, et al. 2012. Deepwater program: studies of Gulf of Mexico lower continental slope communities related to chemosynthetic and hard substrate habitats. Reston (VA): U.S. Department of the Interior, U.S. Geological Survey. 318 p. Report No.: Open-File Report 2012-1032.

Rowe GT, Kennicutt II MC. 2009. Northern Gulf of Mexico continental slope habitat and benthic ecology study, final report. New Orleans (LA): U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region. 417 p. Report No.: OCS Study MMS 2009-039.

Ruppel CD, Weber TC, Staaterman ER, Labak SJ, Hart PE. 2022. Categorizing active marine acoustic sources based on their potential to affect marine animals. Journal of Marine Science and Engineering. 10(9):1278. doi:10.3390/jmse10091278.

Sarà G, Dean JM, D'Amato D, Buscaino G, Oliveri A, Genovese S, Ferro S, Buffa G, Lo Martire M, Mazzola S. 2007. Effect of boat noise on the behaviour of bluefin tuna *Thunnus thynnus* in the Mediterranean Sea. Marine Ecology Progress Series. 331:243–253. doi:10.3354/meps331243.

Sardain A. 2017. Forecasting the global shipping network and the future of marine biological invasions [thesis]. Montreal (CA): McGill University.

Schoeman RP, Patterson-Abrolat C, Plön S. 2020. A global review of vessel collisions with marine animals. Frontiers in Marine Science. 7:292. doi:10.3389/fmars.2020.00292.

Schuyler QA, Wilcox C, Townsend KA, Wedemeyer-Strombel KR, Balazs G, van Sebille E, Hardesty BD. 2016. Risk analysis reveals global hotspots for marine debris ingestion by sea turtles. Global Change Biology. 22(2):567–576. doi:10.1111/gcb.13078.

Schwing FB, O'Farrell M, Steger JM, Baltz K. 1996. Coastal upwelling indices: West Coast of North America 1946–95. Pacific Grove (CA): U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Pacific Fisheries Environmental Laboratory, Southwest Fisheries Science Center. 32 p. Report No.: NOAA-TM-NMFS-SWFSC-231.

Seabrook S, De Leo FC, Baumberger T, Raineault NA, Thurber AR. 2018. Heterogeneity of methane seep biomes in the northeast Pacific. Deep-Sea Research Part II. 150:195–209. doi:10.1016/j.dsr2.2017.10.016.

Sheffield G, Grebmeier JM. 2009. Pacific walrus (*Odobenus rosmarus divergens*): differential prey digestion and diet. Marine Mammal Science. 25(4):761–777. doi:10.1111/j.1748-7692.2009.00316.x.

Siemann L, Smolowitz R. 2017. Southern New England juvenile fish habitat research paper. Sterling (VA): U.S. Department of the Interior, Bureau of Ocean Energy Management, Office of Renewable Energy Programs. 43 p. Report No.: OCS Study BOEM 2017-028.

Simon-Lledó E, Bett BJ, Huvenne VAI, Köser K, Schoening T, Greinert J, Jones DOB. 2019. Biological effects 26 years after simulated deep-sea mining. Scientific Reports. 9(1):8040. doi:10.1038/s41598-019-44492-w.

Simpson SD, Radford AN, Nedelec SL, Ferrari MCO, Chivers DP, McCormick MI, Meekan MG. 2016. Anthropogenic noise increases fish mortality by predation. Nature Communications. 7:10544. doi:10.1038/ncomms10544.

Sloman KA, Bouyoucos IA, Brooks EJ, Sneddon LU. 2019. Ethical considerations in fish research. Journal of Fish Biology. 94(4):556–577. doi:10.1111/jfb.13946.

Smith KE, Aronson RB, Steffel BV, Amsler MO, Thatje S, Singh H, Anderson J, Brothers CJ, Brown A, Ellis DS, et al. 2017a. Climate change and the threat of novel marine predators in Antarctica. Ecosphere. 8(11):e02017. doi:10.1002/ecs2.2017.

Smith MA, Goldman MS, Knight EJ, Warrenchuk JJ, editors. 2017b. Ecological atlas of the Bering, Chukchi, and Beaufort Seas. 2nd ed. Anchorage (AK): Audubon Alaska. 171 p.

Sorte CJB, Williams SL, Carlton JT. 2010. Marine range shifts and species introductions: comparative spread rates and community impacts. Global Ecology and Biogeography. 19(3):303–316. doi:10.1111/j.1466-8238.2009.00519.x.

Speybroeck J, Bonte D, Courtens W, Gheskiere T, Grootaert P, Maelfait J-P, Mathys M, Provoost S, Sabbe K, Stienen EWM, et al. 2006. Beach nourishment: an ecologically sound coastal defence alternative? A review. Aquatic Conservation: Marine and Freshwater Ecosystems. 16(4):419–435. doi:10.1002/aqc.733.

Stabeno PJ, Bond NA, Hermann AJ, Kachel NB, Mordy CW, Overland JE. 2004. Meteorology and oceanography of the Northern Gulf of Alaska. Continental Shelf Research. 24(7-8):859–897. doi:10.1016/j.csr.2004.02.007.

Stanley JA, Van Parijs SM, Hatch LT. 2017. Underwater sound from vessel traffic reduces the effective communication range in Atlantic cod and haddock. Scientific Reports. 7(1):14633. doi:10.1038/s41598-017-14743-9.

Stewart JD, Nuttall M, Hickerson EL, Johnston MA. 2018. Important juvenile manta ray habitat at Flower Garden Banks National Marine Sanctuary in the northwestern Gulf of Mexico. Marine Biology. 165(7):111. doi:10.1007/s00227-018-3364-5.

Stone RP, Cairns SD. 2017. Deep-sea coral taxa in the Alaska region: depth and geographical distribution. Silver Spring (MD): U.S. Department of Commerce, National Oceanic and Atmospheric Administration. 9 p.

Stucker JH, Cuthbert FJ. 2006. Distribution of non-breeding Great Lakes piping plovers along Atlantic and Gulf of Mexico coastlines: 10 years of band resightings. East Lansing (MI) and Panama City (FL): U.S. Department of the Interior, Fish and Wildlife Service, East Lansing Field Office, Panama City Field Office. 20 p.

Sulak KJ, Brooks RA, Luke KE, Norem AD, Randall M, Quaid AJ, Yeargin GE, Miller JM, Harden WM, Caruso JH, et al. 2007. Demersal fishes associated with *Lophelia pertusa* coral and hard-substrate biotopes on the continenatal slope, northern Gulf of Mexico. Bulletin of Marine Science. 81(S1):65–92.

Tissot BN, Hixon MA, Stein DL. 2007. Habitat-based submersible assessment of macro-invertebrate and groundfish assemblages at Heceta Bank, Oregon, from 1988 to 1990. Journal of Experimental Marine Biology and Ecology. 352(1):50–64. doi:10.1016/j.jembe.2007.06.032.

Tiwari M, Wallace BP, Girondot M. 2013. *Dermochelys coriacea* (West Pacific Ocean subpopulation). The IUCN red list of threatened species 2013: e.T46967817A46967821. Cambridge (UK): International Union for Conservation of Nature and Natural Resources. 15 p.

USACE. 2021. Waterborne tonnage for principal U.S. ports and all 50 states and U.S. territories; waterborne tonnages for domestic, foreign, imports, exports and intra-state waterborne traffic. https://usace.contentdm.oclc.org/digital/collection/p16021coll2/id/7447.

van der Hoop JM, Vanderlaan ASM, Cole TVN, Henry AG, Hall L, Mase-Guthrie B, Wimmer T, Moore MJ. 2015. Vessel strikes to large whales before and after the 2008 ship strike rule. Conservation Letters. 8(1):24–32. doi:10.1111/conl.12105.

Van Dolah FM. 2000. Marine algal toxins: origins, health effects, and their increased occurrence. Environmental Health Perspectives. 108(suppl 1):133–141. doi:10.1289/ehp.00108s1133.

Van Parijs SM. 2015. Letter of introduction to the biologically important areas issue. Aquatic Mammals. 41(1):1. doi:10.1578/AM.41.1.2015.1.

Van Waerebeek K, Baker AN, Félix F, Gedamke J, Iñiguez M, Sanino GP, Secchi E, Sutaria D, van Helden A, Wang Y. 2007. Vessel collisions with small cetaceans worldwide and with large whales in the southern hemisphere, an initial assessment. Latin American Journal of Aquatic Mammals. 6(1):43–69. doi:10.5597/lajam00109.

Wang J, He X, Lin H, Lin J, Huang Y, Zheng C, Zheng F, Li R, Jiang J. 2014. Community structure and spatial distribution of macrobenthos in the shelf area of the Bering Sea. Acta Oceanologica Sinica. 33(6):74–81. doi:10.1007/s13131-014-0491-9.

Wassmann P, Duarte CM, AgustÍ S, Sejr MK. 2011. Footprints of climate change in the Arctic marine ecosystem. Global Change Biology. 17(2):1235–1249. doi:10.1111/j.1365-2486.2010.02311.x.

White TP, Veit RR. 2020. Spatial ecology of long-tailed ducks and white-winged scoters wintering on Nantucket Shoals. Ecosphere. 11(1):e03002. doi:10.1002/ecs2.3002.

Wiese FK, Robertson GJ. 2004. Assessing seabird mortality from chronic oil discharged at sea. Journal of Wildlife Management. 68(3):627–638.

Wisniewska DM, Johnson M, Teilmann J, Siebert U, Galatius A, Dietz R, Madsen PT. 2018. High rates of vessel noise disrupt foraging in wild harbour porpoises (*Phocoena phocoena*). Proceedings of the Royal Society B: Biological Sciences. 285(1872):20172314. doi:10.1098/rspb.2017.2314.

Wright AJ, de Soto NA, Baldwin AL, Bateson M, Beale CM, Clark C, Deak T, Edwards EF, Fernández A, Godinho A, et al. 2007. Do marine mammals experience stress related to anthropogenic noise? International Journal of Comparative Psychology. 20(2):274–316.

Wysocki LE, Dittami JP, Ladich F. 2006. Ship noise and cortisol secretion in European freshwater fishes. Biological Conservation. 128(4):501–508. doi:10.1016/j.biocon.2005.10.020.

Xie Y, Michielsens CGJ, Gray AP, Martens FJ, Boffey JL. 2008. Observations of avoidance reactions of migrating salmon to a mobile survey vessel in a riverine environment. Canadian Journal of Fisheries and Aquatic Sciences. 65(10):2178–2190. doi:10.1139/f08-128.

Zunino S, Libralato S, Melaku Canu D, Prato G, Solidoro C. 2021. Impact of ocean acidification on ecosystem functioning and services in habitat-forming species and marine ecosystems. Ecosystems. 24(7):1561–1575. doi:10.1007/s10021-021-00601-3.

Appendix A: Representative List of BOEM's Programmatic NEPA Documents

Final Programmatic Environmental Impact Statement for Geological and Geophysical Activities in the Atlantic *(March 2014)*

This PEIS analyzes potential significant environmental effects of multiple G&G activities on the Mid- and South Atlantic OCS and adjacent state waters, pursuant to NEPA. It examines G&G survey activities for three program areas (oil and gas, renewable energy, and marine minerals) for activity levels projected between 2012 and 2020. The PEIS also identifies mitigation and monitoring measures to avoid, reduce, or minimize impacts.

Draft Environmental Assessment for the Proposed Rule for Oil and Gas Exploration Drilling Activities on the Arctic Outer Continental Shelf for 30 CFR Parts 250, 254, and 550 (*February 2015*)

This Draft Environmental Assessment evaluates the potential environmental and social effects from the promulgation of new regulations for oil and gas drilling activities on the Arctic OCS. It identifies which proposed provisions may cause environmental impacts and discusses the expected direct and indirect effects.

Final Programmatic Environmental Impact Statement for Geological and Geophysical Activities in the Gulf of Mexico *(August 2017)*

This PEIS evaluates potential significant environmental effects of multiple G&G activities on the Gulf of Mexico OCS, pursuant to NEPA, for BOEM's program areas (oil and gas, renewable energy, and marine minerals). This PEIS focuses particularly on off-lease and on-lease geological (bottom sampling and test drilling) and geophysical (deep-penetration, high-resolution geophysical, electromagnetic, deep stratigraphic, and remote sensing) surveys. The PEIS also identifies mitigation and monitoring measures to avoid, reduce, or minimize impacts.

Draft Programmatic Environmental Impact Statement for the 2023–2028 National Outer Continental Shelf Oil and Gas Leasing Program *(July 2022)*

This PEIS analyzes the potential economic, social, and environmental impacts that could result from the activities associated with the lease sale schedule under the national 2023–2028 National OCS Oil and Gas Leasing Program. The document considers a reasonable range of alternatives and potential opportunities for mitigation, both of which could reduce or eliminate potential impacts from the Proposed Action.

Appendix B: Mitigation Measures

Below are examples of potential mitigation measures that could be implemented to minimize impacts of environmental studies activities on OCS resources. **Appendix A** provides documents with additional information on potential mitigations measures.

Avoidance and Reporting of Historic and Prehistoric Sites
All authorizations for seafloor-disturbing activities would include requirements for operators to report suspected historic and prehistoric archaeological resources to BOEM and to take precautions to protect the resource. BOEM also would require reporting and avoidance for any previously undiscovered suspected archaeological resource and precautions to protect the resource.

Avoidance of Sensitive Benthic Communities
All authorizations for seafloor-disturbing activities would be subject to restrictions to protect sensitive benthic communities (e.g., hard/live bottom areas, deep-water coral communities, and chemosynthetic communities). In areas where these communities are known or suspected, authorizations may include requirements for mapping and avoidance as well as pre-deployment photographic surveys where bottom-founded instrumentation and appurtenances are to be deployed.

Endangered Species Act (ESA) and Marine Mammal Protection Act (MMPA) Consultations
Any Federal actions that have the potential to impact marine mammals, sea turtles, and ESA-listed species require formal consultation with the responsible Federal agency, pursuant to the ESA. BOEM regularly consults with NMFS and USFWS to develop and adopt project-specific mitigations that seek to avoid, minimize, or reduce risk to ESA-listed species from the proposed activity. In addition, MMPA authorization may be needed if marine mammals potentially will be “taken.” If MMPA authorization is required, the applicant who will be conducting the field work will need to ensure that all necessary permits, approvals, and authorizations are in place from the applicable permitting/authorizing entity prior to commencing project activities.

Guidance for Activities In or Near National Marine Sanctuaries (NMS)
BOEM would not authorize seafloor-disturbing activities within an NMS, and seafloor-disturbing activities proposed near the boundaries of an NMS would be assigned a setback distance by BOEM in consultation with the Sanctuary Manager. All authorizations for G&G activities would include instructions to minimize impacts on NMS resources and users. If proposed activities involve seafloor disturbance near an NMS or moving the surface marker buoys for a Sanctuary, the operator would be required to contact the Sanctuary Manager for instructions.

Guidance for Marine Debris Awareness
All authorizations for shipboard surveys, regardless of vessel size, would include guidance for marine debris awareness, highlighting the environmental and socioeconomic impacts of marine trash and debris and operator responsibilities for ensuring that trash and debris are not discharged into the marine environment.

Guidance for Military and National Aeronautics and Space Administration (NASA) Coordination
All authorizations for permitted activities would include guidance for military and NASA coordination. Vessel and aircraft operators would be required to establish and maintain early contact and

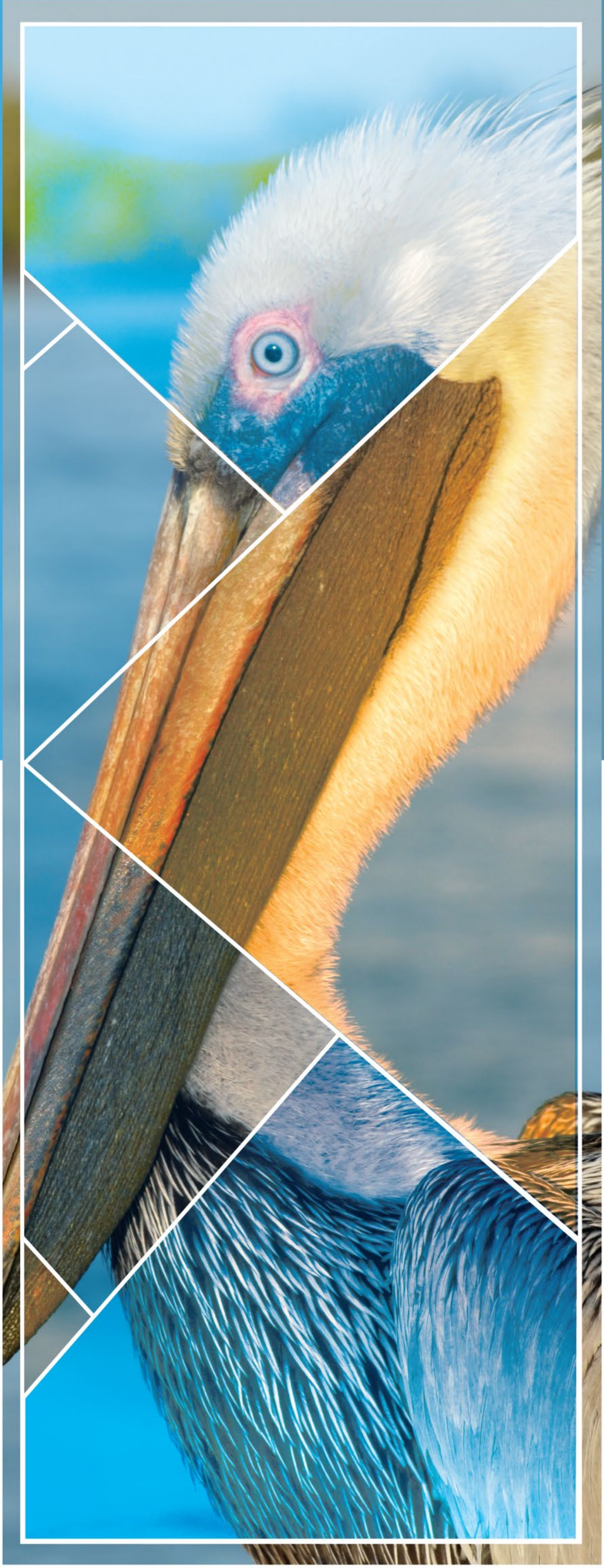
coordination with the appropriate military command headquarters or NASA point of contact. Department of Defense (DoD) and BOEM Interagency Working Groups have been formed specifically to address potential conflicts of BOEM-permitted G&G surveys and DoD operations in the Atlantic.

Implementation of an Adaptive Management Strategy
BOEM would use an adaptive management strategy, which may require additional measures, if warranted, or adjust programmatic mitigations as needed based upon new information and site-specific environmental analyses.

Vessel Strike Avoidance
All authorizations for shipboard surveys, regardless of vessel size, would include guidance for vessel strike avoidance during transit. The guidance would address protected species identification, vessel strike avoidance, and reporting of injured or dead protected species in accordance with the NMFS Compliance Guide for the Right Whale Ship Strike Reduction Rule.

U.S. Department of the Interior

The Department of the Interior protects and manages the Nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities.



Bureau of Ocean Energy Management

The mission of the Bureau of Ocean Energy Management is to manage development of U.S. Outer Continental Shelf energy and mineral resources in an environmentally and economically responsible way. The bureau promotes energy independence, environmental protection, and economic development through responsible management of these offshore resources based on the best available science.