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Interim Market Simulation Model (MarketSim) and the Offshore Environmental Cost Model (OECM) Updates Documentation

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List of Abbreviations and Acronyms

ADFG	Alaska Department of Fish and Game
AEO	Annual Energy Outlook
CH_4	Methane
CHTS	Coastal Household Telephone Survey
CIE	Center for Independent Experts
CO	Carbon Monoxide
CO_2	Carbon Dioxide
DOI	U.S. Department of the Interior
E&D	exploration and development
EIA	Energy Information Administration
ESC	Environmental and Social Costs
FES	Fishing Effort Survey
FPSO	Floating Production, Storage, and Offloading
GDP	Gross Domestic Product
HPI	Housing Price Index
IEc	Industrial Economics, Inc.
MarketSim	Market Simulation Model
MRIP	Marine Recreational Information Program
N_2O	Di-Nitrogen Oxide
NEMS	National Energy Modeling System
NOAA	National Oceanic and Atmospheric Administration
NO_x	Oxides of Nitrogen
OCS	Outer Continental Shelf
OECM	Offshore Environmental Cost Model
OPEC	Organization of the Petroleum Exporting Countries
PM_{10}	Particulate Matter with diameter 10 micrometers and smaller
$PM_{2.5}$	Particulate Matter with diameter 2.5 micrometers and smaller
Program	National OCS Oil and Gas Leasing Program
SO_2	Sulfur Dioxide
VOCs	Volatile Organic Compounds
VSL	Value of a Statistical Life

1 Introduction

The Bureau of Ocean Energy Management (BOEM) contracted Industrial Economics, Inc. (IEc) to make several updates to BOEM's Market Simulation (MarketSim) Model and Offshore Environmental Cost Model (OECM). BOEM relies on MarketSim to estimate National Outer Continental Shelf (OCS) Oil and Gas Leasing Program (Program)-related[1] oil and gas production (as described in an exploration and development [E&D] scenario) effects on consumer welfare and on the rates at which that production would displace substitute energy sources. BOEM uses the OECM to assess the environmental and social costs (ESC) of the Program-related production and the ESC associated with the substitute energy sources displaced by that production. The technical documentation for MarketSim and the OECM present extensive details on the methods and data reflected in the models (Industrial Economics, Inc. 2023a and 2023b). The updates made to both models are summarized in **Table 1** and detailed in the sections below.

Table 1 reflects data updates made by IEc across multiple analytic elements contained within MarketSim and the OECM, as well as more targeted updates made by the Eastern Research Group (ERG) and ABSG Consulting focused on the OECM's air emission factors and oil spill data, respectively. These are interim updates, as research and analysis related to MarketSim and OECM data inputs is ongoing and will culminate in the publication of updated documentation for MarketSim and the OECM and, separately, updated versions of the emissions and oil spill data reports currently included as **Appendices A and B** to this document.

Table 1. Summary of MarketSim and OECM Updates

Model	Update
MarketSim	**Supply elasticities:** Supply elasticity values were updated for select sources of supply for oil, gas, electricity, and coal to reflect updated data available from the Energy Information Administration's (EIA's) *Annual Energy Outlook (AEO) 2025* (EIA 2025a). Updates were limited to those sources of supply for which MarketSim had previously relied on data from an earlier version of the AEO to estimate elasticity values. If the AEO data yielded elasticity values that were unrealistically high, no update was made.
MarketSim	**Adjustment rates:** For onshore wind, offshore wind, and solar, MarketSim's adjustment rates were modified to reflect updated information on the lifespan of onshore wind, offshore wind, and utility-scale solar installations. These values are based on data in Wiser et al. (2020) and Kreider et al. (2024) for solar and wind, respectively.

[1] Program-related is used here to represent any additional OCS production that might need to be analyzed. Most often, these analyses are required for BOEM's Program decisions or associated lease sale decisions. However, in some instances, the model(s) may be used to analyze additional OCS production not tied directly to a specific Program or an underlying lease sale decision document.

Model	Update
MarketSim	**Baseline demand, supply, and price projections:** MarketSim's baseline projections of energy supply, demand, and prices were updated based on data in the *AEO 2025*. Because the *AEO 2025* does not capture non-U.S. oil supply and demand, the *AEO 2025* data were supplemented with data from EIA's *Short-Term Energy Outlook* (EIA 2025e) and the *World Oil Outlook 2050* (OPEC 2025) published by the Organization of the Petroleum Exporting Countries (OPEC).
MarketSim	**Inflation projections:** MarketSim's projections of U.S. inflation were updated based on the inflation projections included in the *AEO 2025*.
MarketSim	**Consumer surplus effects:** MarketSim's approach for estimating consumer surplus was modified to refine the calculations that exclude transfers from U.S. producers to U.S. consumers from the estimated consumer surplus impact.
OECM	**Recreation**: The OECM's baseline data on recreational fishing have been updated to reflect more recent data published by NOAA's Marine Recreational Information Program (2025) and the Pacific States Marine Fisheries Commission (2025).
OECM	**Air quality:** Updated the OECM's air quality module to include revised emissions factors for several emissions sources and updated damage-per-ton values that monetize changes in emissions. The updated emission factors reflect updated emissions inventory data compiled by BOEM for emissions sources supporting OCS oil and gas activity. The updated damage-per-ton values reflect updates to the epidemiological literature on the health effects of air pollution and updated income projections that affect the valuation of these health effects. Specifically, these values now reflect the mortality effects associated with fine particulate matter as estimated by Turner et al. (2016) and income per capita projections derived from the *AEO 2025*.
OECM	**Property values and related data**: The property value data in the OECM have been updated to reflect changes in property values as reflected in the Federal Housing Finance Agency's Housing Price Index (Federal Housing Finance Agency 2025a; 2025b). Because the OECM's estimates of property value impacts are also based on the after-tax discount rate, updated information on average income tax rates at the federal and state level as obtained from the Tax Foundation (2023, 2024) was also incorporated into the OECM.
OECM	**Subsistence harvests:** Updated the OECM's estimates of the subsistence harvest for a given biological group (e.g., fish, marine mammals) as a percentage of the total wild food harvest, based on data from the Alaska Department of Fish and Game's (ADFG's) Division of Subsistence (Fall 2014; 2016; and 2018).
OECM	**Oil spill rates, average spill sizes, and spill size distributions:** The OECM's estimates of oil spill rates, spill sizes, and the distribution of spill sizes were updated based on data in **Appendix B**.
OECM	**Historical exports:** Updated the data for the percentage of U.S. crude oil and refined product output that is exported (by OCS region). These percentages are based on production data from EIA (2025b and 2025d) and export data from the U.S. Census Bureau (2025).[1]

Model	Update
OECM	**Oil production and Alaska OCS region:** In addition to the data updates outlined above, a minor update was made to the OECM code that allocates oil produced in the Alaska OCS region to ports on the West Coast. As originally coded, the model was intended to assume that 50% of the oil produced in the Alaska OCS region would remain in Alaska, in which case no more than 50% could be exported overseas or shipped to the West Coast. Prior to the current update, the model code did not implement this restriction correctly and, in some circumstances, allowed the combined volume of (1) oil exported from an Alaska planning area and (2) the volume shipped to the West Coast to exceed 50% of the planning area's oil production. The coding change addressed this issue so that the OECM now correctly restricts overseas exports and shipments to the West Coast to be no more than 50% of an Alaska planning area's oil production.

Notes:

1. The data on historical exports reside in MarketSim where they can easily be combined with E&D scenario data to estimate how the change in exports estimated by MarketSim is allocated to individual OCS planning areas. However, these data are described in Appendix G of the OECM documentation because they inform the OECM's estimation of export-related impacts. For this reason, we document the updates to these data with the other OECM data updates presented here.

2 MarketSim Updates

The updates to MarketSim include updates to model data as well as one change to the model's approach for estimating consumer surplus effects.

2.1 Supply Elasticities

To model the market response to additional Program-related oil and gas production on the OCS, MarketSim relies on supply and demand elasticities obtained from literature and other sources. Supply elasticities enable MarketSim to capture how energy producers are likely to respond to changes in energy prices associated with Program-related production, while demand elasticities allow the model to capture consumers' responses to these changes. MarketSim uses separate supply and demand elasticities for oil, gas, electricity, and coal. For each energy source, the model includes separate supply elasticities for different sources of supply (e.g., conventional gas production in the contiguous 48 states) and separate demand elasticities for different demand sectors (e.g., the residential and commercial sectors).

For the current model update, we updated a limited number of MarketSim's supply elasticity values to reflect updated data in the *AEO 2025*. These updates were limited to those sources of supply for which MarketSim had previously relied on data from an earlier version of the AEO to estimate elasticity values. If the AEO data yielded elasticity values that were unrealistically high, no update was made. Because MarketSim relies on peer-reviewed elasticity parameters when possible, elasticity parameters in MarketSim that were obtained from the peer-reviewed literature were not replaced with values derived from the AEO. **Table 2** presents the updated supply elasticity values alongside the values that they replace.

Table 2. Updates to MarketSim Supply Elasticity Values

Fuel	Source	Updated Supply Elasticity Value[1]	Previous Supply Elasticity Value
Oil	Alaska Onshore Production	0.42	0.45
Natural Gas	Alaska Onshore Production	0.99	1.93
	Alaska Offshore Production	0.99	1.93
Electricity	Nuclear	0.33	0.53
	Other Electric	0.81	0.68
Coal	Domestic Production	2.83	4.39
	Imports	0.19	1.0

Notes:
1. The updated supply elasticity values are based on data included in the *AEO 2025* and (in the case of coal supply) the supporting NEMS model.

The updated coal supply elasticities presented in **Table 2** are derived from annual supply curve data generated by the Coal Market Module within the Energy Information Administration's National Energy Modeling System (NEMS) (EIA 2025b).[2] The annual supply curve data provided by EIA represent 14 distinct coals for a given year for combinations of coal supply region, mining method, and rank. For example, the Western Region coal supply region has three different supply curves for a given year, representing a mix of underground and surface mines and bituminous and subbituminous coals. In addition, the annual supply curve for each of the 14 coals is represented as 11 data points, with each data point representing production at a given price point.

Using the EIA data, supply elasticities were estimated for each of the 14 coal types and for every year between 2024 and 2050. To generate elasticity values, the log-transformed quantity was regressed on the log-transformed price, which yielded the elasticity of supply as the coefficient. Each regression was performed over the three central points of the appropriate supply curve. The following equation displays this regression:

$$\ln(Q_{s,t}) = \beta_{s,t} \ln(P_{s,t}) + \beta_0$$

where

$Q_{s,t}$ = quantity supplied on supply curve *s* in year *t*

$\beta_{s,t}$ = elasticity of supply for supply curve *s* in year *t*

$P_{s,t}$ = price of coal on supply curve *s* in year *t*

β_0 = regression constant

[2] Though not publicly available, the EIA provided these supply curve data to DOI and provides them to other modelers on a regular basis.

Running the above regression for each of the coal supply regions yields regionally specific coal supply elasticity values. The national coal supply elasticity value in MarketSim reflects the weighted average of the regional estimates, using coal production by region as weights.

The other updated supply elasticities presented in **Table 2** were derived from production and price projections from different scenarios included in the *AEO 2025*. Elasticity estimates may be inferred from the *AEO* projection for a given year by comparing the differences in energy prices between two scenarios with the differences in energy quantities. For a given energy source and fuel, an annual inferred elasticity value was calculated three times: (1) based on the low oil price case versus the high oil price case, (2) the low price case versus the reference case, and (3) the reference case versus the high price case, for all *AEO* projection years from 2024 through 2050. The formula for this annual inferred elasticity is as follows.

$$\eta_t = \frac{\ln\left(\frac{Q_{A,t}}{Q_{B,t}}\right)}{\ln\left(\frac{P_{A,t}}{P_{B,t}}\right)}$$

Where η_t is the inferred elasticity in year *t*, $Q_{A,t}$ and $Q_{B,t}$ represent the quantities supplied in year *t* for cases *A* and *B* respectively (each case is compared with both of the other cases), and $P_{A,t}$ and $P_{B,t}$ are the prices at time *t* for cases *A* and *B*. The resulting series of inferred elasticities are averaged, excluding extreme outlier results derived from the *AEO* data.[3]

The elasticity updates to MarketSim were limited to those shown in **Table 2.** None of the demand elasticity values in MarketSim were changed as part of this update. Similarly, the elasticity values for sources of supply not shown in **Table 2** also remain unchanged relative to the values presented in the 2023 MarketSim documentation (Industrial Economics 2023a).

2.2 Adjustment Rates

To enable the model to capture the transition from the short run to the long run, MarketSim includes adjustment rates in each of its supply and demand equations. We updated three of the adjustment rates included in MarketSim, each of which is related to solar or wind-based electricity supply. The updates were focused on these energy technologies because they are less mature than most others included in MarketSim and because of the availability of updated data for these technologies. Consistent with the other supply-related adjustment rates in MarketSim, the updated adjustment rates were calculated based on the lifespan of energy-producing capital assets, more specifically the inverse of the lifespan (i.e., 1÷lifespan). **Table 3** presents these updated adjustment rates, as well as the previous adjustment rates included in MarketSim. The table presents adjustment rates only for those fuel-sector categories that have been updated.

[3] More specifically, elasticities were estimated based on differentials between the low-price case and reference case, the reference case and the high-price case, and the low-price case and the high-price case. They then were averaged across these three variants and across years.

Table 3. Updates to MarketSim Adjustment Rates

Fuel	Sector	Updated Adjustment Rate[a]	Previous Adjustment Rate
Electricity Supply	Solar	0.033	0.040
	Onshore Wind	0.040	0.050
	Offshore Wind	0.040	0.050

Notes:

a. Updated adjustment rate for solar based on lifespan of 30 years for utility-scale solar installations, as obtained from Wiser et al. (2020). Updated adjustment rate for onshore wind and offshore wind based on onshore and offshore wind lifespan of 25 years, as obtained from Kreider et al. (2024).

2.3 Baseline Projection Data

MarketSim estimates the rates at which additional Program-related production would displace substitute energy sources relative to a baseline energy market forecast included in the model. This forecast consists of energy supply and demand projections by fuel type, as well as projections of fuel prices. The baseline data in MarketSim were updated using the reference case projections in the *AEO 2025*, supplemented by data from EIA's *Short-Term Energy Outlook* (EIA 2025e) and the *World Oil Outlook 2050* (OPEC 2025). The *AEO 2025* includes most of the baseline data required by MarketSim; the only data that the *AEO 2025* lacks for a complete MarketSim baseline are non-U.S. oil supply and non-U.S. oil demand. This gap in the *AEO 2025* forecast was addressed using the following approach:

1. **Develop non-U.S. oil supply forecast through 2026:** The *Short-Term Energy Outlook* (EIA 2025e) includes projections of global oil supply and U.S. oil supply through 2026. Non-U.S. oil supply was calculated by subtracting the latter from the former.

2. **Develop non-U.S. oil supply forecast beyond 2026:** To project non-U.S. oil supply beyond 2026, we applied year-over-year growth rates in non-U.S. oil production derived from data published in OPEC's *World Oil Outlook 2050* (OPEC 2025). For example, the growth rate for non-U.S. oil production between 2026 and 2027 as derived from the *World Energy Outlook* was applied to year 2026 non-U.S. oil production in order to calculate non-U.S. production for 2027. The growth rate between 2027 and 2028 implied by the *World Oil Outlook* was then applied to the year 2027 value to calculate the projected non-U.S. oil supply value for 2028, and so on.

3. **Calculate global oil supply and demand:** Following the estimation of non-U.S. oil supply, we calculated global supply by summing the non-U.S. projections estimated based on step 1 and 2 with U.S. supply as obtained from the *AEO*. Assuming that world oil markets are in equilibrium in the baseline forecast, we then set global oil demand equal to global supply.

4. **Calculate non-U.S. oil demand:** As a final step, we calculated non-U.S. oil demand by subtracting U.S. demand (as obtained from the AEO) from global oil demand (calculated in the step 3).

For previous MarketSim baseline data updates, BOEM relied on a constrained version of the AEO reference case that reflected no new oil and gas leasing on the OCS. For the current update, however, we rely on the AEO reference case rather than a constrained AEO case because the reference case is more aligned with baseline conditions representative of the lease sales included in the One Big Beautiful Bill Act passed in 2025.

2.4 Inflation Projections

MarketSim also includes projections of U.S. inflation so that model users may change the year's dollars in which results are presented. We updated the inflation forecasts in MarketSim with those included in the *AEO 2025*.

2.5 Consumer Surplus Effects

To assess changes in the welfare of U.S. consumers from additional Program-related production, MarketSim estimates the change in consumer surplus for each of the end-use energy markets included in the model (e.g., residential sector gas, industrial sector oil). For the current update to MarketSim, we made a minor refinement to the model's consumer surplus calculations for oil to better account for transfers between U.S. producers and U.S. consumers.

The increase in consumer surplus estimated by MarketSim reflects the welfare gains from increased energy consumption and the reductions in energy prices that result from Program-related increases in energy supply. Consumer welfare gains associated with reduced energy prices, however, represent a transfer from producers to consumers. To exclude transfers from *domestic* oil producers to consumers from MarketSim's consumer surplus estimates (but still include transfers from non-U.S. producers), the model multiplies the portion of the consumer surplus impact that represents a transfer from (or to) producers by the fraction of demand met by non-U.S. sources.

For the oil market, MarketSim would ideally estimate the fraction of U.S. oil demand met by non-U.S. sources as follows:

$$L_f = \frac{U.S.\, Gross\ Oil\ Imports}{U.S.\, Oil\ Demand}$$

where

L_f = fraction of U.S. oil demand met by non-U.S. sources of supply

Focusing on the top portion of the right-hand side of this equation, U.S. gross oil imports is simply the total quantity of oil imported into the U.S. As currently specified, MarketSim does not directly estimate U.S. gross oil imports. However, gross oil imports may be calculated based on other data in MarketSim:[4]

$$Gross\ Oil\ Imports = (D_{US} - Y_{US}) + Gross\ Oil\ Exports$$

[4] Within this equation, $D_{US} - Y_{US}$ is equal to U.S. net imports of oil. The equation in the text substitutes $D_{US} - Y_{US}$ into the standard equation for net imports, in which *net imports = gross imports – gross exports*, and rearranges this equation to estimate gross imports.

where

Gross Oil Imports are as defined above

D_{US} = U.S. oil demand

Y_{US} = U.S. oil production

Gross Oil Exports = the total quantity of oil exported out of the U.S.

Within oil markets, each of the three variables on the right-hand side of the above equation are estimated by MarketSim. However, the model includes two separate (mutually exclusive) values for gross oil exports: gross exports of crude oil and gross exports of refined petroleum products. As the name suggests, gross exports of crude oil represent exports of U.S.-sourced oil. Gross exports of refined products, however, likely include refined products sourced from U.S. crude as well as refined products sourced from non-U.S. crude. Therefore, a key decision in estimating gross oil imports based on the above equation is whether to include or exclude refined product exports from the calculation. The below equations show how the two specifications of gross exports (i.e., including and excluding refined product exports) may be incorporated into the estimated fraction of U.S. oil demand met by non-U.S. sources of supply (L_f as specified above):

$$L_{f1} = \frac{(D_{US} - Y_{US}) + GEX_C + GEX_R}{U.S.\,Oil\;Demand}$$

$$L_{f2} = \frac{(D_{US} - Y_{US}) + GEX_C}{U.S.\,Oil\;Demand}$$

Where

Lf_1 = fraction of U.S. oil demand met by non-U.S. sources of supply when *including* refined product exports in the specification of gross imports (i.e., in the numerator of the equation)

Lf_2 = fraction of U.S. oil demand met by non-U.S. sources of supply when *excluding* refined product exports in the specification of gross imports (i.e., in the numerator of the equation)

D_{US}, Y_{US}, and *U.S. Oil Demand* are as defined above

GEX_C = Crude oil gross exports

GEX_R = Refined product gross exports

Because refined product exports may include refined products sourced from U.S. crude *and* non-U.S. crude, including all refined product exports in the calculation of gross imports (as in the numerator for Lf_1) will likely lead to overestimation of gross imports. If gross imports are overestimated, the fraction of U.S. oil demand met by non-U.S. sources (L_f) will also be overestimated and by extension consumer surplus associated with transfers from non-U.S. producers will similarly be overestimated. Conversely, *excluding* all refined product exports from the specification of gross imports will likely lead to underestimation of these effects.

Prior to the current update, MarketSim excluded refined product exports from the gross imports equation to avoid overestimation of consumer surplus effects. In other words, MarketSim estimated the fraction of U.S. oil demand met by non-U.S. sources of supply (L_f) based on the above equation for Lf_2. In avoiding the overestimation of consumer surplus impacts, however, this approach leads to underestimation of consumer surplus effects for the reasons outlined above.

The current update seeks to avoid systematic overestimation and underestimation of consumer surplus effects with an approach that includes refined product exports in the gross imports calculation. Using projections from the *AEO 2025*, we estimate the portion of U.S. refinery crude feedstock sourced domestically. Making the assumption that the U.S. versus non-U.S. sourcing of crude feedstock is the same for exported petroleum products as for the U.S. petroleum refining sector overall, we estimate gross imports of oil (both crude oil and refined products) as follows:

$$Gross\ Imports = (D_{US} - Y_{US}) + GEX_c + (F_d \times GEX_r)$$

Where

D_{US} and Y_{US} are as specified above and

GEX_c = gross exports of crude oil

GEX_r = gross exports of refined petroleum products

F_d = the percentage of U.S. refiner feedstock sourced domestically

This approach isolates the portion of refined product exports produced from U.S. crude oil, avoiding both the systematic overestimation and systematic underestimation of gross imports, providing a more accurate representation of consumer surplus net of transfers from domestic producers than the approach previously reflected in MarketSim.

3 OECM Updates

The updates to the OECM include several updates to the data supporting the model's ESC calculations and one change to the model code, as detailed below.

3.1 Recreation

The OECM's calculation of impacts related to coastal and marine recreation relies on baseline data on the number of annual recreational fishing trips and recreational beach days. We updated the baseline activity values for recreational fishing for all planning areas using 2020-2024 survey data . As with the previous version of the OECM, estimates of recreational fishing trips for planning areas in the Gulf of America, Atlantic, and Alaska are based on data from NOAA's Marine Recreational Information Program (NOAA Fisheries MRIP 2025). For California, Oregon, and Washington, we rely on data from Pacific States Marine

Fisheries Commission's Recreational Fisheries Information Network (Pacific States Marine Fisheries Commission 2025).

After the prior version of the OECM was published, NOAA's MRIP replaced the Coastal Household Telephone Survey (CHTS) (a random digit–dial landline telephone survey of coastal households) with the Fishing Effort Survey (FES), a mail survey that samples from U.S. Postal Service address lists supplemented with state license/registration frames to better cover the angling population. The switch was made because declining landline use as well as coverage and screening issues caused CHTS to underestimate fishing effort, while FES's address based mail design yields higher response rates, more representative samples, and more accurate estimates of shore and private boat trips on the Atlantic and Gulf coasts. Concurrent sampling with both the CHTS and FES data collection techniques confirmed the CHTS was undercounting recreational fishing trips (Jones 2017). Accordingly, baseline recreational fishing trips in the updated OECM for planning areas in the Atlantic, Gulf of America, and Alaska OCS regions represent an increase from values used in the prior version of the model.

Table 4 presents the updated estimates of annual recreational fishing trips, as well as the values previously included in the OECM. Model data on recreational beach trips have not been updated.

Table 4. Annual Recreational Fishing Trips by Planning Area

Planning Area	Updated Estimates of Annual Angler Trips	Previous Estimates of Annual Angler Trips
North Atlantic	29,930,887	12,715,056
Mid-Atlantic	19,929,171	8,648,391
South Atlantic	19,031,421	5,683,687
Straits of Florida	13,852,320	5,292,396
Eastern Gulf	29,304,615	11,832,589
Central Gulf	7,296,242	4,814,803
Western Gulf	635,387	922,164
Southern CA	1,200,288	2,162,342
Central CA	623,747	792,945
Northern CA	61,133	112,436
Washington/Oregon	374,451	378,340
Gulf of Alaska	534,619	391,680
Cook Inlet	217,375	159,256
TOTAL	**122,991,656**	**53,906,086**

3.2 Air Quality

To estimate the air quality impacts of a given E&D scenario, the OECM relies on emissions factors that enable the model to quantify the emissions associated with the scenario and a series of damage-per-ton values that provide monetized estimates of the adverse impacts associated with these emissions. The OECM's emissions factors are specific to individual pollutants and emissions-generating activities (e.g., well drilling, pipe-laying vessels, platform operations). The scope of pollutants represented by these emissions factors include six criteria pollutants and three greenhouse gases.[5] The damage-per-ton values that the OECM uses to monetize changes in emissions reflect the physical effects of these emissions, which include degradation of human health, reductions in agricultural productivity, and damage to manufactured materials. The OECM applies damage-per-ton values to four of the six criteria pollutants represented in the model: NO_x, SO_2, $PM_{2.5}$, and VOCs. The model does not assign a dollar value to the estimated changes in greenhouse gas emissions.

Several of the emissions factors in the OECM have been updated to reflect more recent emissions data for various emissions sources reflected in the model. The updated emissions factors for this subset of emissions sources are presented in **Table 5**. As shown in the table, these emissions factors vary based on both geography and water depth. Analysis contributing to the updated emissions factors is included in **Appendix A**. For information on the previous emissions factors included in the OECM for these emissions sources (and for emissions factors for emissions sources without updated emission factor data), please refer to the 2023 OECM technical documentation (Industrial Economics 2023b).

Complementing these changes in the OECM's emissions factors, we also made two updates to the model's air pollutant damage-per-ton values. First, we updated these values to reflect more recent literature on the statistical relationship between exposure to ambient fine particulate matter and premature mortality. Previous to this update, the model applied the findings of Krewski et al. (2009) for this relationship. The OECM now relies on the findings of Turner et al. (2016), who found a similar relationship as Krewski (less than 1 percent difference). Second, we updated the damage-per-ton values to reflect more recent projections of U.S. income per capita and what this updated income trajectory implies about the value of a statistical life (VSL) over time. As described in Appendix D of the OECM documentation, the VSL changes as real incomes change over time. The updated damage-per-ton values in the OECM now reflect projections of GDP per capita derived from the macroeconomic data included in the *AEO 2025* reference case.

[5] Criteria pollutants include oxides of nitrogen (NO_x), sulfur dioxide (SO_2), coarse particulate matter (PM_{10}), fine particulate matter ($PM_{2.5}$), carbon monoxide (CO), and volatile organic compounds (VOCs). The greenhouse gases represented in the OECM include carbon dioxide (CO_2), methane (CH_4), and di-nitrogen oxide (N_2O).

Table 5. Updated Emission Factors Incorporated into the OECM

Emission Source (Units)	Depth Range	Geographic Area	CO	$PM_{2.5}$	VOC	NOX	CO_2	SO_X	CH_4	PM_{10}	N_2O
Caisson Production (tons/caisson/year)	All depths	Arctic Alaska	0.30	0.001	1.53	0.20	31.29	0.000	8.29	0.001	0.000
Caisson Production (tons/caisson/year)	All depths	Atlantic	0.30	0.001	1.53	0.20	31.29	0.000	8.29	0.001	0.000
Caisson Production (tons/caisson/year)	All depths	Cook Inlet	0.30	0.001	1.53	0.20	31.29	0.000	8.29	0.001	0.000
Caisson Production (tons/caisson/year)	All depths	General Alaska	0.30	0.001	1.53	0.20	31.29	0.000	8.29	0.001	0.000
Caisson Production (tons/caisson/year)	All depths	Gulf of America	0.30	0.001	1.53	0.20	31.29	0.000	8.29	0.001	0.000
Caisson Production (tons/caisson/year)	All depths	Pacific	0.30	0.001	1.53	0.20	31.29	0.000	8.29	0.001	0.000
Development/Production Wells (tons/well)	> 1,600 m	Atlantic	24.20	2.38	1.53	107.93	6,221.40	0.13	0.36	2.46	0.25
Development/Production Wells (tons/well)	> 1,600 m	Gulf of America	24.20	2.38	1.53	107.93	6,221.40	0.13	0.36	2.46	0.25
Development/Production Wells (tons/well)	> 1,600 m	Pacific	24.20	2.38	1.53	107.93	6,221.40	0.13	0.36	2.46	0.25
Development/Production Wells (tons/well)	0 - 60 m	Atlantic	1.78	0.17	0.25	8.40	442.84	0.09	0.01	0.18	0.01
Development/Production Wells (tons/well)	0 - 60 m	Gulf of America	1.78	0.17	0.25	8.40	442.84	0.09	0.01	0.18	0.01
Development/Production Wells (tons/well)	0 - 60 m	Pacific	1.78	0.17	0.25	8.40	442.84	0.09	0.01	0.18	0.01
Development/Production Wells (tons/well)	60 - 800 m	Atlantic	2.76	0.27	0.34	12.86	663.63	0.10	0.02	0.28	0.02
Development/Production Wells (tons/well)	60 - 800 m	Gulf of America	2.76	0.27	0.34	12.86	663.63	0.10	0.02	0.28	0.02
Development/Production Wells (tons/well)	60 - 800 m	Pacific	2.76	0.27	0.34	12.86	663.63	0.10	0.02	0.28	0.02
Development/Production Wells (tons/well)	800 – 1,600 m	Atlantic	32.30	4.32	2.12	158.38	9,146.90	0.16	0.79	4.46	0.43
Development/Production Wells (tons/well)	800 – 1,600 m	Gulf of America	32.30	4.32	2.12	158.38	9,146.90	0.16	0.79	4.46	0.43
Development/Production Wells (tons/well)	800 – 1,600 m	Pacific	32.30	4.32	2.12	158.38	9,146.90	0.16	0.79	4.46	0.43
Drilling Exploration/Delineation Wells (tons/well)	> 1,600 m	Atlantic	33.01	3.70	2.38	150.25	8,577.87	0.15	1.82	3.82	0.32
Drilling Exploration/Delineation Wells (tons/well)	> 1,600 m	Gulf of America	33.01	3.70	2.38	150.25	8,577.87	0.15	1.82	3.82	0.32
Drilling Exploration/Delineation Wells (tons/well)	> 1,600 m	Pacific	33.01	3.70	2.38	150.25	8,577.87	0.15	1.82	3.82	0.32
Drilling Exploration/Delineation Wells (tons/well)	0 - 60 m	Atlantic	1.34	0.19	0.29	6.21	322.20	0.16	0.01	0.18	0.005
Drilling Exploration/Delineation Wells (tons/well)	0 - 60 m	Gulf of America	1.34	0.19	0.29	6.21	322.20	0.16	0.01	0.18	0.005
Drilling Exploration/Delineation Wells (tons/well)	0 - 60 m	Pacific	1.34	0.19	0.29	6.21	322.20	0.16	0.01	0.18	0.005
Drilling Exploration/Delineation Wells (tons/well)	60 - 800 m	Atlantic	23.96	1.21	1.67	66.78	5,822.39	0.13	0.16	1.25	0.14
Drilling Exploration/Delineation Wells (tons/well)	60 - 800 m	Gulf of America	23.96	1.21	1.67	66.78	5,822.39	0.13	0.16	1.25	0.14
Drilling Exploration/Delineation Wells (tons/well)	60 - 800 m	Pacific	23.96	1.21	1.67	66.78	5,822.39	0.13	0.16	1.25	0.14
Drilling Exploration/Delineation Wells (tons/well)	800 – 1,600 m	Atlantic	29.22	2.86	2.31	127.96	7,102.38	0.14	1.83	2.95	0.21
Drilling Exploration/Delineation Wells (tons/well)	800 – 1,600 m	Gulf of America	29.22	2.86	2.31	127.96	7,102.38	0.14	1.83	2.95	0.21
Drilling Exploration/Delineation Wells (tons/well)	800 – 1,600 m	Pacific	29.22	2.86	2.31	127.96	7,102.38	0.14	1.83	2.95	0.21
FPSO Operation (tons/FPSO/year)	> 1,600 m	Arctic Alaska	164.84	13.69	197.77	799.37	157,237	6.09	300.87	14.10	4.19
FPSO Operation (tons/FPSO/year)	> 1,600 m	Atlantic	164.84	13.69	197.77	799.37	157,237	6.09	300.87	14.10	4.19
FPSO Operation (tons/FPSO/year)	> 1,600 m	Cook Inlet	164.84	13.69	197.77	799.37	157,237	6.09	300.87	14.10	4.19
FPSO Operation (tons/FPSO/year)	> 1,600 m	General Alaska	164.84	13.69	197.77	799.37	157,237	6.09	300.87	14.10	4.19
FPSO Operation (tons/FPSO/year)	> 1,600 m	Gulf of America	164.84	13.69	197.77	799.37	157,237	6.09	300.87	14.10	4.19

Emission Source (Units)	Depth Range	Geographic Area	CO	$PM_{2.5}$	VOC	NOX	CO_2	SO_X	CH_4	PM_{10}	N_2O
FPSO Operation (tons/FPSO/year)	> 1,600 m	Pacific	164.84	13.69	197.77	799.37	157,237	6.09	300.87	14.10	4.19
Helicopters (tons/platform/year)	All depths	Arctic Alaska	3.04	0.01	0.26	0.40	163.28	0.08	0.001	0.01	0.01
Helicopters (tons/platform/year)	All depths	Atlantic	3.04	0.01	0.26	0.40	163.28	0.08	0.001	0.01	0.01
Helicopters (tons/platform/year)	All depths	Cook Inlet	3.04	0.01	0.26	0.40	163.28	0.08	0.001	0.01	0.01
Helicopters (tons/platform/year)	All depths	General Alaska	3.04	0.01	0.26	0.40	163.28	0.08	0.001	0.01	0.01
Helicopters (tons/platform/year)	All depths	Gulf of America	3.04	0.01	0.26	0.40	163.28	0.08	0.001	0.01	0.01
Helicopters (tons/platform/year)	All depths	Pacific	3.04	0.01	0.26	0.40	163.28	0.08	0.001	0.01	0.01
Pipe-laying Vessels (tons/mile)	All depths	Arctic Alaska	4.35	0.62	1.03	26.57	2,613.32	0.07	0.02	0.64	0.13
Pipe-laying Vessels (tons/mile)	All depths	Atlantic	4.35	0.62	1.03	26.57	2,613.32	0.07	0.02	0.64	0.13
Pipe-laying Vessels (tons/mile)	All depths	Cook Inlet	4.35	0.62	1.03	26.57	2,613.32	0.07	0.02	0.64	0.13
Pipe-laying Vessels (tons/mile)	All depths	General Alaska	4.35	0.62	1.03	26.57	2,613.32	0.07	0.02	0.64	0.13
Pipe-laying Vessels (tons/mile)	All depths	Gulf of America	4.35	0.62	1.03	26.57	2,613.32	0.07	0.02	0.64	0.13
Pipe-laying Vessels (tons/mile)	All depths	Pacific	4.35	0.62	1.03	26.57	2,613.32	0.07	0.02	0.64	0.13
Platform Construction (tons/(platforms + caissons))	> 600 ft	Atlantic	11.28	0.88	1.09	41.00	2,424.03	0.08	0.31	0.91	0.03
Platform Construction (tons/(platforms + caissons))	> 600 ft	Gulf of America	11.28	0.88	1.09	41.00	2,424.03	0.08	0.31	0.91	0.03
Platform Construction (tons/(platforms + caissons))	> 600 ft	Pacific	11.28	0.88	1.09	41.00	2,424.03	0.08	0.31	0.91	0.03
Platform Construction (tons/(platforms + caissons))	0 - 300 ft	Atlantic	0.09	0.02	0.04	0.22	24.70	0.01	0.09	0.02	0.00
Platform Construction (tons/(platforms + caissons))	0 - 300 ft	Gulf of America	0.09	0.02	0.04	0.22	24.70	0.01	0.09	0.02	0.00
Platform Construction (tons/(platforms + caissons))	0 - 300 ft	Pacific	0.09	0.02	0.04	0.22	24.70	0.01	0.09	0.02	0.00
Platform Construction (tons/(platforms + caissons))	300 - 600 ft	Atlantic	0.71	0.05	0.07	2.65	136.88	0.001	0.0067	0.047	0
Platform Construction (tons/(platforms + caissons))	300 - 600 ft	Gulf of America	0.71	0.05	0.07	2.65	136.88	0.001	0.0067	0.047	0
Platform Construction (tons/(platforms + caissons))	300 - 600 ft	Pacific	0.71	0.05	0.07	2.65	136.88	0.001	0.0067	0.047	0
Platform Production (tons/platform/year)	All depths	Atlantic	44.01	0.53	24.33	52.10	9,051.11	0.37	126.81	0.54	0.19
Platform Production (tons/platform/year)	All depths	Gulf of America	44.01	0.53	24.33	52.10	9,051.11	0.37	126.81	0.54	0.19
Platform Production (tons/platform/year)	All depths	Pacific	44.01	0.53	24.33	52.10	9,051.11	0.37	126.81	0.54	0.19
Platform Removal (tons/(platforms + caissons))	> 600 ft	Atlantic	11.28	0.88	1.09	41.00	2,424.03	0.08	0.31	0.91	0.03
Platform Removal (tons/(platforms + caissons))	> 600 ft	Gulf of America	11.28	0.88	1.09	41.00	2,424.03	0.08	0.31	0.91	0.03
Platform Removal (tons/(platforms + caissons))	> 600 ft	Pacific	11.28	0.88	1.09	41.00	2,424.03	0.08	0.31	0.91	0.03
Platform Removal (tons/(platforms + caissons))	0 - 300 ft	Atlantic	0.09	0.02	0.04	0.22	24.70	0.01	0.09	0.02	0.00

Emission Source (Units)	Depth Range	Geographic Area	CO	$PM_{2.5}$	VOC	NOX	CO_2	SO_X	CH_4	PM_{10}	N_2O
Platform Removal (tons/(platforms + caissons))	0 - 300 ft	Gulf of America	0.09	0.02	0.04	0.22	24.70	0.01	0.09	0.02	0.00
Platform Removal (tons/(platforms + caissons))	0 - 300 ft	Pacific	0.09	0.02	0.04	0.22	24.70	0.01	0.09	0.02	0.00
Platform Removal (tons/(platforms + caissons))	300 - 600 ft	Atlantic	0.07	0.05	0.07	2.65	136.88	0.00	0.01	0.05	0.00
Platform Removal (tons/(platforms + caissons))	300 - 600 ft	Gulf of America	0.07	0.05	0.07	2.65	136.88	0.00	0.01	0.05	0.00
Platform Removal (tons/(platforms + caissons))	300 - 600 ft	Pacific	0.07	0.05	0.07	2.65	136.88	0.00	0.01	0.05	0.00
Support Vessels (tons/platform/year)	All depths	Arctic Alaska	0.99	0.15	0.28	7.15	573.85	0.09	0.01	0.16	0.03
Support Vessels (tons/platform/year)	All depths	Atlantic	0.99	0.15	0.28	7.15	573.85	0.09	0.01	0.16	0.03
Support Vessels (tons/platform/year)	All depths	Cook Inlet	0.99	0.15	0.28	7.15	573.85	0.09	0.01	0.16	0.03
Support Vessels (tons/platform/year)	All depths	General Alaska	0.99	0.15	0.28	7.15	573.85	0.09	0.01	0.16	0.03
Support Vessels (tons/platform/year)	All depths	Gulf of America	0.99	0.15	0.28	7.15	573.85	0.09	0.01	0.16	0.03
Support Vessels (tons/platform/year)	All depths	Pacific	0.99	0.15	0.28	7.15	573.85	0.09	0.01	0.16	0.03
Survey Vessels (tons/(platforms + caissons+FPSOs)/year)	All depths	Arctic Alaska	0.09	0.01	0.04	0.61	39.36	0.02	0.00	0.01	0.00
Survey Vessels (tons/(platforms + caissons+FPSOs)/year)	All depths	Atlantic	0.09	0.01	0.04	0.61	39.36	0.02	0.00	0.01	0.00
Survey Vessels (tons/(platforms + caissons+FPSOs)/year)	All depths	Cook Inlet	0.09	0.01	0.04	0.61	39.36	0.02	0.00	0.01	0.00
Survey Vessels (tons/(platforms + caissons+FPSOs)/year)	All depths	General Alaska	0.09	0.01	0.04	0.61	39.36	0.02	0.00	0.01	0.00
Survey Vessels (tons/(platforms + caissons+FPSOs)/year)	All depths	Gulf of America	0.09	0.01	0.04	0.61	39.36	0.02	0.00	0.01	0.00
Survey Vessels (tons/(platforms + caissons+FPSOs.)/year)	All depths	Pacific	0.09	0.01	0.04	0.61	39.36	0.02	0.00	0.01	0.00

3.3 Property Values and Related Data

The OECM's assessment of the property value impacts of a given E&D scenario are based, in part, on baseline property values and the after-tax discount rate, the latter of which reflects income tax rates at the federal and state level. The current updates to the OECM include both updated property value estimates and updated federal and state tax rates.

As described in the OECM documentation, the model uses residential property values from assessor and Census data from the 2000–2009 period that were scaled forward to 2017 using the Federal Housing Finance Agency's Housing Price Index (HPI). For the current update to the OECM, we used the most recent (2025) release of the HPI to scale property values to the year 2024 (Federal Housing Finance Agency 2025a and 2025b). **Table 6** and **Table 7** present these updated property values, as well as the property values previously included in the OECM. As shown in the tables, the model includes two separate specifications of property values. For property value impacts associated with oil spills, the OECM uses residential property values per meter of coastline from the shore to one house width inland. For property value impacts associated with visual disamenity effects, the model uses estimates of residential property value per mile of coastline from the shore to one-eighth mile inland. In both cases, the OECM uses averages for these values specific to each of the 23 planning areas adjacent to U.S. coastlines.

In addition to the property values presented in **Table 6** and **Table 7**, we updated the marginal federal income tax rate and the marginal state income tax rate in the OECM, both of which are inputs for calculating the after-tax discount rate. The federal tax rate at the 2024 median household income of $83,730 is 22 percent, and state taxes at the median household income level weighted by coastline for the states adjacent to each planning area vary between 0 and 9.30 percent.[6] These values did not change significantly relative to the previous version of the OECM.

[6] U.S. median household income for 2024 obtained from the Federal Reserve Bank of St. Louis (2025a). Median household income for individual states obtained from Federal Reserve Bank of St. Louis (2025b). Federal tax rates obtained from Tax Foundation (2023). State tax rates obtained from Tax Foundation (2024).

Table 6. Total Residential Property Value per Meter of Coastline to an Average Property Width Inland

Region	Planning Area	UPDATED VALUES Total Residential Property Value Per Meter of Coastline (2024$)	PREVIOUS VALUES Total Residential Property Value Per Meter of Coastline (2024$)	PREVIOUS VALUES Total Residential Property Value Per Meter of Coastline (2010$)
Atlantic	North Atlantic	$15,937	$10,859	$7,760
	Mid-Atlantic	$4,206	$3,023	$2,160
	South Atlantic	$10,709	$6,171	$4,410
Gulf of America	Eastern Gulf	$17,188	$10,033	$7,170
	Straits of Florida	$52,733	$27,847	$19,900
	Central Gulf	$718	$501	$358
	Western Gulf	$1,587	$1,131	$808
Pacific	Southern California	$25,308	$17,212	$12,300
	Central California	$16,638	$13,504	$9,650
	Northern California	$781	$553	$395
	Washington/Oregon	$2,174	$1,483	$1,060
Alaska	Beaufort Sea	$0.05	$0.042	$0.0298
	Kodiak	$162.84	$127.20	$90.9
	Gulf of Alaska	$78.46	$61.29	$43.8
	Cook Inlet	$0.90	$0.71	$0.504
	Norton Basin	$15.28	$11.94	$8.53
	Hope Basin	$27.13	$21.13	$15.1
	St. Matthew-Hall	$0.84	$0.66	$0.472
	North Aleutian Basin	$3.21	$2.50	$1.79
	Shumagin	$1.66	$1.30	$0.927
	Aleutian Arc	$3.50	$2.73	$1.95
	St. George Basin	$9.79	$7.64	$5.46
	Chukchi Sea	$10.38	$8.12	$5.80

Table 7. Total Residential Property Value per Mile of Coastline from the Coast to One-Eighth Mile Inland

Region	Planning Area	UPDATED VALUES Total Residential Property Value Per Mile Coastline from the Coast to 1/8-Mile Inland (2024$)	PREVIOUS VALUES Total Residential Property Value Per Mile Coastline from the Coast to 1/8-Mile Inland (2024$)	PREVIOUS VALUES Total Residential Property Value Per Mile Coastline from the Coast to 1/8-Mile Inland (2010$)
Atlantic	North Atlantic	$68,736,587	$45,214,167	$32,310,459
	Mid-Atlantic	$18,141,763	$12,572,296	$8,984,278
	South Atlantic	$46,187,874	$25,682,575	$18,353,004
Gulf of America	Eastern Gulf	$74,132,895	$41,749,448	$29,834,539
	Straits of Florida	$227,442,339	$116,023,098	$82,911,171
	Central Gulf	$3,086,843	$2,085,201	$1,490,104
	Western Gulf	$6,844,285	$4,706,932	$3,363,617
Pacific	Southern California	$109,157,245	$71,487,279	$51,085,466
	Central California	$71,761,453	$56,183,495	$40,149,241
	Northern California	$3,370,182	$2,302,579	$1,645,444
	Washington/Oregon	$9,377,788	$6,177,822	$4,414,728
Alaska	Beaufort Sea	$231	$174	$124
	Kodiak	$702,325	$529,380	$378,300
	Gulf of Alaska	$338,397	$255,068	$182,274
	Cook Inlet	$3,892	$2,933	$2,096
	Norton Basin	$65,923	$49,690	$35,509
	Hope Basin	$117,022	$88,206	$63,033
	St. Matthew-Hall	$3,643	$2,746	$1,962
	North Aleutian Basin	$13,842	$10,434	$7,456
	Shumagin	$7,164	$5,400	$3,859
	Aleutian Arc	$15,099	$11,381	$8,133
	St. George Basin	$42,204	$31,812	$22,733
	Chukchi Sea	$44,777	$33,751	$24,119

3.4 Subsistence Harvests

The OECM's calculations of the subsistence impacts associated with oil spills occurring in or adjacent to the Alaska OCS region rely on estimates of the subsistence harvest as a percentage of the total wild food harvest. For whales, the OECM assumes (and continues to assume) that subsistence accounts for 100 percent of the total harvest. For other harvested species, we updated the OECM's assumed value using data from the ADFG's Division of Subsistence. Based on ADFG data (Fall 2014; 2016; and 2018), we estimate that the subsistence harvest accounts for 0.967 percent of the harvest.[7] The OECM previously applied a value of 1.0 percent.

3.5 Oil Spill Rates, Average Spill Sizes, and Spill Size Distributions

To estimate the ESC associated with a given E&D scenario, the OECM relies on data characterizing oil spill rates, average spill sizes, and the distribution of oil spills across different spill size categories. These estimates vary by oil spill source and oil type. For the current update, the oil spill data for platform spills and pipeline spills have been updated. These updated data are presented in **Table 8**, along with the previous oil spill data for these spill sources. Information on the derivation of the updated oil spill data for platforms and pipelines is presented in **Appendix B**.

[7] The values reported by ADFG are 1.1 percent in 2012, 0.9 percent in 2014, and 0.9 percent in 2017. See Fall (2014, 2016, & 2018).

Table 8. Updated Oil Spill Rates and Spill Size Distributions Incorporated into the OECM

Source	Type	Spill Class	Spill Range (bbl)	UPDATED Mean Spill Rate (bbl spilled per bbl produced)	UPDATED Mean Spill Size (bbl)	UPDATED Spill % of frequency (count) by spill source and oil type	PREVIOUS Mean Spill Rate (bbl spilled per bbl produced)	PREVIOUS Mean Spill Size (bbl)	PREVIOUS Spill % of frequency (count) by spill source and oil type
OCS Platform	Crude Oil	Very small	1 to 10	1.24E-06	2.96	78.92%	2.16E-06	2.79	67.18%
		Small	11 to 100		31.77	16.81%		33.44	22.11%
		Medium	101 to 1,000		259.26	4.13%		277.30	10.20%
		Large	1,001 to 10,000		2,000.00	0.14%		1,688.67	0.51%
		Very large	10,001 to 100,000		0.00	0.00%		0.00	0.00%
	Diesel	Very small	1 to 2	8.11E-07	1.33	35.29%	1.23E-06	1.00	22.60%
		Small	2 to 10		4.28	14.71%		3.70	44.58%
		Medium	10 to 100		38.72	26.47%		33.44	22.11%
		Large	100 to 1,000		295.46	11.76%		277.30	10.20%
		Very large	1,000 to 3,600		2,046.18	11.76%		1,688.67	0.51%
OCS Pipeline	Crude Oil	Very small	1 to 10	2.99E-06	3.15	59.81%	1.31E-06	3.35	56.62%
		Small	11 to 100		32.75	24.30%		28.27	31.62%
		Medium	101 to 1,000		382.85	13.55%		341.95	9.56%
		Large	1,001 to 10,000		1,659.00	1.87%		1,512.00	2.21%
		Very large	10,001 to 100,000		16,152.00	0.47%		0.00	0.00%
	Diesel	Very small	1 to 2	8.31E-11	1.00	100.00%	4.97E-10	1.00	25.00%
		Small	2 to 10		0.00	0.00%		4.14	75.00%
		Medium	11 to 100		0.00	0.00%		0.00	0.00%
		Large	101 to 1,000		0.00	0.00%		0.00	0.00%
		Very large	1,001 to 10,000		0.00	0.00%		0.00	0.00%

3.6 Historical Exports

For a given E&D scenario, the OECM calculates the ESC associated with changes in crude oil and refined petroleum product exports projected by MarketSim. Prior to estimating these export-related ESC, the exports projected by MarketSim are allocated to individual OCS planning areas, since the impacts associated with exports depend on where they originate. This allocation is based on both the distribution of production across OCS planning areas (as specified in the E&D scenario) and the percentage of each OCS region's crude and refined petroleum production that is exported, the latter of which is calculated based on data for all production and exports for the coastal states adjacent to each OCS region.[8] For the current OECM update, we incorporated more recent data on these export percentages into the model. These updated values are presented in **Table 9** and **Table 10** for crude oil and refined products, respectively, along with the previous values.

Table 9. Regional Crude Oil Exports as a Percentage of Regional Production

OCS Region	Updated Crude Exports as a Percent of Production[a]	Previous Crude Exports as a Percent of Production
Atlantic	40.09%	9.21%
Gulf of America	31.96%	13.01%
Pacific	0.00%	1.36%
Alaska	3.02%	0.94%

Notes:

[a] Updated percentages based on 2024 production and export data. Production data obtained from EIA (2025b). Export data based on U.S. Census Bureau (2025). https://usatrade.census.gov/

Table 10. Regional Refined

OCS Region	Updated Crude Exports as a Percent of Production[a]	Previous Crude Exports as a Percent of Production
Atlantic	17.26%	4.71%
Gulf of America	32.50%	39.86%
Pacific	17.43%	7.79%
Alaska	0.27%	13.24%

Notes:

[a] Updated percentages based on 2024 production and export data. Production data obtained from EIA (2025d). Export data based on U.S. Census Bureau (2025).

[8] The region-specific export percentages are assumed to apply to each planning area within an OCS region.

3.7 Model Coding Change

In addition to the data updates outlined above, we made a minor correction to the OECM code that allocates oil produced in the Alaska OCS region to ports on the West Coast. As originally coded, the model was intended to assume that 50% of the oil produced in the Alaska OCS region would remain in Alaska, in which case no more than 50% could be exported overseas or shipped to the West Coast. Prior to the current update, the model code did not implement this restriction correctly and, in some circumstances, allowed the combined volume of (1) oil exported from an Alaska planning area and (2) the volume shipped to the West Coast to exceed 50% of the planning area's oil production. The coding change addressed this issue so that the OECM now correctly restricts overseas exports and shipments to the West Coast to be no more than 50% of an Alaska planning area's oil production.

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APPENDIX A: Air Emission Factor Calculations for Interim Updates to the Offshore Environmental Cost Model (OECM)

U.S. Department of the Interior
Bureau of Ocean Energy Management

Air Emission Factor Calculations for Interim Updates to the Offshore Environmental Cost Model (OECM)

June 2026

Bureau of Ocean Energy Management
U.S. Department of the Interior

Contents

List of Tables

List of Abbreviations and Acronyms

AIS	Automatic Identification System
AP-42	Compilation of Air Pollutant Emissions Factors from Stationary Sources
BOEM	Bureau of Ocean Energy Management
BSEE	Bureau of Safety and Environmental Enforcement
CH_4	Methane
CO	Carbon Monoxide
CO_2	Carbon Dioxide
DOI	U.S. Department of the Interior
EF	Emissions Factor
E&D	Exploration and Development
EPA	U.S. Environmental Protection Agency
ERG	Eastern Research Group, Inc.
eWell	BSEE's Permitting and Reporting System
FAA	Federal Aviation Administration
GHG	Greenhouse Gas
GOA	Gulf of America
HAP	Hazardous Air Pollutant
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act
NextGen	Next Generation Air Transportation System
NO_x	Nitrogen Oxides
NTL	Notice to Lessee
N_2O	Nitrous Oxides
OCS	Outer Continental Shelf
OCSLA	Outer Continental Shelf Lands Act

OCS AQS	Outer Continental Shelf Air Quality System
OECM	Offshore Environmental Cost Model
ONRE	Operating but Not Reporting Emissions
Pb	Lead
PM-FIL	PM-Filterable
PM-PRI	PM-Prime
$PM_{2.5}$	Particulate Matter with diameter less than 2.5 microns
PM_{10}	Particulate Matter with diameter less than 10 microns
QA	Quality Assurance
QC	Quality Control
ROW	Right of Way
SO_2	Sulfur Dioxide
SOx	Sulfur Oxides
VOC	Volatile Organic Compounds

1. Introduction

The Bureau of Ocean Energy Management (BOEM) is mandated to develop five-year National Outer Continental Shelf (OCS) Oil and Gas Leasing programs (National OCS Programs). To calculate estimated impacts of lease sales occurring from the National OCS Program, BOEM uses the Offshore Environment Cost Model (OECM). This model requires air emissions factors (EF) from the OCS oil and gas activities. This document presents an interim update of the data sources, methodology, and calculations used to develop EFs for the OECM. Additional data refinements and/or updates will be completed at a future date.

The OECM is a crucial tool used by BOEM to assess the environmental and social costs associated with oil and gas activities on the OCS. It provides estimates for the monetized impact of typical activities associated with OCS production. The model uses economic inputs, resource estimates, and expected exploration and development (E&D) scenarios to calculate these costs. It also estimates emissions resulting from exploration, development, production, transportation to shore, as well as their substitutes. The OECM is essential for BOEM's decision making process, as it helps decisionmakers and the public understand the full scope of environmental and social impacts associated with OCS oil and gas development.

OECM requires EFs by region (Gulf of America, Alaska, Pacific, and Atlantic). OECM data needs also vary depending on equipment source type, as some sources require discerning by water depth.

OECM source types that require EFs by all water depths include the following:

- Caisson production
- FPSO Installation
- FPSO Removal
- Helicopters
- Pipelaying vessels
- Platform Production
- Support vessels
- Survey vessels

OECM source types that require EFs by water depth category are as follows:

- Development and Production Wells
- Drilling Exploration and Delineation Wells
- FPSO Operation
- Platform Construction (special water depth categories, includes 0-300ft, 300-600ft, >600ft)
- Platform Removal (special water depth categories, includes 0-300ft, 300-600ft, >600ft)
- Subsea Construction

Unless otherwise indicated in the above list, OECM water depth categories for EFs are the following:

- 0–60m

- 60–800m
- 800–1,600m
- >1,600m

BOEM estimates EFs for input into OECM using emissions inventories, tracking technologies and historical data. These estimated EFs are multiplied by proposed activity in the E&D scenarios to calculate potential air emissions for BOEM's leasing program.

1.1 Background

The Outer Continental Shelf Lands Act (OCSLA) required the U. S. Department of the Interior (DOI) to prescribe regulations for compliance with the national ambient air quality standards (NAAQS) pursuant to the Clean Air Act (42 U.S.C. 7401 et seq.), to the extent that activities authorized significantly affect the air quality of any State (43 U.S.C. 1334(a)(8)). The DOI BOEM's air regulations are codified at 30 CFR §§ 550.302 through 30 CFR 550.304. The Clean Air Act Amendments of 1990, Sec. 328 Air Pollution of Outer Continental Shelf Activities, limits the application of the OCSLA to certain areas of the U.S. OCS, to include offshore Texas, Louisiana, Mississippi, and Alabama. In addition, the Consolidated Appropriations Act of 2012 expanded DOI's air quality authority to offshore of the North Slope Borough of the State of Alaska. The State Department announced in December 2023 in Public Notice 12244 the extended continental shelf (see *Public Notice 12244: Continental Shelf and Maritime Boundaries; Notice of Limits, **88 FR 88470***).

Because DOI's BOEM has air quality jurisdiction on the OCS west of 87° 30' West longitude in the Gulf of America Central and Western Planning Areas, where most of the offshore oil and gas activity occurs, BOEM has detailed emissions data for these sources. BOEM also has air quality jurisdiction on the OCS on the North Slope Borough of the State of Alaska in the Beaufort and Chukchi Seas with a portion of the Hope Basin. However, because there is not a significant amount of oil and gas activity in the Alaska OCS Region, no inventory was created for the Alaska region. As a result, emissions factors were not generated from an inventory, since there were no sources to report. Similarly, there were also no sources reporting to BOEM for the Pacific and Atlantic Regions, so regional emission factors were not specifically generated for those regions either.

BOEM compiles emissions inventories in areas where DOI has air jurisdiction to evaluate the effectiveness of its regulations under OCSLA, to support BOEM's National Programs, and to support modeling impact assessments as required by 43 U.S.C. §§1334 and 1344.

Pollutants covered in the emissions inventories, which in some cases may be used as inputs for OECM, are the following:

- Criteria and precursor pollutants:
    - carbon monoxide (CO)
    - nitrogen oxides (NO_x)
    - sulfur dioxide (SO_2)
    - volatile organic compounds (VOCs)
    - lead (Pb)
    - particulate matter with diameter less than 2.5 microns ($PM_{2.5}$)

    - particulate matter with diameter less than 10 microns (PM_{10})
- Greenhouse gases (GHGs)
    - methane (CH_4)
    - carbon dioxide (CO_2)
    - nitrous oxides (N_2O)
- Hazardous air pollutants (HAPs)

The emissions data sources used to develop emissions factors for OECM in the Gulf of America (GOA) region are the following:

- The Outer Continental Shelf Air Quality System (OCS AQS) Main Portal—calendar year 2023
- Ongoing BOEM Contract #140M0124F0061 "Using Coast Guard's AIS Vessel and Federal Aviation Administration's NextGen Helicopter Data to Track BOEM's Authorized Sources" (AIS study)—calendar year 2023 (BOEM 2026c)

For other OCS regions, different methodologies were applied to develop emissions factors.

1.1.1 Facility Emissions Inventory from OCS AQS

BOEM has developed and maintained a web-based emissions tool called the Outer Continental Shelf Air Quality System (OCS AQS) to calculate and collect the facility emissions reported by the operators. BOEM Notice to Lessee (NTL) No. 2022-N01 was issued in October 2022 requiring operators in DOI air jurisdiction areas to report facility emissions for calendar year 2023 by March 29, 2024. The 2023 inventory has been quality assured and quality controlled (QA/QC) by BOEM's contractors and is now final in the web-based tool. However, the final inventory and report will not be publicly available until after April 2026.

BOEM required operators to report facility emissions in OCS AQS as defined in 30 CFR § 550.302. This includes any installation or device permanently or temporarily attached to the seabed which is used for exploration, development, and production activities for oil, gas, or sulfur and which emits or has the potential to emit any air pollutant from one or more sources. Therefore, according to the definition of facility, vessels supporting the facility were not reported. In addition, drilling was only reported when the drill rig was attached to the seabed, not while in transit. Emissions from transit vessels are accounted for in the AIS study discussed in Section 1.1.2.

OCS AQS collects monthly emissions source data from production facilities and drilling rigs reported by lessees. OCS AQS includes emissions from all fixed and floating OCS facilities, such as the following:

- Caissons
- Production platforms
- Floating production, storage, and offloading (FPSO) units
- Platform and FPSO construction and removal activities
- Drilling operations (when attached to the seabed)

For reporting, OCS AQS provides two menus:

- Platforms (production facilities)
- Lease operations (drilling or installation/removal of a facility).

Platform emissions sources reported in OCS AQS include the following:

- Amine gas sweetening units
- Boilers
- Diesel and gasoline engines
- Drilling equipment
- Flares
- Fugitive emissions
- Glycol dehydrators
- Loading operation emissions
- Losses from flashing
- Mud degassing
- Natural gas engines
- Natural gas/diesel dual-fuel turbines
- Pneumatic pumps
- Pneumatic controllers
- Storage tanks
- Cold vents

Lessees provide facility, emissions sources, and activity data into OCS AQS. The tool performs basic QA/QC, such as range checks, on individual emission sources and facilities. Once QA/QC is passed, OCS AQS calculates emissions based on the U.S. Environmental Protection Agency (EPA)'s AP-42 emissions factors and equations (EPA 2026). The operators can utilize analytic and mapping features in the tool to review their emissions data before submittal. Operators submit the emissions data to BOEM through the tool. BOEM's contactors then perform overall QA/QC across all facilities. The Outer Continental Shelf Air Quality System (OCS AQS) Operator User Manual Version 1.14 (BOEM 2024-067) provides the details on the required fields of activity data, emissions factors and emissions equations for individual source types (Thé et al. 2023).

Operators are also required to account for emissions from lease operations such as the following:

- Drilling rigs for crude oil exploration and production wells
- Drilling rigs for natural gas exploration and production wells
- Domestic and foreign self-propelled drilling rigs
- Installation support vessels
- Well stimulation vessels
- Non-platform combustion flares (including the flare pilot process)
- Non-platform mud degassing

BOEM's contactor prepopulated most of the lease operations 2023 activity data in OCS AQS with DOI's Bureau of Safety and Environmental Enforcement (BSEE) eWell Data found on the BSEE Data Center website. The operators are responsible for verifying the lease activity and dates, plus adding additional lease operations not included in the eWell dataset. Once verification by the operator is complete, OCS AQS calculates the lease source emissions. To view the required fields of activity data, emissions factors and emissions equations per source type, please see The Outer Continental Shelf Air Quality System (OCS AQS) Operator User Manual Version 1.14 (Thé et al. 2023).

For more information on the 2023 OCS Emissions Inventory, visit BOEM's website.

1.1.2 AIS Data Collection for Vessel and Helicopter Emissions

In order to have a complete oil and gas emissions inventory in the Gulf of America for the 2023 calendar year, BOEM required emissions from the numerous oil and gas related vessel and helicopter trips; this information is needed for required impact assessments under the National Environmental Policy Act (NEPA) and the Outer Continental Shelf Lands Act (OCSLA), to generate emissions factors for BOEM's Offshore Environmental Cost Model (OECM). BOEM has contracted with Eastern Research Group, Inc. (ERG) for the ongoing study, *Using Coast Guard's AIS Vessel and Federal Aviation Administration's Helicopter Data to Track BOEM-Authorized Activities* (AIS study) (BOEM 2026c).

This study integrates vessel tracking data from the U.S. Coast Guard's Automatic Identification System (AIS) and helicopter activity data from the Federal Aviation Administration (FAA)'s Next Generation Air Transportation System (NextGen) data, which enable accurate attribution of emissions to BOEM-authorized offshore oil and gas activities.

Mobile sources (not attached to the seabed) include the following:

- Support vessels
- Pipelaying vessels
- Drilling vessels
- Survey vessels
- Helicopters

For more details on the vessel and helicopter emissions calculations, please see Interim Report "2023 BOEM Gulf of America Draft OECM Emissions Factors" in Attachment A-3.

For this effort, BOEM developed an Excel Spreadsheet, titled "OECM GOA EF Spreadsheet" (see Attachment A-1 for Tables). This tool allows BOEM to input total emissions data from OCS AQS and AIS, and OECM emissions factors calculations are performed automatically. Most emissions factors calculations are based on dividing total emissions by units of activity. For example, dividing the total caisson NO_x emissions by the number of caissons produces a NO_x emissions factor for caissons. This spreadsheet has four tabs:

- Input OCS AQS (covered in Section 2)
- Input AIS (covered in Section 3)
- Total EFs Calcs- OCS AQS+AIS (covered in Section 4)
- EF Summary GOA (covered in Section 4)

This document not only describes the methodology to calculate emissions factors in the GOA for each source type, but also provides estimated emissions factors for the Alaska, Pacific and Atlantic Regions for use in OECM.

1.2 Objectives

The objective of this effort was to calculate emissions factors for air pollutants per source type (and, in some cases, by water depth) and region for use in OECM.

2. GOA OCS AQS-derived Emission Factors for OECM

All Section 2 data and calculations are on the "Input OCS AQS" tab on the OECM GOA EF spreadsheet (see Tables A-1-1 and A-1-2 in Attachment A-1). Section 2 emissions data all come from the OCS AQS tool.

2.1 Platform Sources

BOEM can access emissions factor data (including counts and emissions) for all structure types in OCS AQS under the project "PRD_BOEM" and the inventory "2023-2023 Platform Inventory". Since OECM inputs are required for Caissons, FPSOs, and Production Platforms, the OCS AQS structure types were grouped into these three categories (see Table 1). This grouping aligns with terminology used in the BOEM's Exploration and Development (E&D) Scenario.

2.1.1 Platform Emitting Counts

To determine the number of emitting structures by type, BOEM accessed the OCS AQS main production dashboard, selected the "Analytics Module- Emissions", and then chose "Annual Emissions by Pollutant-Grid". For purpose of generating OECM emissions factors, only the operating count was used, not the total count as certain facilities may not be emitting or reporting. In addition, some operators reported structures as "Operating, but Not Reporting Emissions" (ONRE)-specifically for 17 FIXED, ROW structures. These facilities may still have emissions despite the lack of reported data; however, they were excluded from this analysis (both counts and emissions).

Table 1. Emitting platform counts by structure type (2023) with OECM grouping

Structure Type (OCS AQS)	Definition	Count Emitting	OECM Grouping
CAIS	Caisson	115	Caisson
WP	Well Protector	15	Caisson
Subtotal – Caisson	-	**130**	-
FIXED	Fixed Leg Platform	643	Platform
CT	Compliance Tower	2	Platform
MOPU	Mobile Production Unit	1	Platform
MTLP	Mini Tension Leg Platform	4	Platform
SEMI	Semi-submersible Floating Platform	14	Platform
SPAR	Floating Production System	16	Platform
TLP	Tension Leg Platform	14	Platform
Subtotal – Platform	-	**694**	-
FPSO	Floating Production, Storage, and Offloading	2	FPSO
Subtotal – FPSO	-	**2**	-
Total Emitting	-	**826**	-

Note: Derived from BOEM (2026b).

2.1.2 Emissions by Structure Type

To view emissions by structure type, BOEM accessed the “OCS AQS Analytics Module- Emissions”, selected “Annual Emissions by Pollutant-Grid”, and chose the desired pollutant (e.g. NOx). The Emissions Group was set to “Structure Type” to generate emissions by structure type for 2023. This process was repeated for all pollutants. Emissions in OCS AQS are reported in short tons.

The following assumptions were made:

- For particulate matter emissions (PM_{10} and $PM_{2.5}$), BOEM added the PM primary (PM-PRI) with the PM-Filterable by structure type because AP-42 doesn’t have PM-PRI emissions factors for most emissions sources.
- For SO_x emissions, BOEM uses SO_2 as a proxy, since emissions from conventional combustion systems are predominantly in the form of SO_2, according to AP-42 Volume I, Section 1.3: Fuel Oil Combustion. Therefore, AP-42, which BOEM uses to estimate offshore emissions, usually provides SO_2 emissions factors by source type, rather than total SO_x.

Table 21. Platform emissions by structure type for 2023 (tons/year)

Pollutant	CAIS	CT	Fixed	FPSO	MOPU	MTLP	SEMI	SPAR	TLP	WP	Total
CO_2	4,067.461	63,103.182	1,805,685.324	132,318.171	52,270.084	138,207.908	1,655,243.38	1,331,625.55	1,235,337.895	0	6,417,858.955
CO	38.815	62.105	23,932.587	109.619	195.119	151.239	2,870.623	1,673.288	1,661.191	0	30,694.586
CH_4	947.497	579.177	70,520.711	300.647	220.965	920.223	3,774.476	8,782.105	3,205.162	130.140	89,381.104
NO_x	26.646	215.903	20,869.473	402.541	518.951	418.036	5,450.336	4,593.528	4,088.425	0	36,583.838
N_2O	0.053	1.637	20.410	3.010	0.436	3.476	40.050	31.989	31.245	0	132.306
PM_{10}-PRI	0.005	2.783	146.708	2.802	6.239	0.8134	8.563	27.387	14.449	0	209.749
PM_{10}-FIL	0.145	1.058	90.222	2.349	0.271	2.115	28.701	21.180	21.803	0	167.845
$PM_{2.5}$-PRI	0.005	2.779	146.225	2.796	6.058	0.803	8.468	27.005	14.313	0	208.453
$PM_{2.5}$-FIL	0.145	1.058	90.222	2.298	0.271	2.115	28.701	21.180	21.804	0	167.793
SO_2	0.025	2.788	189.988	2.885	0.484	1.701	26.082	17.450	18.461	0	259.862
VOC	156.833	160.213	13,017.255	186.085	32.589	151.660	1,202.351	1,657.123	663.206	42.369	17,269.682
No. of Emitting Structures	115	2	643	2	1	4	14	16	14	15	826

Note: This emissions spreadsheet might not match exactly the OECM Spreadsheet due to rounding. Derived from BOEM (2026b).

2.1.3 Emissions Factors Calculations for OECM

For each source type, emissions factors (EF) are calculated as:

$$OECM\ EF = \frac{Total\ Emissions\ (\frac{tons}{year})}{Count\ \ (\frac{number\ per\ source\ type}{year})}$$

- Caisson Production (all water depths)
  - Total Emissions: Combined total from CAIS and WP
  - Count: CAIS + WP =130
- FPSO Operation (by water depth)
  - Total Emissions: From FPSOs
  - Count: Total FPSOs = 2
  - In 2023, all FPSOs operated at depths >1,600m, so emissions factors apply only to the OECM category > 1,600m.
    - FPSO in Walker Ridge 249: 8,300 ft (2,530 m)
    - FPSO in Walker Ridge 551: 9,560 ft (2,914 m)
  - For FPSO Operations in other water depth categories, BOEM used historical OECM data (see Section 5).
- Platform Production (all water depths)
  - Total Emissions: Sum of CT, FIXED, MOPU, MTLP, SEMI, SPAR, TLP
  - Count: Total of CT, FIXED, MOPU, MTLP, SEMI, SPAR, and TLP = 694

2.2 Lease (Non-Platform) Sources

BOEM collects emissions from facility construction and removal (decommissioning) and drilling activities under the Analytics "Lease Operations Emissions-Detail" in OCS AQS. These emissions are recorded only when a vessel is stationary and attached to the seabed—not while in transit. For transit vessel emissions, refer to Section 3. In addition, to calculate total emissions for some source types (e.g., drilling), BOEM combines stationary emissions with transit emissions as outlined in Section 4.

Assumption:

- For lease-based emissions sources in OCS AQS, there were no PM-Filterable (PM-FIL) emissions. BOEM only used PM-Prime (PM-PRI) emissions, mostly due to the lack of PM-Filterable emissions factors for these sources in AP-42.

The OCS AQS Lease Operations includes the following categories and methods:

- Platform Construction and Platform Removal (by water depth)
  - By importing BSEE's eWell dataset into OCS AQS, operators only had to check if that activity occurred, verify the dates, and let OCS AQS calculate emissions based on eWell information.

    - There is not a distinct platform construction category from platform removal, so these categories are combined together and the same total emissions per water depth were used for both categories.
    - Count used unique Lease number per water depth.
    - Only used status of "subject to reporting" as other statuses had no emissions data.
    - Platform Construction and Platform Removal source categories had different water depth categories requirements in OECM: 0-300ft, 300-600ft, and > 600ft.
- FPSO Installation and FPSO Removal (all water depths)
    - There were no FPSOs installed or removed in 2023.
- Drilling (while attached to the seabed, by water depth)
    - By importing BSEE's eWell dataset into OCS AQS, operators only had to check if that activity occurred, verify the dates, and let OCS AQS calculate emissions based on eWell information.
    - Drilling is grouped into Development/Production Wells, Drilling Exploration/Delineation Wells, and Well Stimulation by water depth.
    - Count used unique API Well ID # per water depth.
    - Only used status of "subject to reporting" as other statuses had no emissions data.
    - Well stimulation data was a separate category in the BSEE's eWell dataset (and thus OCS AQS).
        - All well stimulation emissions are included in total drilling development emissions.
        - Well Type "BLANK" not included in analysis (no API Well #).

3. GOA AIS-derived Emission Factors for OECM

The AIS study source types (vessels and helicopters) emissions and emissions factors calculations are included in the "Input AIS" tab on the OECM GOA EF Spreadsheet (see Tables A-1-3 and A-1-4 in Attachment A-1).

3.1 Vessels Using AIS

3.1.1 Total Vessel Emissions

BOEM used only the total emissions from Attachment A-3: Gulf of America Draft OECM Emissions Factors (interim document) as input to the OECM GOA Spreadsheet. The emission factors calculated in the interim document were not used in this report.

For this interim update, an assumption was made that certain vessel types were all oil and gas related; however for a future update, the plan is to discern vessel types into oil and gas related and non-oil and gas related categories:

- Support vessels, including:
    - Anchor Handling tugs
    - Crew Boats

    - Supply Boats
    - Other Support Vessels

- Pipelaying vessels
- Drilling vessels
- Survey vessels

Table 32. Total emissions per vessel type in the GOA for 2023 (tons)

Vessel Type	CO	CO_2	CH_4	N_2O	NO_x	PM_{10}	$PM_{2.5}$	SO_2	VOC
Anchor Handling Tugs	23.85	11,689.74	0.14	0.58	176.64	4.12	3.95	2.17	7.63
Crew boats	345.15	193,767.46	1.5	9.6	2,111.75	52.68	51.1	1.78	78.88
Drillships	17.52	9,091.78	0.17	0.4	144.41	2.7	2.49	6.33	9.14
FPSO	110.44	49,837.35	0.44	2.37	793.65	17.9	17.23	6.42	23.38
Jack-ups	8.75	4,641.75	0.08	0.2	73.04	1.37	1.26	3.27	4.38
Pipelaying Vessels	17.2	10,288.99	0.15	0.45	153.44	2.89	2.66	6.39	7.77
Supply Vessels	647.41	389,384.96	2.93	19.21	3,959.48	95.45	92.41	10.94	154.08
Support Vessels	303.38	182,508.94	1.95	8.49	2,522.81	48.12	45.48	53.37	102.68
Survey Vessels	70.59	32,513.91	0.69	1.58	506.44	11.23	10.57	16.72	36.47

Note: Derived from Attachment A-2: Year 2023 Gulf of America Vessel and Helicopter Activity Draft Report.

3.1.2 EF Calculations for OECM

For the support vessels source type calculation methods (all water depths):

- In the “Input AIS” tab on the spreadsheet, total support vessel emissions were summed using the following categories: anchor handling tugs, crewboats, support vessels and supply vessels.
- The count used was the production facility count (excluding caissons, WPs, and FPSOs)
- OECM emission factor (EF) = total support vessel emissions ÷ facility count

For the pipelaying vessels source type calculation methods (all water depths):

- In the “Input AIS” tab on the spreadsheet, total pipelaying vessel emissions were used from the AIS report.
- Miles used was from BSEE’s Pipeline Permits Online Query for 2023 in the GOA.
- OECM EF = total pipelaying vessel emissions ÷ miles

For the survey vessels source type calculation methods (all water depths):

- In the “Input AIS” tab on the spreadsheet, total survey vessels emissions were used from the AIS report.
- The count used was the total production facility count (including caissons, WPs and FPSOs).
- OECM EF = total survey vessel emissions ÷ count

For the drilling vessels source type calculation methods (by water depths):

- In the “Input AIS” tab on the spreadsheet, total drilling vessels emissions were added by the drilling and the jackup categories summed from the AIS report.
- The count used was the total well spud from BSEE’s eWell data.
- Since water depths are unknown, the drilling vessels emissions factors were applied to all water depths for both developmental and exploration drilling.
- OECM EF = total drilling vessels emissions ÷ count

For the FPSO transit source type calculation methods (by water depth):

- In the “Input AIS” tab on the spreadsheet, FPSO transit emissions were used from the AIS report.
- Count was the number of FPSOs operational (2).
- OECM EF = FPSO transit emissions ÷ count
- In 2023, all FPSOs operated at depths >1,600m, so emissions factors apply only to the OECM category > 1,600m.

3.2 Helicopters Using FAA NextGen

3.2.1 Total Helicopter Emissions

For this interim update, an assumption was made that all helicopters in the GOA were oil and gas related. ERG plans on discerning sources for a future update between oil and gas related and non-oil and gas related. In addition, the AIS study used Swiss emissions factors to generate total helicopter emissions in the GOA.

Table 43. Total helicopter emissions in the GOA for 2023 (tons)

Pollutant	CO	CO_2	CH_4	N_2O	NO_x	PM_{10}	$PM_{2.5}$	SO_2	VOC
Total Helicopter Emissions (Tons)	2,111	113,317	0.837	3.321	278.1	8.324	8.124	57.38	180.6

Note: Data from Attachment A-2: Year 2023 Gulf of America Vessel and Helicopter Activity Draft Report.

3.2.2 EF Calculations for OECM

For the helicopter source type (all water depths):

- In the "Input AIS" tab on the spreadsheet, helicopter emissions were used from the AIS report (see Table 4).
- Count was platform count (excluding caissons, WPs, FPSOs).
- OECM EF = total helicopter emissions ÷ count

4. Integration of GOA Emission Factors Using OCS AQS and AIS Data

Some source types are both transit and stationery such as drilling wells and FPSO. These transit and stationary emissions factors should be summed together for the total source type contribution for OECM. Therefore, a tab was added in the OECM GOA EF Spreadsheet titled "Total EF Calcs-OCS AQS+AIS" (see Table A-1-5 in Attachment A-1).

4.1 Calculation of Total Drilling Emission Factors for OECM

For the OECM source types, Development/Production Wells and Drilling Exploration Wells, simply adding the appropriate transit emissions factors from the "Input AIS" tab to the appropriate stationary emissions factors from the "Input OCS AQS" tab by water depth will yield total Well source type emissions factors.

4.2 Calculation of Total FPSO Emission Factors for OECM

For the OECM source type, FPSO, simply adding the appropriate transit emissions factors from the "Input AIS" tab to the appropriate stationary emissions factors from the "Input OCS AQS" tab will yield total FPSO emissions factors.

4.3 Summary of the GOA Emission Factors

BOEM created a tab at the beginning of the OECM GOA EF Spreadsheet for a summary of all emissions factors in the same order as the OECM input spreadsheet (see Table A-1-6 in Attachment A-1). BOEM only mapped emissions factors from all the individual tabs into this tab to make data transfer into the OECM Spreadsheet (all regions) easier.

Lastly, BOEM conducted QA/QC during the development of the OECM emissions factors by reviewing calculation methods and analyzing the changes from emissions factors used previously in OECM.

5. Application of Past OECM Emissions Factors in the GOA

There were no updates for some source types in the GOA. Previous OECM emissions factors were therefore applied to the following categories/sources:

- FPSO Installation- Billings et al. 2015
- FPSO Removal- Billings et al. 2015
- FPSO Operations (other than 1,600m)- Billings
- LNG Tanker Cruising- Jaramillo et al. (2007) and Afon and Ervin (2008)
- LNG Tanker Unloading- Jaramillo et al. (2007) and Afon and Ervin (2008)
- LNG Tanker Loading- Jaramillo et al. (2007) and Afon and Ervin (2008)
- Oil Barge Cruising- Eric Wolvovsky (2012) and Billings et al. (2012)
- Oil Barge Unloading- Eric Wolvovsky (2012) and Billings et al. (2012)
- Oil Barge Loading- Eric Wolvovsky (2012) and Billings et al. (2012)
- Oil Tanker Cruising- Calculated by SC&A, Inc. May 2023
- Oil Tanker Export Cruising- Calculated by SC&A, Inc. May 2023
- Oil Tanker Export Loading- Calculated by SC&A, Inc. May 2023
- Oil Tanker Loading- Calculated by SC&A, Inc. May 2023
- Oil Tanker Unloading- Calculated by SC&A, Inc. May 2023
- Subsea Construction- ERG 2012

6. Emission Factors for Alaska, Pacific, and Atlantic Regions

Because DOI's BOEM has air quality jurisdiction on the OCS west of 87° 30' West longitude in the Gulf of America Central and Western Planning Areas, where most of the offshore oil and gas activity occurs, BOEM has detailed emissions data for these sources as presented in the previous sections. BOEM also has air quality jurisdiction on the OCS on the North Slope Borough of the State of Alaska in the Beaufort and Chukchi Seas with a portion of the Hope Basin. However, because there isn't significant oil and gas activity in the Alaska OCS Region, Alaska emissions factors could not be generated using an Alaska specific emissions inventory. Assumptions are made about the emissions factors for the Pacific and Atlantic Regions due to limited oil and gas activity.

6.1 Alaska Region

In the OECM, Alaska Region includes the Arctic Alaska, Cook Inlet, and General Alaska. Some of these emissions factors' calculations were based on AERMOD inputs for a Cook Inlet Sale conducted by BOEM. BOEM derived the emissions factor data for a simulated facility by using AERMOD to get the relevant modeled values. This is the most detailed information that BOEM has compiled on an Alaska OCS facility to date and represents the best available data.

Inputs for source types in AERMOD for a Cook Inlet Sale:

- Exploration and Development Semisubmersible (by water depth) Per Well – Boiler, Heaters, Diesel Engines, Flare System

- Platform Drilling (all water depths) – Boiler, Heaters, Diesel Engines
- Platform Production (all water depths) – Turbines, Compressors, Flare System, Diesel Engines, Incinerator

However, OECM requires more source types than just drilling and platform production. No new information was available for other source types in the Alaska Regions. When data for a specific OECM source type was not available from the output values of AERMOD for a Cook Inlet Sale, BOEM used the GOA emissions factors for that source type for OECM. If those were also unavailable, then past OECM emissions factors were used.

Source types using GOA data:

- Caisson Production
- FPSO Operation (greater than 1,600m)
- Helicopters
- Pipelaying Vessels
- Support Vessels
- Survey Vessels

Source types using past OECM emissions factors:

- FPSO Installation- Billings et al. 2015
- FPSO Removal- Billings et al. 2015
- FPSO Operation (other than 1,600m)- Billings
- LNG Tanker Cruising- Jaramillo et al. (2007) and Afon and Ervin (2008)
- LNG Tanker Unloading- Jaramillo et al. (2007) and Afon and Ervin (2008)
- LNG Tanker Loading- Jaramillo et al. (2007) and Afon and Ervin (2008)
- Oil Barge Cruising- Eric Wolvovsky (2012) and Billings et al. (2012)
- Oil Barge Unloading- Eric Wolvovsky (2012) and Billings et al. (2012)
- Oil Barge Loading- Eric Wolvovsky (2012) and Billings et al. (2012)
- Oil Tanker Cruising- Calculated by SC&A, Inc. May 2023
- Oil Tanker Export Cruising- Calculated by SC&A, Inc. May 2023
- Oil Tanker Export Loading- Calculated by SC&A, Inc. May 2023
- Oil Tanker Loading- Calculated by SC&A, Inc. May 2023
- Oil Tanker Unloading- Calculated by SC&A, Inc. May 2023
- Subsea Construction- ERG 2012

6.2 Pacific and Atlantic Regions

Because there are limited oil and gas activities currently in both Pacific and Atlantic Regions, most of the emissions factors used for these regions are from the GOA, and if not available, then past OECM emissions factors were used.

Source types using GOA derived data:

- Caisson Production
- Drilling (all water depths)
- Helicopters
- Pipelaying Vessels
- Platform Construction
- Platform Removal
- Platform Production
- Support Vessels
- Survey Vessels
- FPSO Operation (greater than 1,600m)

Source types using past OECM emission factors data:

- FPSO Installation- Billings et al. 2015
- FPSO Removal- Billings et al. 2015
- FPSO Operation (other than 1,600m)- Billings
- LNG Tanker Cruising- Jaramillo et al. (2007) and Afon and Ervin (2008)
- LNG Tanker Unloading- Jaramillo et al. (2007) and Afon and Ervin (2008)
- LNG Tanker Loading- Jaramillo et al. (2007) and Afon and Ervin (2008)
- Oil Barge Cruising- Eric Wolvovsky (2012) and Billings et al. (2012)
- Oil Barge Unloading- Eric Wolvovsky (2012) and Billings et al. (2012)
- Oil Barge Loading- Eric Wolvovsky (2012) and Billings et al. (2012)
- Oil Tanker Cruising- Calculated by SC&A, Inc. May 2023
- Oil Tanker Export Cruising- Calculated by SC&A, Inc. May 2023
- Oil Tanker Export Loading- Calculated by SC&A, Inc. May 2023
- Oil Tanker Loading- Calculated by SC&A, Inc. May 2023
- Oil Tanker Unloading- Calculated by SC&A, Inc. May 2023
- Subsea Construction- ERG 2012

7. Conclusions

The OECM emission factors were estimated using emissions data in the 2023 emissions inventory and 2023 tracking data rather than direct measurements. The 2023 emission inventory is based on AP-42 emission factors, which in some cases has limited coverage for OCS oil and gas emissions data. As described in the AIS interim and OCS AQS reports, these estimates have several limitations. Additionally, some activity descriptions in OECM do not fully align with those in the AIS or OCS AQS datasets. For instance, decommissioning emissions data is incomplete within the 2023 emissions inventory in OCS AQS. Furthermore, recent data remains unavailable for several OECM source types, including LNG tanker, oil barge, oil tanker, and subsea construction.

Because the Atlantic and Pacific regions lack oil and gas activity, most emissions factors were substituted with those from the GOA. The AIS dataset gathered information for the entire GOA region, whereas OCS AQS is limited to the Western and Central GOA. Overall, the calculations of emission factors for air pollutants by source type, and in some cases by water depth and region, for use in OECM was qualitatively adequate. It is recommended to further refine the analysis by incorporating subgroups such as water depth categories for production facilities in OECM. Another recommendation is to conduct detailed analysis of those source types that weren't currently updated.

8. References

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Attachment A-1: Values Supporting the OECM GOA Emission Factors

Table A-1-1. Development of OECM Emission Factors Using OCS AQS Data.

Activity	Count Operating	NO_x	SO_2	PM_{10}	$PM_{2.5}$	VOC	CO	CO_2	CH_4	N_2O	Units	Source
CAIS	115	26.65	0.02	0.15	0.15	156.83	38.81	4,067.46	947.50	0.05	tons/yr	OCS AQS Analytics "Annual Emissions by Pollutant - Grid" (selected emissions group was "structure type")
CT	2	215.90	2.79	3.84	3.84	160.21	62.11	63,103.18	579.18	1.64	tons/yr	OCS AQS Analytics "Annual Emissions by Pollutant - Grid" (selected emissions group was "structure type")
FIXED	643	20,869.48	189.99	236.93	236.45	13,017.25	23,932.59	1,805,685.41	70,520.71	20.41	tons/yr	OCS AQS Analytics "Annual Emissions by Pollutant - Grid" (selected emissions group was "structure type")
FPSO (>1600m)	2	402.54	2.88	5.15	5.09	186.08	109.62	132,318.17	300.65	3.01	tons/yr	OCS AQS Analytics "Annual Emissions by Pollutant - Grid" (selected emissions group was "structure type")
MOPU	1	518.95	0.48	6.51	6.33	32.59	195.12	52,270.08	220.97	0.44	tons/yr	OCS AQS Analytics "Annual Emissions by Pollutant - Grid" (selected emissions group was "structure type")
MTLP	4	418.04	1.70	2.93	2.92	151.66	151.24	138,207.91	920.22	3.48	tons/yr	OCS AQS Analytics "Annual Emissions by Pollutant - Grid" (selected emissions group was "structure type")
SEMI	14	5,450.34	26.08	37.26	37.17	1,202.35	2,870.62	1,655,243.38	3,774.48	40.05	tons/yr	OCS AQS Analytics "Annual Emissions by Pollutant - Grid" (selected emissions group was "structure type")

Activity	Count Operating	NO_x	SO_2	PM_{10}	$PM_{2.5}$	VOC	CO	CO_2	CH_4	N_2O	Units	Source
SPAR	16	4,593.53	17.45	48.57	48.19	1,657.12	1,673.29	1,331,625.55	8,782.11	31.99	tons/yr	OCS AQS Analytics "Annual Emissions by Pollutant - Grid" (selected emissions group was "structure type")
TLP	14	4,088.42	18.46	36.25	36.12	663.21	1,661.19	1,235,337.90	3,205.16	31.25	tons/yr	OCS AQS Analytics "Annual Emissions by Pollutant - Grid" (selected emissions group was "structure type")
WP	15	-	-	-	-	42.37	-	-	130.14		tons/yr	OCS AQS Analytics "Annual Emissions by Pollutant - Grid" (selected emissions group was "structure type")
Development/ Production Wells (0-60m)	73	487.87	1.05	10.54	10.25	10.63	114.92	24,432.99	0.81	0.41	tons/yr	OCS AQS Analytics "Leasing Operations Emissions-Detail", includes well stim
Development/ Production Wells (60-800m)	72	802.93	1.91	17.76	17.27	16.63	184.16	39,995.63	1.19	0.81	tons/yr	OCS AQS Analytics "Leasing Operations Emissions-Detail", includes well stim
Development/ Production Wells (800-1600m)	26	4,073.34	2.19	115.15	111.55	52.48	834.40	235,007.83	20.52	10.95	tons/yr	OCS AQS Analytics "Leasing Operations Emissions-Detail", includes well stim
Development/ Production Wells (>1600m)	32	3,398.92	1.81	77.55	75.19	45.44	767.84	195,624.30	11.47	7.81	tons/yr	OCS AQS Analytics "Leasing Operations Emissions-Detail", includes well stim
Drilling Exploration (0-60m)	7	31.51	0.58	1.02	1.10	1.30	7.93	1,498.41	0.06		tons/yr	OCS AQS Analytics "Leasing Operations Emissions-Detail"
Drilling Exploration (60-800m)	14	910.94	0.73	17.00	16.54	21.82	332.51	79,999.49	2.24	1.88	tons/yr	OCS AQS Analytics "Leasing Operations Emissions-Detail"

Activity	Count Operating	NO_x	SO_2	PM_{10}	$PM_{2.5}$	VOC	CO	CO_2	CH_4	N_2O	Units	Source
Drilling Exploration (800-1600m)	38	4,797.41	2.45	110.93	107.61	83.69	1,102.66	265,781.37	69.58	7.91	tons/yr	OCS AQS Analytics "Leasing Operations Emissions-Detail"
Drilling Exploration (>1600m)	37	5,495.73	2.90	140.06	135.73	84.08	1,213.65	313,380.14	67.22	11.84	tons/yr	OCS AQS Analytics "Leasing Operations Emissions-Detail"
FPSO Installation (at sea operation)	-	-	-	-	-	-	-	-	-	-	tons/yr	OCS AQS Analytics "Leasing Operations Emissions-Detail"
FPSO Removal (at sea operation)	-	-	-	-	-	-	-	-	-	-	tons/yr	OCS AQS Analytics "Leasing Operations Emissions-Detail"
Platform Construction (0-300ft)	2	0.43	0.02	0.03	0.03	0.08	0.18	49.40	0.18	0.00	tons/yr	OCS AQS Analytics "Leasing Operations Emissions-Detail"
Platform Construction (300-600ft)	1	2.65	0.00	0.05	0.05	0.07	0.71	136.88	0.01	0.00	tons/yr	OCS AQS Analytics "Leasing Operations Emissions-Detail"
Platform Construction (>600ft)	44	1,803.83	3.70	40.02	38.81	48.01	496.45	106,657.43	13.42	1.16	tons/yr	OCS AQS Analytics "Leasing Operations Emissions-Detail"
Platform Removal (0-300ft)	2	0.43	0.02	0.03	0.03	0.08	0.18	49.40	0.18	0.00	tons/yr	OCS AQS Analytics "Leasing Operations Emissions-Detail"
Platform Removal (300-600ft)	1	2.65	0.00	0.05	0.05	0.07	0.71	136.88	0.01	0.00	tons/yr	OCS AQS Analytics “Leasing Operations Emissions-Detail”
Platform Removal (>600ft)	44	1,803.83	3.70	40.02	38.81	48.01	496.45	106,657.43	13.42	1.16	tons/yr	OCS AQS Analytics “Leasing Operations Emissions-Detail”
Subtotal Total Operating Count	826											

Activity	Count Operating	NO_x	SO_2	PM_{10}	$PM_{2.5}$	VOC	CO	CO_2	CH_4	N_2O	Units	Source
Subtotal Production Platform Count (without CAIS, WP, FPSO)	694											
Subtotal Caisson + WP Count	130											

Table A-1-2. OECM Developed Emission Factors Using OCS AQS Data.

Activity	NO_x	SO_2	PM_{10}	$PM_{2.5}$	VOC	CO	CO_2	CH_4	N_2O	Units
Platforms Production (including ROW platforms)	52.10	0.37	0.54	0.53	24.33	44.01	9,051.11	126.81	0.19	tons/platform/yr
Caissons + WP Production	0.20	0.00	0.00	0.00	1.53	0.30	31.29	8.29	0.00	tons/caisson/yr
FPSO Operation (>1600m)	201.27	1.44	2.58	2.55	93.04	54.81	66,159.09	150.32	1.50	tons/FPSO/yr
Development/Production Wells (0-60m)	6.68	0.01	0.14	0.14	0.15	1.57	334.70	0.01	0.01	tons/well/water depth/yr
Development/Production Wells (60-800m)	11.15	0.03	0.25	0.24	0.23	2.56	555.49	0.02	0.01	tons/well/water depth/yr
Development/Production Wells (800-1600m)	156.67	0.08	4.43	4.29	2.02	32.09	9,038.76	0.79	0.42	tons/well/water depth/yr
Development/Production Wells (>1600m)	106.22	0.06	2.42	2.35	1.42	24.00	6,113.26	0.36	0.24	tons/well/water depth/yr
Drilling Exploration (0-60m)	4.50	0.08	0.15	0.16	0.19	1.13	214.06	0.01	0.00	tons/well/water depth/yr
Drilling Exploration (60-800m)	65.07	0.05	1.21	1.18	1.56	23.75	5,714.25	0.16	0.13	tons/well/water depth/yr
Drilling Exploration (800-1600m)	126.25	0.06	2.92	2.83	2.20	29.02	6,994.25	1.83	0.21	tons/well/water depth/yr
Drilling Exploration (>1600m)	148.53	0.08	3.79	3.67	2.27	32.80	8,469.73	1.82	0.32	tons/well/water depth/yr
FPSO Installation (at sea operation)	-	-	-	-	-	-	-	-	-	tons/FPSO/yr
FPSO Removal (at sea operation)	-	-	-	-	-	-	-	-	-	tons/FPSO/yr
Platform Construction (0-300 ft)	0.22	0.01	0.02	0.02	0.04	0.09	24.70	0.09	0.00	tons/platform/yr
Platform Construction (300-600ft)	2.65	0.00	0.05	0.05	0.07	0.71	136.88	0.01	0.00	tons/platform/yr
Platform Construction (>600ft)	41.00	0.08	0.91	0.88	1.09	11.28	2,424.03	0.31	0.03	tons/platform/yr
Platform Removal (0-300ft)	0.22	0.01	0.02	0.02	0.04	0.09	24.70	0.09	0.00	tons/platform/yr
Platform Removal (300-600ft)	2.65	0.00	0.05	0.05	0.07	0.07	136.88	0.01	0.00	tons/platform/yr
Platform Removal (>600 ft)	41.00	0.08	0.91	0.88	1.09	11.28	2,424.03	0.31	0.03	tons/platform/yr

Note: Use the Table Notes style for sources or additional info.

Table A-1-3. Development of OECM Emission Factors Using AIS Study Data.

Activity	Count	NO_x	SO_2	PM_{10}	$PM_{2.5}$	VOC	CO	CO_2	CH_4	N_2O	Units	Source
Anchor Handling tugs	-	176.6	2.2	4.1	4.0	7.6	23.9	11,689.7	0.1	0.6	tons/yr	Att. A-3 Table 3, 2023 BOEM GOA Draft OECM EF 2025
Crew boats	-	2,111.8	1.8	52.7	51.1	78.9	345.2	193,767.5	1.5	9.6	tons/yr	Att. A-3 Table 3, 2023 BOEM GOA Draft OECM EF 2025
Support vessels	-	2,522.8	53.4	48.1	45.5	102.7	303.4	182,508.9	1.95	8.5	tons/yr	Att. A-3 Table 3, 2023 BOEM GOA Draft OECM EF 2025
Supply vessels	-	3,959.5	10.9	95.5	92.4	154.1	647.4	389,385.0	2.93	19.21	tons/yr	Att. A-3 Table 3, 2023 BOEM GOA Draft OECM EF 2025
Total Support Vessels	694	8,770.7	68.3	200.4	192.9	343.3	1,319.8	777,351.1	6.5	37.9	tons/yr	-
Survey Vessels	826	506.4	16.7	11.2	10.6	36.5	70.6	32,513.9	0.7	1.6	tons/yr	Att. A-3 Table 3, 2023 BOEM GOA Draft OECM EF 2025
Pipe-laying Vessels	149 miles	153.4	6.4	2.9	2.7	7.8	17.2	10,289.0	0.2	0.5	tons/yr	Att. A-3 Table 3, 2023 BOEM GOA Draft OECM EF 2025; BSEE Pipelines for miles
Helicopters	694	278.1	57.4	8.3	8.1	180.6	2111.0	113,317.0	0.8	3.3	tons/yr	Att. A-3 Table 5
Drillship	-	144.4	6.3	2.7	2.5	9.1	17.5	9,091.8	0.2	0.4	tons/yr	Att. A-3 Table 3, 2023 BOEM GOA Draft OECM EF 2025
Jack-ups	-	73.0	3.3	1.4	1.3	4.4	8.8	4,641.8	0.1	0.2	tons/yr	Att. A-3 Table 3, 2023 BOEM GOA Draft OECM EF 2025
Total Drilling Transit (by well spud)	127	217.5	9.6	4.1	3.8	13.5	26.3	13,733.5	0.3	0.6	tons/yr	-
FPSO	2	793.7	6.4	17.9	17.2	23.4	110.4	49,837.4	0.4	2.4	tons/yr	Att. A-3 Table 3, 2023 BOEM GOA Draft OECM EF 2025

Table A-1-4. Developed Emission Factors for OECM Using AIS Study Data.

Activity	NO_x	SO_2	PM_{10}	$PM_{2.5}$	VOC	CO	CO_2	CH_4	N_2O	Units
Total Support Vessels	12.64	0.10	0.29	0.28	0.49	1.90	1,120.10	0.01	0.05	tons/platform/yr
Survey Vessels	0.61	0.02	0.01	0.01	0.04	0.09	39.36	0.00	0.00	tons/(plts+caissons)/yr
Pipe-laying Vessels	1.03	0.04	0.02	0.02	0.05	0.12	69.05	0.00	0.00	tons/mile/yr
Helicopters	0.40	0.08	0.01	0.01	0.26	3.04	163.28	0.001	0.005	tons/platform/yr
Development/Production Wells (0-60m) -transit	1.71	0.08	0.03	0.03	0.11	0.21	108.14	0.002	0.005	tons/well/yr
Development/Production Wells (60-800m)	1.71	0.08	0.03	0.03	0.11	0.21	108.14	0.002	0.005	tons/well/yr
Development/Production Wells (800-1600m)	1.71	0.08	0.03	0.03	0.11	0.21	108.14	0.002	0.005	tons/well/yr
Development/Production Wells (>1600m)	1.71	0.08	0.03	0.03	0.11	0.21	108.14	0.002	0.005	tons/well/yr
Drilling Exploration/Delineation Wells (0-60m)	1.71	0.08	0.03	0.03	0.11	0.21	108.14	0.002	0.005	tons/well/yr
Drilling Exploration/Delineation Wells (60-800m)	1.71	0.08	0.03	0.03	0.11	0.21	108.14	0.002	0.005	tons/well/yr
Drilling Exploration/Delineation Wells (800-1600m)	1.71	0.08	0.03	0.03	0.11	0.21	108.14	0.002	0.005	tons/well/yr
Drilling Exploration/Delineation Wells (>1600m)	1.71	0.08	0.03	0.03	0.11	0.21	108.14	0.002	0.005	tons/well/yr
FPSO Transit	396.83	3.21	8.95	8.60	11.69	55.22	24,918.68	0.22	1.19	tons/FPSO/yr

Table A-1-5. Developed Emission Factor Totals Using OCSAQS and AIS Study Data.

Activity	NO_x	SO_2	PM_{10}	$PM_{2.5}$	VOC	CO	CO_2	CH_4	N_2O	Units
Development/ Production Wells (0-60m)	8.40	0.09	0.18	0.17	0.25	1.78	442.84	0.01	0.01	tons/well/yr
Development/ Production Wells (60-800m)	12.86	0.10	0.28	0.27	0.34	2.76	663.63	0.02	0.02	tons/well/yr
Development/ Production Wells (800-1600m)	158.38	0.16	4.46	4.32	2.12	32.30	9,146.90	0.79	0.43	tons/well/yr
Development/ Production Wells (>1600m)	107.93	0.13	2.46	2.38	1.53	24.20	6,221.40	0.36	0.25	tons/well/yr
Drilling Exploration/Delineation Wells (0-60m)	6.21	0.16	0.18	0.19	0.29	1.34	322.20	0.01	0.00	tons/well/yr
Drilling Exploration/Delineation Wells (60-800m)	66.78	0.13	1.25	1.21	1.67	23.96	5,822.39	0.16	0.14	tons/well/yr
Drilling Exploration/Delineation Wells (800-1600m)	127.96	0.14	2.95	2.86	2.31	29.22	7,102.38	1.83	0.21	tons/well/yr
Drilling Exploration/Delineation Wells (>1600m)	150.25	0.15	3.82	3.70	2.38	33.01	8,577.87	1.82	0.32	tons/well/yr
FPSO	799.37	6.09	14.10	13.69	197.77	164.84	157,236.85	300.87	4.19	tons/FPSO/yr

Table A-1-6. Summary of the OECM Emission Factors for the GOA.

Emission Source (Units)	Depth Range	Region	CO	$PM_{2.5}$	VOC	NO_x	CO_2	SO_x	CH_4	PM_{10}	N_2O	Source
Caisson Production (tons/caisson/year)	All depths	Gulf of America	0.30	0.00	1.53	0.20	31.29	0.00	8.29	0.001	0.00	OCS AQS 2023
Development/ Production Wells (tons/well)	> 1600 m	Gulf of America	24.20	2.38	1.53	107.93	6,221.4	0.13	0.36	2.46	0.25	OCS AQS + AIS 2023
Development/ Production Wells (tons/well)	0 - 60 m	Gulf of America	1.78	0.17	0.25	8.40	442.84	0.09	0.01	0.18	0.01	OCS AQS + AIS 2023
Development/ Production Wells (tons/well)	60 - 800 m	Gulf of America	2.76	0.27	0.34	12.86	663.63	0.10	0.02	0.28	0.02	OCS AQS + AIS 2023
Development/ Production Wells (tons/well)	800 - 1600 m	Gulf of America	32.30	4.32	2.12	158.38	9,146.90	0.16	0.79	4.46	0.43	OCS AQS + AIS 2023
Drilling Exploration/ Delineation Wells (tons/well)	> 1600 m	Gulf of America	33.01	3.70	2.38	150.25	8,577.87	0.15	1.82	3.82	0.32	OCS AQS + AIS 2023
Drilling Exploration/ Delineation Wells (tons/well)	0 - 60 m	Gulf of America	1.34	0.19	0.29	6.21	322.20	0.16	0.01	0.18	0.005	OCS AQS + AIS 2023
Drilling Exploration/ Delineation Wells (tons/well)	60 - 800 m	Gulf of America	23.96	1.21	1.67	66.78	5,822.39	0.13	0.16	1.25	0.14	OCS AQS + AIS 2023
Drilling Exploration/ Delineation Wells (tons/well)	800 - 1600 m	Gulf of America	29.22	2.86	2.31	127.96	7,102.38	0.14	1.83	2.95	0.21	OCS AQS + AIS 2023
FPSO Installation (At Sea Operations) (tons/FPSO/year)	All depths	Gulf of America	42.88	1.51	1.18	145.78	5,591.11	0.05	0.03	1.56	0.27	Billings et al., 2015
FPSO Installation (Underway) (tons/mile/FPSO)	All depths	Gulf of America	0.05	0.00	0.01	0.20	6.78	0.03	0.00	0.00	0.00	Billings et al., 2015
FPSO Operation (tons/FPSO/year)	> 1600 m	Gulf of America	164.84	13.69	197.77	799.37	157,236.85	6.09	300.87	14.10	4.19	OCS AQS + AIS 2023
FPSO Operation (tons/FPSO/year)	0 - 60 m	Gulf of America	51.25	0.38	30.19	39.52	2,759.35	0.35	147.92	0.38	0.05	Billings et al., 2015
FPSO Operation (tons/FPSO/year)	60 - 800 m	Gulf of America	76.12	0.98	74.22	84.66	9,964.10	2.95	285.79	0.98	0.24	Billings et al., 2015
FPSO Operation (tons/FPSO/year)	800 - 1600 m	Gulf of America	177.24	5.13	57.03	626.64	144,970.15	60.81	261.17	5.15	2.63	Billings et al., 2015
FPSO Removal (At Sea Operations) (tons/FPSO/year)	All depths	Gulf of America	20.34	0.72	0.56	69.16	2,652.36	0.03	0.02	0.74	0.13	Billings et al., 2015

Emission Source (Units)	Depth Range	Region	CO	$PM_{2.5}$	VOC	NO_X	CO_2	SO_X	CH_4	PM_{10}	N_2O	Source
FPSO Removal (Underway) (tons/mile/FPSO)	All depths	Gulf of America	0.05	0.00	0.01	0.20	6.78	0.03	0.00	0.00	0.00	Billings et al., 2015
Helicopters (tons/platform/year)	All depths	Gulf of America	3.04	0.01	0.26	0.40	163.28	0.08	0.001	0.01	0.01	AIS 2023
LNG Tanker / Cruising (tons/billion cubic feet per mile)	N/A	Gulf of America	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.00	0.00	Jaramillo et al. (2007) and Afon and Ervin (2008)
LNG Tanker / Unloading (tons/billion cubic feet)	N/A	Gulf of America	0.02	0.01	0.00	0.06	0.77	0.14	0.00	0.01	0.00	Jaramillo et al. (2007) and Afon and Ervin (2008)
LNG Tanker / Loading (tons/billion cubic feet)	N/A	Gulf of America	0.00	0.00	0.00	0.00	19.08	0.00	0.00	0.00	0.00	Jaramillo et al. (2007) and Afon and Ervin (2008)
Oil Barge / Cruising - Lower 48 States (tons/million bbl per mile)	N/A	Gulf of America	0.02	0.00	0.00	0.18	9.06	0.02	0.00	0.00	0.00	Eric Wolvovsky, BOEM, May, 2012 and Billings et al. (2012).
Oil Barge / Loading - Lower 48 States (tons/million bbl per mile)	N/A	Gulf of America	1.06	0.19	12.47	5.09	344.08	0.86	2.17	0.19	0.01	Eric Wolvovsky, BOEM, May, 2012 and Billings et al. (2012).
Oil Barge / Unloading - Lower 48 States (tons/million bbl)	N/A	Gulf of America	1.06	0.19	6.33	5.09	344.08	0.86	1.09	0.19	0.01	Eric Wolvovsky, BOEM, May, 2012 and Billings et al. (2012).
Oil Tanker / Cruising - Lower 48 States (tons/million bbl per mile)	N/A	Gulf of America	0.00	0.00	0.01	0.04	1.47	0.00	0.00	0.00	0.00	Calculated by SC&A, Inc., May 2023
Oil Tanker / Export Cruising (tons/million bbl per mile)	N/A	Gulf of America	0.00	0.00	0.01	0.02	0.57	0.00	0.00	0.00	0.00	Calculated by SC&A, Inc., May 2023
Oil Tanker / Export Loading (tons/million bbl)	N/A	Gulf of America	1.78	0.17	11.75	14.12	585.61	0.49	1.93	0.19	0.02	Calculated by SC&A, Inc., May 2023
Oil Tanker / Loading - Lower 48 States (tons/million bbl per mile)	N/A	Gulf of America	0.95	0.10	11.34	7.76	342.00	0.27	1.93	0.11	0.01	Calculated by SC&A, Inc., May 2023
Oil Tanker / Unloading - Lower 48 States (tons/million bbl)	N/A	Gulf of America	0.95	0.10	6.88	7.76	342.00	0.27	1.14	0.11	0.01	Calculated by SC&A, Inc., May 2023

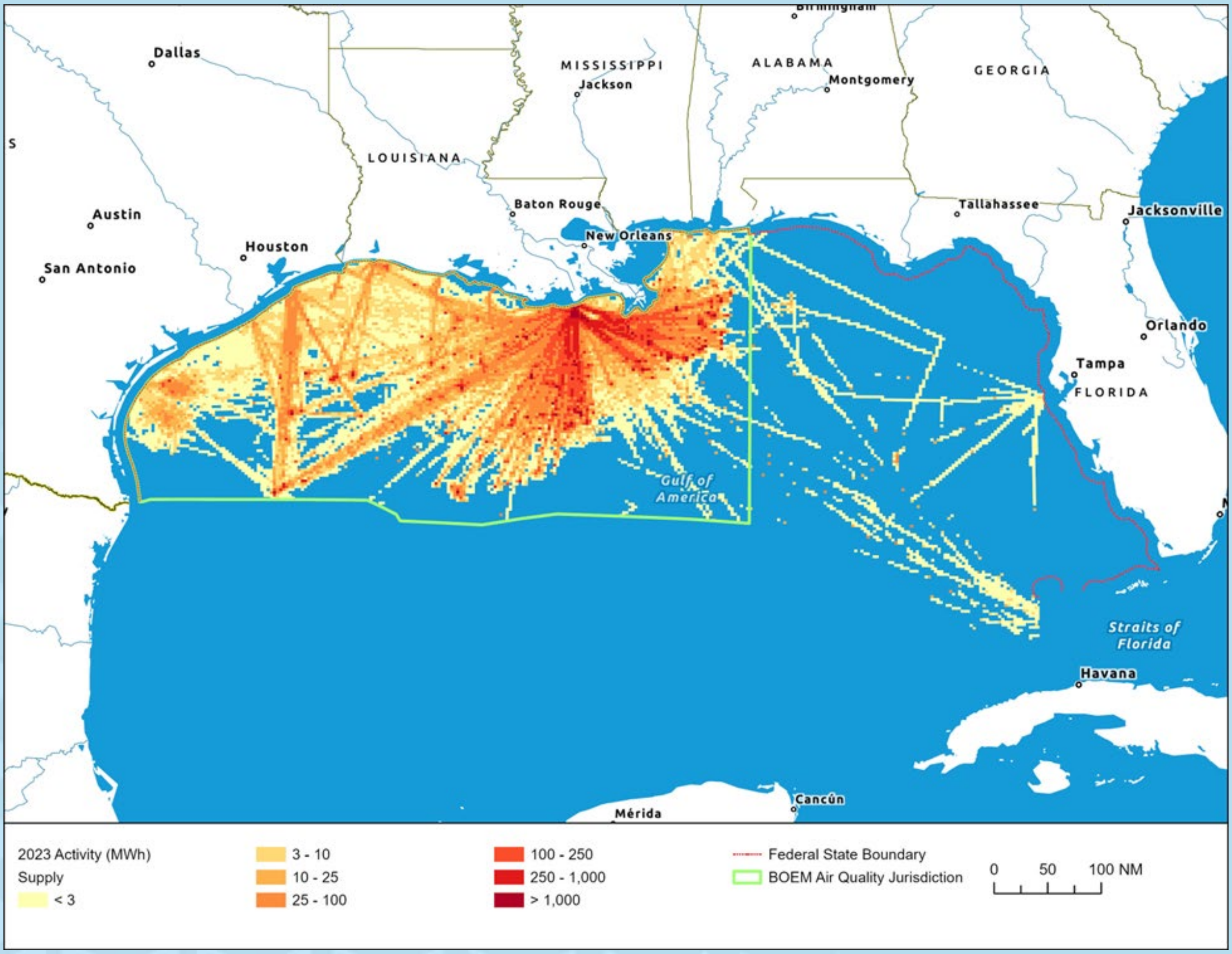
Emission Source (Units)	Depth Range	Region	CO	$PM_{2.5}$	VOC	NO_X	CO_2	SO_X	CH_4	PM_{10}	N_2O	Source
Pipe-laying Vessels (tons/mile)	All depths	Gulf of America	0.12	0.02	0.05	1.03	69.05	0.04	0.001	0.02	0.003	AIS 2023
Platform Construction (tons/(platforms + caissons))	> 600 ft	Gulf of America	11.28	0.88	1.09	41.00	2,424.03	0.08	0.31	0.91	0.03	OCS AQS 2023-facility only
Platform Construction (tons/(platforms + caissons))	0 - 300 ft	Gulf of America	0.09	0.02	0.04	0.22	24.70	0.01	0.09	0.02	0.00	OCS AQS 2023-facility only
Platform Construction (tons/(platforms + caissons))	300 - 600 ft	Gulf of America	0.71	0.05	0.07	2.65	136.88	0.001	0.01	0.05	0.00	OCS AQS 2023-facility only
Platform Production (tons/platform/year)	All depths	Gulf of America	44.01	0.53	24.33	52.10	9,051.11	0.37	126.81	0.54	0.19	OCS AQS 2023
Platform Removal (tons/(platforms + caissons))	> 600 ft	Gulf of America	11.28	0.88	1.09	41.00	2,424.03	0.08	0.31	0.91	0.03	OCS AQS 2023-facility only
Platform Removal (tons/(platforms + caissons))	0 - 300 ft	Gulf of America	0.09	0.02	0.04	0.22	24.70	0.01	0.09	0.02	0.00	OCS AQS 2023-facility only
Platform Removal (tons/(platforms + caissons))	300 - 600 ft	Gulf of America	0.07	0.05	0.07	2.65	136.88	0.001	0.01	0.05	0.00	OCS AQS 2023-facility only
Subsea Construction (tons/subsea/year)	> 1600 m	Gulf of America	118.98	18.80	8.48	518.55	37,081.20	11.37	0.26	19.38	1.54	Eastern Research Group, Inc., 2012.
Subsea Construction (tons/subsea/year)	0 - 60 m	Gulf of America	11.21	1.79	1.73	58.37	5,221.90	1.60	0.06	1.85	0.00	Eastern Research Group, Inc., 2012.
Subsea Construction (tons/subsea/year)	60 - 800 m	Gulf of America	19.60	3.14	3.08	102.69	9,244.00	2.84	0.11	3.24	0.00	Eastern Research Group, Inc., 2012.
Subsea Construction (tons/subsea/year)	800 - 1600 m	Gulf of America	59.37	9.40	4.79	264.54	19,556.35	6.00	0.15	9.69	0.89	Eastern Research Group, Inc., 2012.
Support Vessels (tons/platform/year)	All depths	Gulf of America	1.90	0.28	0.49	12.64	1,120.10	0.10	0.01	0.29	0.05	AIS 2023
Survey Vessels (tons/(platforms + caissons)/year)	All depths	Gulf of America	0.09	0.01	0.04	0.61	39.36	0.02	0.001	0.01	0.00	AIS 2023

Attachment A-2. Year 2023 Gulf of America Vessel and Helicopter Activity Draft Report

U.S. Department of the Interior
Bureau of Ocean Energy Management

Year 2023 Gulf of America Vessel and Helicopter Activity Draft Report

June 2026



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About the Cover	Cover image shows Gulf of America and surrounding states and jurisdictional boundaries and depicts the lease block-level activity in megawatt-hours for supply vessels operating in the 2023 calendar year.

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List of Abbreviations and Acronyms

AET	American Eagle Tankers
AIS	Automatic Identification Systems
API	American Petroleum Institute
BOADS	Breton Offshore Activities Data System
BOEM	Bureau of Ocean Energy Management
BSEE	Bureau of Safety and Environmental Enforcement
CAAA	Clean Air Act Amendments
CFR	Code of Federal Regulations
CH_4	methane
CMV	commercial marine vessel
C1C2	Category 1 and Category 2 marine vessels
C3	Category 3 marine vessels
CO	carbon monoxide
CO_2	carbon dioxide
CO_2e	CO_2 equivalents
CSG	corrected specific gravity of gas
CSV	Comma-separated values
DBMS	database management system
DMS	dimethylsulfide
DOI	Department of Interior
ECA	Emission Control Area
EIA	Energy Information Administration
EIS	Environmental Impact Statement
ESPIS	Environmental Studies Program Information System
FAA	Federal Aviation Administration
FAQs	Frequently Asked Questions
FCC	Federal Communication Commission
FPSO	Floating Production Storage and Offloading
FSO	Floating Storage and Offloading
GEIA	Global Emission Inventory Activity
GHG	greenhouse gas
GIS	Geographic Information Systems
GOA	Gulf of America
GOADS	Gulfwide Offshore Activities Data System
GOR	gas-to-oil ratio
GPS	Global Positioning System
GRI	Gas Research Institute
GTI	Gas Technology Institute
H_2S	hydrogen sulfide
HAP	hazardous air pollutant
HC	Hydrocarbon
Hp	Horsepower
HSAC	Helicopter Safety Advisory Conference
ID	Identification
IMO	International Maritime Organization
IPCC	Intergovernmental Panel on Climate Change
Km	Kilometers

LDAR	Leak Detection and Repair
LNG	Liquefied Natural Gas
LOOP	Louisiana Offshore Oil Port
LPG	Liquified Natural Gas
LTO	landing and takeoff
MMS	Minerals Management Service
MOVES	MOtor Vehicle Emission Simulator
MPEH	Main Pass Energy Hub
MRIP	Marine Recreational Information Program
N_2O	nitrous oxide
NAAQS	National Ambient Air Quality Standards
NCDC	National Climate Data Center
NEI	National Emissions Inventory
NEPA	National Environmental Policy Act
NH_3	ammonia
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NO_x	nitrogen oxides
NTL	Notice to Lessees and Operators
NTRL	National Technical Reports Library
OCS	Outer Continental Shelf
OCS AQS	Outer Continental Shelf Air Quality System
OCSLA	Outer Continental Shelf Lands Act
OEIS	Oversees Environmental Impact Statement
OGOR	Oil and Gas Operations Report
ONRR	Office of Natural Resources Revenue
OSMA	Offshore Marine Service Association
PAH	polycyclic aromatic hydrocarbons
Pb	Lead
PM_{10}	particulate matter-10
PM_{10}-FIL	PM_{10} filterable
PM_{10}-PRI	PM_{10} primary
$PM_{2.5}$	particulate matter-2.5
$PM_{2.5}$-FIL	$PM_{2.5}$ filterable
$PM_{2.5}$-PRI	$PM_{2.5}$ primary
PM-CON	PM condensable
Ppm	parts per million
PRI	PM primary
PTE	potential to emit
QA/QC	quality assurance/quality control
ROM	Regional Oxidant Model
RORO	roll-on/roll-off
ROS	Register of Ships
ROW	right-of-way
RUE	right-of-use easement
SAR	Synthetic Aperture Radar
SCC	Source Classification Code
SFSC	Southeast Fisheries Science Center

SIP	State Implementation Plan
SO_2	sulfur dioxide
SOP	Suspension of Production
SPT	Skaugen Petrotrans
TEU	Twenty-foot equivalent unit, general unit of cargo capacity used for container ships
THC	total hydrocarbons
TIMS	Technical Information Management System
TOC	total organic compounds
TORP	Terminal Offshore Regas Plant
USACE	U.S. Army Corps of Engineers
USCG	U.S. Coast Guard
USDOI	U.S. Department of Interior
USEPA	U.S. Environmental Protection Agency
VIN	Vessel Identifier Number
VOC	volatile organic compounds

Equation Unit Definitions

Unit	Definition
Avg	Average
Bbl	Barrel
Btu	British thermal unit
C_{VOC}	concentration of VOC
CF	conversion factor
E_{CG}	USCG emissions
EF_{C}	emission factor for pollutant c
EF_{THC}	THC emission factor
E_{HAP}	HAP emission estimate
E_{THC}	THC emissions (in pounds per month)
°F	degrees Fahrenheit
Fps	foot per second
Ft	Feet
ft^3	cubic feet
G	Gram
Gal	Gallon
GOR	gas-to-oil ratio
GOR_{U}	gas-to-oil ratio (scf/bbl) for upstream vessel
GOR_{V}	gas-to-oil ratio (scf/bbl) for vessel
Hp	Horsepower
Hr	Hour
HVO	vapor space outage (ft)
kW	Kilowatt
kWh	kilowatt-hour
Lb	Pound
LF	load factor
LTO	landing and takeoff
m^2	meter squared
MMBtu	million British thermal unit
Mscf	thousand standard cubic feet
MMscf	million standard cubic feet
MMscfd	million standard cubic feet per day
Ppm	parts per million
Ppmv	parts per million volume
Psia	pounds per square inch absolute
Psig	pressure per square inch gauge
°R	degrees rankine
Scf	standard cubic feet
Sec	Second
S_{TD}	surface area of all lease block in USCG district
T_{LA}	daily average liquid surface temperature
V_{LX}	tank maximum liquid volume (ft)
μmol	Micromole
Wt	Weight

1 Introduction

1.1 Background

The U.S. Department of the Interior's Bureau of Ocean Energy Management (BOEM) is required under the Outer Continental Shelf Lands Act (OCSLA) (43 U.S.C. § 1334(a)(8)) to comply with the National Ambient Air Quality Standards (NAAQS) to the extent that OCS oil and gas exploration, development, and production sources do not significantly affect the air quality of any state. The Gulf of America (GOA) Region's area of possible influence includes the States of Texas, Louisiana, Mississippi, Alabama, and Florida. The Clean Air Act Amendments (CAAA) of 1990 designate air quality authorities, giving BOEM air quality jurisdiction westward of longitude 87°30'W and the U.S. Environmental Protection Agency (USEPA) air quality jurisdiction eastward of longitude 87°30'W.

According to the USEPA's Greenbook, there are coastal areas in nonattainment (USEPA 2026). Texas has a coastal area that is designated as nonattainment for the 2015 eight-hour ozone standard. Ozone forms in the presence of sunlight from the reaction of volatile organic compounds (VOCs) and oxides of nitrogen (NO_x). Louisiana has two areas designated as nonattainment for SO_2. According to the Clean Air Act, a Class I area is one in which visibility is protected more stringently than under the NAAQS and includes national parks, wilderness areas, monuments, and other areas of special national and cultural significance. The Gulf Region, along with air quality jurisdiction, nonattainment, and Class I areas, is displayed in Figure 1.

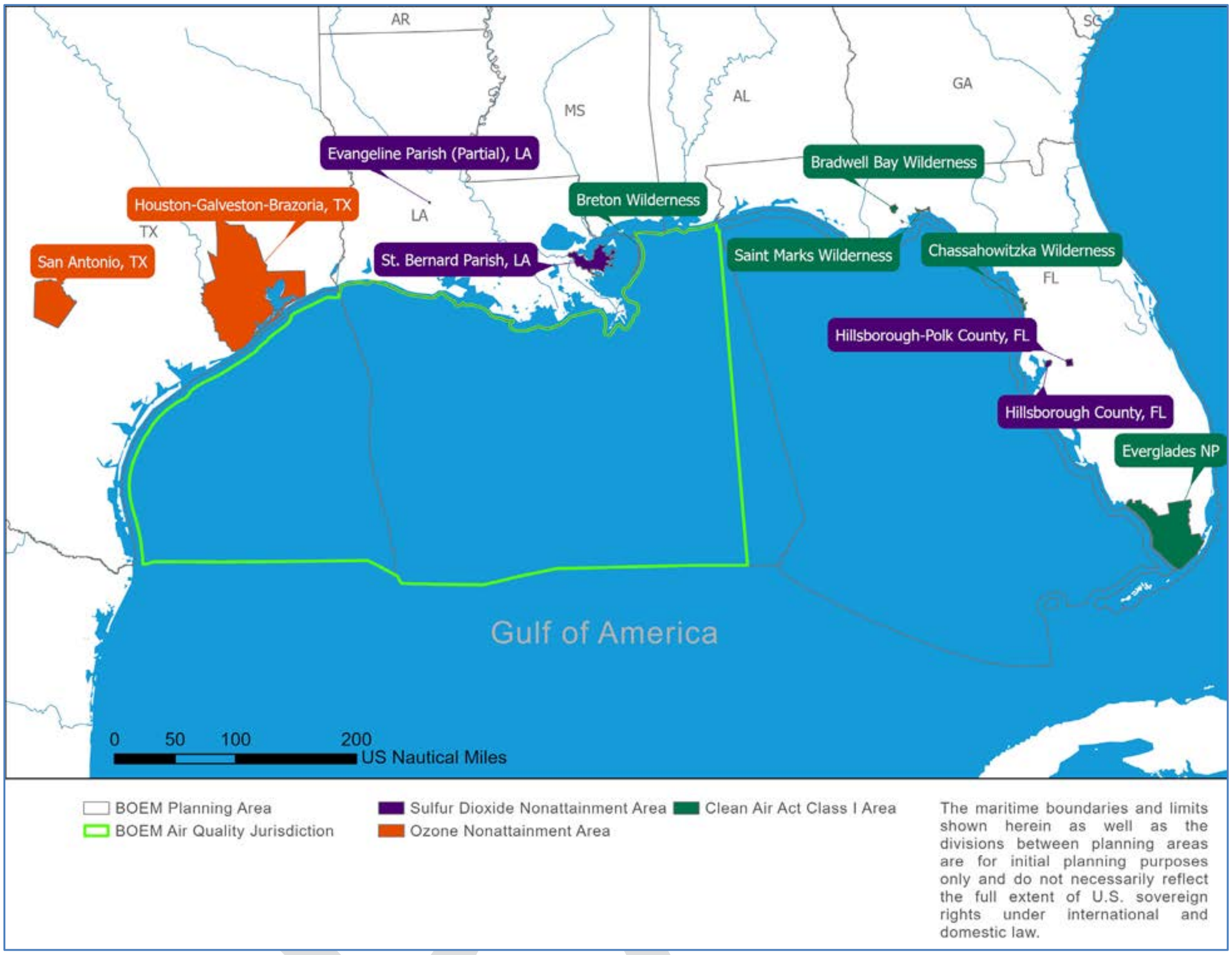

Figure 1. Gulf of America Region with the Planning Areas, Nonattainment Areas, Air Quality Jurisdiction, and Class I Areas

In 1990 CAAA (CAAA Title VIII, Sec 328[b]) specifically mandate that BOEM conduct a research study to assess the potential for onshore impacts of certain types of air pollutant emissions from Outer Continental Shelf (OCS) oil and gas exploration, development, and production in regions of the GOA. This mandate grew out of concerns regarding the cumulative onshore impacts of air pollutant emissions from more than 3,000 offshore facilities on Federal waters in the central and western Gulf. BOEM launched a series of studies, beginning in the 1980s, to assess the emissions of these OCS oil and gas platforms and their associated emissions. In 1991, BOEM sponsored a regional ozone modeling effort conducted by the USEPA using the Regional Oxidant Model (ROM). The Gulf of Mexico Air Quality Study was initiated that same year based on the CAAA mandate, and activity data for a Gulfwide emissions inventory were collected for a one-year period in 1991–1992 (Systems Applications International et al. 1995).

BOEM has sponsored several more recent air quality emission inventory projects. BOEM required affected platform operators to collect activity data used in these studies. One study affected only platforms within 100 kilometers (km) of the Breton National Wilderness Area in the GOA, where visibility and regional haze concerns apply. As part of its program to collect activity data, a Microsoft® Visual Basic® program was developed, known as the Breton Offshore Activities Data System (BOADS), for platform operators to submit activity data on a monthly basis. An Oracle® database management system (DBMS) was updated and used to develop the emissions estimates for calendar year 2000 using USEPA emissions factors and calculations (Billings and Wilson 2004).

The *Gulfwide Emission Inventory Study for Regional Haze and Ozone Modeling Effort Study* (Wilson et al. 2004) built upon the previous BOEM studies with the goal of developing criteria pollutant and greenhouse gas (GHG) emission inventories for all oil and gas production-related sources on the OCS in the GOA for calendar year 2000. The Gulfwide Offshore Activities Data System (GOADS) was developed from the BOADS; BOADS was modified to request activity data for additional emission sources. The emission estimation procedures in the Breton Oracle® DBMS were also expanded (Wilson et al. 2004). The 2005, 2008, 2011, and 2014 Gulfwide Emission Inventory Studies covered the same sources, pollutants, and geographic area as the 2000 inventory (Wilson et al. 2007; 2010; 2014; 2017). Updates were made to the GOADS-2005, GOADS-2008, GOADS-2011, GOADS-2014, and GOADS-2017 programs as needed.

The BOEM Gulf OCS Region sponsored the *Year 2017 Emissions Inventory Study* (referred to as the "BOEM 2017 inventory") (Wilson et al. 2019), with the goal of developing a calendar year 2017 air pollution emissions inventory for all OCS oil and gas production-related sources on the Gulf OCS, along with an inventory of all non-oil and gas production-related sources for impacts assessment modeling purposes. Pollutants covered in that inventory included the following:

- Criteria pollutants—carbon monoxide (CO), Pb, NO_x, SO_2, particulate matter-10 (PM_{10}), $PM_{2.5}$
- Criteria precursor pollutants—ammonia (NH_3) and VOCs
- Greenhouse gases (GHGs)—carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O)
- Select hazardous air pollutants (HAPs) and sources

BOEM required affected platform lessees and operators to collect and submit the activity data needed to develop air pollutant emissions estimates from platform activities for calendar year 2017. The activity data were collected based on BOEM Notice to Lessees and Operators (NTL) No. 2016-N03, "2017 Outer Continental Shelf Emissions Inventory Gulf of Mexico and North Slope Borough of the State of Alaska." Operators used the GOADS software (Wilson et al. 2018) to collect activity data for amine units; boilers, heaters, and burners; diesel engines; drilling equipment; fugitive sources; combustion flares; glycol dehydrators; loading operations; losses from flashing; mud degassing; natural gas engines; natural gas, diesel, and dual-fuel turbines; pneumatic pumps; pressure and level controllers; storage tanks; and cold vents.

In 2021, BOEM replaced GOADS with the OCS Air Quality System (OCS AQS), a new online reporting system for reporting platform emissions. While it requires similar inputs compared to the previous system, it includes new features that include emissions for drilling rigs and construction supply vessels, importing and exporting capabilities, and an online mapping tool. However, the non-platform component of the inventory has not been updated since the 2017 effort. In order to have a comprehensive calendar year (CY) 2023 oil and gas emissions inventory in the GOA for modeling impact assessments, BOEM needs to analyze the environmental impacts from the numerous vessel and helicopter trips in support of multiple efforts including BOEM's oil and gas (O&G) activity in the GOA, required impact assessments under the National Environmental Policy Act (NEPA) and the OCSLA, to generate emissions factors for BOEM's Offshore Environmental Cost Model (OECM), and for the Endangered Species Act (ESA) consultation reporting requirements per the 2025 National Marine Fisheries Service (NMFS) Biological Opinion (BiOp) for O&G activity (NMFS 2025).

1.2 Scope and Purpose of this Study

BOEM is responsible under OCSLA for determining if oil and natural gas platforms and other oil and natural gas production sources on the OCS Federal waters in the central and western Gulf (west of longitude 87.5°) significantly influence the air quality of any state. The BOEM also has responsibilities under the NEPA to assess the cumulative air quality impacts of oil and natural gas production on the OCS in the GOA. Therefore, the collection and compilation of an emissions inventory for OCS marine vessel and helicopter sources for calendar year 2023 is imperative, in that it not only provides BOEM the essential tools to comply with the Congressional mandate to coordinate air pollution control regulations between OCS and states onshore sources, but it also provides BOEM the essential tools needed to assess OCS oil and gas activities impacts to the states as mandated by the OCSLA and provides the states inputs needed to perform their State Implementation Plan (SIP) demonstrations to the USEPA.

The goal of this project is to develop a calendar year 2023 air pollutant emissions inventory for vessel and helicopter non-platform sources related to oil and gas production, as well as other sources in the GOA. This vessel and helicopter inventory complements the developments on the platform side by improving upon activity and emissions estimations for marine vessels and helicopters in the GOA. Emission estimates for non-platform sources on the OCS in the GOA include both oil and natural gas production-related sources as well as non-oil and natural gas production sources. Production sources consist of survey vessels, drilling rigs, pipelaying operations, support vessels, and support helicopters. Non-oil and natural gas production sources include sightseeing or transiting helicopters and commercial marine vessels such as fishing cargo vessels, containerships, general cargo, and cruise vessels. Users can query the final non-platform emissions databases by pollutant, month, source, etc.

1.3 Study Objectives

This interim report reflects the first year of the project, which focused on accurate characterization of activity and included the following objectives:

- Collect, describe, quality assure and quality check (QAQC), and archive activity data from relevant non-platform sources on the OCS that emit air pollutants over the course of calendar year 2023.
- Estimate activity for support helicopters using the Federal Aviation Administration's (FAA's) NextGen flight management data and estimate marine vessel emissions using Automatic Information Systems (AIS) data.

Because the activity values are used in emissions calculation values in year two of the project, QA/QC is an ongoing objective, such that the values reported in the sections that follow will change in future interim and the final report.

1.4 Report Organization

Following this introduction, the *Year 2023 Gulf of America Vessel and Helicopter Activity Draft Report* is organized as follows:

- Section 2: Description of the non-platform emissions sources and the data sources used.
- Section 3: Processing of the activity data, implementation of quality assurance/quality control (QA/QC) procedures, and calculation methods applied to obtain activity values.
- Section 4: Presentation of the oil and gas-related activity results.
- Section 5: Presentation of the non-oil and gas-related activity results.
- Section 6: Presentation of activity in formats more suitable for 2025 NMFS BiOp and OECM needs.
- Section 7: Literature cited.
- Section 8: Appendices.

2 Non-Platform Activity Inventory Approach

2.1 Emissions Sources

BOEM needs to develop emission activity estimates for criteria air pollutants, criteria pollutant precursors, GHGs, and HAPs for non-platform OCS sources operating in Federal waters of the GOA (i.e., west of longitude 87.5°) for the 2023 calendar year. The activity inventory will be used to develop emission estimates for the O&G and non-O&G-related non-platform sources listed below.

Non-platform oil and gas production sources:

- Support helicopters that carry supplies and personnel to and from the platforms
- Pipelaying vessels that support oil and gas related activities
- Mobile drilling units such as jack-ups, submersibles, semisubmersibles, platform rigs, and drill ships
- Survey vessels that identify oil-bearing locations and map ocean floors to support design and construction of production platforms
- Support vessels that assist in exploration, construction and removal of production platforms, construction and maintenance of pipelines, development and maintenance of subsea systems (including well simulation vessels), and carry supplies, equipment, and personnel to production platforms

Non-platform non-oil and gas production sources:

- Commercial fishing vessels, managed by the Gulf Council in coordination with National Oceanic and Atmospheric Administration (NOAA) Fisheries
- Commercial marine vessels, such as containerships, cargo vessels, and other activities including lightering services and tankers that are not related to Gulfwide O&G activities
- Military vessels such as U.S. Coast Guard and navy training exercises
- Recreational vessels such as pleasure craft and non-commercial fishing

2.2 Activity Data Sources

The purpose of this first year of effort was to calculate support helicopter activity using the FAA's NextGen flight management data and marine vessel activity using AIS data for 2023, with an ultimate goal of providing vessel and helicopter emissions spatially distributed in the GOA. These data systems allow real-time tracking of aircraft and marine vessels, and historical data files (in this case, for 2023) provide a complete picture of activity both spatially and temporally. While there are differences between the two systems, they are very similar in terms of how they function. Each helicopter or vessel has a transponder that sends two messages at two different intervals. The first message, referred to as the "static" element, is transmitted less frequently and contains data that are relatively constant such as the entity's name, identifiers, and a small set of characteristics. The second message, referred to as the "dynamic" element, is transmitted very frequently (i.e., in sub-minute intervals), and contains data such as location (latitude and longitude coordinates), timestamp, bearing, speed, etc. These messages are collected by receivers and then compiled and married together to provide a more complete picture of the movement of each entity. Data providers may also add other data elements such as unique record or trip identifiers, calculated speed, or others. The following sections discuss the data systems and processing in greater detail.

2.2.1 Helicopter Source Data

Helicopters are used extensively in the GOA to move light supplies and personnel to and from platforms. In 2023, over 2,000 helicopters completed nearly 360,000 trips in the Gulf, and transported approximately 0.7 million passengers (HSAC 2024). This level of activity provides special aviation challenges for the GOA area, specifically regarding the navigation and the safety of these operations.

To address these types of challenges, the FAA's NextGen air traffic system was introduced in select regions of the U.S. Because of the density of helicopter traffic in the GOA, it was selected as one of the locations for the early introduction of this enhanced air traffic management system. It has grown in coverage. The NextGen uses Global Positioning System (GPS) satellite-based tracking of the helicopters. This dataset is being provided by PASSUR and their ARiVA Data system which collects National Airspace System wide surveillance data from 1,000+ sensors nationwide. These sensors include 658 Automatic Dependent Surveillance-Broadcast (ADS-B), over 460 terminal and enroute radars, and 35 Airport Surface Detection Equipment, Model X (ASDE-X) systems. When using ADS-B, helicopter data are relayed from the rotocraft to ground-based and satellite receivers and then to the Houston Center, where it is combined with radar data, allowing air traffic controllers the ability to accurately monitor helicopter positions and provide safer and more efficient services over the GOA airspace. NextGen data coverage has improved significantly since the BOEM 2017 inventory because the transponders were mandated by 2020 (FAA 2023).

2.2.2 Vessel Source Data

For vessel activity, AIS data and vessel classification datasets continue to be used in the 2023 inventory to track individual vessel movements and quantify kilowatt-hours of their operation. The AIS dataset obtained from Marine Cadastre (NOAA 2025) consists of 1-minute interval records that include the vessel name, type, International Maritime Organization (IMO) identification number, Maritime Mobile Service Identity (MMSI), radio call sign, position, actual speed, and timestamp of the data transmittal. As in previous Gulfwide inventories, activity was calculated in terms of kilowatt-hours using duration calculated from timestamp data and engine load using speed over ground as described in greater detail later in this document.

Vessel names, MMSIs and IMO identifying codes in the AIS dataset were matched to vessels in the Clarksons World Fleet Register (WFR) to obtain accurate engine and equipment data needed to calculate activity (Clarksons Research 2025) as well as group and classify vessels into the various vessel types and categories. Clarksons WFR is a comprehensive database of individual marine vessels with several associated characteristics, including the following:

- Ship identification information
    - International Maritime Organization (IMO) identification number
    - Maritime Mobile Service Identity (MMSI)

- U.S. Coast Guard Registration number
- Ship call sign
- Ship name
- Statcode 5 identifier
- Vessel status
- Vessel type
- Vessel category

- Ship design information:
  - Deadweight
  - Twenty-foot equivalent unit (TEU)
  - Gross tonnage
  - Net registered tonnage
  - Depth/Draught
  - Displacement
  - Ship breadth
  - Length overall
  - Length on perpendiculars
  - Service speed
  - Bollard pull

- Information needed to determine emission factors in the next project phase:
  - Ship build date
  - Ship keel-laid date
  - Propulsion type
  - Emission abatement features (shore-power ready, scrubber fitted, etc.)

- Propulsion engine(s) data:
  - Total installed main engine power
  - Number of engines
  - Propulsion power
  - Engine bore
  - Engine stroke
  - Number of cylinders
  - Cylinder displacement
  - Engine stroke type (e.g., 2-stroke, 4-stroke)
  - Engine manufacture
  - Engine model
  - Exhaust stack height

- Auxiliary engine(s) data:
  - Number of auxiliary engines
  - Auxiliary power

While some of these data elements are available in the AIS data, they are infrequently populated and contain several data quality issues. Matching the AIS data to WFR allows for gap-filling, data verification, and increased confidence in the quality of the calculations overall.

3 Non-Platform Activity Development

3.1 Support Helicopters

In developing the activity dataset, the PASSUR's NextGen flight management data were used to quantify individual helicopter movements and were derived from speed, location, and elevation data. The NextGen helicopter data noted data transcription errors in January and February data for 2023. As a result, January and February 2024 data were provided as a substitute. March 2023 and March 2024 datasets were evaluated and found comparable, lending confidence that substituting two months' of data was reasonable. Total production for the two years were also found comparable, so the helicopter dataset used contained data from March 2023 through February 2024.

Some non-helicopter data were included in the dataset from PASSUR, but these were all filtered out using FAA's registry data before continuing the activity dataset development. One important improvement to the helicopter activity data for 2023 is that data are in 10-second intervals instead of 5-minute intervals from 2017. Non-helicopter aircraft, ultralights, and gyrocopters were supposed to be removed by the data provider, but the few that remained within the dataset were removed. This accounted for around 2%. The 10-second interval data were used to calculate flight hours which were then mapped to the lease blocks where the activity occurred based on the latitude/longitude coordinates.

The FAA Advisory Circular 91 36D (2004) encourages pilots to maintain an altitude of higher than 610 meters (2,000 ft) over noise-sensitive areas. Corporate helicopter policy states that helicopters should maintain a minimum altitude of 231 meters (700 feet) while in transit offshore and 152 meters (500 feet) while working between platforms (FAA 2004). Because of potential noise impacts on sensitive species, altitude data is a particularly important component of our helicopter data. Flight data were plotted and verified for reasonability. Figure 2 provides one example trip each for two helicopters flying on April 19, 2023. The teal lines indicate flight track of one helicopter with a single roundtrip or out-and-back flight from an airport to a platform (symbolized by yellow pins). The light blue line shows the track of a helicopter going to multiple platforms before flying back to the airport.

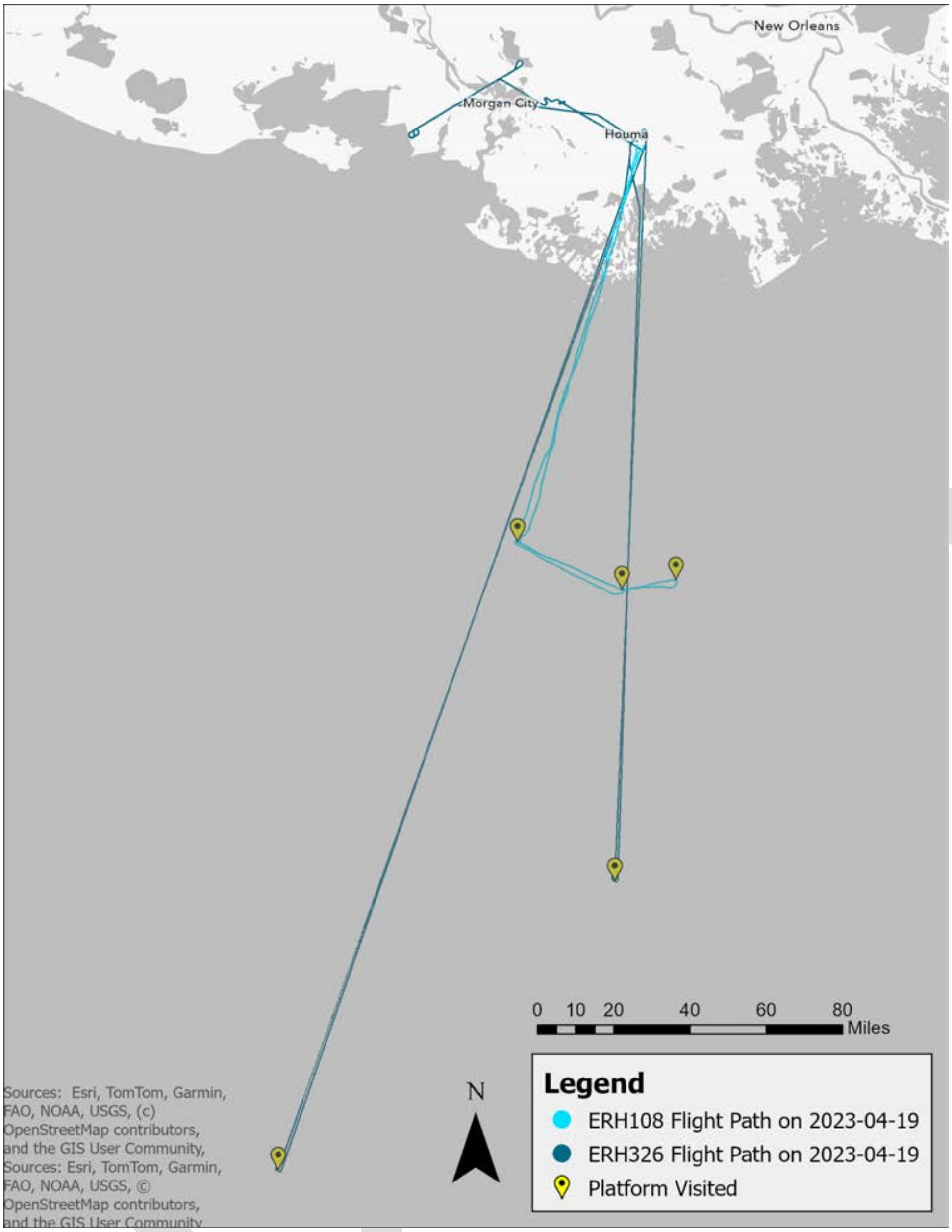

Figure 2. Example of Helicopter Tracking on April 19, 2023

Figure 3 shows a portion of one of the flights in Figure 2 that demonstrates the descent and subsequent take-off of a helicopter near a platform.

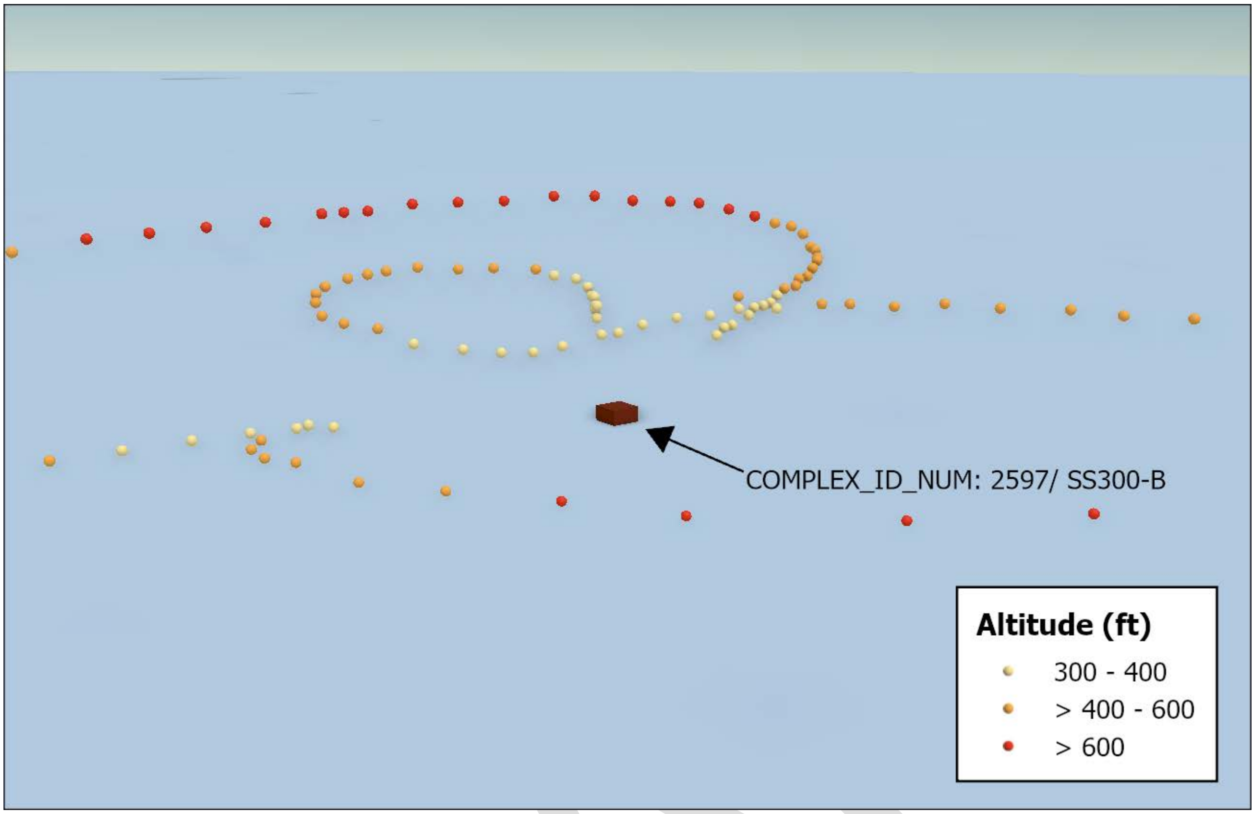

Figure 3. Helicopter Altitude during Multiple Stops at a Platform on 4/19/2023
Color indicates helicopter altitude, where the yellow is 300-400 ft, orange is greater than 400 to 600 feet and red is greater than 600 feet.

Helicopter operations differ from fixed wing aircraft, where the engine load varies relative to the operating mode (i.e., idle, ascent, descent, and cruising). The following statistics were calculated for the activity dataset: Delta Altitude, Delta velocity per 10 sec, and Great Circle Distance. The Great Circle Distance was determined using the haversine formula, which calculates the distance between two points on a sphere required for determining idling and flight modes. In determining which modes the helicopters were in, ERG used change in vertical velocity per 10 secs greater than +2.5 ft/10 sec for ascent, less than -2.5 ft/10 sec for descent and anything between +/-2.5 ft/10 sec for cruising.

We are still working to associate helicopters with O&G production. Additional data refinements and/or updates will be completed at a future date.

3.2 Marine Vessels

3.2.1 AIS Data Processing

The AIS dataset obtained from Marine Cadastre (NOAA 2025) consists of 1-minute interval records that include the vessel name, type, IMO identification number, MMSI, radio call sign, vessel type, position, actual speed, and timestamp of the data transmittal. While in-depth documentation regarding Marine Cadastre preprocessing is not available, the data processing steps include data cleaning (handling gaps and noise), trajectory extraction and compression (reducing redundant points to highlight key movement features), and data integration (combining vessel position, speed, and other characteristics for analysis) (D. Martin, personal communication, October 30, 2024).

Daily AIS data for the entire year 2023 was downloaded from Marine Cadastre as comma-separated values (CSV) files. The files contained over three billion AIS records, many of which were removed through preprocessing tasks. The geographic coverage of the AIS dataset expands beyond the scope of this project. A bounding box depicted in Figure 4 was created from a 10 nautical mile buffer of the GOA boundary. AIS records outside of this bounding box were removed from the dataset. Duplicate AIS records consisting of identical vessel identifiers and timestamps were removed. Additionally, AIS transmitters unrelated to marine vessel combustion sources were identified and removed from the AIS dataset. These miscellaneous entities were identified using USCG-verified MMSI patterns, based on information obtained from the USCG Navigation center. This reduced the AIS dataset size to approximately one billion records which is 35.8% of the original dataset.

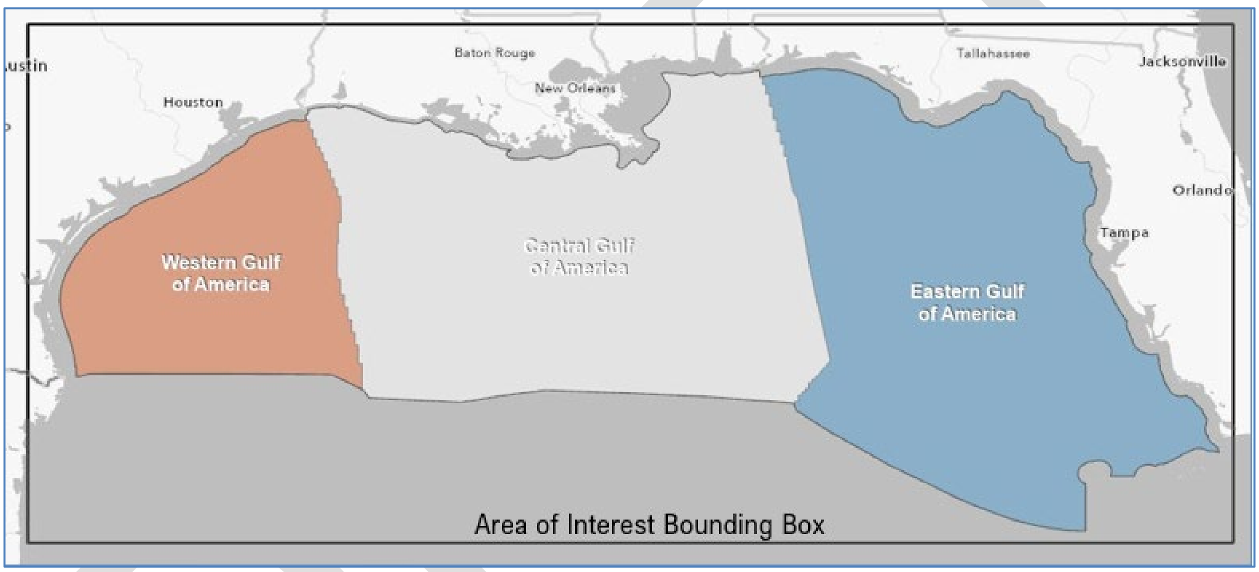

Figure 4. Area of Interest Used to Clip AIS Data for Processing

Every record within the AIS dataset is assigned an internal unique vessel identifier that corresponds to a record within the ship characteristics dataset described in Section 3.2.2. Vessels that reported only a single AIS record throughout the year were removed, because at least two records are needed per ship to calculate activity durations. Consecutive hoteling activity of each ship was aggregated in the dataset to reduce the dataset size. Hoteling records were aggregated to no more than an hour to ensure that hoteling activity was properly represented. Duration and distance were calculated between two consecutive records of each vessel's annual transit and assigned to the later timestamp, with time calculated in hours and great circle distance calculated in meters using the haversine method (Peterson 2021). In the rare case where activity intervals exceeded 24 hours, they were omitted from emissions estimates as there was too much uncertainty in a vessel's movement and potential indication of a data gap or data error.

AIS datasets include speed over ground (SOG) as a standard data field which reports the velocity at the time of the observation and incorporates the influences of currents, winds, etc. at the moment of the observation. Calculated speed, however, is computed by comparing consecutive observations, calculating the haversine distance between them, and dividing by the elapsed time between those observations. This results in an average speed over the reporting interval and is frequently used to QC data and identify anomalies, inconsistencies, or errors in reported data.

Records associated with a calculated speed greater than 40 knots (kn) helped identify AIS messages that had erroneously reported their location and/or time, as the activity needed to transit to that distance during that time interval would have been impossible. These records were removed, and time and distance were recalculated across the new gap. Erroneous vessels were identified if 30% or more of their daily records were associated with erroneous calculated speeds, and records from these erroneous vessels were removed from that day's emissions estimates. Where SOG was under 40 kn, it was used for all emissions estimations calculations. However, where SOG was greater than 40 kn and time, distance, and calculated speed were considered within reason, SOG was replaced by calculated speed. Finally, each remaining AIS record was assigned a block lease ID based on its position for aggregation purposes.

3.2.2 Vessel Characteristics Augmentation

To calculate a vessel's activity, additional information about the vessel is needed beyond its position and speed. For that data, ERG primarily used the Clarksons World Fleet Registry supplemented with and validated by smaller datasets (Clarksons Research 2025). The combined Clarksons and supplemental vessel attribute datasets are known as the compiled ship registry. Vessel-specific information was linked to AIS records by matching the AIS fleet MMSIs and IMOs with those in the compiled ship registry dataset. Category 3 (C3) vessels that could not be matched on both identifiers were matched initially on IMO and then MMSI, in that order. In contrast, Category 1 and 2 (C1C2) vessels were matched on MMSI before IMO if they could not be matched on both identifiers.

The AIS data includes ship and cargo type information, but because these data are entered by the user, there might be issues with regards to the accuracy of this field. The current version of the Marine Cadastre AIS data includes updated vessel type information that tries to address some of these data quality issues. Another proprietary vessel characteristics dataset referred to as "BOEM" was incorporated for all records in the compiled ship registry. This dataset was originally compiled during the BOEM 2017 inventory. Gulfwide inventory and has been augmented through years of online research and compilation of other publicly available data.

Each unique vessel in the compiled ship registry was then evaluated to determine which vessel type it most accurately represents. The vessel type assignments were used to gap-fill missing attributes values within the compiled ship registry that are required to calculate vessel activity. The gap-filling values were calculated from the time-weighted average of existing attribute values of vessels with the same vessel type and ship category. The average engine kW ratings used to gap-fill missing non-AIS data are shown in Attachment A-2-1. While this general approach holds for all vessel types, Section 4.2 provides discussion on individual vessel types in more detail.

3.2.3 Activity Calculation

Once the AIS data had been cleaned and processed and all the data gaps in the vessel characteristics were populated, propulsive power was calculated using the Propeller Law, which requires each vessel's total installed propulsive power in addition to their optimal service speed, as documented in Equation 1.

$$P_p = P_{ref} \times LF = P_{ref} \times \left(\frac{V}{V_{ref}}\right)^3 \qquad \text{Eq. 1}$$

where:

P_p	=	propulsion engine operating power (kW)
P_{ref}	=	total installed propulsive power (kW)
LF	=	*load factor*
V	=	AIS-reported speed (kn)
V_{ref}	=	service speed (kn)

Equation 1 is used to estimate the likely propulsive power applied for each vessel between consecutive AIS messages. The cubic ratio of the AIS reported speed following the message interval (i.e., each minute) and the vessel's optimal service speed is calculated to estimate a load factor (LF). The load factor represents the percentage of the vessel's total installed propulsive power assumed to be used during that activity interval. If the AIS reported speed exceeds the vessel's optimal speed, the LF is assigned to 1.

Equation 1 was also used to estimate the likely auxiliary power applied for each vessel between consecutive AIS messages. The installed auxiliary engine operating power is used in place of total installed propulsive power and uses 0.43 as the default load factor.

The sum of the propulsion power and the auxiliary power in kilowatts is then multiplied by the duration in hours to obtain total activity in kilowatt-hours.

3.2.4 Geospatial Analysis

Each AIS message contains a latitude and longitude value that represents the reported position of the vessel at its timestamp. The coordinates were used to determine the lease block that the vessel was located within at this time through a spatial overlay. Annual activity for each vessel type and lease block was calculated by performing an aggregate sum on every AIS message. This was visualized as a series of maps for O&G-related sources in Section 4.2 and non-O&G-related sources in Section 5.2. These maps contain lease block activity (MWh) along with the BOEM Air Quality Jurisdiction and the Federal State Boundary.

4 Oil and Gas Production-Related Activity Results

4.1 Helicopters

Helicopter flight hours by mode and total hours for 2023 along with platforms can be seen in Figures 5 through 8. Table 1 shows the monthly break-out of total flight hours. The graphs for total flight hours and cruise flight hours are similar because cruising represents approximately 70% of the total flight hours. As expected, the ascent and descent plots are similar, each accounting for 15% of the total flight hours.

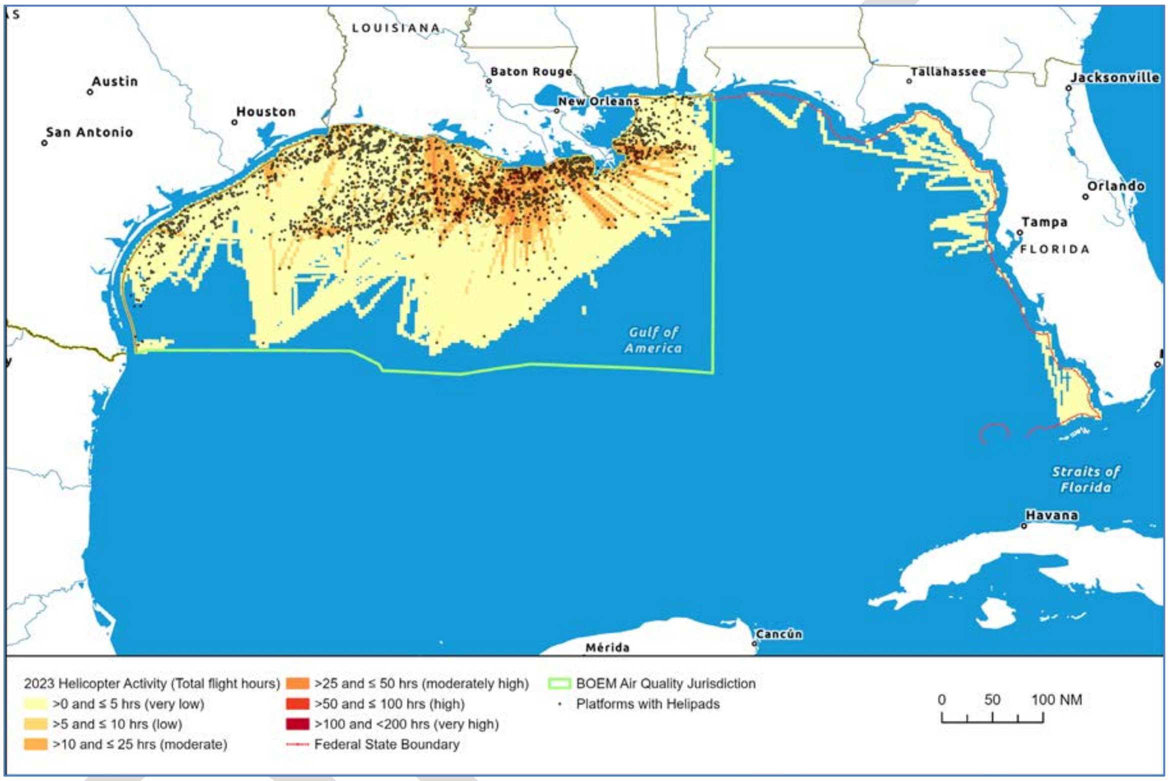

Figure 5. 2023 Annual Total Helicopter Flight Hours

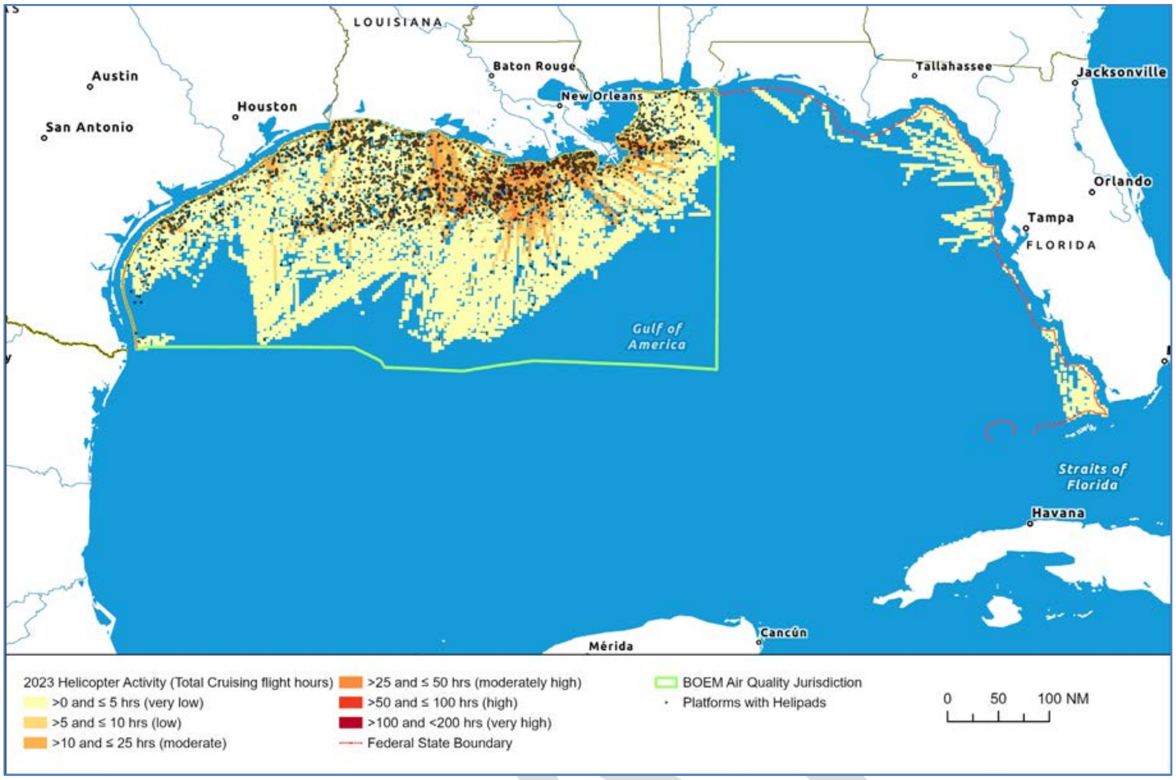

Figure 6. 2023 Annual Helicopter Cruising Flight Hours

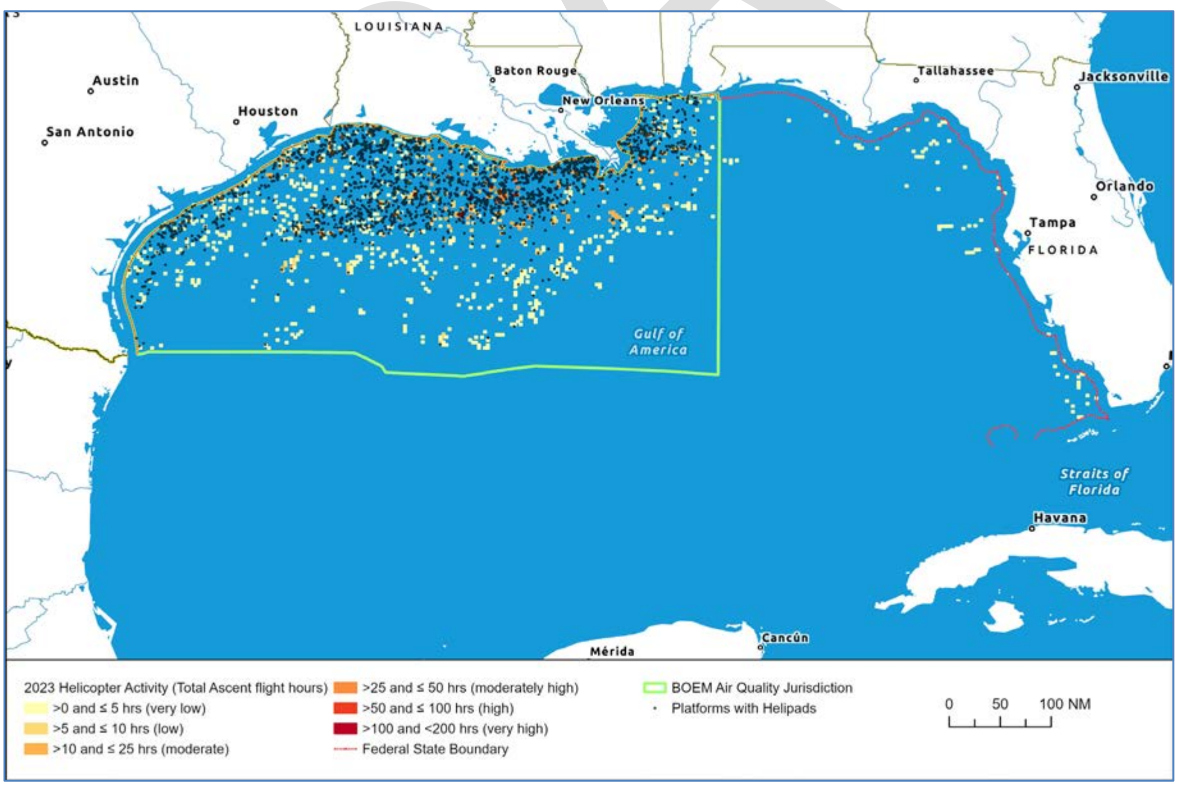

Figure 7. 2023 Annual Helicopter Ascent Flight Hours

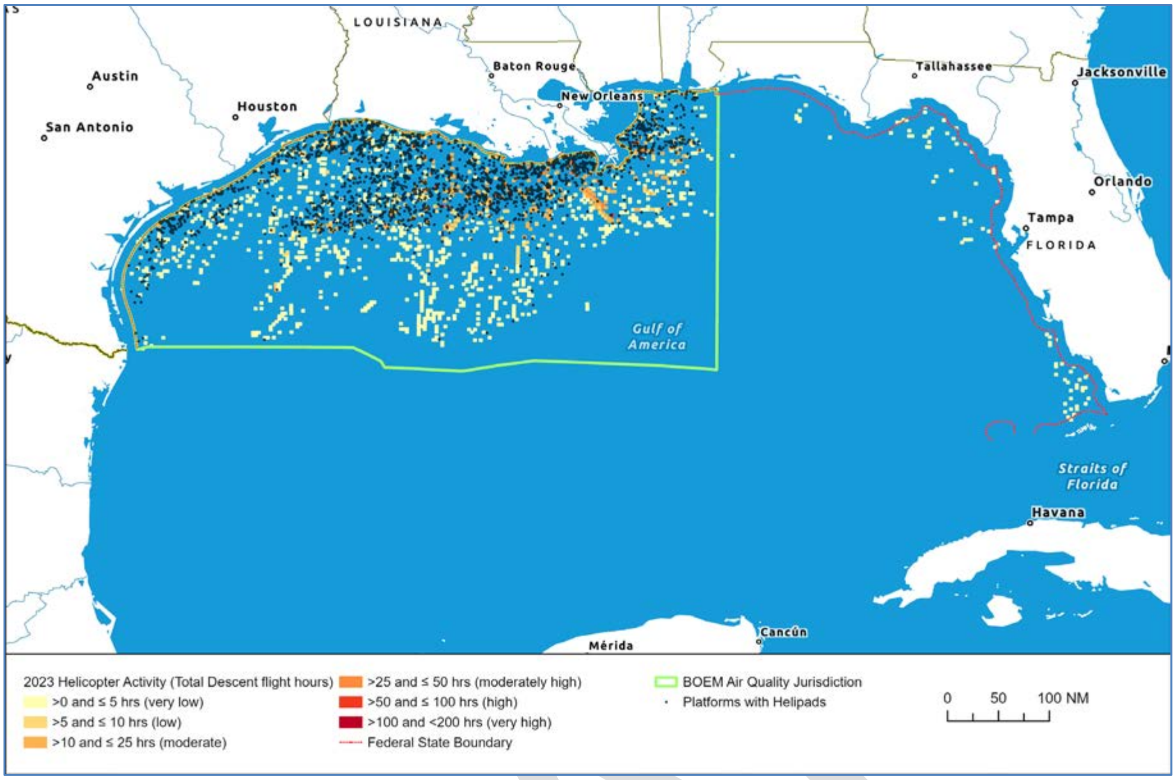

Figure 8. 2023 Annual Helicopter Descent Flight Hours

Table 1. Monthly Support Helicopter Activity Profile

Month	2023 Monthly Total Flight Hours	2023 Percent of Annual Total Flight Hours (%)[b]
January[a]	12,115	7%
February[a]	13,698	8%
March	13,861	8%
April	13,243	8%
May	14,999	9%
June	14,521	9%
July	14,528	9%
August	15,652	9%
September	13,930	8%
October	13,914	8%
November	11,914	7%
December	13,004	8%

[a] January and February 2024 used due to errors in these months for 2023.

[b] Percentages are rounded and will not add up to 100%

4.2 Marine Vessels

Table 2 shows megawatt hours by vessel type (all categories) in 2023. The vessels with the largest activity values within the Gulf are primarily Category 3 vessels with multiple, large engines that spend more time in the area via long transits, long hoteling times, or both. This includes vessel types such as bulk carriers, chemical carriers, and containerships. Tugs and tow boats also show high levels of activity in the area for similar reasons, even though many of them are not Category 3 vessels. Additional data refinements and/or updates will be completed at a future date. The following sections provide greater insight into vessels' activity levels and their spatial patterns.

Table 2. 2023 Gulfwide Oil and Gas Production-Related Annual Activity (megawatt-hours)

Vessel Type	2023 Annual MWh
Anchor Handling Tug	51,055
Crew Boat	352,216
Drillship	208,504
FPSO	66,432
Jack-up	8,225
Offshore Oil and Gas Support	639,018
Pipelaying	19,329
Research	42,437
Supply	991,366
Support	633,853
Survey	54,546
Tanker	2,455,276
Towboat	1,318,454
Tug Tow	2,572,357
Well Stimulation	27,288
Workboat	163,161

4.2.1 Survey Vessels

Survey vessels are used in the Gulf to map geologic formations and seismic properties. These survey mapping activities are needed to evaluate potential oil reserves, evaluate underwater topography, and assess platform construction issues. The most common survey technique uses blasts from underwater air guns. The sound waves from the air gun blasts are deflected by underground geologic strata and detected by sound wave receptors trailed behind the survey vessel. There are different types of surveys that can be performed. Two dimensional are most commonly used for larger areas and simpler geological observations. Three dimensional surveys are frequently employed in the GOA to location potentially profitable oil and gas reservoirs. Four dimensional surveys use three dimensional surveys at regular time intervals to monitor changes in reservoirs (BOEM n.d.).

Using AIS data for 2023 allowed BOEM to identify 30 survey vessels. The AIS data include details concerning the locations where these vessels operated and the duration of their activities. Activity values were developed for individual vessels included in the AIS data and summed within lease blocks.

Activity associated with survey vessels are primarily from marine diesel engines used for propulsion and to provide electricity and compressed air to operate the survey equipment. Low-load adjustments were made for calculated propulsion operating loads based on AIS actual vessel speeds. For vessels with propulsion engine operating loads less than 20%, the adjustment factors in USEPA's latest Port Inventory Guidance (USEPA 2022) were applied to the emissions estimate to account for increased emissions at low-load operations.

Annual activity estimates per lease block can be found in Figure 9. The estimates from survey operations were provided for each month based on the month indicated in the AIS date time stamp (Table 3).

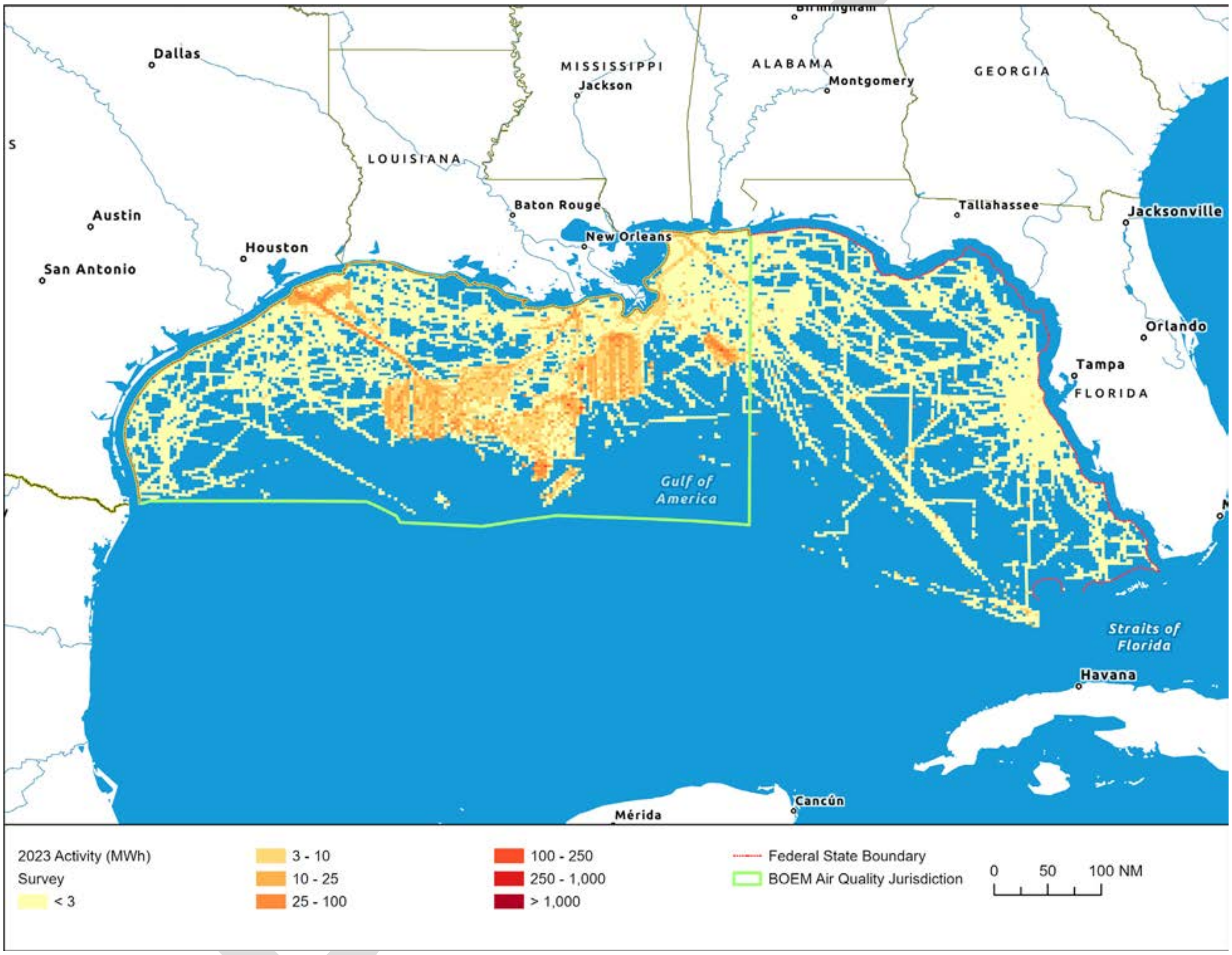

Figure 9. Annual Survey Vessel Activity in the Gulf for 2023

Table 3. Monthly Survey Vessel Profile

Month	2023 Percent of Annual Activity (%)
January	7
February	7
March	7
April	8
May	9
June	9
July	8
August	2
September	7
October	12
November	8
December	11

4.2.2 Drilling Vessels

Drilling vessels are used for exploratory drilling to supplement the geologic information provided by survey vessels. The drilling rig bores into the ocean floor by turning a drill bit attached to lengths of tubular pipe. Several different types of drill rigs operate in the Gulf, including barges, jack-ups, semisubmersibles, submersibles, platform rigs, and drill ships. The activity data for drilling rigs only include the transit. The activity and emissions from drilling will be captured with the BOEM OCS AQS.

Twenty-nine drill ships were identified in the original 2023 AIS data, and all but two had engine information reported, so the remaining 2 were assumed to also be self-propelled. One drillship was in the original AIS data pull but did not operate within the GOA, so it was also removed. In 2023, only 9 jack-ups were identified, with engine information for 6 of them; these were also assumed self-propelled and were given averaged engine characteristics. Application of the appropriate drilling rig varies relative to the water depth where they operate. For example, jack-ups can work in water up to 375 feet deep, and drill ships operate in waters with depths greater than 2,000 feet. For the BOEM 2017 inventory, no barges or submersibles were used in Federal waters of the Gulf. For 2023, only a handful of these vessels were identified as self-propelled and they were categorized as offshore support.

Drilling rigs with propulsion engines include some semisubmersible rigs and all drill ships, both of which typically use their thrusters to maintain the vessel's drilling position at the drill site. These engines tend to operate at relatively low loads and/or run fewer engines at higher loads with electric-powered thrusters to keep the vessel in place (dynamic positioning). BOEM in previous inventories assumed that propulsion engines operate at 10% load to maintain the rig's position. For 2023 actual engine load was calculated and used due to the improvements in AIS data.

Transit emissions for drill ships and semisubmersibles were quantified by applying the kW rating of each vessel's propulsion engines to the duration and engine operating load developed from the AIS data. Tugs or other support vessels that move jack-ups, platform rigs and some semisubmersibles to and from drilling sites are captured in the AIS tug, tow, and support vessel data. Drilling operations will also be mapped to the lease blocks where the activity occurred based on exploratory plan submissions and directional surveys and AIS data. Figure 10. Shows only the AIS portion of drilling activity currently.

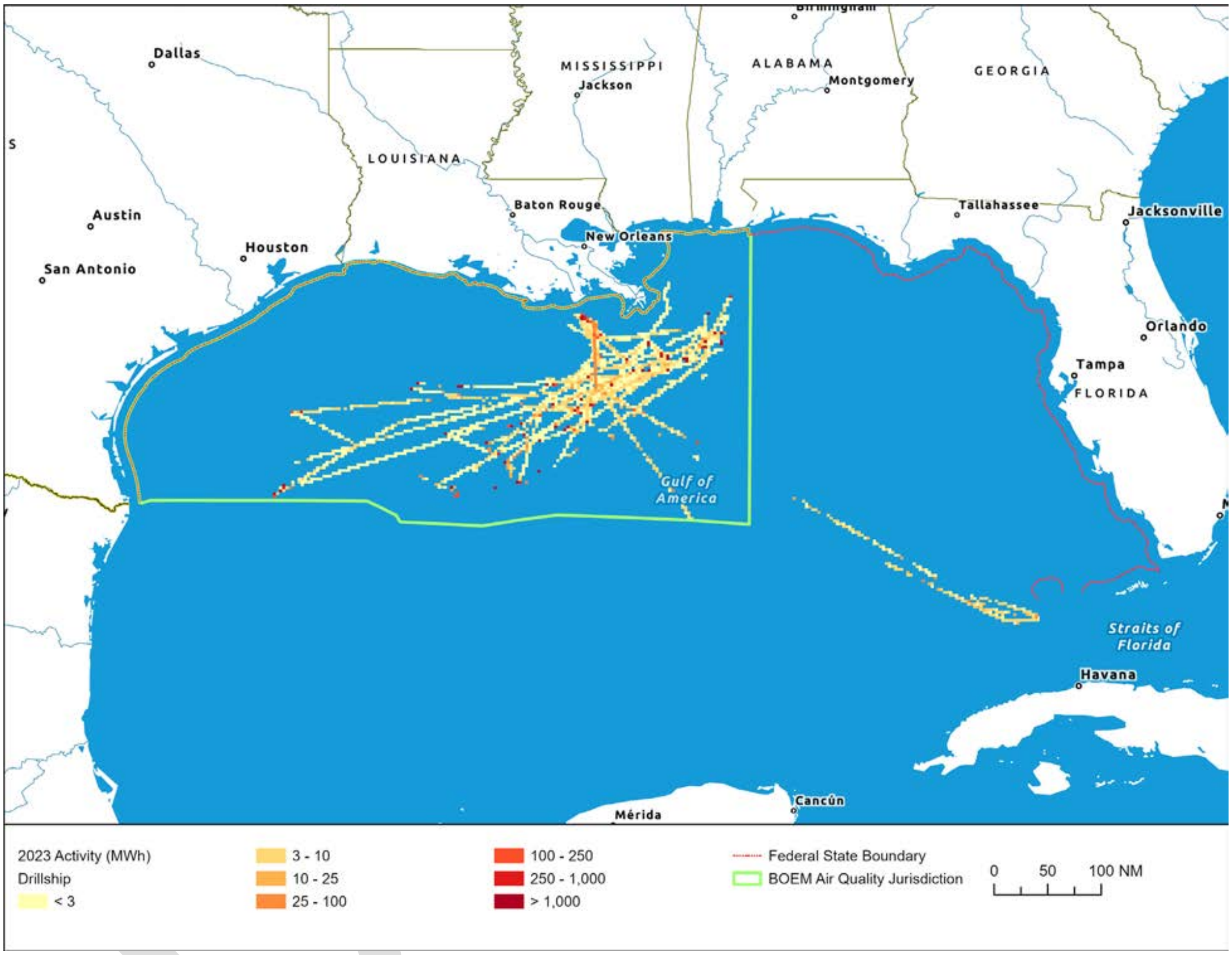

Figure 10. Annual Self-propelled Drilling Vessel Activity for 2023

The monthly activity estimates for drilling operations were based on the AIS date time stamp (Table 4).

Table 4. Monthly Drilling-Related Activity as Percent of Annual 2023 Activity

Month	2023 Percent of Jack-Ups Annual Activity (%)	2023 Percent of Drillship Annual Activity (%)
January	1	8
February	1	7
March	13	9
April	25	8
May	1	10
June	1	10
July	4	11
August	5	10
September	1	7
October	7	8
November	14	6
December	27	6

4.2.3 Pipelaying Operations

Product from oil platforms is generally transported to shore through pipelines. New pipelines are constantly being laid, linking new wellheads and platforms to shore or increasing the capacity of the existing pipeline network. Pipelines also require occasional maintenance and repair. To install, maintain, or replace sections of pipeline, considerable vessel support is required. For the 2023 inventory, pipelaying vessels that operate in the GOA were identified in the AIS data and linked to their actual vessel power. Operating hours were estimated based on the period of time that the vessel was operating as noted in the AIS data. Propulsion engine load was estimated using the propeller law (USEPA 2022) in conjunction with the actual vessel speed and maximum design speed. As noted previously, many of the operational assumptions used in the past Gulfwide inventories have been replaced with actual engine power data, hours of operation, and engine operating loads.

AIS does not have data on the auxiliary engine operating loads; the load factors presented in USEPA's Port Guidance (USEPA 2022) were therefore used (15% load while cruising, 45% load while onsite maneuvering, and 22% while stationary). AIS pipeline construction and repair activities were mapped to the lease blocks where the activity occurred (shown in Figure 11).

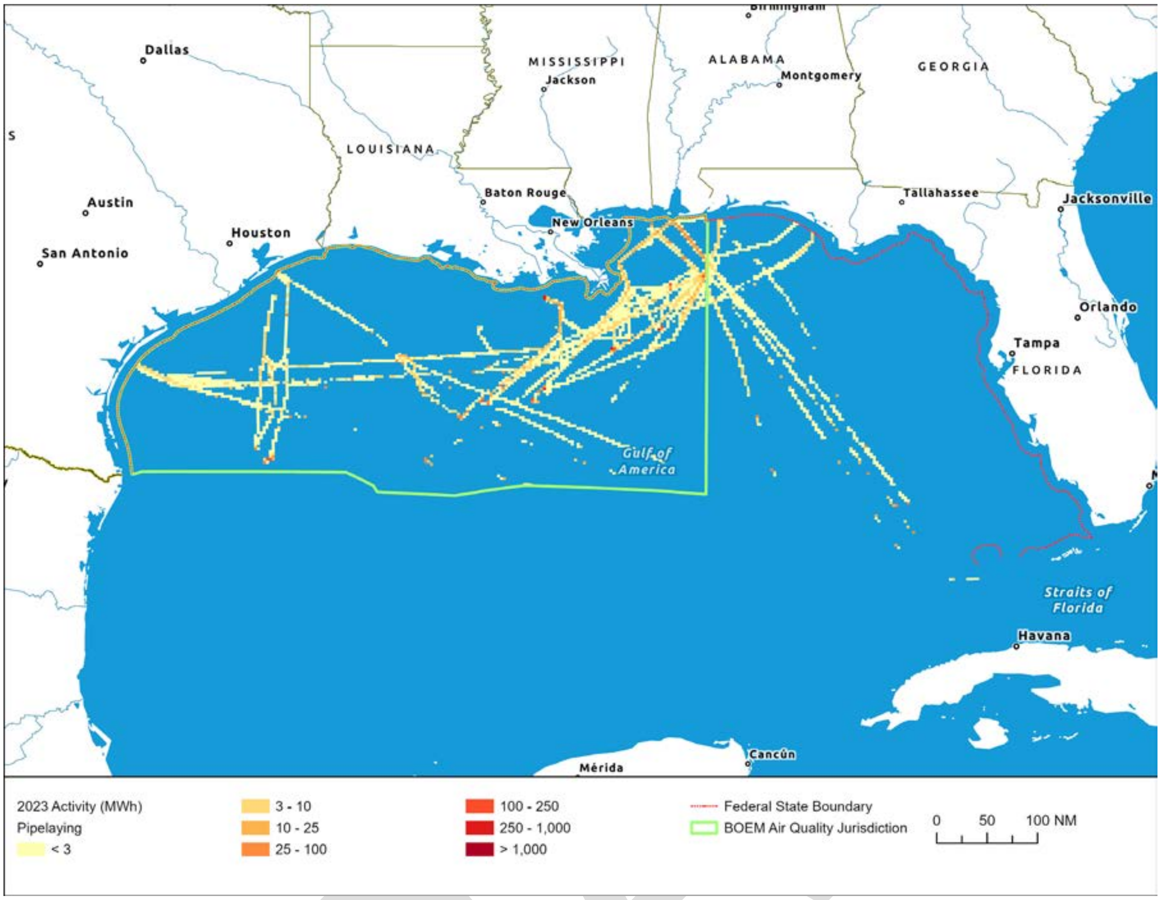

Figure 11 Annual Pipelaying Vessel Activity Data for 2023

The estimates from pipelaying operations were provided for each month based on the month indicated in the AIS date time stamp (Table 5). Note that the map and table below include a small amount of pipelaying vessel activity outside of the BOEM air quality jurisdiction, likely related to pipeline maintenance.

Table 5. Monthly Pipelaying Operation Profile

Month	Percent of Annual 2023 Activity (%)
January	8
February	8
March	7
April	1
May	5
June	8
July	8
August	12
September	12
October	10
November	12
December	9

4.2.4 Support Vessels

Support vessels include crew boats that transport workers to and from work sites, supply vessels that carry supplies to offshore sites, and tug and tow boats that transport heavy equipment and supplies. Emissions associated with support vessels are attributed to the operation of the primary diesel engine used for propulsion and other smaller diesel engines that are used to run generators or small cranes and winches for loading and unloading the vessels.

The 2023 support vessel data were derived from the AIS dataset which included 291 support vessels and 73 dedicated offshore O&G support vessels. These categories are both related to offshore oil and gas; in most cases, the only differentiation between them is the specificity of the underlying vessel data available. For example, almost all offshore O&G support vessels were identified as such in the AIS or Clarksons data, whereas support vessels are a more general category including vessels such as diving operations, floating cranes, “support vessel,” etc.

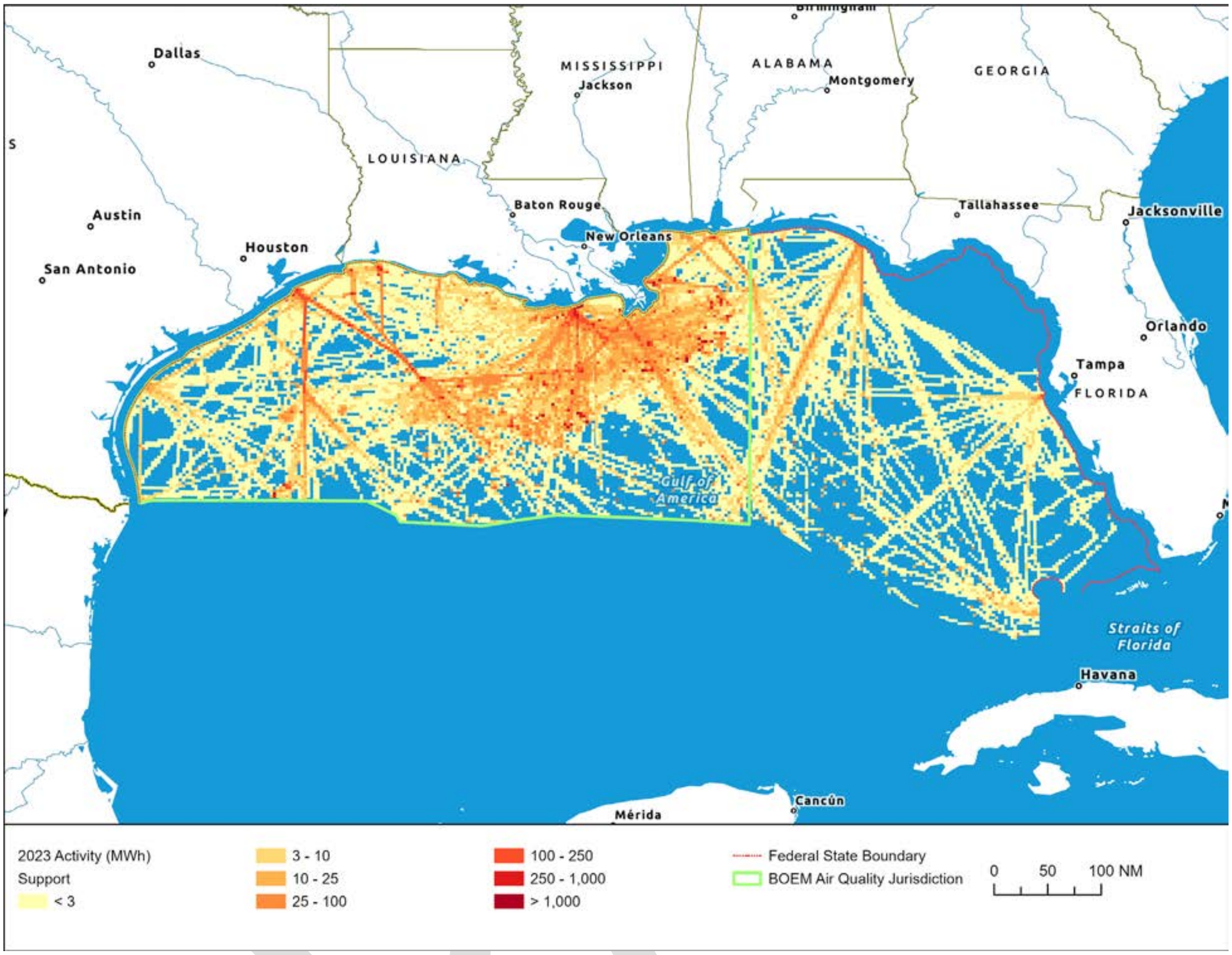

Figure 12. Annual Support Vessel Activity for 2023

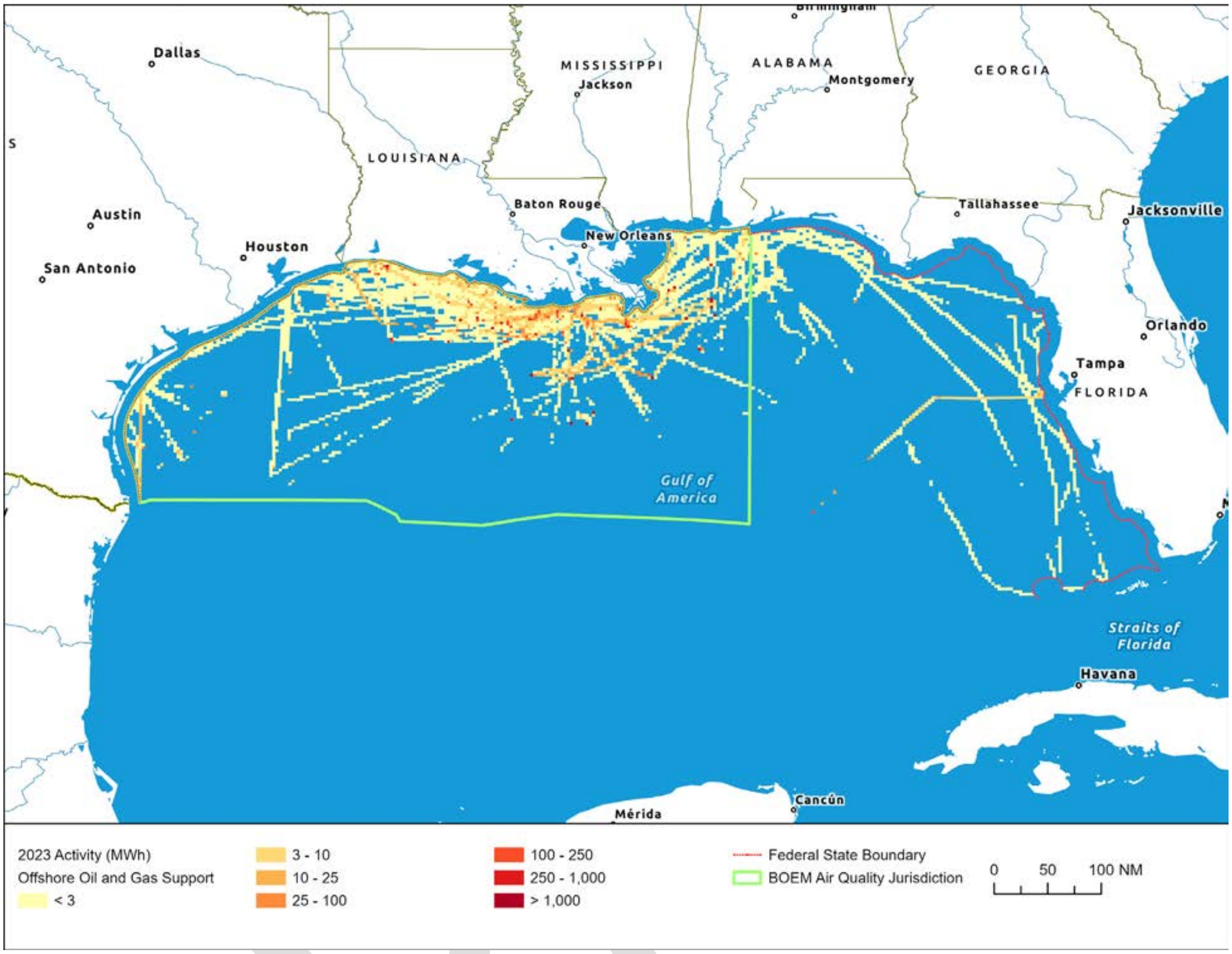

Figure 13. Annual Offshore Oil & Gas Support Vessel Activity for 2023

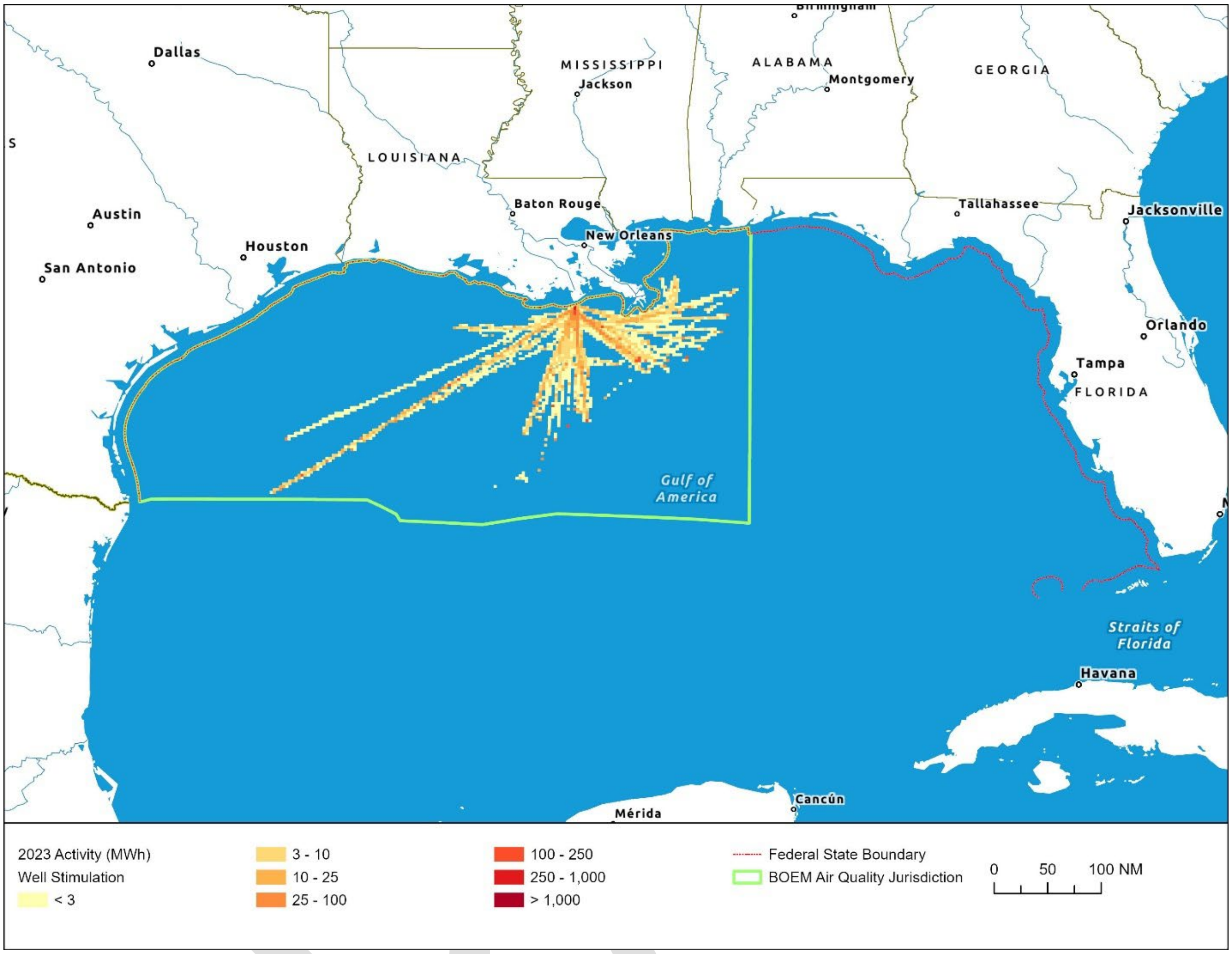

Figure 14. Annual Well Stimulation Vessel Activity for 2023

The estimates from support vessel operations were provided for each month based on the month indicated in the AIS date time stamp (Table 6).

Table 6. Monthly Support Vessel Profile

Month	2023 Offshore O&G Support Annual Activity (%)	2023 Support Vessel Activity (%)	2023 Well Stimulation Vessel Activity (%)
January	9	7	7
February	8	7	7
March	9	7	7
April	8	8	7
May	9	9	9
June	9	9	10
July	10	8	9
August	10	7	8
September	6	7	7
October	8	12	12
November	7	8	8
December	8	11	10

Tugs are included in the support vessel emission estimates presented in Section 6 (Table 7). Figure 15 shows the 2023 activity for tugs.

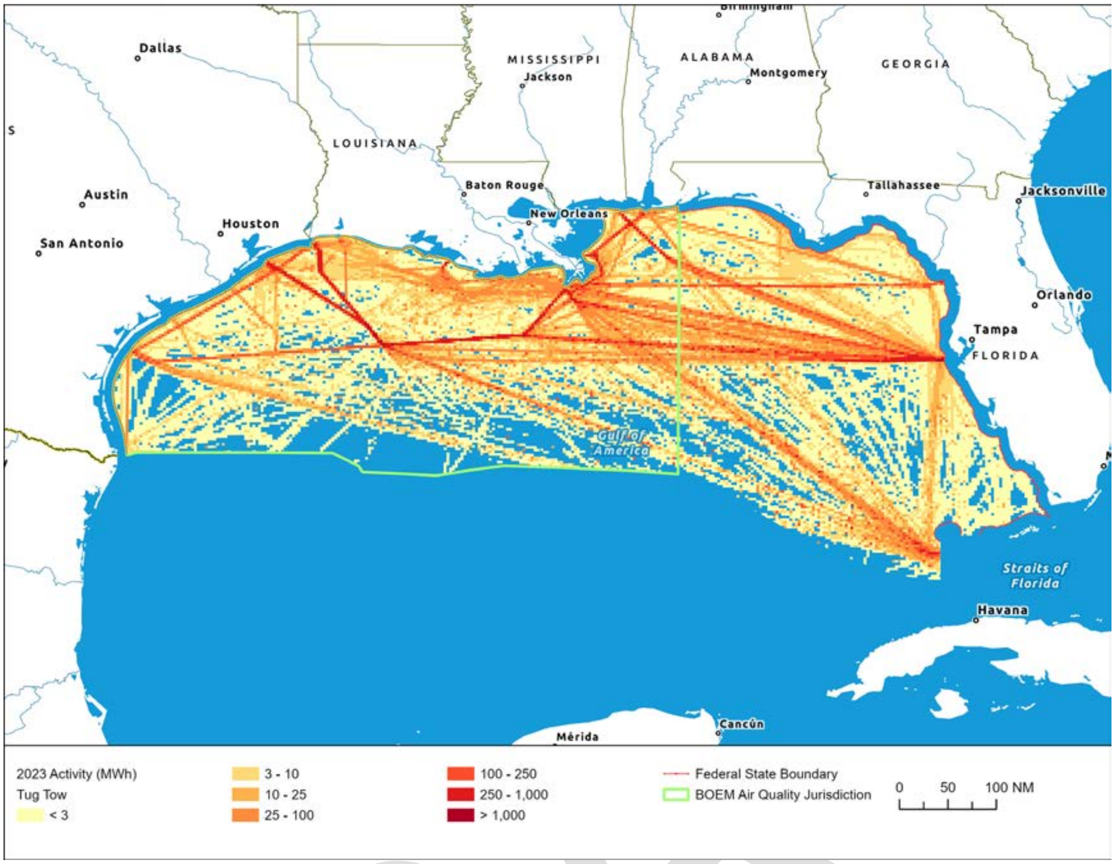

Figure 15. Annual Tug Tow Activity for 2023

Table 7. Monthly Tug Tow Activity for 2023

Month	2023 Tug Tow Annual Activity (%)
January	8
February	8
March	9
April	8
May	9
June	8
July	8
August	8
September	8
October	8
November	8
December	8

5 Non-Oil and Gas Production-Related Sources

Non-platform emission sources not directly associated with offshore oil and gas operations included in this inventory are:

- Non-O&G production-related helicopter activity
- Commercial marine vessels (CMVs) that transit the GOA carrying passengers and cargo to and from GOA ports
- Military vessels (U.S. Coast Guard and Navy)
- Commercial fishing operations
- Recreational vessels including non-commercial fishing and pleasure craft

CMVs transport a wide range of agricultural, manufacturing, and chemical products through the GOA. CMVs are powered by engines that combust marine diesel fuel which is a blend of distillate and residual oils that are compliant with the North America Emission Control Areas (ECA) requirements (USEPA 2025). In 2015, the fuel sulfur content limit was reduced to 1,000 parts per million (ppm). For the 2023 inventory, AIS data were used to estimate emissions from larger vessels equipped with Category 3 engines that transit the Central and Western Planning Areas of the GOA and a portion of the Eastern Planning Area using North America ECA fuels with a sulfur content of 1,000 ppm. As noted previously, vessels can comply with the ECA standard using high sulfur fuels in conjunction with scrubbers as long as the emissions are at or below the level associated with use of low sulfur fuels; therefore, whether operators choose to use low sulfur fuels or a scrubber, the emissions should be equivalent. Smaller vessels equipped with Category 1 and 2 engines that are fueled at U.S. ports are dispensed ultra-low sulfur content fuels (15 ppm) that comply with a USEPA fuel regulation.

Any activities in this section for vessel types that are also listed above in Section 4.2 have been separated from the O&G-related activities as described above, such that there is no double-counting.

5.1 Non-O&G Helicopters

Non-O&G production-related helicopter activity in the Gulf includes recreational/sight-seeing tours and military training or enforcement activities. Any helicopter flights that do not start or end at an oil platform are assumed to be non-O&G.

5.2 Non-O&G Marine Vessels

AIS data were assumed to be complete for CMVs (including tankers that visit the LOOP and tankers that are involved in lightering operations). As previously mentioned, AIS coverage, particularly for large vessels such as tankers) have been mandated for years, and the data clearly show vessel movements in the LOOP and lightering zones. Many smaller recreational vessels were also included in the data, further supporting the increase in AIS coverage. Missing data is possible but would be difficult to ascertain. As mentioned previously, AIS coverage for military vessels likely does not include activities related to sensitive operations such as enforcement efforts, patrols, and perhaps training exercises; however, as the extent of these practices is unknown, military activity is assumed to be underreported but no correction factors are available.

Table 8 shows the 2023 annual activity by non-O&G vessel type. Figures 16 through 19 show the 2023 AIS CMV vessel traffic for major CMV categories (bulk carriers, cargo ships, containerships, and tankers). The estimates from CMV operations were provided for each month based on the AIS date time stamp (Table 8).

Table 8. Annual and Monthly Gulfwide Non-Oil and Gas Production-Related Annual Activity for 2023 (megawatt-hours)

Vessel Type	2023 Annual MWh	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Bulk Carrier	2,213,997	11	9	9	8	9	9	8	8	7	8	7	8
Cargo	274,656	7	8	9	9	9	8	9	8	8	10	6	7
Carrier	1,259,502	10	7	10	9	9	9	9	8	7	7	6	8
Chemical Carrier	3,115,069	9	7	9	8	10	9	8	9	7	8	7	9
Containership	2,147,639	8	9	8	9	8	9	9	9	8	9	7	8
Cruise Ship	871,847	11	11	11	10	8	7	7	6	6	6	8	9
Dredge	377,064	8	7	7	7	9	8	8	8	9	10	10	9
Fishing	103,782	4	4	6	9	13	12	13	12	12	7	5	4
LNG Carrier	2,091,410	10	10	11	9	8	8	8	8	6	7	7	8
LPG Carrier	1,042,236	9	8	10	9	8	8	8	8	8	8	8	9
Merchant	209,230	8	8	8	8	9	9	8	9	8	8	8	8
Military	177,873	9	11	9	9	8	8	9	8	8	9	6	6
Miscellaneous	5,867	2	2	4	34	15	10	3	4	5	5	8	8
Passenger	87,299	9	9	12	9	9	8	7	7	7	7	7	8
Pleasure Craft	13,976	8	8	10	9	8	8	8	7	7	8	10	9
Reefer	42,118	8	8	8	9	12	8	9	11	7	6	6	7
Reefer Tanker	31,502	9	11	9	8	9	6	7	10	11	7	4	9
Research	42,437	11	9	12	9	10	9	10	8	6	5	5	6
Ro-Ro	189,275	9	8	9	9	8	10	8	6	10	8	6	7
Survey	54,546	7	7	7	8	9	9	8	7	7	12	8	11
Tanker	2,455,276	9	9	11	9	8	9	7	8	7	7	7	8
Tender	5,491	13	10	6	7	6	4	8	7	9	7	9	13
USCG	15,644	11	6	8	8	9	12	7	10	6	6	8	8

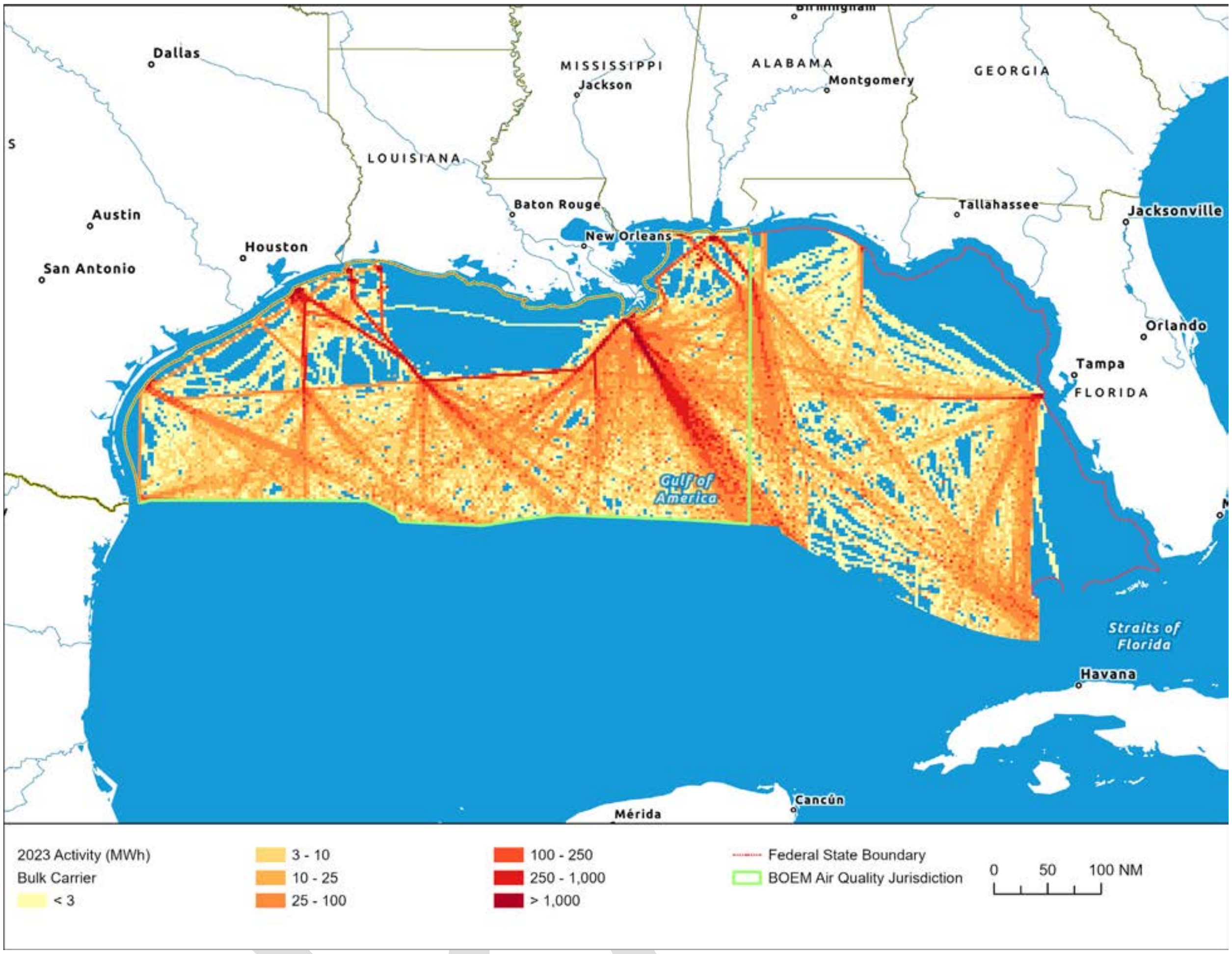

Figure 16. Annual Bulk Carrier Activity for 2023

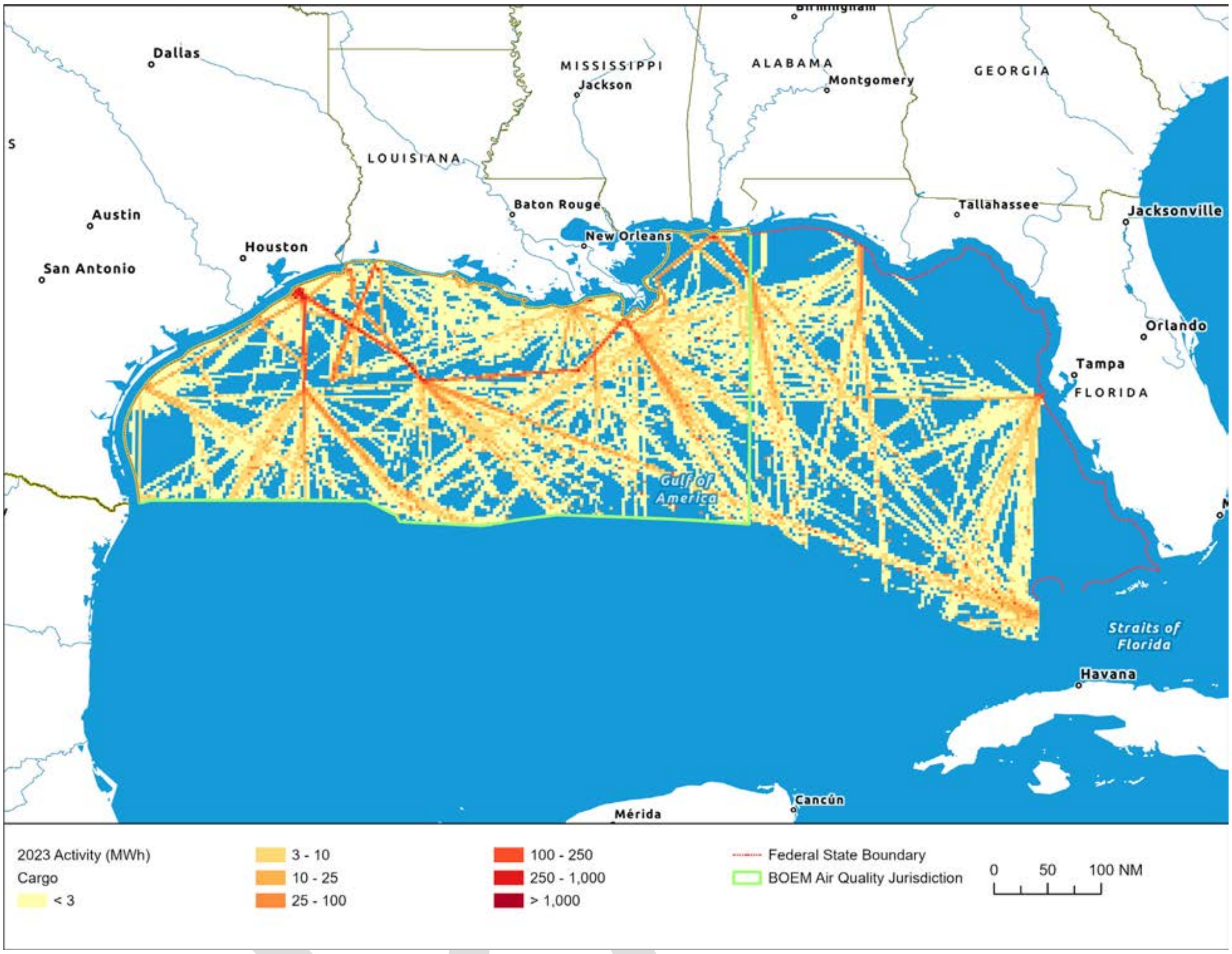

Figure 17. Annual Cargo Vessel Activity for 2023

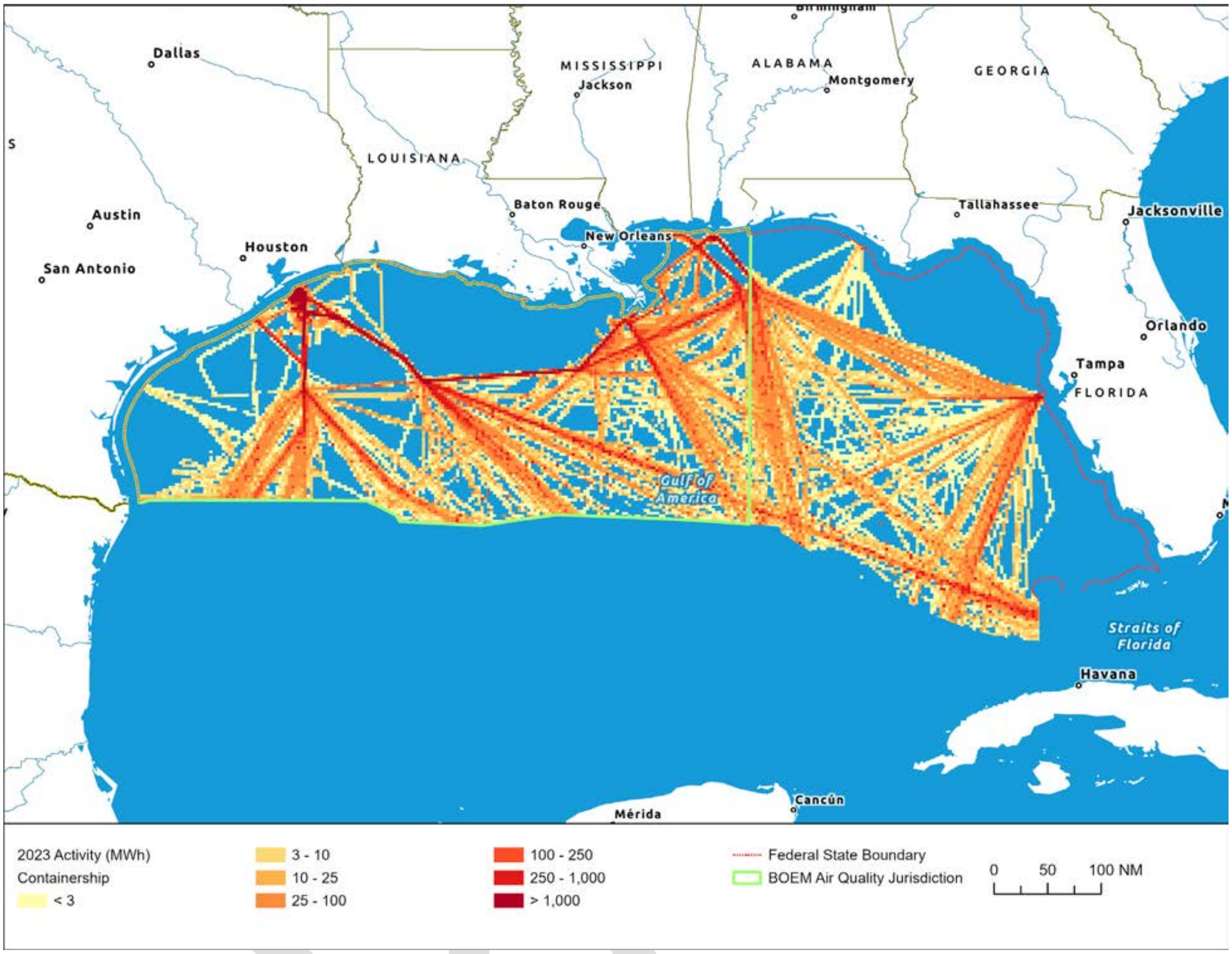

Figure 18. Annual Containership Vessel Activity for 2023

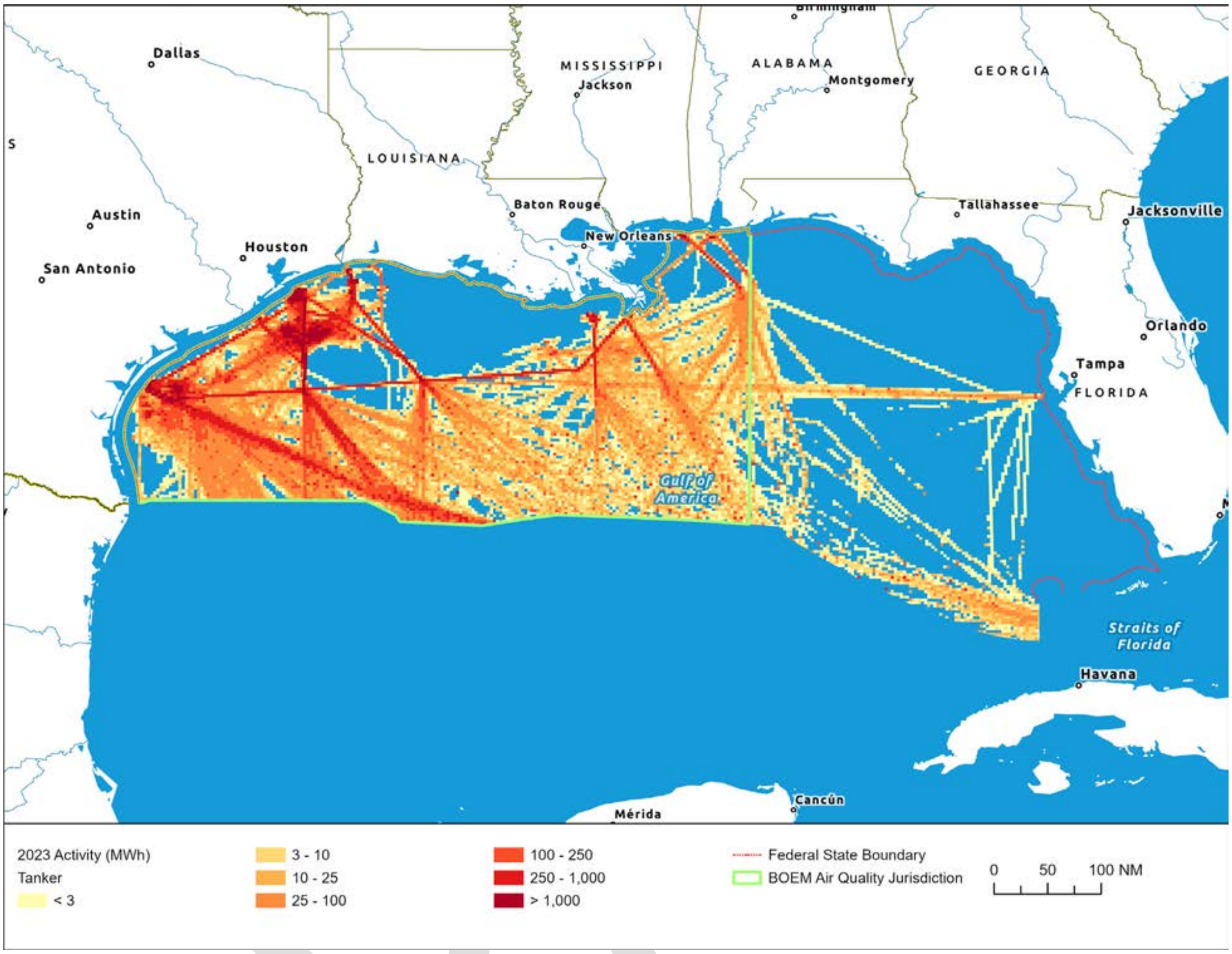

Figure 19. Annual Tanker Vessel Activity for 2023

Table 9. Monthly Commercial Marine Vessel Profile

Month	Percent Activity by Month (%)
January	8
February	7
March	9
April	8
May	9
June	8
July	8
August	9
September	8
October	9
November	8
December	9

5.2.1 Military Vessels

The U.S. Navy and USCG fleets consist of vessels powered by a variety of engines, including older residual-fueled steam turbines, marine diesel engines, and high-speed diesel turbines.

Over the years, the U.S. Navy's base closure program has shut down the remaining Naval installations in the central and western areas of the GOA, such that there are no regular Naval operations in the area outside of training exercises. In the BOEM 2017 inventory, Coast Guard data was obtained from the 2017 National Emissions Inventory (NEI) (USEPA 2019), and the U.S. Navy indicated no activities in the GOA. For the 2023 inventory, the AIS data was considered more comprehensive, even while noting its limitations. Table 10 summarizes the average hours of operation and horsepower ratings for these categories, and spatial profiles of military activities are found in Figures 20 and 21.

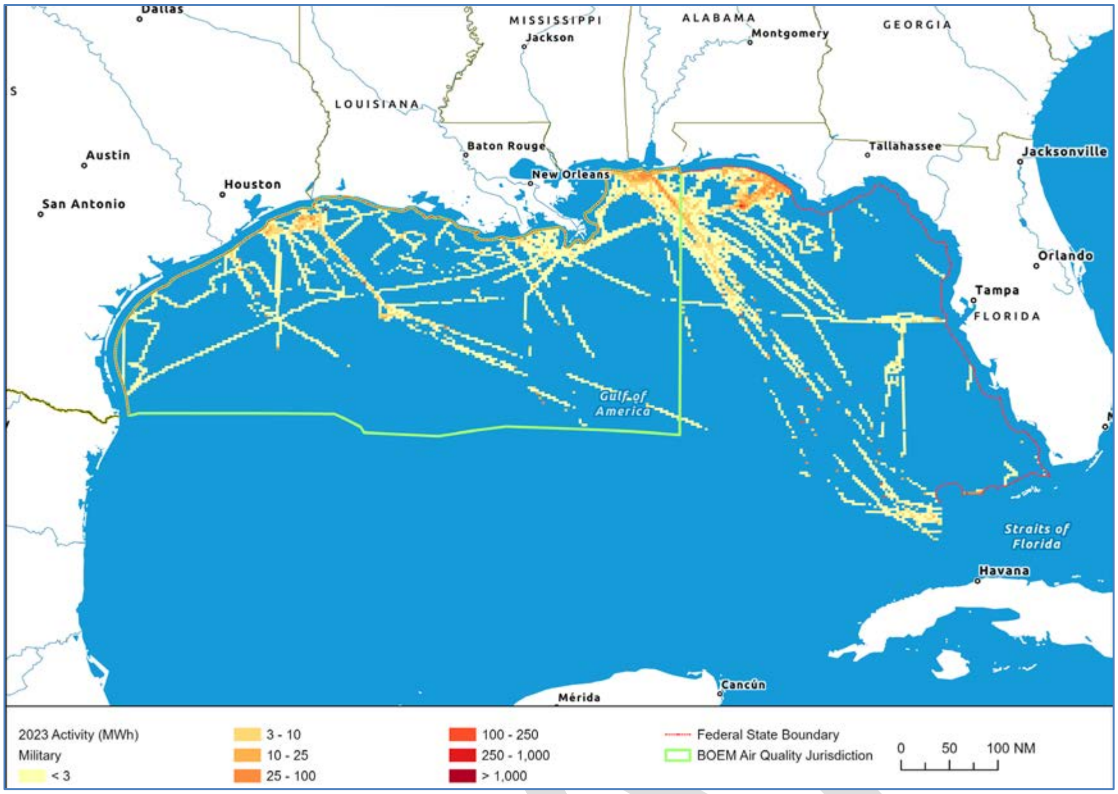

Figure 20. Annual Military Vessel Activity for 2023

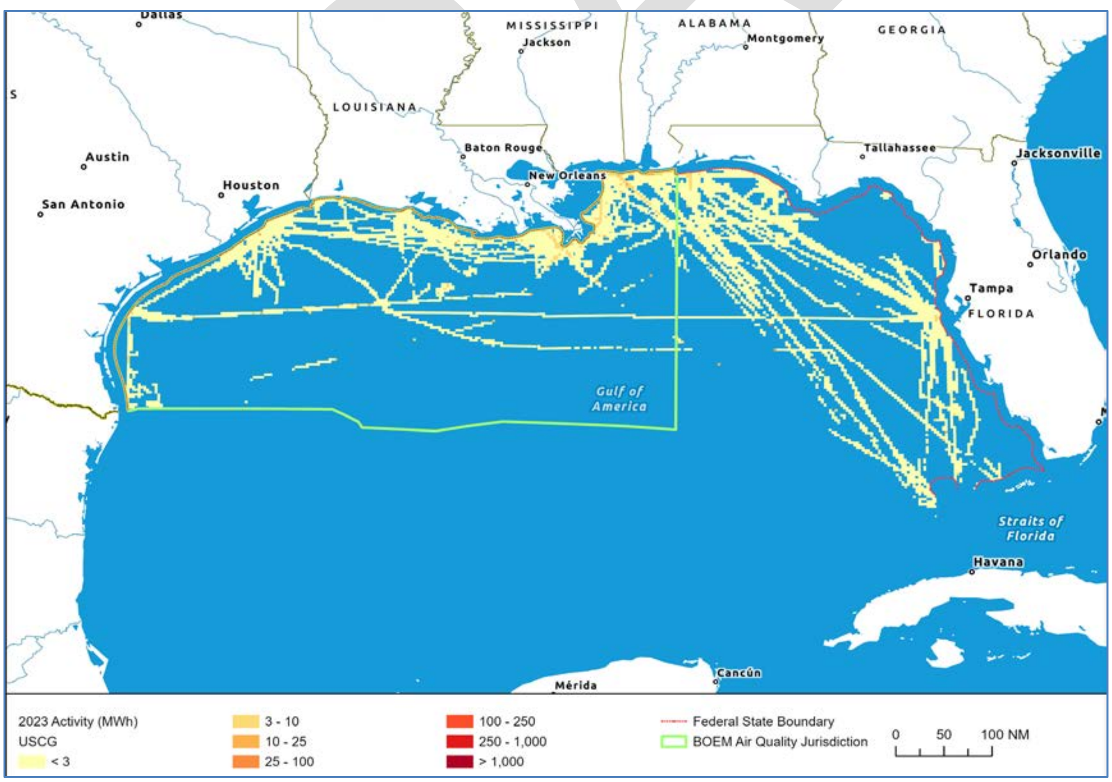

Figure 21. Annual U.S. Coast Guard Vessel Activity for 2023

Table 10. Monthly Military Vessel Activity

Month	2023 USCG Activity by Month (%)	2023 Military Activity by Month (%)
January	11	9
February	6	11
March	8	9
April	8	9
May	9	8
June	12	8
July	7	9
August	10	8
September	6	8
October	6	9
November	8	6
December	8	6

5.2.2 Louisiana Offshore Oil Port

The LOOP is located 18 nautical miles offshore from the town of Port Fourchon, LA. This offshore port allows up to three large oil tankers, either foreign or domestic, to simultaneously unload product without having to enter and maneuver inside urban ports with dense vessel traffic.

The tankers and support vessels associated with the LOOP were included in the AIS datasets; vessel emissions were not calculated separately for LOOP-related operations but rather are included in the appropriate tanker vessel type, which are at this point considered non-O&G-related.

5.2.3 Commercial Fishing Vessels

The Gulf is an active commercial fishing area, providing a wide range of fish and seafood products. Eight hundred and seven commercial fishing vessels were identified in the AIS data for 2023.

Table 11. Monthly Commercial Fishing Profile

Month	2023 Activity by Month (%)
January	4
February	4
March	6
April	9
May	13
June	12
July	13
August	12
September	12
October	7
November	5
December	4

The commercial fishing activity estimates were spatially assigned to lease blocks based on the fishing activity data available from AIS (Figure 22).

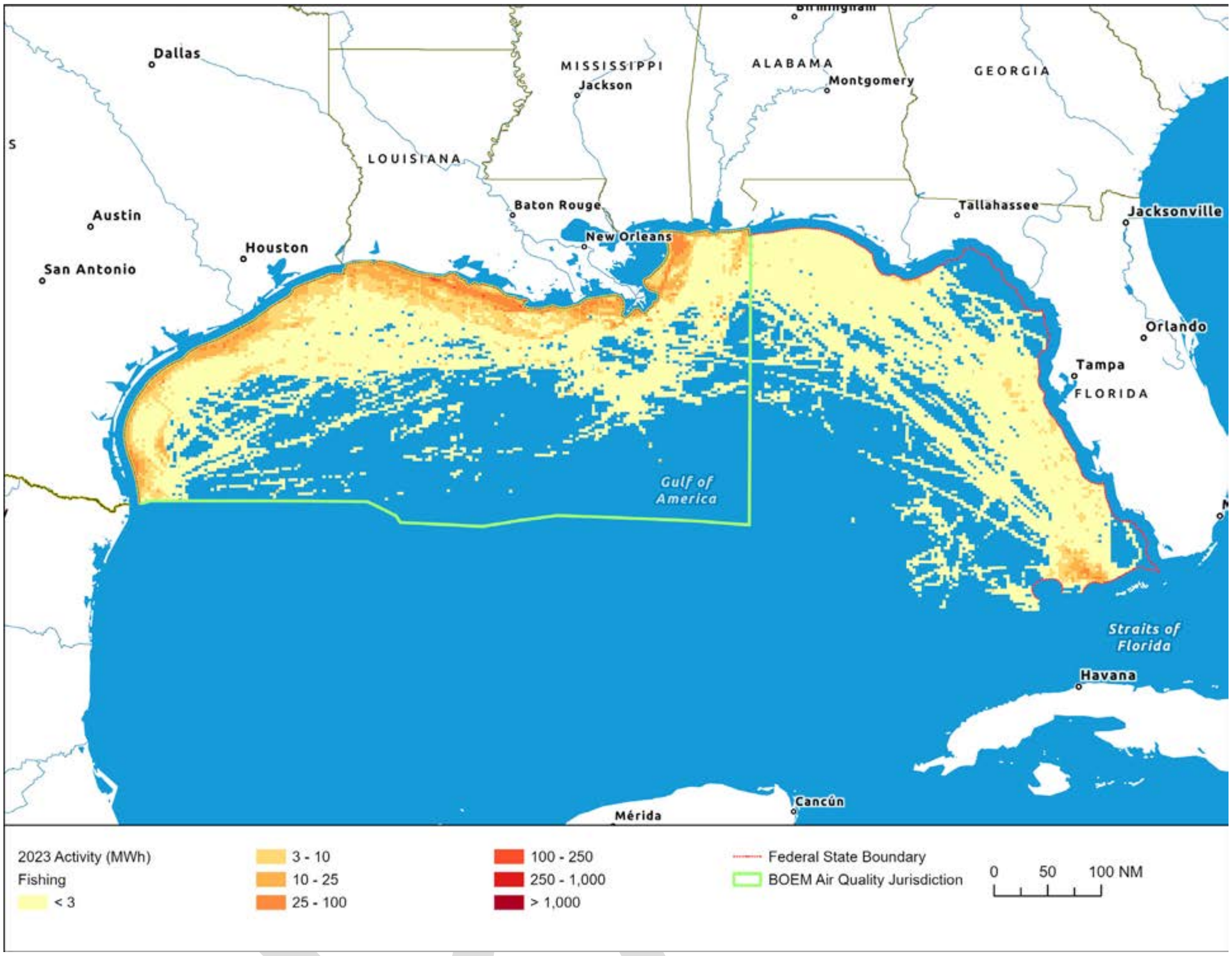

Figure 22. Annual Commercial Fishing Activity for 2023

5.2.4 Recreational Fishing and Miscellaneous Vessels

In the BOEM 2017 inventory, it was assumed that recreational fishing vessels were also underreported in the AIS data. However, due to the reduction in cost associated with class B AIS transponders, the number of smaller vessels represented in AIS data has grown significantly, as many vessel owners opt for the technology for increased safety. Additional review is currently being performed to see if there are significant class B transponders. As such, recreational fishing vessels and pleasure craft including yachts, motorboats, and sailing boats have been combined with other miscellaneous vessels, all of which are smaller, Category 1 vessels. Table 12 shows monthly activity profiles of these vessels, and Figure 23 reflects the spatial distribution of their annual activity.

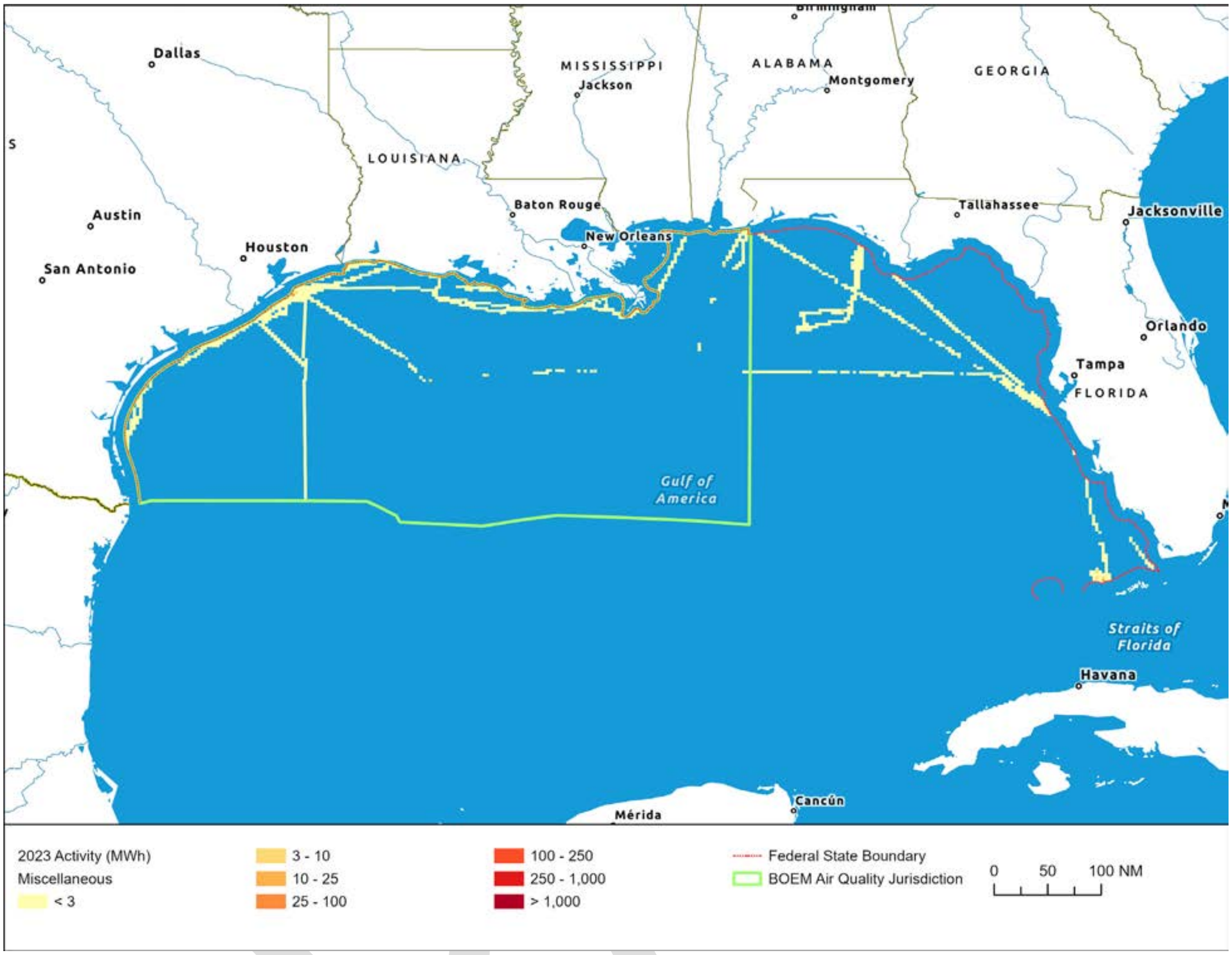

Figure 23. Annual Miscellaneous Vessel Activity for 2023

Table 12. Monthly Activity Profile for Miscellaneous Vessels

Month	2023 Activity by Month (%)
January	2
February	2
March	4
April	34
May	15
June	10
July	3
August	4
September	5
October	5
November	8
December	8

6 Non-platform QA/QC and Discussion

ERG implemented QA/QC checks at critical points in the development of the non-platform inventory, starting with review of the data compiled for this effort. Data sources were checked to ensure they represented the latest available data for the 2023 base year. The transferred data files were compared to the original data to ensure that the complete dataset was transferred and the data files were not corrupted during the transfer process. Transferred data were archived on a shared drive, and a working copy was developed for calculations.

Because the non-platform activity and vessel characteristics tend to be very large datasets, processing and calculations were implemented using R code. The processing within the scripts used for calculations was reviewed by experienced staff who were not directly involved in the original calculations. Additional queries specifically designed for QA were included throughout the calculations, including confirming record counts between processes and checking activity sums before and after spatial allocation. Special attention was given to unit conversions. Additional QA/QC checks were done in GIS to ensure that the spatial distribution was consistent with expectations and in-line with other data sources. Finally, results were compared to previous Gulfwide inventories.

6.1 Limitations

Limitations exist for some of the non-platform emission estimates based on the quality of the emission factors and the availability of source data. A significant previous limitation that has been addressed in this inventory year over the BOEM 2017 inventory is the temporal refinement of the data. As the 2017 vessel inventory was based on hourly AIS data, the 2023 dataset's 1-minute interval data is more precise to provide vastly superior resolution. Similarly, the helicopter's 10-second interval data is 30 times more frequent than the previous 5-minute interval, which is of particular importance to the ascending and descending portions of the flights where engine loads and emission factors are most variable.

The increased use of digital tracking data for marine vessels and helicopters provides emission estimates based on actual data rather than using assumptions about activity. These systems continue to evolve, both in terms of the number of vessels and helicopters that transmit tracking signals, as well as the geographic area these systems cover. Of particular note, the FAA completed and began relying on the ADS-B ground-station network (NextGen surveillance) and then required ADS-B Out for most aircraft operating in controlled U.S. airspace effective Jan 1, 2020 (FAA 2023). That mandate increased the share of aircraft — including many helicopters — that broadcast position and get "captured" in NextGen data.

BOEM evaluates the coverage of these sources to ensure that the data used are complete. For example, AIS coverage continues to improve in vessel adoption of coverage, receiver improvement (e.g., through the addition of more receivers including offshore), and initial data processing such as via the incorporation of satellite data, improvements in matching static and dynamic data elements, initial error detection, etc. However, intentionally disabling AIS technology is a recognized limitation, for both legitimate and illegitimate purposes. For example, it is understood that military vessels frequently turn off their AIS transponder when performing enforcement or other sensitive activities. "Ghost" or "dark" vessels may disable their AIS so as to avoid sanctions or protect what they view as confidential information such as fishing locations. Both of these actions result in data gaps within the AIS dataset.

A known issue with matching vessels identified in the AIS data to their vessel attributes is that smaller vessels are not well represented in classification society datasets (e.g., Clarksons) as the larger vessels. Much of the O&G-related vessels operating in the Gulf are small to medium sized ships equipped with smaller Category 1 and 2 engines. BOEM continues to compile information about these smaller vessels from alternative data sources (e.g., trade associations, web searches, and U.S. Waterborne Commerce data), though we have noted an increase in coverage of these smaller vessels in Clarksons over the years and expect this trend to continue. In addition to limitations on the side of registry data, some vessels may "spoof" their AIS identifier, by intentionally or unintentionally using incorrect vessel identifiers such as MMSI or IMO. This can result in an incorrect vessel category or type assignment, confusing route information (e.g., if multiple vessels are using the same identifier), of other challenges that could result in data that is impossible or incorrectly interpreted. QC processes at many steps of AIS data collection, verification, processing, and post-processing attempt to identify and manage these concerns so that the overall impact is limited but difficult to quantify.

The limitation on the NextGen helicopter data are that the 2023 January and February data were not available due to data transcription errors. Data from January and February of 2024 were used as a surrogate. Though the data for both March 2023 and 2024 were used and production data were compared between 2023 and 2024, 2024 is still a substitute for the actual missing January and February 2023 data.

As with the previous BOEM emission inventories, this inventory provides emission estimates for directly emitted pollutants; it does not take into account changes of the emissions due to physical and chemical processes that affect atmospheric concentration. These changes are based on the reactivity of the individual pollutant species and transformation rates to secondary pollutants. For example, the inventory does not quantify how the NO_x and VOC emissions affect the chemical composition of the marine boundary layer, particularly in the formation of ozone and hydroxyl radicals. The transformation of pollutants needs to be modeled to account for all factors that impact the transformation rate. These considerations come into play when the inventories are modeled to assess impacts.

6.2 Comparison with Other Studies

6.2.1 Helicopters

Pending comparison to BOEM 2017 inventory.

6.2.2 Marine Vessels

Pending comparison to BOEM 2017 inventory and 2023 NEI.

6.3 Conclusion

Data coverage for both marine vessels and helicopters increased in 2023 compared to the BOEM 2017 inventory. More vessels and helicopter were captured and data points were more accurate with shorter time durations. Activity for both helicopter and marine vessels have improved from previous inventories and can be used for more accurate emissions estimates. Additional conclusions are forthcoming.

6.4 Recommendations

Pending. With additional time and resources, there is much more that can be explored in further analysis of the data. Gathing information by helicopter altitude or vessel type and by water depth could be of use for BiOp's consideration on species' impacts. Additional research on seasonality variations could lead to more refined insight on how activities varied geospatially and temporally, which could help in modeling or projecting potential impacts of, for example, different weather conditions or operating concerns. As mentioned in the conclusion, additional analysis about the differences in marine load factors needs to be completed.

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Attachment A-2-1: Gap-Filling Vessel Characteristics by Vessel Type for 2023 Gulfwide Inventory

Vessel Type	Ship Category	Main Engine Power (kW)	Auxiliary Engine Power (kW)
Anchor Handling Tug	1	3,903.88	-
Anchor Handling Tug	2	6,444.55	-
Bulk Carrier	2	-	1,494.00
Bulk Carrier	3	8,491.74	2,221.70
Cargo	2	4,764.40	416.22
Cargo	3	6,404.81	1,799.01
Chemical Carrier	2	8,118.96	338.89
Chemical Carrier	3	-	2,867.78
Containership	3	44,387.83	9,010.14
Crew Boat	1	4,311.43	254.76
Cruise Ship	1	10,321.97	167.63
Cruise Ship	2	5,984.67	2,977.28
Cruise Ship	3	40,994.58	1,894.93
Dredge	1	-	1,009.64
Dredge	2	3,999.68	1,520.15
Drillship	2	-	0.00
Drillship	3	30,922.29	3,355.26
Fishing	1	664.84	157.26
Fishing	2	-	303.69
Jack-up	3	11,208.15	3,311.29
LNG Carrier	3	26,036.18	10,717.85
LPG Carrier	3	11,322.06	3,957.96
Military	1	32,077.59	1,616.62
Military	2	36,400.00	2,560.00
Military	3	-	2,427.25
Miscellaneous	1	1,491.40	0.00
Miscellaneous	3	-	5,061.00
Offshore Oil and Gas Support	1	1,921.54	459.03
Offshore Oil and Gas Support	2	19,952.74	1,158.49
Passenger	1	6,808.02	118.70
Pipelaying	3	13,297.08	688.11
Pleasure Craft	1	3,231.98	464.65
Reefer	3	10,428.29	3,738.28
Reefer Tanker	3	-	3,978.36
Research	1	2,240.99	2,305.64
Ro-Ro	2	-	2,360.00
Ro-Ro	3	13,758.18	4,037.36

Vessel Type	Ship Category	Main Engine Power (kW)	Auxiliary Engine Power (kW)
Supply	1	3,097.05	1,078.93
Supply	2	4,688.42	1,373.17
Supply	3	5,020.66	-
Support	1	3,980.67	1,439.28
Support	2	10,769.49	1,754.89
Support	3	5,677.86	1,285.08
Survey	1	-	423.97
Survey	2	-	1,228.11
Tanker	3	16,095.34	3,334.57
Tender	1	-	142.47
Tender	2	2,280.00	-
Towboat	1	900.56	113.65
Tug Tow	1	2,872.07	142.23
Tug Tow	2	4,594.47	296.90
Tug Tow	3	-	667.19
USCG	1	1,860.10	0.00
Workboat	1	1,555.84	328.59

Attachment A-3. 2023 BOEM Gulf of America Draft OECM Emissions Factors

Eastern Research Group, Inc.

2023 BOEM Gulf of America Draft OECM Emission Factors

Prepared for:

Bureau of Ocean Energy Management

U.S. Department of the Interior

Sterling, VA 20166

Prepared by:

Eastern Research Group, Inc.

3800 Gateway Centre Blvd., Suite 307

Morrisville, NC 27312

June 2026

ERG No. 0400.52.002.004

2023 BOEM GULF OF AMERICA DRAFT OECM EMISSION FACTORS

Contract Number GS-00F-079CA
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Prepared by:

Eastern Research Group, Inc.
3800 Gateway Centre Blvd., Suite 307
Morrisville, North Carolina 27560

June 2026

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1. BACKGROUND

This document details the approach used for developing 2023 total emissions for the Bureau of Ocean Energy Management's (BOEM) Offshore Environmental Cost Model (OECM) for the Gulf of America (GOA). The 2023 inventory was developed using Automatic Identification System (AIS) data from the Marine Cadastre for marine vessels and the Federal Aviation Administration's (FAA) NextGen data for helicopters. These datasets provide spatially and temporally refined representations of vessel and helicopter movements which, along with supplemental data on engine characteristics, allow for the calculation of high-resolution activity values in kilowatt-hours. Activity values are then used with emission factors from the Environmental Protection Agency's (EPA) Port Emissions Inventory Guidance to generate total annual emissions values (EPA 2022).

The last inventory based on AIS and NextGen data was conducted in 2017. Data and methodology have improved in the past several years and are reflected in the total emissions for 2023. Adoption and usage of the transponders for both AIS and NextGen has increased dramatically, resulting in more comprehensive coverage of the fleets (Skyquest 2025, FAA 2023). In 2017 the NextGen data was used to characterize typical helicopter trips and to validate helicopter trip assumptions. For the 2023 inventory emissions were calculated using the actual NextGen data. There are, however, still some limitations to the data. While most vessels and aircraft keep their transponders on for safety and regulatory compliance, users are able turn off their transponders if they desire, for both AIS and NextGen. This is a practice most commonly seen in military exercises and illegal operations, but quantifying the amount of missing data is not possible at this time. The following sections provide additional details on data processing to develop the vessel and helicopter emissions in the GOA for 2023 for use in OECM. More technical information will be available in the final BOEM inventory documentation (see interim report).

2. MARINE VESSELS

2.1 Marine Vessel Activity Data

AIS dataset from Marine Cadastre (NOAA 2024) consists of 1-minute interval records that include the vessel name, type, International Maritime Organization (IMO) identification number, Maritime Mobile Service Identity (MMSI), radio call sign, vessel type, position, actual speed, and timestamp of the data transmittal. Vessel identifiers were matched to Clarksons World Fleet Registry (WFR) and other vessel datasets to accurately identify each vessel's type, category, and engine characteristics including keel laid date, cylinder displacement, service speed, and power rating. Data gaps were filled using vessel type-specific averages and assumptions, details of which are described in detail in the BOEM GOA inventory documentation (see interim report).

Once all the data gaps in the vessel characteristics were populated, propulsive power was calculated using the Propeller Law, which requires each vessel's total installed propulsive power in addition to their optimal service speed, as documented in Eq. 1.

$$Power\ (kW) = \mathrm{LF} \times P_{ref} = \left(\frac{V}{V_{ref}}\right)^3 \times P_{ref} \qquad \textbf{Eq. 1}$$

where:

LF	=	load factor
P_{ref}	=	total installed propulsive power (kW)
V	=	AIS-reported speed (kn)
V_{ref}	=	service speed (kn)

Equation 1 is used to estimate the likely propulsive power applied for each vessel between consecutive AIS messages. The cubic ratio of the AIS reported speed following the message interval (i.e., each minute) and the vessel's optimal service speed is calculated to estimate a load factor (LF). The load factor represents the percentage of the vessel's total installed propulsive power assumed to be used during that activity interval.

2.2 Marine Vessel Emissions Data

The marine vessel emission factors used in this inventory to calculate total vessel emissions take into consideration the EPA's marine vessel fuel regulations as well as exhaust standards based on the year that the vessel was manufactured to assign the appropriate regulatory tier. These values are reported as grams per kilowatt-hour (g/kWhr) in Table 1 and Table 2 and were developed using engine tier factors reported in EPA's Port Emissions Inventory Guidance (EPA 2022). Note that the PM reported is primary and includes both filterable and condensable particulate matter. If the year of manufacture was unknown, the average keel laid date by vessel type and category was used to assume a default tier. As needed, low load adjustment factors were applied as described in the forementioned Port Guidance.

Once emissions for all gulfwide vessel activities were calculated, they were summed by vessel type in Table 3. Some vessel types were assumed to be exclusively dedicated to oil and gas (O&G)-related activities, while other vessel types are assumed to have activities that may or may not be O&G-related. For example, tugs and towboats may assist large vessels and/or equipment near platforms or they may be engaged in escorting barges or other non-O&G-related vessels into port areas. As it is challenging to differentiate activities that are related to O&G operations versus not, emissions for tankers and tugs/towboats are not reported at this time. Additional data refinements and/or updates will be completed at a future date. The vessel types assumed to be dedicated to O&G activities are as follows:

- Anchor handling tugs
- Crew boats
- Drillships
- FPSOs
- Jack-ups
- Support vessels
- Pipelaying
- Supply
- Survey

Table 1. 2023 Category 3 Vessel Emission Factors from EPA

Tier	Engine	CO (g/kWhr)	CO_2 (g/kWhr)	CH_4 (g/kWhr)	N_2O (g/kWhr)	NO_x (g/kWhr)	PM_{10} (g/kWhr)	$PM_{2.5}$ (g/kWhr)	SO_2 (g/kWhr)	VOC (g/kWhr)
0	Main	1.1	657.23	0.01	0.029	13.2	0.1867	0.1718	0.4008	0.5265
	Aux		695.702	0.008	0.029	13.8	0.1886	0.1735	0.4242	0.4212
1	Main	1.1	657.23	0.01	0.029	12.2	0.1867	0.1718	0.4008	0.5265
	Aux		695.702	0.008	0.029		0.1886	0.1735	0.4242	0.4212
2	Main	1.1	657.23	0.01	0.029	10.5	0.1867	0.1718	0.4008	0.5265
	Aux		695.702	0.008	0.029		0.1886	0.1735	0.4242	0.4212
3	Main	1.1	657.23	0.01	0.029	2.6	0.1867	0.1718	0.4008	0.5265
	Aux		695.702	0.008	0.029		0.1886	0.1735	0.4242	0.4212

Source: EPA, 2022. Port Emissions Inventory Guidance: Methodologies for Estimating Port-related and Goods Movement Mobile Source Emissions, EPA-420-B-22-11. April 2022. https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P1014J1S.pdf

Table 2. 2023 Category 1/Category 2 Vessel Emission Factors from EPA[1]

Tier	Engine	CO (g/kWhr)	CO_2 (g/kWhr)	CH_4 (g/kWhr)	N_2O (g/kWhr)	NO_x (g/kWhr)	PM_{10} (g/kWhr)	$PM_{2.5}$ (g/kWhr)	SO_2 (g/kWhr)	VOC (g/kWhr)
0	Main	1.6126	679.47	0.0056	0.0332	10.2815	0.2589	0.2511	0.0062	0.2956
	Aux			0.0056	0.0332					
1	Main	1.61	679.47	0.0056	0.0332	9.6240	0.2589	0.2511	0.0062	0.2956
	Aux			0.0056	0.0332					
2	Main	0.9187	679.47	0.0056	0.0332	5.642	0.1480	0.1436	0.0062	0.2956
	Aux			0.0056	0.0332					
3	Main	0.9187	679.47	0.0024	0.0332	4.7492	0.0830	0.0805	0.0062	0.1248
	Aux			0.0024	0.0332					
4	Main	0.9187	679.47	0.0024	0.0332	1.3	0.03	0.0291	0.0062	0.1248
	Aux			0.0024	0.0332					

Source: EPA, 2022. Port Emissions Inventory Guidance: Methodologies for Estimating Port-related and Goods Movement Mobile Source Emissions, EPA-420-B-22-11. April 2022. https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P1014J1S.pdf

2.3 Marine Vessel Spatial Representation

All activity within the GOA region should be included in total emissions as inputs to OECM. However, certain adjustments and assumptions were made to efficiently maximize quality given project schedule limitations. For this effort, activities and associated emissions were included for all lease blocks within the western, central, and eastern planning regions of the GOA (shown in gray in Figure 1). Note that this approach does not include the traffic from the port to the lease block boundaries; future revisions will attempt to include these emissions as well.

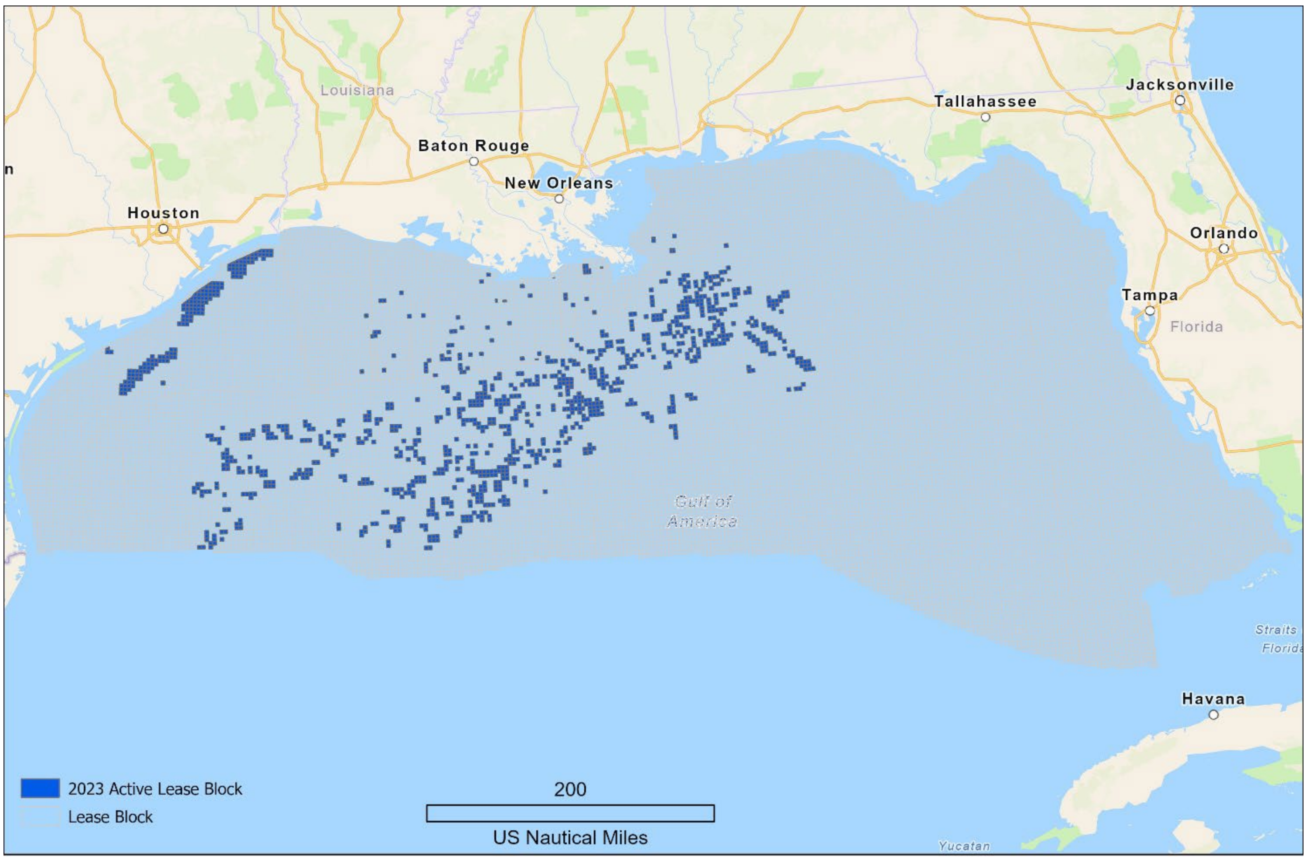

Figure 1. Lease Blocks (gray) and Active Lease Blocks (blue) in the Gulf of America in 2023

Total emissions within all lease blocks were summed and are presented in Table 3. Note that drillship emissions at the platforms are already included in OCS AQS, such that offshore hoteling activities were removed from the AIS-based activity and only underway emissions are represented above in Table 3.

Table 3. 2023 Gulfwide Marine Vessel Emissions (tons) by Vessel Type

Vessel Type	CO	CO_2	CH_4	N_2O	NO_x	PM_{10}	$PM_{2.5}$	SO_2	VOC
Anchor handling tugs	23.85	11,689.74	0.14	0.58	176.64	4.12	3.95	2.17	7.63
Crew boats	345.15	193,767.46	1.5	9.6	2,111.75	52.68	51.1	1.78	78.88
Drillships	17.52	9,091.78	0.17	0.4	144.41	2.7	2.49	6.33	9.14
FPSO	110.44	49,837.35	0.44	2.37	793.65	17.9	17.23	6.42	23.38
Jack-ups	8.75	4,641.75	0.08	0.2	73.04	1.37	1.26	3.27	4.38
Pipelaying Vessels	17.2	10,288.99	0.15	0.45	153.44	2.89	2.66	6.39	7.77
Supply Vessels	647.41	389,384.96	2.93	19.21	3,959.48	95.45	92.41	10.94	154.08
Support Vessels	303.38	182,508.94	1.95	8.49	2,522.81	48.12	45.48	53.37	102.68
Survey Vessels	70.59	32,513.91	0.69	1.58	506.44	11.23	10.57	16.72	36.47

Operations from other vessel types were assumed not to be related to oil and gas activities. Emissions from these non-O&G vessel types are not presented here and include the following:

- Bulk Carrier
- Cargo Carrier
- Chemical Carrier
- Containership
- Cruise Ship
- Dredge
- Ethylene/LPG
- Fishing
- LNG Carrier
- LPG Carrier
- Merchant
- Military
- Miscellaneous
- Passenger
- Pleasure Craft
- Reefer
- Research
- Ro-Ro
- Sailing
- Tanker*
- Tender
- Tug/Tow*
- USGS
- Yacht

Tankers, tugs, and towboats have some activities that may be O&G-related and other activities that are transit only or are not related to BOEM-authorized activities. A future version of this work will attempt to differentiate which activities are BOEM-related and provide emissions for these vessel types as well.

3. HELICOPTERS

3.1 Helicopter Activity Data

PASSUR's NextGen flight management data were used to quantify individual helicopter movements and were derived from speed, location, and elevation data (for more details, see interim report). 10-second observations from March 2023 through February 2024 were used to ensure one year of quality observation data. For this iteration, observation timestamps were used to calculate hours of activity by helicopter models.

ERG is working to characterize the activity data into O&G and non-O&G. For this version, all helicopter trips were assumed to be O&G, which is an over estimation. However, the NextGen data does not currently include idling times. Idling times will need to be added to the data which would underestimate activity and emissions. It is currently assumed these two would balance each other out so it's assumed that the emissions and activity will be similar once idling and O&G activity are accounted for in a future version compared to this current version. In the future version, non-O&G will be assumed to be all activity that starts and ends at a helipad located inland. All other activities will then be assumed to be O&G. The current flight hours are estimated to be 163,643 hours between 2,247 helicopters.

3.2 Helicopter Emissions

Emission factors from the Swiss Confederation's Guidance on the Determination of Helicopter Emissions (Swiss Confederation, 2015) were matched to helicopters based on helicopter make and model and when possible, also by engine make and model. Table 4 presents the emissions factors used to calculate total helicopter emissions in the GOA in 2023.

Table 4. Hourly Emission Factors by Helicopter Model

Model	Fuel Usage (kg/hr)	CO (kg/hr)	NO_x (kg/hr)	PM_{10} (kg/hr)	$PM_{2.5}$ (kg/hr)	SO_2 (kg/hr)	VOC (kg/hr)	Activity Percent
205A-1	109.5	1.03	0.61	0.0193	0.0188	0.175	0.943	0.0164%
206A	109.5	1.03	0.61	0.0193	0.0188	0.175	0.943	0.2554%
206A-1	109.5	1.03	0.61	0.0193	0.0188	0.175	0.943	0.0120%
206B	109.5	1.03	0.63	0.0194	0.0189	0.175	0.943	2.0645%
206B-III	101	0.9	0.58	0.0180	0.0176	0.162	0.828	0.2780%
206L-1	149.4	0.96	1.11	0.0320	0.0312	0.239	0.886	0.9383%
206L-3	149.4	0.96	1.11	0.0320	0.0312	0.239	0.886	0.3309%
206-L4	149.4	0.96	1.11	0.0320	0.0312	0.239	0.886	2.6858%
206L-4	149.4	59.8	1.11	0.0320	0.0312	0.239	0.828	1.0855%
212	360	1.12	4.1	0.1120	0.1093	0.576	2.024	0.0402%
214ST	271.3	0.62	3.09	0.0841	0.0821	0.434	0.610	0.0016%
222B	282.6	1.7	1.98	0.0590	0.0576	0.452	1.587	0.0023%
234	1223.6	0.98	24.23	0.4710	0.4597	1.958	0.955	0.0001%
269A	54.6	54.58	0.11	0.0080	0.0078	0.087	0.851	0.0094%
269C	54.6	54.5	0.11	0.0080	0.0078	0.087	0.851	0.3512%
269C-1	54.6	54.58	0.11	0.0080	0.0078	0.087	0.851	0.9139%
269D	54.6	54.58	0.11	0.0080	0.0078	0.087	0.851	0.0005%
280C	54.6	54.58	0.11	0.0080	0.0078	0.087	0.851	0.0045%
369A (OH-6A)	116.7	0.96	0.7	0.0216	0.0211	0.187	0.886	0.0146%
369D	116.7	0.96	0.7	0.0216	0.0211	0.187	0.886	0.3588%
369E	116.7	1.2	0.7	0.0216	0.0211	0.187	1.104	0.0992%
369FF	116.7	1.2	0.7	0.0216	0.0211	0.187	1.104	0.1199%
369HS	116.7	0.96	0.7	0.0216	0.0211	0.187	0.886	0.0167%
407	149.4	0.82	1.11	0.0320	0.0312	0.239	0.759	35.2074%
412	360	1.12	4.1	0.1120	0.1093	0.576	2.024	0.0057%
412EP	360	1.12	4.1	0.1120	0.1093	0.576	2.024	0.0134%
427	197.4	1.91	1.19	0.0370	0.0361	0.316	0.000	0.0036%
429	197.4	1.91	1.19	0.0370	0.0361	0.316	0.000	0.3789%
430	277.8	1.72	1.92	0.0570	0.0556	0.444	1.599	0.0749%
47D1	40.9	49.94	0.1	0.0035	0.0034	0.065	0.725	0.0007%
47G	40.9	49.94	0.1	0.0035	0.0034	0.065	0.725	0.0003%
47G-3B-1	40.9	49.94	0.1	0.0035	0.0034	0.065	0.725	0.0065%
47G-4	40.9	49.94	0.1	0.0035	0.0034	0.065	0.725	0.0068%
47G-4A	40.9	49.94	0.1	0.0035	0.0034	0.065	0.725	0.0040%
47G-5	64.6	64.62	0.13	0.0045	0.0044	0.103	0.874	0.0033%
480B	59.9	59.86	0.12	0.0095	0.0093	0.096	0.828	0.0330%

Model	Fuel Usage (kg/hr)	CO (kg/hr)	NO_x (kg/hr)	PM_{10} (kg/hr)	$PM_{2.5}$ (kg/hr)	SO_2 (kg/hr)	VOC (kg/hr)	Activity Percent
500N	116.7	1.2	0.7	0.0216	0.0211	0.187	1.104	0.0101%
505	114	0.98	0.66	0.0210	0.0205	0.182	0.909	0.7029%
525	564.7	1.24	6.66	0.1800	0.1757	0.904	1.185	0.0001%
600N	175.7	0.76	1.46	0.0420	0.0410	0.281	0.713	0.0124%
A109C	209.7	3.73	1.11	0.0359	0.0350	0.336	2.001	0.0418%
A109E	194.4	3.73	1.01	0.0358	0.0349	0.311	1.150	0.5006%
A109S	177.7	3.4	0.93	0.0350	0.0342	0.284	1.046	0.0790%
A119	216	0.78	1.77	0.0540	0.0527	0.346	0.081	0.4990%
AB139	412.2	1.65	3.55	0.1010	0.0986	0.660	1.576	0.5532%
AS 350 B2	146.5	0.7	1.16	0.0330	0.0322	0.234	0.656	1.1269%
AS 350 B2 ECUREUIL	146.5	0.7	1.16	0.0330	0.0322	0.234	0.656	0.2833%
AS 350 B3	200.3	0.72	1.82	0.0520	0.0508	0.320	0.679	0.2046%
AS 350B3	200.3	0.72	1.82	0.0520	0.0508	0.320	0.679	0.1617%
AS 355N	216.2	2.08	1.19	0.0380	0.0371	0.346	1.921	0.0048%
AS 365 N2 DAUPHIN	289.5	1.68	2.08	0.0610	0.0595	0.463	1.553	0.0081%
AS332L1	453.6	1.32	3.1	0.1510	0.1474	0.726	0.219	0.0097%
AS350 B2 ECUREUIL	146.5	0.7	1.16	0.0330	0.0322	0.234	0.656	0.0763%
AS350B	133.2	0.75	0.97	0.0290	0.0283	0.213	0.690	0.0126%
AS-350B ECUREUIL	146.5	0.7	1.16	0.0330	0.0322	0.234	0.656	0.0021%
AS350B2	146.5	0.7	1.16	0.0330	0.0322	0.234	0.656	0.1639%
AS350B3	308.9	1.61	2.35	0.0680	0.0664	0.494	1.507	1.0463%
AS350B3E	200.3	0.72	1.82	0.0520	0.0508	0.320	0.679	0.0017%
AS350BA	164.5	0.77	1.3	0.0380	0.0371	0.263	0.725	0.3493%
AS350BB	146.5	0.7	1.16	0.0330	0.0322	0.234	0.656	0.0002%
AW109SP	177.7	3.4	0.93	0.0350	0.0342	0.284	1.046	0.1391%
AW119	216	0.78	1.77	0.0540	0.0527	0.346	0.081	0.0208%
AW119 MKII	216	0.78	1.77	0.0540	0.0527	0.346	0.081	0.3653%
AW119MKII	216	0.78	1.77	0.0540	0.0527	0.346	0.081	0.3178%
AW139	412.2	1.98	3.55	0.1120	0.1093	0.660	1.576	9.0475%
AW169	360	1.98	2.56	0.1120	0.1093	0.576	0.299	0.4600%
AW189	360	1.98	2.56	0.1120	0.1093	0.576	0.299	1.4582%
BHI H60 (UH-60A)	507.6	1.32	5.43	0.0150	0.0146	0.812	1.277	0.0124%
BK 117 B-2	283.3	1.7	1.98	0.0590	0.0576	0.453	1.587	0.0001%
BO 105 P	203.5	2.28	1.04	0.0340	0.0332	0.326	2.093	0.0105%

Model	Fuel Usage (kg/hr)	CO (kg/hr)	NO_x (kg/hr)	PM_{10} (kg/hr)	$PM_{2.5}$ (kg/hr)	SO_2 (kg/hr)	VOC (kg/hr)	Activity Percent
BO 105M	203.5	2.28	1.04	0.0340	0.0332	0.326	2.093	0.0049%
BO 105S	203.5	2.28	1.04	0.0340	0.0332	0.326	2.093	0.0045%
BO105 CBS4	203.5	2.28	1.04	0.0340	0.0332	0.326	2.093	0.0099%
CABRI G2	72	72	0.14	0.0065	0.0063	0.115	0.966	0.0189%
CH-46E	541.3	1.25	6.17	0.1680	0.1640	0.866	1.219	0.0002%
CH47D	1223.6	0.98	24.23	0.4710	0.4597	1.958	0.955	0.0023%
CH-47D	1223.6	0.98	24.23	0.4710	0.4597	1.958	0.955	0.0034%
CH-54B	1083.4	0.98	20.37	0.4270	0.4168	1.733	0.932	0.0038%
EC 130 B4	182.6	0.75	1.57	0.0446	0.0435	0.292	0.702	0.4705%
EC 130 T2	259.3	1.84	1.66	0.0510	0.0498	0.415	1.714	0.2163%
EC 130B4	182.6	0.75	1.57	0.0446	0.0435	0.292	0.702	0.0003%
EC 135 P2	259.3	1.84	1.66	0.0510	0.0498	0.415	1.714	0.6805%
EC 135 P2+	259.3	1.84	1.66	0.0510	0.0498	0.415	1.714	3.4646%
EC 135 T2+	259.3	1.84	1.66	0.0510	0.0498	0.415	1.714	0.7276%
EC 155 B1	337.4	1.55	2.73	0.0790	0.0771	0.540	1.449	0.0534%
EC 155B	337.4	1.61	2.73	0.0790	0.0771	0.540	1.507	0.0085%
EC 155B1	337.4	1.55	2.73	0.0790	0.0771	0.540	1.449	0.0021%
EC 225 LP	621.2	1.18	7.89	0.2110	0.2059	0.994	1.127	0.0090%
EC120	114	0.98	0.66	0.0210	0.0205	0.182	0.909	0.0000%
EC120B	114	0.98	0.66	0.0210	0.0205	0.182	0.909	0.1451%
EC135 P2+	259.3	1.84	1.66	0.0510	0.0498	0.415	1.714	0.2018%
EC135 P3	259.3	1.84	1.66	0.0510	0.0498	0.415	1.714	0.1230%
EC135 T2+	259.3	1.84	1.66	0.0510	0.0498	0.415	1.714	0.3873%
EC135P1	259.3	1.84	1.66	0.0510	0.0498	0.415	1.714	0.2363%
EC135T1	259.3	1.84	1.66	0.0510	0.0498	0.415	1.714	0.9551%
EC135T2	259.3	1.84	1.66	0.0510	0.0498	0.415	1.714	0.4881%
EC135T2+	259.3	1.84	1.66	0.0510	0.0498	0.415	1.714	0.0019%
EC135T3	259.3	1.84	1.66	0.0510	0.0498	0.415	1.714	0.2176%
EC225 LP	621.2	1.18	7.89	0.2110	0.2059	0.994	1.127	0.0666%
EH-60A	507.6	1.32	5.43	0.0150	0.0146	0.812	1.277	0.0257%
EXEC 162F	34.5	34.5	0.07	0.0024	0.0023	0.055	0.552	0.0057%
F-28A	59.9	59.86	0.12	0.0095	0.0093	0.096	0.828	0.0025%
F-28C	59.9	59.86	0.12	0.0095	0.0093	0.096	0.828	0.0318%
F-28F	59.9	59.86	0.12	0.0095	0.0093	0.096	0.828	0.0062%
GAZELLE SA341F2	148.5	0.82	1.08	0.0320	0.0312	0.238	0.771	0.0007%
H-23D	40.9	49.94	0.1	0.0035	0.0034	0.065	0.725	0.0011%
HH-1N	271.3	0.62	3.09	0.0841	0.0821	0.434	0.610	0.0289%

Model	Fuel Usage (kg/hr)	CO (kg/hr)	NO_x (kg/hr)	PM_{10} (kg/hr)	$PM_{2.5}$ (kg/hr)	SO_2 (kg/hr)	VOC (kg/hr)	Activity Percent
HH-60L	507.6	1.32	5.43	0.0150	0.0146	0.812	1.277	0.0589%
HO5-S1	105	0.86	0.63	0.0194	0.0189	0.168	0.805	0.0007%
HUMMINGBIRD	64.6	64.62	0.13	0.0095	0.0093	0.103	0.874	0.0218%
JETEXEC	34.5	34.5	0.07	0.0024	0.0023	0.055	0.552	0.0024%
K-1200	283.9	0.62	3.35	0.0910	0.0888	0.454	0.587	0.0263%
MBB-BK 117 C-1	283.3	1.7	1.98	0.0590	0.0576	0.453	1.587	0.0464%
MBB-BK 117 C-2	283.3	1.7	1.98	0.0590	0.0576	0.453	1.587	1.7644%
MBB-BK 117 C-2E	283.3	1.7	1.98	0.0590	0.0576	0.453	1.587	0.1057%
MBB-BK 117 D-2	283.3	1.7	1.98	0.0590	0.0576	0.453	1.587	0.5446%
MBB-BK117 D-3	283.3	1.7	1.98	0.0590	0.0576	0.453	1.587	0.0270%
MD 900	223.2	3.39	1.08	0.0430	0.0420	0.357	1.001	0.1278%
MI-171E	485.1	1.41	4.95	0.1380	0.1347	0.776	1.323	0.0541%
MI-17-V5	485.1	1.41	4.95	0.1380	0.1347	0.776	1.323	0.0003%
MI-24D	621.2	1.18	7.89	0.2110	0.2059	0.994	1.127	0.0009%
OH-58	109.5	1.03	0.61	0.0193	0.0188	0.175	0.943	0.0183%
OH58A	112.3	1	0.64	0.0200	0.0195	0.180	0.920	0.0993%
OH-58A	112.3	1	0.64	0.0200	0.0195	0.180	0.920	1.0918%
OH-58C	112.3	1	0.64	0.0200	0.0195	0.180	0.920	0.5123%
OH-6	116.7	0.96	0.7	0.0216	0.0211	0.187	0.886	0.0068%
OH-6A	116.7	0.96	0.7	0.0216	0.0211	0.187	0.886	0.0085%
R22	72	72	0.14	0.0065	0.0063	0.115	0.966	0.1870%
R22 BETA	72	72	0.14	0.0065	0.0063	0.115	0.966	2.7597%
R22 MARINER	72	72	0.14	0.0065	0.0063	0.115	0.966	0.0762%
R44	59.9	59.86	0.12	0.0095	0.0093	0.096	0.828	4.2856%
R44 ASTRO	59.9	59.86	0.12	0.0095	0.0093	0.096	0.828	0.0012%
R44 II	59.9	59.86	0.12	0.0095	0.0093	0.096	0.828	5.1897%
R66	59.9	59.86	0.12	0.0095	0.0093	0.096	0.828	3.4431%
ROTORWAY 162F	34.5	34.5	0.07	0.0024	0.0023	0.055	0.552	0.0051%
ROTORWAY TALON A600	34.5	34.5	0.07	0.0024	0.0023	0.055	0.552	0.0049%
RPI 209	541.3	1.25	6.17	0.1680	0.1640	0.866	1.219	0.0037%
RW TALON TURBO	34.5	34.5	0.07	0.0024	0.0023	0.055	0.552	0.0025%
RW162F	34.5	34.5	0.07	0.0024	0.0023	0.055	0.552	0.0004%
S-58DT	196	2.43	0.94	0.0320	0.0312	0.314	2.231	0.0140%
S-58JT	196	2.43	0.94	0.0320	0.0312	0.314	2.231	0.0083%
S-58T	196	2.43	0.94	0.0320	0.0312	0.314	2.231	0.0023%
S-61A	507.6	1.32	5.43	0.0150	0.0146	0.812	1.277	0.0342%

Model	Fuel Usage (kg/hr)	CO (kg/hr)	NO_x (kg/hr)	PM_{10} (kg/hr)	$PM_{2.5}$ (kg/hr)	SO_2 (kg/hr)	VOC (kg/hr)	Activity Percent
S-61N	507.6	1.32	5.43	0.0150	0.0146	0.812	1.277	0.0357%
S-64E	1083.4	0.98	20.37	0.4270	0.4168	1.733	0.932	0.0227%
S70A-27	507.6	1.32	5.43	0.0150	0.0146	0.812	1.277	0.0083%
S-70C	507.6	1.32	5.43	0.0150	0.0146	0.812	1.277	0.0546%
S-70I	507.6	1.32	5.43	0.0150	0.0146	0.812	1.277	0.0009%
S-70M	507.6	1.32	5.43	0.0150	0.0146	0.812	1.277	0.0111%
S-76	313.4	1.6	2.38	0.0700	0.0683	0.501	1.495	0.0149%
S-76A	360	1.81	2.99	0.0850	0.0830	0.576	1.679	0.3006%
S-76B	360	0.79	2.99	0.0850	0.0830	0.576	1.495	0.0226%
S-76C	324.5	1.6	2.56	0.0740	0.0722	0.519	1.495	4.7881%
S-76C-2	324.5	1.6	2.56	0.0740	0.0722	0.519	1.495	0.4688%
S-76D	313.4	1.6	2.38	0.0700	0.0683	0.501	1.495	0.0931%
S-92A	735.1	1.1	10.59	0.2710	0.2645	1.176	1.047	1.6890%
S-97A	360	0.79	2.99	0.0850	0.0830	0.576	1.495	0.0025%
SA341F2	148.5	0.82	1.08	0.0320	0.0312	0.238	0.771	0.0182%
SA341G GAZELLE	148.5	0.82	1.08	0.0320	0.0312	0.238	0.771	0.0182%
SA342M	139.4	0.85	0.98	0.0289	0.0282	0.223	0.794	0.0029%
SH-3H	507.6	1.32	5.43	0.0150	0.0146	0.812	1.277	0.0110%
TH-13T	40.9	49.94	0.1	0.0035	0.0034	0.065	0.725	0.0092%
TH-1F	271.3	0.62	3.09	0.0841	0.0821	0.434	0.610	0.0005%
TH-55	54.6	54.58	0.11	0.0080	0.0078	0.087	0.851	0.0161%
UH-1	271.3	0.62	3.09	0.0841	0.0821	0.434	0.610	0.0073%
UH-12B	82.3	82.33	0.16	0.0058	0.0057	0.132	1.047	0.0002%
UH-1D	271.3	0.62	3.09	0.0841	0.0821	0.434	0.610	0.0104%
UH-1H	271.3	0.62	3.09	0.0841	0.0821	0.434	0.610	0.1267%
UH-1N	271.3	0.62	3.09	0.0841	0.0821	0.434	0.610	0.0171%
UH-1V	271.3	0.62	3.09	0.0841	0.0821	0.434	0.610	0.0301%
UH-60	507.6	1.32	5.43	0.0150	0.0146	0.812	1.277	0.0006%
UH-60A	507.6	1.32	5.43	0.0150	0.0146	0.812	1.277	0.0713%

Emission coefficients for CO_2, N_2O, and CH_4 were obtained from various sources as a function of fuel usage. Jet A fuel is the primary fuel used by helicopters. 3.16 kg CO_2 are released per kg of Jet A fuel usage (IATA, 2022), 0.716 g of CH_4 are released per gallon Jet A fuel usage (CARB, 2023), and 0.284 g of N_2O are released per gallon of Jet A fuel usage (CARB, 2023b).

The helicopters annual 10 second observations were summed up and converted into hours. These annual hours were then used with the hourly emission factors to estimate total annual emissions for 2023, which are summarized in Table 5 below. The 2023 emissions are almost double the emissions calculated for the 2017 Gulfwide Inventory. This is to be expected because NextGen Data was only voluntarily used by aircraft in 2017 but the equipment was mandated by 2020 (FAA, 2023). As a result, coverage has grown significantly for the 2023 inventory, and higher activity reflects this improvement.

Table 5. 2023 Annual Gulfwide Helicopter Emissions (tons)

Tons	CO	CO_2	CH_4	N_2O	NO_x	PM_{10}	$PM_{2.5}$	SO_2	VOC
Helicopters	2,111	113,317	0.837	3.321	278.1	8.324	8.124	57.38	180.6

The emissions totals for both helicopters and marine vessels are then reworked into new BOEM factors specifically for use in OECM.

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APPENDIX B: 2026 Interim Update of Mean Spill Rates for Offshore Environmental Cost Model (OECM)

U.S. Department of the Interior
Bureau of Ocean Energy Management

2026 Interim Update of Mean Spill Rates for Offshore Environmental Cost Model (OECM)

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List of Abbreviations and Acronyms

BOEM	Bureau of Ocean Energy Management
BSEE	Bureau of Safety and Environmental Enforcement
CI	Confidence Interval
CV	Coefficient of Variation
DFM	Diesel Fuel Marine
FFO	Furnace Fuel Oil
HFO	Heavy Fuel Oil
HS/LS	High Sulfur/Low Sulfur
IFO	Intermediate Fuel Oil
ITOPF	International Tanker Owners Pollution Federation
MDO	Marine Diesel Oil
MFO	Marine Fuel Oil
MGO	Marine Gas Oil
MMS	US Minerals Management Service
NOAA	National Oceanic and Atmospheric Administration
NRC	National Response Center
NSFO	Navy Special Fuel Oil
OCS	Outer Continental Shelf
OCSLA	Outer Continental Shelf Lands Act
OECM	Offshore Environmental Cost Model
OPA	Oil Pollution Act
PHMSA	Pipeline and Hazardous Materials Safety Administration
SEM	Standard Error of Mean
TIMS	Technical Information Management System
USACE	US Army Corps of Engineers
USCG	US Coast Guard
WOR	Water to Oil Ratio

1 Introduction

The Offshore Environmental Cost Model (OECM) uses mean spill rates to measure how much oil is spilled compared to how much is produced or transported in a given region over a specific time period. These rates are calculated by analyzing historical spill data from platforms, pipelines, and vessels operating on the US Outer Continental Shelf (OCS). Each spill incident is reviewed for inclusion based on its volume, material type, and operational source.

For each operational source, all spills that occurred on the OCS during a specific time period were identified. The total volume of oil spilled across these incidents was then calculated and divided by the total volume of oil produced or transported during the same period. This produces a mean spill rate expressed as barrels spilled per barrel handled, representing the historical average relationship between operational activity and spill occurrence.

The mean spill rate is calculated as:

$$\textit{Mean spill rate} = \frac{\sum_{i=1}^{n} \boldsymbol{V_i}}{\boldsymbol{P}}$$

Equation 1: Mean spill rate

where:
V_i= volume of individual spill i in barrels
n= total number of spills
P= total production or transportation volume in barrels

2 Classification

Mean spill rates are estimated for combinations of three key characteristics: the operational source of the spill, the spill volume, and the material type. This classification captures the full range of spill scenarios that occur during offshore oil and gas operations.

2.1 Operational Sources

Spills are evaluated across five operational sources in offshore operations, shown in **Table 1**. Each source operates under different conditions and handles oil and gas differently, resulting in distinct mean spill rates.

Table 1: Operational source of spills

Source	Description
OCS platforms	Offshore structures where oil and gas are extracted from beneath the ocean floor
OCS pipelines	Underwater pipelines that transport oil from platforms to shore or to other facilities
OCS vessels	Supply and support vessels that operate around offshore platforms

Source	Description
Crude oil and gas tankers	Large ships that transport unrefined oil and natural gas
Refined oil tankers	Ships that carry refined petroleum products like diesel

2.2 Size Category

Spills are classified into size categories based on the volume of oil released, measured in barrels (equal to 42 US gallons). The specific size ranges vary depending on the oil type and operational source, reflecting differences in operational scale and typical spill volumes observed historically.

Spills are classified into six size categories: Very Small, Small, Medium, Large, Very Large, and Extra Large (specific to tankers). **Table 2** and **Table 3** define the size categories used in this analysis.

Table 2: Crude oil spill size category boundaries by operational source (barrels)

Source	Very Small	Small	Medium	Large	Very Large	Extra Large
OCS Platforms	1 to 10	11 to 100	101 to 1,000	1,001 to 10,000	10,001 to 100,000	—
OCS Pipelines	1 to 10	11 to 100	101 to 1,000	1,001 to 10,000	10,001 to 100,000	—
OCS Vessels	1 to 10	11 to 101	101 to 1,001	1,001 to 10,001	10,001 to 100,001	—
Crude Oil and Gas Tankers	0.1 to 11	11 to 100	101 to 1,001	1,001 to 10,001	10,001 to 100,001	Over 100,001
Refined Oil Tankers	0.1 to 11	11 to 101	101 to 1,001	1,001 to 10,001	10,001 to 100,001	Over 100,001

***Crude Oil:** Crude oil includes condensate, as both are often produced simultaneously and handled through the same infrastructure. Available data does not provide distinguishing information between differing types of crude oil, so a generic definition was used.

Note: Category boundaries use exclusive upper bounds except for the final category in each row.

Table 3: Diesel spill size category boundaries by operational source (barrels)

Source	Very Small	Small	Medium	Large	Very Large	Extra Large
OCS Platforms	1 to 2	2 to 10	11 to 100	101 to 1,000	1,001 to 3,600	—
OCS Pipelines	1 to 2	2 to 10	11 to 100	101 to 1,000	1,001 to 10,000	—
OCS Vessels	1 to 2	2 to 11	11 to 100	101 to 1,001	1,001 to 10,000	—
Crude Oil and Gas Tankers	0.1 to 11	11 to 101	101 to 1001	1,001 to 10,001	10,001 to 100,001	Over 100,001
Refined Oil Tankers	0.1 to 11	11 to 101	101 to 1001	1,001 to 10,001	10,001 to 100,001	Over 100,001

Note: Category boundaries use exclusive upper bounds except for the final category in each row.

2.3 Types of Oil

Spills are evaluated across two oil types, shown in **Table 4**. By tracking these different oil types separately, we can better estimate the environmental impacts of potential spills, since different oils spread, weather, and affect marine environments in different ways.

Table 4: Oil types

Oil Type	Description
Crude & Condensate	Unrefined petroleum extracted from subsurface reservoirs, including lighter condensate hydrocarbons that separate from natural gas during production
Diesel	All refined petroleum fuel products, including light distillates and heavy fuel oils used in marine operations

Due to varying terminology and classification systems across agencies and organizations, we established standardized definitions to prevent bias and ensure that comparable incidents were included regardless of which dataset they came from.

2.3.1 Crude Oil and Condensate

A key limitation of the available incident data is that there is an inconsistent level of detail provided to distinguish between specific crude oil types based on viscosity or origin. Consequently, all crude oil spills in this analysis apply a single generic crude oil classification rather than reflecting the specific characteristics of different crude oil types.

2.3.2 Diesel

Diesel fuels have terminological differences across global markets and industries. The numbered fuel oils (No. 1 through No. 6) include aliases shaped by regional preferences, industry-specific applications, and regulatory frameworks. The common terms found within each dataset are identified in **Table 5**, below.

Table 5: Diesel material types

Fuel Oil Grade	Alias
No. 1	Kerosene, Paraffin, Jet Fuels
No. 2	Diesel Fuel Marine (DFM), Marine Gas Oil (MGO), Road/Rail Diesel
No. 3	Marine Diesel Oil (MDO)
No. 4	Bunker A, Intermediate Fuel Oil (IFO), High/Low Sulfur IFO (HS/LS)
No. 5	Bunker B, Heavy Fuel Oil (HFO), Navy Special Fuel Oil (NSFO), Furnace Fuel Oil (FFO), Residual Fuel Oil
No. 6	Bunker C, Marine Fuel Oil (MFO)

2.3.3 Mixtures

Spills involving mixtures of two or more material types were excluded from the analysis when incident reports did not provide specific volume breakdowns for each component. This exclusion primarily affected spills of produced water, which is typically reported as a single volume despite being a mixture of water and crude oil.

While it might seem logical to estimate oil volumes in produced water using Water to Oil Ratios (WOR), this approach was rejected for two reasons. First, available WOR data comes primarily from inland facilities and may not accurately reflect offshore conditions. Second, produced water typically contains significantly more water than oil, and applying potentially inappropriate ratios could substantially overestimate oil quantities and compromise the analytical integrity of the study.

Rather than risk introducing systematic errors through unreliable estimation methods, spills were excluded when reports identified them as mixed materials but failed to specify individual component volumes. This conservative approach prioritizes data accuracy over dataset completeness

2.3.4 Exclusions

Based on these definitions, the following petroleum product categories are excluded from spill rate calculations:

- Certain distillation products (naphthas, thermal fluids)
- Non-fuel refined products (lubricants, waxes, bitumen, asphalt)
- Solid refining by-products
- Intermediate refinery streams (petrochemical feedstocks such as coker/catalytic feed oils)
- Manufactured derivatives (synthetics, resins, aromatics)
- Blended products containing non-petroleum components (e.g., biodiesel blends)
- Vegetable-based oils (e.g., coconut oil)

This definition may result in decreasing reported spill counts over time as synthetic and bio-blend fuels become more prevalent in marine operations. This trend will likely accelerate as regulatory requirements, economic incentives, and environmental policies drive the transition from conventional petroleum products to alternative fuels outside the defined scope.

3 Spill Data Source

The study integrates data from six primary sources:

1. Bureau of Safety and Environmental Enforcement (BSEE) Technical Information Management System (TIMS)
2. Anderson et al. (2012) *Update of occurrence rates for offshore oil spills* - Supplemental Data
3. US Coast Guard National Response Center (NRC) incident reports
4. Pipeline and Hazardous Materials Safety Administration (PHMSA) hazardous liquid pipeline reports
5. National Oceanic and Atmospheric Administration (NOAA) incident tracking system
6. International Tanker Owners Pollution Federation (ITOPF) vessel spill records

3.1.1 Technical Information Management System (TIMS)

BSEE oversees offshore facilities on the OCS under 30 CFR §254. These facilities must maintain detailed response plans, equipment inventories, and personnel training records. Data collection requirements include real-time operational monitoring, regular equipment inspections, and immediate incident reporting protocols. Spill event documentation covers volume estimates, source identification, weather conditions, and response effectiveness. Under BSEE NTL No. 2019-N05, operators must provide immediate oral notification to the BSEE Regional Supervisor for any spill of one barrel or more. This requirement also applies when operators suspect a potential spill meeting this threshold. Operators must additionally report spills observed from other offshore facilities to both BSEE and the responsible party. Initial notifications must include the NRC report number, spill description, location coordinates, estimated volume and release rate, hydrocarbon characteristics, response status, and environmental conditions. A written report must be submitted to the Chief of the Oil Spill Preparedness Division within 15 days after the spill has been stopped, detailing the hydrocarbon type, observed conditions, operational context, cause, and facility status.

TIMS is an internal database containing sensitive operational data, including detailed incident reports, proprietary company information, and confidential investigation materials. Due to security requirements, TIMS is not publicly accessible. BOEM and BSEE provided TIMS data for developing the spill rates in this study.

3.1.2 *Update of occurrence rates for offshore oil spills* Supplemental Data

There are very few spills in the TIMS dataset prior to 1995 as a result of switching from the US Minerals Management Service (MMS) information system to TIMS. A supplemental dataset curated by Anderson et al. (2012) was included that provides a historical spills prior to 1995. The supplemental dataset includes additional verification information for each spill and includes communication notes that confirm spill volume and/or location.

3.1.3 NRC Reports

Th NRC Reports, maintained by the US Coast Guard (USCG), are the initial notifications of potential marine casualties, pollution incidents, or security threats. These reports serve as the first alert mechanism and are required by law for certain incidents. When someone reports an incident to the NRC, it generates a report number and immediately notifies the appropriate federal, state, and local agencies. The NRC dataset begins from 1990 as a result of the passing of the Oil Pollution Act (OPA), requiring mandatory reporting of oil and chemical spills. Before 1990, reporting was voluntary, and data collection was inconsistent. The OPA 1990 standardized reporting requirements and established the modern NRC reporting system.

3.1.4 PHMSA Pipeline Reports

PHMSA regulates pipeline operations under 49 CFR 194, requiring documentation of system specifications, maintenance activities, and response capabilities. When spills occur, operators must document incident causes, response measures, and remediation effectiveness.

PHMSA reporting requirements for oil spill incidents are outlined in 49 CFR Part 195. Under §195.50, operators must report accidents that meet any of these criteria:

- Releases of five gallons or more of hazardous liquid (including petroleum and petroleum products)
- Releases resulting in death or injury requiring hospitalization

- Releases resulting in fire or explosion
- Releases causing property damage exceeding $50,000
- Releases that could significantly affect the environment

Operators must notify the NRC at the earliest practicable moment, but no later than one hour after confirmed discovery. Written reports must be submitted on Form PHMSA F 7000-1 within 30 days of the accident. These Form F 7000-1 submissions populate PHMSA's Hazardous Liquid Pipeline Incident Database, which documents all reportable pipeline incidents since 1968. Supplemental reports are required within 30 days when new information becomes available, updating the original database entries. The complete database is publicly accessible through PHMSA's Pipeline Safety Data and Statistics webpage.

3.1.5 NOAA Incident News

NOAA maintains an incident tracking system that documents oil and chemical spills, releases, and other incidents affecting marine resources and coastal areas. This system operates alongside the NRC but serves a distinct purpose focused on environmental assessment and scientific support rather than initial emergency notification.

NOAA's Office of Response and Restoration uses incident reports to assess potential threats to marine resources, protected species, and coastal habitats. The system enables NOAA to deploy scientific support coordinators, model spill trajectories, evaluate environmental impacts, and support natural resource damage assessments. This specialized focus allows NOAA to provide scientific expertise during response operations and track long-term environmental consequences.

While the NRC serves as the primary national contact point for immediate notification of all hazardous substance releases nationwide, NOAA's system specifically targets environmental impacts to coastal and marine ecosystems. The NRC emphasizes rapid coordination of emergency response across federal, state, and local authorities. NOAA focuses on environmental protection, scientific assessment, and resource restoration.

3.1.6 ITOPF Vessel Records

The ITOPF, headquartered in the UK, is a nonprofit organization established by the world's shipowners to promote effective response to marine spills of oil, chemicals, and other hazardous substances. While the NRC serves as the United States' primary point of contact for spill reporting, ITOPF maintains its own global incident tracking system to serve the international maritime community and support worldwide spill response efforts.

ITOPF's incident tracking system serves several distinct purposes from the NRC's domestic reporting requirements. The organization uses this data to provide technical support and advice during marine spills, conduct research on spill impacts and response methods, and develop best practices for the shipping industry.

3.2 Spill Incident Data Reliability

The six datasets capture spill information at different stages, from initial detection through environmental response. In some instances the same spill was captured in multiple datasets. When duplicate records appeared, data from the most reliable sources were prioritized.

Data sources were classified into three reliability levels:

Low: Information collected during the immediate response phase
Medium: Operator-reported information that has not undergone independent verification
High: Information has been reviewed, verified, or validated by regulatory agencies or other authoritative sources.

This classification reflects data collection stage and verification status, not organizational credibility. Spill information naturally evolves as investigations progress, with initial estimates routinely revised through detailed post-incident analysis. The data sources are sorted by reliability in **Table 6** below.

Table 6. Spill data sources (Sorted by reliability)

Data Source	Agency	Facilities	Time Period	Reliability Type	Data Reliability
Anderson Report (2012)	BSEE	Platforms, vessels, pipelines	1964-2011	Systematic Review	High
ITOPF Vessel Records	ITOPF	Vessels	1964-2005	Systematic Review	High
TIMS	BSEE	Platforms, vessels, pipelines	1995-2024	Reporting Requirements	Medium
PHMSA Pipeline Reports	PHMSA	Pipelines	1985-2024	Reporting Requirements	Medium
NOAA Incident Reports	NOAA	Platforms, vessels, pipelines	1969-2024	Emergency Response	Low
NRC Incident Reports	USCG	Platforms, vessels, pipelines	1990-2024	Initial Sighting	Low

4 Geographic Location

This study focuses solely on incidents within the US OCS Planning Areas, shown in **Figure 1**. The OCS is defined and regulated by the Outer Continental Shelf Lands Act (OCSLA) of 1953, which establishes federal jurisdiction over submerged lands beginning where state jurisdiction ends. State waters typically extend 3 nautical miles from shore (9 nautical miles for Texas and Florida's Gulf coast, as designated by the Submerged Lands Act of 1953), and the OCS extends to approximately 200 nautical miles offshore. OCSLA authorizes the Department of the Interior to manage mineral exploration and development in this region. Subsequent legislation has expanded this authority to include renewable energy (Energy Policy Act of 2005) and established environmental protections (NEPA and the Coastal Zone Management Act). Spills occurring outside the OCS may involve different response agencies, regulatory frameworks, causal factors, and environmental outcomes.

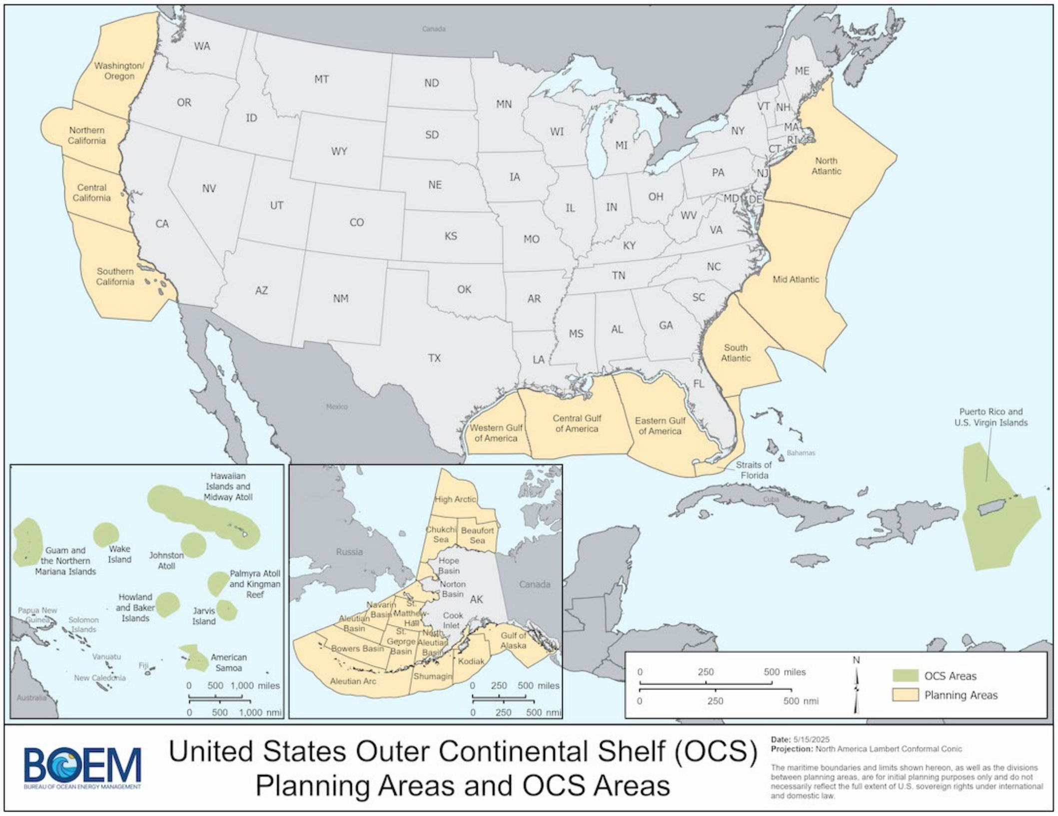

Figure 1: US Outer Continental Shelf
(BOEM 2025)

4.1 Coordinate Precision

When possible, spill locations were validated by comparing reported coordinates to OCS boundary shapefiles. A shapefile is a geospatial data format that stores the location and polygon shape of geographic features defining the OCS boundaries. By overlaying spill coordinates, latitude and longitude points, with these boundary polygons, one can determine whether an incident occurred within the OCS.

However, coordinate precision significantly affects the accuracy of boundary determination, particularly at the 3 nautical mile limit separating state and federal waters. Coordinate precision refers to the number of decimal places in latitude and longitude values, which determines how accurately a location can be specified, as seen in **Table 7**.

Table 7: Precision

Decimal Places (Example)	Precision	Example
1 (29.1°)	±11 km	City-level accuracy
2 (29.12°)	±1.1 km	Neighborhood-level
4 (29.1234°)	±11 m	Building-level
6 (29.123456°)	±11 cm	Survey-grade

Low-precision coordinates can misplace incidents by miles, incorrectly classifying them relative to the OCS boundary. Additionally, some coordinates represent estimates from unverified sources rather than measured locations. Low-precision values were verified against additional sources when possible.

4.2 Impact on Vessels

Limitations of the study to the OCS largely impact the number of vessels (tankers and barges) included in the study as most oil transport vessels typically follow established shipping lanes closer to shore or in international waters. The OCS region represents only a portion of the total maritime traffic area, with many tankers and barges preferring to travel along coastal routes for more efficient port access and shorter transit times. This geographical constraint significantly reduces the sample size of vessels traversing the study area, which may explain the notably lower incidence of recorded spills relative to coastal waters where vessel density is substantially higher. The spill location is the estimated point of origin. It reflects the initial point of observation. This limitation means that some spills may originate in the OCS but go undetected until found within state waters.

4.3 Limited Location Information

Within the PHMSA Pipeline Reports, different reporting forms across time periods created varying challenges for identifying OCS incidents. Incidents between 1968 and 1986 have no coordinate information or any additional fields that could be used to determine if the spill location was on the OCS. After exhausting all options, we proceeded by dropping incidents within this range for PHMSA from the study. The reporting form changed in 1985, and incidents from 1985 through 2002 may still be missing coordinate information or contain latitude-longitude coordinates without a point of origin or datum. However, this later form included additional location-related fields not available in the earlier period. When possible, we used these available fields from the 1985-2002 form to determine if a spill occurred inland or offshore. However, not all offshore spills could be specifically placed on the OCS. When possible, we hand-validated large spills (>1,000 bbls) to reduce the overall impact to the study.

5 Volume Handled

To calculate accurate spill rates, we need to establish the total volume of oil handled by each operational source, which serves as the denominator in the rate equation. We define volume handled as annual production volume for platforms and pipelines, which extract and transport domestically produced oil, and as annual transportation volume for vessels, which move both domestic production and foreign imports through federal waters.

5.1.1 Annual Production Volume

Total US crude oil and condensate production on the OCS is used as a proxy for total volume handled by platforms and transported by pipeline. For the purposes of our study, annual production volume was provided by the Bureau of Ocean Energy Management (BOEM).

5.1.2 Annual Transportation Volume

For vessels, including tankers and barges, volume transported (rather than production volume) was used as the proxy for volume handled, reflecting how vessels transport both domestic production and foreign imports.

Volume data were extracted from US Army Corps of Engineers USACE Waterborne Commerce annual reports (Part 5, Section 2), which itemize commodities such as crude oil. Foreign imports/exports and domestic coastal and intra-territory freight volumes were included. Foreign volumes were adjusted by half to account for the estimated portion of transit time within the OCS. Domestic volumes from lakewise, internal, intraport, and local sources were excluded as these movements occur outside the OCS.

6 Large Spills

Large spills are those where the volume release exceeds 1,000 barrels. The large spills by operational source are provided in Tables 8-9 (**Attachment B-1: Large Spills)**. Large spills have a disproportionate impact on the mean spill rate despite their infrequent occurrence. For OCS pipeline crude oil spills from 2009-2024, large spills (over 1,000 barrels) represent only 5.1% of total spill incidents but account for 81.3% of the total volume spilled. In contrast, very small spills (1 to 10 barrels) comprise 62.1% of all incidents but contribute only 0.4% of the total spill volume.

The limited sample size for large spills makes it difficult to establish statistical patterns or predict future occurrence rates with confidence. Each large spill event carries substantial weight in the overall analysis, meaning that the inclusion or exclusion of a single large spill can materially alter mean spill rates, frequency distributions, and risk assessments for the entire dataset.

6.1 Taylor Energy

The Taylor Energy oil spill, which began in September 2004 when Hurricane Ivan triggered an underwater mudslide in the Gulf of America, represents the longest continuous oil spill in US history. The mudslide destroyed Taylor Energy's production platform and buried multiple wellheads under sediment approximately 150 feet below the sea surface in Mississippi Canyon Block 20, about 11 miles off the Louisiana coast. Oil has leaked continuously from these damaged wells for decades, with estimates of daily discharge rates varying widely.

For the purposes of this analysis, the Taylor Energy spill is treated as a sequence of smaller spills as they are reported rather than aggregated into one large spill. This approach better reflects the ongoing nature of the incident and its alignment with the cumulative environmental impact of continuous smaller releases.

7 Developed Spill Rates

The mean spill rates are provided in **Table 10** within **Attachment B-2: Spill Rates**. For OCS platforms, crude oil spill rates have decreased from 9.99E-06 spills per barrel in a 60-year period to 3.98E-07 in the most recent 15 years. Platform crude oil spills in the very small category (1 to 10 barrels) account for 79-

86% of incidents across all time periods. Platform diesel spill rates range from 5.74E-07 to 8.11E-07 spills per barrel depending on the time period.

For OCS pipelines, crude oil spill rates have decreased from 5.93E-06 spills per barrel in a 60-year period to 2.55E-06 in the most recent 15 years. Pipeline crude oil spills in the very small category (1 to 10 barrels) account for 60-72% of incidents across all time periods. Pipeline diesel spill rates range from 1.06E-09 to 1.19E-09 spills per barrel depending on the time period.

8 Validation

The reliability of spill rate estimates depends on the quality and representativeness of the underlying data. To assess the analysis, a set of statistical metrics was calculated for each combination of source, oil type, and spill size category. These metrics evaluate both central tendency and variability within each category. For all key metrics, 90% confidence intervals were calculated to quantify uncertainty in the estimates. These validation steps allow for the identification of categories with sufficient data for reliable estimates and recognition of where uncertainty is high due to limited sample sizes or high variability. In addition, it provides a better understanding of how the distribution characteristics of spill volumes affect the interpretation of calculated rates. Additional details are provided in **Attachment B-3: Statistical Validation.**

9 Limitations

This analysis relies on existing regulatory and operational datasets rather than data collected specifically for the model. Each data source was designed for different regulatory, operational, or response purposes, presenting unique challenges in applying consistent selection criteria across sources. While efforts were made to reconcile these disparate sources through common selection criteria, the underlying data collection methods, reporting requirements, and quality standards vary significantly across sources and time periods. Because mean spill rates are heavily influenced by total volume spilled, larger spills were validated to reduce the impact of data variance on calculated rates. This prioritization ensures that high-volume incidents, which disproportionately affect mean spill rates, are based on the most reliable information available.

Attachment B-1: Large Spills

Table 8: Platforms

Date	Volume (bbl)	Material	Description	Hurricane	Dataset
4/8/1964	2,559	Crude oil	EL 208 Platform A	-	TIMS; Anderson et al. (2012)
10/3/1964	5,180	Crude oil	EL 208 Platforms A, C, and D	Hurricane Hilda	TIMS; Anderson et al. (2012)
10/3/1964	5,100	Crude oil	SS 149 Platform B	Hurricane Hilda	TIMS; Anderson et al. (2012
10/3/1964	1,589	Crude oil	SS 199 Platform A	Hurricane Hilda	TIMS; Anderson et al. (2012)
7/19/1965	1,688	Crude oil	SS 029 Caisson #7	-	TIMS; Anderson et al. (2012)
1/28/1969	80,000	Crude oil	WD 073 12" Seg #7791 (DOT)	-	TIMS; Anderson et al. (2012); NOAA
3/16/1969	2,500	Crude oil	SS 072 Well #3, Drill Rig	-	TIMS; Anderson et al. (2012)
2/10/1970	65,000	Crude oil	MP 041 Platform C	-	TIMS; Anderson et al. (2012)
12/1/1970	53,000	Crude oil	ST 026 Platform B Well #B-21	-	TIMS; Anderson et al. (2012)
1/9/1973	9,935	Crude oil	WD 079 Platform A	-	TIMS; Anderson et al. (2012)
1/26/1973	7,000	Crude oil	PL 023 Platform CA Storage Barge B1-363	-	TIMS; ITOPF
11/23/1979	1,500	Diesel	MP 151 MODU Pacesetter #3	-	TIMS
11/14/1980	1,456	Crude oil	HI 206 Platform A	Hurricane Jeanne	TIMS; Anderson et al. (2012)
9/24/2005	2,000	Crude oil	EL 314 Platform J	Hurricane Rita	Anderson et al. (2012)
9/24/2005	1,494	Diesel	SM 146 Platform B	Hurricane Rita	Anderson et al. (2012)
9/24/2005	1,572	Diesel	SS 250 Jac-up Rig Rowan Odessa	Hurricane Rita	Anderson et al. (2012)
4/20/2010	4,880,952	Crude oil	MC 252 Drillship TO Deepwater Horizon	-	NOAA

Table 9: Pipelines

Date	Volume (bbl)	Material	Description	Hurricane	Dataset
10/15/1967	160,638	Crude oil	WD 073 Seg #7791 (DOT)	-	TIMS; Anderson et al. (2012)
3/12/1968	6,000	Crude oil	ST 131 Seg #3573 (DOT)	-	TIMS; Anderson et al. (2012)
2/11/1969	7,532	Crude oil	MP 299 Seg #3469 (DOT)	-	TIMS; Anderson et al. (2012)
5/12/1973	5,000	Crude oil	WD 073 Seg #807 (DOT)	-	TIMS; Anderson et al. (2012)
4/17/1974	19,833	Crude oil	EL 317 Seg #1128 (DOI)	-	TIMS; Anderson et al. (2012)
9/11/1974	3,500	Crude oil	MP 073 Seg #36 (DOI)	Hurricane Carmen	TIMS; Anderson et al. (2012)
12/18/1976	4,000	Crude oil	EL 297 Seg #1184 (DOI)	-	TIMS; Anderson et al. (2012)
12/11/1981	5,100	Crude oil	SP 060 Seg #4715 (DOT)	-	TIMS; Anderson et al. (2012)
2/7/1988	15,576	Crude oil	GA A002 Seg #4879 (DOT)	-	TIMS; Anderson et al. (2012); PHMSA
1/24/1990	14,423	Crude oil	SS 281 Seg #8324 (DOI)	-	TIMS; Anderson et al. (2012)
5/6/1990	4,569	Crude oil	EL 314 Seg #4030 (DOI)	-	TIMS; Anderson et al. (2012)
8/31/1992	2,000	Crude oil	PL 008 Seg #4006 (DOT)	Hurricane Andrew	TIMS; Anderson et al. (2012); PHMSA
11/16/1994	4,533	Crude oil	SS 281 Seg #8324 (DOI)	-	TIMS; Anderson et al. (2012); PHMSA
1/26/1998	1,211	Crude oil	EC 334 Seg #11007 (DOT)	-	TIMS; Anderson et al. (2012); PHMSA; NOAA
9/29/1998	8,212	Crude oil	SP 038 Seg #5625 (DOT)	Hurricane Georges	TIMS; Anderson et al. (2012)
7/23/1999	3,180	Crude oil	SS 241 Seg #6462 (DOT)	-	TIMS; NOAA; PHMSA
1/21/2000	2,240	Crude oil	SS 332 Seg #10903 (DOT)	-	TIMS; NOAA; PHMSA
9/15/2004	1,720	Crude oil	MC 020 Seg #7296 (DOI)	Hurricane Ivan	Anderson et al. (2012)
9/13/2008	1,316	Crude oil	HI A264 Seg #7364 (DOT)	Hurricane Ike	TIMS; Anderson et al. (2012)
7/25/2009	1,500	Crude oil	SS 142 Seg #4006 (DOT)	-	TIMS; Anderson et al. (2012); NOAA
5/12/2016	2,100	Crude oil	GC 248	-	TIMS; NOAA
10/12/2017	16,152	Crude oil	MC 209	-	TIMS; NOAA

Attachment B-2: Spill Rates

Table 10: Developed spill rates

				1964-2024 (60 years)			1974-2024 (50 years)			2004-2024 (20 years)			2009-2024 (15 years)		
Source	Type	Spill Class	Spill Range (bbl)	*a**	*b**	*c**	*a**	*b**	*c**	*a**	*b**	*c**	*a**	*b**	*c**
OCS Platform	Crude Oil	Very small	1 to 10	9.99E-06	2.95	85.95%	1.09E-06	2.89	84.45%	1.24E-06	2.96	78.92%	3.98E-07	2.99	86.50%
		Small	11 to 100		30.06	11.07%		30.42	12.60%		31.77	16.81%		25.69	13.12%
		Medium	101 to 1,000		260.30	2.39%		251.86	2.83%		259.26	4.13%		324.00	0.38%
		Large	1,001 to 10,000		3,900.70	0.45%		1,728.00	0.12%		2,000.00	0.14%		0.00	0.00%
		Very large	10,001 to 100,000		66,000.00	0.14%		0.00	0.00%		0.00	0.00%		0.00	0.00%
	Diesel	Very small	1 to 2	7.27E-07	1.26	19.92%	7.85E-07	1.25	21.28%	8.11E-07	1.33	35.29%	5.74E-07	1.46	40.00%
		Small	2 to 10		3.75	48.44%		3.76	45.96%		4.28	14.71%		0.00	0.00%
		Medium	11 to 100		31.58	20.31%		30.64	21.28%		38.72	26.47%		42.81	20.00%
		Large	101 to 1,000		304.91	9.38%		312.67	9.36%		295.46	11.76%		125.80	20.00%
		Very large	1,001 to 3,600		1,936.95	1.95%		1,936.95	2.13%		2,046.18	11.76%		2,559.52	20.00%
OCS Pipeline	Crude Oil	Very small	1 to 10	5.93E-06	2.75	72.40%	5.75E-06	2.70	72.38%	2.99E-06	3.15	59.81%	2.55E-06	2.58	62.07%
		Small	11 to 100		32.90	16.93%		31.35	16.51%		32.75	24.30%		36.63	13.79%
		Medium	101 to 1,000		398.87	7.68%		390.33	8.25%		382.85	13.55%		378.51	18.97%
		Large	1,001 to 10,000		3,747.82	2.42%		3,227.21	2.22%		1,659.00	1.87%		1,800.00	3.45%
		Very large	10,001 to 100,000		16,496.00	0.57%		16,496.00	0.63%		16,152.00	0.47%		16,152.00	1.72%
	Diesel	Very small	1 to 2	1.06E-09	1.00	33.33%	1.19E-09	1.00	33.33%	8.31E-11	1.00	100.00%	1.05E-10	1.00	100.00%
		Small	2 to 10		7.10	33.33%		7.10	33.33%		0.00	0.00%		0.00	0.00%
		Medium	11 to 100		20.00	33.33%		20.00	33.33%		0.00	0.00%		0.00	0.00%
		Large	101 to 1,000		0.00	0.00%		0.00	0.00%		0.00	0.00%		0.00	0.00%
		Very large	1,001 to 10,000		0.00	0.00%		0.00	0.00%		0.00	0.00%		0.00	0.00%

a* = Mean Spill Rate

b* = Mean Spill Size (bbl)

c* = Spill percentage of frequency (count) for operational source and oil type combination.

Attachment B-3: Statistical Validation

Table 11 summarizes all statistical metrics calculated for each combination of source, oil type, and size category:

Table 11: Statistical metrics calculated for each spill category

Metric
Count
Mean spill volume
Mean confidence interval (90%)
Median spill volume
Median confidence interval (90%)
Standard deviation
Coefficient of variation
Standard error of mean
Distribution type
Spill rate
Spill rate confidence interval (90%)

B-3-1 Mean Confidence Intervals

For each spill category, we calculated both mean and median spill volumes along with their 90% confidence intervals. These metrics provide different perspectives on spill patterns: the mean represents the arithmetic average and is useful for calculating total volumes, while the median represents the typical spill size and is less influenced by extremely large outliers.

Confidence intervals for mean spill volumes were calculated using the t-distribution method, which accounts for sample size and variability in the data:

$$\text{CI} = \bar{x} \pm t_{\alpha/2,n-1} \times \text{SEM}$$

Equation 2: Confidence intervals

where:
$\bar{x}$= sample mean
$t_{\alpha/2,n-1}$= t-statistic for 90% confidence level with $n - 1$degrees of freedom
SEM= standard error of the mean = $\frac{s}{\sqrt{n}}$
s= sample standard deviation
n= sample size

The t-distribution method is appropriate because spill volumes do not follow a normal distribution and our sample sizes vary across categories.

B-3-2 Median Confidence Intervals

Median confidence intervals were calculated using bootstrap resampling, a non-parametric method that makes no assumptions about the underlying distribution of the data. This approach is particularly appropriate for spill data, which tends to be highly skewed with occasional very large values.
The bootstrap procedure works as follows:

1. From the original sample of n spill volumes, we randomly select n values with replacement
2. Calculate the median of this bootstrap sample
3. Repeat steps 1-2 for 1,000 iterations to create a distribution of 1,000 bootstrap medians
4. The 90% confidence interval is defined by the 5th and 95th percentiles of this bootstrap distribution

With1,000 bootstrap iterations, the confidence intervals are stable and reliable even for relatively small sample sizes.

B-3-3 Spill Rate Confidence Intervals

Confidence intervals for spill rates were derived from the mean volume confidence intervals:

$$\text{Rate Lower CI} = \frac{\text{Mean Lower CI} \times n}{P}$$

$$\text{Rate Upper CI} = \frac{\text{Mean Upper CI} \times n}{P}$$

Equation 3: Upper and lower spill rate confidence intervals

where:
Mean Lower CI and Mean Upper CI are the bounds of the mean confidence interval
n= number of spills in the category
P= total production or transportation volume

This approach provides an approximate confidence interval for the spill rate that reflects uncertainty in the mean spill volume. The approximation multiplies the per-spill confidence bounds by the number of observed spills to estimate total volume bounds.

B-3-4 Standard Deviation

The standard deviation measures the variability in spill volumes within each category:

$$s = \sqrt{\frac{\sum_{i=1}^{n}(V_i - \bar{x})^2}{n-1}}$$

Equation 4: Standard deviation

where:
- s= sample standard deviation
- V_i= volume of individual spill i (in barrels)
- $\bar{x}$= sample mean spill volume
- n= number of spills in the category

We use the sample standard deviation (dividing by $n - 1$rather than n) to provide an unbiased estimate of population variability.

B-3-5 Coefficient of Variation

The coefficient of variation (CV) expresses variability relative to the mean, allowing comparison across categories with different average spill sizes:

$$\text{CV} = \frac{s}{\bar{x}} \times 100\%$$

Equation 5: Coefficient of variation

where:
- CV= coefficient of variation (expressed as a percentage)
- s= sample standard deviation
- $\bar{x}$= sample mean spill volume

Higher CV values indicate greater relative variability in spill volumes within a category.

B-3-6 Standard Error of Mean

The standard error of the mean (SEM) quantifies the precision of the mean estimate:

$$\text{SEM} = \frac{s}{\sqrt{n}}$$

Equation 6: Standard error of mean

where:
- SEM= standard error of the mean

s= sample standard deviation
n= number of spills in the category

Smaller SEM values indicate more precise mean estimates, typically achieved with larger sample sizes or less variable data.

B-3-7 Distribution Characterization

Understanding the shape of the distribution of spill volumes within each category helps inform appropriate analytical approaches and interpretation of results.
We characterized distributions using two complementary methods:

Shapiro-Wilk Test for Normality

For categories with 3 to 5,000 spills, we applied the Shapiro-Wilk test to assess whether the data follow a normal distribution. This test calculates a test statistic and p-value:

- If $p > 0.05$, the data are consistent with a normal distribution
- If $p \leq 0.05$, the data significantly deviate from normality

The Shapiro-Wilk test is not applied to very small samples (n < 3) due to insufficient statistical power, or to very large samples (n > 5,000) due to computational limitations.

Skewness Analysis

Skewness measures the asymmetry of a distribution:

$$\text{Skewness} = \frac{\frac{1}{n}\sum_{i=1}^{n}(V_i - \bar{x})^3}{s^3}$$

Equation 7: Skewness analysis

where:
V_i= volume of individual spill i(in barrels)
$\bar{x}$= sample mean spill volume
s= sample standard deviation
n= number of spills in the category

We classify distributions based on skewness values:
Right-skewed (Skewness > 1): The distribution has a long tail toward larger values, meaning most spills are relatively small but occasional large spills pull the mean upward
Left-skewed (Skewness < -1): The distribution has a long tail toward smaller values
Approximately symmetric ($-1 \leq$ Skewness ≤ 1): The distribution is relatively balanced around the mean

Most spill volume distributions are right-skewed, which is why we report both means and medians. The median provides a better indicator of the typical spill size in skewed distributions.

Distribution Classifications

Based on the Shapiro-Wilk test and skewness analysis, each category is assigned one of the following distribution classifications:

- **Normal**: Data passed the Shapiro-Wilk test ($p > 0.05$)
- **Right-skewed**: Data failed normality test and have skewness > 1
- **Left-skewed**: Data failed normality test and have skewness < -1
- **Approximately symmetric**: Data failed normality test but $-1 \leq$ skewness ≤ 1
- **Insufficient data**: Fewer than three spills in the category
- **No data**: Zero spills in the category

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