OCS Study
BOEM 2018-067

Forecasting Environmental and Social Externalities Associated with Outer Continental Shelf (OCS) Oil and Gas Development, Volume 2: Supplemental Information to the 2018 Revised Offshore Environmental Cost Model (OECM)

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Forecasting Environmental and Social Externalities Associated with Outer Continental Shelf (OCS) Oil and Gas Development, Volume 2: Supplemental Information to the 2018 Revised Offshore Environmental Cost Model (OECM)

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DISCLAIMER

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Contents

List of Tables

List of Figures

Acronyms

ADFG	Alaska Department of Fish and Game
BOEM	Bureau of Ocean Energy Management
CDEs	catastrophic discharge events
CRFS	California Recreational Fisheries Survey
CSIS	Community Subsistence Harvest Information System
CWA	Clean Water Act
CZMA	Coastal Zone Management Act
DARP/EA	Damage Assessment and Restoration Plan/Environmental Assessment
DSAY	discounted service-acre-year
DWH	*Deepwater Horizon*
E&D	exploration and development
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
FPSO	floating production, storage, and offloading
FPU	floating production unit
FWS	U.S. Fish and Wildlife Service
GOM	Gulf of Mexico
LIS	Long Island Sound
LNG	liquefied natural gas
MMPA	Marine Mammal Protection Act
NAA	No Action Alternative
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRDA	Natural Resource Damage Assessment
OCS	Outer Continental Shelf
OCSLA	Outer Continental Shelf Lands Act
OECM	Offshore Environmental Cost Model
PAD-US	Protected Areas Database of the United States
PDARP	Preliminary Damage Assessment and Restoration Plan
PM	particulate matter
PTS	permanent threshold shift
RecFIN	Recreational Fisheries Information Network
RMCs	Resource Management Codes
RUM	Randomized Utility Maximization
SCORPs	Statewide Comprehensive Outdoor Recreation Plans
SEL	sound exposure level
SHEP	Savannah Harbor Expansion Project

SIMAP	Integrated Oil Spill Impact Model System
SPL	sound pressure level
TTS	temporary threshold shift
USACE	U.S. Army Corps of Engineers
VSL	value of a statistical life
WTP	willingness to pay

1 Introduction

The Bureau of Ocean Energy Management (BOEM) assists the Secretary of the U.S. Department of the Interior (DOI) in carrying out the mandates of the Outer Continental Shelf (OCS) Lands Act (OCSLA). OCSLA calls for expedited exploration and development (E&D) of the OCS to, among other goals, "reduce dependence on foreign sources and maintain a favorable balance of payments in world trade." OCSLA also requires that BOEM prepare forward-looking five-year schedules of proposed OCS lease sales that define as specifically as possible the size, timing, and location of the OCS territory(ies) to be offered for lease. As part of the development of these National OCS Oil and Gas Leasing Programs (National OCS Programs), BOEM completes an analysis of the anticipated environmental and social costs attributable to the exploration, development, production, and transport of oil and natural gas, net of the environmental and social costs attributable to the No Action Alternative (NAA) (i.e., the costs associated with energy production from sources that would substitute for OCS production in the absence of the Program) and net of any benefits (measured as "negative costs") attributable to OCS oil- and natural gas-related activities.[1]

To estimate the anticipated environmental and social costs attributable to oil and natural gas E&D activities on the OCS, as specified in an E&D scenario,[2] BOEM utilizes the Offshore Environmental Cost Model (OECM), a revised Microsoft (MS) Access-based model, which has been updated in conjunction with development of the 2020–2025 Program. The OECM was designed to focus on capturing the most significant environmental and social costs from the program proposal and NAA. The report *Forecasting Environmental and Social Externalities Associated with the Outer Continental Shelf (OCS) Oil and Gas Development, Volume 1: 2018 Revised Offshore Environmental Cost Model (OECM)* (BOEM 2018-066) presents the model's cost calculation methodologies as well as descriptions of each calculation driver, including the sources of underlying data and any necessary assumptions. The purpose of this companion report (Volume 2) is to present supplemental information on environmental and social costs that BOEM considers in conjunction with the OECM results.

The OECM was designed to estimate impacts that are well understood and can be estimated credibly based on historical experience. Although many of the impacts that the OECM estimates are associated with the possibility of oil spills from pipelines, tankers, and OCS platforms, it does not include impacts from catastrophic discharge events (CDEs) because—unlike the case for more common events—the rarity of such events and the large variability in the factors that contribute to their impacts have together resulted in a lack of historical data that could be used to estimate likely environmental and social costs with reasonable confidence. In addition, because of the potential magnitude of such impacts, inclusion of even the best estimates of costs caused by a CDE would result in an overall estimate resting largely a somewhat arbitrary set of decisions as to location, size, distance from shore, season, weather, and other

[1] The NAA and the No Sale Option (NSO) both refer to absence of proposed sales for one or more planning areas as a new National OCS Leasing Program is being prepared. The NAA is the alternative in a Programmatic Environmental Impact Statement to not propose any sales at all for the entire five-year period. However, in the actual decision process, the Secretary usually makes decisions for one planning area at a time; the NSO is the option to not propose any lease sales for a specific planning area and is the term used in the supporting analyses included in the decision documents. The OECM and accompanying documentation use "NAA" generically to refer to the absence of sales for any combination of planning areas.

[2] An E&D scenario defines the incremental level of OCS exploration, development, and production activity anticipated to occur within planning areas expected to be made available for leasing in the National OCS Program. Elements of an E&D scenario include the number of exploration wells drilled, the number of platforms installed, the number of development wells drilled, miles of new pipeline constructed, anticipated aggregate oil and gas production, and the number of platforms removed.

factors for an event that is very unlikely to occur. To supplement the costs considered in the OECM, Chapter 2 of this report, *Analysis of Impacts from a Catastrophic Spill,* provides information on the potential environmental and social costs of a CDE. This chapter provides an overview of the available data and literature on potential CDE impacts, including response costs, ecological impacts, recreational impacts, commercial fishing impacts, fatal and non-fatal injuries, and value of oil spilled.

Complementing the CDE impact analysis, Chapter 3 examines impacts associated with the development and expansion of onshore infrastructure that may be necessary to support OCS oil and gas activity. This assessment builds upon the OECM's estimation of (1) air quality impacts, (2) property value effects, (3) recreation impacts, (4) ecological impacts, (5) subsistence impacts, and (6) impacts to the commercial fishing industry. Because these categories have historically captured the most significant social and environmental costs associated with OCS exploration and development, the OECM was designed to focus on these impacts. However, to the extent that a National OCS Program decision option includes areas where OCS oil and gas development has historically been limited or non-existent, the construction of new onshore infrastructure to support this activity may be necessary. Both the construction and operation of this infrastructure would likely result in social and environmental costs and benefits not captured by the OECM. In addition, the expansion or retrofitting of existing onshore infrastructure could result in social and environmental costs and benefits, though these impacts are likely to be less than those for new facilities.

2 Analysis of Impacts from Catastrophic Oil Spills

After the *Deepwater Horizon* (DWH) oil spill in April 2010, BOEM began more explicitly considering the potential impacts of low-probability high-consequence events in its assessments of future exploration, development, and production activities on the OCS.[3] A decision as to whether or not to proceed with proposed lease sales (auctions) necessarily carries with it the risk, however slight, of CDEs. Because these events are extremely infrequent and only limited data are available on their impacts, the OECM—the model that BOEM uses to assess the net environmental costs associated with its National OCS Program—was not designed to estimate the costs of a CDE. To supplement results generated by the OECM for BOEM's 2017–2022 Proposed Final Program, the Bureau performed an analysis of the potential environmental and social costs of a catastrophic spill in the Gulf of Mexico (GOM), the Mid-Atlantic, Cook Inlet, and the Arctic (BOEM 2012). The purpose of this chapter is to re-visit the data and literature on these impacts and, where possible, present updated estimates of the per-barrel impacts associated with a catastrophic spill and expand the analysis to all four OCS regions. In reviewing this information, we consider potential impacts associated with a well blowout as well as impacts related to a catastrophic tanker spill. The former is likely to occur several miles from shore, while the latter is more likely to occur in the nearshore environment.

As a preemptive caveat to the data and methods presented in this chapter, we emphasize that the environmental impacts of a CDE are highly uncertain. The magnitude of these impacts depends on multiple factors, including the volume of oil spilled, the duration of the spill, the proximity of the spill location to sensitive resources, meteorological conditions at the time of the spill (e.g., whether the wind is blowing toward shore), the type of oil spilled, and response and containment capabilities. Compounding these uncertainties is the limited data available on CDE impacts. Only two catastrophic spills have occurred in U.S. waters: the *Exxon Valdez* spill in 1989 and the *Deepwater Horizon* blowout and spill in 2010. Although a wealth of data are available on both spills, it is uncertain whether these spills are representative of future catastrophic spills.

The remainder of this chapter presents a review of the available data and literature on potential CDE impacts and, where possible, our estimates of these impacts on a regional basis for the following categories of impacts:

- Response costs;
- Ecological impacts;
- Recreation, inclusive of beach recreation, recreational fishing, boating, and wildlife viewing;
- Commercial fishing impacts;
- Subsistence;
- Fatal and non-fatal injuries; and
- Value of spilled oil.

After presenting the available information on the impacts above, we discuss the impacts associated with response actions such as the use of dispersants and *in situ* burns. We conclude by identifying the most significant uncertainties in our analysis and their implications for our estimates of catastrophic impacts.

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[3] BOEM historically considered the impacts of catastrophic oil spills in developing the National OCS Program, but discontinued the practice in response to declining frequency and severity of oil spills. This practice was resumed following the *Deepwater Horizon* oil spill.

In addition to the impacts identified above, a CDE may result in other impacts not quantified in this document due to limitations in data availability. For example, a CDE may disrupt commercial shipping activity, imposing costs on the shipping industry as well as industries dependent on marine shipping. The magnitude of such an effect would depend, among other factors, on the location of a spill and the volume of commercial vessel traffic in the area. In addition, a blowout close to the water surface could result in significant air pollutant emissions detrimental to human health. Criteria pollutant emissions from the blowout could result in increased risk of adverse cardio-pulmonary impacts for onshore populations, and if high concentrations of sulfur are present in the produced gas, hydrogen sulfide could represent a hazard to onsite personnel. If oil from a CDE reaches shore, the evaporative emissions from the oil could cause temporary eye, nose, or throat irritation, nausea, or headaches (U.S. EPA 2010a). A catastrophic spill would also have the potential to impact offshore archaeological resources such as shipwrecks, coastal forts, or pre-historic resources.

2.1 Response Costs

Spill containment and cleanup refers to all costs related to emergency response following an oil spill and the physical cleanup of any spilled oil. This includes a number of fixed costs, such as setting up a response center and mobilizing labor and equipment, in addition to a variety of costs tied to the length and intensity of the cleanup effort, such as equipment rental costs and wages for cleanup and monitoring crews.

2.1.1 Variability and Uncertainty of Response Costs

Several factors may affect the spill containment and cleanup costs associated with a given CDE. Most of these factors are related to the specific circumstances of the spill, creating significant uncertainty in efforts to generalize the average cost of oil spill response. Some of the key uncertainties include the following:

- Proximity of the spill to infrastructure critical for response, such as ports, airports, and population centers;
- Proximity of the spill to response/cleanup equipment resources;
- Proximity to potentially affected resources, particularly shoreline (i.e., distance from shore that spill occurs);
- Oil type (different types volatilize at different rates);
- Wind, weather, and prevailing currents;
- Season, which is a determinant of temperature and ice cover;
- Differences in technical feasibility of cleanup, as affected by shoreline habitat type; and
- Cleanup strategy (mechanical, dispersants, *in situ* burn, etc.).

Despite the uncertainty surrounding the circumstances of any given spill, a body of research exists related to response costs based on historical spill data. In particular, this research indicates response costs per barrel are significantly correlated with the length of shoreline oiled, the type of oil spilled, and the volume of oil spilled (Etkin 1999, 2000).

The correlation between response costs and the length of shoreline oiled is particularly strong because shoreline cleanup requires much more complex, time consuming, and expensive techniques than cleanup of oil in open water. Etkin (2000) notes that in almost any spill, shoreline cleanup is the most expensive and time-intensive phase of the cleanup. Additionally, the type of shoreline oiled can have a considerable impact on the cleanup cost. For instance, a rocky shore is much easier to access and clean than a coastal marsh. Etkin (2004) estimates that on average, oiled wetland is more than three times as expensive to clean up as oiled rocky shore. Additionally, Etkin (2004) estimates that oiled sandy shore is 20 percent more expensive to clean up than oiled rocky shore.

The historical spill record also shows a clear relationship between the barrels of oil spilled and the response cost per barrel. In general, as the size of an oil spill increases, the response cost per barrel decreases (Etkin 1999,2000). This is a result of the considerable fixed costs associated with an oil spill cleanup operation, such as the need to set up a response center and mobilize equipment and labor. However, response costs associated with the two historical catastrophic spills in U.S. waters, *Exxon Valdez* and *Deepwater Horizon*, do not follow this trend.

The *Exxon Valdez* incident resulted in the spillage of 257,000 barrels of oil into Prince William Sound (ADFG, Exxon Valdez Oil Spill Trustee Council). Exxon spent approximately $3.9 billion dollars (year 2019$)[4] to contain and clean up the spill, or roughly $15,000 per barrel of oil spilled. The *Deepwater Horizon* incident resulted in the leakage of 3.19 million barrels into the GOM (U.S. District Court 2015).[5] BP spent approximately $16.8 billion on cleanup and containment, or roughly $5,300 per barrel of oil spilled (BP 2015). In contrast, historical data on non-catastrophic spills from the OSIR International Oil Spill Database indicates that, in the U.S., the average response cost for a spill greater than 23,800 barrels is only $163 per barrel (Etkin 2000).[6]

2.1.2 Estimation of Response Costs by Region

Because the response costs associated with non-catastrophic oil spills do not appear to be reliable indicators of the response costs associated with catastrophic spills, our estimates of the per-barrel response costs associated with a catastrophic spill are based on the response costs for the *Deepwater Horizon* and *Exxon Valdez* spills. The per-barrel response costs observed for the *Exxon Valdez* serve as our point estimate of response costs in Gulf of Alaska, and the response costs observed for the Deepwater Horizon spill serve as our estimate for response costs in the GOM.

We also use response costs observed for the *Deepwater Horizon* spill as the basis for our response cost estimate for the Atlantic and Pacific Regions. We would expect response costs in the Atlantic and Pacific to be similar to or less than response costs in the GOM for two reasons. First, like the GOM, the Atlantic and Pacific both have heavily populated coastal areas, with ready access to ports, airports, equipment, and labor. Additionally, the shoreline habitat types observed in the GOM are generally more sensitive to shoreline oiling than the habitat types observed in the Atlantic and Pacific. For example, the Atlantic and Pacific have a higher proportion of beaches and rocky shorelines and a lower proportion of wetlands than the Central Gulf. Because shoreline cleanup commands such a large portion of response resources, the less sensitive shoreline habitats in the Atlantic and Pacific indicate that shoreline cleanup is likely to be less expensive in the Atlantic and Pacific than in the Central Gulf. As a result, using the response costs observed for the *Deepwater Horizon* spill as the basis for the response cost estimate in the Atlantic and Pacific is likely to provide a conservative estimate. Table 1 presents the distribution of shoreline types in the Central Gulf, Atlantic, and Pacific, as calculated from the National Oceanic and Atmospheric

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[4] All monetized values presented in this report are in year 2019 dollars, unless indicated otherwise.

[5] The *Deepwater Horizon* incident resulted in the release of approximately 4 million barrels, of which 800,000 barrels were recovered. Thus, 3.19 million barrels of oil were released into the Gulf of Mexico and not recovered. To minimize the potential for underestimating response costs per barrel, we calculate per-barrel costs using the 3.19 million barrel estimate.

[6] This estimate does not take into account oil spills that occurred since 2000. Although it is possible that average response costs have changed during this time, this source remains the most comprehensive analysis of oil spill response costs available.

Administration (NOAA) Environmental Sensitivity Index data (NOAA Office of Response and Restoration 2015).

Similarly, we use the response costs observed for *Exxon Valdez* as the basis for response costs in the Cook Inlet, Kodiak, and Shumagin Planning Areas. Although the spill occurred in the Gulf of Alaska, shoreline adjacent to these three planning areas was also impacted. As a result, the response costs for the *Exxon Valdez* spill are likely to be representative.

Table 1. Distribution of shoreline habitat

Shoreline Classification	Percent of Shoreline in Central Gulf	Percent of Shoreline In Atlantic Region	Percent of Shoreline in the Pacific Region
Marshes and swamps	67%	34%	5%
Beaches	17%	41%	54%
Tidal flats	6%	0%	0%
Man-made structures	5%	5%	1%
Riprap	3%	9%	9%
Rocky and steep shorelines	1%	10%	30%
Vegetated banks	1%	1%	0%

Source: NOAA Office of Response and Restoration (2015).

Notes:
(1) The NOAA Environmental Sensitivity Index data include shoreline information for coastal rivers and other inland waterways that are unlikely to be impacted by CDEs. As a result, we exclude information on these inland waterways when calculating regional proportions of shoreline habitat types. For instance, the Environmental Sensitivity Index data include information on shoreline habitat along the Potomac River, but we do not include this information in our calculation of shoreline types in the Atlantic.
(2) Additionally, we exclude coastal areas landward of the Outer Banks in North Carolina from our calculation of shoreline habitat types in the Atlantic. We assume that the Outer Banks would prevent oil from reaching this area.
(3) Shoreline types which account for less than 1 percent of total shoreline are not included in this table.

The western and Arctic regions of Alaska present the greatest difficulty in estimating cleanup and containment costs. This is a result of both the unique geography of these regions and the lack of historical spill response operations to examine. Although the *Exxon Valdez* spill provides the best comparison available, there are several reasons why a spill in the western and Arctic regions may result in considerably different response costs than a spill in southern Alaska. One major difference is that the western and Arctic planning areas are hundreds of miles away from major ports, airports, and population centers. In the event of a spill, it would likely take longer to move equipment and labor to the spill site than in any other region. A delayed initial response to a spill has the potential to result in a greater volume of oil spilled, or a greater amount of shoreline oiling. Additionally, the western and Arctic planning areas are relatively open as compared to the relatively enclosed Cook Inlet (and Prince William Sound). As a result, a catastrophic oil spill may disperse into open water to a greater extent in these areas, resulting in comparatively less shoreline oiling. The greater preponderance of ice cover along the Arctic shoreline in particular as compared to Cook Inlet also has the potential impact spill response costs. Often times, ice can act as a natural barrier, containing oil out at sea where it is easiest to clean up (Transportation Research Board and National Research Council 2014). However, if sea ice is spread too thin to contain the oil, it may just hinder response activities. Additionally, under certain conditions spilled oil may become encapsulated by ice, potentially adding to the length of the response effort when the ice melts and releases the trapped oil.

The Arctic Drilling Rule would potentially mitigate some of these effects in the Chukchi Sea and Beaufort Sea Planning Areas. The rule requires that companies engaged in exploration activities in the

Arctic must maintain and, in the event of a spill, promptly deploy source control and containment equipment in the area. The rule also requires firms engaged in exploration in the Arctic to maintain ready access to a separate relief rig that is able to drill a relief well in a timely manner if needed[7].

As a result of the particularly significant uncertainty associated with responding to a spill in the western and Arctic planning areas, we present the cleanup and containment costs for this region as a range. At the low end of the range, we assume a per-barrel response cost equal to that associated with *Deepwater Horizon*. For the high end of the range, we apply the per-barrel response cost associated with *Exxon Valdez*. Table 2 presents cleanup and containment cost estimates for catastrophic spills in the GOM, Atlantic, Pacific, and Alaska Regions.

Table 2. Estimated response costs per barrel by OCS region

Cost Category	GOM	Atlantic	Pacific	Alaska—Gulf of Alaska, Kodiak, Cook Inlet, Shumagin	Alaska—All Other Planning Areas
Response Cost	$5,300/barrel	$5,300/barrel	$5,300/barrel	$15,000/barrel	$5,300/barrel–$15,000/barrel

Note: All values presented in 2019 dollars.

[7] For more information on the Arctic Drilling Rule, see 81 FR 46477.

2.2 Ecological Damages

Similar to response costs, the ecological damages associated with a CDE are variable and dependent upon a number of uncertain factors. Many of these factors are the same as those that contribute to uncertainty in response costs, such as oil type, weather, proximity to shoreline, and habitat type. Among these, oil type and weather conditions affect the dispersion, evaporation, and volatilization rate of oil, which influence the quantity of ecological resources oiled. Oil type, proximity to shoreline, and habitat type all influence the magnitude of damages associated with oiled ecological resources. For instance, a mile of oiled wetland typically causes greater ecological damage than a mile of oiled beach. Similarly, a mile of shoreline oiled with crude typically causes greater ecological damage than a shoreline oiled with a lighter petroleum product such as gasoline. Ecological damages are also dependent on the season, which affects the presence or absence of migrating species, and the vulnerability of species to oiling. For instance, shoreline oiling may be considerably more damaging during the growing season, when the oil could impact plant reproduction and seed development.

Given these significant uncertainties and the lack of historic data on catastrophic spills, we estimate a range of ecological cost estimates for each region. The high-end ecological cost estimates are derived from settlement data for the two catastrophic oil spills that have occurred in the U.S., the *Deepwater Horizon* and *Exxon Valdez* spills. Because historic examples of catastrophic spills in the Atlantic, Pacific, and the rest of the Alaska Region do not exist, we developed the high-end estimates for these regions by applying scaling factors to the *Deepwater Horizon* and *Exxon Valdez* damage estimates.

The low-end estimates of ecological costs are based on the per-barrel damages for other (non-catastrophic) spills, using settlement and assessment data published by NOAA and the U.S. Fish and Wildlife Service (FWS). Although these spills are smaller in size relative to the *Deepwater Horizon* and *Valdez* spills and may have occurred in circumstances different than what might be expected from offshore oil and gas development, they still provide insight into geographic differences in ecological costs and the potential per-barrel magnitude of these costs.

2.2.1 Gulf of Mexico

The low-end estimate of the per-barrel ecological damages resulting from a catastrophic spill in the GOM is based on the damages for five previous spills in the region. Table 3 presents the number of barrels spilled and estimated ecological costs associated with each spill, as obtained from the associated natural resource damage assessment (NRDA) documents.[8] Across these five spills, the per-barrel ecological damage ranges from $140 to $1,400, with an average value of $850 per barrel. This value serves as our low-end per-barrel value for the GOM.

The settlement for the *Deepwater Horizon* spill serves as the basis for the high-end ecological costs per barrel spilled in the GOM (U.S. District Court for the Eastern District of Louisiana 2015). The settlement includes approximately $8 billion[9] to compensate for damages to natural resources (NOAA 2015). This value represents total natural resource damages, including any damages to recreational resources. To isolate the ecological portion of these damages, we subtract approximately $750 million (adjusted from 2015$ to 2019$) in recreational use damages, as estimated in the Preliminary Damage Assessment and

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[8] See Appendix A for summaries of many of these spills.

[9] $8 billion reflects $1 billion in early restoration costs, a $7.1 billion settlement paid out over 15 years, and an additional $700 million to cover any presently unknown future natural resource damages. All of these costs were adjusted to 2017 dollars. In addition, the 15-year stream of payments for $7.1 billion was adjusted for inflation to convert from nominal dollars to real year 2019 dollars.

Restoration Plan (PDARP) for the *Deepwater Horizon* spill. Total ecological damages are thus estimated to be approximately $7.3 billion, or $2,300 per barrel of oil spilled (in 2019$).[10]

Table 3. NRDA estimates of ecological damages from past spills on the Gulf Coast (2019$)

Spill Name	Spill Year	Barrels Spilled	NRDA Settlement	NRDA Cost Per Barrel
Mosquito Bay[1]	2001	3,000	$1,900,000	$630
Equinox Oil, Alma Energy[2]	1998	1,500	$1,200,000	$810
OCEAN 255/B-155/BALSA 37 Spill[3]	1993	8,600	$11,000,000	$1,300
Blake IV and Greenhill Petroleum Corp. Well 25[4]	1992	2,900	$4,100,000	$1,400
Texaco Pipeline Company Lake Barrel Oil Spill[4]	1997	6,500	$900,000	$140
Average		**4,500**	**$3,800,000**	**$850**

Notes:
All values rounded to two significant digits. When it was possible to make a distinction, NRDA settlement values represent only the ecological portion of natural resource damages.
We excluded NRDA estimates associated with spills less than 500 barrels. Per-barrel ecological damages from spills of this size are likely to have limited applicability to a catastrophic spill.

Sources:
[1] See Settlement Agreement, Mosquito Bay (2001)
[2] See In re Equinox Oil Company, Inc. / Alma Energy Corporation, Debtors. Settlement Agreement (2006).
[3] See FLDEP, NOAA, and U.S. DOI (1997)
[4] See BOEMRE (2010)

2.2.2 Atlantic

We estimate low-end ecological cost values for CDEs occurring in the Atlantic based on the estimated damages or settlement values for 14 previous spills in the region. Table 4 lists these 14 spills, and the associated settlement values for ecological damages.[11] As indicated in the table, the ecological damages or settlement values for these spills average approximately $770 per barrel.

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[10] Note that the estimate of $720 million in recreational damages from the *Deepwater Horizon* spill differs from the $600 million estimate presented later in this document. This is due to the fact that the $720 million figure reflects compounding between the time of the spill and the publication of the PDARP. Because the time between a CDE's occurrence and the publication of a PDARP depends on factors unrelated to damages (e.g., the negotiating strategies of the responsible parties and the Trustees, the number of Trustees involved), we excluded compounded interest from our estimates of damages where possible. For impacts other than recreation, we made no adjustments for compounding, however, since the *Deepwater Horizon* PDARP does not describe the monetization of ecological damages.

[11] See Appendix A for summaries of many of these spills.

Table 4. NRDA estimates of ecological damages from past spills on the Atlantic coast (2019$)

Spill Name	Spill Year	Barrels Spilled	NRDA Settlement	NRDA Cost Per Barrel
Anitra[1]	1996	1,000	$1,400,000	$1,400
North Cape[2]	1996	20,000	$11,000,000	$540
T/V Bow Mariner[3]	2004	82,000	$670,000	$8
Cibro Savannah[4]	1990	17,000	$490,000	$29
Exxon Bayway[5]	1990	14,000	$16,000,000	$1,200
B.T. Nautilus[6]	1990	6,200	$4,500,000	$720
Bouchard Barge[7]	2003	2,300	$1,600,000	$680
Julie N[8]	1996	4,300	$1,300,000	$300
M/S Star Evviva[9]	1999	570	$2,600,000	$4,500
Barge RTC 380[10]	1992	640	$320,000	$500
Chelsea Creek (Global Oil/Irving Oil Pipeline)[11]	2006	520	$12,000	$24
Jahre Spray[11]	1995	1,400	$200,000	$140
M/V Presidente Rivera[12]	1989	6,000	$3,800,000	$640
M/V World Prodigy[13]	1989	7,000	$980,000	$140
Average		**12,000**	**$3,200,000**	**$770**

Notes:
All values rounded to two significant digits. When there was enough information available, NRDA settlement values represent only the ecological portion of natural resource damages.
We excluded NRDA estimates associated with spills less than 500 barrels. Per-barrel ecological damages from spills of this size are likely to have limited applicability to a catastrophic spill.

Sources:
[1] See NJDEP (2004)
[2] See NOAA, U.S. DOI, State of Rhode Island (1999)
[3] See U.S. FWS (2010)
[4] See Montauk Oil Transportation Corp. v. Steamship Mutual Underwriting Association (Bermuda)
[5] See United States of America, the State of New York, the State of New Jersey, and the city of New York v. Exxon Corporation.
[6] See United States of America, the State of New York, the State of New Jersey, and the city of New York v. Nautilus Motor Tanker Co., Ltd.
[7] See United States of America, Commonwealth of Massachusetts, and the State of Rhode Island v. Bouchard Transportation Company, Inc., Tug Evening Tide Corporation, and B. No 120 Corporation.
[8] See United States of America and the State of Maine v. Amity Products Carriers, Inc.
[9] See U.S. FWS, S.C. DNR, Office of the Governor (2004)
[10] See Settlement Agreement, in the matter of Barge RTC 380 (1994)
[11] See BOEMRE (2010)
[12] See NJDEP (1996)
[13] See NOAA (1996)

Ideally, the high-end estimate of ecological damages for a catastrophic spill in the Atlantic would be estimated based on one or more historic examples of such a spill in the region. Because a catastrophic oil spill has never occurred off the Atlantic coast of the U.S., we estimate the high-end costs of a catastrophic spill in the region by scaling the per-barrel damages associated with the *Deepwater Horizon* oil spill in the GOM. The sample of non-catastrophic oil spills used to estimate low-end costs (presented in Tables 3 and 4) indicated that the average oil spill in the Atlantic resulted in per-barrel ecological damages 9 percent lower than the average ecological damages in the GOM ($770 per barrel versus $850 per barrel). As a result, this analysis assumes that a catastrophic spill in the Atlantic would result in ecological damages per barrel that are 9 percent less than the damages from the *Deepwater Horizon* spill. Scaling the

Deepwater Horizon settlement value in this way suggests that a catastrophic spill in the Atlantic would result in ecological damages of approximately $2,100 per barrel.

2.2.3 Pacific

We estimate low-end ecological cost values for CDEs occurring in the Pacific based on the damages for 12 previous spills in the region. Table 5 lists these 12 spills and the associated settlement values for ecological damages.[12,13] As indicated in the exhibit, the ecological damages or settlement values for these spills average approximately $5,400 per barrel. This value is considerably higher than the low-end ecological damages estimated for the GOM and the Atlantic. However, this is consistent with the assumptions in the OECM about ecological impacts in the Pacific. For instance, the OECM spill consequence equations predict that a 10,000 barrel spill in Southern California would cover 12 times the water surface area as the same size spill in the GOM. Furthermore, the OECM estimates that a 10,000 barrel spill in Central California, Northern California, or Washington/Oregon would cover 65 times the water surface area as the same size spill in the GOM.

Ideally, the high-end estimate of ecological damages for a catastrophic spill in the Pacific would be estimated based on one or more historic examples of such a spill in the region. Because a catastrophic oil spill has never occurred off the Pacific coast of the U.S., we estimate the high-end costs of a catastrophic spill in the region by scaling the per-barrel damages associated with the *Deepwater Horizon* oil spill in the GOM. The sample of non-catastrophic oil spills used to estimate low-end costs (presented in Tables 3 and 5) indicated that the average oil spill in the Pacific resulted in per-barrel ecological damages six times higher than the average ecological damages in the GOM ($5,400 per barrel versus $850 per barrel). As a result, this analysis assumes that a catastrophic spill in the Pacific would result in per-barrel ecological damages that are six times greater than the damages from the *Deepwater Horizon* spill. Scaling the *Deepwater Horizon* settlement value in this way suggests that a catastrophic spill in the Pacific would result in ecological damages of approximately $14,000 per barrel.

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[12] The 1969 Santa Barbara oil spill is not among the spills shown in the table. The table includes spills for which a natural resource damage assessment (NRDA) was conducted, and the Santa Barbara spill occurred before formal NRDA regulations and procedures were enacted pursuant to the Oil Pollution Act.

[13] See Appendix A for summaries of many of these spills.

Table 5. NRDA estimates of ecological damages from past spills on the Pacific coast (2019$)

Spill Name	Spill Year	Barrels Spilled	NRDA Settlement	NRDA Cost Per Barrel
Cosco Busan[1]	2007	1,300	$47,000,000	$37,000
MV New Carissa[2]	1999	3,300	$13,000,000	$4,000
Luckenbach[3]	1953	7,100	$25,000,000	$3,500
American Trader[4]	1990	9,900	$4,500,000	$450
Anacortes[5]	1991	950	$560,000	$580
Apex Houston Spill[5]	1986	600	$7,300,000	$12,000
El Segundo[5]	1991	500	$180,000	$360
Martinez[5]	1988	9,500	$13,000,000	$1,400
McGrath Lake[5]	1993	2,100	$1,600,000	$750
Nestucca[5]	1988	5,500	$4,000,000	$720
SS *Cape Mohican* Oil Spill[5]	1996	2,300	$4,800,000	$2,100
Tenyo Maru[5]	1991	11,000	$11,000,000	$1,000
Average		**4,500**	**$11,000,000**	**$5,400**

Notes:
All values rounded to two significant digits. When there was enough information available, NRDA settlement values represent only the ecological portion of natural resource damages.

We excluded NRDA estimates associated with spills less than 500 barrels. Per-barrel ecological damages from spills of this size are likely to have limited applicability to a catastrophic spill.

Sources:
[1] See Cosco Busan Oil Spill Trustees (2012)
[2] See U.S. DOI, USDA, State of Oregon, Confederated Tribes of Siletz Indians of Oregon, Confederated Tribes of the Coos, Lower Umpqua and Siuslaw Indians (2006)
[3] See California Department of Fish and Game, NOAA, U.S. FWS, and NPS (2006)
[4] See American Trader Trustee Council (2001)
[5] See BOEMRE (2010)

2.2.4 Alaska

2.2.4.1 Gulf of Alaska, Kodiak, Cook Inlet, and Shumagin

We estimate the ecological damages associated with a CDE in the southern Alaska planning areas (Gulf of Alaska, Kodiak, Cook Inlet, and Shumagin) based on the damages associated with the *Exxon Valdez* spill in the Gulf of Alaska Planning Area. Because of the similarities between the Gulf of Alaska and the three other southern Alaska planning areas, we use the per-barrel ecological damages associated with the *Exxon Valdez* spill as the high-end estimate for the ecological damages expected to result from a catastrophic oil spill in each of these planning areas. The *Exxon Valdez* settlement included approximately $1.1 billion to compensate for damages to ecological resources, or approximately $4,100 per barrel of oil spilled (in 2019 dollars). We note, however, that the ecological impacts of the *Valdez* spill are likely to be more representative of impacts associated with catastrophic spills from tankers or pipelines located close to shore than spills from OCS well blowouts. Although the *Valdez* was located close to shore near Prince William Sound when it struck Bligh Reef, OCS oil and gas wells are likely to be located farther from shore, which may reduce shoreline oiling and the impacts per barrel spilled relative the *Valdez* spill.

A review of NRDAs led by NOAA and FWS did not identify any non-catastrophic spills in the southern Alaska planning areas that might inform the estimation of a low-end ecological damages value for these areas. In the absence of such data, we develop a low-end estimate by scaling the low-end value for the GOM by the ratio of ecological damages from *Exxon Valdez* compared to *Deepwater Horizon*. Specifically, as noted above, the eight historic NRDAs in the GOM indicated average ecological damages of $850 per barrel. Additionally, the *Deepwater Horizon* agreement indicates ecological damages of $2,300 per barrel, while the *Exxon Valdez* settlement resulted in ecological damages that were 80 percent higher, at $4,100 per barrel. As a result, we assume that the low-end ecological damages for the southern Alaska planning areas are 80 percent greater than the average settlement of $850 per barrel seen in the GOM, or $1,500 per barrel.

2.2.4.2 All Other Alaska Planning Areas

The uncertainty surrounding ecological damages is particularly high in the western and Arctic Alaska planning areas, given the limited historical record of NRDAs associated with oils spills of any size in these regions.[14] We identified only a single historical NRDA in these planning areas, a 929-barrel spill off of Unalaska Island (located on the border of the St. George Basin and Aleutian Arc Planning Areas). Because the western Alaska and Arctic environments are most similar to that of southern Alaska, the ecological damage estimates produced for the southern Alaska planning areas serve as the starting point for the estimation of values specific to the rest of Alaska. Lacking sufficient data to compare historical spills between the two regions, the OECM was used to develop scaling factors to apply to the low-end and high-end values for the southern Alaska planning areas (where the *Exxon Valdez* spill occurred).

To identify the relative difference in ecological impacts between the southern Alaska planning areas and the western and Arctic planning areas, a single 250,000 barrel spill was modeled for Cook Inlet and for planning areas outside southern Alaska.[15] We used Cook Inlet as the comparison region due to the similarities to Prince William Sound, the location of the Exxon Valdez spill.[16] Because we modeled the same size spill in each area, any difference in estimated ecological damages will reflect the influence of environmental factors specific to each region.

Based on the OECM results, Table 6 presents the ratio of ecological impacts in each of the western and Arctic areas to ecological impacts in Cook Inlet. As the exhibit shows, ecological impacts range from 2.2 to 4.4 times greater than ecological impacts in Cook Inlet (in the Chukchi Sea and Beaufort Sea regions, respectively). The difference in results between the various western and Arctic areas may be driven by a number of factors, including sensitivity of shoreline habitat, presence of biota populations, and the impact of ocean currents on shoreline oiling. To avoid underestimation of potential impacts, we use the largest ratio (the 4.4 multiplier estimated for the Beaufort Sea Planning Area) to scale the per-barrel damage values for Cook Inlet. Applying this factor to the low-end estimate for ecological damages in the southern Alaska planning areas ($1,500 per barrel) yields a low-end value for the western and Arctic planning areas of $6,800 per barrel. Using this same approach, we estimate a high-end cost value for the western and Arctic planning areas of $18,000 per barrel.

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[14] As noted in the discussion of response costs above, the Arctic Drilling Rule could limit the extent of ecological damages should a major spill occur in the Arctic. Specifically, rule requirements related to the maintenance of response and containment capability and access to a relief rig could limit the extent of shoreline and/or surface oiling and the volume of oil spilled.

[15] 250,000 barrels represents the largest spill size reflected in the OECM spill consequence equations.

[16] Although Prince William Sound is located adjacent to the Gulf of Alaska Planning Area, the modeled spill sites for the Gulf of Alaska are located in open water. The modeled spill sites in Cook Inlet are located in partially enclosed areas and are therefore likely to be more similar to Prince William Sound.

Table 6. Ratio of ecological impacts in western and Arctic Alaska to ecological impacts in Cook Inlet

Region	Ratio of Ecological Impacts to Impacts in Cook Inlet
Beaufort Sea	4.4
Bering Sea Planning Areas[1]	2.6
Chukchi Sea	2.2

Notes:
1. The Bering Sea Planning Areas include Aleutian Basin, Bowers Basin, Navarin Basin, North Aleutian Basin, Norton Basin, St. George Basin, and St. Matthew-Hall. The ratio of 2.6 applies to each of these planning areas.

2.2.5 Summary

Table 7 presents the range of ecological costs estimated to result from a catastrophic oil spill in the GOM, Atlantic, Pacific, and Alaska Regions. The lowest ecological impacts associated with a catastrophic oil spill are expected in the Atlantic, while the highest impacts are expected in the western and Arctic Alaska planning areas.

Table 7. Range of NRDA costs by geographic region (2019$)

Region	Low-End Ecological Cost	High-End Ecological Cost
GOM	$850/barrel	$2,300/barrel
Atlantic	$770/barrel	$2,100/barrel
Pacific	$5,400/barrel	$14,000/barrel
Alaska—Gulf of Alaska, Kodiak, Cook Inlet, Shumagin	$1,500/barrel	$4,100/barrel
Alaska—All Other Planning Areas	$6,800/barrel	$18,000/barrel

2.3 Recreational Use

Coastal and marine resources provide recreational services such as beach use, boating, fishing, and wildlife viewing that are valuable to the public and that enhance the welfare of those who consume these services. If these resources are oiled as a result of a CDE (or expected to be oiled), the recreational value that they provide may be diminished, as oiling may impair the use of these resources. The diminished recreational value provided by affected resources may be reflected in reduced use of these resources (e.g., reduction in the number of beach trips) or reductions in individuals' willingness to pay (WTP) to use the affected resource. In the case of a CDE affecting large portions of the coast, these impacts are likely to be particularly substantial because widespread oiling would limit the ability of individuals to engage in coastal recreation at other sites located near their preferred site. For a smaller spill affecting a single beach, the availability of substitutes in the same area may partially mitigate the recreational impact of the spill. Given the potential scale and duration, a CDE could limit these substitution options.

Estimating the recreational value lost as a result of CDE requires information on (1) the baseline level of activity for the full suite of recreational activities affected, (2) the change in the level of recreational activity, and (3) the per unit (e.g., per user day or per beach trip) value that individuals place on these activities in the baseline and during the impact period. This information would allow one to estimate recreational value in the absence of the CDE and with the CDE. Obtaining this information, however, presents a number of challenges, as described below for each of the items outlined above.

- ***Specification of baseline recreational resource use:*** The specification of the baseline would ideally reflect use in the impacted area in the absence of a CDE. However, the timing and location of a CDE, both of which are substantial determinants of a CDE's impact, are highly uncertain. With offshore oil production occurring year-round, a CDE could occur during periods of high use or during periods when use is relatively low. Similarly, a CDE could affect coastal and marine areas frequented by recreators or areas where recreation is more limited.

  Aside from uncertainties related to CDE location and timing, gauging baseline use is also complicated by the fact that variables besides the occurrence of a CDE affect the use of recreational resources. In particular, changes in weather affect the use of coastal recreation sites, with higher temperatures and a lack of precipitation typically leading to higher use than cooler temperatures and/or rain. Thus, even if use data are available for an impacted area in the aftermath of a CDE, the prior year's data may not be representative of the actual baseline for that CDE. For example, if a hurricane had struck during the prior year but not during the spill year, use during the prior year would likely be an under-representation of baseline use.

- ***Estimating the change in coastal recreation activity:*** Estimating changes in the use of coastal resources attributable to a CDE is complicated by the non-spill factors described in the baseline discussion above. Changes in the use of coastal recreation sites could reflect the impact of a CDE as well as the weather, macroeconomic conditions, gas prices, and other variables. Distinguishing between the influence of a CDE and these other variables may not be possible in all cases. In addition, the spatial resolution of the available use data may not allow one to focus exclusively on use in areas affected by a CDE. For example, some data sources report use by state rather than for individual sites.

- ***Valuation:*** The value of the recreational uses of coastal and marine resources is highly variable depending on the attributes of the sites potentially affected by a CDE. Key attributes that affect value include the amenities available at the site (e.g., fish pier), how crowded a site is, the cleanliness of the site, or the prevalence of fish at the site (for recreational fishing sites). Furthermore, because a CDE may affect the attributes of a site, the value that individuals place on the site may change as a result of a CDE. Thus, even if existing literature provides estimates of recreational value under non-CDE conditions, the occurrence of a CDE could affect the value of recreational activity that still takes place after the CDE occurs.

In addition to the challenges outlined above related to the measurement of baseline use, changes in use associated with a CDE, and recreation value, the available data on each of these variables is also fairly limited for most coastal areas. Although use data are available from a few sources, many of these sources are either outdated or limited in the scope of activities or geographic areas that they cover. For example, many states prepare Statewide Comprehensive Outdoor Recreation Plans (SCORPs), but they have inconsistent methodologies. Data on the changes in use associated with a CDE are even more limited, as only two catastrophic spills have ever occurred in the U.S. (i.e., the *Exxon Valdez* spill in 1989 and the *Deepwater Horizon* spill in 2010). Although data associated with these spills may inform the assessment of the recreational impacts associated with a CDE, these events represent just two data points in a wide distribution of recreational impacts that may occur as a result of a CDE. Finally, while the environmental economics literature includes several studies related to the value of different coastal recreational activities, many of these studies are fairly dated or focus on marginal changes in the value of recreation that are not transferrable to assessment of the impacts of a CDE. For example, some studies estimate changes in the value of a recreational fishing day per acre of coastal marsh developed or preserved.

Despite these and other limitations, the available data nevertheless can be used to approximate the potential recreational costs of a CDE for four recreational activities: beach use, recreational fishing, boating (GOM only), and wildlife viewing (Cook Inlet and Gulf of Alaska only). We present our estimates of these damages, on a per-barrel basis, and our approach for developing these estimates in the sections that follow. Although a CDE would likely affect activities other than those examined here, such as scuba diving, the available data for these other activities were insufficient to support development of impact estimates.

2.3.1 Shoreline Recreation and Boating

Our assessment of the potential per-barrel damages related to shoreline recreation (beach use and inland fishing) and boating focuses on impacts in the GOM, Atlantic, Pacific, and two planning areas in the Alaska Region: Cook Inlet and Gulf of Alaska.[17] For the GOM Region, we present the estimated damages associated with the *Deepwater Horizon* spill as an indicator of potential impacts. We obtained this information from the PDARP and the associated administrative record issued by the *Deepwater Horizon* Oil Spill Natural Resource Trustees (the Trustees) (NOAA 2016). The PDARP provides aggregate results from the Trustees' comprehensive study of the spill's impacts on recreational activities, including swimming, sunbathing, shoreline fishing, inland fishing, and boating. The Trustees' assessment of lost recreational use associated with the *Deepwater Horizon* spill represents one of the most comprehensive and robust economic studies of coastal recreation ever conducted.

Due to the more limited data available for the Atlantic, Pacific, and Alaska, we apply a different approach for these regions. For each of these regions, we assume that a CDE would occur near the beginning of the peak season for coastal recreation and would affect recreational activity for several months. Based on this information, we develop estimates of baseline use in these areas for an extended period of several months. We then estimate the percent reduction in use based on the observed changes in use for the *Deepwater Horizon* and *Exxon Valdez* spills. Applying these percentage reductions to the estimates of baseline use yields estimates of the lost user days associated with a CDE. We value the reduction in recreational use based on estimates presented in the economic literature. We present the details of this approach below by region.

Note that the recreational activity examined in this section includes beach use (inclusive of fishing on sandy beaches), inland fishing, and boating. Although much of the environmental economics literature examines beach use and fishing separately, we examine them together here because the most robust and detailed data that we identified combine the two.

2.3.1.1 Gulf of Mexico

As noted above, we rely on the results of the lost recreational use assessment included in the *Deepwater Horizon* (DWH) PDARP and the associated administrative record to approximate the impacts of a CDE on coastal recreation in the GOM Region. The DWH assessment examines three categories of recreation: shoreline use, inland fishing, and boating. Shoreline use includes any and all saltwater recreation occurring on sandy beaches, including swimming, sunbathing, and fishing. Inland fishing, as distinct from shoreline fishing, represents fishing at saltwater locations not located on sandy beaches. Boating refers to pleasure boating and fishing on motorboats or sailboats.

To estimate changes in recreational use associated with the spill, the Trustees mounted a significant data collection effort that involved a series of onsite recreator surveys and aerial counts of recreators partaking in recreational activities at coastal sites. The Trustees measured the number of recreators at 743 beach segments throughout the Gulf through overflights (conducted by low-flying airplanes), and onsite interviews and counts (conducted by survey teams on foot). To capture the impacts to recreational anglers at non-beach saltwater access points, the Trustees sampled 323 sites from a list of non-beach saltwater sites provided by NOAA's Marine Recreational Information Program (MRIP). For the boating study, the

[17] Our review of the available data for other portions of Alaska suggested that marine recreation is minimal in these areas.

Trustees conducted counts and interviews to measure the number of recreational boaters entering the Gulf at 103 sites in the North Gulf and 90 sites in the Florida Peninsula. Sites were selected from MRIP's list of 534 saltwater boating access points open to the public. Using these various data, the study team estimated the level of recreational activity during the impact period and after recreational use returned to baseline levels. The difference between the two represents the change in use associated with the spill.

The Trustees estimated the changes in shoreline recreation associated with the *Deepwater Horizon* spill over a large area spanning the North Gulf and the Florida Peninsula over a period of 19 months. Figure 1 below shows a map of the sites sampled throughout the impact area (including non-beach fishing and boating sites). The duration of spill impacts to recreation varied within the area shown in Figure 1 and by activity. For example, the impact period for shoreline use in the Florida Peninsula was June 2010 through January 2011, while the impact period for shoreline use in the North Gulf (i.e., closer to the blowout site) was May 2010 through November 2011. In addition, within the North Gulf, impacts for shoreline use were longer in duration than impacts for inland fishing. Table 8 outlines the different impact periods by activity and region.

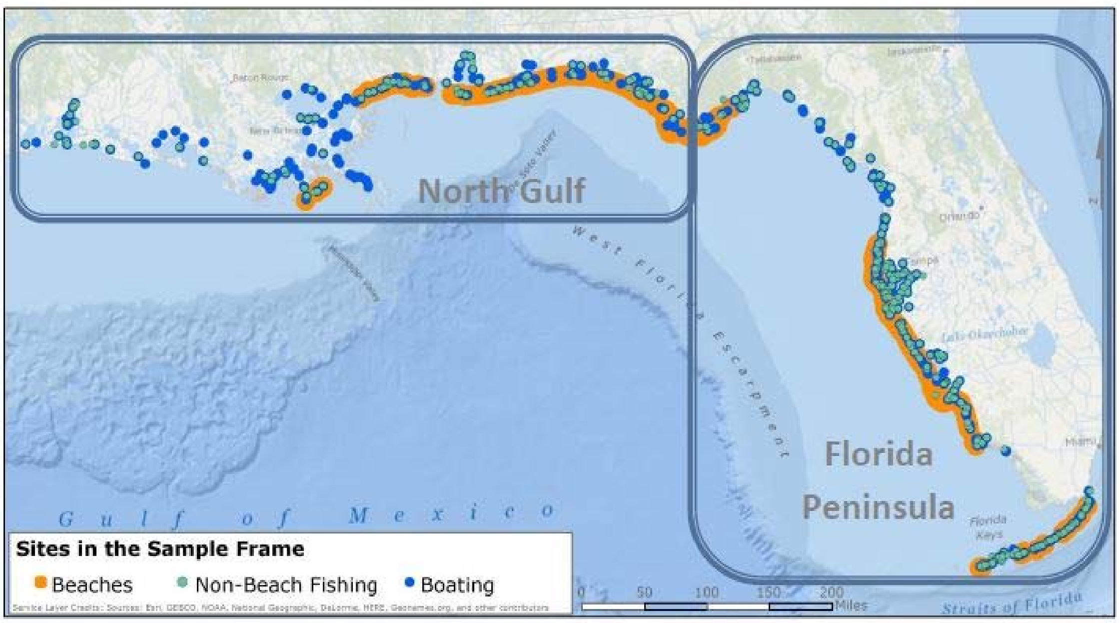

Figure 1. Map of recreation sites sampled in the *Deepwater Horizon* lost recreational use assessment
Source: NOAA (2016)

Table 8. Duration of losses to shoreline recreation, by region and activity, for the *Deepwater Horizon* lost recreational use assessment

Activity	Region	Duration
Shoreline Use	North Gulf	May 2010–Nov 2011
	Peninsula	Jun 2010–Jan 2011
Inland Fishing	North Gulf	May 2010–Mar 2011
Boating	North Gulf	May 2919–Aug 2010

Tables 9 and 10 below, taken from the PDARP, present the recreational use estimates from what the Trustees refer to as Tier 1 of the damage assessment.[18] These Tier 1 damages are based on the Trustee's detailed infield data collection effort and cover the period June 2010 through November 2011. Consistent with the PDARP's presentation of results, Table 9 presents use estimates for shoreline use and inland fishing combined. As shown in the table, the Trustees' Tier 1 assessment estimated that the *Deepwater Horizon* spill resulted in 12.47 million lost user days for shoreline use and inland fishing. This value represents a 23.3 percent reduction relative to the baseline of 53.4 million user days over the entire 18-month impact period for Tier 1. Note that Table 9 splits the impact period for shoreline use and inland fishing into two separate sub-periods. For the first period—June 2010 through January 2011—the estimated reduction in use is 32.5 percent, whereas the estimate for the second period—February 2011 through November 2011—is lower at 10.0 percent.

Table 9. *Deepwater Horizon* shoreline and inland fishing study lost use estimates (Tier 1)

Region	Baseline Estimate	Spill Estimate (User Days During Spill)	Loss Estimate (Lost User Days)	Percent Decline
June 2010 through January 2011				
North Gulf	14,207,507	7,782,270	6,425,237	45.2%
Peninsula	17,471,871	13,601,695	3,870,176	22.2%
Overall	31,679,378	21,383,965	10,295,413	32.5%
February 2011 through November 2011				
North Gulf	21,754,732	19,580,582	2,174,149	10.0%
Total (Months 1–18)	**53,434,109**	**40,964,547**	**12,469,562**	**23.3%**

Source: NOAA (2016)

Table 10. *Deepwater Horizon* boating study lost use estimates (Tier 1)

Region	Baseline Boating Days	Boating Days During Spill Impact Period	Lost Boating Days	Percent Decline
North Gulf	759,605	544,231	215,374	28.4%

Source: NOAA (2016)

To estimate the economic value of recreational losses associated with the *Deepwater Horizon* spill, the Trustees developed two Randomized Utility Maximization (RUM) models for saltwater recreation in the GOM Region. One model covers both shoreline use and inland fishing, while the other is specific to boating. These models capture the value of lost trips, as well as the value of substitute trips and diminished-value trips (i.e., trips that still occurred with the spill but were of lesser value because of the spill). The Trustees collected the data necessary to estimate these models from a local survey targeting adults who live in Louisiana, Mississippi, Alabama, Florida, and selected counties in Texas and Georgia, and a national survey that targeted adults living in the contiguous U.S., excluding the areas targeted in the local survey.

[18] The Trustees' Tier 2 estimates of damages, which rely on less detailed information than the Tier 1 estimates, as summarized below.

Using the survey data, the valuation models provide a quantitative description of people's recreation behavior. For example, the shoreline valuation model estimates the number of recreation trips from throughout the contiguous U.S. to different shoreline areas in the GOM Region. This behavior, combined with the costs associated with different site choice options, form the basis of the models' valuation of recreation. Calibrating the models to the reduction in use measured through the overflights and infield surveys (see Tables 9 and 10), the Trustees estimated a value per lost user day of $36.25 for shoreline use and inland fishing and $16.20 per day for boating, both in year 2015 dollars. In year 2019 dollars, these values are $39.17 and $17.51, respectively. When applied to the lost user day estimates presented above in Tables 9 and 10, this translates to losses of more than $497 million in total, as summarized in Table 11.

Table 11. Summary of Tier 1 recreation impacts associated with the *Deepwater Horizon* spill

	Lost User Days	Value Of Recreation Impacts (2019$)
Shoreline	**12,325,512**	$482,800,000
North Gulf	8,599,386	$336,900,000
Peninsula	3,870,176	$151,600,000
Inland Fishing	**144,050**	$5,600,000
Boating	**215,374**	$3,800,000
Total		**$497,900,000**

Note: The value of recreation impacts presented in this table is lower than the estimate of approximately $523 million in the PDARP for the *Deepwater Horizon* spill. The difference reflects the compounding of damages from 2010 to 2015 in the PDARP. For the purposes of the present analysis, we do not compound impacts.

Source: Values derived from English and McConnell (2015). Values from this memorandum were converted to year 2019 dollars.

The Tier 1 losses shown in Table 11 reflect the extensive infield data collection undertaken by the Trustees. The coverage of the infield studies, however, does not include all locations, times of day, or months impacted by the spill. For example, the study team's primary infield data collection did not capture use of the beach at night. To address these gaps in coverage, the Trustees performed a series of supplemental analyses using various other data sources. These Tier 2 analyses and the losses estimated by each analysis are summarized in Table 12.

Table 12. Tier 2 secondary shoreline study damages

<table>
<tr><th></th><th>Coverage Gap Filled</th><th colspan="2">Lost User Days</th><th>Damages ($2019)</th></tr>
<tr><td rowspan="4">Early data collection</td><td rowspan="4">Lost user days in May 2010 not included in Tier 1</td><td>Shoreline use</td><td>1,550,137</td><td rowspan="4">$62,900,000</td></tr>
<tr><td>Inland fishing</td><td>22,708</td></tr>
<tr><td>Boating</td><td>72,871</td></tr>
<tr><td>Total:</td><td>1,645,716</td></tr>
<tr><td>Supplemental shoreline study</td><td>Shoreline activity before regular sampling hours for the Tier 1 study</td><td colspan="2">1,234,821</td><td>$48,400,000</td></tr>
<tr><td>Backyard boating</td><td>Boating activity for boats launched from private residences</td><td colspan="2">22,895</td><td>$400,000</td></tr>
<tr><td>Night fishing</td><td>Fishing occurring outside the daily sampling hours</td><td colspan="2">152,517</td><td>$6,000,000</td></tr>
<tr><td>For-hire fishing</td><td>Fishing from for-hire fishing boats</td><td colspan="2">216,089</td><td>$8,500,000</td></tr>
<tr><td>Fixed costs of boating</td><td>Underestimate of value due to fixed costs incurred</td><td colspan="2">Not applicable</td><td>$2,700,000</td></tr>
<tr><td>National parks and other Federal lands</td><td>Federal lands outside Tier 1 sample area</td><td colspan="2">23,276</td><td>$900,000</td></tr>
<tr><td colspan="4">TOTAL</td><td>$129,700,000</td></tr>
</table>

Source: Adapted from NOAA (2016). Monetized values converted to year 2019 dollars without compounded interest.

Combining the Tier 1 and Tier 2 damages yields 15,669,110 lost user days for shoreline use and inland fishing and 311,140 lost user days for boating. Together, these correspond to damages of approximately $628 million, as shown below in Table 13. Dividing this estimate by the *Deepwater Horizon* spill size (3.19 million barrels, net of oil recovered by BP), the estimated impacts to GOM beach recreation on a per-barrel basis are approximately $197.[19]

Table 13. Summary of recreational impacts associated with the *Deepwater Horizon* oil spill

Tier	Value Of Recreational Impacts (2019$)
Tier 1 (Primary Analysis)	$497,900,000
Tier 2 (Supplemental Analyses)	$129,700,000
Total	**$627,600,000**

Note: Totals may not sum due to rounding.

[19] See U.S. District Court (2015) for the estimate of the spill volume.

2.3.1.2 Atlantic

As noted above, the impacts of a CDE on coastal recreation will depend on when and where a CDE occurs. For the purposes of estimating the recreational impacts of a CDE in the Atlantic Region, we examine two hypothetical CDE scenarios per planning area: one scenario affecting recreational use in that planning area only and a second scenario affecting recreation in that planning area plus one state north of the planning area and one state south. For the Straits of Florida Planning Area, the second scenario assumes a reduction in recreation for the entire State of Florida.

In addition to a CDE's location, its timing and the duration of its impact are also highly uncertain. As a simplifying assumption, this analysis examines the impacts of a hypothetical CDE in the Atlantic with timing and duration of impacts consistent with the *Deepwater Horizon* spill in the GOM. Specifically, we assume that the CDE would occur in the spring and would affect shoreline recreation (beach use and fishing on sandy beaches) and recreational fishing as follows:

- ***Shoreline recreation:*** We assume that the CDE would affect shoreline recreation from May of the year that the spill occurs through November of the following year. This time horizon is consistent with the duration of shoreline impacts in the North Gulf following the *Deepwater Horizon* spill (see Table 8 above). Although it is possible that the duration of impacts may be shorter for areas relatively far from the CDE site (i.e., similar to the Florida Peninsula for the *Deepwater Horizon* spill), we assume a 19-month impact period consistent with that for the North Gulf to avoid potential underestimation of impacts.

  In specifying shoreline recreation in the baseline, we split the 19-month period into two sub-periods: May to January and February to November. As described in greater detail below, we assume different percent changes in use for these two periods, based on the changes observed following the *Deepwater Horizon* spill.

- ***Recreational fishing:*** We assume that a CDE in each of the planning areas in the Atlantic Region would affect inland fishing from May of the spill year through March of the following year across the entire area. We assume that non-inland boat fishing would be affected from May through August of the spill year. These time horizons are consistent with the assessments of inland fishing impacts and boating impacts for the *Deepwater Horizon* spill.

Note that our quantitative assessment of potential recreational impacts in the Atlantic does not include boating impacts outside of boat-based fishing or wildlife viewing. Although a CDE is likely to affect other boating in the Atlantic, the available data on boating in this region are limited. In addition, the results of the *Deepwater Horizon* lost recreational use assessment suggest that boating impacts are small relative to impacts related to beach use and fishing. Similarly, we also do not have consistent estimates of baseline wildlife viewing outside of Alaska.

To develop estimates of baseline beach use for the Atlantic planning areas, we rely on beach recreation data from a recent study on Atlantic beach recreation (Parsons and Firestone 2018), along with data on beach length to extrapolate to other regions. Parsons and Firestone (2018) provided annual estimates of the number of beach trips for the ocean beaches for most of the Atlantic states between South Carolina and Massachusetts. We calculate the total days of beach visitation by multiplying by the average length of each type of trip.[20] In addition, we use the baseline shoreline visitation data related to the *Deepwater Horizon* damage assessment to derive baseline beach use for the Straits of Florida and the portion of the South Atlantic Planning Area adjacent to Florida.

[20] Parsons and Firestone (2018) estimates the frequency of each of three types of trips: day trips, short overnights (three or fewer nights) and long overnight trips (four to 29 days). The average length of a short overnight trip was 2.1 days; the average length of a long overnight trip was 6.3 days.

To estimate the percentage of annual beach visits occurring during the May–January period and the February–November period, we examined the National Park Service's monthly visitation data for 2013–2017 for all Atlantic National Seashores, including Cape Cod (Massachusetts), Fire Island (New York), Assateague Island (Maryland), Cape Hatteras (North Carolina), Cape Lookout (North Carolina), Cumberland Island (Georgia), and Canaveral (Florida) (NPS 2014). Based on these monthly data, we estimate the percentage of trips, by planning area, occurring during each of these two periods (May–anuary and February–November). We then apply these percentages to the annual use data derived from the sources described above. Individual seashores were mapped to planning areas as follows:

- ***Straits of Florida and South Atlantic:*** Canaveral and Cumberland National Seashores.
- ***Mid-Atlantic:*** Assateague Island, Cape Hatteras, and Cape Lookout National Seashores.
- ***North Atlantic:*** Fire Island and Cape Cod National Seashores.

Table 14 presents our baseline estimates for the Atlantic planning areas and indicates the basis of the estimate for each state. To provide additional perspective on use in the Atlantic, the exhibit also includes subtotals for each planning area.[21]

Table 14. Shoreline visits baseline for the Atlantic

State/ Region	**Baseline Shoreline Visitation (Millions of User Days)**		**Source/Method**
	Annual	**18-month spill period**	
Maine	18.3	33.7	Apply estimated beach use per beach mile for Rhode Island, as derived from Parsons and Firestone (2018) and EPA (2018), to Maine beach miles reported in EPA (2018).
New Hampshire	5.2	9.47	Apply estimated beach use per beach mile for Rhode Island, as derived from Parsons and Firestone (2018) and EPA (2018), to New Hampshire beach miles reported in EPA (2018).
Massachusetts	36.2	66.6	Parsons and Firestone (2018) only report visitation for the outer coast of Cape Cod. Extrapolate estimated day-trip beach use per beach mile on Cape Cod, as derived from Parsons and Firestone (2018) and EPA (2018), to rest of MA beaches.
Rhode Island	14.8	27.3	Parsons and Firestone (2018) only report visitation for the ocean beaches in RI. Extrapolate estimated beach use per beach mile, as derived from Parsons and Firestone (2018) and EPA (2018) to rest of RI beaches (Narragansett Bay).
Connecticut	9.1	16.8	Apply estimated beach use per beach mile for Rhode Island, as derived from Parsons and Firestone (2018) and EPA (2018), to Connecticut beach miles reported in EPA (2018).
New York	39.5	72.6	Parsons and Firestone (2018) only report visitation for the ocean beaches in New York. Extrapolate estimated beach use per beach mile, as derived from Parsons and Firestone (2018) and EPA (2018), to rest of New York beaches (Long Island Sound).
New Jersey	45.1	82.9	Estimated beach use from Parsons and Firestone (2018)
North Atlantic Total	168.3	309.3	

[21] Baseline data are only presented for periods in which impacts are expected.

State/ Region	Baseline Shoreline Visitation (Millions of User Days)		Source/Method
	Annual	18-month spill period	
Delaware	11.3	20.8	Parsons and Firestone (2018) reports visitation only for the ocean beaches in Delaware. Calculated total beach use for Delaware based on the sum of estimated beach use from Parsons and Firestone (2018) and beach use at Delaware Bay beaches from Parsons (2013).
Maryland	12.1	22.2	Use estimated beach use for ocean beaches in Maryland. Apply estimated beach use per bay beach mile for Delaware's bay beaches, as derived from Parsons (2013), to Maryland bay beach miles reported in EPA (2018).
Virginia	13.7	25.1	Use estimated beach use for ocean beaches in Virginia from Parsons and Firestone (2018). Extrapolate estimated beach use per bay beach mile for Delaware, as derived from Parsons (2013) and EPA (2018), to bay beach miles in Virginia reported in EPA (2018).
North Carolina	33.4	61.3	Estimated beach use from Parsons and Firestone (2018).
Mid-Atlantic Total	70.5	129.4	
South Carolina	47.2	74.6	Estimated beach use from Parsons and Firestone (2018).
Georgia	14.4	22.8	Apply estimated beach use per beach mile for North Carolina, as derived from Parsons and Firestone (2018) and EPA (2018), to Georgia beach miles reported in EPA (2018).
Florida (South Atlantic)	12.4	19.5	Extrapolate *Deepwater Horizon* damage assessment beach use values for Florida to entire state using the regional distribution of beach use estimated in the Florida SCORP (2013) and Florida Participation Survey (2018).
South Atlantic Total	74.0	116.9	
Straits of Florida Total	24.5	38.8	Extrapolate *Deepwater Horizon* damage assessment beach use values for Florida to entire state using the regional distribution of beach use estimated in the Florida SCORP (2013) and Florida Participation Survey (2018).

We estimate baseline use for recreational fishing for the Atlantic Region based on inland angler trip and non-inland boat-based angler trip data from NOAA's MRIP (NOAA 2018).[22] NOAA's MRIP was initiated in 2007 and generates estimates of angler's catch and effort; the data are collected in six two-month periods (i.e., waves). Angler trip data for Wave 1 (January and February), Wave 2 (March and April), Wave 3 (May and June), Wave 4 (July and August), Wave 5 (September and October), and Wave 6 (November and December) were downloaded for all Atlantic states for the years 2012–2016. To limit the angler trip data to the assumed impact period of a CDE for inland fishing (May–March), we divide Wave 2 data for each year and state by two, assuming that fishing activity is evenly split between the two months in each wave. For every state and wave, we then calculate the average number of inland angler trips across the five years for which we compiled data. For example, we average the number of angler

[22] Note that we include only inland fishing (by boat or shore) and all other boat-based fishing. We do not use the data for all angling to avoid potential double counting of anglers that are likely to be reflected in the data that we use to estimate beach visitation. Because the beach visitation data include any activities on the beach, we only analyze recreational fishing impacts outside of sandy beaches.

trips taken during Wave 3 (May and June) in Delaware across the years 2012, 2013, 2014, 2015, and 2016. We then sum the wave-level averages for each state to determine the average number of trips during the assumed impact period (May–March). For Florida planning areas, we use county-level angler trip data from MRIP and aggregate by planning area. Summing across states, we estimate slightly less than 21.5 million baseline angler trips for the Atlantic Region, as shown in Table 15 below. We follow a similar process to estimate baseline non-inland boat-based fishing trips using the same data source. However, we use the impact period of May–August for these additional boat-based trips, following the *Deepwater Horizon* damage assessment's impact period for boating trips, as shown in Table 8.

To estimate the change in recreation associated with a CDE in the Atlantic Program Area, we assume that proportional changes in recreational activity estimated in the GOM due to the *Deepwater Horizon* spill would also apply to the Atlantic. Thus, consistent with the data presented above in Tables 9 and 10 for shoreline use, inland fishing and boating, we assume that a CDE occurring in the spring would lead to a 32.5 percent reduction in shoreline use and inland fishing combined from May through January across the entire Mid-Atlantic.[23] For February through November during the year following the CDE, we assume a 10 percent reduction in use. For boat-based fishing not captured in the inland data, we assume that the same 28.4 percent reduction in recreational boating from the *Deepwater Horizon* spill applies. Based on these assumptions and the baseline data presented above in Tables 14 and 15, we estimate the reductions in shoreline visits and recreational fishing trips for a CDE occurring in each planning area, as presented below in Table 16. As described above, we estimate reductions in use for two CDE scenarios per planning area: one scenario in which the reduction in recreation is limited to that planning area and another in which the reduction in use occurs in that planning area as well as the states immediately north and south of the planning area.

[23] Ideally, we would derive separate estimates of the percent reduction in use for shoreline use and inland fishing. The PDARP and associated administrative record for the *Deepwater Horizon* spill, however, do not include baseline estimates for inland fishing alone. Instead, the baseline data include shoreline use and inland fishing together.

Table 15. Recreational inland angler trips baseline for the Atlantic: May–March impact period

State	Estimated Number of Inland Angler Trips May–March (millions)	Non-Inland Boat Angler Trips May–August (millions)	Total Baseline Angler Trips (millions)
Maine	0.172	0.0645	0.237
New Hampshire	0.0969	0.0452	0.142
Massachusetts	1.94	0.157	2.09
Rhode Island	0.608	0.0557	0.664
Connecticut	1.29	0.0218	1.31
New York	2.61	0.218	2.83
New Jersey	2.53	0.227	2.76
North Atlantic Total	9.24	0.789	10.0
Delaware	0.537	0.0185	0.555
Maryland	2.22	0.0419	2.26
Virginia	1.92	0.0185	1.94
North Carolina	1.89	0.278	2.17
Mid-Atlantic Total	6.57	1.59	8.16
South Carolina	0.957	0.0885	1.04
Georgia	0.511	0.0297	0.540
Florida (South Atlantic)	2.07	0.435	2.50
South Atlantic Total	3.54	0.553	4.09
Straits of Florida Total	2.17	0.711	2.88
Atlantic Total	21.5	3.64	25.2

Table 16. Estimated reduction in recreational activity in the Atlantic Region following a CDE

Region of CDE	Estimated Reduction in Shoreline Visits (millions)	Estimated Reduction in Recreational Fishing Trips (millions)
North Atlantic		
Scenario 1: Reduced use in North Atlantic only	64.9	3.18
Scenario 2: Reduced use in North Atlantic, Delaware, Maryland, and Virginia	79.0	4.68
Mid-Atlantic		
Scenario 1: Reduced use in Mid-Atlantic Only	26.9	2.51
Scenario 2: Reduced use in Mid-Atlantic, New Jersey, and South Carolina	59.1	3.69
South Atlantic		
Scenario 1: Reduced use in South Atlantic Only	23.2	1.32
Scenario 2: Reduced use in South Atlantic, North Carolina, and Straits of Florida	43.7	2.94
Straits of Florida		
Scenario 1: Reduced use in Straits of Florida Only	7.71	0.951
Scenario 2: Reduced use in Straits of Florida and Florida (South Atlantic)	11.6	1.79
SCERARIO 1 TOTAL	123	7.96
SCENARIO 2 TOTAL	193	13.1

We estimate the value of lost recreational use in the Atlantic based on the results of studies from the empirical environmental economics literature. For beach use in the North Atlantic, we rely on a single study. Parsons (2000) applies a per beach trip value of $28.02 in 1997 dollars for the damage assessment of lost human use for the Buzzards Bay oil spill, which we adopt here ($42.66 converted to 2019 dollars) (Bouchard B-120 Oil Spill Lost Use Technical Working Group 2009).[24] For beach use in the Mid-Atlantic, we rely on two specific studies from this literature. Parsons et al. (2013) estimates $32.89 per lost trip (in 2011 dollars) associated with Delaware Bay. Focusing on the value of seven different beaches in North Carolina, Bin (2005) estimates user day values ranging from $21 to $72 for these beaches. Averaging across these studies and converting to year 2019 dollars, we estimate a value of $51.81 per activity day for the Mid-Atlantic. For the South Atlantic, we rely on the average of Landry and McConnell (2007), which estimates between $7.38 and $8.75 per beach day in Georgia (1998 dollars) and Bell and Leeworthy (1990), which estimates a value of $34 per beach day at Florida beaches. We apply an average of $36.31 for the South Atlantic Region (2019 dollars). For the Straits of Florida, we apply the values of the Eastern GOM used in the *Deepwater Horizon* damage assessment, as discussed above.

As shown in Table 17, applying these value to the estimated reduction in beach visitor days associated with a CDE, we estimate a range of losses in the value of beach recreation of $298 million for the Straits of Florida to $3.50 billion in the North Atlantic.

[24] This value was derived using a model that was originally developed by Parsons (2000), The model was adapted for use in the Buzzards Bay assessment.

To estimate the value of the reduction in recreational fishing in the Atlantic, we apply value-per-trip estimates obtained from valuation studies that focus specifically on this region.[25] For the North Atlantic, McConnell and Strand (1994) estimate a mean WTP for one day fishing trips by wave (e.g., March/April, May/June, etc.) for nine East Coast states, with a weighted average of $46.26 across all North Atlantic States and waves (in 1988 dollars).[26] Johnston et al. (2003) estimates a per-trip value of $40.25 in New York (1995 dollars). We use the average of the McConnell and Strand (1994) and the Johnston et al. (2003) studies to estimate a value of $76.10 for the North Atlantic in 2019 dollars. For the Mid-Atlantic, we use the average value across the Mid-Atlantic states analyzed in McConnell and Strand (1994), or $83.84 in 2019 dollars. For the South Atlantic, Haab, Whitehead, and McConnell (2000) estimate the value per recreational fishing trip from North Carolina to Louisiana. We use the average of the values for South Atlantic states from Haab, Whitehead and McConnell (2000) and McConnell and Strand (1994), which results in an estimate of $80.84 in 2019 dollars. Similar to estimating beach use values, we apply the inland fishing value from the *Deepwater Horizon* Damage Assessment to the Straits of Florida. Based on these value and the lost shoreline and fishing trips estimated above, we estimate total recreation losses from a CDE in Table 17 below.

Table 17. Summary of recreational damages associated with a CDE in the Atlantic

Planning Area/Scenario	Recreation Damages (2019$)				
	Shoreline Use		Recreational Fishing		
	Total (million$)	Per Barrel	Total (million$)	Per Barrel	Total (million$)
North Atlantic					
Scenario 1: North Atlantic Only	$2,769	$868	$242	$75.8	$3,011
Scenario 2: North Atlantic, Delaware, Maryland, and Virginia	$3,501	$1,098	$367	$115	$3,868
Mid-Atlantic					
Scenario 1: Mid-Atlantic Only	$1,391	$436	$211	$66.1	$1,602
Scenario 2: Mid-Atlantic, New Jersey, and South Carolina	$2,672	$838	$302	$94.7	$2,974
South Atlantic					
Scenario 1: South Atlantic Only	$844	$265	$107	$33.4	$951
Scenario 2: South Atlantic, North Carolina, and Straits of Florida	$1,801	$565	$201	$63.0	$2,002
Straits of Florida					
Scenario 1: Straits of Florida Only	$298	$93.5	$38.4	$12.0	$337
Scenario 2: Straits of Florida and Florida (South Atlantic)	$439	$138	$106	$33.2	$545
SCENARIO 1 TOTAL	$5,303	N/A	$598	N/A	$5,900
SCENARIO 2 TOTAL	$8,414	N/A	$976	N/A	$9,390

[25] Although we find regional studies, most of the studies include other types of fishing than inland fishing (e.g., fishing trips on charter boats), which may overestimate the per-trip valuation.

[26] Average is calculated by weighting by total fishing trips in sample.

To estimate recreational damages on a per-barrel basis, we divide the estimated shoreline and inland fishing damages by the spill volume associated with the *Deepwater Horizon* spill (3.19 million barrels) (U.S. District Court for the Eastern District of Louisiana 2015), which results in a range of estimates from $94 to $1,098 per barrel for shoreline use and $12 to $115 per barrel for inland- and boat-based fishing, both in year 2019 dollars. Although the spill volume associated with a CDE in the Atlantic may differ from the volume associated with the *Deepwater Horizon* blowout, we determined that this would be the most appropriate spill volume to use given that our analysis for the Atlantic uses the percentage reduction in shoreline use for the GOM.

2.3.1.3 Pacific

This section follows the same methods and structure as the estimation of damages to recreation from a CDE in the Atlantic. Lacking any other catastrophic spill examples in the continental U.S., we use the same assumptions from the *Deepwater Horizon* damage assessment as applied in the Atlantic section above. First, we present baseline recreational use data for shoreline use and fishing in the Pacific Region. We then estimate lost trips and apply valuation studies from the empirical economic literature to estimate the total damages related to potential CDEs in the region.

To estimate baseline beach visitation, we rely on SCORPs from Oregon and Washington, which provide estimates of resident beach visitation. For Southern California, we use an estimate of beach use from the South Coast Recreation Survey and another California state survey conducted by the California state parks to estimate beach use outside of Southern California.

As for the Atlantic OCS regions, we use seasonal visitation data for National Seashores to distribute and scale annual baseline visisation data to the two impact periods (May to January, February to November). For all planning areas in the Pacific Region, we use Point Reyes National Seashore data from 2013 to 2017 as the basis for distributing annual visition data to individual months of the year. With baseline visition specified by month, we are able to estimate use for each of the two impact periods. Table 18 below presents baseline shoreline visitation for the Pacific planning areas along with the source used to derive the estimated visitation.

Table 18. Shoreline use baseline for the Pacific

State/Region	Number of Beach Visits (millions)		Source/Method
	Annual	18-Month Impact Period	
Washington	12.4	20.1	Estimate number of beach days from Washington SCORP (2013) using reported average days of participation, percent of beach use occurring at saltwater beaches, and percent of residents participating in beach activities.
Oregon	17.3	28.0	Use value reported in Oregon SCORP (2013) for saltwater beach activities.
Washington/Oregon Total	29.7	48.1	
Northern California	5.13	8.32	Extrapolate total beach visitation from the South Coast Recreation Survey (Chen et al. 2015) to planning area based on distribution of residential beach use in the CA Survey of Public Opinions and Attitudes (SPOA 2012).
Central California	40.6	65.9	
Southern California	69.8	113	Use value reported in South Coast Recreation Survey (Chen et al. 2015) for beach visitation.

We estimate baseline use for recreational fishing for the Pacific planning areas using recreational fishing survey data similar to that used for the Atlantic. The California Recreational Fisheries Survey (CRFS) has similar inland boat-based angler trip data as reported by MRIP. Both this data and recreational fishing trip data for Washington and Oregon was accessed from the Recreational Fisheries Information Network (RecFIN) database. We use the average monthly angler trips over the last five years (2013–2017) to estimate the total angler trips taken during the assumed May–March spill period. The RecFIN data for recreational angler trips is available for two regions in California: Southern California and Northern California. We assume that all Southern California angler trips in the RecFIN data are also in the Southern California Planning Area. To divide the Northern California RecFIN region into the Central and Northern California Planning Areas, we use RecFIN data on total fish caught at the county level. Specifically, we assume that baseline recreational fishing in the Northern California RecFIN region is divided between Central and Northern California Planning Areas in proportion to the total fish caught in the counties that comprise the Northern California region reported in RecFIN. In addition, because the angler trip data available for Oregon and Washington do not include inland fishing, we assume that the percent of fishing trips in Northern California that are inland trips applies to Washington and Oregon. Table 19 below displays the baseline recreational fishing trip data during the impact period.

Consistent with the analysis for the Atlantic planning areas, we assume the same proportional changes in baseline recreation activity estimated due to the *Deepwater Horizon* oil spill would apply to the Pacific. Table 20 below shows the estimated reduction in shoreline visits and recreational angler trips for each planning area for two scenarios: one in which the reduction in use is limited to the planning area where the CDE occurs and a second in which the reduction in use also occurs in the neighboring planning area(s).

We estimate the value of lost recreational use in the Pacific based the literature for the regions of interest. We use the same value for beach use of $22.65 (2007 dollars) applied in the Damage Assessment for the *Cosco Busan* oil spill in the San Francisco Bay Area, cited in English (2010) for all Pacific planning areas outside of Southern California. Adjusting for inflation, this value is $27.66 in year 2019 dollars. For Southern California, we use the average of two studies that estimate the value of beach use: Lew and Larson (2008) and Leggett et al. (2014), which yields a value of $33.91 in 2019 dollars.

Table 19. Baseline recreational angler trips for the Pacific Region: May–March impact period

State/Planning Area	Inland Fishing Trips (May–March)	Non-Inland Boat Fishing Trips (May–Aug)	Total Recreational Fishing Trips
Southern CA	651,030	957,875	1,608,904
Central CA	268,458	232,518	500,976
Northern CA	57,484	254,632	312,117
Washington/Oregon	109,997	41,792	101,505
Oregon	59,713	41,659	91,943
Washington	50,284	83,451	193,448
TOTAL	**1,086,968**	**1,528,476**	**2,615,445**

Table 20. Estimated reduction in recreation use related to a CDE in the Pacific

Planning Area and Scenario	Estimated Reduction in Shoreline Visits (millions)	Estimated Reduction in Fishing Trips (millions)
Washington/Oregon		
Scenario 1: Reduced use in WA/OR only	9.84	0.0588
Scenario 2: Reduced use in WA/OR and Northern CA	11.5	0.148
Northern California		
Scenario 1: Reduced use in North CA only	1.70	0.0891
Scenario 2: Reduced use in WA/OR, Northern CA, and Central CA	25.0	0.293
Central California		
Scenario 1: Reduced use in Central CA only	13.5	0.145
Scenario 2: Reduced use in all CA	38.3	0.702
Southern California		
Scenario 1: Reduced use in South. CA only	23.1	0.468
Scenario 2: Reduced use in Southern CA and Central CA	36.6	0.613
SCENARIO 1 TOTAL	48.2	0.760
SCENARIO 2 TOTAL	111.5	1.76

To estimate the value of lost recreational fishing trips related to a CDE, we use the value of a recreational fishing trip of $53.85 in 2019 dollars used in Leggett and Curry (2010) related to the *Cosco Busan* oil spill for all the entire Pacific Region.[27] The total estimated damages from a CDE to each Pacific planning area are shown in Table 21 below for the same two scenarios described above. The total estimated damages are also presented per barrel of oil spilled, assuming the size of the *Deepwater Horizon* spill is representative of an oil spill in the Pacific.

[27] Leggett and Curry adjust Kling and Thompson (1996) for use in the *Cosco Busan* damage assessment. We use the values adjusted by Leggett and Curry for shore-based and boat-based fishing, and apply a single weighted average based on the average proportion of boat and shore trips as collected from RecFIN.

Table 21. Estimated economic damages related to a CDE in the Pacific

Planning Area/Scenario	Recreation Damages (2019$)				
	Shoreline Use		Fishing		
	Total (million$)	Per Million Barrels	Total (million$)	Per Million Barrels	Total (million$)
Washington/Oregon					
Scenario 1: Reduced use in WA/OR only	$272	$85	$3.16	$0.992	$276
Scenario 2: Reduced use in WA/OR and Northern CA	$319	$100	$7.97	$2.50	$327
Northern California					
Scenario 1: Reduced use in Northern CA only	$47.1	$15	$4.80	$1.505	$52
Scenario 2: Reduced use in WA/OR, Northern CA, and Central CA	$692	$217	$15.8	$4.94	$708
Central California					
Scenario 1: Reduced use in Central CA only	$373	$117	$7.79	$2.44	$381
Scenario 2: Reduced use in all CA	$1,205	$378	$37.8	$11.8	$1,242
Southern California					
Scenario 1: Reduced use in Southern CA only	$785	$246	$25.2	$7.9	$810
Scenario 2: Reduced use in Southern CA and Central CA	$1,158	$363	$33.0	$10.3	$1,191
SCENARIO 1 TOTAL	$1,477	N/A	$41	N/A	$1,518
SCENARIO 2 TOTAL	$3,374	N/A	$94	N/A	$3,469

2.3.1.4 Alaska

For Alaska, our assessment of the shoreline recreational impacts of a CDE is limited to recreational fishing in the Gulf of Alaska and Cook Inlet Planning Areas, as beach use is likely to be minimal in the area's relatively cool climate, and recreational fishing activity is minimal outside these planning areas.[28] The data sources that we apply for Alaska, however, differ significantly from those applied in other OCS regions, as detailed below.

To estimate the baseline number of recreational fishing trips in Alaska, we use data available from MRIP on the annual number of saltwater angler trips in the State of Alaska, obtained through the same method as for the Atlantic Region. We also integrate these data with regional recreational fishing data for the Gulf of Alaska and Cook Inlet from the Alaska Department of Fish and Game's Sport Fishing Survey to estimate the regional distribution of the total annual angler trips (ADFG 2018b). The Department's Sport Fish Division has conducted the survey annually by mail since 1977 and uses the data collected to estimate the state's sport fishing harvest by species and the total level of sport fishing activity. Table 22

[28] According to ADFG (2018), 98 percent of all recreational saltwater fishing days were spent in either the Gulf of Alaska or Cook Inlet.

below displays the average annual recreational saltwater angler trips by Alaska planning area between 2013–2017.[29]

As an indicator of the potential reduction in recreational fishing in Cook Inlet and the Gulf of Alaska in response to a CDE, we assume that the reduction observed in southcentral Alaska following the *Exxon Valdez* spill would also apply to recreational fishing in both planning areas. Based on the Alaska Department of Fish and Game's annual survey of Alaska anglers, Mills (1992) estimates that the *Exxon Valdez* spill led to a 14.9 percent reduction in fishing trips between 1988 and1989 in the area affected by the spill. Applying this percent reduction to the baselines of 159,300 angler trips in Cook Inlet and 391,700 angler trips in the Gulf of Alaska results in angler trip losses of 23,700 trips and 58,400 trips in the two planning areas, respectively.

To place a value on angler days in Cook Inlet and the Gulf of Alaska, we draw from the values estimated in two studies: Hamel (2000) and Hausman (1995). Hamel (2000) estimates the mean compensating variation per fishing day for Central and Lower Cook Inlet for both Alaskans ($81.47 in year 1997 dollars) and non-residents ($119.79 in year 1997 dollars). Together, the average compensating variation in year 2019 dollars is $153.20. In the context of the *Exxon Valdez* spill, Hausman (1995) estimates a 1989 consumer surplus per sport fishing trip of $148. Inflated to 2019 dollars, this estimate is $273.25. Averaging across studies, we arrive at $213.23 per fishing trip in year 2019 dollars. Applying this value to the estimated lost angler trips lost due to a CDE occurring in Cook Inlet or the Gulf of Alaska results in total damages of $5.06 million and $12.4 million for the two areas, respectively. On a per-barrel basis (using the spill size from *Exxon Valdez* of 257,000 barrels), estimated loses are $19.69 and $48.42 in 2019 dollars for Cook Inlet and the Gulf of Alaska, respectively. We use the spill volume from the *Exxon Valdez* spill to calculate damages on a per-barrel basis because the percentage reduction in recreational fishing reflected in our damages estimate is based on the impact of the *Valdez* spill.

Table 22. Summary of recreational fishing damages for CDEs occurring in Alaska Region

CDE Planning Area	Baseline Recreational Fishing Trips	Lost Trips	Estimated Damages (2019$)	
			Total	Per Barrel
Gulf of Alaska	391,680	58,360	$12,444,006	$48.42
Cook Inlet	159,256	23,729	$5,059,699	$19.69
TOTAL	550,937	82,090	$17,503,705	N/A

2.3.2 Wildlife Viewing

In addition to impacting beach use and recreational fishing, a CDE may also affect recreational wildlife viewing in coastal areas. Our assessment of the impacts of a CDE on wildlife viewing focuses on Cook Inlet and the Gulf of Alaska, as wildlife viewing represents an appreciable portion of coastal recreation in these areas. We were unable to identify wildlife viewing data specific to Cook Inlet and the Gulf of Alaska, but such data are available in aggregate for southcentral and southeast Alaska. Because Cook Inlet makes up a substantial portion of southcentral Alaska and offers an abundance of wildlife viewing opportunities, we apply the data for southcentral Alaska as an indicator of wildlife viewing in Cook Inlet.

[29] The Sport Fishing Survey from ADFG (2018b) only provides angler *days* by region. We instead use the total number of angler trips reported in the state-level MRIP data for inland fishing, and apply the spatial distribution of angler days from ADFG to develop the angler trip estimates for Alaska Planning Areas.

Similarly, a majority of the Gulf of Alaska Planning Area borders the entirety of the southeast Alaska Region.

To develop an estimate of baseline wildlife viewing, we integrate data from several sources, based on the following three-step approach.

1. ***Estimate visitation to southcentral and southeastern Alaska:*** As an initial step in estimating the baseline level of wildlife viewing on an annual basis, we estimate the total visitation to southeastern and southcentral Alaska in the typical year. We assume that southeast Alaska is representative of the Gulf of Alaska Planning Area and southcentral Alaska is representative of the Cook Inlet Planning Area. Based on visitation data for the years 2012 through 2016 from the McDowell Group (2017), we estimate that there are approximately 1,715,000 non-resident trips to Alaska each year on average. According the same report, 67 percent and 52 percent of visitors visited the southeast and southcentral regions, respectively, in 2016 (McDowell Group 2017). Applying these values to the total number of visitors to the state, we estimate that approximately 1.15 million individuals visit southeastern Alaska each year and 892,000 individuals visit southcentral Alaska annually. Although much of the wildlife viewing in Alaska may be in areas other than Cook Inlet or the Gulf of Alaska, we use these data to develop a conservative (i.e., potentially high end) estimate of the potential impacts of a CDE occurring in either of these two areas.
2. ***Estimate number of visitors to southcentral and southeastern Alaska engaged in wildlife viewing:*** The McDowell Group (2017) also indicates that 45 percent of visitors to Alaska engage in wildlife viewing. Based on this value and the estimated visitors to southeastern and southcentral Alaska on an annual basis, we estimate that approximately 517,000 visitors to southeastern Alaska and 401,000 visitors to southcentral Alaska engage in wildlife viewing on an annual basis.
3. ***Estimate wildlife viewing days:*** To translate the number of wildlife viewing visitors to the number of wildlife viewing days in southeastern and southcentral Alaska, we derive a multiplier using valuation data from the FWS (2014). The FWS study reports that the average days per trip for non-residents for wildlife watching was four days in Alaska in 2011. Applying this value to the numbers of visitors presented above (517,000 visitors in southeastern Alaska and 401,000 visitors in southcentral Alaska), we estimate an average of 2.07 million and 1.61 million wildlife viewing days in the two areas, respectively.

Consistent with BOEM's 2015 analysis of catastrophic spill impacts, we assume a high-impact spill scenario in which a CDE occurs in the summer and lasts for 80 days, which represents 53 percent of the summer season (BOEM 2012). Based on this value and assuming that wildlife viewing is uniformly distributed over the summer season, we estimate that a CDE in the Gulf of Alaska would affect 1.10 million wildlife viewing days and that a CDE in Cook Inlet would affect 851,000 wildlife viewing days. To estimate the economic value of these losses, we assume that half of the value of a wildlife viewing day will be lost for affected trips. Applying this assumption to the FWS (2009) estimate of the mean per-day value of wildlife viewing in Alaska for non-residents ($132 adjusted to year 2019 dollars), we estimate a loss of approximately $66 per affected viewing day. Thus, we estimate wildlife viewing losses of approximately $72.2million for a CDE occurring in the Gulf of Alaska and $56.0 million for a CDE occurring in Cook Inlet (BOEM 2012). Because the assumptions specified in this section may apply to CDEs of varying sizes, we do not express these damages on a per-barrel basis.

2.4 Commercial Fishing

The occurrence of a CDE could have wide-ranging impacts on commercial fisheries in the affected region. Most directly related to the supply of commercially harvested species, exposure to discharged oil may result in several adverse effects to these species, such as premature hatching, reduced growth rates, genetic abnormalities, and mortality, each of which would contribute to reduced landings (Sumaila et al. 2012). In addition to these direct effects, indirect exposure to discharged oil through the food web may adversely affect the condition and/or abundance of harvested species. Even if vessel operators are able to maintain landings at historical levels in the face of these direct and indirect effects, the cost of achieving these landings may increase, putting upward pressure on seafood prices. With respect to demand, consumers may reduce their consumption of seafood in response to a spill to avoid real or perceived risks associated with consuming contaminated seafood. In effect, consumers' WTP for seafood (i.e., the value that they derive from seafood) may fall, at least temporarily, as a result of a spill.

Accurately estimating the welfare losses associated with the commercial fishery impacts of a CDE would require detailed information on affected fisheries, both before the spill and in its aftermath. In particular, such an analysis would require information on changes in landings, production costs, consumption, and pricing. Gauging the changes in these variables, however, is fraught with uncertainty. Depending on the timing and location of a CDE, changes in landings could vary. For example, a spill that occurs in close proximity to a fishery immediately before the start of the fishing season would likely lead to higher impacts to landings than spills farther away from fisheries at the end of the season. The extent to which vessel operators are able to make operational changes to minimize the impact of a spill is also likely to vary. Fishermen harvesting mobile species that limit their exposure to discharged oil might be able to fish in areas not impacted by the spill and achieve the same or similar landings as they would absent the spill, whereas such a change may not be possible in fisheries for oysters and other less mobile species. Other examples of potential mitigating behaviors, the success of which would vary depending on the circumstances, include switching to other species or fishing earlier or later in the season.

The reaction of seafood consumers to a CDE is also highly uncertain. Although the literature includes demand functions for several harvested species[30], the occurrence of a CDE could fundamentally change these functions in uncertain ways for an unspecified period of time. Factors affecting these changes may include the size of the area oiled, the species potentially affected by oiling, and consumer attitudes regarding the potential risks of consuming contaminated seafood. Because of the limited number of CDEs to have occurred historically, the nature of the changes in demand due to these and other factors is unknown.

2.4.1 Commercial Fishing Approach

Due to the uncertain magnitude of the changes in seafood prices, production costs, and demand functions that would result from a CDE, we present estimated changes in revenues—rather than changes in producer and consumer surplus—as the metric of impacts for the commercial fishing sector. For each region—GOM, Atlantic, Pacific, and Alaska—we compiled recent landings data to serve as the baseline.[31] We then estimated the reduction in landings for each region based on a series of region-specific assumptions, as described in greater detail below.[32] These estimated reductions in landings assume that the fishing industry recovers within one year of a CDE occurring. It is possibile, however, that a CDE could have a longer-term impact on individual fisheries if the fish stock requires several years to recover, in which case landings impacts may persist for an extended period of time.

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[30] For example, see Blomo et al. (1982) and Houston et al. (1989) for demand of Gulf of Mexico shrimp and Park et al. (2004) for demand of snapper/grouper.

[31] Commercial fishing is currently banned in the Arctic.

[32] The approach described in this section focuses on potential impacts related to reduced fisheries production. We note, however, that vessel owners and commercial fishing personnel may be hired in the event of CDE to assist with spill response, offsetting the losses that they may experience due to reduced commercial fishing activity.

2.4.1.1 Gulf of Mexico

To estimate the reduction in commercial fishery revenues associated with a CDE in the GOM, we draw from the observed changes in commercial fisheries in response to the *Deepwater Horizon* spill. Based on historical landings data published by NOAA's National Marine Fisheries Service (NMFS undated), we estimate that the total volume of landings in 2010 in the Gulf was approximately 22 percent lower than the average of the three previous years (2007 through 2009). Using a slightly different baseline of 2008–2009 and 2011–2013, the estimated reduction in the volume of landings increases to 25 percent, as summarized in Table 23. When measured in terms of revenues rather than volume, the landings impacts of the *Deepwater Horizon* spill are lower than the estimated changes in volume. As shown in Table 24, we estimate that landings revenues declined by 8 to 16 percent as a result of the spill, depending on the years used as the baseline. This lower impact may reflect an increase in prices associated with the spill-related reduction in harvests. If there was an increase in prices, however, this coupled with reduced landings would represent a welfare loss to consumers.

Table 23. Estimated change in GOM landings volume following the *Deepwater Horizon* oil spill

Species	Change in Volume of Landings in 2010 Relative to 2007–2009	Change in Volume of Landings in 2010 Relative to 2008–2009 and 2011–2013
Mehhaden	102,100 metric tons (-23%)	135,900 metric tons (-28%)
Shrimp	19,300 metric tons (-19%)	17,200 metric tons (-17%)
Eastern Oysters	2,800 metric tons (-28%)	2,100 metric tons (-23%)
Blue Crab	6,800 metric tons (-27%)	5,100 metric tons (-22%)
Other	5,500 metric tons (-13%)	6,000 metric tons (-14%)
TOTAL	**136,500 metric tons (-22%)**	**166,200 metric tons (-25%)**

Note: Values in first line of each cell represent the change in landings measured in metric tons. The value in parentheses represents the percent change in landings.
Source: Data based on landings data reported by NOAA/NMFS.

Table 24. Estimated change in GOM landings revenue following the *Deepwater Horizon* oil spill (2019$)

Species	Change in Landings Revenue in 2010 Relative to 2007–2009	Change in Landings Revenue in 2010 Relative to 2008–2009 and 2011–2013
Mehhaden	$14,700,000 (-19%)	$26,500,000 (-30%)
Shrimp	$28,900,000 (-7%)	$71,300,000 (-15%)
Eastern Oysters	$17,400,000 (-21%)	$15,600,000 (-19%)
Blue Crab	$4,400,000 (-8%)	$7,440,000 (-13%)
Other	$2,620,000 (-2%)	$17,000,000 (-9%)
TOTAL	$68,000,000 **(-8%)**	$138,000,000 **(-16%)**
Note: Values in first line of each cell represent the change in landings revenue measured in year 2019 dollars. The value in parentheses represents the percent change in landings revenue.		

For the purposes of estimating the impacts associated with a future CDE, we assume a 16 percent reduction in landings revenue, consistent with the higher of the two values shown in Table 24. We use the estimated percentage change in landings revenue rather than the percent change in landings volume because the change in landings revenue is our metric of impacts in the absence of information that would allow us to estimate changes in producer and consumer surplus. Applying the 16 percent value to the average of landings revenues for 2014 through 2016, the three most recent years for which data are available, we estimate commercial fishery damages of $144 million (year 2019$). Based on the estimated 3.19 million barrels of oil spilled and not recovered as a result of the *Deepwater Horizon* blowout, this value translates to $45.12 in commercial fishing damages per barrel spilled.

2.4.1.2 Atlantic

To estimate the commercial fishing impacts of a CDE in the Atlantic, we rely on the impacts estimated for the GOM following the *Deepwater Horizon* blowout and spill. More specifically, we assume that the proportional change in landings revenues estimated for the GOM in the aftermath of the *Deepwater Horizon* spill (16 percent) also applies to the commercial fishing impacts of a CDE occurring in the Atlantic. We apply this proportional change in landings revenues to two different impact scenarios, consistent with our approach for recreational impacts. In the first scenario, we assume that only fisheries in states bordering each planning area would be affected by a CDE. In the second scenario, we assume that a CDE would also impact fisheries in the states immediately adjacent to each planning area. For instance, the first scenario for the Mid-Atlantic assumes that a CDE affects fishery landings in North Carolina, Virginia, Maryland, and Delaware (the states bordering the planning area). The second scenario assumes that a CDE affects these states in addition to New Jersey and South Carolina (immediately north and south of the Mid-Atlantic Planning Area). This second scenario represents a more conservative estimate, taking into account the possibility that a spill within a given planning area could spread to adjacent planning areas.

Table 25 presents the baseline landings revenues reported by NMFS for the affected states and the estimated reduction in landings under each spill impact scenario. As indicated in the table, baseline landings in the Atlantic total more than $2.2 billion per year, with the majority of landings occurring in the North Atlantic. Note that many of the species shown in the table are typically caught in embayments or other areas close to shore, far removed from potential well sites on the OCS. However, because a catastrophic spill could occur from a tanker transporting oil to shore, including these nearshore fisheries in the assessment is appropriate. The table also presents the estimated change in landings revenue due to a CDE in each planning area under the two spill impact scenarios. As indicated in the table, we estimate that the loss in commercial fishing revenues would be greatest from a CDE in the North Atlantic ($249–$299 million) and smallest from a CDE in the South Atlantic ($13.4–$46.7 million). Based on these values and the 3.19 million barrels of unrecovered oil discharged during the *Deepwater Horizon* spill, we estimate that a CDE in the North Atlantic would lead to commercial fisheries damages of $78–$94 per barrel and a CDE in the South Atlantic would lead to damages of $4–$15 per barrel.

2.4.1.3 Pacific

We estimate impacts to commercial fishing in the Pacific Region using the same methodology described above for the Atlantic. Specifically, we estimate average annual commercial landings by planning area based on NMFS data for 2014 to 2016, and estimate losses based on the 16 percent reduction estimated from the *Deepwater Horizon* spill. Similar to the Atlantic calculations, we estimate losses under two different CDE scenarios. Scenario 1 assumes that only commercial landings bordering each planning area would be affected by a CDE, and Scenario 2 assumes that commercial landings in adjacent planning areas would also be affected. Table 26 presents baseline commercial landings revenue and the estimated change in revenue associated with a catastrophic spill by planning area. The table also presents the estimated change in revenues per barrel spilled, based on the 3.19 barrels discharged during the *Deepwater Horizon* spill. Under Scenario 1, estimated losses are greatest for Washington/Oregon ($75.5 million, or $23.70/barrel) and lowest for Northern California ($7.96 million, or $2.50/barrel). In contrast, under Scenario 2, commercial fishing impacts are highest for CDEs occurring in the Northern California Planning Area and lowest for CDEs in the Southern California Planning Area.

Table 25. Commercial fishery landings revenue and catastrophic spill impacts in the Atlantic (2019$)

Planning Area	Scenario 1			Scenario 2		
	Average Annual Landings Revenue: 2014–2016	Estimated Change in Landings Revenue Due to a Catastrophic Spill	Change in Revenues/ Barrel	Average Annual Landings Revenue: 2014–2016	Estimated Change in Landings Revenue Due to a Catastrophic Spill	Change in Revenues/ Barrel
North Atlantic	$1,590,000,000	$249,000,000	$78	$1,910,000,000	$299,000,000	$94
Mid-Atlantic	$418,000,000	$65,300,000	$21	$623,000,000	$97,400,000	$31
South Atlantic	$85,900,000	$13,400,000	$4	$299,000,000	$46,700,000	$15
Straits of Florida	$111,000,000	$17,400,000	$5	$270,000,000	$42,100,000	$13
TOTAL	$2,210,000,000			$3,100,000,000		

Notes:
2014–2016 landings revenue from the NMFS.
Scenario 1 presents data for the states bordering each planning area. Scenario 2 also presents data for states adjacent to the bordering states.

Table 26. Commercial fishery landings revenue and catastrophic spill impacts in the Pacific (2019$)

Planning Area	Scenario 1			Scenario 2		
	Average Annual Landings Revenue: 2014–2016	Estimated Change in Landings Revenue Due to a Catastrophic Spill	Change in Revenues/ Barrel	Average Annual Landings Revenue: 2014–2016	Estimated Change in Landings Revenue Due to a Catastrophic Spill	Change in Revenue/ Barrel
Southern California	$87,300,000	$13,600,000	$4.28	$165,000,000	$25,800,000	$8.10
Central California	$77,600,000	$12,100,000	$3.80	$216,000,000	$33,700,000	$10.60
Northern California	$50,900,000	$7,960,000	$2.50	$611,000,000	$95,500,000	$30.00
Washington/ Oregon	$483,000,000	$75,500,000	$23.70	$534,000,000	$83,400,000	$26.10
TOTAL	$699,000,000			$1,530,000,000		

Notes:
2014–2016 landings revenue from the NMFS.
Scenario 1 presents data for the listed planning area. Scenario 2 also presents data for planning areas adjacent to the listed planning area.

2.4.1.4 Alaska (Excluding Cook Inlet)

Our approach for estimating the commercial fishing impacts of a CDE in the Alaska Region is similar to our approach for the Atlantic and Pacific. As with the Atlantic and Pacific, we assume that the proportional change in landings revenues estimated for the *Deepwater Horizon* spill (16 percent) also applies to the commercial fishing impacts of a CDE occurring in Alaska. However, we rely on commercial landings data from the Alaska Department of Fish and Game (ADFG 2018a) instead of NMFS, due to the greater geographic detail available in the ADFG dataset.[33] Additionally, we do not estimate changes in revenues for multiple spill scenarios. Given the large number of Alaska planning areas and relatively open geography of these areas, a spill in a single planning area could impact a variety of surrounding planning areas. For instance, depending on prevailing winds and currents, oil spilled in the Aleutian Basin could drift southwards and affect fisheries in Bowers Basin, St. George Basin, and the Aleutian Arc, or drift toward the northeast and affect fisheries in Navarin Basin, St. Matthew-Hall, and Norton Basin.

Table 27 summarizes the value of commercial fishery landings at risk in each planning area, as well as the estimated change in revenue associated with a spill that impacts each planning area. Due to the uncertainty surrounding the spatial distribution of oiling for a CDE in Alaska, these values represent estimated losses associated with a spill affecting each planning area, as opposed to the losses associated with a spill occurring in a given planning area.

Table 27. Commercial fishery landings revenue and potential catastrophic spill impacts in Alaska planning areas (2019$)

Planning Area	Average Annual Landings Revenue: 2015–2017	Estimated Change in Landings Revenue Due to a Catastrophic Spill
Gulf of Alaska	$257,000,000	$40,100,000
Cook Inlet	$30,200,000	$30,200,000
Kodiak	$43,300,000	$6,780,000
Shumagin	$20,200,000	$3,150,000
North Aleutian Basin	$206,000,000	$32,300,000
Aleutian Arc	$12,800,000	$2,000,000
St. George Basin	$10,600,000	$1,650,000
St. Matthew-Hall	$4,430,000	$692,000
Bowers Basin	$0	$0
Aleutian Basin	$0	$0
Navarin Basin	$0	$0
Norton Basin	$1,010,000	$158,000
Hope Basin	$1,080,000	$169,000
Chukchi Sea	$0	$0
Beaufort Sea	$0	$0
TOTAL	$587,000,000	
Notes: 2015–2017 landings revenue from ADFG		

[33] We matched Commercial Salmon Harvest Areas from ADFG to the Alaska planning areas. In the few cases where harvest areas overlapped multiple planning areas, we divided landings evenly between the relevant planning areas.

2.4.1.5 Alaska—Cook Inlet

Our approach for estimating the commercial fishing impacts of a CDE in Cook Inlet reflects the unique geographic features of Cook Inlet relative to the GOM and the Atlantic. More specifically, because Cook Inlet is small relative to the GOM and Atlantic and has limited access to open water, we assume that a catastrophic spill in Cook Inlet would affect all fisheries in the area and that a full year's landings would be lost. Table 28 presents the average annual ex-vessel revenues over the 2015–2017 period (the three most recent years for which data are available). Based on the data in the table, we estimate that a catastrophic spill in Cook Inlet would result in $30.2 million in commercial fisheries damage. Because these impacts could be realized across a wide range of spill volumes, we do not generate a per-barrel estimate of damages.

Table 28. Average annual Cook Inlet commercial fishery landings (2019$)

Species	Average Annual Ex-Vessel Value: 2012–2014[1]
Chinook	$630,000
Sockeye	$24,400,000
Coho	$1,330,000
Pink	$2,420,000
Chum	$1,390,000
TOTAL	$30,200,000

Source: ADFG (2018).

2.5 Subsistence

Many coastal communities throughout the U.S. rely on coastal and marine natural resources for subsistence. In particular, Alaska Native communities in Cook Inlet and the Arctic depend on resources such as bowhead whales and other marine species to meet their basic needs. Oil released during a CDE may contaminate large portions of the Alaskan coastal and marine environment, making it impossible for communities to subsist on the resources that are normally available. These communities would be particularly impacted if a CDE were to occur during the peak season for subsistence harvest.

To estimate the impacts of a CDE on subsistence, we would ideally use data on baseline subsistence harvests, estimates of the change in subsistence associated with a CDE, and the economic value of lost subsistence. Information on all three of these variables, however, is quite limited. With respect to baseline subsistence activity, the ADFG's Division of Subsistence maintains subsistence data in *The Community Subsistence Harvest Information System (CSIS)* (ADFG Division of Subsistence 2015). However, these data vary considerably between communities in terms of the years and species covered. Information on the change in subsistence associated with a CDE is even more limited, with a sample of only two catastrophic spills to draw from. Even if better data on changes in subsistence were available, estimating the value of these changes is complicated by the cultural value of subsistence harvests to many communities.

Based on the limited data available, we estimate the potential subsistence impacts of a CDE for each of the planning areas in Alaska, as presented below. Although a CDE in the GOM, the Atlantic, or the Pacific may affect subsistence in these areas as well, insufficient data are readily available to support analysis of these impacts.

Cleanup efforts in the aftermath of a catastrophic spill can result in a massive inflow of funds into local communities. The additional income provided by participating in or supporting such efforts can benefit local businesses and households. However, especially for rural communities, the magnitude and suddenness of this injection of funds and the dramatic increase in activity can introduce new financial and societal stresses, potentially compounding the negative effects on subsistence activities. The costs of such disruptions are very difficult to assess, and appropriate data are not available to estimate them. The estimates of subsistence losses described below do not include losses resulting from inability to harvest or diversion of time and effort away from subsistence activities and toward income-producing activities related to spill cleanup.

2.5.1 Alaska (Non-Arctic Areas)

A CDE in a non-arctic Alaska planning area, like the *Exxon Valdez* spill, could have major impacts on local residents who engage in subsistence fishing and hunting. According to a 2014 report on subsistence in Alaska, the annual wild food harvest for rural areas in Alaska is 275 pounds per capita, of which 194 pounds constitute marine harvest (ADFG Division of Subsistence 2016). We use this as our baseline for the annual subsistence harvest for communities along Cook Inlet that would be affected by a CDE in the area.

To estimate the reduction in subsistence associated with a CDE in non-arctic planning areas, we draw from the estimated subsistence impacts of the *Exxon Valdez* spill on communities in southcentral Alaska. A study published by the Minerals Management Service and the ADFG on the long-term consequences of the *Valdez* spill estimates that the spill led to approximately a 50 percent reduction in per capita subsistence in the year of the spill and a 25 percent reduction the following year (MMS 2001).[34] Applying these values to our baseline estimate of 194 pounds per capita yields a loss of 97 pounds per capita in the year of a spill and a loss of 49 pounds per capita the following year.

To determine the total Alaska Native population potentially affected by a CDE in non-arctic planning areas, we rely on 2016 American Community Survey data on Alaska Native Village Statistical Areas (ANVSAs). For the purposes of this analysis, we assume that all ANVSAs located within 50 miles of the coastline would be affected by a CDE.[35] We estimate the reduction in subsistence as a result of a CDE in each planning area based on population estimates for nearby ANVSAs and the estimated subsistence loss per capita outlined above.

As described above, placing a value on subsistence harvests is made difficult by the important cultural value of subsistence among many Alaska Native communities. As an indicator of value, we rely on the average replacement cost value derived from two sources: Sharpe (2001) and Duffield, Neher, and Patterson (2014). The Sharpe value was developed in the context of valuing the total replacement costs of subsistence harvests, including the cultural dimension of subsistence, to local communities if a spill were to occur. Adjusted for inflation, this value is $120 per kilogram (or approximately $55 per pound) in year 2019 dollars. Duffield, Neher, and Patterson calculated the replacement value of subsistence harvests using a compensating wage differential approach, which assumes that the time and resources spent on subsistence harvests can be valued as the opportunity cost of traditional full-time employment. Using recent income, subsistence harvest, education, and cost of living data, Duffield, Neher, and Patterson estimate a value of $189.73 per kilogram (2009$). Based on these two sources, we estimate an average replacement value of $173.10 per kilogram (2019$). Table 29 presents estimates of the value of subsistence losses in each planning area based on nearby Alaska Native population, estimated kilograms lost per capita, and the value of subsistence harvest per kilogram. We estimate subsistence losses from a CDE would be largest in St. Matthew-Hall ($72 million) and smallest in the Aleutian Arc ($1.1 million).

[34] See Tables VII-1 and VII-2 of the cited MMS source.

[35] We included all ANVSAs within 50 miles based on the distances from coastline for communities affected by the Exxon Valdez spill. The farthest community was located approximately 45 miles from the coastline.

To estimate subsistence damages per barrel of oil spilled, we divide total damages by the spill volume associated with the *Exxon Valdez* spill (257,000 barrels). This yields estimates ranging from $4 to $280 across non-arctic planning areas. Because the change in subsistence per capita applied in this analysis is based on the impacts of *Valdez*, the *Valdez* spill volume is the most appropriate for deriving a per-barrel estimate.

Table 29. Estimated subsistence losses (2019$)

Planning Area	Alaska Native Population	Estimated Kilograms Lost	Value at $173/kg ($2019)	Per-Barrel Losses
Aleutian Arc	142	6,266	$1,084,595	$4
Cook Inlet	3,813	168,249	$29,123,678	$113
Gulf of Alaska	7,283	321,362	$55,627,523	$216
Hope Basin	5,651	249,350	$43,162,314	$168
Kodiak	576	25,416	$4,399,486	$17
North Aleutian Basin	3,288	145,083	$25,113,730	$98
Norton Basin	7,122	314,258	$54,397,806	$212
Shumagin	1,196	52,774	$9,135,043	$36
St. George Basin	680	30,005	$5,193,837	$20
St. Matthew-Hall	9,418	415,569	$71,934,644	$280

2.5.2 Arctic

Given their remote location, communities near the Chukchi Sea and Beaufort Sea in the Arctic rely greatly on subsistence use to meet their basic needs. To calculate the baseline subsistence harvests in the Arctic, we use data found in the *Final Environmental Impact Statement for Issuing Annual Quotas to the Alaska Eskimo Whaling Commission for a Subsistence Hunt on Bowhead Whales for the Years 2013 through 2018* from NOAA's NMFS (2013).[36] To determine the reduced subsistence harvest, we assume that the fall bowhead whale hunt and marine mammal harvest are lost in the year of a catastrophic spill and that both the spring and fall harvests are lost the following year. These assumptions are consistent with those in BOEM (2012).

Table 30 summarizes our calculations for the estimated value of Alaska Native lost subsistence harvests for a CDE in the Arctic. At $173/kg, the total value of Arctic lost subsistence harvest due to a CDE is estimated at approximately $302 million (year 2019$). Because these damages may occur for a range of potential catastrophic spill sizes, we do not present these damages on a per-barrel basis.

[36] Beaufort communities are Kaktoviki and Nuiqsut; Chukchi communities are Barrow, Kivalina, Point Hope, and Wainwright.

Table 30. Estimated Arctic subsistence losses

	Average Whales[37] [A]	Estimated KG Harvested[38] [B=A × 11,472]	Value of Annual Bowhead Harvest [C=B × $166]	Ratio Marine Mammals Harvest (kilos)[39] [D]	Estimated Marine Mammals Harvest (kilos) [E=B×D]	Estimated Value of Other Marine Mammals [F=E × $166]	Estimated Value of Fall BW & Annual Marine Mammal Harvest for Year of Spill [G]	Estimated Value of All Bowhead Whale & Marine Mammal Harvest for Year Following Spill ($166/KG) [H]
Fall Beaufort Harvest	4.1	47,399	$8,204,768	Calculated in the row for Beaufort marine mammals below	Calculated in the row for Beaufort marine mammals below	Calculated in the row for Beaufort marine mammals below	$8,204,768	$8,204,768
Spring Beaufort Harvest	0	-	-				-	$0
Beaufort Marine Mammals	Specified above by season			0.080	3,788	$655,660	$655,660	$655,660
Total Beaufort	4.1	47,399	$8,204,768	-	3,788	$655,660	$8,860,428	$8,860,428
							Total Estimated Beaufort Subsistence Losses	**$17,720,857**
Fall Chukchi Harvest	7.5	85,741	$14,841,746	Calculated in the row for Chukchi marine mammals below	Calculated in the row for Chukchi marine mammals below	Calculated in the row for Chukchi marine mammals below	$14,841,746	$14,841,746
Spring Chukchi Harvest	14.2	162,727	$28,167,962				-	$28,167,962
Chukchi Marine Mammals	Specified above by season			2.63	652,975	$113,029,387	$113,029,387	$113,029,387
Total Chukchi	21.7	248,469	$43,009,709	-	652,975	$113,029,387	$127,871,134	$156,039,096
							Total Estimated Chukchi Subsistence Losses	**$283,910,230**
							TOTAL ARCTIC SUBSISTENCE LOSSES	**$301,631,087**

[37] Calculated based on 38 years of historical harvest data in Figure 3.5.2-3 in NOAA/NMFS (2013). We sum the cumulative totals by spring and fall for Chukchi communities and Beaufort communities and divide the sums by 38 to obtain the seasonal average number of bowhead whales harvested.

[38] The average whale weighs 25,239 pounds, or 11,472 kilograms. See Table 3.5-2 in NOAA/NMFS (2013).

[39] Calculated from comparing whale and marine mammal harvests in the Beaufort and Chukchi communities, see Table 3.5-3 in NOAA/NMFS (2013).

2.6 Fatal and Non-fatal Injuries

CDEs may unfortunately cause serious injuries or fatalities to individuals located near the well. To estimate the costs associated with the loss of life and non-fatal injuries associated with a CDE, we draw upon the historical experience of the two well blowout events in the U.S. that led to fatalities. The first event, which occurred in 1970, caused four fatalities and 36 non-fatal injuries (U.S. DOI BSEE undated). The second event, the *Deepwater Horizon* blowout in 2010, resulted in 11 fatalities and 17 non-fatal injuries (BOEMRE 2010). For the purposes of estimating the impacts of a potential CDE in the future, we average the fatalities and non-fatal injuries across these two events. This results in an average of eight fatalities and 27 non-fatal injuries per incident.

We estimate the economic value of fatalities based on the value of a statistical life (VSL). Drawing from the U.S. Environmental Protection Agency's (EPA's) meta-analysis of the VSL literature, we estimate that the VSL in year 2019 dollars and at year 2019 income levels is approximately $9.8 million (U.S. EPA 2014). The adjustment for income reflects a VSL elasticity with respect to income (i.e., the percent change in VSL due to one percent change in income) of 0.4, consistent with the value from Kleckner and Neumann (1999) used in EPA regulatory impact analyses. Based on the estimated value of eight deaths per incident and the VSL of $9.8 million, the total cost of fatalities due to a CDE is estimated to be $78.3 million (in year 2019$).

Viscusi (2005) estimates that workers place a value on non-fatal injuries that ranges from $20,000 to $70,000 per expected job injury. Using the midpoint of this range ($45,000), and inflating it to year 2019 dollars, we estimate a value of $58,200 per injury. Applying this value to the assumed 27 injuries per incident, we estimate costs of approximately $1.5 million associated with non-fatal injuries resulting from a CDE. Summing this with the $78.3 million associated with CDE-related fatalities, we estimate $79.8 million in damages associated with fatalities and non-fatal injuries. Because a blowout resulting in these impacts would result in spills ranging substantially with respect to the volume of oil spilled, we do not estimate the value of fatal and non-fatal injuries on a per-barrel basis.

2.7 Value of Spilled Oil Not Recovered

Another cost associated with a CDE is the value of spilled oil not recovered. Recognizing that the dollar per-barrel value of oil is highly unpredictable and will vary over time and that the timing of a CDE is highly uncertain, we estimate the value of spilled oil using the range of oil prices BOEM considers when evaluating economic impacts within the National OCS Program decision document. These values are $40, $100, and $160 per barrel, respectively.

2.8 Impacts of Dispersants and *In Situ* Burns

Although dispersants and *in situ* burns can be effective oil spill response strategies, they also have potential environmental costs. *In situ* burns produce large amounts of smoke, which contains particulate matter and air pollutants such as sulfur dioxide, nitrogen dioxide, and carbon monoxide. These pollutants have the potential to negatively impact the health of response workers and residents of nearby coastal areas. PM—from direct PM emissions or from precursor emissions that transform into PM—presents the greatest concern, as studies have demonstrated that concentrations of particulate matter within the smoke plume can remain above background levels several miles downwind of the burn site. *In situ* burns also have the potential to damage vegetation in coastal areas, and leave behind an oil residue that can sink and smother benthic resources under certain conditions (Barnea 1995).

Dispersants can reduce oil exposure for surface dwelling organisms, and prevent oil from reaching the shoreline habitat. However, these benefits come with the tradeoff of distributing oil throughout the water column and into the benthic environment. Even in a diluted form, exposure to dispersed oil can cause injury to fish, oysters, coral reefs, and other subsurface ecological resources. As a result, the net ecological impact of dispersant usage is necessarily dependent on the relative vulnerability of surface and subsurface habitats in a given location (NRC 2005). The ecological impacts of the chemical dispersants themselves are not as large of a concern, as the dispersants in use today are generally less toxic than the dispersed oil. Research on dispersant use during the *Deepwater Horizon* spill confirmed this lower toxicity, finding that dispersant-oil mixtures were generally no more harmful to aquatic species than oil alone (EPA 2010).

Neither the air quality impacts associated with *in situ* burns nor impacts related to the use of dispersents are reflected in the impact estimates presented in previous sections.

2.9 Uncertainties

Due to the various assumptions and limitations of the available data described in the previous sections, the CDE damage estimates presented throughout this chapter exhibit substantial uncertainty. Table 31 documents the most significant of these uncertainties and describes their potential impact on our estimates of CDE-related damages.

Table 31. Uncertainties, limitations, and assumptions of analysis

Impact Category	Uncertainties, Limitations, and Assumptions	Implications for Impact Estimates
Response Costs	• We assume that the response costs for the *Deepwater Horizon* spill are representative of response costs for CDEs occurring in the GOM.	• Assumption could lead to overestimation or underestimation of impacts, depending on the timing and location of a CDE and conditions when the CDE occurs (e.g., currents and wind direction).
	• We assume that response costs in the Atlantic and Pacific are the same as those in the GOM.	• Because wetlands are less prevalent on the Atlantic and Pacific shorelines, we may overestimate response costs for these regions.
	• We assume that the response costs for the *Exxon Valdez* spill are representative of response costs for CDEs occurring in southern Alaska planning areas (Gulf of Alaska, Kodiak, Cook Inlet, Shumagin).	• Assumption could lead to overestimation or underestimation of impacts, depending on how the timing, size, and duration of a CDE in these planning areas differ from the experience of the *Exxon Valdez* spill in Prince William Sound (Gulf of Alaska Planning Area).
	• We assume that response costs for a CDE in the western and Arctic Alaska planning areas will be greater than or equal to the response costs for the *Deepwater Horizon* spill ($5,100/barrel) and less than or equal to the response costs for the *Exxon Valdez* spill ($16,000/barrel).	• Assumption could lead to overestimation or underestimation of impacts, depending on the location of a CDE and conditions when the CDE occurs.
Ecological Damages	• We assume that the ecological damages for the *Deepwater Horizon* spill are representative of ecological damages for CDEs occurring in the GOM.	• Assumption could lead to overestimation or underestimation of impacts, depending on the timing and location of a CDE and conditions when the CDE occurs (e.g., currents and wind direction).
	• We assume that average NRDA values for non-catastrophic oil spills will be representative of low-end ecological damages for a CDE.	• Assumption could lead to overestimation of impacts if a CDE matches the trend seen in the historical spill record suggesting that ecological damages per barrel generally decrease as spill size increases. • Assumption could lead to underestimation of impacts if a CDE results in ecological damages similar in magnitude to the two previous catastrophic spills in U.S. waters (*Exxon Valdez* and *Deepwater Horizon)*, which produced significantly higher ecological damages per barrel than historical non-catastrophic spills.
	• We assume that high-end ecological damages from a CDE in the Atlantic will be 9 percent lower than the ecological damages for the *Deepwater Horizon* oil spill, based on lower average NRDA values for non-catastrophic oil spills in the Atlantic versus the Gulf.	• Assumption could lead to overestimation or underestimation of impacts, depending on whether the factors determining ecological damages from non-catastrophic spills are the same factors that would determine ecological damages from a CDE.
	• We assume that high-end ecological damages from a CDE in the Pacific will be six times higher than the ecological damages for the *Deepwater Horizon* oil spill, based on higher average NRDA values for non-catastrophic oil spills in the Pacific versus the Gulf.	• Assumption could lead to overestimation or underestimation of impacts, depending on whether the factors determining ecological damages from non-catastrophic spills are the same factors that would determine ecological damages from a CDE.

Impact Category	Uncertainties, Limitations, and Assumptions	Implications for Impact Estimates
	• We assume that the ecological damages for the *Exxon Valdez* spill are representative of ecological damages for a CDE occurring in southern Alaska planning areas (Gulf of Alaska, Kodiak, Cook Inlet, Shumagin).	• Assumption could lead to overestimation or underestimation of impacts, depending on how the timing, size, and duration of impacts for a CDE in these planning areas differ from the experience of the *Exxon Valdez* spill in Prince William Sound (Gulf of Alaska planning area).
	• We assume that ecological damages resulting from a CDE in the western or Arctic Alaska planning areas will be 4.4 times higher than the ecological damages resulting from the *Exxon Valdez* oil spill, based on results generated by the CG OECM for the Cook Inlet and Beaufort Sea regions.	• Assumption could lead to overestimation or underestimation of impacts, depending on how the timing, size, and duration of impacts for a CDE in the western and Arctic Alaska planning areas differ from the experience of the *Exxon Valdez* spill in Prince William Sound.
Recreation	• We assume the *Deepwater Horizon* spill is representative of a CDE in the GOM Region.	• Assumption could lead to overestimation or underestimation of impacts, depending on the timing and location of a CDE.
	• We assume that the timing, size, and duration of impacts for a CDE in the Atlantic and Pacific is consistent with the observed experience for the GOM following the *Deepwater Horizon* spill.	• Assumption could lead to overestimation or underestimation of impacts, depending on how the timing, size, and duration of impacts for a CDE in the Atlantic differ from the experience of the *Deepwater Horizon* spill.
	• We assume that the two scenarios that we specify for the spatial extent of impacts associated with CDEs occurring in the Atlantic or the Pacific capture the range of impacts associated with a CDE in these areas.	• Assumption could lead to overestimation or underestimation of impacts, depending on the location of a CDE and conditions when the CDE occurs. For example, oil from a CDE could spread up the coast to the North Atlantic, impacting New Jersey. Alternatively, the oil from a CDE on the Atlantic could drift into the open ocean away from the coast.
	• Our quantitative assessment of potential recreational impacts in the Atlantic and Pacific does not include boating impacts.	• Likely leads to slight underestimation of impacts. Based on the experience of the *Deepwater Horizon* spill, however, boating impacts are small relative to beach use and coastal fishing.
	• We assume that the reduction in recreational fishing observed in southcentral Alaska following the Exxon *Valdez* spill would also apply to recreational fishing in Cook Inlet and the Gulf of Alaska more broadly.	• Assumption could lead to overestimation or underestimation of impacts, depending on amount of oiling relative to the *Valdez* spill and the timing of a CDE relative to the timing of *Valdez*.
	• For recreational fishing in Cook Inlet and the Gulf of Alaska, we assume a CDE volume equal to that of the Exxon *Valdez* spill to calculate damages on a per-barrel basis.	• Assumption could lead to overestimation or underestimation of impacts depending on damages per barrel for future CDEs relative to damages per barrel for the *Valdez* spill.
	• In the absence of wildlife viewing data specific to Cook Inlet and the Gulf of Alaska, we used data for southcentral Alaska as a whole.	• Likely leads to overestimation of wildlife viewing impacts since not all wildlife viewing in southcentral and southeastern Alaska is in Cook Inlet and the Gulf of Alaska, respectively.

Impact Category	Uncertainties, Limitations, and Assumptions	Implications for Impact Estimates
	• Consistent with BOEM's 2012 analysis of catastrophic spill impacts, we assume a high-impact spill scenario for wildlife viewing in Cook Inlet in which a CDE occurs in the summer and last for 80 days, which represents 53 percent of the summer season.	• Assumption could lead to overestimation of impacts if a CDE occurs during another time of the year.
	• To estimate the economic value of Cook Inlet and Gulf of Alaska wildlife viewing losses, we assume that half of the value of a wildlife viewing day will be lost for affected trips.	• Assumption could lead to overestimation or underestimation of impacts, depending on the extent to which recreators change their wildlife viewing behavior in response to a CDE.
Subsistence	• Information on baseline subsistence harvests, estimates of the change in subsistence associated with a CDE, and an economic value of lost subsistence is limited.	• Because these data are so limited, our estimates of subsistence impacts are highly uncertain and may be overestimates or underestimates.
	• Economic valuation methods are ill-suited to quantifying the cultural value of subsistence for Alaska Native communities.	• Value of subsistence to Native Alaska communities may be underestimated.
	• We assume that the reduction in subsistence observed in southcentral Alaska following the Exxon *Valdez* spill would also apply to subsistence in all non-arctic Alaska planning areas.	• Assumption could lead to overestimation or underestimation of subsistence impacts depending on the extent to which future CDEs affect the level of subsistence relative to the impacts of the *Valdez* spill.
	• For subsistence in all non-Arctic Alaska planning areas, we use the spill volume from the *Exxon Valdez* spill to calculate damages on a per-barrel basis.	• Assumption could lead to overestimation or underestimation of impacts depending on damages per barrel for future CDE relative to damages per barrel for the *Valdez* spill.
	• In the Artic, consistent with BOEM (2012), we assume that the fall bowhead whale hunt and marine mammal harvest are lost in the year of a catastrophic spill and that both the spring and fall harvests are lost the following year.	• Assumption could lead to overestimation or underestimation of subsistence impacts depending on the extent to which future CDEs affect subsistence harvests.
Fatal and Non-fatal Injuries	• Our estimate of the number of fatalities associated with a CDE is based only on two data points: a blowout in 1984 spill and the *Deepwater Horizon* blowout in 2010.	• Assumption could lead to overestimation or underestimation of the number of fatalities associated with a CDE. The actual number is likely to vary depending on the cause of the spill and the number of people aboard a platform during a CDE.
Value of Oil Spilled	• We assume a range of oil price values based on the low and high price assumptions that inform BOEM's low and high E&D scenarios.	• Given the wide range of oil prices used, impacts are most likely within the range estimated.

3 Impacts of Onshore Infrastructure

3.1 Introduction

To quantify and monetize the social and environmental costs attributable to oil and natural gas exploration and development activities under each National OCS Program decision option (net of the costs associated with the No Sale option), BOEM utilizes the OECM. The OECM estimates six categories of environmental and social impacts across OCS planning areas: (1) air quality impacts, (2) property value effects, (3) recreation impacts, (4) ecological impacts, (5) subsistence impacts, and (6) impacts to the commercial fishing industry. Although OCS activities are likely to result in additional impacts, the OECM focuses on these specific categories of impacts because they likely capture the most significant social and environmental costs associated with OCS exploration and development. To the extent that a National OCS Program decision option includes areas where OCS oil and gas development has historically been limited or non-existent, the construction of new onshore infrastructure to support this activity may be necessary. Both the construction and operation of this infrastructure would likely result in social and environmental costs and benefits not captured by the OECM. In addition, the expansion or retrofitting of existing onshore infrastructure could result in social and environmental costs and benefits, though these impacts are likely to be less than those for new facilities. The OECM does not currently estimate these costs and benefits because doing so would require information on the precise location of onshore infrastructure development required under individual exploration & development scenarios that is not currently available. More detailed information on specific onshore infrastructure projects may be available at later stages of the 2020–2025 Program's implementation (e.g., in the environmental impact statements (EISs) for individual lease sales).

To supplement the results generated by the OECM for BOEM's 2020–2025 Proposed Final Program, this chapter assesses the impacts of potential onshore infrastructure development associated with the 2020–2025 Program. For most onshore infrastructure impacts, this assessment is qualitative though impacts are quantified where possible. Because the exact magnitude of impacts would depend on the amount of infrastructure to be developed and the exact location where it would be developed relative to potentially affected resources (e.g., coastal wetlands), this chapter does not quantify most of the impacts examined.

This chapter's assessment of the social and environmental costs associated with onshore infrastructure is presented in the following sections:

- ***Types of infrastructure associated with OCS oil and gas activity:*** To provide context for the assessment of onshore infrastructure impacts, this section identifies the types of onshore infrastructure that typically supports OCS oil and gas activity.
- ***Existing regulatory environment:*** The development and use of onshore infrastructure is subject to several policies and regulations designed to avoid, minimize, or mitigate adverse environmental impacts. To provide perspective on these policies and regulations as they pertain to onshore infrastructure, this section describes the key Federal statutes and regulations that reduce the risks that onshore infrastructure may pose to various natural resources.
- ***Environmental and social impacts of onshore infrastructure:*** This section provides an overview of the environmental and social impacts that may result from the construction and operation of onshore infrastructure and expansion/retrofitting of existing onshore infrastructure, highlighting the specific stresses imposed by onshore infrastructure and impacts to physical, biological, and sociocultural resources.
- ***Impacts of onshore infrastructure by region:*** Based on the infrastructure currently in place and the potentially affected resources in individual regions, the last four sections of this chapter

characterize the social and environmental costs and benefits of onshore infrastructure development by region.

3.2 Infrastructure Associated with OCS Oil and Gas Activity

The onshore infrastructure supporting OCS oil and gas activity includes a variety of facilities that provide specialized goods and services to the industry. In general, these facilities construct or fabricate much of the equipment used in OCS oil and gas activities or provide services that support these activities. As described in greater detail below, while much of this infrastructure is likely to be necessary for OCS oil and gas activities, some types of onshore infrastructure may not be necessary under certain circumstances, depending on how the industry plans to bring OCS oil and gas to market (e.g., whether to ship OCS crude to refineries overseas or to U.S. refineries). In addition, some types of onshore infrastructure that support OCS oil and gas activity may also support other activities, such as onshore oil and gas production. Any social or environmental impacts associated with such infrastructure would not be solely attributable to OCS activities.

This section identifies the types of onshore infrastructure associated with OCS oil and gas activities. For each type of infrastructure, this section describes its function relative to OCS oil and gas activities, the physical characteristics typical of these facilities, and the typical location of these facilities (e.g., at a port, near intercoastal waterways, etc.).

3.2.1 Construction/Fabrication Infrastructure

OCS oil and gas activity is highly capital intensive and requires specialized equipment and materials suitable for individual lease sites. This equipment is typically fabricated at onshore facilities that specialize in the construction of this equipment and is then transported to exploration/production sites. The most common types of fabrication facilities are platform fabrication yards, shipbuilding and shipyards, and pipe-coating plants and yards.

3.2.1.1 Platform Fabrication Yards

Platform fabrication yards construct and assemble drilling rigs and offshore platforms used in the exploration and development of OCS oil and gas. These facilities are typically located onshore near intercoastal waterways (BOEM 2016) and span several hundred acres (BOEM 2011, page 35). The large size of these facilities reflects the need to maintain an inventory of diverse construction components onsite, such as metal pipes and beams, and to house several types of heavy equipment frequently used during rig or platform fabrication, such as cranes, welding equipment, lifts, rolling mills, and sandblasting machinery. In addition, because the rigs and platforms that they fabricate are large, these facilities often have large open spaces for assembly. Despite the large size of these facilities, most fabrication yards specialize in the fabrication of a specific type of rig, platform, or platform component. Due to this specialization, multiple fabrication yards are necessary to support significant levels of OCS oil and gas development in a given area. Regardless of the type of structure(s) produced by a specific fabrication yard, production operations at these facilities typically include cutting and welding of steel components, construction of living quarters and other structures, and assembly of platform components (BOEM 2011).

The types of drilling rigs constructed at fabrication yards include:

- **Jackups:** Typically used in water depths up to approximately 160 meters, jackups are common in offshore oil and gas operations across the globe. Upon arriving at site, a jackup drops its legs to the seabed while its hull is lifted (“jacked up”) above the water.

- **Drill ships:** Drill ships are seagoing vessels equipped with drilling equipment on top and an opening (commonly referred to as a “moon pool”) in the hull for drilling operations. To maintain their position in the water, drill ships are typically anchored or continuously positioned with GPS systems.

- **Submersible rigs:** Most appropriate for use in shallow waters, submersibles are large pontoon-like structures. Once a submersible is positioned at the drill site, the pontoon structure is flooded and the rig is lowered to the seafloor.
- **Semisubmersible rigs:** Semisubmersibles, which may be used for both well drilling and production operations, are designed to be partially submerged in the water. They are supported by ballasted, watertight pontoons that are situated below the ocean surface and wave action. Structural columns attached to the pontoons support the operating deck above the surface.

In addition to drilling rigs, fabrication yards construct platforms used during the production phase of offshore oil and gas development. The types of platforms commonly produced by these facilities include:

- **Fixed platforms:** Fixed platforms are one of the most common offshore production systems in use today. They consist of a structural jacket, usually made of tubular steel, that is attached to the seafloor with piles and a topside deck where support equipment and crew living quarters are located.
- **Compliant towers:** Compliant towers are similar to fixed platforms but are designed to be more flexible. Instead of an inflexible jacket, the underwater portion of a compliant tower has a narrow, pliable tower that can move horizontally in response to wind and wave action. This flexibility enables compliant towers to operate in deeper water than most fixed platforms.
- **Tension mini-tension leg platforms:** Similar to semisubmersible drilling rigs, tension and mini-tension platforms use buoy systems that allow them to be partially submerged in the water. After these platforms are towed and vertically moored to a specific location, they are tethered to the seabed to minimize vertical movement.
- **Semisubmersible platform:** Similar to semisubmersible drilling rigs, semisubmersible platforms are partially submerged in water, with pontoons under the surface of the water, columns rising from the pontoons above the surface of the water, and a deck above the water supported by the pontoons and columns.
- **SPAR platforms:** Designed for production in deepwater environments, SPAR platforms are floating structures with buoyancy chambers at the top, a flooded structure in their midsection, and a keel at the bottom of the structure for stability (BOEM 2014). SPAR platforms also have the capability of moving horizontally, by adjusting the mooring line tensions, and positioning themselves over nearby wells not location at the main platform site.
- **Floating production units:** A floating production unit (FPU) is a variant of the semisubmersible platform described above. FPUs propel themselves in the water but are kept stationary by wires, chains, or dynamic positioning systems.
- **Subsea systems:** Subsea systems are wells or a cluster of wells situated on the seabed rather than on the surface. These wells are connected to a nearby platform or production facility (e.g., a tension leg platform or a SPAR) through a pipeline, umbilical, and manifold system (BOEM 2011). The equipment on subsea systems consists of both surface equipment and seafloor equipment. Surface equipment, which may be located on a platform far from the wells themselves, includes the control system and production machinery. Seafloor equipment includes the wells, manifolds, umbilicals, pumping/processing equipment, and flowlines.
- **Floating production, storage, and offloading (FPSO) systems:** FPSOs are a specialized type of tanker vessel equipped to collect and store oil produced from several subsea wells. Because FPSOs are often used in remote fields without extensive pipeline infrastructure, the oil collected

on FPSOs is typically offloaded to shuttle tankers for transportation to refining and distribution (BOEM 2011).

3.2.1.2 Shipbuilding Yards

Shipbuilding yards are critical to the offshore oil and gas industry as they construct and repair several types of vessels that support the industry. To meet the diverse needs of the offshore oil and gas industry (and other industries dependent on marine vessels), shipbuilding yards often specialize in a particular aspect of shipbuilding and repair. Based on these specializations, shipbuilding yards may be classified into four broad categories: (1) major shipyards that construct and repair ships, (2) major ship-repair and dry-dock facilities, (3) smaller shipyards that support water-based transport on coastal and inland waterways, and (4) topside-repair facilities (BOEM 2014). The types of vessels built or serviced by these facilities include tugs, marine platform supply vessels, anchor handling and towing supply vessels, fast support vessels, lift boats, and mini-supply vessels.

With respect to the footprint of shipbuilding yards, they must be sufficiently large to accommodate the delivery and handling of shipbuilding materials as well as vessel assembly. Depending on the availability of water access and land, shipyards may be expanded over time to accommodate increased offshore oil and gas activity. The layout and characteristics of shipbuilding yards varies considerably across facilities, though characteristics common to most facilities include:

- Dry docks
- Shipbuilding, piers, and berthing positions
- Electrical, pipe cutting and machining, assembly, painting and sanding workshops
- Spaces for carpentry, sheet metal, and construction activities
- Warehouses and storage space
- Service and fueling stations
- Office space (BOEM 2014)

3.2.2 Support Facilities

Equally important to platform fabrication yards and shipbuilding yards, which build much of the physical capital used by the offshore oil and gas industry, support facilities provide a variety of services essential to the functioning of the industry. Most support facilities specialize in a specific type of support and are located along or near the coast. The primary types of support facilities that service the offshore oil and gas industry are described in detail below.

3.2.2.1 Ports

As a central hub of activity supporting offshore oil and gas operations, ports are essential to the functioning of the industry. Many of the vessels and helicopters that support the industry are based and maintained at ports. Ports are also the launching point for the delivery and transfer of equipment, supplies, personnel, and other inputs necessary for offshore oil and gas operations (BOEM 2014). The ports that support the offshore oil and gas industry include relatively small ports developed specifically or primarily for the industry as well as large-scale ports (e.g., the Port of New Orleans) that support multiple activities, including offshore oil and gas development. Operations common across most ports include loading, unloading, crane lifting, heavy machinery use, storage, transfer, and vessel fueling.

Similar to shipbuilding yards, the characteristics of ports vary from facility to facility. However, ports may generally be characterized as either (1) deep-draft seaports or (2) inland river and intra-coastal waterway port facilities. The former typically accommodate ocean-going vessels and are often publicly owned, while the latter accommodate vessels with a smaller draft and are more likely to be privately owned. Although offshore drilling platforms are more likely to be supplied through deep-draft seaports, both types of ports are important to offshore oil and gas operations. Despite the differences between these different types of ports, the logistics systems of both generally include the following (BOEM 2014):

- ***Inland transportation connections:*** Supplies, equipment, and personnel must be transported to most ports from inland locations. Thus, ports are typically accessible by highway, road, rail, air, and/or inland waterway.
- ***Physical port infrastructure:*** All ports include a number of physical structures necessary for their operations. Although the physical infrastructure at ports varies between port facilities, structures that are common to ports include docks, berths, buildings, storage facilities, and transfer machinery (e.g., cranes and lifts). The physical infrastructure at ports also includes channels and their depths, turning basins, and additional amenities and utilities (e.g., electricity and water treatment capabilities).
- ***Offshore operations:*** The offshore operations of vessels based from a given port vary significantly. Ports with similar physical infrastructure may have different offshore operations.

3.2.2.2 Support and Heliport Facilities

Offshore oil and gas operations are reliant on an extensive support system to ensure that they have adequate supplies. Through this support system, offshore facilities receive several types of equipment essential to their functioning, including electric generators, chains, gears, tools, pumps, and compressors. In addition, this support system enables the transport of various materials required for the daily operation of offshore oil and gas facilities, such as drilling muds, chemicals, and lubricants. Onshore support facilities also serve as the base from which offshore oil and gas workers are transported to and from offshore platforms and other structures. Several types of facilities make up this onshore support system, including general support facilities, repair and maintenance yards, supply bases, and heliports.

- ***General support facilities***: These facilities are diverse in their capabilities and physical features, but infrastructure common to most of these facilities includes protected wharfs, docks, and dry docks; storage facilities; crew housing; access to transportation networks; communications facilities; and machine tool shops.
- ***Repair and maintenance yards***: Although some repair and maintenance for offshore oil and gas equipment occurs at offshore drilling/production sites, much of this activity also occurs at onshore (or coastal) repair and maintenance facilities. Specific repair and maintenance activities occurring at these facilities include, but are not necessarily limited to, blasting and repainting ship hulls or interior tanks; major re-building and installation of diesel engines, turbines, and other heavy equipment; systems overhauls and maintenance; system replacement (e.g., navigation); propeller and rudder repairs; and creation of raw materials (e.g., pipes).
- ***Supply bases***: Supply bases vary in both their physical size and the level of serve they provide. Large supply yards may provide full logistics and supply chain management for the offshore oil and gas industry. In this capacity, they may transport several types of equipment and supplies from onshore facilities to offshore platforms. In contrast, small shops that specialize in providing one type of item used on offshore platforms or marine vessels may operate more like retail and equipment rental vendors.
- ***Heliports***: Heliports are facilities from which helicopters disembark to transport crew and equipment to offshore oil and gas sites. Although supply vessels typically service offshore facilities located relatively short distances from shore, helicopters are the primary means of transportation for longer distances offshore or for situations when the speed of delivery is important.

3.2.2.3. Waste Disposal Facilities

The offshore oil and gas industry generates a variety of solid and liquid wastes that must be managed through disposal or (in some cases) recycling. The largest waste stream generated by the industry is drilling fluids and cuttings (NPC 2011a as in BOEM 2014). Drilling fluids, also referred to as drilling muds, are a combination of clay, water, and chemical additives that are pumped through the drill pipe down the hole in the seabed to aid with the drilling process. As the drill penetrates into the seabed, it creates cuttings (ground rock) that are suspended in the drill fluid, which carries the cuttings back to the surface. In addition to drilling fluids and cuttings, common wastes generated by offshore oil and gas operations include:

- Aqueous fluids with minimal solids content, such as produced waters, acids used in stimulation activities, and wash waters used in drilling and production operations
- Naturally occurring radioactive materials, including tank bottoms, pipe scale, and sediments containing naturally high levels of radioactive materials
- Industrial hazardous wastes, such as solvents and other waste materials that exhibit one or more of the characteristics of a hazardous waste (i.e., ignitability, reactivity, corrosivity, or toxicity) under Subtitle C of the Resource Conservation and Recovery Act
- Non-hazardous oily waste streams generated by machinery operations
- Municipal solid waste generated by personnel on offshore rigs, platforms, and vessels

Although drilling muds and cuttings are often managed through offshore discharge or re-injection into underground formations, some classes of drilling muds and cuttings and most other wastes generated by the offshore oil and gas industry must be managed at onshore facilities. These facilities may include the following:

- ***Transfer facilities:*** Typically located at ports, transfer facilities receive wastes delivered by boat from multiple offshore oil and gas sites and consolidate and transfer these wastes to another mode of transportation (i.e., barge or truck) for delivery to a disposal site.
- ***Pits and landfills:*** Pits are commonly used for the disposal of cuttings from offshore drilling sites. These pits are lined and no other chemicals, refuse, or debris are disposed within them. Landfills are used for the disposal of many other wastes generated by the offshore oil and gas industry. Non-hazardous wastes are dispose of in municipal solid waste landfills or industrial waste landfills, while hazardous wastes must be disposed of in permitted hazardous waste management landfills.
- ***Thermal treatment facilities:*** In addition to landfills, non-hazardous and hazardous waste generated by the offshore oil and gas industry may be disposed of in thermal treatment facilities, such as municipal solid waste incinerators and hazardous waste incinerators.

3.2.2.4. Support Facilities Unique to the Arctic

The landscape of Alaska may, in many cases, necessitate the construction of support facilities that are unique to the region. In particular, three broad categories of onshore support infrastructure may be required in Alaska but not in other OCS regions:

- ***Ice Roads, Ice Pads, and Other Seasonal Infrastructure:*** Seasonal infrastructure such as ice roads or ice pads allows for the transportation or placement of equipment during the winter months, avoiding the need to construct permanent infrastructure. Ice roads and other seasonal infrastructure are constructed each winter and typically operate during the months of January through April. This infrastructure is typically sufficient for the initial development of oil and gas fields (Sullender 2017).

- ***Gravel Roads, Airstrips, and Pads:*** Gravel roads and other permanent infrastructure are often necessary during production activities to provide year-round access to onshore support facilities. For example, gravel pads are constructed at onshore pipeline tie-in points or landfalls and are also used as the base for vertical support members for aboveground pipelines (Sullender 2017).
- ***Artificial Gravel Islands and Well Pads:*** Nearshore production facilities that house drill rigs and other production infrastructure are often constructed on gravel islands, which offer a viable alternative to constructing bottom-founded platforms (North Slope Borough 2014). The gravel required for the construction of artificial gravel islands is extracted from onshore gravel mines.

3.2.3. Coastal Pipelines

Onshore coastal pipelines transport OCS oil and gas from where it is brought onshore (often via pipeline) to processing facilities, refineries, petrochemical plants, and other facilities. The onshore pipeline networks for oil and gas are complex systems made up of multiple components including piping, valves, metering points, and compressors. More broadly, pipeline systems are made up of three different components: (1) gathering systems which collect oil and gas from multiple production sites and consolidate them into a smaller number of lines[40], (2) interstate and intrastate pipeline systems that transport oil and gas over long distances to serve customers located far from production sites, and (3) distribution systems (natural gas only). Pipeline systems also vary significantly in length.

3.2.4. Pipe-coating Facilities

For protection against corrosion and other damage, pipelines used to transport OCS oil and gas may be coated on their exterior and/or interior. These coatings are typically applied at a coating mill before pipe is delivered to the installation site, though some pipe coatings are installed at the job site. Coating mills apply coatings to pipelines bound for installation locally as well as pipelines to be installed at more distant locations.

3.2.5. Natural Gas Processing and Storage Facilities

Natural gas produced on the OCS and in other locations typically occurs as a combination of light hydrocarbon gases, impurities, and liquid hydrocarbons. Natural gas processing facilities remove the impurities and separate the various hydrocarbons, which may be marketed as separate products (e.g., methane, propane, butane). Because water vapors, solids, and other impurities occurring in natural gas may interfere with the pipeline transmission and marketing of gas, processing must typically occur prior to sending natural gas into the transmission network. Processing plants are often centrally located so that they may serve multiple gas fields. The typical stages in the processing of natural gas include gas-oil separation (when natural gas and crude oil are extracted together), condensate separation, dehydration, contaminant removal, nitrogen extraction, methane separation, and fractionation (i.e., the process of separating the natural gas liquids remaining in the gas stream into individual components such as butane and propane).

The functioning of the U.S. natural gas system is also dependent on ample storage capacity. Although gas processing facilities are typically located in close proximity to wells, storage facilities may be located significant distances from where gas is produced. To minimize storage costs, natural gas is normally stored in depleted reservoirs in oil or gas fields, aquifers, or salt cavern formations.

[40] Most of the gas line mileage for gather systems is located offshore in the context of OCS oil and gas development.

3.2.6. Other Facilities

In addition to the types of onshore infrastructure described above, OCS oil and gas development may be associated with the development (or expansion of) onshore infrastructure for the processing of OCS oil and gas. Although these facilities are not necessary for OCS oil and gas development and may be developed due to other factors, OCS oil and gas development may nonetheless influence investment decisions regarding the construction of new facilities or expansion of existing facilities. These facilities include the following:

- ***Petroleum Refineries:*** Petroleum refineries produce a variety of petroleum products—such as gasoline, diesel fuel, jet fuel, and heating fuel—using various heating, distilling, and catalytic conversion technologies. Refineries vary in terms of their size and the specific equipment onsite depending on the types of crude oil that they refine (e.g., light sweet crude versus heavy sour crude) and the petroleum products that they manufacture.
- ***Liquefied Natural Gas (LNG) Terminals:*** LNG terminals are facilities where natural gas may be converted from gaseous to liquid form (or vice versa) to facilitate the transportation of natural gas to market where it is demanded. Once liquefied, natural gas may be transported via LNG tanker to markets across the globe.
- ***Petrochemical Plants:*** The non-fuel components of natural gas and crude oil that are removed during processing and refining are typically used as a feedstock in the production of petrochemicals. Because petrochemical plants are often located in close proximity to raw materials and extensive transportation routes, the development of OCS oil and gas may contribute to the expansion or development of these facilities. Petrochemical plants are typically laid out as large industrial complexes that produce multiple primary, intermediate, and end-use chemical products (BOEM 2011). The specific technologies used by these facilities changes over time with market conditions.

3.3 Existing Regulatory Environment

Construction and operation of any coastal infrastructure, including infrastructure related to oil and gas exploration and development, is subject to Federal, state, and local regulations and policies focused on avoiding, minimizing, or mitigating adverse impacts of the project to physical and biological resources. To provide perspective on the regulatory requirements associated with onshore infrastructure development and operation, the following discussion characterizes key Federal regulations designed to reduce the risk to environmental resources, including examples of specific management practices and mitigation measures. These regulations include the:

- Clean Water Act
- Clean Air Act
- Coastal Zone Management Act
- Endangered Species Act
- Marine Mammal Protection Act

3.3.1 Clean Water Act[41]

The Clean Water Act (CWA) regulates discharges into waters of the U.S. and requires states to establish water quality standards for surface waters. The CWA regulates the construction and operation of onshore infrastructure primarily through Sections 404 and 402. Section 404 of the CWA requires parties to obtain a permit from the U.S. Army Corps prior to discharging dredge or fill material into waters of the U.S. As part of the section 404 permit process, the Army Corps reviews the potential effects of proposed projects on plant and animal populations and recommends efforts to avoid adverse effects to these populations in addition to the wetlands themselves. In general, conservation efforts for plants and animals may include:

- Select sites or manage discharges to ensure that habitat remains suitable for indigenous species;
- Avoid sites having unique habitat or other value, including habitat of threatened or endangered species;
- Utilize habitat development and restoration techniques to minimize adverse impacts and compensate for destroyed habitat;
- Time discharge to avoid biologically critical time periods; and
- Avoid the destruction of remnant natural sites within areas already affected by development.

Additionally, the Army Corps authorizes nationwide and regional general permits which streamline the permitting process for specific categories of activities that involve discharges of dredged and fill material and only cause minimal environmental effects. These CWA permits are subject to general conditions specifying specific management measures to avoid particular types of impacts. For instance, the 2017 Nationwide General Permit includes a number of general conditions that approved projects must satisfy which protect physical and biological resources, including:

- **Aquatic Life Movements.** No activity may substantially disrupt the necessary life cycle movements of those species of aquatic life indigenous to the waterbody, including those species that normally migrate through the area, unless the activity's primary purpose is to impound water. All permanent and temporary crossings of waterbodies shall be suitably culverted, bridged, or otherwise designed and constructed to maintain low flows to sustain the movement of those aquatic species.
- **Spawning Areas.** Activities in spawning areas during spawning seasons must be avoided to the maximum extent practicable. Activities that result in the physical destruction (e.g., through excavation, fill, or downstream smothering by substantial turbidity) of an important spawning area are not authorized.
- **Migratory Bird Breeding Areas.** Activities in waters of the U.S. that serve as breeding areas for migratory birds must be avoided to the maximum extent practicable.
- **Shellfish Beds.** No activity may occur in areas of concentrated shellfish populations, unless the activity is directly related to a shellfish harvesting activity authorized by Nationwide Permits (NWPs) 4 and 48, or is a shellfish seeding or habitat restoration activity authorized by NWP 27.
- **Suitable Material.** No activity may use unsuitable material (e.g., trash, debris, car bodies, asphalt, etc.). Material used for construction or discharged must be free from toxic pollutants in toxic amounts (see section 307 of the CWA).

[41] 33 U.S.C. §1251 et seq. (1972)

- **Adverse Effects from Impoundments.** If the activity creates an impoundment of water, adverse effects to the aquatic system due to accelerating the passage of water, and/or restricting its flow must be minimized to the maximum extent practicable.
- **Management of Water Flows.** To the maximum extent practicable, the pre-construction course, condition, capacity, and location of open waters must be maintained for each activity, including stream channelization, storm water management activities, and temporary and permanent road crossings, except as provided below. The activity must be constructed to withstand expected high flows. The activity must not restrict or impede the passage of normal or high flows, unless the primary purpose of the activity is to impound water or manage high flows. The activity may alter the pre-construction course, condition, capacity, and location of open waters if it benefits the aquatic environment (e.g., stream restoration or relocation activities).
- **Soil Erosion and Sediment Controls.** Appropriate soil erosion and sediment controls must be used and maintained in effective operating condition during construction, and all exposed soil and other fills, as well as any work below the ordinary high water mark or high tide line, must be permanently stabilized at the earliest practicable date. Permittees are encouraged to perform work within waters of the U.S. during periods of low-flow or no-flow, or during low tides.
- **Wild and Scenic Rivers.** No NWP activity may occur in a component of the National Wild and Scenic River System, or in a river officially designated by Congress as a “study river” for possible inclusion in the system while the river is in an official study status, unless the appropriate Federal agency with direct management responsibility for such river, has determined in writing that the proposed activity will not adversely affect the Wild and Scenic River designation or study status.
- **Endangered Species.** No activity is authorized under any NWP which is likely to directly or indirectly jeopardize the continued existence of a threatened or endangered species or a species proposed for such designation, as identified under the Endangered Species Act (ESA), or which will directly or indirectly destroy or adversely modify the critical habitat of such species.
- **Designated Critical Resource Waters.** Critical resource waters include NOAA-managed marine sanctuaries and marine monuments, and National Estuarine Research Reserves.
- **Water Quality.** Where states and authorized Tribes, or EPA where applicable, have not previously certified compliance of an NWP with CWA Section 401, Individual 401 Water Quality Certification must be obtained or waived (see 33 CFR 330.4(c)). The district engineer or state or Tribe may require additional water quality management measures to ensure that the authorized activity does not result in more than minimal degradation of water quality (USACE 2017).

Individual Army Corps districts also authorize regional general permits for specific geographic areas and activities. For instance, the Florida State Programmatic General Permit conveys general authority from the Army Corps to the Florida Department of Environmental Protection for authorizing CWA permit requests for the following types of minor work throughout the state:

- Shoreline stabilization;
- Boat ramps and boat launch areas and structures associated with such ramps or launch areas;
- Docks, piers, associated facilities, and other minor piling supported structures; and
- Maintenance dredging of canals and channels.

Similar to the Nationwide General Permit, projects authorized under the Florida State Programmatic General Permit must satisfy a variety of management practices which minimize impacts to physical and biological resources.

Additionally, under Section 402 of the CWA, EPA maintains permit authority to protect U.S. navigable waters from pollution at the point at which a discharge originates or will originate. Any applicant proposing to undergo construction or other activities that may result in any discharge into navigable waters must obtain a National Pollutant Discharge Elimination System (NPDES) permit, generally administered by the state. The permit limits what may be discharged and establishes monitoring and reporting requirements for the permittee.

3.3.2 Clean Air Act[42]

The Clean Air Act regulates air emissions from stationary and mobile sources in the U.S.. Under the authority of the Clean Air Act, EPA establishes National Ambient Air Quality Standards for six criteria air pollutants (carbon monoxide, lead, nitrogen dioxide, ozone, particulate matter, and sulfur dioxide). Areas that do not meet the standards for these pollutants ("non-attainment areas") may be subject to more stringent emission standards. Construction and operation of all onshore infrastructure results in the emission of criteria air pollutants. If an onshore infrastructure facility emits or has the potential to emit more than 10 tons of a single pollutant or more than 25 tons of all pollutants per year, the facility will be designated as a "major source" and will be subject to technology-based emission standards.

3.3.3 Coastal Zone Management Act[43]

The Coastal Zone Management Act (CZMA) of 1972 provides for management of the nation's coastal resources and aims to balance economic development with environmental conservation. The National Coastal Zone Management Program authorized by the CZMA is a voluntary partnership between the Federal government and coastal states. The program is administered at the Federal level by NOAA's Office of Ocean and Coastal Resource Management, but allows states to design programs that best address their unique coastal challenges and laws and regulations. Currently all coastal states except for Alaska have approved coastal management programs.

The National Coastal Zone Management Program includes a number of components that may provide protection to physical and biological resources from onshore infrastructure construction. The Federal consistency provision ensures that Federal actions, including federally authorized and funded actions, with reasonably foreseeable effects on coastal uses and resources must be consistent with the policies of a state's approved coastal management program. The Coastal Zone Enhancement Program provides incentives to states to enhance their coastal zone management programs within nine key areas including wetlands, special area management planning, and ocean and Great Lakes resources. The below sections highlight some of the protections provided by a Coastal Management Program in the Atlantic, GOM, and Pacific Regions (Texas, North Carolina, and California).

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[42] 42 U.S.C. §7401 et seq. (1970)

[43] 16 U.S.C. §§ 1451 et seq. (1972),

3.3.3.1 North Carolina

The North Carolina Coastal Area Management Act requires that project proponents receive a permit for any sort of development within designated Areas of Environmental Concern, which include almost all coastal waters and wetlands.[44] The Coastal Resources Commission has established requirements that apply to all development in each type of Area of Environmental Concern. For example, all development in Estuarine Waters, Coastal Wetlands, and Public Trust Areas must meet the following requirements, among others:

- The project must follow the air and water quality standards set by the N.C. Environmental Management Commission. Generally, development will not be permitted if it lowers water quality for any existing uses of the water (such as shellfishing, swimming or drinking).
- The project must not significantly increase siltation or erosion, which can smother important habitats, block sunlight from aquatic plants, and choke fish and shellfish.
- The project construction must be timed to have the least impact on the life cycles and migration patterns of fish, shellfish, waterfowl and other wildlife (North Carolina Department of Environmental Quality 2014).

The permitting process considers whether a proposed project meets the Coastal Resources Commission rules and the local government's land use plan and includes an agency and public comment period.

3.3.3.2 Texas

The Texas Coastal Management Program has assigned Resource Management Codes (RMCs) to all state-owned waters (Harte Research Institute 2015). The RMCs provide guidelines for development activities near sensitive natural resources. The natural resources used to designate RMCs include bird rookeries, coastal wetlands, critical dune areas, critical erosion areas, critical habitat areas, and submerged aquatic vegetation, among others. Dredging and other construction activities may not be allowed in sensitive areas, or may only be allowed at a specific setback distance based on the types of sensitive natural resources present. Additionally, the RMCs provide recommendations to minimize adverse impacts to sensitive natural resources, such as the use of silt curtains or other barriers to reduce turbidity and sedimentation impacts.

3.3.3.3 California

The California Coastal Commission regulates development activities in the coastal zone of California through the California Coastal Act (State of California 1976).[45] The Commission requires project proponents to receive permits for activities including construction of buildings, divisions of land, and activities that change the intensity of use of land or public access to coastal waters. Through the permitting process, the Commission aims to protect environmentally sensitive habitat areas and maintain healthy populations of marine organisms. Additionally, the California Coastal Act contains provisions specific to oil and gas infrastructure, including tanker terminals, refineries, and pipelines. For instance, Section 30262 of the Act requires that oil produced offshore California is transported onshore via pipeline, and that these pipelines “utilize the best achievable technology to ensure maximum protection of

[44] The North Carolina Department of Environmental Quality defines an Area of Environmental Concern as “an area of natural importance: It may be easily destroyed by erosion or flooding; or it may have environmental, social, economic or aesthetic values that make it valuable to our state.”

[45] San Francisco Bay, which is regulated by the San Francisco Bay Conservation and Development Commission, is not covered by this Act.

public health and safety and of the integrity and productivity of terrestrial and marine ecosystems" (State of California 1976).

3.3.4 Marine Mammal Protection Act[46]

The Marine Mammal Protection Act (MMPA) prohibits the "take" of marine mammal species, defined as "to hunt, harass, capture, or kill" marine mammals. Section 101(a)(5) of the MMPA allows the incidental, but not intentional, take of marine mammals associated with a specified activity and geographical region if NMFS finds that the total taking will have a negligible impact on the species or stocks and will not have an unmitigable adverse impact on the availability of the species or stock for subsistence uses (where relevant). In this capacity and if appropriate, NMFS must issue MMPA incidental take regulations prescribing (a) the permissible methods of taking; (b) other means of effecting the least practicable adverse impact on the species or stocks and their habitat; and (c) monitoring and reporting requirements. The majority of incidental take authorizations are granted to fishery activities. However, activities that produce underwater noise, such as pile driving and other construction activities, may also require incidental take authorizations. Construction of onshore infrastructure in coastal areas which produces underwater noise with the potential to harass marine mammals would need to comply with incidental take regulations aimed to minimize adverse impacts.

3.3.5 Endangered Species Act[47]

The ESA, jointly administered by the NMFS and the FWS, aims to protect species at risk of extinction and the habitat upon which they depend. Under Section 7 of the ESA, Federal agencies are required to consult with NMFS or FWS to ensure that any action they authorize, fund, or carry out is not likely jeopardize the continued existence of any endangered or threatened species. Through the consultation process, NMFS may recommend modifications to these activities to avoid jeopardizing the continued existence of the species. Additionally, critical habitat areas are determined for each endangered species based on the presence of physical and biological features that are essential to the conservation of the species. Once critical habitat is designated for a species, the Section 7 consultation process also requires Federal agencies to ensure that Federal actions are not likely to result in the destruction or adverse modification of critical habitat.

Onshore infrastructure projects with a Federal nexus that are located in areas with endangered species or critical habitat would be required to go through this consultation process and, if necessary, implement project modifications to avoid jeopardizing the species of adversely modifying critical habitat. Onshore infrastructure projects with a Federal nexus include all projects that require CWA permits, such as dredging and construction.

3.4 Environmental and Social Impacts of Onshore Infrastructure

This section broadly describes the environmental impacts associated with the various types of onshore infrastructure outlined above. As analytic context for the characterization of these impacts, this section first presents a short summary of the various information sources reviewed to identify these impacts. The individual types of onshore infrastructure are then mapped with various environmental impacts, differentiating between impacts associated with the construction of onshore infrastructure and impacts associated with its operation.

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[46] 16 U.S.C. §§ 1361 et seq. (1972)

[47] 16 U.S.C. §1531 et seq. (1973)

3.4.1 Sources of Information Consulted

To assess the environmental impacts of onshore infrastructure, this section draws upon information from the following information sources:

- ***BOEM EISs for OCS Oil and Gas Activity.*** Programmatic EISs and EISs for individual lease sales identify the resources affected by different aspects of OCS oil and gas activity. These documents highlight the impacts of onshore infrastructure to different types of resources and also identify various stressors associated with the use of this infrastructure, such as vessel noise, vessel traffic, and physical presence (including lights).
- ***Biological Opinions.*** The FWS and the NMFS publish biological opinions for projects that could impact endangered species. These biological opinions examine impacts at different stages of infrastructure development and use, apply a variety of methods (e.g., exposure analysis) to estimate the effect of infrastructure on biological resources (when feasible), and provide recommendations to mitigate the impact of the stressors introduced or exacerbated by the project.
- ***EISs for Other Coastal Infrastructure Projects***. Because there has been no new leasing activity in the Pacific or Atlantic OCS regions for more than three decades, no recent studies focus specifically on the impacts of developing onshore infrastructure to support OCS oil and gas activity in these areas. However, EIS documents for port expansion and LNG terminal construction projects in these areas have examined the impacts of some types of onshore infrastructure. The findings of these assessments may be transferable to onshore infrastructure supporting offshore oil and gas activities.
- ***Other Reports or Publications.*** The information presented in this section also reflects other BOEM reports, EISs of projects submitted to entities such as the U.S. Army Corps of Engineers (USACE), and other publications that estimated the environmental and social impacts of onshore infrastructure.

3.4.2 Characterization of Environmental and Social Impacts

For the purposes of characterizing onshore infrastructure impacts to physical and biological resources, impacts associated with the construction of onshore infrastructure are differentiated from the impacts associated with its operation. In addition, to provide clarity regarding the ways in which onshore infrastructure may result in environmental impacts, the environmental stressors associated with specific types of onshore infrastructure are linked with the various impacts.

The construction and operation of onshore infrastructure imposes multiple stressors on physical, biological, and sociocultural resources, including noise, air pollutant emissions, wastewater discharge, and disturbance due to collisions. Table 32 identifies the specific types of onshore infrastructure associated with these and other stressors and indicates how, if at all, each stressor relates to the construction and/or operation of onshore infrastructure. The table also shows some aspects of onshore infrastructure development that, rather than imposing stress on physical, biological, and sociocultural resources, may be beneficial to these resources. As shown in Table 32, a given stressor/factor may be relevant to both the construction and operation of infrastructure. The significance of a given stressor/factor, however, may differ between these two phases. For example, emissions related to pipelines are likely to be higher during construction than during the pipeline operations.

The severity of the stressors/factors identified in Table 32 is likely to be more significant for the construction and operation of new facilities than the expansion or retrofit of existing facilities. Therefore, the magnitude of impacts related to a specific stressor/factor is likely to be greater for new infrastructure than for existing onshore infrastructure expanded or modified to support OCS oil and gas activity.

Table 32. Stressors/factors associated with construction and operation of onshore infrastructure

Stressor or Positive Factor	Onshore Infrastructure	Construction Stage	Operation Stage
Noise	Helicopters[1]; Marine Vessels; Pipelines; Onshore Infrastructure Facilities	• Noise generated during the construction of onshore infrastructure includes noise from (1) the operation of construction equipment, (2) the delivery and unloading of construction materials, and (3) pile driving and hammering during the construction of structures.	• Noise produced from the (1) operation of marine vessels, helicopters, and compressors (for pipelines); (2) platform- and rig-construction at fabrication and shipbuilding yards, which often have open-air work environments; and (3) operations of other facilities.
Collisions with Biota	Helicopters; Marine Vessels	• Collisions of marine vessels with marine species during construction of onshore infrastructure	• Collisions of marine vessels with marine species and helicopter collisions with birds.
Water and Wastewater Discharge	Onshore Waste Disposal Facilities, Other Infrastructure	• Discharges of dredge or fill material generated during construction	• Bilge and ballast water discharges from vessels operating at onshore infrastructure sites. • Wastewater discharge and runoff from onshore waste disposal facilities and other infrastructure.
Air Pollutant Emissions[2]	All Onshore Facilities	• Criteria pollutant and greenhouse gas emissions from equipment involved in the construction of onshore infrastructure facilities • Fugitive dust emissions from construction activity, when dust is not wet due to proximity to the water	• Criteria pollutant and greenhouse gas emissions from vessels, compressors, cranes, and other equipment used in the normal operations of onshore infrastructure facilities. • Fugitive dust emissions from road transport, especially on gravel roads, if the road surface is not wet.
Lighting and Physical Presence	All Types	• The presence of cranes and other equipment used during construction, including lighting, may alter the habitat of species that live along the coast • Coastal erosion resulting from infrastructure obstructing sediment flows that naturally nourish beaches	• Lighting necessary for night-time operations of some types of onshore infrastructure (e.g., supply bases, ports) alters the physical environment and biological resources (e.g., sea turtles) in the local area. • Tall infrastructure may provide resting or nesting places for certain bird species. • The presence of tall infrastructure in coastal areas may alter the ecological balance between predatory birds and the species on which they prey. • The ongoing operation of onshore infrastructure may alter the habitat of coastal species. • The presence of new infrastructure may disturb the view shed for local populations, as well as the way of life for local populations accustomed to living in an environment/setting with limited development.

Stressor or Positive Factor	Onshore Infrastructure	Construction Stage	Operation Stage
Land Use Change	Pipelines, Roads	• Habitat fragmentation and/or disturbance • Increased runoff due to increase in impervious surfaces • Water withdrawals (for ice road construction in Alaska)	• Habitat fragmentation and/or disturbance. • Increased runoff due to increase in impervious surfaces. • Changes in land use may provide for greater connectivity within a local area, for example if new roads are developed.
Maintenance of Onshore infrastructure	All Types	N/A	• Maintenance dredging of navigation channels could increase turbidity; maintenance of onshore pipelines other onshore infrastructure facilities could affect physical, biological, and sociocultural resources.
Leaks	Pipelines and Tanks at Production or Processing Facilities	• Discharges during pipeline testing	• Accidents, pipeline corrosion, and other operation-related events could cause leakages from pipelines and production/processing facilities.
Economic activity/ growth	All types	• Economic activity during construction may provide short-term employment opportunities for local workers that result in positive spillover effects to the local economy.	• The ongoing operation of onshore infrastructure may create employment opportunities for local workers that result in spillover effects to the local economy. • During the operational stage, new or expanded onshore infrastructure facilities may expand the local property tax base.
Notes: 1. The term "helicopters" includes impact from other aerial transportation modes such as fixed-wing aircrafts. 2. Because the emissions from support and survey vehicles and helicopters are included in the OECM, this chapter does not address the air quality impacts associated with these emissions sources.			

Table 33 links the stressors/factors identified above in Table 32 to specific impacts to physical resources. The physical resources impacted by the construction and operation of onshore infrastructure are categorized into three groups: air quality, water quality, and lands. The majority of onshore infrastructure facilities associated with specific stressors/factors that affect the environment are located in coastal areas or navigation canals, but some support facilities may be located inland. In addition to the physical resource categories listed in Table 33, other physical resource types that are not applicable to all OCS regions (e.g., sea ice in Alaska) are described in the region-specific discussions below.

Table 33. Summary of physical resource impacts

Physical Resource Category	Stressor/ Factor	Impact of Stressor/Factor to Resource	Examples of Quantitative Metrics in the Literature
Air Quality	Emissions	• Increased criteria pollutant emissions increase concentrations of ambient particulate matter ($PM_{2.5}$ and PM_{10}) and/or ozone, depending on the pollutant. This increase in concentrations can result in adverse impacts to human health. In addition, increased NO_x emissions may lead to increased acid deposition. • Increased greenhouse gas emissions may contribute to global climate change.	• Emissions of criteria pollutants and greenhouse gases due to construction and operation of onshore infrastructure facilities
Water Quality	Discharges, physical presence	• Seafloor disturbance and habitat alteration caused by water discharges. • Smothering of marine habitats from siltation. • Increase in water turbidity due to the construction of pipelines and maintenance of harbors/canals (dredging) causes habitat alteration. • Increase in salinity, suspended solids, and temperature of sea water due to discharge from construction and operation activities of onshore infrastructure.	• Estimate of oil discharged by marine vessels during normal operation • Distance/radius of various effects (e.g., temperature effect) due to wastewater discharge • Extent of area of high turbidity from the dredging or dredged material discharge site
Lands	Vessel movement, physical presence	• Land loss from coastal erosion. • Disturbance of wetlands removes natural barrier to storm surge. • Presence of roads in Arctic alters freeze-thaw cycles and creates thermokarst.	• Land loss due to erosion caused by marine vehicles that support OCS oil and gas activity

Depending on the region, various types of biological resources such as fish species, marine mammals, marine and coastal birds, and lower trophic organisms may be impacted by onshore infrastructure. Table 34 summarizes the impacts to biological resources that may result from each of the stressors/factors outlined above. Although these impacts may be disaggregated to numerous biological resource categories, they are grouped into three categories for ease of exposition: marine species, terrestrial animals; and marine and coastal birds.

Table 34. Summary of biological resource impacts

Biological Resource Category	Stressors/ Factors	Impact of Stressor/Factor to Resource	Examples of Quantitative Metrics in the Literature
Marine Species	Noise, collisions, physical presence	• Habitat disturbance, including from noise and collisions associated with construction and operation of various onshore infrastructure facilities • Noise could cause auditory masking, hearing loss, and physiological injuries to marine species • Artificial lighting could impact the orientation, reproduction, and predation and communication behavior of marine and coastal species • Wastewater discharges could affect the habitat of marine species, causing injury and mortality to sensitive life stages exposed for a long period • Siltation from dredging could block sunlight required by aquatic plants, and could smother fish and shellfish • The presence of infrastructure could provide hard habitat for encrusting organism	• Measured sound level; Sound exposure level (SEL); sound pressure level (SPL) etc. from operations of vessels, and their potential to cause a permanent threshold shift (PTS) or temporary threshold shift (TTS) injury • Take counts of various marine species due to vessel collisions • Rate of mortality and serious injury to marine mammals
Terrestrial Animals	Noise, physical presence,	• Habitat disturbance/ fragmentation due to onshore infrastructure presence • Habitat loss from increased coastal erosion • Artificial habitat creation through creation of potential nesting locations for certain bird species	• Area of habitat disturbed for terrestrial mammal species • Habitat fragmentation • Estimates of take by harassment • Detectability-related variables such as comparison of sighting rate vs. operational state
Marine and Coastal Birds	Noise, collisions with helicopters	• Habitat disturbance caused by heavy equipment, vessels, and support aircraft, construction of onshore infrastructure (including pipelines)	• Area of habitat disturbed • Take counts of birds due to habitat disturbance from noise/collisions
Although included in Table 33 (Summary of Physical Resource Impacts), air and water quality are the primary pathways that cause habitat disturbance to biological resources.			

Sociocultural resources such as recreational facilities, archaeological remains, and the region's economy may also be positively or negatively impacted by the construction or presence of onshore infrastructure to support OCS oil and gas activity. Table 35 summarizes the sociocultural resources affected by various impact producing factors based on EISs of lease sales in the GOM and Alaska Regions.

Table 35. Summary of socioeconomic impacts

Sociocultural Resource Category or Impact Type	Stressors or Positive Factors	Affect to Resource	Examples of Quantitative Metrics in the Literature
Recreation and Land Use	Visual and space-use conflicts	• Increased coastal infrastructure necessary to support OCS activity can create space-use conflicts concentrated around major wildlife viewing and beach areas.	None available
Archaeological Resources	Bottom/land disturbance	• Chains attached to anchors have the potential to sweep along or lie on the seafloor adjacent to onshore infrastructure facilities, potentially impacting archaeological resources.	None available
Economic Development	Increased access, migration, and tourism	• In areas where OCS activity will occur, communities could benefit through access to or maintenance of healthcare services, community centers, and commercial and residential development, and from increased employment leading to economic benefits. • Increased infrastructure and services would also serve tourists who visit the region for outdoor recreation.	• Number of new jobs created due to OCS oil and gas activity • Income to the local population due to employment and economic opportunities • Impact on angler days, equipment sales, and income from hotel rentals and hiring of commercial sport fishing guides.
Fiscal	Increased tax and licensing revenues	• Construction of onshore infrastructure in undeveloped regions could result in sales, property, and income taxes (if applicable) and other licensing fees for the local government.	• Property tax revenues associated with property development for onshore infrastructure. • Income tax revenues associated with the employment of workers at onshore infrastructure facilities. • Revenue from licensing fees from fishing activity.

3.5 Impacts for the Atlantic Region

The Atlantic Region consists of four planning areas covering an area of more than 270 million acres. Ten oil and gas lease sales were held between 1976 and 1983 and 51 wells were drilled, but there has been no production from the Atlantic OCS. BOEM's 2007–2012 Program included one lease sale for the region, which was canceled in wake of the *Deepwater Horizon* oil spill (USDOI, BOEM 2018).

3.5.1 Potential Infrastructure Needs in the Atlantic Region

Table 36 presents information on the number of ports, private shipbuilding yards, and refineries located in states adjacent to the Atlantic Region. As indicated in the table, there are a total of 34 major ports, 39 private shipyards[48], and eight refineries on the U.S. Atlantic coast. Dismukes (2014) provides further insights into the presence of onshore infrastructure to support OCS activity in the Mid-Atlantic Planning Area, including their suitability to support OCS activity.

[48] Private shipyards include active shipbuilding yards, other shipyards with building positions, repair yards with drydock facilities, and topside repair yards.

Table 36. Ports, refineries, and shipyards located in Atlantic planning areas

Planning Area	State	Number of Facilities			
				Shipyards[3]	
		Major Ports[1]	Refineries[2]	Building	Repair
North Atlantic	Maine	2	0	1	0
	New Hampshire	1	0	0	0
	Massachusetts	2	0	0	1
	Rhode Island	1	0	0	3
	Connecticut	2	0	1	0
	New York	4	0	0	3
	New Jersey	2	3	1	2
	Pennsylvania	5	4	2	1
Mid-Atlantic	Delaware	2	1	0	0
	Maryland	1	0	1	2
	Virginia	2	0	1	10
	North Carolina	2	0	2	0
South Atlantic	South Carolina	1	0	1	3
	Georgia	2	0	0	2
Straits of Florida	Florida (Atlantic)	5	0	1	1
TOTAL		**34**	**8**	**11**	**28**

Notes:
1. U.S. Army Corps of Engineers (2011).
2. U.S. Department of Energy, Energy Information Administration (2017). The information from this source does not indicate which type(s) of crude oil each refinery is able to use as feedstock. Thus, it is possible that some of the refineries reflected here cannot process all varieties of crude oil.
3. Data for shipyards for New Jersey–Georgia from Dismukes (2014). All other states' data from U.S. DOT (2007).

Although some existing infrastructure on the East Coast could support OCS oil and gas activity in the Atlantic Region, significant investment would nonetheless be required to ensure sufficient support facility and processing capacity (Dismukes 2014). In particular, if development in the Atlantic is extensive, the region would likely require platform fabrication yards located along the Atlantic coast, as there are currently no such facilities in the region. In addition, the region would likely, at a minimum, require support yards, additional waste disposal capacity, natural gas pipeline capacity, and gas storage capacity (Dismukes 2014).

3.5.2 Impacts to Physical Resources—Atlantic Region

The onshore infrastructure impacts to physical resources in the Atlantic Region will be similar in nature to the impacts described in Section 3.4.2. Although analyses of the physical resource impacts of onshore infrastructure related to OCS oil and gas activities in the region are not readily available, the impacts examined for other large coastal projects in the region may shed light on potential onshore infrastructure projects. For example, the EIS documents for the Savannah Harbor Expansion project and the Long Island Sound Dredged Material Management Plan examined the physical resource impacts of these projects in detail:

- ***Savannah Harbor Expansion Project EIS.*** The Savannah Harbor Expansion Project (SHEP) EIS assessed the environmental impacts to four categories of physical resources: sediments, air quality, water quality, and wetlands/floodplains; and proposed mitigation (U.S. Army Corps of Engineers (USACE) 2012).

- ***Long Island Sound Dredged Material Management Plan—Final EIS.*** The Long Island Sound (LIS) Dredged Material Management Plan assessed the environmental impacts of dredging activities and management of dredged material to facilitate safe navigation and marine commerce in Connecticut, New York, and Rhode Island rivers, harbors, and coastal areas throughout the Long Island Sound region. The EIS assessed impacts to sediment and soil quality and water quality in three environments: open water, nearshore/shoreline, and upland (U.S. Army Corps of Engineers (USACE) 2015).

Table 37 identifies the stressors and physical resource impacts evaluated in the two EIS documents that are likely to be applicable to construction of OCS onshore infrastructure. Due to the non-recurring nature of activity in these projects, these EIS documents focus only on construction-related stressors and impacts that are similar to those included in Section 3.4.2. In addition, because the stressors (activities) shown in the table are likely to be more significant for the construction of new onshore infrastructure rather than the expansion or modification of existing infrastructure, the resulting impacts are also likely to be more significant for new infrastructure.

Table 37. Stressors and impacts from the Atlantic Region EISs reviewed (U.S. Army Corps of Engineers (USACE) 2015, 2012)

Physical Resource	Stressor [Activity]	Location and Description of Impact	Examples of Quantitative Impact Measures
Water Quality	Decrease in oxygen level	Specifically in estuarine waters, harbor deepening reduces the ability of oxygen to reach the estuary bottom; additional saltwater moves to upper portions of the harbor; reduced mixing of oxygen throughout water column (SHEP).	Percent Change in Dissolved Oxygen with and without Mitigation Options
Water Quality (including seafloor)	Dredging, onshore operations	Dredged material placed in open water may have short-term impacts on water quality, and could also result in physical changes to the seafloor; accumulation of dredged material decreases the relative water depth above the placement site, modifying ambient current and sediment transport (LIS).	None available
Air Quality	Dredging, Vessel Movement, Land-based Operations	Maintenance dredging and increase in movement of various types of vessels (especially container vessels) will cause air emissions. Among onshore infrastructure, toplifts at terminals are likely to produce most emissions (SHEP).	Tons of emissions of various criteria pollutants, toxics, and greenhouse gases
Wetlands	Discharge	Impacts to non-tidal wetlands due to construction of water storage impoundment; required marsh land calculated for mitigating impact (SHEP).	Acres of Wetland Area Impacted due to Project
Sediment Quality	Dredging / Sediment Removal	The deepening of navigation channel will require sediment removal and placement in confined dredged material disposal facilities . The presence of chemicals in the sediment could impact the disposal area (LIS).	None available

3.5.3 Biological Resources Impacts—Atlantic Region

The onshore infrastructure impacts to biological resources in the Atlantic Region will be similar in nature to the impacts described in Section 3.4.2. The magnitude of these impacts, however, will be dependent on the location of onshore infrastructure development and the extent to which new infrastructure needs are met through new infrastructure development or the expansion or modification of existing infrastructure. For potential insights on which portions of the Atlantic coast may be vulnerable to more significant impacts, Figures 2a and 2b present spatial information on the following: (1) protected areas,[49] (2) wetlands, (3) CWA impaired waters, and (4) critical habitat for endangered species.

As suggested by Figures 2a and 2b, the location of onshore infrastructure would be particularly important for impacts to endangered species. Because coastal regions in Maine, New Hampshire, Massachusetts, South Carolina, Georgia, and Florida are designated as critical habitat for endangered species, onshore infrastructure development in these areas would have a greater likelihood of impacting endangered species than onshore infrastructure on other portions of the Atlantic coast. In addition, Figures 2a and 2b show that much of the waters along the Atlantic coast are impaired waters under the CWA. Biological resources in these areas may therefore be particularly sensitive to onshore infrastructure development and use. However, because of these impaired water designations for these areas, a number of measures would likely be required to limit these impacts pursuant to the CWA, as described in Section 3.3.

In addition, during the public comment period for BOEM’s 2019–2024 Draft Proposed Program, the Chesapeake Bay Foundation warned against impacts of onshore infrastructure development to service offshore oil and gas activity, which could lead to permanent destruction or alteration of existing habitats in the Chesapeake Bay, impacting Maryland and Virginia’s coasts (Chesapeake Bay Foundation 2018; USDOI, BOEM 2018).

[49] The USGS Protected Areas Database of the United States (PAD-US) is the nation’s inventory of protected areas, including public open space and voluntarily provided, private protected areas. Most areas are public lands owned in fee; however, long-term easements, leases, and agreements or administrative designations documented in agency management plans may be included.

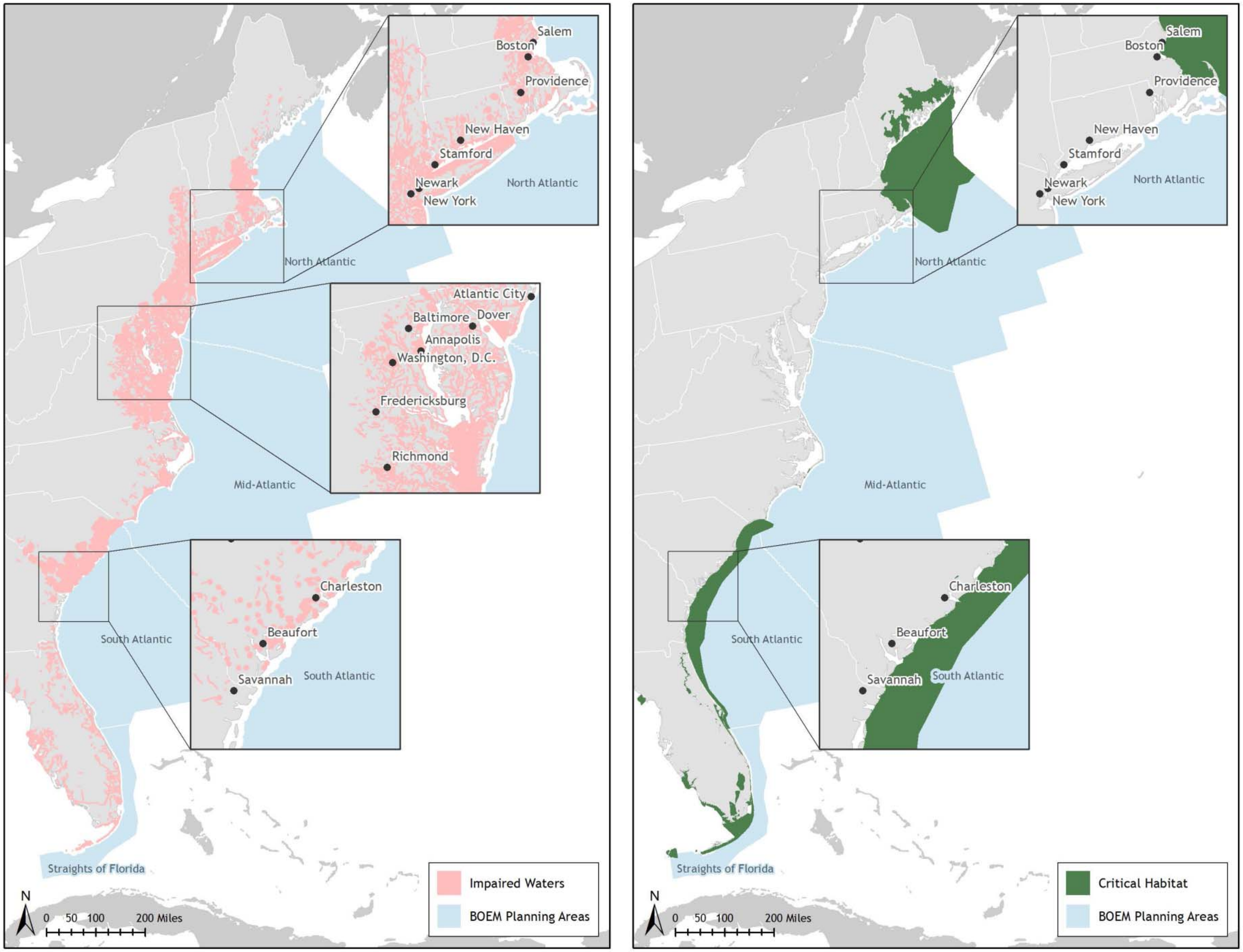


Figure 2a. Select resources in or near the Atlantic Region: impaired waters and critical habitat

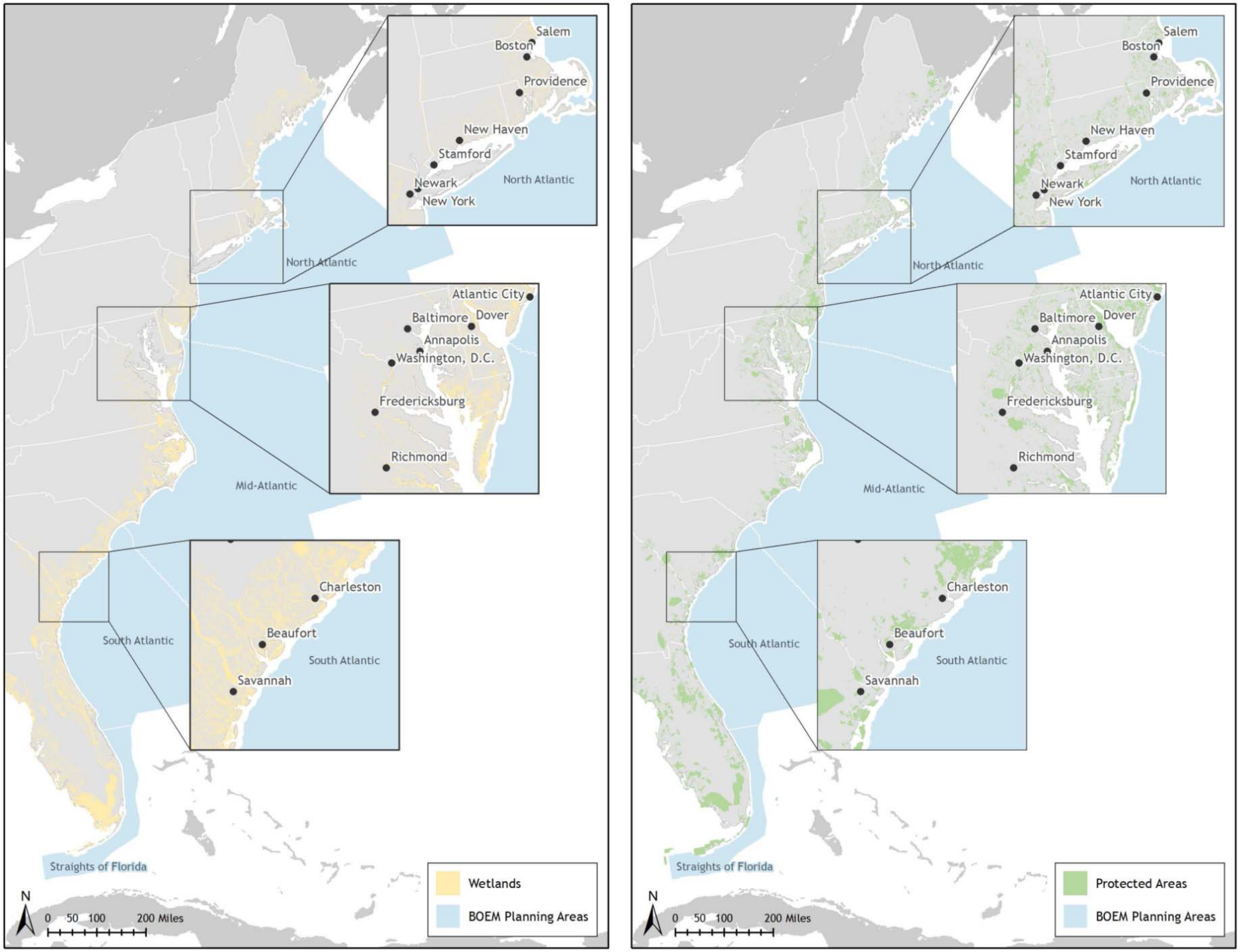


Figure 2b. Select resources in or near the Atlantic Region: wetlands and protected areas

3.5.4 Socioeconomic Impacts—Atlantic Region

The socioeconomic impacts of onshore infrastructure development in the Atlantic Region will also be similar to the impacts described in Section 3.4.2 (see Table 35). The magnitude of these impacts will depend on the location of onshore infrastructure and the degree to which infrastructure development involves the construction of new infrastructure or the expansion/retrofitting of existing facilities. Regardless of the location, however, shore-based OCS oil and gas activity at onshore infrastructure facilities is likely to create new jobs, which may have positive spillover effects for the local economy. In addition, the construction of new facilities or expansion of existing facilities may increase the value of infrastructure properties, which would increase property tax revenues for local governments. Whether onshore infrastructure development adjacent to the Atlantic Region results in the space-use conflicts or damage to archaeological resources described in Table 35 will depend on where specific uses occur relative to infrastructure facilities and whether archaeological resources are located near these facilities.

3.6 Impacts for the GOM Region

The GOM Region consists of three planning areas—Central GOM, Western GOM, and Eastern GOM—covering a total of approximately 160 million acres. The Central GOM and Western GOM Planning Areas are the most mature, with ongoing production for over 60 years, generating approximately 98 percent of all OCS oil and gas production in the US (USDOI, BOEM 2018). Thus, the coastal regions near the Central Gulf and Western Gulf have highly developed onshore infrastructure to support OCS oil and gas activities (USDOI, BOEM 2018). The following sections discuss potential infrastructure needs associated with new leasing in the GOM and the impacts associated with this additional infrastructure.

3.6.1 Potential Infrastructure Needs in the GOM Region

The GOM Region already has a significant amount of onshore infrastructure due to its long history of OCS oil and gas activity. Therefore, the need for additional onshore infrastructure to support increased oil and gas exploration may be limited. For insights on the level of existing infrastructure in the region, Table 38 presents an inventory of existing GOM onshore infrastructure as reported in the 2017–2022 Multi-sale EIS for the GOM Region (henceforth referred to as GOM-MEIS)[50] (USDOI, BOEM 2016a).

Table 38. Onshore infrastructure in the GOM Region

Onshore Infrastructure Type	Texas	Louisiana	Mississippi	Alabama	Florida (Gulf Coast)	Total
Pipeline Landfalls	14	122	3	5	0	144
Platform Fabrication Yards	12	37	4	1	0	54
Shipyards	32	64	9	18	14	137
Pipe-coating Facilities	9	6	0	2	2	19
Supply Bases	32	55	2	7	0	96
Ports	11	14	3	1	5	34
Waste Disposal Facilities	16	29	3	3	2	53
Natural Gas Storage Facilities	13	8	0	1	0	22

[50] The types of infrastructure facilities may differ from the list in Section 3.2 because some infrastructure types are categorized interchangeably if facilities serve multiple functions.

Onshore Infrastructure Type	Texas	Louisiana	Mississippi	Alabama	Florida (Gulf Coast)	Total
Helicopter Hubs	118	115	4	4	0	241
Pipeline Shore Facilities	13	40	0	0	0	53
Barge Terminals	110	122	6	6	8	252
Tanker Ports	4	6	0	0	0	10
Gas Processing Plants	39	44	1	13	1	98
Refineries	20	16	3	3	0	42
Petrochemical Plants	126	66	2	9	13	216

As shown in Table 38, Alabama, Mississippi, Texas, and Louisiana, which are located in close proximity to the Central GOM and Western GOM Planning Areas, have relatively more onshore infrastructure facilities than the Gulf Coast of Florida, which is near the Eastern GOM Planning Area. An increase in OCS leases in the Western GOM and Central GOM Planning Areas will leverage the presence of this existing onshore infrastructure. Even if additional onshore infrastructure capacity is required for some operations, companies owning existing facilities are likely to expand their capacity rather than construct new facilities due to the environmental and regulatory challenges in permitting for new facilities (USDOI, BOEM 2012). The expansion of capacity of existing facilities could also result in social and environmental costs, although expansion-related impacts are likely to be less than those associated with new facility construction (USDOI, BOEM 2017a). The issuance of new leasing in the Eastern GOM Planning Area may also leverage the existing infrastructure near the Central GOM and Western GOM Planning Areas. Additional onshore infrastructure along the coast of Florida, however, may be required. Key factors that would influence decision-making regarding the development of such infrastructure include the location of Eastern GOM leases relative to onshore infrastructure that already supports oil and gas activity in the Central GOM and whether the level of leasing activity in the Eastern GOM is sufficient to justify the development of new onshore infrastructure facilities.

3.6.2 Impacts to Physical Resources—GOM Region

As suggested in the previous section, the physical resource impacts of additional onshore infrastructure in coastal areas near the GOM Region will depend significantly on where new leasing occurs. Because new leasing in the Central GOM and Western GOM Planning Areas would likely rely on existing onshore infrastructure near these areas, the incremental impacts to physical resources from infrastructure construction are likely to be limited. New leasing activity in the Central and/or Western GOM, however, will likely result in incremental physical resource impacts related to the *operation* of onshore infrastructure. For example, while existing shipyards and fabrication yards may support new leasing in these areas, the number of vessel trips to these facilities may increase, as may the overall level of activity at these facilities.

Drawing on the information presented in Section 3.4.2 and the GOM-MEIS, Table 39 summarizes the onshore infrastructure impacts associated with physical resources for new leasing activity in the Central GOM and Western GOM Planning Areas. Consistent with the GOM-MEIS, the impacts for various resources are defined as none, negligible, minor, moderate, or major, with their definition varying for each resource type. The majority of stressors are expected to have negligible or no impact on physical resources.

The table also provides examples of potential quantitative impact measures for specific physical resource impacts. For example, erosion in navigable channels due to the wake of marine vessels is a significant impact expected in the GOM due to increased OCS oil and gas activity. Using the observed annual widening rate of 0.99 meters per year, the average land loss attributable to OCS activity ranges from 0.4

to 5.02 hectares each year (USDOI, BOEM 2017a). Estimates of loss of wetlands due to pipeline vary widely. According to Baumann and Turner (1990), onshore pipelines in coastal wetlands contribute to an annual land loss of 2.5 hectares for each kilometer of the pipeline. A more recent study estimates that the annual wetland loss from pipeline canals ranges from 6.3 to 31.3 hectares per kilometer of pipeline (Johnston et al. 2009).

Table 39. Physical resource impacts in the Western GOM and Central GOM Planning Areas (USDOI, BOEM 2016a, 2012)

Physical Resource	Stressor [Activity]	Description of Impact	Examples of Quantitative Impact Measures
Air Quality	Emissions	Additional use of onshore infrastructure results in the generation of air pollutant emissions	Data reported, but not separately for onshore infrastructure facilities[1]
Water Quality	Discharge	Discharge from operation and wastewater disposal from onshore facilities impacts the water quality and disturbs the seafloor bottom	None available
Water Quality and Land	Maintenance Dredging	Increase in turbidity and erosion due to dredging activity for maintenance of navigational canals	Extent of area of high turbidity from the point of dredging
Land	Vessel trips	Erosion caused by waves due to operation of marine vessels and barges in navigable channels	Hectares of land lost annually due to OCS activity from marine vessels
Land	Physical Presence (pipeline)	Land loss in wetland regions due to pipelines	Wetland loss per unit length of pipeline
Notes: 1. Because the emissions from support and survey vehicles and helicopters are included in the OECM, this chapter does not address the air quality impacts associated with these emissions sources.			

The magnitude of physical resource impacts associated with onshore infrastructure will also depend on measures in place to protect these resources and the quantity and quality of resources in the region. Although this section does not exhaustively characterize existing measures or physical resources in the region, Figures 3a nad 3b present the spatial information on the following: (1) protected areas, (2) wetlands, (3) CWA impaired waters, and (4) critical habitat for endangered species. As shown in the figures, impaired waters are located along much of the Texas and Louisiana coasts. In addition, much of the Alabama coastline and coastal waters are critical habitat for species listed as endangered under the ESA.

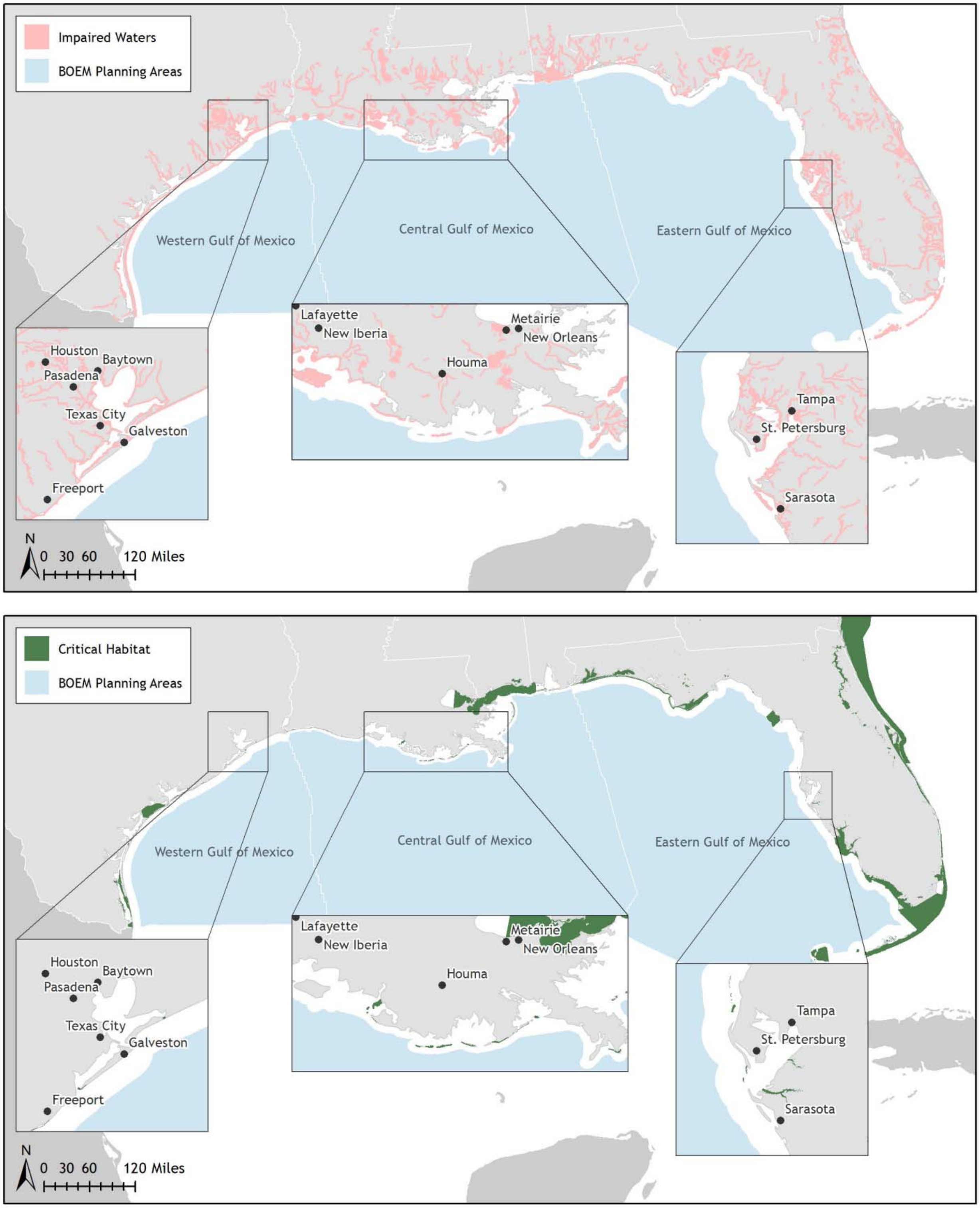


Figure 3a. Select resources in or near the GOM Region: impaired waters and critical habitat

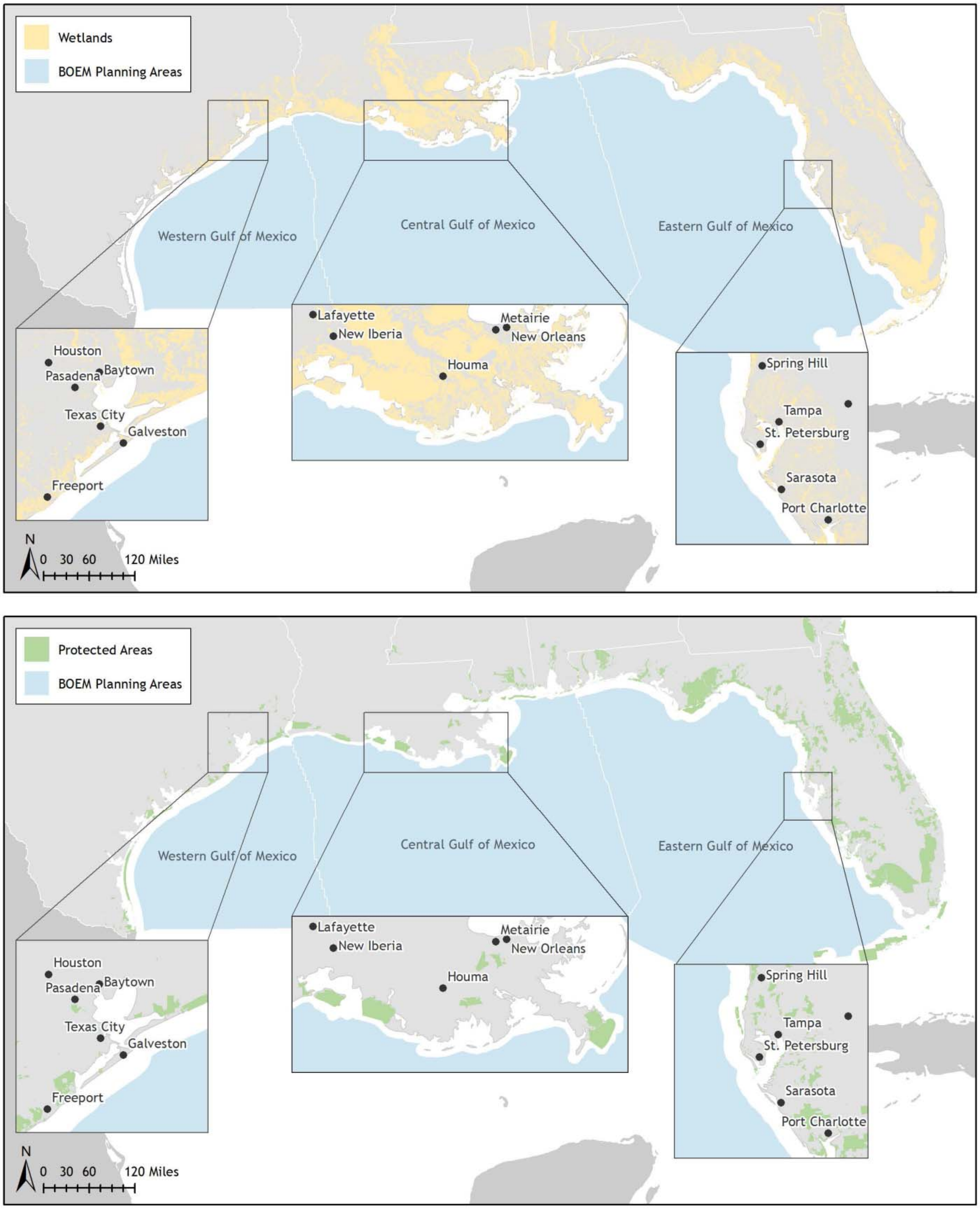


Figure 3b. Select resources in or near the GOM Region: wetlands and protected areas

As described above, physical resource impacts related to onshore infrastructure near the Eastern GOM Planning Area may depend on both the location of Eastern GOM leases and the level of leasing activity in the area. To the extent that extensive onshore infrastructure development occurs on the Florida coast to support OCS oil and gas activity in the Eastern GOM, impacts such as those described in Section 3.4.2 are likely to materialize. In addition, as shown in Figures 3a and 3b, significant portion of the waters along Florida's Gulf coast are impaired waters under the CWA or are designated as critical habitat for endangered species. Physical resources in these areas may therefore be particularly sensitive to onshore infrastructure development and use. However, because of the impaired water and critical habitat designations for these areas, a number of measures would likely be required to limit these impacts pursuant to the CWA and ESA, as described in Section 3.3.

3.6.3 Biological Resources Impacts—GOM Region

Similar to physical resource impacts, the impacts of increased lease activity on biological resources will depend on the spatial distribution of leasing activity in the GOM Region and the extent to which new infrastructure needs are met through new infrastructure development or the expansion or modification of existing infrastructure. If most activity is limited to the Central GOM and Western GOM Planning Areas, biological resource impacts will primarily include noise and disturbances from marine vessels and aircrafts, and habitat disturbance from operation of onshore infrastructure. In addition, the extensive use and maintenance of navigation canals in the GOM Region will involve frequent dredging activity. If leasing activity occurs in the Eastern GOM Planning Area, construction-related impacts of onshore infrastructure on biological resources will be similar to those discussed in Section 3.4.2, depending on the extent of new infrastructure required.

Table 40 identifies the most significant stressors and the associated biological resource impacts related to onshore infrastructure in the Western GOM and Central GOM Planning Areas, given the existing infrastructure already in place in these areas (USDOI, BOEM 2012). Similar to the characterization of physical resource impacts, Table 40 also indicates the severity of impact for biological resources based on the GOM-MEIS. The resource maps in Figures 3a and 3b above also shed light on potential efforts to alleviate the impacts of new onshore infrastructure in the Central GOM and Western GOM Planning Areas. As indicated in the figure, much of the coast line in the Central GOM and Western GOM Planning Areas is either a protected area, critical habitat, or adjacent to impaired waters.

Biological resource impacts related to onshore infrastructure near the Eastern GOM Planning Area will depend on the location of any leasing occurring in the area and the level of leasing activity. To the extent that Eastern GOM leasing is far from existing infrastructure in the Central GOM and the level of leasing activity is significant, onshore infrastructure is more likely to be developed on Florida's Gulf coast, resulting in impacts such as those described in Section 3.4.2 above. In addition, as shown in Figures 3a and 3b, significant portion of the waters along Florida's Gulf coast are impaired waters under the CWA or are designated as critical habitat for endangered species. Biological resources in these areas may therefore be particularly sensitive to onshore infrastructure development and use. However, because of the impaired water and critical habitat designations for these areas, a number of measures would likely be required to limit these impacts pursuant to the CWA and ESA, as described in Section 3.3.

Table 40. Examples of biological resources impacts assuming GOM lease activity concentrated in the Western GOM and Central GOM Planning Areas (USDOI, BOEM 2012)

Biological Resource	Stressor(s)	Impact of Stressor to Resource	Examples of Activity and Impacts
Marine Species	Collision	Incidental take of marine mammals and sea turtles	Collisions with vessels and onshore activity disturbs the habitat of various marine species, including protected species of marine mammals for which Potential Biological Removal estimates are provided for various endangered and threatened species, and vary by species type (Waring et al. 2016).
Marine Species	Vehicle Traffic, Beachfront Erosion, Artificial Lighting	All the listed stressors disturb sea turtles and their nesting beaches	
Marine Species	Noise	Noise at onshore infrastructure facilities may disturb marine species and produce temporary stress.	Noise may disturb marine species and birds. Impacts range from negligible to minor, and depend on the species.
Marine and Coastal Birds	Noise and collisions	Change in bird behavior due to noise at onshore infrastructure facilities	
Marine and Coastal Birds	Physical presence	Pipeline landfalls, terminals, and other onshore OCS-related infrastructure can destroy or fragment otherwise suitable avian habitats.	One pipeline landfall was projected in the GOM Region for the 2012–2017 Program.

3.6.4 Socioeconomic Impacts—GOM Region

The socioeconomic impacts of onshore infrastructure development in the GOM Region will be similar to the impacts described in Section 3.4.2 (see Table 35), but will depend significantly on the location of OCS oil and gas activity. If most activity is limited to the Central GOM and Western GOM Planning Areas, such activity will likely rely upon existing infrastructure (or minor expansions of existing infrastructure), in which case socioeconomic impacts are likely to be limited. However, if OCS oil and gas activity expands into the Eastern GOM Planning Area, additional infrastructure development along the Florida coast may occur, resulting in many of the socioeconomic impacts identified in Table 35.

3.7 Impacts for the Pacific Region

The Pacific Region consists of four planning areas—Washington/Oregon, Northern California, Central California, and Southern California—covering an area of more than 248 million acres. All four planning areas have had lease sales, with the most recent lease sold in 1984. As of 2017, the Southern California Planning Area has 43 existing leases. Oil and gas production in the Southern California Planning Area, which began in June 1968, totaled more than 1.35 billion barrels of oil and 1.84 trillion cubic feet (Tcf) of natural gas through December 2016.

3.7.1 Potential Infrastructure Needs in the Pacific Region

The limited information readily available regarding the existing onshore infrastructure near the Pacific Region is presented below in Table 41. As indicated in the table, there are 20 major ports,[51] 14 private shipyards, and 23 refineries on the U.S. Pacific coast (U.S. Army Corps of Engineers (USACE) 2011; U.S. Dept. of Energy, Energy Information Administration 2017). Although these facilities may help support OCS oil and gas activity in the Pacific Region, an increase in such activity in the region will likely require significant investment in onshore infrastructure. During the public comment period for the 2019–2024 Draft Proposed Program, many entities from the Pacific Region commented on the 2019–2024 Draft Proposed Program (USDOI, BOEM 2018), highlighting the lack of support infrastructure as a barrier to offshore oil and gas (California Coastal Commission 2017; California State Lands Commission 2018).

Table 41. Ports, refineries, and shipyards located in Pacific planning areas

	Number of Facilities			
			Shipyards	
Planning Area	**Ports**	**Refineries**	**Building**	**Repair**
Washington/Oregon	11	5	1	7
Northern California	0	0	0	0
Central California	5	5	0	3
Southern California	4	13	1	2
TOTAL	**20**	**23**	**2**	**12**

3.7.2 Physical Resources Impacts—Pacific Region

The onshore infrastructure impacts to physical resources in the Pacific Region will be similar in nature to the impacts described in Section 3.4.2. Although analyses of the physical resource impacts of onshore infrastructure related to OCS oil and gas activities in the region are not readily available, the impacts examined for other large coastal projects in the region may shed light on potential onshore infrastructure projects. For example, the EIS for the Jordan Cove LNG Terminal and Pipeline Construction project in Oregon assessed impacts on four categories of physical resources: land use, geological resources, soils and sediments, and water resources (including groundwater, surface water, and wetlands) (Federal Energy Regulatory Commission 2015). Table 42 identifies the individual stressors and impacts from the Jordan Cove LNG Terminal EIS that may be applicable to the construction of OCS onshore infrastructure.

[51] Table 41 includes major and minor ports that can support OCS activity, however, the data from USACE provides a list of only major ports.

Table 42. Stressors and impacts from the Jordan Cove LNG Terminal and Pipeline Project EIS (Federal Energy Regulatory Commission 2015)

Physical Resource	Stressor [Activity]	Location and Description of Impact	Example of Measure of Impact
Existing Land Use Impacts	Construction and Operation	Various land uses (open water, open land, forest, industrial) will be affected during construction and operation of individual facilities as part of the LNG terminal and pipeline construction project	Quantity and type of land affected during construction and operation
Land	Construction	Geological impacts such as land subsidence due to the required earthwork (e.g., trench excavation etc.)	Potential of geological impact and mitigation alternatives
Land	Construction	LNG facility and pipeline construction will affect soils and sediments in the area of construction with specific locations having higher impact based on their sensitivity	Summary of risk and sensitivity by administrative unit and watershed; relevant mitigation measures
Water Resources and Wetlands	Construction	The water quality of groundwater, surface water, and wetlands will be impacted by the construction and operation of various infrastructure, including the pipeline crossings of various watersheds and streams	Impacts to water quality through wastewater generated and contamination of various types of resources listed in this category; potential mitigation alternatives
Upland Vegetation and Timber	Construction	The construction of pipeline from the LNG terminal to related facilities inland will affect forested woodland, shrubs, and disturbed land; required compensation for loss of habitat for vegetation removal calculated	Quantities of various land types impacted, included vegetation, which was used to calculate the amount of land to be purchased for long-term preservation

The magnitude of physical resource impacts associated with onshore infrastructure will also depend on measures in place to protect these resources and the quantity and quality of resources in the region and the extent to which new infrastructure needs are met through new infrastructure development or the expansion or modification of existing infrastructure. Although this section does not exhaustively characterize the existing measures or physical resources in the region, Figures 4a and 4b present the spatial information on the following: (1) protected areas, (2) wetlands, (3) CWA impaired waters, and (4) critical habitat for endangered species. As indicated in the figures, much of the Pacific coast is made up of protected areas and impaired waters.

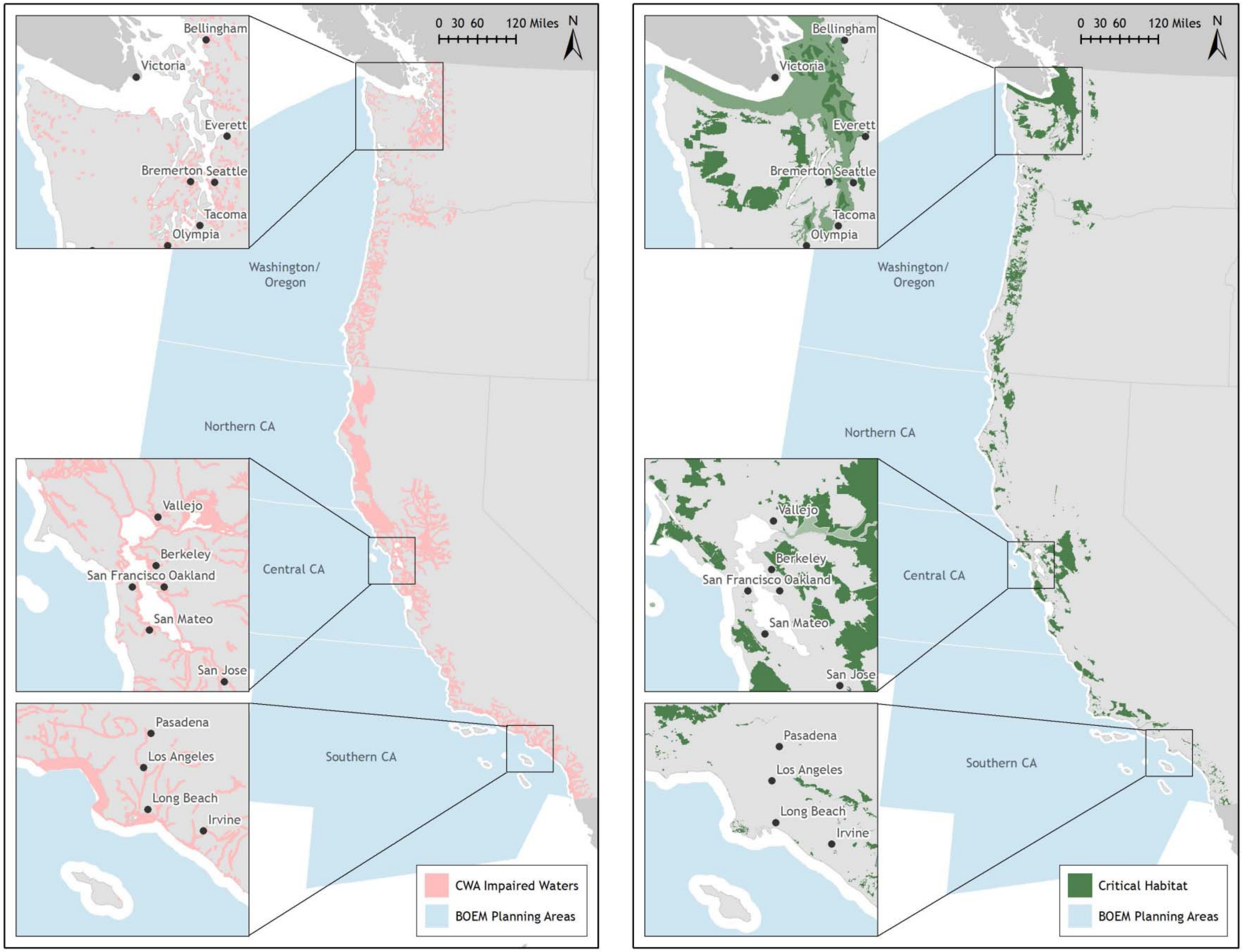


Figure 4a. Select resources in or near the Pacific Region: impaired waters and critical habitat

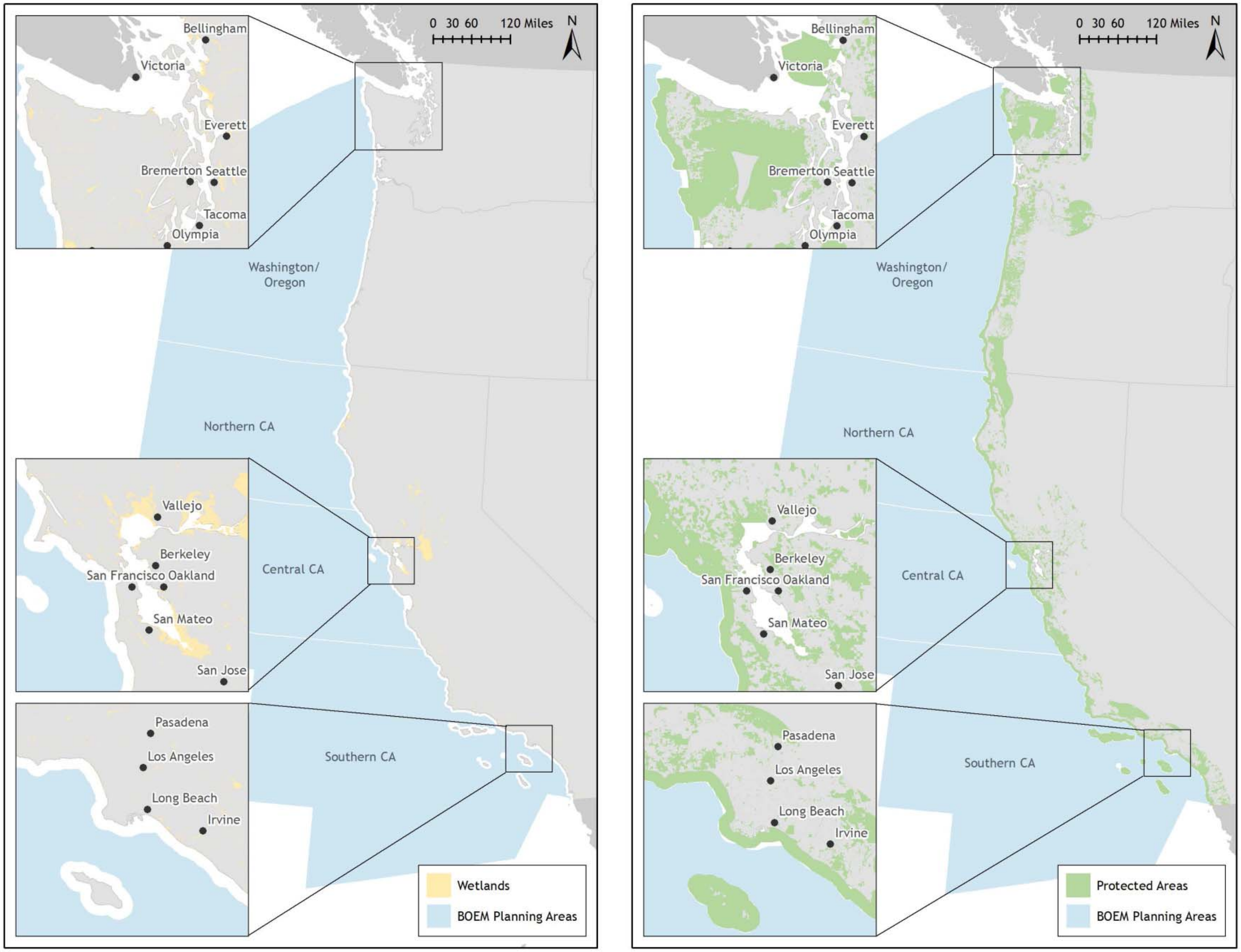


Figure 4b. Select resources in or near the Pacific Region: wetlands and protected areas

3.7.3 Biological Resources Impacts—Pacific Region

Given the significant investment in onshore infrastructure that would be necessary to support OCS oil and gas activities in the Pacific Region, the development and use of such infrastructure would likely result in the full suite of biological resource impacts described in Section 3.4.2. In addition, as shown in Figures 4a and 4b, significant portion of the waters along the Pacific coast are protected areas, impaired waters under the CWA, or designated as critical habitat for endangered species. Biological resources in these areas may therefore be particularly sensitive to onshore infrastructure development and use. However, because of the impaired water and critical habitat designations for these areas, a number of measures would likely be required to limit these impacts pursuant to the CWA and ESA, as described in Section 3.3.

During the public comment period for BOEM's 2019–2024 Draft Proposed Program, the California State Lands Commission warned that increased oil and gas exploration and extraction will likely lead to greater vessel traffic for offshore platform and pipeline construction, as well as transport of petroleum products to onshore facilities, such as marine oil terminals. The disturbances will also impact coastal ecosystems, rocky intertidal habitat, coastal islands, and wetlands, which serve vital functions for climate regulation, carbon sequestration, fisheries, wildlife habitat, and water and air quality. Air emissions from OCS activity could also impact air breathing species such as marine mammals and sea turtles, many of which are endangered (California State Lands Commission 2018).

The threatened marine resources and birds in the Pacific Region that will be potentially impacted by onshore infrastructure off the coasts of California, Oregon, and Washington include stellar sea lion, least tern, marbled murrelet, western gull, sooty shearwater, snowy plover, glaucous-winged gull, harbor porpoise, and sperm whale (Niedoroda et al. 2014; USDOI, BOEM 2018).

3.7.4 Socioeconomic Impacts—Pacific Region

The socioeconomic impacts of onshore infrastructure development in the Pacific Region will be similar to the impacts described in Section 3.4.2 (see Table 35). Because significant investment in onshore infrastructure would be necessary to support OCS oil and gas activity in the Pacific Region, the development of this infrastructure will likely result in most if not all of the socioeconomic impacts identified in Table 35. The magnitude of these impacts will depend on the location of onshore infrastructure and the degree to which infrastructure development involves the construction of new infrastructure or the expansion/retrofitting of existing facilities. Regardless of the location, however, shore-based OCS oil and gas activity at onshore infrastructure facilities is likely to create new jobs, which may have positive spillover effects for the local economy. In addition, the construction of new facilities or expansion of existing facilities may increase the value of infrastructure properties, which would increase property tax revenues for local governments. Whether onshore infrastructure development adjacent to the Pacific Region results in the space-use conflicts or damage to archaeological resources described in Table 35 depends on where specific uses occur relative to infrastructure facilities and whether archaeological resources are located near these facilities.

3.8 Impacts for the Alaska Region

The Alaska Region consists of 15 planning areas, covering an area of more than 1,035 million acres. BOEM has issued leases in eight of these 15 areas, with the most recent sale in 2008 in the Chukchi Sea Planning Area. This was also the largest lease sale in the history of the Alaska Region, but all leases in the planning area have been relinquished by existing leaseholders in part due to high costs associated with the extraction due to the challenging physical environment (Marex 2016; Rosen 2016). The Beaufort Sea and Cook Inlet are the only planning areas in the region with active leases. Figure 5 shows the planning areas and large marine ecosystems in the Alaska Region (USDOI, BOEM 2018).

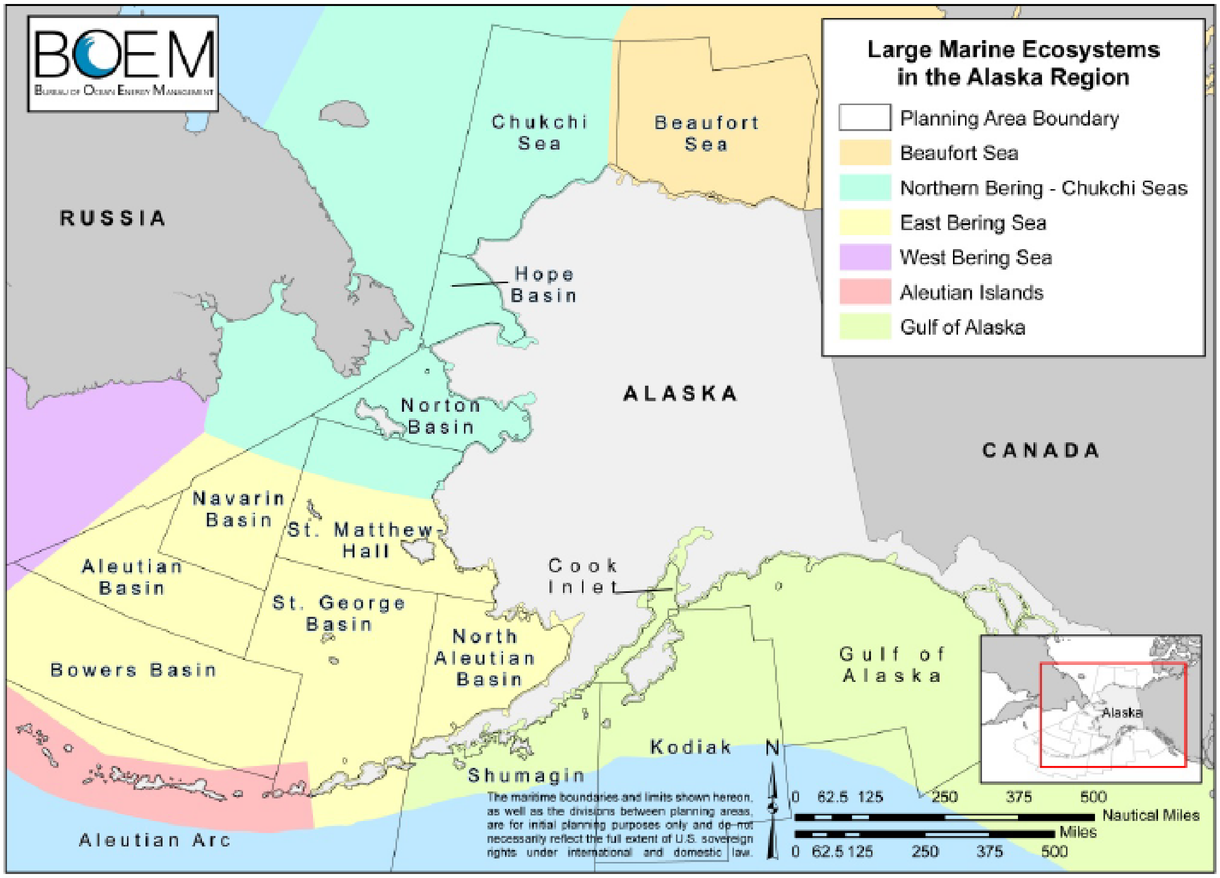


Figure 5. Large marine ecosystems and planning areas in the Alaska Region
Source: USDOI, BOEM (2018)

3.8.1 Potential Infrastructure Needs in the Alaska Region

The existing onshore infrastructure to support oil and gas activities in the Alaska Region is limited. Across the region, the Upper Cook Inlet (in the Cook Inlet Planning Area) is the only mature basin containing oil and gas pipelines, onshore drill pads, and processing and support facilities. Table 43 includes an inventory of the various onshore infrastructure near the Cook Inlet Planning Area, and Table 44 provides statewide estimates of the number of ports, refineries, and shipyards in coastal areas.

Table 43. Onshore infrastructure in the Cook Inlet Planning Area, Alaska Region

Onshore Infrastructure Type	Number of Facilities	Source and Additional Details
Production Facilities	21 (6 not producing)	Talberth and Branosky ((2013)
Processing Facilities	5	Talberth and Branosky (2013)
Terminal / Supply Bases	1	Talberth and Branosky (2013)
Onshore Pipelines	82 miles	Based on a 2000 estimate (66 miles) and additional 16 miles of onshore pipeline (Goff 2003; Robertson and Parker Horn Company 2000)
Refineries	5	Tesoro Refinery is in Cook Inlet, which can process up to 72,000 barrels of crude oil per day (USDOI, BOEM 2016b)
Natural Gas Storage Facilities	5	These facilities have a total storage capacity of 11 BCF, with a potential storage capacity of 17 BCF
Airports	3	Kenai, Soldotna, and Homer are the three airports in Cook Inlet Planning Area (USDOI, BOEM 2016b)
Marine Facility	1	This is a drift terminal (USDOI, BOEM 2016b)
Ports	4	USDOI, BOEM (2016b)

Table 44. Ports, refineries, and shipyards located near Alaska planning areas

Planning Area	Number of Facilities			
			Shipyards[3]	
	Ports[1]	Refineries[2]	Building	Repair
Gulf of Alaska	3	1	0	1
Cook Inlet	2	2	0	0
Aleutian Arc	1	0	0	0
Hope Basin	1	0	0	0
Beaufort Sea	0	2	0	0
TOTAL	**7**	**5**	**0**	**1**

1. U.S. Army Corps of Engineers (2011).
2. U.S. Department of Energy, Energy Information Administration (2017).
3. U.S. DOT (2007).

Some onshore infrastructure also exists in the Arctic. Hillmer-Pegram (2014) estimate that there are 1,138 miles of roads, 901 miles of pipelines, and 460 structures in Arctic Alaska (including gravel pads, gravel islands, gravel airstrips, gravel helipads, bridges, and facilities). All of these structures, and the majority of the roads and pipelines, are located on land adjacent to the Beaufort Sea Planning Area. For instance, infrastructure in Prudhoe Bay (neighboring the Beaufort Sea) includes Deadhorse Airport, West Dock, the Dalton Highway, and access to the Trans-Alaska Pipeline System. However, significant additional infrastructure such as ice roads, gravel pads, ice pads, hovercraft shelter, and a gravel mine site will be required for transporting OCS resources, as detailed in the Liberty Development Project EIS (USDOI, BOEM 2017b). Unlike the Beaufort Sea Planning Area, the Chukchi Sea Planning Area will require significant infrastructure construction related to producing and transporting extracted resources to the Trans-Alaska pipeline.

New OCS oil and gas activity outside of Cook Inlet would require significant investment in onshore infrastructure. As the information presented above indicates, the existing onshore infrastructure across most of the region is limited. The level of infrastructure investment necessary to accommodate OCS oil and gas activity in the region would depend on the location of new leases and the level of activity on these leases. However, in addition to the onshore infrastructure typically required for OCS activity in other regions (e.g., the GOM), the remote nature of the planning areas in the Alaska Region may require the construction of significant support infrastructure such as roads to access the shore and gravel pads to support pipeline landfalls. As an indicator of some of the onshore infrastructure needs associated with new leasing in the Beaufort Sea, Chukchi Sea, and Cook Inlet Planning Areas, Table 45 shows estimates of the onshore pipeline miles and pipeline landfalls expected under the 2017–2022 Program (USDOI, BOEM 2016a).

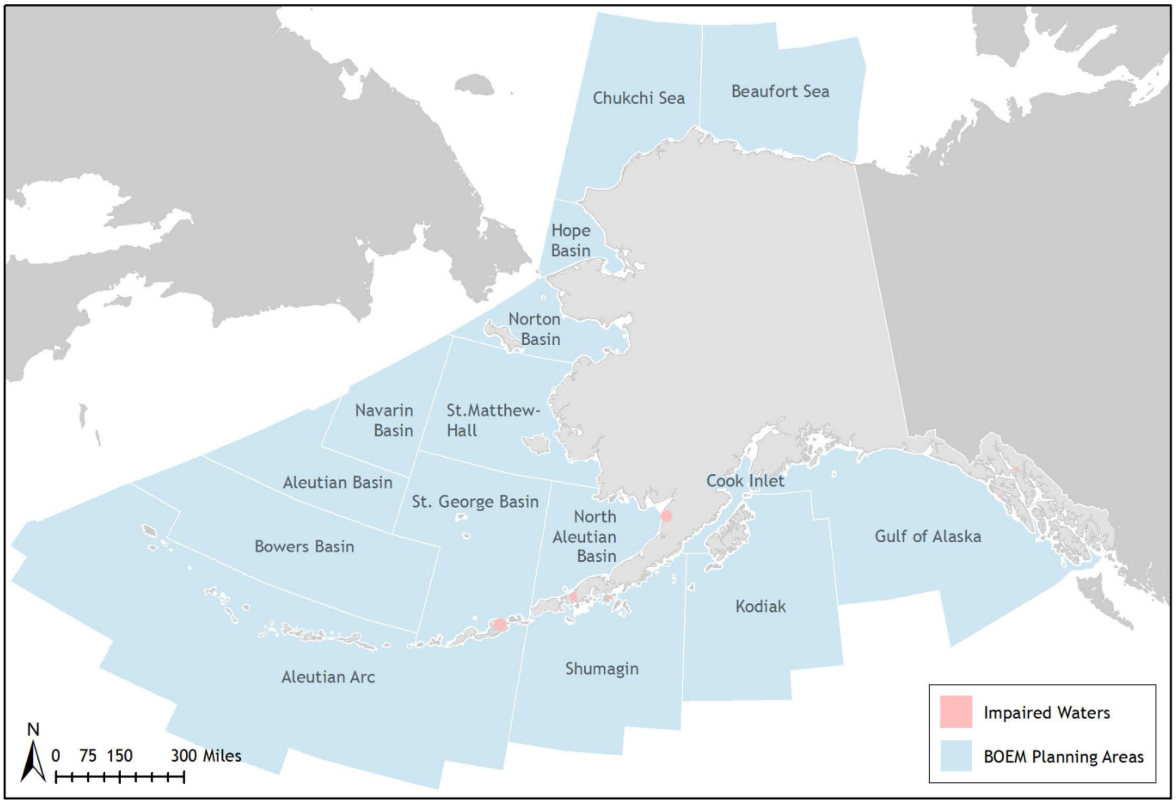
Table 45. Inventory requirement estimates in Alaska Region (USDOI, BOEM 2016a)

Estimated Item	Beaufort Sea	Chukchi Sea	Cook Inlet
New Onshore Pipeline (Miles)	Up to 10	Up to 300 oil; Up to 300 gas	0
New Pipeline Landfalls	Up to 10	Up to 2	1 to 5

3.8.2 Impacts to Physical Resources—Alaska Region

Due to the limited onshore infrastructure in the region and the pristine nature of the physical resources in most of Alaska, the physical resource impacts associated with onshore infrastructure development in the region could be substantial. Specifically, the development and use of onshore infrastructure in the region could lead to measurable impacts for each of the categories of physical resource impacts described in Section 3.4.2. Figures 6a and 6b show areas that may be particularly sensitive to onshore infrastructure development. For example, the figures show that wetlands make up much of Alaska's western and northern coasts.

For further insights on potential impacts to physical resources, Table 46 provides examples of the wide range of impacts for onshore infrastructure development in the Arctic and Cook Inlet, based on recent lease sale EISs in the Chukchi Sea, Beaufort Sea, and Cook Inlet (USDOI, BOEM 2017b, 2016b, 2015).



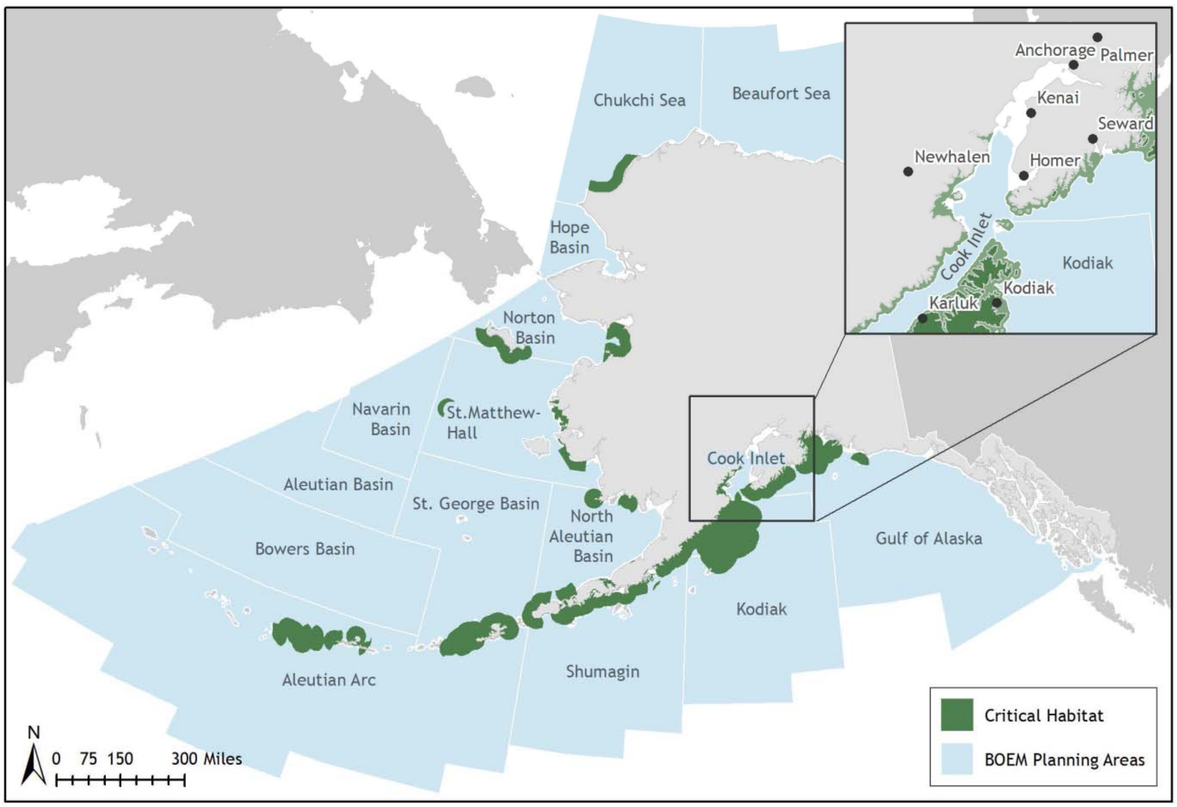


Figure 6a. Select resources in or near the Alaska Region: impaired waters and critical habitat

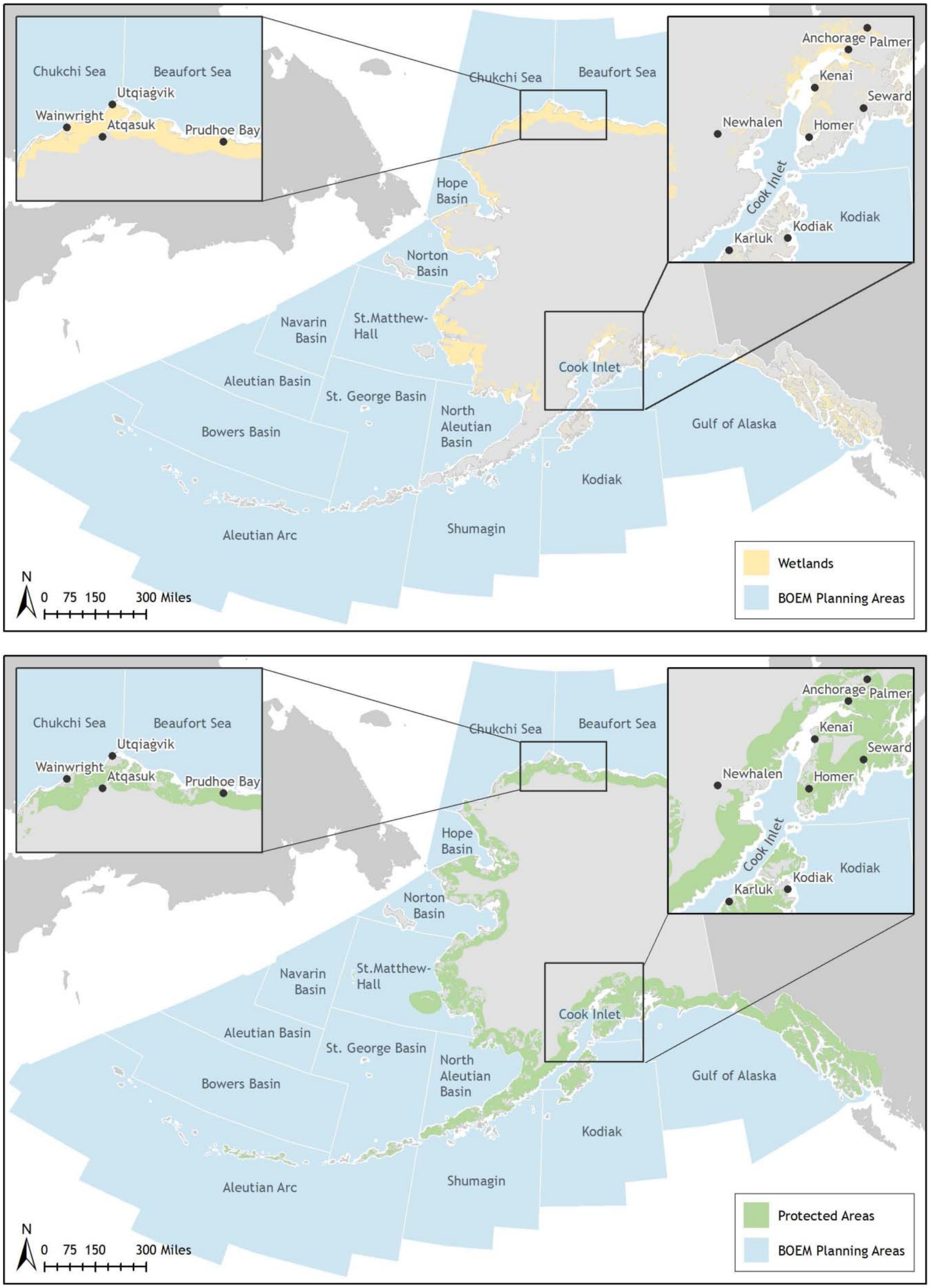


Figure 6b. Select resources in or near the Alaska Region: wetlands and protected areas

Table 46. Examples of physical resource impacts in the Alaska Region for Cook Inlet, Chukchi Sea, and Beaufort Sea Lease Sales

Physical Resource	Stressor [Activity]	Location and Description of Impact	Example Measure of Impact
Air Quality	Emissions	Emissions Estimates from Arctic Air Quality Modeling Study, which separately estimates emissions from construction of onshore camps and terminals in Chukchi Sea	Tons of air pollutant emissions.
Water Quality	Physical Presence (pipeline)	In Chukchi Sea, presence of onshore pipelines would cause water quality impacts when located at stream, river, or pond crossings.	None available
Water Quality	Discharge	In Chukchi Sea, construction of onshore infrastructure and gravel extraction for various construction activities; operational discharges from wastewater, processing, housing facilities and marine vessels	None available
Other Physical Environment (Wetlands)	Pipeline Construction	In Cook Inlet, wetlands, including stream crossings, would be excavated and then backfilled for construction of pipelines.	Area of wetlands excavated
Other Physical Environment	Waste Discharge	In Cook Inlet rock cuttings may be transported by barge for disposal onshore.	Impacts due to barge trips required to transport rock cuttings for onshore disposal
Other Physical Environment	Physical Presence	In Beaufort Sea, construction of gravel pads (to support pipeline tie-ins), ice roads, ice pads, and hovercraft shelter will have either temporary or year-round physical presence, and will impact the physical environment Gravel roads cause geophysical changes to the landscape by altering permafrost freeze-and-thaw cycles and creating thermokarst.	None available
Other Physical Environment (Vegetation)	Gravel Mining and Fill	Excavation of gravel from mines/ quarries would result in loss of the existing vegetation within the mine footprint. Gravel fill for shore-based facilities directly covers and kills vegetation. Placement of gravel fill also has the potential to divert, impede, or block natural drainages in areas adjacent to the fill.	Changes in vegetation and other physical/biological resources around gravel pads and roads. More details available in Sullender (2017).

As indicated in the first row of Table 46 above, the development and use of new onshore infrastructure to support OCS oil and gas activity in the Alaska Region may adversely affect air quality in the area through increased air pollutant emissions. BOEM’s Arctic Air Quality Monitoring Study provides some insight on these impacts, as it modeled the emissions associated with various types of infrastructure required for activity in the Chukchi Sea Planning Area, including emissions from aircrafts, supply bases, and the construction of pipelines (USDOI, BOEM 2014). Emissions from construction and operation of one onshore camp and terminal are shown in Table 47. As indicated in the table, emissions during construction of an onshore camp are significantly higher than emissions associated with operations.

Table 47. Air emissions due to construction and operation of onshore infrastructure facilities in the Chukchi Sea (USDOI, BOEM 2014)

Criteria Air Pollutant Emissions from One Onshore camp and Terminal (tons/year)			Greenhouse Gas Emissions from One Onshore camp and Terminal (tons/year)		
Pollutant	Construction	Operation (Annual)	Pollutant	Construction	Operation (Annual)
$PM_{2.5}$	25.3	1.4	N_2O	1.4	4.5
PM_{10}	26.6	1.4			
SO_2	10.3	0.9	CH_4	1.1	0.3
NO_x	391.1	21.0			
VOCs	44.5	1.2	CO_2	94151.0	1270.4
CO	510.0	3.4			
Pb	0.1	0.1	Total CO_2 eq.	94599.0	1275.0
NH_3	3.3	0.2			

3.8.3 Biological Resources Impacts—Alaska Region

Given the limited onshore infrastructure in the Alaska Region and the significant biological resources in Alaska's coastal areas, the biological resource impacts associated with onshore infrastructure development in the region could be substantial. Specifically, the development and use of onshore infrastructure in the region could lead to measurable impacts for each of the categories of biological resource impacts described in Section 3.4.2. For example, drawing on the biological opinions published by the FWS on Lease Sale 193 in the Chukchi Sea, potential impacts to two endangered species could include the following:

- ***Spectacled and Steller's Eider.*** During future incremental steps, direct and permanent loss could result from onshore excavation and fill in support of a production shorebase, pipelines, roads, and other infrastructure, potentially impacting 2,015 acres of wetlands. Dust and gravel spray during construction and facilities operation, and altered hydrology associated with excavation, fill and ice road construction could lead to secondary habitat degradation (USDOI, FWS 2015). Onshore activities such as facility operations and transportation of personnel could cause disturbance and displacement. NMFS assumes that Spectacled and Steller's Eiders avoid nesting within 200 meters of infrastructure with human activities, and therefore onshore infrastructure in high density areas of the species could have substantial localized impacts on their reproduction potential. The Biological Opinion estimated 1.5 eider collisions per support vessel per season based on reported data for kind and common eiders in the Chukchi Sea (USDOI, FWS 2015).
- ***Polar Bears.*** In addition to disturbances to polar bears from aircrafts, vessels, onshore vehicle traffic and human-polar bear interactions, waste discharge at landfarms could affect polar bears. Denning polar bears will be impacted by noise, resulting in terrestrial denning habitat loss (USDOI, FWS 2015).

Related to these potential impacts to endangered species, Figure 6 shows that the coastline of much of southern Alaska—from the western edge of the Aleutian Islands to Prince William Sound—is designated as critical habitat. Onshore infrastructure development in these areas would therefore have a greater likelihood of impacting endangered species than onshore infrastructure on other portions of the Alaska coast.

3.8.4 Socioeconomic Impacts—Alaska Region

The socioeconomic impacts of onshore infrastructure development in the Alaska Region will be similar to the impacts described in Section 3.4.2 (see Table 35). Given the significant investment in onshore infrastructure necessary to support expanded OCS oil and gas activity in the Alaska Region, the socioeconomic impacts associated with developing this infrastructure may be significant. The magnitude of these impacts will depend on the location of onshore infrastructure and the degree to which infrastructure development involves the construction of new infrastructure or the expansion/retrofitting of existing facilities. Regardless of the location, however, shore-based OCS oil and gas activity at onshore infrastructure facilities is likely to create new jobs, which may have positive spillover effects for the local economy. In addition, the construction of new facilities or expansion of existing facilities may increase the value of infrastructure properties, which would increase property tax revenues for local governments. In relatively undeveloped areas, the construction of roads may also increase connectivity between communities. Whether onshore infrastructure development adjacent to the Alaska Region results in the space-use conflicts or damage to archaeological resources described in Table 35 depends on where specific uses occur relative to infrastructure facilities and whether archaeological resources are located near these facilities.

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Appendix A: Summaries of Natural Resource Damage Assessments Reviewed

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Table of Contents

List of Tables

1 American Trader Spill

On February 7, 1990, the American Trader ran aground off the coast of Southern California, spilling 416,598 gallons of crude oil. By February 12, nearly 160 square kilometers of ocean were covered by oil. On February 13, a storm washed much of the remaining oil over 14 miles of shoreline. The spill resulted in ecological damages to coastal habitat, benthic communities, birds, and fish. Human recreation was also affected. Many beaches were closed to the public until early March, with the last beaches opening March 14. Offshore waters in the area were closed to boating and fishing for approximately two weeks.

The aftermath of American Trader was unique in that the case went to trial, the first and one of the few Natural Resource Damage cases to do so. The jury sided with the plaintiffs, awarding the State of California $18 million.

1.1 Damages Estimates and Types of Damages Evaluated

Trustees quantified damages as summarized in Table 1-1. Effects were monetized per the cost of compensatory restoration as described in Table 1-2.

Table 1-1. American Trader spill:summary of injuries quantified

Resource	Impacts	Restoration or Monetary Value
Ecological		
Birds	5,390 oiled, 5,544 died	Brown pelican and other seabird roosting and general habitat improvements
Fish	Not quantified	White sea bass fish hatchery program
Shoreline habitat	14 miles injured	Coastal and marine pollution mitigation program
Recreation		
Beach recreation	733,267 trips lost	$10,188,500
Boat losses	31,000 trips lost	$1,231,609

Table 1-2. American Trader spill:summary of settlement amounts—American Trader Spill

Category	Amount
Settlement with British Petroleum (1993)	
Bird injuries	$2,484,566 plus $487,174 in interest
Injuries to state white sea bass fishery	$400,000 plus interest
Ocean and coastal pollution mitigation	$300,000 plus interest
Injuries to California Department of Parks	$79,680 plus interest
Response costs	$630,000 plus interest
Settlement with Trans-Alaska Pipeline Fund (1994)	
Lost recreation and cleanup costs	$3 million
Settlement with Golden West (1996)	
Lost recreation and cleanup costs	$4.15 million
Settlement after the ATTRANSCO Trial (1996)	
Lost recreation plus assessment and legal costs	$16 million

1.2 Methods Applied

1.2.1 Ecological Damages

Trustees conducted a study of rehabilitated brown pelicans using radio and aerial tracking techniques. Most rehabilitated birds died within six months of being released, while the surviving minority failed to successfully reproduce over the two breeding seasons observed. The Trustees also studied scavenging rates among smaller deceased birds and found 80 percent were eaten within a few hours, making them more difficult to recover.

1.2.2 Recreation Damages

The American Trader spill was the first time recreation impacts were monetized in California. No large-scale original data collection efforts (e.g., a travel cost survey) were undertaken, in part because the Trustees expected a settlement, but also because large-scale recreation use data for the area were already available. These estimates consisted largely of counts for lifeguarding purposes. Some of the affected beaches were administered by the California Department of Parks and Recreation, which tracked beach use for fee purposes. Much of these use estimates were based on vehicle counts, so adjustments had to be made to account for the number of people per vehicle, as well as ratio of walk-on beach goers to car-arriving beach goers. The Trustees incorporated these data into a parametric model of beach attendance. Explanatory variables included maximum and minimum temperatures, precipitation, and day-of-the-week and holiday dummies. One important issue the Trustees had to take into account was substitution to other, non-affected beaches.

In all, Trustees estimated 733,267 beach trips were lost. As to the monetary value of each trip, they cited a study developed for Florida beaches in 1984 and updated it to 1990 values, or $13.19. They estimated recreators placed a higher value on surfing, which they put at $16.95. Boating losses were estimated at 31,000 trips, which a benefits transfer analysis estimated the value at $1,231,609.

2 Anitra Spill

On May 10, 1996, the *T/V Anitra*, a Bahamian vessel, inadvertently pumped 40,000 gallons of Nigerian light crude oil into the Delaware River. The ship was carrying more than 40 million gallons of oil at the time. Although containment booms were deployed the next day, a storm allowed oil to escape. Initially, officials expected most of the leaking oil to float, which caused them to misjudge the spill's size. It was not until over a week later, when the hitherto submerged and undiscovered oil washed ashore in Delaware Bay, that officials realized the full extent of the spill. In all, more than 50 miles of beaches were oiled, including some located in state parks, wildlife management areas and a National Wildlife Refuge.

2.1 Damages Estimates and Types of Damages Evaluated

Trustees quantified damages as summarized in Table 2-1. Effects were monetized per the cost of compensory restoration as described in Table 2-2.

Table 2-1. Anitra spill: summary of injuries quantified

Resource	Impact	Restoration
Piping Plovers (birds)	16.2 killed	Funding 5 years of habitat management
Sanderlings (birds)	3,324 oiled	New Jersey habitat restoration and enhancement; South American wintering ground habitat protection and management
Other migrating birds	1,019 oiled	New Jersey habitat restoration and enhancement; South American wintering ground habitat protection and management

Table 2-2. Anitra spill: summary of settlement amounts

Restoration Category	Cost
Piping Plover restoration	$700,000
Migratory shorebird protection	$550,000

2.2 Methods Applied

Following the spill, response crews collected 51 oiled piping plovers, all of which were cleaned and subsequently released. However, even rehabilitated birds may suffer mortality impacts after oiling, so Trustees tagged and observed 8 oiled birds in order to compare survival rates with normal populations. Based on the results, they calculated that approximately 25 percent of the oiled birds, or 13.5 individuals, were lost as a result of the spill. Trustees also examined plover nesting rates in 1996 and found they were lower than the previous 5 year average. Nesting impacts were estimated at 2.7 adult birds, bringing total losses 16.2 birds. Impacts to sanderlings and other migrating birds were estimated via ground surveys.

Damages were monetized by estimating the cost of projects that would replace the birds lost as a result of the spill. These projects included supporting and increasing the intensity of previous piping plover protection efforts. Other restoration projects as part of this case involved restoring and enhancing wintering habitat for other migratory birds in South America.

3 B.T. Nautilus Spill

On June 7, 1990, the tanker B.T. Nautilus ran aground in the Kill Van Kull and leaked approximately 6,190 barrels of number six fuel oil into the waters of New York and New Jersey. The responsible party was the ship's owner, Nautilus Motor Tanker Co., Ltd. The Trustees were the City and State of New York, the State of New Jersey, FWS, and NOAA.

The oil spill impacted shoreline habitat in New York and New Jersey, including the habitat of the federally threatened piping plover. The Trustees conducted an NRDA, and in April of 1994 the responsible party agreed to pay $3.3 million in natural resource damages resulting from the oil spill.

3.1 Assessment Methods

Restoration planning commenced in 2006, and in 2009 the Trustees completed a final restoration plan aimed at providing compensatory restoration to offset natural resource losses from the B.T. Nautilus and Exxon Bayway[52] spills. Because this restoration planning activity occurred 12 years after the settlement of natural resource damages, it does not appear that the Trustees used a compensatory restoration framework when determining the scale of natural resource damages resulting from the oil spill. In fact the available documentation does not indicate how the Trustees assessed natural resource damages following the 1990 oil spill. As the spill occurred a little more than 2 months before the Oil Pollution Act went into effect, natural resource damages were sought under the CWA and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Detailed information on damages is not readily available. Accordingly, an exhibit presenting damages by category is not included in this narrative.

[52] The Exxon Bayway spill occurred on January 1, 1990 when an underwater pipeline released approximately 567,000 gallons of number two fuel oil into the Arthur Kill.

4 Bouchard Barge Spill

On April 27, 2003, the Bouchard Barge-120 ruptured its hull after running aground and spilled approximately 2,333 barrels of No. 6 fuel oil into Buzzards Bay. Oil was driven by winds and currents throughout the bay and nearby coastal waters of Massachusetts and Rhode Island. Response activities were coordinated by the U.S. Coast Guard, which included the deployment of 1,500 ft. of containment boom. The responsible party was the owner and operator of the tug and barge, the Bouchard Transportation Company, Inc. The Trustees were the FWS, the Commonwealth of Massachusetts, and the State of Rhode Island.

The oil spill impacted more than 98 miles of shoreline in both Massachusetts and Rhode Island. Oiling was observed at different levels throughout the bay, with the heaviest oiling occurring on exposed shoreline headlands and peninsulas. In addition, public shellfish harvesting was closed on state shellfish areas within Buzzards Bay for one to six months. The Trustees conducted an NRDA and on May 17, 2011, the responsible party agreed to pay more than $6 million in natural resource damages resulting from the oil spill.

4.1 Assessment Methods

The Trustees assessed natural resource damages using a compensatory restoration framework. In this context, the value of the natural resource damages are expressed by the value of the restoration activities necessary to compensate for the injury sustained by the natural resource and its services. The Trustees assessed damages to four main resource categories: shoreline resources, aquatic resources, recreational uses, and birds and wildlife resources. They also assessed injury independently to the shoreline resources on Ram Island, a unique state-owned wildlife preserve. Injury to shoreline, aquatic, and bird and wildlife resources were quantified in terms of the percent loss in ecological services due to the spill and the timeline required for the natural recovery of these services. Injury to recreational use was quantified as the reduction in visitation resulting from the spill.

The Trustees assessed injury to shoreline resources in three habitat types: coarse substrate, sand beach, and tidal salt marsh. Using field observations, technical literature, and other data collected as part of the injury assessment, the Trustees calculated the extent and severity of oiling across the impacted area. Using a habitat equivalency analysis (HEA) the Trustees calculated that the oil spill resulted in a loss of 84.49 discounted service-acre-years (DSAYs). Injury to aquatic resources was assessed to three habitat types: water column, subtidal benthic habitat, and nearshore habitat and two resources of concern: bivalves and American lobster. The Trustees collected water samples, bivalve and lobster tissue samples, and conducted submerged oil surveys. Based on polycyclic aromatic hydrocarbons (PAH) sampling concentrations, the Trustees determined that acute injury had not occurred to bivalves or other aquatic organisms in the water column. Using a HEA, the Trustees did conclude that the oil spill resulted in injury to subtidal benthic and nearshore habitat, including American lobster habitat, equivalent to 119.5 DSAYs.

Lost recreational use services were quantified by the Trustees as the value of lost recreational shellfishing trips, lost recreational boating trips, and lost shoreline trips. Using visitation data from before and after the incident, the Trustees determined that 36,441 shoreline trips, 47,928 shellfishing trips, and 987 boating trips had been lost. They used a benefit transfer method to determine the value of lost shoreline and boating trips and conducted a site-specific study to determine the value of lost shellfishing trips. The site-specific study used shellfishing license data and a travel cost model to determine the average value per shellfishing trip. The total value of lost recreational use services was calculated to be $3,091,996.

Finally, the Trustees identified compensatory restoration activities that would offset the quantified injuries to shoreline, aquatic, and recreational use resources. The Trustees calculated the required compensatory restoration for aquatic and shoreline resources by converting lost service-acre-years into acres of lost salt marsh and then applying a NOAA derived per acre cost to restore salt marshes[53]. The final value of the compensatory restoration also included administration and monitoring costs. On May 17, 2011, the Trustees reached a settlement with the responsible party that provided $1,522,000 for proposed restoration activities to injured shoreline and aquatic resource and $3,305,393 for recreational use restoration activities. Although the available documentation does not detail their assessment methods, in the May 2011 settlement, the Trustees also accepted $715,000 for injuries to piping plover and $534,000 for injuries to shoreline resources on Ram Island. See Table 4-1 for a summary of restoration costs by activity and injured resource.

Table 4-1. Bouchard Barge spill: restoration costs and assessment method by injured resource

Injured Resource	Assessment Method	Quantified Injury	Restoration Action Costs[1]
Shoreline Resources	HEA	84.5 DSAYs	$1,522,000
Aquatic Resources	HEA	119.5 DSAYs	
Recreational Use	Benefit Transfer, Travel Cost Model	$3,091,996	$3,305,393
Piping Plovers	Unknown	Unknown	$715,000
Ram Island Shoreline Resources	Unknown	Unknown	$534,000
Total Value of Restoration Activities			**$6,076,393**
Note: All values include administrative and monitoring costs.			

[53] Unfortunately, the available documentation does not detail the exact method used to determine final restoration costs.

5 Bow Mariner Spill

On February 28, 2004, the chemical tanker T/V Bow caught fire, exploded, and sank off the coast of Virginia, killing 21 of its 27 crew and spilling 3,88,711 gallons of ethyl alcohol, 192,904 gallons of fuel oil and 48,426 gallons of diesel into the Atlantic Ocean. Although the offshore site of the spill made bird carcass recovery impossible, aerial surveys identified more than 2,000 live birds in the general vicinity. Trustees decided to limit their claims to two species, northern gannets, and razorbills. Overall bird losses were between 100 and 9,000 individuals, 50 to 450 of which were estimated as razorbills or northern gannets. These 50 to 450 birds were the only injury claimed. In 2009, the Trustees and the responsible party agreed to a settlement of $563,295 to restore razorbill nesting habitat in Maine.

5.1 Damages Estimates and Types of Damages Evaluated

Trustees quantified damages as summarized in Table 5-1. Settlement amounts are described in Table 5-2.

Table 5-1. Bow Mariner spill: summary of injuries quantified

Resource	Impacts
Northern Gannet	48–417 killed
Razorbills	3–28 killed

Table 5-2. Bow Mariner spill: summary of settlement amounts

Restoration Category	Cost
NRDA expenses	$45,367
Restoration costs	$563,295
Total	$608,662

5.2 Methods Applied

The location of the spill in open water complicated damage assessment. Although scientists typically quantify bird mortality by applying a multiplier to the number of birds collected, this approach was not feasible for this particular spill. Instead, Trustees assembled a 50-spill database that included information on spill size and bird mortality, allowing them to model the latter as a function of the former. The estimated relationship was as follows:

$$\ln(birds\ recovered) = 0.990 + 0.373 * \ln(spill\ volume)$$

Using the 193,000 gallons spilled as an input in the above equation yields an average of 927 (median of 252) birds recovered, with 90th percentile confidence intervals of 106 to 9,064. Due to case-specific factors (e.g., gannets are less vulnerable to oiling than many of the birds killed in other spills in the database), the Trustees believed mortality for this spill was likely in the low end of this range, which they set at 106–927 lost.

The Trustees also conducted an aerial survey to determine relative numbers of nearby bird species. Ultimately, they decided to limit claims to northern gannets and razorbills, which accounted for 45 percent and 3 percent of the birds observed, respectively. Applying these these percentages to the 106–927 range of birds lost gives about 50–450 northern gannets and razorbills lost total. Factoring in average lifespans and including next generation losses, this represents 656 to 5,705 bird-years lost.

Trustees and the responsible party agreed to a settlement of $563,295 to restore razorbill nesting habitat in Maine, which they estimate will replace 2,000–3,000 bird-years.

6 Cibro Savannah Spill

On March 6, 1990, an explosion and fire on the barge Cibro Savannah caused the release of 16,904 barrels of No. 2 fuel oil into the Arthur Kill waterway near Linden, New Jersey. Although much of the released oil was boomed on site, an unknown amount of oiled shoreline was observed in both New Jersey and New York. The responsible party was the barge's owner, Montauk Oil Transportation Corporation. The Trustees were the State of New Jersey, the State of New York, and NOAA. The case settled in December 1998.

6.1 Assessment Methods

The available documentation does not indicate how the Trustees assessed natural resource damages following the 1990 oil spill. As the spill occurred a little more than five months before the Oil Pollution Act when into effect, natural resource damages were sought under the CWA and CERCLA. In December, 1998, a settlement was reached where the responsible party agreed to pay $328,940 in natural resource damages. Detailed information on damages is not readily available. Accordingly, an exhibit presenting damages by category is not included in this narrative.

7 Command Spill

On September 26, 1998, the tanker Command released approximately 3,000 gallons of Intermediate Bunker Fuel (IBF) 380, also known as Fuel Oil No. 6, off the coast of San Francisco and San Mateo County in California. During the week after the spill, oil began washing ashore across 15 miles of beaches. This oil primarily appeared on shore in the form of tarballs. As part of response efforts in the open water, response vessels attempted to skim oil off the sea; however, little oil could be recovered. On shore, response personnel cleaned up oil in the form of tarballs and tar patties. Although the spill did not cause any beach closures, the spill and the subsequent response efforts did impact coastal access.

Following the spill, the Trustees worked to assess natural resource injuries caused by the spill. The Trustees determined that the primary impacts from the spill included injuries to seabirds, injuries to beach and shoreline habitats, and lost and diminished recreational use of beaches.

To compensate for these natural resource injuries, the Trustees entered into a settlement with the responsible party in 2000. This settlement called for the responsible party to pay a total of $5,518,000 to resolve all civil claims. Of this total, $4,007,242 was allocated to funding restoration projects that would compensate the public for the natural resource injuries.

7.1 Assessment Methods

Natural resource damages were assessed using a compensatory restoration framework. In this context, the value of the natural resource damages are expressed by the cost of the restoration projects necessary to compensate for the injury sustained by the natural resource and its services.

As part of the spill response efforts, the Trustees conducted surveys to identify injured wildlife and resources at risk due to the spill. These surveys included aerial surveys, boat surveys, and shoreline surveys. Based on survey results and the evaluation of potential injuries, the Trustees determined that the primary impacts from the spill were injuries to seabirds, injuries to sandy beach and rocky intertidal shoreline habitats, and lost and diminished recreational use of beaches.

To assess injuries to seabirds, the Trustees used survey results, a literature review, and mathematical modeling to estimate seabirds at risk and seabird mortality due to the spill. Following the spill, response personnel recovered 171 injured birds along the shoreline. Of this total, 96 were collected dead, 38 were collected alive and then died during rehabilitation, and 37 were collected alive and then successfully rehabilitated. The majority of the affected birds observed by survey personnel were Common Murres (129). Other affected species observed included Sooty Shearwaters, Brown Pelicans, and Western Gulls. Consistent with other oil spill assessments, the Trustees estimated that many bird injuries may not have been observed during survey efforts. Birds may have been injured at sea, scavenged, or missed by survey workers (Ford et al. 1996). In addition, injured birds may have flown out of the search area or crawled into secluded spots on land.

A literature review supported the Trustees' estimation that bird injuries were greater than those observed during survey efforts. The literature shows that the likelihood of recovering a bird carcass is positively related to the body size of the bird (Carter et al. 2000). This means that for smaller birds such as marbled murrelets, survey workers are less likely to observe bird carcasses due to factors such as ocean currents, carcasses sinking at sea, and carcasses being scavenged by other wildlife (Ford et al. 1996). Baseline surveys in the area affected by the spill show marbled murrelet carcasses were historically recovered at a rate of 0.001 carcasses per km (Roletto et al. 2001). In comparison, baseline surveys observed the larger bodied Common Murre at a rate of 0.316 birds per km (Roletto et al. 2001). In previous evaluations of oil spill injuries to sea birds, Ford et al. (2000, 2002) estimated that only about 1 in 18 marbled murrelet carcasses would be recovered. Based on this information, the Trustees determined that though no marbled murrelet carcasses were recovered following the Command Spill, it was reasonable to assume that some mortality had occurred.

Following the survey results and literature review, the Trustees used mathematical modeling to estimate total birds at risk and total bird mortality caused by the spill (Boyce and Hampton 2002). Specifically, the model used aerial survey results and the extent of affected sea and shoreline habitat to develop an estimate of the total bird population that was at risk; the model then estimated bird mortality by scaling up the 129 injured murres observed after the spill to account for the extent of coastline that was inaccessible (average of 70.2 percent, Research Planning Institute 1994) and bird carcass recovery rates observed following other spills (average of 29.0 percent, Ford 2002). The model results estimated that the spill put 11,193 common murres at risk and killed 1,490 common murres. Assuming the proportion of marbled murrelets that died from oil exposure was the same as the proportion of common murres, the Trustees estimated that 87 marbled murrelets were at risk due to the spill and 6 to 12 marbled murrelets were killed. The Trustees felt that other seabird species such as Cassin's Auklets and black-vented shearwaters could have been injured by the spill; however, to maximize the funds available for restoration, the Trustees did not quantitatively model impacts to these other species.

In addition to seabird injuries, the spill negatively impacted beach recreation. Beach access was interrupted for five days from September 30 to October 4, 1998 due to oil washing ashore and cleanup efforts. The Trustees used historic visitation data to estimate that 18,228 beach trips would have been taken during this 5 day period if not for the spill.[54] Using professional judgment, it was estimated that 10 percent of beach trips were avoided during this five day impact period. Further, it was estimated that two percent of beach trips were avoided during the week following the completion of cleanup activities. These assumptions generated a lost trips estimate of 2,333 beach trips. Applying a consumer surplus value of $20.19 per person per day of beach recreation (benefits transfer from the estimated value for beach recreation from the *American Trader* case), the value of lost beach use was estimated to be $47,108 (Brown, Levine, and Curry 2001).

The spill also diminished the quality of beach trips taken during the oil spill impact period. The Trustees estimated that 16,405 diminished trips were taken during this time period. Based on prior work evaluating oil spill impacts in California, the Trustees estimated that these trips experienced a 20 percent loss in quality ($4.04 per trip) due to the oil spill and subsequent response activities. Aggregated across the total diminished trips, the spill was estimated to have caused diminished recreational use value of $66,278 (Brown, Levine, and Curry 2001).

To compensate for the natural resource injuries that occurred due to the spill, the responsible party reached a settlement with the Trustees that included $4,007,242 in funding for compensatory restoration projects. Following the settlement, the Trustees entered into a Memorandum of Understanding (MOU) designed to provide for a more precise allocation of the restoration funds. This MOU allocated approximately $2,850,000 for seabird projects (particularly benefitting Common Murres), $400,000 for marbled murrelet projects, and $200,000 for projects focused on restoring shoreline and recreational use. These allocations were subject to post-settlement injury assessment work. Following this work, the Trustees adjusted these allocations to account for greater injury to marbled murrelet seabirds than was originally estimated. The MOU also granted up to $463,016 to cover the Trustees' costs for planning, implementing, and overseeing restoration efforts.

Table 7-1 summarizes the natural resource injuries that were quantified by the Trustees.

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[54] The Trustees used two sources of historic visitation data. The California Department of Parks and Recreation provided historical beach use data for seven California State Beaches and the Point Montara Lighthouse. Likewise, park rangers at the James V. Fitzgerald Marine Reserve provided historic visitation data for the marine reserve. The Trustees used both of these data sources to estimate baseline beach visitation during the 5 day period of impact.

Table 7-1. Command spill: summary of injuries quantified

Resource	Quantified Injury	Settlement Amount
Seabirds		
Common Murres	11,193 at risk, 1,490 killed	$2,850,000
Marbled Murrelets	87 at risk, 6 to 12 killed	$400,000
Recreational Use		
Lost Beach Trips	2,333 trips valued at $47,108	$200,000
Diminished Beach Trips	16,405 trips valued at $66,278	
All Resources		**$3,450,000**

8 Cosco Busan Spill

On the morning of November 7, 2007, the container ship *Cosco Busan* struck a tower of the San Francisco-Oakland Bay Bridge. The gash in the hull of the vessel created by the allision resulted in the release of 53,569 gallons of heavy fuel oil into the San Francisco Bay over the course of approximately 53 minutes. Winds and currents caused the spill to spread rapidly and moved some of the oil outside of the bay, impacting an area from Half Moon Bay to Point Reyes. Within the bay, the impacted water and shoreline stretched from Tiburon to San Francisco on the west side and from Richmond to Alameda on the east side. Boom was deployed to contain the spill and skimmers were used to extract oil from the water surface. More than 50 public beaches were closed and fishing of all types was prohibited across an eight-county area. About one-third of the fuel was recovered through a year-long cleanup effort that totaled over $68 million.

8.1 Damages Estimates and Types of Damages Evaluated

Injuries from the spill were divided into four main categories: birds, fish, shoreline habitats, and human uses. Overall, an estimated 6,849 birds representing 65 different species were killed. Diving ducks, grebes, cormorants, and murres were the primary species impacted. The marbled murrelet and the snowy plover were two special status species in the impacted area of the spill. Between 14 and 29 percent of the 2007–2008 winter herring spawn was lost due to widespread egg mortality attributed to the oil. The impacted shoreline area amounted to 3,367 acres, with 34.45 miles of heavy to moderate oiling. The rate of recovery of the shoreline habitats was dependent on the specific habitat type and on the degree of oiling experienced by a particular shoreline area. Finally, over one million human user days, representing activities from recreational fishing to general beach use and surfing, were lost during the nine-month period following the spill.

The damages claim for each of the resource groups and the ultimate settlement amount are presented in Table 8-1.

Table 8-1. Cosco Busan spill: Trustee claim and settlement amounts for resource groups injured

Resource Group	Trustee Claim	Settlement
Birds	$6.6 million	$5 million
Fish & Eelgrass	$2.7 million	$2.5 million
Habitat	$6.5 million	$4 million
Recreational Use	$26 million	$18.8 million

Twelve restoration projects were designed to address the resources impacted by the spill as described above, allocating funds based on the settlement.

8.2 Methods Applied to Assess Damages

In order to assess the environmental damages of the spill, the Trustees employed a Resource Equivalency Analysis (REA). Under this methodology, the amount of injury to natural resource services provided by impacted resources is equated to the quantity of similar services created by proposed compensatory restoration projects. The cost of restoring a comparable amount of resources to those lost or injured is the basis for the compensatory damages. In this way, damages were evaluated using the replacement cost of the lost years of natural resource services. The extent and severity of the injuries to different resources was estimated using field data, focused studies, and expert scientific judgment. Services were measured using different metrics depending on the resource. The summary of the REAs for each resource group considered is as follows:

- **Birds:** A REA using the metric of bird-years (i.e., the service of one bird surviving for one year) was employed to determine injury and compensatory restoration to the bird populations affected by the oil spill. To understand impacts to birds, 19 field studies, data collection tasks, or analyses were utilized. These included live and dead bird intake data, bird surveys, and a bird mortality model. Bird injury was equated to bird restoration projects using the bird-year metric (the restoration projects were scaled to provide the same number of bird-years as those determined lost from the injury assessment). Selected restoration projects for birds (a total of six of the 12 projects) included the creation of grebe nesting habitat; the creation of over-wintering duck and grebe habitat; the creation of nesting and roosting habitat for cormorants, pelicans, and shorebirds; the creation of a grant project to benefit surf scoters, and restoration of marbled murrelets.
- **Fish:** No specific damages assessment methodology for understanding impacts to fish and eelgrass appears in the DARP/EA.[55] Various field studies, data collection tasks and analyses were used to assess injury to five species of fish. A noted species of interest was the Pacific herring because the affected nearshore areas are a primary spawning location for herring. An overall herring injury report concluded that a component of Cosco Busan bunker oil accumulated in natural spawn and interacted with sunlight during low tides to produce lethal phototoxicity in embryos. To compensate for this injury, a program to restore eelgrass around the bay to enhance successful production of early life stages of herring was selected and presumably scaled to match the estimated damage.
- **Habitat:** For habitats, HEAs were employed using the metric of acre-years (i.e., the service provided by one acre of shoreline habitat over the course of one year). Fourteen studies, analyses, and data collection efforts were undertaken to understand injuries to the shoreline habitat; separate analyses were conducted for different types of coastal habitat (marsh wetlands versus mud tidal flats, for example). In general, the degree of injury was determined to be related to the degree of oiling. Recovery was assumed to begin after initial cleanup efforts ended. The time to recovery was based on the life histories of the flora and fauna in each habitat type, relative to the degree of initial injury. Three restoration projects were selected to benefit sandy beach, salt marsh and mudflat, and rocky intertidal communities. The cost of these restoration projects once they were appropriately scaled to the habitat injury to provide an equivalent amount of acre-years of services represented the Trustee claim of environmental damages to habitat.
- **Human use:** A benefits transfer approach was employed to estimate damages to recreational use. Studies were first conducted to understand the baseline number of different types of trips. These baseline values were then compared to survey data collected following the spill to understand the impact of the oil on recreational trips made. Specifically, these studies compiled data on baseline park use and fishing activity, along with visitation figures obtained post-spill from park databases and visitor and telephone surveys. The specific metric utilized to monitor changes in activity was a user-year, or the engaging of an individual in a particular activity for an entire year. The value of the loss in activity, as measured by user-years, was estimated separately for beach use, recreational fishing, and boating. For beach use, the Trustees performed a telephone survey of Bay Area residents to compile data on their recreational trips to shoreline sites in the Bay Area. The data collected from this survey were then used in a travel cost model, yielding an estimate of \$18.25 per lost trip (in year 2007 dollars), though this value changed from \$22.65 in November 2007 to \$8.90 in June 2008. This reduction in lost value reflects the increased availability of

[55] DARP/EA refers to the Damage Assessment and Restoration Plan/Environmental Assessment document. The document is drafted to summarizes injuries, present damages, and identify the restoration plans that will appropriately compensate for the damages incurred.

substitutes as the number of sites affected by the spill declined over time. For recreational fishing, the Trustees adapted estimates from Kling and Thomson (1996) to arrive at a value of \$37.49 per day for shore fishing and \$50.48 per day for boat fishing. For boating, the Trustees applied values of \$78 per trip for sailboat and motorboat trips and \$52 for dragon boats, as derived from Loomis (2005).

In summary, new and past studies, data collection efforts, and analyses for each resource area were synthesized to understand the focal impacts of the spill and to carry out equivalency analyses or benefits transfer analyses using metrics such as bird-years or user-years to equate losses to restoration gains. The costs of the restoration projects identified for all resource groups were discussed during settlement negotiations, resulting in the final agreement.

9 Equinox Spill

On September 22, 1998, a well blowout occurred along the coastline of Louisiana, resulting in the discharge of medium weight crude oil into the waters of the Lake Grande Ecaille embayment in Plaquemines Parish, Louisiana. The volume of the spill was unknown but estimated to be up to 64,500 gallons. As a result of the spill, several thousand acres of surface water in Lake Grande Ecaille and the GOM were covered by slicks or sheens and approximately 1,233 acres of wetlands were exposed to oil. Hurricane Georges moved through the area during response efforts and removed some of the oil from the marshes and surface waters. Response activities included the removal of oil through efforts including the vacuuming of contaminated sediments from the subtidal zone. Although recreational activities were recognized as potentially affected by the spill, the limited scope of the injury and response, as well as the presence of a hurricane soon after the spill were thought to contribute to the minimization of impacts on recreation.

9.1 Damages Estimates and Types of Damages Evaluated

In this case, injuries to six different resource types were considered and damages to five of these were measured through restoration scaling. Table 9-1 displays the injury assessed for each resource and, where applicable, the amount of restoration determined to appropriately compensate for the loss. Ultimately, the cost of the restoration activities was settled to be $904,150. Although the amount of marsh creation is disaggregated by specific resources and injuries, the costing of the restoration alternative is presented only in aggregate.

Table 9-1. Equinox spill: injury and compensatory restoration requirements for resources impacted

Resource	Resource Type	Injury Or Loss	Scaled Restoration
Habitat	Marsh	1,233 acres exposed to oil 26.62 DSAYs[1] lost	Creation of 3.81 acres of marsh
	Subtidal Sediments	21 acres adversely affected 6.1 DSAYs[1] lost	Creation of 0.18 acres of marsh
	Mangrove	12.2 acres exposed to oil (considered as marsh)	
Water Column	Finfish and shellfish	Less than 1,707 kg of biomass lost	Creation of 0.85 acre marsh
Birds	Birds	95 killed	
Recreation	Boat-based	Too small to quantify	

[1] DSAY = discounted service acre-year, or the present value of ecological function flowing from one acre of habitat in one year.

9.2 Methods Applied to Assess Damages

- **Habitat (Marsh and Subtidal):** HEA, a service-to-service approach to estimating damages, was employed to determine damages to injured habitats. Specifically, the habitats considered for the Lake Grande Ecaille spill were the subtidal, benthic zone and coastal marshes. The subtital or benthic times to recovery were based on literature values rather than on specific sampling efforts which would have been an expensive undertaking. A field study was conducted, however, for the marsh habitat in order to assess reduction in marsh service flows and understand recovery timeframes.
- **Fauna (Water Column Finfish & Shellfish and Birds):** Damages to these two biological resource categories were extrapolated from results of the assessment for similar injuries in a

previous oil spill. Specifically, a site-specific model to assess water column injury resulting from crude oil in nearby Lake Barre had been developed not long before the Lake Grande Ecaille spill. Although this spill was from a submerged pipeline, injury results suggested that the results for water column injury could be scaled to the current spill and would result in a conservative estimate. Using a biomass per volume of oil released scaler derived from the estimated injury for the Lake Barre spill, the Trustees estimated that marsh creation required to compensate for damages to water column resources ranged from 0.04 to 0.12 acres of marsh. Using a similar approach for birds, the Trustees estimated that injury to birds would be compensated for by the equivalent of 0.99 acres of marsh creation. Thus, damages to water column fauna and birds together require 1.03 to 1.11 acres of marsh as compensatory restoration. After further considering mitigation factors (i.e., differences existing between the Lake Barre oil spill and the current Lake Grande Ecaille spill), the Trustees concluded that 0.85 acres of marsh creation was sufficient for compensation for bird and water column injuries resulting from the spill.

10 Exxon Bayway Spill

On January 1, 1990, an underwater pipeline in Linden, New Jersey, released approximately 13,500 barrels of number two fuel oil into the Arthur Kill, a saltwater channel between New Jersey and Staten Island. The responsible party was the pipeline owner, Exxon Inc. The Trustees were the City and State of New York, the State of New Jersey, the city of Elizabeth, New Jersey, the FWS, and NOAA.

The oil spill impacted more than 100 acres of tidal salt marsh and some wetlands experienced large-scale die-offs of salt marsh cordgrass. The Trustees conducted an NRDA and, in March of 1991, Exxon agreed to pay $9,550,000 in natural resource damages resulting from the oil spill. Detailed information on damages is not readily available. Accordingly, an exhibit presenting damages by category is not included in this narrative.

10.1 Assessment Methods

The available documentation does not indicate how the Trustees assessed natural resource damages following the 1990 oil spill. As the spill occurred a little more than seven months before the Oil Pollution Act went into effect, natural resource damages were sought under the CWA and CERCLA.

The available documentation does not indicate how the Trustees determined the scale of compensatory restoration. Restoration activities include the 1998 acquisition of 25 acres of freshwater wetlands in the Rahway River, a tributary of the Arthur Kill, and the purchase of over 30 acres of land in the Goethals Bridge Pond complex on Staten Island. Additional restoration planning commenced in 2006, and in 2009 the Trustees completed a final restoration plan aimed at providing compensatory restoration to offset natural resource losses from the B.T. Nautilus[56] and Exxon Bayway spills.

[56] The B.T. Nautilus spill occurred on June 7, 1990, when the tanker B.T. Nautilus ran aground and leaked 260,000 gallons of number six fuel oil into the Kill Van Kull.

11 Foss Maritime Spill

On December 30, 2003, an oil spill occurred during the loading of oil onto a Foss Maritime Company barge at an asphalt facility in Shoreline, Washington. The spill released approximately 4,637 gallons of bunker fuel into the Puget Sound. Impacted areas included 3.5 acres of oiled Indianola shoreline, 2.8 acres of oiled Doe-Kag-Wats marsh, and shellfish habitats within the salt marsh estuary of Port Madison. In addition to affected habitat, the Trustees found evidence of oiling impacts to birds, mammals, fish, and shellfish. Finally, beach closures as a result of the oil spill and its cleanup negatively impacted recreational access and contributed to lost recreational uses.

To compensate for these natural resource injuries, the Trustees entered into a settlement with the responsible party in 2008. This settlement called for the responsible party to pay $265,281 for compensatory restoration projects and $73,000 for the Trustees' assessment costs. The compensatory restoration projects selected by the Trustees included debris removal and invasive species management in the Doe-Kag-Wats marsh, restoration in the Indianola Waterfront Preserve Marsh, shellfish enhancement, acquisition of tidelands, and beach berm enhancement at the Doe-Kag-Wats Beach.

11.1 Assessment Methods

Natural resource damages were assessed using a compensatory restoration framework. In this context, the value of the natural resource damages are expressed by the cost of the restoration projects necessary to compensate for the injury sustained by the natural resource and its services.

To evaluate potential injuries, the Trustees focused their assessment efforts on the following categories: marsh, shoreline, open water, birds, marine mammals, bivalves, and recreation.

The Trustees conducted surveys of the Doe-Kag-Wats marsh to assess potential impacts to marsh habitat. Based on these surveys, it was determined that oil entered the marsh via the tidal inlet following the spill. This oil impacted a total of 2.8 acres of marsh. Of the 2.8 acres, 0.1 acre was heavily oiled, 0.5 acre was moderately oiled, and 2.2 acres were lightly or very lightly oiled. The Trustees also conducted water sampling in the marsh inlet following the spill. This water sampling did not find evidence of elevated levels of dissolved petroleum hydrocarbon constituents.

Based on field observations and shoreline surveys, the Trustees determined that 3.5 acres of shoreline were oiled as a result of the spill. Of the 3.5 acres, 2.4 acres were categorized as heavily oiled, 0.7 acre was moderately oiled, 0.4 acre was lightly oiled, and less than 0.1 acre was very lightly oiled.[57] Most of the oiled shoreline was located on the western shore of Puget Sound between Indianola and Port Jefferson. The most heavily oiled shoreline was near the Doe-Kag-Wats tidal inlet; this shoreline required extensive flushing and sediment reworking to remove subsurface oil that penetrated into the sediments. There was no evidence of shoreline oiling along the eastern shore of Puget Sound.

The Trustees conducted water and sediment sampling to assess whether the oil spill impacted open water habitat in the Puget Sound. The sampling found little evidence of oil in the water column or sediment along the eastern shore of Puget Sound. Within the containment boom located at the Point Wells asphalt facility, the Trustees determined that Total Petroleum Hydrocarbon (TPH) concentrations diminished quickly after the spill, falling from 10 ppm within 24 hours of the spill to less than one ppm within 48 hours. Eastside water sampling found that all total PAH concentrations were below 0.5 ppm, including those collected at Point Wells.

[57] Based on standard shoreline oiling assessment methods developed for oil spills by the USCG.

Immediately following the spill, the Trustees began conducting wildlife surveys to evaluate potential injuries to birds and marine mammals. The surveys were conducted for one week in the general spill area in Central Puget Sound and for more than two months in oiled areas along the Indianola shoreline and the Doe-Kag-Wats marsh. For assessing bird injuries, the Trustees recovered 16 birds and documented six of these birds as oiled. Two of the oiled birds were rehabilitated and released. More birds were observed as oiled but were not captured. The Trustees estimated that total bird mortality was likely greater than reflected by survey evidence because carcasses could have been sunk, scavenged, or not found by response personnel. For evaluating potential injury to marine mammals, the Trustees focused on impacts to seals in the local area. Two seals were reported within the containment booms following the oil spill. One of these seals was oiled and subsequently died, while the other seal escaped the boomed area. Two additional reports of oiled seals came from the public, but survey workers could not confirm these reports or find evidence of further oiled seals. One dead seal was collected outside of the spill area, but this seal was not oiled.

To assess injuries to bivalves, the Trustees sampled tissues of intertidal bivalves along the heavily oiled shoreline areas. These areas provided intertidal and subtidal habitat for shellfish/bivalves. Tissue sampling found that PAH concentrations in bivalve tissues ranged from less than 200 parts per billion (ppb) to more than 17,000 ppb. A literature review determined that these PAH concentrations were well below lethal levels identified by DiToro et al. (2000) and levels that could affect feeding, impair growth rates, or cause other chronic impacts (Widdows et al. 1987, Donkin et al. 1989, DiToro et al. 2000). Although PAH levels were determined to be below levels that could cause acute injury, shoreline cleanup efforts did cause negative impacts to local bivalves. Cleanup work included sediment reworking and extensive flushing to remove subsurface oil that had penetrated into shoreline sediments. Field observations determined that cleanup efforts disrupted bivalve habitat and resulted in bivalve mortality. Based on historic bivalve population surveys conducted by the Suquamish Tribe, the Trustees estimated that 400 kg/acre of bivalve biomass were present in the upper intertidal zone. This bivalve biomass estimate was applied to the estimated 2.4 acres of heavily oiled shoreline to estimate a total bivalve injury of approximately 1,000 kilograms.

The primary impacts to human recreational use included a 115-day beach closure in the area of cleanup operations along Indianola and the Doe-Kag-Wats marsh, and a 246-day shellfish harvest closure along approximately 2 miles of the Indianola shoreline. In addition, there was a 96-day geoduck harvest closure for subtidal tidelands in the North Port Madison and Jefferson Head area. For the purposes of determining compensatory restoration requirements, the Trustees assumed that the spill impacted recreational use of approximately two miles of beach, including the 1.5 miles of previously oiled shoreline.

To compensate the public for the natural resource injury that occurred due to the spill, the responsible party paid the Trustees a total of $338,281. Of these funds, $265,281 were to be used for compensatory restoration projects focused on restoring the Doe-Kag-Wats marsh, restoring the Indianola Waterfront Preserve Marsh, enhancing shellfish, acquisition of tidelands, and beach enhancement at the Doe-Kag-Wats Beach.

Table 11-1 summarizes the natural resource injuries found by the Trustees.

Table 11-1. Foss Maritime spill: summary of natural resource injuries

Category	Injury Estimate
Doe-Kag-Wats Salt Marsh	2.8 acres of oiled marsh (*0.1 acres heavy oiling, 0.5 acres moderate oiling, 1.1 acres light oiling, 1.1 acres very lightly oiled)*
Intertidal Shoreline	3.5 acres of oiled shoreline (*2.4 acres heavily oiled, 1.1 acres lightly oiled)*
Birds, marine mammals, salmon, marine fish, aquatic biota	<u>Birds:</u> 6 oiled birds; 2 rehabilitated and released. Other birds were observed in the spill area but not recovered. <u>Marine Mammals:</u> Harbor seals observed in spill area. Two dead harbor seals observed (1 oiled), but their deaths were likely not associated with the spill. <u>Salmon, Marine Fish, and Aquatic Biota:</u> Salmon and marine fish in the spill area were likely exposed and injured from the spill.
Intertidal Shellfish/Bivalves	An estimated 1,000 kilograms of clams were killed as a result of the oil spill and shoreline cleanup activities.
Recreational Use	Beach closure restricted access to 1.5 miles of oiled beach during cleanup activities at Port Jefferson for 115 days. These impacts appear not to have been monetized. Recreational intertidal shellfish harvest closure on two public access beaches at East Indianola and West Port Jefferson for 246 days. Subtidal tidelands in North Port Madison and Jefferson Head area were closed to geoduck harvest for 96 days.

12 Julie N Spill

On September 27, 1996, the oil tanker Julie N struck a bridge in the harbor of Portland, Maine and spilled approximately 179,634 gallons of diesel fuel and heavy fuel oil out of the breached hull. Following the collision, the tanker was boomed, but high winds and tides drove an unspecified amount of oil out of the containment zone. The responsible party was Amity Products Carriers, Inc. and Trustees included the Maine Departments of Environmental Protection, Marine Resources, Inland Fisheries and Wildlife, and Conservation, as well as the U.S. Department of the Interior and NOAA.

The impacted area included the Portland Harbor, Fore River, Stoudwater Marsh, and Long Creek. The spill caused the closure of commercial and sport marine fisheries and impacted harbor use (though these impacts are not examined in the assessment documentation), including the operation of regional ferry service. In addition, signage at the Wayneflete School Trail in the Stoudwater Marsh warned the public of oil impacted marshes for nine months. The Trustees conducted a natural resources damage assessment in order to determine the extent of required restoration. Their analysis assessed ecological and recreational use injuries resulting from the oil spill. On May 2, 2000, a settlement agreement was reached with the Trustees that provided $1,000,000 for proposed restoration activities.

12.1 Assessment Methods

The Trustees assessed natural resource damages using a compensatory restoration framework. In this context, the value of the natural resource damages are expressed by the value of the restoration activities necessary to compensate for the injury sustained by the natural resource and its services. After conducting 16 pre-assessment studies, the Trustees decided to assess injury to ecological resources impacted by the oil spill as well as the lost and/or diminished value of recreational and transportation trips taken by the public. The Trustees did not estimate the impact to private parties, such as commercial fisherman, as these claims are outside the scope of natural resource damages.

During their assessment, the Trustees identified injury to marine vegetation, vertical wall communities, mussels, soft-shell clams, marine sediment, wetlands, and birds. They determined that 1,143 square feet and 340 pounds of marine vegetation had been cut and removed during response activities. They also found that 115,580 square feet of vertical wall communities had been exposed to heavy oiling or washing during response activities. Using tissue and sediment sampling, they identified elevated PAH levels in sediment, mussels, and soft-shell clams. Using aerial and ground surveys they identified 25.6 acres of lightly to heavily oiled wetland. They also observed 27 dead birds, and 1,679 birds with visible signs of oiling. From the available documentation, it is unclear how these observed and measured damages were scaled to a measure of total injury.

To quantify the lost human use services, the Trustees measured the number of lost and diminished trips. They estimated that in addition to 250 lost ferry trips, an additional 2,700 ferry trips had been diminished in value. The Trustees also determined that 4,986 recreational fishing trips, 300 tour boat trips, and 225 whale watching trips had been lost. Finally, the Trustees estimated that 1,380 recreational trail activities trips to the Wayneflete School Trail had been lost and diminished as a result of nine months of cautionary signage regarding the oil impacted marshes. From the available documentation, it does not appear that the Trustees quantified the economic value of these lost trips.

The Trustees selected restoration projects aimed at restoring the marine environment, wetlands and bird habitat, and lost human uses. The selected projects included a project to reduce the discharge of oil and greases into the Fore River, the enhancement of 130 acres of salt marsh habitat, the acquisition and protection of marine bird nesting habitat, and the construction of a one-mile segment of recreational trail along the Fore River. Although it is unclear how the Trustees determined the appropriate scale of restoration to offset natural resource losses resulting from the oil spill, they estimated that the previously mentioned restoration projects, including oversight and administration costs, would cost $1,000,000.

Table 12-1 summarizes the assessed injury and restoration projects by resource category. On May 2, 2000 the responsible party, Amity Products Carriers, agreed to pay $1,000,000 for restoration activities.

Table 12-1. Julie N spill: Resource damage and restoration costs by injured resource

Injured Resource	Quantified Injury	Restoration Action	Restoration Action Costs
Marine Environment	1,143 sq. ft. and 340 lbs of removed vegetation, 115,580 sq. ft. of impacted vertical wall communities, elevated PAH concentrations in sediment, mussels and soft-shell clams.	Reduction of oil and grease discharge into Fore River.	$350,000
Wetlands and Birds	25.6 acres of oiled wetlands, 27 dead birds, and 1,679 visibly oiled birds.	Enhancement of 130 acres of salt marsh habitat, acquisition and protection of marine bird nesting habitat (Trustees contributed 5% of the costs to acquire 117 acres of bird habitat).	$475,000
Lost Public Uses	250 lost ferry trips, 2,700 ferry trips of diminished value, 4,862 lost recreational boating trips, 124 lost charter boat trips, 300 lost tour boat trips, 225 lost whale watching trips, 1,380 lost and diminished trail activity trips.	Construction of one-mile segment of recreational trail along Fore River.	$125,000
Total Value of Restoration Activities			**$1,000,000[1]**
Note: Includes $50,000 in oversight and administration costs.			

13 Kure Spill

On November 5, 1997, the M/V Kure spilled 4,500 gallons of Intermediate Fuel Oil after puncturing a fuel tank while docked in Humboldt Bay, California. Although 150 feet of boom were deployed, oil escaped and spread with the tide. More than 28 miles of shoreline were eventually oiled. The spill killed numerous birds and impacted human recreation.

13.1 Damages Estimates and Types of Damages Evaluated

Damages quantified are presented in Table 13-1. Proposed restoration projects are summarized in Table 13-2.

Table 13-1. Kure spill: summary of injuries quantified

Resource	Impacts	Restoration
Loons and Grebes	243 killed	Nesting colony protection in California
Pelicans, Cormorants, Large Gulls	220 killed	Protection of Brown Pelican roost sites
Alcids and Procellarids	910 killed	Contribution to Redding Rock project
Marbled Murrelets	130 killed	Corvid habitat protection/enhancement
Waterfowl	414 killed	Restore 11.6 acres of wetland habitat
Shorebirds	2,033 killed	Restore 3.8 acres of wetland habitat
Shoreline habitat	6,200 acres	Restore 7.5 acres of wetland habitat
Sea Kayaking	73 lost user days	Contribute toward projects benefitting recreation use
Surfing	400 lost user days	
Camping	294 lost user days	

Table 13-2. Kure spill: summary of settlement amounts

Restoration Category	Cost
Nesting colony protection in California	$250,000
Protection of Brown Pelican roost sites	$250,000
Contribution to Redding Rock project	$450,000
Corvid habitat protection/enhancement	$750,000
Restore wetland habitat (includes recreation)	$420,000
Forest conservation easement	$2,400,000
Total	$4,520,000

13.2 Methods Applied

Trustees initiated pre-assessment activities immediately after the spill. These included ground, aerial and boat surveys, as well as wildlife collection efforts and documenting beach closings.

Effects on shoreline habitat were estimated using an HEA. Trustees determined the extent and intensity of oiling (very light, light, moderate, heavy) over various types of habitat (mudflat, wetland, rip rap shoreline, sand and gravel beaches) and made assumptions about lost productivity for each. For example, Trustees assumed moderately oiled mudflat had 50% productivity for 60 days following the spill and was back to normal after that. Services were ultimately presented as DSAYs lost.

The Trustees quantified bird mortality by taking the number of oiled individuals collected and applying a multiplier to represent population impacts. For example, factors influencing the relationship between number of birds collected and number of birds that ultimately die include: extent of unsearched areas, volunteers ability to identify birds, the extent oil birds travel inland or out of the area, removal or burying by public, etc. Trustees took these various factors into account to come up with a multiplier for each species, which they applied to the number of animals collected—along with average lifespan estimates—to derive bird-years lost. Because so many bird species were impacted by the spill, Trustees decided to group them according to habitat requirements for restoration.

Recreation losses quantified include forgone kayaking, surfing and camping trips, and were estimated based on interviews with local business owners. For example, the spill affected only one campground, where the local manager reported 84 reservations were canceled due to the spill. He estimated that three to four people typically use one campsite, making total camping losses 3.5*84 = 294. The value per lost trip was obtained from the relevant economics literature, and varied by activity. The total value of lost recreation came to $47,000. Because of the relatively smaller recreation impacts, Trustees made no attempt to calculate the value of recreation undertaken but of diminished quality.

Apart from recreation, for which Trustees arrived at an explicit monetary value, damages were monetized by estimating the costs of projects that would restore the lost natural resources. This was not necessarily a one to one relationship, as one project can benefit multiple resource categories. For example, the $420,000 in Kure settlement funds allocated to the McDaniel slough project is meant to restore recreation, waterfowl, shorebird, and shoreline habitat damages.

14 Luckenbach Spill

On July 14, 1952 the SS *Jacob Luckenbach* collided with another vessel and sank off the coast of California in the Gulf of the Farallones. In 2002, researchers discovered the ship had been leaking oil on and off for at least 30 years. Although the Luckenbach is likely the source for most of the "mystery" oil spills that have occurred in the area since at least 1972 (see Table 14-1), oil fingerprint analysis does show a percentage of the oil is attributable to other unknown sources. Damages from these unknown sources are included in this case. Because the owners of the Luckenbach were no longer viable (and the source of the other oil unknown), restoration costs came out of the Federal Oil Spill Liability Trust Fund.

Table 14-1. Luckenbach spill: oiling events likely associated with the spill

Oiling Episode	Notes
Winter 1973–1974	100+ live oiled birds collected by public
Winter 1981–1982	218 oiled birds observed
August 1983	500 live oiled birds collected by public
Winter 1989–1990	243 oiled birds observed
Winter 1990–1991	195 live oiled birds collected by public; 127 oiled birds observed
Winter 1992–1993	46 oiled birds observed
Winter 1995–1996	< 100 oiled birds collected by the public
Winter 1997–1998 (Pt. Reyes Tarball Incidents)	2,964 oiled birds collected by public and response teams
Winter 2001–2002 (San Mateo Mystery Spill)	1,921 oiled birds collected by public and response teams
Summer 2002 (Luckenbach oil removal)	257 oiled birds collected by public and response teams
Winter 2002–2003	546 oiled birds collected by public and response teams

14.1 Damages Estimates and Types of Damages Evaluated

Damages are presented in Table 14-2. Proposed restoration projects are summarized in Table 14-3.

Table 14-2. Luckenbach spill: wildlife mortality since 1990

Species	Mortality
Birds	
Waterfowl (primarily surf scoter)	862
Loons (primarily Pacific loon)	1,314
Grebes (primarily western grebe)	4,106
Procellarids (primarily northern fulmar)	4,796
Brown pelican	278
Cormorants (primarily Brandt's cormorant)	1,460
Gulls (primarily California, western, and glaucous-winged gulls)	2,388
Snowy plover	30
Other shorebirds (primarily red phalarope)	1,554
Common murre	31,806
Marbled murrelet	45
Other alcids (primarily ancient murrelet, and Cassin's and rhinoceros auklets)	2,763
Total bird mortality	51,402
Other	
Sea Otters	8

Table 14-3. Luckenbach spill:summary of restoration amounts

Restoration Category	Cost
Nest Protection at Kokechik Flats, Alaska	$561,631
Grebe Colony Protection at Northern California Lakes	$965,435
Mouse Eradication on the Farallon Islands	$975,597
Shearwater Colony Protection at Taiaroa Head, New Zealand	$55,649
Seabird Colony Protection on Baja California Islands, Mexico	$3,736,475
Dune Habitat Restoration at Point Reyes National Seashore	$501,447
Common Murre Colony Protection Project	$9,526,603
Corvid Management at Point Reyes National Seashore	$500,000
Reading Rock Common Murre Colony Restoration	$255,307
Old Growth Forest Acquisition and Protection	$1,745,000
Corvid Management in the Santa Cruz Mountains	$695,363
Rat Eradication in the Queen Charlotte Islands, Canada	$695,363
Nesting Habitat Restoration on Año Nuevo Island	$974,037
Sea Otter Pathogens Education and Outreach	$121,155
Total	$21,309,06

14.2 Methods Applied

Apart from the eight sea otters, the Luckenbach injury consists entirely of birds. To quantify these injuries, the Trustees applied a multiplier to the number of oiled birds collected, yielding an extrapolated estimate of population impacts. Factors influencing the relationship between the number of birds collected and number of birds that ultimately die in a spill include: extent of oiled but unsearched areas, the number of scavenged birds, volunteers ability to identify birds, the number of birds washed away by tides, the extent oil birds travel inland or out of the area, removal or burying by public, and at-sea loss. Trustees took these various factors into account to come up with a multiplier for each species, which they then applied and aggregated to come up with total bird-years lost.

Sea otter injuries were calculated similarly. Four oiled, dead sea otters were found. The scientific literature says that on average 46 percent of oiled sea otters are recovered, which implies that approximately eight died in this case.

15 New Carissa Spill

On February 4, 1999, the M/V *New Carissa*, a bulk cargo ship in ballast, ran aground in the Pacific Ocean approximately five kilometers north of the entrance to Coos Bay, Oregon. As a result of the grounding, oil began leaking from the vessel. During remediation efforts, the vessel split in two. The bow section was refloated and towed offshore. The tow broke, however, and this section re-grounded at Waldport, Oregon, 110 kilometers north of the initial grounding, on March 3, 1999. This second grounding released additional oil. The bow section was eventually re-towed offshore and sunk, and the stern section remained stranded in the surf until nine years after the spill. The total amount of oil released was estimated to be between 25,000 and 70,000 gallons by the response effort, but was thought to be up to 140,000 gallons according to an additional estimate made as part of the NRD effort. Public recreation was affected by the spill at three areas: the North Spit area of Coos Bay, the Oregon Dunes National Recreation Area, and Governor Patterson Memorial State Park. Recreational activities including shellfishing, crabbing, and fishing were also affected along a number of beaches and estuaries along the southern Oregon Coast.

15.1 Damages Estimates and Types of Damages Evaluated

Injuries to avian populations and to recreational activities were identified and quantified. A summary of the injuries are found in Table 15-1. Table 15-2 illustrates the restoration costs, apportioned from the $4 million NRD settlement as well as the original damage estimate for recreation.[58]

Table 15-1. New Carissa spill: environmental injuries sustained following the spill

Resource Category	Resource Type	Injury Or Loss
Birds	Western snowy plovers	4–8 birds
	Shorebirds	672 birds
	Marbled murrelets	262 birds
	Seabirds (other than marbled murrelets)	2,203 birds
Recreation	Lost/diminished trips	27,974–29,204 trips

Table 15-2. New Carissa spill: restoration costs summary

Resource Category	Resource Type	Restoration Cost	Damages
Birds	Western snowy plover	$195,000	Not estimated
	Shorebirds	$181,000[1]	Not estimated
	Seabirds	$1,650,000[1]	Not estimated
Recreation	Recreation	$404,000	$395,356–$413,056
Total		$2,439,000[1]	
[1] These costs represent only partial restoration costs as Trustees were unable to accurately estimate the costs of two of the proposed restoration projects at the time of the DARP publication.			

[58] It appears that the original damages estimates for birds were prepared up through a comparison of debits and credits but the cost of the appropriate amount of credit was never quantified prior to settlement.

15.2 Methods Applied to Assess Damages

- **Birds:** Damages to birds were calculated using an REA approach in which various restoration activities were scaled to bird injury, quantified as lost bird-years. Such analyses were conducted for different populations of birds separately first before aggregating the damages. Inputs to the REAs were provided by observational data collected during the spill response (i.e., number of dead birds) as well as from literature values (i.e., average life span).
- **Recreation:** Recreational damages were estimated through a benefits-transfer valuation approach. The method involved determining the number of recreational trips affected (either lost altogether or reduced in quality) and the value-per-trip for each of the affected recreational activities. The total recreational lost value is equal to the aggregate sum of the number of trips affected multiplied by the value of such a trip across all recreational activities considered. A study was undertaken to assign values to these variables; field and historical data were used to understand the number of affected visits and an extensive literature review was undertaken to assign a value to the recreational activities lost or diminished. Ultimately, lost trips were considered to have a consumer surplus value of $14.39 per trip and diminished trips (i.e., the park is open but beach access is prohibited) a consumer surplus loss of $7.20 per trip, resulting in the damages estimate presented in Table 15-2.

16 North Cape Spill

On January 19, 1996, the *North Cape*—a tank barge carrying 94,000 barrels of home heating oil—went aground near Moonstone Beach in South Kingstown, RI, after the tug boat towing it caught fire and was abandoned during a storm. With winds reaching 50 knots, leaking oil was dispersed throughout the water column and in contact bottom sediments. An estimated 828,000 gallons of oil were spilled.

In the days following the spill, many lobsters and shellfish washed up on shore, and the RI Department of Health closed more than 200 square miles of commercial fisheries. The fisheries did not fully reopen for five months.

16.1 Damages Estimates and Types of Damages Evaluated

The Trustees evaluated 14 damage categories, as listed below:

1. Lobster Mortality
2. Surf Clam Mortality
3. Loss of Primary Production in the Offshore Water Column
4. Mortality of Offshore Benthic Fauna Other than Lobsters and Surf Clams
5. Fish Mortality
6. Loss of Piping Plover Production
7. Seabird and Wintering Waterfowl Acute Mortality
8. Waterfowl Habitat Degradation
9. Mortality of Salt Pond Water Column and Sediment Biota
10. Loss of Salt Pond Vegetation
11. Lost Beach Use
12. Lost Party and Charter Boat Fishing Trips
13. Lost Recreational Diving Trips
14. NWR Refuge Visitation Reduction

Of these damage categories, the Trustees quantified the ecological injuries summarized in Table 16-1.

Table 16-1. North Cape spill: summary of ecological injuries quantified

Resource	Biomass Killed (Kg)	Recovery Time
Offshore impacts		
Lobsters	312,400	4–5 years
Surf Clams	547,600	3–5 years
Other Marine Benthic Organisms	362,900	5 months–3 years
Fish	81,000	1-2 years
Salt pond impacts		
Worms/Amphipods	66,000	5 months
Crabs and Shrimp	3,300	1–2 years
Soft-shell Clams and Oysters	7,600	1–2 years
Forage Fish	2,700	1—2 years
Winter Flounder	1,400	1 year
Birds		
Piping Plovers	5–10 fledged chicks	Threatened species
Seabirds and Wintering Waterfowl	6,895 bird-years	1–6 years
Pond Birds	476 kg	1 year
Recreation		
Party and Charter Boat Fishing	3,305 trips; value of $281,685	6 months

As part of the settlement, the responsible parties agreed to pay the amounts presented in Table 16-2.

Table 16-2. North Cape spill: summary of settlement amounts

Restoration Category	Settlement Amount
Salt Pond Land Acquisition	$1.6 million
Multi-species Shellfish Restoration	$1.5 million
Loon Nesting Habitat Purchase	$3 million
Eider Nesting Habitat Purchase	$400,000
Piping Plover Nesting Habitat Management	$140,000
Anadromous Fish Restoration	$160,000
Lobster Restoration	$800,000

16.2 Methods Applied

Many of the ecological damages—including those to surf clams, marine benthic organisms, fish and salt ponds—were calculated using the Integrated Oil Spill Impact Model System (SIMAP), a comprehensive oil fate and transport and biological effects model. The Trustees used SIMAP primarily to estimate quantities of animals lost; the estimated time to recovery was calculated on a species-by-species basis using information from the scientific literature in addition to local knowledge and experience.

Salt pond injuries were also informed by shellfish tissue samples. For lobsters, the Trustees conducted comprehensive on and off shore sampling to estimate mortality. The Trustees estimated the number of birds killed by applying a multiplier to the number of deceased birds collected. Past oil spill cases have used a multiplier from 1 to 10, although Trustees considered case-specific factors. For example, the fact the spill occurred closer to shore means (with all else equal) that oiled birds are typically *more* likely to make it to shore, and the multiplier should be lower. However, offshore winds also blew for 60 hours during and immediately after the spill, increasing the spatial extent of oiling and making it *less* likely oiled birds could swim to shore, in which case the multiplier would be higher. In the end, Trustees decided on bird damages six times those collected.

Human use impacts were estimated by interviewing charter and party boat captains to estimate the quantity of forgone trips due to the spill. These were multiplied by the value of each trip according to a 1994 paper by McConnell and Strand, which was $85.23 in 1996 dollars. The Trustees also interviewed recreational divers and determined that the spill did not impact any of their plans to dive in Rhode Island. To gauge impacts on beach use, Trustees compared use data before and after the spill and found no discernable difference.

17 Ocean Energy Spill

On September 22, 2002, an estimated 12,600 gallons of crude oil was released through an accidental discharge from an aboveground storage tank at a storage and transfer facility at North Pass in the Mississippi River Delta, Plaquemines Parish, Louisiana. The bottom of the 10,000 barrel aboveground storage tank, owned by Ocean Energy Inc. (later Devon) ruptured as a result of internal corrosion. The oil was released first into a containment berm and then escaped this area to flow into the surrounding water and marsh. Response activities began immediately and included deployment of sorbent and protective booms as well as skimmers to collect the discharged oil from the surface of the water. Cleanup activities were halted due to the passage of Tropical Storm Isidore and Hurricane Lili. Oil transported deep within the marsh by these storms was not subsequently recovered because of the anticipated greater damage response activities would have on the area.

17.1 Damages Estimates and Types of Damages Evaluated

Injuries to freshwater marsh habitat were considered in the damage assessment.[59] It was determined that 120 acres of marsh habitat, shoreline, and water column had experienced moderate oiling and were considered injured. No numerical damages estimate is presented in the Final Damage Assessment and Restoration Plan and Environmental Assessment. Because assessment and restoration costs owed to the FWS are presented in aggregate in the settlement document, the exact overall restoration amount as owed to all Trustees is not known. Rather, a range can be concluded from the information available. The restoration costs were at least $21,370 but no more than $42,539.22.

17.2 Methods Applied to Assess Damages

A HEA was used to relate natural resource and service losses to compensatory restoration. Reasonably conservative assumptions to ensure that the environment and the public would be adequately compensated for losses incurred were employed when determining the inputs for the injury side of the model. For example, a 75 percent service loss of the entire 120-acre area of impacted marsh was determined to be a conservative and reasonable assumption representing the average of marsh habitat loss ranging from near 0 percent in areas exposed only to sheen to 100 percent in areas covered with heavy oil. Other key inputs and the output of the HEA model are presented in Table 17-1. Losses were quantified as lost habitat service acre-years, where a service acre-year is the flow of services from one acre of habitat for one year. The analysis assumes that this measure of injury accounts for reductions in the entire flow of marsh habitat services, including those that support birds and aquatic fauna.

Table 17-1. Ocean Energy spill: Key parameters used in or produced from the North Pass HEA

Parameter		Assumption Or Value
Inputs	Injured area	120 acres
	Loss of services	75%
	Time to recovery	1 year
	Discount rate	3%
Output	Damages	56.20 DSAYs[1]

[1] DSAY, or discounted service acre-year, is the present value of the current and future loss of habitat services as measured by service acre-years.

[59] The Trustees also considered potential injuries to wildlife, birds, fish, and water column biota. Through helicopter overflights, ground surveys, and on-water surveys, no evidence of such injuries was observed.

18 Polar Tankers Spill

On October 13, 2004, approximately 7,200 gallons of crude oil were released into Puget Sound during a ballasting operation on the oil tanker, Polar Texas. Response activities, supported by the U.S. Coast Guard, recovered 59 tons of oily debris and 6,842 gallons of oily water. The responsible party was the vessel's owner, Polar Tankers, Inc., a wholly owned subsidiary of ConocoPhillips. Trustees included the Muckleshoot Indian Tribe, the Puyallup Tribe of Indians, the State of Washington Department of Ecology and Department of Fish and Wildlife, NOAA, and FWS.

Up to 19 miles of shoreline were impacted by the oil spill, including one mile of heavily oiled beach and three miles of light to moderately oiled beaches. Additionally, oil was observed across approximately seven square miles of open water. As a result of the oil spill, King County temporarily closed several parks on Vashon and Maury islands and the Washington State Department of Health closed several beaches to shellfish and seaweed harvesting for three weeks.

18.1 Assessment Methods

The Trustees assessed natural resource damages using a compensatory restoration framework. In this context, the value of the natural resource damages are expressed by the value of the restoration activities necessary to compensate for the injury sustained by the natural resource and its services. Believing that it would not have met the Oil Pollution Act standard for reasonable assessment costs, the Trustees did not conduct a formal injury assessment. Instead they performed a pre-assessment screening and determined that injury had occurred. Because a formal assessment was not conducted, detailed information on damages is not readily available. Accordingly, an exhibit presenting damages by category is not included in this narrative.

During the pre-assessment screening process, the Trustees performed shoreline surveys and helicopter overflights to determine the extent of oiling. They also collected water, sediment, and shellfish tissue samples for chemical analysis. They determined that injury had occurred to shoreline habitat, shellfish, migratory birds, and several fish species, including endangered Chinook and Chum salmon juveniles, Pacific herring, surf smelt, and Pacific sand lance. They also determined that visitor use of beaches and parks in impacted area, as well as recreational harvesting of shellfish, had been impacted by the spill.

Given that the Trustees did not quantify the amount of injury, it is unclear how they determined the appropriate scale of compensatory restoration. Even so, they compiled a list of restoration activities that they believed would provide adequate compensation to the public for spill-related injuries. Although they did not quantify the cost of individual restoration projects, the Trustees signed a consent decree with the responsible party in May 2010 that provided $487,300 for compensatory restoration activities.

19 Star Evviva Spill

On January 14, 1999, the cargo ship *M/S Star Evviva* had an engine room malfunction that resulted in the release of approximately 24,000 gallons of fuel oil into the Atlantic Ocean. At the time of the spill, the ship was located approximately 30 to 50 miles off the coast of South Carolina. Though there were no reported sightings of an oil spill, oiled birds began washing ashore along the coastline in South Carolina and North Carolina shortly after the spill occurred.

In the month after the spill, a total of 194 injured birds were recovered along a 195 mile stretch of coastline between Folly Beach, South Carolina and Topsail Beach, North Carolina. Of the 194 birds, 189 were oiled. The birds were taken to a temporary facility for treatment, but only four of the oiled birds survived to be released. The Trustees estimated that total bird mortality due to the spill was greater than the amount of oiled birds that perished. The Trustees used spill data and a literature review (see below) to estimate total bird mortality due to the spill. Once this natural resource injury was quantified, the Trustees determined the extent of required restoration necessary to offset the lost services due to the spill. Based on this determination, the Trustees entered into a settlement with the responsible party in 2003. The settlement called for the responsible party to pay $1,875,946 toward the cost of implementing restoration projects and $124,054 for assessment costs.

19.1 Assessment Methods

The Trustees assessed natural resource damages using a compensatory restoration framework. In this context, the value of the natural resource damages are expressed by the cost of the restoration projects necessary to compensate for the injury sustained by the natural resource and its services. Based on data gathered after the spill, the Trustees determined that the natural resource of primary concern related to the spill was marine birds. Although oil was released into the offshore water column, there was no documented injury to marine fishes or mammals. In contrast, there was documented injury to birds as a result of the spill.

The Trustees used data gathered during shoreline surveys after the spill to estimate natural resource injuries to marine birds. Based on data for the birds that were retrieved, the Trustees determined that the majority of the affected birds were species of loons. Therefore, only loon injuries were assessed, as summarized in Table 19-1.

To determine total loon mortality attributable to the spill, the Trustees used a literature review to scale up the observed loon mortality to total loon mortality. Of the 194 injured birds recovered along the shoreline, the Trustees observed that 179 loons died as a result of exposure to the spill. Based on the literature (Tanis and Morzer Bruijns 1968, Burger 1993, Hope-Jones et al. 1970, Hlady and Burger 1993), the Trustees used a multiplier of 10 to estimate that the total loon mortality was 1,790 birds.

The Trustees then used the REA methodology to calculate the natural resource injury in terms of the number of loon-years lost as a result of the spill. This methodology relies on assumptions about the extent of resources affected, the service loss of the affected resources, and the recovery time for the affected resources to quantify the injury in terms of compensatory restoration requirements. To perform the REA calculations, the Trustees used the injury quantification models from the *North Cape* spill NRDA. The Trustees used the same assumptions (discount rate, recovery time) utilized in these models with the exception of the total bird mortality multiplier, which was set to 10.

The REA calculations determined that the natural resource injury necessitated the restoration of 14,270 loon-years.

To compensate the public for the natural resource injury that occurred due to the spill, the responsible party paid the Trustees $1,875,946 in restoration funds. These funds were used to design and build a permanent bird rehabilitation center in South Carolina. The rehabilitation center is dedicated to treating injured, diseased, or displaced birds, and has the capability to treat oiled birds in the event of an oil spill. The facility began operations in 2007 and is now recognized as one of the premier oil spill response facilities in the U.S.

Table 19-1. Star Evviva spill: Summary of quantified injury and restoration actions

Resource	Quantified Injury	Restoration Action
Loons	1,790 lost birds resulting in 14,270 loon-years	Construction of permanent bird rehabilitation center

20 Stuyvesant Spill

On September 6, 1999, the dredge *M/V Stuyvesant* spilled at least 2,100 gallons of Intermediate Fuel Oil 180 (IFO-180) into the Pacific Ocean near the mouth of Humboldt Bay, near Eureka, California. A dredge arm on the vessel punctured one of its fuel tanks. Although the puncture occurred near the entrance to Humboldt Bay, the spill likely began approximately four miles offshore when the vessel dumped its dredging spoils and became sufficiently light to have the puncture rise above the water line. The vessel then moved back to the mouth of Humboldt Bay. An out-going tide prevented the oil from entering the bay. The ship then moved away from the shore, eventually moving as far as 15 miles offshore, and the leak was stopped. Oil slicks and tarballs in the ocean were identified as far as 15 miles offshore and as far north as Patrick's Point, approximately 20 miles north of the bay's opening. Two days after the spill, oil was observed on the shore of the South Spit, the southern entrance to Humboldt Bay. Clam Beach and Indian Beach, both north of the channel opening to Humboldt Bay, were closed for three and seven days, respectively. Shoreline Cleanup and Assessment Teams (SCAT) conducted surveys daily for at least 10 days following the spill. In total, the affected environment included 354 square miles of ocean, 60 miles of shoreline from Eel River Wildlife Area to Sharpes Point, Humboldt Lagoon State Park, and the mouths of Little River, Mad River, various smaller creeks, and Humboldt Bay.

20.1 Damages Estimates and Types of Damages Evaluated

Injuries to natural resources and recreational services were both identified as resulting from the spill. A summary of the injury quantification is presented in Table 20-1.

Table 20-1. Stuyvesant spill: Quantification of injuries resulting from the spill by resource and resource category

Resource Category	Resource	Quantified Injury
Birds	Marbled murrelets	135 estimated dead
	Common murres	1,600 estimated dead
	Other birds	670 estimated dead
Water Column	Fish	Over 6,000 epipelagic fish estimated dead[1]
	Shrimp	3,282 kg of shrimp estimated dead[1]
Habitat	Sandy beach habitat	3,054 acres of shoreline lightly, moderately, or heavily oiled
	Rocky intertidal habitat	162 acres of shoreline lightly, moderately, or heavily oiled
Human Use	Recreational services	9,415 lost user days; 197 diminished user days

[1] Estimates of shrimp and fish killed by the oil spill were made using a model of the physical fate of oil in the water column, developed by a Trustee-RP technical working group.

The value of the impact to recreation was calculated directly to be $226,780. The damages to the other natural resources were determined by scaling restoration options to the calculated injury. The total restoration costs (which presumably also include those for recreational activities) were $6.7 million.

20.2 Methods Applied to Assess Damages

Overall, damages to environmental resource categories were determined utilizing a service-to-service based approach, such as REA or HEA,[60] or a benefits transfer technique. The Final Damage Assessment and Restoration Plan / Environmental Assessment provides detailed information on the inputs and outputs

[60] HEA and REA methodologies are fundamentally the same. Generally, HEA captures all services in aggregate stemming from an area of land, while REA focuses on a particular resource (i.e., birds, fish, etc.).

of the damage calculations by resource type. Table 20-2 illustrates several comparisons of debit to credit scaling for different resources injured by this spill.

- **Birds:** Damage quantification for birds relied on the REA method, a service-to-service restoration-based approach. Bird injuries were quantified using the Beached Bird Model (Ford et al. 1987; 1996), with modifications made by a Trustee-RP technical working group. The Beached Bird Model estimates the number of birds that come in contact with an oil spill and partitions these birds into four possible fates: (1) swimming or flying ashore; (2) carried out to sea by wind and currents; (3) carried inshore but lost before beaching; (4) beached by winds and currents. This latter group is further divided into birds that are recovered and birds that are not recovered. As such, this approach allows for an understanding of the total number of birds affected based on the number of oiled birds recovered on the beach. The metric used to scale restoration to match the injury was bird-years. The bird-years metric was calculated using life history information for different species as well as the results of the modified Beached Bird Model. A single-generation stepwise replacement approach was used with the assumption that a representative section from each age class was killed by the spill.[61] The single-generation stepwise replacement assumes that each year after the spill the juvenile age class will be entirely replaced, such that the first-year age class will fully recover a year after the spill, the second-year age class two years after the spill, etc. Restoration options were then scaled such that an equal number of bird-years to those lost would be gained. In order to account for debits and credits in the future, a 3 percent discount rate was employed.
- **Habitat:** Service-to-service scaling methods were also used for assessing damages to the water column and shoreline habitats. Observations of dead shrimp and models of oil toxicity in the ocean served as inputs to a trophic-level REA in order to scale an appropriate restoration project. For shoreline habitats, the number of acres oiled, the degree of oiling, and the associated degree and duration of injury associated with the oiling were entered into a HEA to scale restoration of dunes and wetlands.
- **Recreational Use:** For recreational use impacts, a direct dollar value of the loss to the public was determined using a benefits transfer technique. This process relied on determining the types of recreational activities impacted, quantifying the number of trips lost due to beach and boat ramp closures, quantifying the number of trips diminished in value due to the spill, determining the appropriate values per trip per activity, based on economic literature, and finally, multiplying the value per lost trip or diminished trip by the number of affected trips of this type. This approach was carried out by consultants in a joint study commissioned by the Trustees and the RP.

[61] This approach was used for all birds with the exception of the Marbled Murrelet. The Marbled Murrelet assessment relied on a formula which took into account the number of female birds in the subpopulation before and after the spill as well as the age at which adults attempt successful breeding.

Table 20-2. Stuyvesant spill: several examples of injury to credit scaling for various injured resources

Resource	Injury Method	Injury	Unit	Credit	Unit	Notes
Sandy Beach to Dunes	REA	58.6	DSAYs	7.1	Acres	
Rocky Intertidal Injury to Wetlands	REA	10.4	DSAYs	0.8	Acres	
Loon/Grebe	REA	414	Bird-Years	592	Bird-Years	Credit represents bird-years gained with one year of nest protection program
Cormorant/Gull/Pelican	REA	627	Bird-Years	51	Bird-Years	Credit is based on benefits per nest. In this case, (627/51)=12 nests would need to be protected
Murre	REA	14,194	Bird-Years	49,184	Bird-Years	Contribution to a similar project on which the credit was based would be (14,194/49,184)=29%

21 Torch Spill

On September 28, 1997, a pipe connected to the offshore oil extraction platform Torch/Irene broke, spilling 163 barrels of crude oil. The spill impacted approximately 17 miles of coast near Santa Barbara, California, affecting beach and marine habitats, wildlife, and human use.

Compensatory restoration projects include seabird colony enhancement, beach, dune and mussel bed restoration projects, as well as an abalone educational program and the construction of a boardwalk along the beach.

21.1 Damages Estimates and Types of Damages Evaluated

Trustees quantified damages as summarized in Table 21-1. Effects were monetized per the cost of restoration as described in Table 21-2.

Table 21-1. Torch spill: summary of injuries quantified

Resource	Impacts
Birds	635–815 killed
Sand and Gravel Beach Habitat	Not quantified
Rocky Intertidal Shoreline Habitat	Not quantified
Recreation	2,000 lost user days, 7,000 diminished user days

Table 21-2. Torch spill: summary of settlement amounts

Restoration Category	Budget
Seabird Colony Enhancement Project	$1,193,833
Sandy Beach & Dune Habitat Restoration	$396,000
Mussel Bed Restoration	$104,650
Rocky Intertidal Habitat Protection Program—Focus on Abalone & Other Rocky Intertidal Species	$136,500
Boardwalk at Ocean Beach Park	$65,520 (total cost: $93,140)
Contingency for Restoration Projects	$100,497
Total	$1,997,000

21.2 Methods Applied

The Trustees quantified damages to birds by applying a multiplier to the number of oiled birds collected, yielding an estimate of population impacts. Factors influencing the relationship between number of birds collected and number of birds that ultimately die include the extent of unsearched areas, the number of scavenged birds, volunteers' ability to identify birds, the number of birds washed away by tides, the extent to which oiled birds travel inland or out of the area, removal or burying by public, and at-sea loss. Trustees took these various factors into account—along with estimates on average lifespan—to derive a multiplier for each species, which they applied to the number of animals collected to estimate bird-years lost.

For recreation losses, Trustees divided use into two categories: general and specialized beach use (i.e., surfing or surf fishing). For both categories, the Trustees conducted surveys to estimate the number of trips lost as well as those undertaken but of diminished in value. Based on primary research conducted following the American Trader spill, the Trustees applied a user day value of $18.55 per user day; the Trustees estimated specialized use was 25 percent higher, or $23.19 per user day. It was assumed the reduction in value for diminished trips was 20 percent. Total recreation losses were approximately $65,000.

Habitat impact calculations supporting the values presented above are not publicly available.

22 Williams Field Services Group Spill

On April 5, 2001, a pipeline operated by the Williams Field Services Group, Inc. discharged between 100,000 and 126,000 gallons of natural gas condensate oil near Mosquito Bay in Terrebonne Parish, Louisiana. In all, 106 acres of marshland were affected, most of it burned unintentionally after the *in situ* burns set as a part of cleanup efforts escaped their planned boundaries. As part of the settlement, the responsible party agreed to create 6.5 acres of brackish marsh via a dredge and fill operation. Total restoration costs were $1.6 million.

22.1 Damages Estimates and Types of Damages Evaluated

Trustees quantified damages as summarized in Table 22-1. Settlement amounts are given in Table 22-2.

Table 22-1. Williams Field Services Group spill: summary of injuries quantified

Resource	Acres	Service Loss	Recovery
Marshland			
Burned; not affected by natural gas	93.30	10%	6 months
Burned; lightly affected by natural gas	7.83	50%	2 years
Burned; moderately affected by natural gas	0.87	100%	10 years
Burned; heavily affected by natural gas	3.00	100%	4 years
Site of spill location; will recover	0.50	100%	5 years
Site of spill location; will not recover	0.50	100%	15 years

Table 22-2. Williams Field Services Group spill:summary of settlement amounts

Restoration Category	Cost
Assessment costs	$76,251.01
Trustee costs	$143,076.36
Restoration costs	$1,624,048.35
Settlement Total	$1,843,375.72

22.2 Methods Applied

Although they considered separate fish, wildlife and water column injuries, the Trustees ultimately decided these injuries would be sufficiently captured by a single marsh habitat injury calculated through an HEA. In doing this, they determined via ground and aerial surveys both the extent and intensity of contamination (light, moderate, heavy), as well as whether the area was burned during cleanup.

Once the affected areas were partitioned, the Trustees and the responsible party made assumptions about the lost productivity of each section. These ranged from a 10 percent loss in productivity for 6 months (burned, lightly affected marsh) to 100 percent losses for 15 years (“ground zero”). Estimates for service reduction were based on “professional judgment and experience with other natural gas condensate discharges.” The report explicitly mentions that investigators did *not* do any original studies to further refine these estimates.

In total, this approach resulted in a loss of 6.25 acres of marsh habitat. As part of the settlement, the responsible party agreed to pay more than $1.6 million to restore the habitat loss.

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